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First Observations on the Stomach Contents of Devil Firefish, *Pterois miles* (Bennett, 1828) in the Gulf of Antalya, Turkey

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ABSTRACT

The present study examined stomach contents of 35 individuals of *Pterois miles* (Bennett, 1828) captured using scuba diving gears in Antalya Gulf. Total length and total weight in the specimens of *P. miles* collected from the Gulf of Antalya were 13.1-35.2 cm (mean±SD; 19.98±4.40) and 36.88-456.6 g (mean±SD; 103.82±91.29), respectively. The dominant prey were fish (IFO=106.67%, IP=59.38%) and the rest were crustaceans (IFO=53.33%, IP=40.63%). It was determined that *P. miles* was carnivorous and predominantly piscivorous. This study is the first to show how kind of consumption preys *P. miles* obtained from the Gulf of Antalya. The result of this study strengthens the existing knowledge on the consumption preys of devil firefish in the eastern Mediterranean. The distribution of this species continues in the Turkish Seas. The fishery and consumption of lionfish should be improved. The development of a lionfish fishery could provide a management tool to ameliorate impacts to coastal ecosystems of the Mediterranean Sea.

INTRODUCTION

Following the opening of the Suez Canal, the Mediterranean has been heavily exposed to Indo-Pacific species for a long time (Zenetos et al., 2012; Katsanevakis et al., 2014; Ayas et al., 2018). The ever-increasing sea water temperature in the Mediterranean with the effect of climate change causes the transition of tropical species to the Mediterranean, the formation of populations and the expansion of their distribution (Lejeusne et al., 2010; Kletou & Hall-Spencer, 2012; Ayas et al., 2018). One of the last species of this tropical process is the devil firefish, which has recently crossed into the Mediterranean. In the Mediterranean, one *Pterois miles* (Bennett, 1828) was recorded off the coast of Israel in 1991 (Golani & Sonin, 1992), *P. miles* was notified from Lebanon, Cyprus, Turkey, Greece and Tunisia (Bariche et al., 2013; Turan et al., 2014; Crocetta et al., 2015; Iglésias & Frotté, 2015; Oray et al., 2015; Turan and Öztürk, 2015; Dailianis et al., 2016; Jimenez

et al., 2016; Kletou et al., 2016; Mytilineou et al., 2016; Özgür Özbek et al., 2017; Al Mabruk & Rizgalla, 2019). Biological invasions threaten marine environments as they can harm native species at all trophic levels (Savva et al., 2020). The invasion and settlement of alien species is a major threat to marine biodiversity, structure and function, with economic and human health implications (Otero et al., 2013; Turan et al., 2017). The introduction of *P. miles* into the Mediterranean has posed a potential threat to the native species (Ayas et al., 2018). The successful range expansion and reproduction of lionfish being attributed to a broad set of biological traits, including their wide ecophysiological tolerance, high fecundity and rapid growth, predator defences and general feeding habits (Savva et al., 2020). Lionfish continue to spread to areas close to their thermal boundaries, although population density is declining where they first invaded (Savva et al., 2020).

The high feeding rates of lionfish pose a serious threat to its benthic ecosystems (Kulbicki et al., 2012; Turan et al., 2017). Lionfishes are predator species (Ayas et al., 2018). They are generalist carnivores and can feed on a wide variety of fish and crustaceans, although large individuals prefer almost exclusively fish (Côté et al., 2013; Kletou et al., 2016; Zannaki et al., 2019; Savva et al., 2020).

The aim of our study is to define stomach content of *P. miles* obtained from the Gulf of Antalya and its potential impact on the ecosystem.

MATERIAL AND METHOD

A total of 35 *P. miles* were collected with the use of scuba diving gears at depths of 8-22 m in the Gulf of Antalya (between 36°52'54.49"N and 30°41'37.67"E) on October 16, 2018 and May 15, 2019 in the daytime.

The lionfish was observed at depths ranging from 3 to 43 m and the majority were found on vertical rock walls or at the entrance of small caves. The specimens were immediately transferred to the laboratory. The total length (TL) measured with measuring board (cm) and the total weight weighed by the digital balance to the nearest 0.1 g. Fish were dissected to determine the sexes. The sex determination was made by examining the ovaries with the naked eye and under a light microscope. The ovaries and testes were removed, weighed to the nearest 0.1 g.

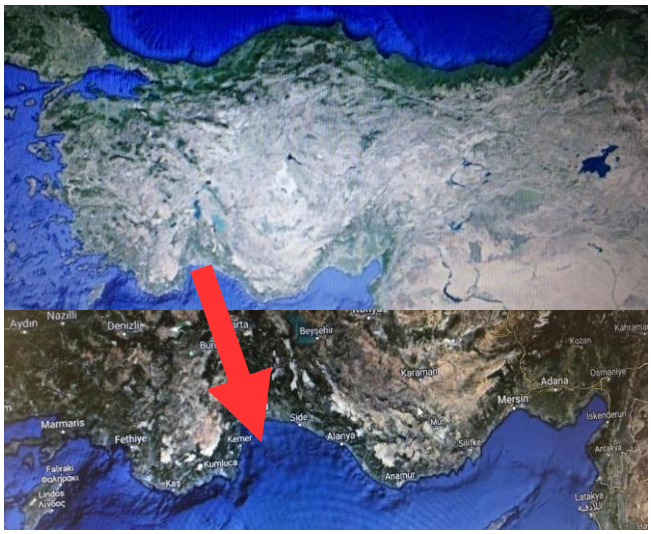

Figure 1. The Gulf of Antalya, Turkey (photos taken from Google Earth, 2021)

Figure 2. *Pterois miles* from the Gulf of Antalya

The food items in each stomach were identified to the lowest-possible taxa using light microscopy. When identification was not possible because of advanced digestion, the prey items were classified as "unidentified". The number of empty stomachs was also recorded. The pebble stones were considered as "accidental items". Weight and length measurements of undigested species were taken. The otoliths extracted from the stomach contents were examined under a light microscope and the genus and species determinations were made (Lombarte et al., 2006). The prey items divided into main taxon categories to facilitate dietary comparisons and eliminate biases associated with comparisons based on variable levels of identification (Savva et al., 2020).

To analyse the data obtained from the stomach content analysis, the methods described by Hyslop

(1980) and Kelleher et al. (2000) were used, and the following indices (Eq. (1) and Eq. (2)) were calculated:

$$IFO = \frac{n}{N_s} \times 100 \quad (1)$$

$$IP = \frac{n'}{N_p} \times 100 \quad (2)$$

Where I_{FO} is the frequency of occurrence, *IP* is the percentage of prey, *n* is the number of stomachs containing a certain prey, *Ns* is the total number of stomachs examined, *n'* is the total number of individuals of a certain prey and *Np* is the total number of prey individuals. According to IP values, prey categories were distinguished as preferential (I_P>50%) and secondary (10%<I_P<50%) (Savva et al., 2020; Zannaki et al., 2019)

RESULTS

In this study, the specimens of *P. miles* displayed the total lengths of 13.1 to 35.2 cm (19.98±4.40) and the total weights of 36.88 to 456.6 g (103.82±91.29) in the material collected from the Gulf of Antalya.

The gender of one sampled individual was determined as male. The gender of the others was found as female.

The majority of *P. miles* (20 samples) ranged from 15.0 to 20.0 cm. 9 individuals were found in the length class of 20.0 to 25.0 cm. The eight preys were detected in the stomach of 9 individuals. The length of 8 prey varied between 0.3-1 cm. The prey size could not be determined in other length groups.

It was determined that 24 (I_{FO}=68.57%) of the stomachs of 35 individuals was full and 11 (I_{FO}=31.43%) was empty. There were digested foods (I_{FO}=34.29%) in the stomach of twelve individuals (Table 1).

The stomach content analysis yielded 34 stomach items, of which 32 were considered as prey items belonging to 12 prey categories. The dominant prey item was bone fishes (I_{FO}=106.67%, I_P=59.38%) and secondly was crustaceans (I_{FO}=53.33%, I_P=40.63%). Among fishes, unidentified species was the dominant category in terms of frequency and abundance. It was found that 9 otoliths in the stomach contents of *P. miles* belonged to *Oblada melanura* (I_P 9.38, I_{FO} 13.33), *Gobius geniporus* (I_P 6.25, I_{FO} 6.67), *Serranus scriba* (I_P 3.13, I_{FO} 6.67), *Siganus rivulatus* (I_P 3.13, I_{FO} 6.67), *Chromis chromis* (I_P 3.13, I_{FO} 6.67) and *Scorpaena porcus* (I_P 3.13, I_{FO} 6.67). It was not determined to which species the 2 otoliths belonged. The 10 crustaceas in the stomach contents of *P. miles* was found as *Hemigrapsus* sp. (I_P 18.75, I_{FO} 13.33), *Pachygrapsus* sp. (I_P 9.38, I_{FO} 13.33) and *Scyllarus pygmaeus* (0.19 g) (I_P 3.13, I_{FO} 6.67) (Table 1).

DISCUSSION

In our study, the total lengths and the total weights of *P. miles* specimens were found to be between 13.1-35.2 cm and 36.88-456.6 g, respectively. The gender of one sampled individual was determined as male. The gender of the others was found as female. The reason for this difference in the sex distribution may be related to the number of samples, the sampling location and depth. It was determined that 24 (I_{FO}=68.57%) of the stomachs of 35 individuals was full and 11 (I_{FO}=31.43%) was empty. The reason for this may be related to the size of the specimens, the feeding of the specimens and nutrient availability at the sampling area.

In our study, the predominant prey was fish (I_{FO}=106.67%, I_P=59.38%) and the rest were crustaceans (I_{FO}=53.33%, I_P=40.63%). We determined that *P. miles* was carnivorous and predominantly piscivorous. Similarly, these results had been reported from the eastern side of Cyprus and Rhodes Island (Zannaki et al., 2019; Savva et al., 2020).

The distribution of this species continues in Turkish Seas (Özgür Özbek at al., 2017; Bilge et al., 2017; Turan, 2020; Özgül, 2020). This species, which is an invasive species, can adversely affects natural species after it settles in its environment (Bariche et al., 2013; Otero et al., 2013; Turan et al., 2017; Ayas et al., 2018; Savva et al., 2020; Taşkavak et al., 2021). The rapid response was the first line of defense to mitigate the effects of lionfish invasion (Morris et al., 2009; Kletou at al., 2016). The removal of lionfish by divers was reported to reduce its abundance at shallow depths (Morris et al., 2009; Kletou at al., 2016). In order to reduce the lionfish population and stocks in Turkey, a study can be conducted to catch these species with underwater rifles by divers. Additionally, although awareness-raising activities have been carried out for fishermen, divers, the public and inspectors in Turkey (H, 2019; AT, 2019;

AA, 2020), it is not enough for the awareness of this species, its consumption (meat high in protein) and suppression of its population and stocks (Ayas et al., 2018; TRTnews, 2019). For this reason, awareness raising activities should continue to be given weight so that the public can recognize, catch and consume lionfish in Turkey. In order for the public to consume lion fish more safely, products that have been cleaned of poisonous spines by experts should be sold (H, 2020).

On the other hand, the blue-spotted cornetfish *Fistularia commersonii* and the groupers (*Epinephelus striatus, Myceteroperca tigris, Ephinephelus marginatus and Ephinephelus costae*) were reported to be natural predators of this species (Bernadsky & Goulet, 1991; Mumby et al., 2011; Bariche et al., 2013; Turan et al., 2017). Additionally, predation by large carnivores such as groupers and sharks was also stated to represent one of the best controls for invasive devil firefish (Bernadsky & Goulet, 1991; Muñoz et al., 2011). Additional research is needed to understand predatory interactions between lionfish and native predators. This study is the first to show how kind of consumption preys *P. miles* obtained from the Gulf of Antalya.

By ensuring the continuity of legal regulations for the protection of the population and stocks of groupers and sharks in Turkey (CN 5/1, 2020, CN 5/2, 2020), it should be determined its population, stocks, feeding, effects on local species and fisheries of this species and whether is the predator of the lionfish in Turkey seas, which was reported to be consumed by sharks, the grouper and *F. commersonii.*

Table 1. Prey categories found in the stomachs of the individuals of *Pterois miles*

Stomach contents	n	n'	I_P	I_{FO}
Pisces				
Unidentified Pisces	7	8	25	46.67
Otolith				
Unidentified Otolith	2	2	6.25	13.33
Oblada melanura	2	3	9.38	13.33
Gobius geniporus	1	2	6.25	6.67
Serranus scriba	1	1	3.13	6.67
Siganus rivulatus	1	1	3.13	6.67
Chromis chromis	1	1	3.13	6.67
Scorpaena porcus	1	1	3.13	6.67
Total pisces	16	19	59.38	106.67
Crustacea				
Unidentified Crustacea	3	3	9.38	20
Crab				
Hemigrapsus sp.	2	6	18.75	13.33
Pachygrapsus sp.	2	3	9.38	13.33
Lobster				
Scyllarus pygmaeus	1	1	3.13	6.67
Total crustacean	8	13	40.63	53.33
Accidental				
Pebble stones	2	2		13.33
The digested food	12			34.29
The full stomach	24			68.57
The empty stomach	11			31.43

Note: *n*, number of stomachs containing a certain prey; *n'*, the total number of individuals of a specific prey; I_P, percentage of prey index; I_{FO}, frequency of occurrence index.

CONCLUSION

The current information on the diet of *P. miles* is that they are carnivorous and can feed on a wide variety of fish and crustaceans. The result of this study strengthens the existing knowledge on the consumption preys of devil firefish in the eastern Mediterranean. The distribution of this species continues in the Turkish Seas. The increased densities observed over time, coupled with its generalist diet and consumption of ecologically and socio-economically important fish, could result in the competition of native predators of the same trophic level and further degradation of local marine communities in an already anthropogenically stressful marine environment. The fishery and consumption of lionfish should be improved. The fishing gears should be developed to catch lionfishes concentrated in rocky-stony area. The development of a lionfish fishery could provide a management tool to ameliorate impacts to coastal ecosystems of the Mediterranean Sea. The information and promotion activities should be continued in order to increase and popularize the consumption of lionfish by the public.

Compliance With Ethical Standards

Authors' Contributions

MG designed the study and collected samples by diving.

RT carried out the transport of samples to the laboratory and laboratory work, statistical analysis and data management.

JK provided the laboratory facilities.

The species identification from otolith was executed by MG and RT. All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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