

## Piscis non grata in the Mediterranean Sea: *Pterois miles* (Bennett, 1828)

### Akdeniz'de istenmeyen balık: *Pterois miles* (Bennett, 1828)

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**Abstract:** *Pterois miles* is currently considered a marine invader, especially in the western Atlantic where the species has been introduced in the middle of 1980's, at about the same time the species first appeared in the eastern Mediterranean. West Atlantic experience and the relevant literature told us that 'a *P. miles* invasion has begun in the Mediterranean'. Here, the research is presented providing important integrating data from the invasion by the same species in the Atlantic, the current status and historical distribution of *P. miles* in the Mediterranean with a northernmost occurrence of the species from the Aegean Sea (off Didim coast, Turkey).

**Keywords:** Lionfish, *Pterois miles*, biological invasion, Mediterranean Sea, range expansion

**Öz:** Özellikle 1980'lerin ortasında batı Atlantik'e giriş yapan, denizel bir istilacı tür olarak kabul edilen *Pterois miles*, benzer zaman diliminde ilk kez doğu Akdeniz'de ortaya çıkmıştır. Batı Atlantik deneyimi ve ilgili literatür bize "Akdeniz'de *P. miles* saldırısının başladığını" söylemektedir. Bu çalışma Akdeniz'deki *P. miles*'in bugünkü durumu, tarihsel dağılımı ile Ege Denizi'ndeki en kuzey dağılımı hakkında (Didim sahili, Türkiye) önemli entegre veriler sunmaktadır.

**Anahtar kelimeler:** Aslan balığı, *Pterois miles*, biyolojik istila, Akdeniz, dağılım genişlemesi

## INTRODUCTION

Now, we are witnessing a rapid invasion of lionfish, *Pterois miles* (Bennett, 1828), in the Mediterranean from a single specimen in 1991 to several sightings between 2014 and 2016 in the eastern Mediterranean Sea (Bilge et al., 2016). This increase is very similar to the pattern of invasion recorded for lionfishes (*P. volitans/miles*) in western Atlantic (Albins and Hixon, 2013). Judging from the recent increase in *P. miles* in the eastern Mediterranean Sea (Filiz et al., 2017), we suspect that a rapid expansion throughout the Mediterranean Sea. Indeed, in both its native and introduced ranges, lionfishes thrive in warm waters ideally between 20 and 30 °C (Turingan and Sloan, 2016), so, given the predicted increases in water temperature expected in the Mediterranean, the ability for long distance dispersal of planktonic larvae, and the generality of habitat use it is expected that the invaded area will continue to expand. All the recent findings of *P. miles* may be an

indication of a new wave of arrivals of the species in the eastern Mediterranean, raising justifiable concerns of a possible onset of a new invasion mentioned by Bariche et al. (2013) in the Mediterranean Sea.

Here, we presented a review providing important integrating data from the invasion by *P. miles* in the Atlantic, the current status and historical distribution of *P. miles* in the eastern Mediterranean with a northernmost occurrence of the species from the Aegean Sea (off Didim coast, Turkey).

## MATERIAL AND METHODS

On 05 April 2017, one specimen of *P. miles* (Figure 1) was observed and photographed by a SCUBA diver from off Didim coast (37°20'N, 27°14'E) on a rocky bottom at depths of 18 m. The water temperature was 14.3 °C. The specimen was identified based on the description provided by Golani et al. (2006) using high quality photos.

**Figure 1.** Underwater view of new recorded *P. miles* specimen in the Aegean Sea



Peer-viewed publications were priority sources, so a total of 26 reliable literatures were compared to obtain all available information on biogeographical (locality, coordinates) and historical traits (sampling date), and biological (sample size, catching/observation method) and ecological characteristics (habitat type, depth, temperature) of *P. miles* for the Mediterranean.

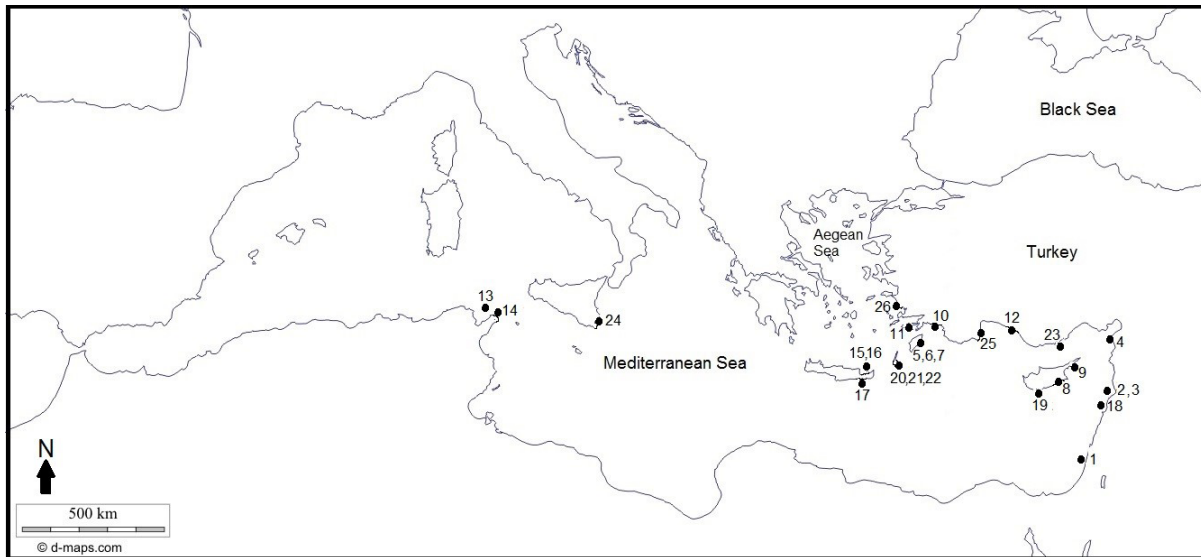
## RESULTS

Unique features of specimen were clearly visible and noticeable: Long and venomous dorsal spines longer than body. Body is reddish to tan and numerous thin dark bars on body and head vertically; visible small spots in the median fins.

The chronological order of the *P. miles* sightings, which accounts for the period July 1991 to April 2017, showed a progressive expansion of the *P. miles* in the eastern and western Mediterranean (Table 1 and Figure 2). To our best knowledge, no published records of the *P. miles* are available for the Mediterranean coasts of Egypt and Libya (Froese and Pauly, 2018), but recently from Italy in the western Mediterranean by Azzurro et al. (2017). A total of 26 reliable records of *P. miles*

were reported in the Mediterranean Sea (Table 1). The species was collected by a variety of different fishing gears along the Mediterranean coasts like bottom trawl, trammel and gill nets, wire trap, spearfishing and collected net or via scuba diving from 2 m (Crocetta et al., 2015; Jimenez et al., 2016) to 110 m (Yağlıoğlu and Ayaş, 2016), mostly ranged 2-35 m, since the data were collected primarily by SCUBA divers and, therefore, is limited in its application to relatively shallow depths.

**Figure 2.** The distribution map of scientific reports of *P. miles* occurrences in the Mediterranean Sea (<sup>1</sup>Golani and Sonin (1992), <sup>2,3</sup>Bariche et al. (2013), <sup>4</sup>Turan et al. (2014), <sup>5-7</sup>Crocetta et al. (2015), <sup>8</sup>Iglésias and Frotté (2015), <sup>9</sup>Oray et al. (2015), <sup>10</sup>Turan and Öztürk (2015), <sup>11,12</sup>Bilge et al. (2016), <sup>13-18</sup>Daillianis et al. (2016), <sup>19</sup>Jimenez et al. (2016), <sup>20-22</sup>Mytilineou et al. (2016), <sup>23</sup>Yağlıoğlu and Ayaş (2016), <sup>24</sup>Azzurro et al. (2017), <sup>25</sup>Özgür Özbek et al. (2017) and <sup>26</sup>Present study. For further details, see Table 1).



**Table 1.** Locations in the Mediterranean and Aegean Seas where *P. miles* individuals have been recorded between 1991 and 2017 (\*). The number in front of each locality was shown in Figure 2)

Source	*Locality	Coordinates	n	Length Range (cm TL)	Habitat	Depth (m)	T (°C)	Date	Catching/Observation method
Golani and Sonin (1992)	<sup>1</sup> Herzliya, Israel	-	1	32.8	-	35	-	28.07.1991	Trawl
Bariche et al. (2013)	<sup>2</sup> Al Minie, Lebanon	34.29N 35.54E	1	-	Coralligenous bottom	30	-	02.10.2012	Wire trap
Bariche et al. (2013)	<sup>3</sup> Al Minie, Lebanon	34.29N 35.54E	1	20.9	Coralligenous bottom	30	-	12.12.2012	Trammel net
Turan et al. (2014)	<sup>4</sup> Kaleköy, Iskenderun, Turkey	36.17N 35.46E	1	27.6	Rocky bottom	25	-	13.04.2014	-
Crocetta et al. (2015)	<sup>5</sup> Kallithea, Rhodes, Greece	36.38N 28.24E	1	-	Under a large rock covered by vegetation on a sandy bottom	7	-	15.07.2015	Diving
	<sup>6</sup> Pilimiri Bay, Rhodes, Greece	35.91N 27.85E	1	-	in the shipwreck	-	-	02.08.2015	Diving
	<sup>7</sup> Psaropoula, Rhodes, Greece	36.45N 28.21E	1	-	-	2	-	23.09.2015	Diving
Iglésias and Frotté (2015)	<sup>8</sup> Ormida, Cyprus	-	1	17.0	-	10	-	22.05.2014	Net
Oray et al. (2015)	<sup>9</sup> Karpas, Cyprus	-	1	37.3	Rocky bottom	40	-	26.02.2015	Gill net
Turan and Öztürk (2015)	<sup>10</sup> Dalyan, Mugla, Turkey	-	1	-	Sandy bottom	11	-	08.2015	Diving
Bilge et al. (2016)	<sup>11</sup> Datça, Mugla, Turkey	36.69N 27.68E	1	-	-	10	-	04.2016	Gill net
	<sup>12</sup> Levantine coasts, Turkey	-	13	-	Rocky bottom	4-25	20.0-29.0	08.2014-07.2016	Diving
Daillanis et al. (2016)	<sup>13</sup> Zembra Island, Gulf of Tunis, Tunisia	37.10N 10.87E	1	20.2	Sandy bottom	5	-	06.2015	Gill net
	<sup>14</sup> Haouaria, Cape Bon, Tunisia	37.02N 11.04E	1	-	Sandy bottom	-	-	09.2015	Diving
Daillanis et al. (2016)	<sup>15</sup> Kavo Sidero, NE Crete, Greece	35.31N 26.29E and 35.31N 26.32E	2	-	Rocky bottom and reefs.	-	-	11.2015	reported by artisanal fishermen
	<sup>16</sup> Kouremenos Bay, NE Crete, Greece	35.20N 26.30E	1	25.0	Rocky bottom	33	-	-	Collected net
	<sup>17</sup> AgiosPanteleimonas, SE Crete, Greece	35.01N 25.96E	1	10.0	Rocky and sandy bottom	18-30	-	24.07.2016	nets
	<sup>18</sup> Labanese coasts	-	47	-	Rocky	12-37	-	06.2013-10.2015	-
Jimenez et al. (2016)	<sup>19</sup> Cyprus	-	90	5.0-30.0	Rocky and coralligenous substrate, artificial substrate	2-35	-	-	Based on a network of information set up in Cyprus in 2011
Mytilineou et al. (2016)	<sup>20</sup> Achata, Karpathos Island, Greece	35.55N 27.20E	1	10	Rocky	17	-	18.08.2016	Diving
	<sup>21</sup> Agia Petros, Karpathos Island, Greece	35.50N 27.22E	1	20	Rocky	16	-	20.08.2016	Diving
	<sup>22</sup> Kastellia, Karpathos Island, Greece	35.47N 27.19E	1	10	Rocky	9	-	20.08.2016	Diving
Yağlıoğlu and Ayaş (2016)	<sup>23</sup> Yeşilovacık Bay, Mersin, Turkey	36.08N-33.40E to 36.07N-33.33E	1	25.0	-	100-110	-	20.12.2015	Bottom trawl
Azzurro et al. (2017)	<sup>24</sup> Vendicari coast, Sicily, Italy	36.49N 15.06E	1	12.0	Sandy bottom intermingled with sparse calcareous rocks where patches of algae dominated	3.5	-	23.09.2016	Scuba survey
Özgür Özbek et al. (2017)	<sup>25</sup> Kemer, Antalya, Turkey	-	8	8.5-29.3	Sandy and rocky	10-15	14.9-16.0	20.01.2017-10.02.2017	Spearfishing
Present study	<sup>26</sup> Off Didim coast, Aydın, Turkey	37.20N 27.14E	1	-	Rocky bottom	18	14.3	05.04.2017	Scuba diving



The species found in a variety of habitats. Recorded numbers ranged from one (most records) to 90 (Jimenez et al., 2016) individuals, lengths ranged from 5 cm (Jimenez et al., 2016) to 37.3 cm (Oray et al., 2015). The most west, east, north, and south records of the species were in Sicily (Italy), Al Minie (Lebanon), Didim coast (Turkey), and Haifa (Israel), respectively (Table 1). Most of the records were obtained in summer, the seawater temperatures were ranged from 14.3 °C in April 2017 (present study) to 29.0 °C in August 2015 (Bilge et al., 2016).

## DISCUSSION

The lionfishes' introduction provides a reminder of how rapidly a non-native species can become established and potentially compete with native fishes for resources (Morris et al., 2008). The lionfishes' invasion in the western Atlantic represented one of the most rapid and extensively documented marine fish invasion in history. After the lionfishes have colonized large areas of the western Atlantic, resulting in an immense ecological damage, Albins and Hixon (2013) commented on the situation as: "with an eye on the future, we describe a possible worst case scenario". *P. miles* has been recorded as a first time on the western Atlantic coast in 1985 (Schofield, 2009), during a dark 15 years, no sightings were mentioned until 2000. Thereafter, it was again started to report, increasingly, became fully established throughout the southeast United States (US) and the Caribbean Sea, extending to South America and much of the Gulf of Mexico (Schofield, 2009 and references therein; Kletou et al., 2016), becoming the first non-native marine fish to establish self-sustaining populations in these region (Ruttenberg et al., 2012). The most likely vectors for the introduction were releases or escapes either intentional or accidental from marine aquaria (Albins and Hixon, 2011; Kletou et al., 2016), since the lionfishes are a popular ornamental aquarium fish that have been imported into the U.S.A in large numbers (Morris and Akins, 2009). But, still, the exact cause of introduction has not been determined (NMFS, 2015). Betancur-R et al. (2011) showed that the invasive population of lionfishes in the western Atlantic has a significantly lower genetic diversity than populations from their native range, which is associated with a strong founder effect, and is thought to originate a relatively small number of founder population in the southeast US. Similarly, in the Mediterranean Sea, a single specimen of *P. miles* was recorded from the Levantine coast in 1991 (Golani and Sonin, 1992). During the twenty-one years' period, no observation was happened in the Mediterranean, even, just before Johnston and Purkis (2014) claimed that a natural invasion of the Mediterranean Sea by *P. miles* was unlikely, two *P. miles* individuals were captured separately in the northern part of Lebanon (Bariche et al., 2013). Then, additional sightings were reported one after another along the coasts of Cyprus (Iglésias and Frotté, 2015; Oray et al., 2015; Jimenez et al., 2016;

Kletou et al., 2016), Turkey (Turan et al., 2014; Turan and Öztürk, 2015; Bilge et al., 2016; Yağlıoğlu and Ayaş, 2016), Rhodes (Crocetta et al., 2015), Tunisia (Dailianis et al., 2016), and rarely from western Mediterranean (Azzurro et al., 2017). The time passed between the first and the second records of this species both in Atlantic and Mediterranean seems lengthy. Azzurro et al. (2016) explained this phenomenon as a failed introduction: "Considering the conspicuous appearance of *P. miles*, and its relatively ease in recognition, the lack of observations until 2012 is unlikely "a detection lag" and the 1991 record (Golani and Sonin, 1992) can be considered as evidence of a failed introduction". While marine scientists in the Mediterranean region were trying to understand the introduction vectors (aquarium release, transport by ship ballast water, dispersal event from an Atlantic source or passage through the Suez Canal as Lessepsian immigrant) of the invading population in the Mediterranean Sea, recently, Bariche et al. (2017) showed that the very first individuals establishing populations in the Mediterranean Sea displayed haplotypes that nest within the large genetic diversity of Red Sea individuals, thus indicating an invasion via the Suez Canal, concluded that the Mediterranean invasion was the result of a movement of individuals from the Red Sea. While a model predicted that a natural invasion of the Mediterranean Sea by *P. miles* was unlikely to be successful (Johnston and Purkis, 2014) since the oceanographic conditions in the Mediterranean were unfavourable for the dispersion of *P. miles* larvae, and Mediterranean marine scientists discussed whether the species could invade this region like it has in the western Atlantic, recently Kletou et al. (2016) warned us that "A lionfish (*Pterois miles*) invasion has begun in the Mediterranean Sea". Although, Azzurro and Bariche (2017) stated that current abundances of *P. miles* are still below the threshold of a "true invasion", recently, in order to see and compare the invasiveness of the Lessepsian fishes, a threshold was calculated as 18.5 using AS-ISK (Aquatic Species Invasiveness Screening Kit; available at <https://www.cefas.co.uk/nns/tools/>) analysis (Bilge et al., 2017). Considering the high Basic Risk Assessment (BRA) score 45.5 for *P. miles* (Bilge et al., 2017) now, it can be considering that *P. miles* is possibly the most invasive marine fish in the Mediterranean and possesses a very high risk to biodiversity. In contrast to Johnston and Purkis (2014)'s assumption, it's obvious that, now, *P. miles* may have already been found a favourable oceanographic conditions in the Mediterranean. Supporting this idea, Poursanidis (2015) provided an insight to the potential expansion of the *P. miles* in the Mediterranean Sea and the identification of the suitable areas for it to establish. On the other hand, in contrast to limited gene pool in the Atlantic population (Betancur-R et al., 2011), rich genetic diversity in the Mediterranean population (Bariche et al., 2017) may support invading success and also have distribute in wider habitats and live at lower

temperatures in the Mediterranean Sea. Furthermore, CO<sub>2</sub> emissions which are warming the Mediterranean Sea and the construction of a deeper and wider Suez Canal are expected to increase invasion rates (Galil et al., 2015; Hall-Spencer and Allen, 2015).

*P. miles* has been considered highly temperature dependent (Dabruzzi et al., 2017), according to Kimball et al. (2004) *P. miles* unable to survive below 10 °C. It was mentioned some temperature limitations for the Lessepsian fishes in the Mediterranean. For example, while Corsini and Stamatellos (1998) suggested that water temperatures around 12 °C may constitute a fatal limit for *Pteragogus pelycus*, controversially, it was reported *Stephanolepis diaspros* can be survive at 11.5 °C (Béjaoui et al., 2008) and 12 °C (Corsini-Foka et al., 2010). Recently, Özgür Özbek et al. (2017) noted that the *P. miles* continued feeding in low winter temperature (14.9 °C). This low winter inshore temperature is below the temperature threshold (16.1°C) at which experimental lab studies have suggested the lionfish stops feeding (Kimball et al., 2004). The more widespread colonisation of the Mediterranean and Aegean region by *P. miles* seems no temperature dependent. In a way that support it, Bilecenoğlu (2016) tested six environmental variables on Lessepsian fish assemblage by the multivariate analysis, and he found that only a single species (*Nemipterus randalli*) had a positive correlation with water temperature. Anyway, further studies in the Mediterranean should focus on the interaction between lionfishes and seasonal water-temperature variation in order to better understand whether temperature has a more significant role at the invasion range limit.

The data were presented in Table 1 collected primarily by SCUBA divers and, therefore, is limited in relatively shallow depths. According to literature, *P. miles* is naturally distributed in the tropical waters of the Indian Ocean, Persian Gulf and the Red Sea from South Africa to Indonesia up to 60 or 65 m (Froese and Pauly, 2017). But there is evidence from the Atlantic literature that lionfishes (*Pterois* spp.) may found on mesophotic zone. For example, lionfishes reported from 100 m off North Carolina (Meister et al., 2005), over 100 m in the Bahamas (Bejarano et al., 2014), 112 m in northwestern Gulf of Mexico (Nuttall et al., 2014), 120 m in Honduras (Schofield, 2010), 126 m on Puerto Rico coast and 167 m on Conrad Seamount (Quattrini et al., 2017), 247 m in Çuraçao (Tornabene and Baldwin, 2017), 240 m in Roatan and 304 m in Bermuda (Gress et al., 2017). On the other hand, Johnston and Purkis (2011) suggested that lionfish may extend their maximum depth to 610 m. It seemed the deeper waters can be used as a potential refuge for invasive lionfish as indicated by Andradi-Brown et al. (2017). But these studies' data included two species (*P. volitans* and *P. miles*), and since no separated data presented, we cannot be sure which species really occur deeper waters, one we could accept that *P. volitans* and *P. miles* are considered to be ecologically similar as they have non-overlapping native ranges it would be worth acknowledging they are likely to

be deeper. Recently, a more certain evidence, regarding only *P. miles*, was provided by Yağlıoğlu and Ayaş (2016) from the Mediterranean. They reported that, a *P. miles* was captured by commercial bottom trawl fishery at a depth of 100 to 110 m from Yesilovacık Bay, Mersin, Turkey (North-Eastern Mediterranean). There are very few observations available for depths beyond recreational SCUBA diving limits in the Mediterranean. West Atlantic examples showed that additional sampling beyond traditional diver surveys is needed to gain a more complete understanding of the *P. miles* invasion process and the threats it poses to different habitat and ecosystem types. Previous studies have documented that *P. miles* invasions can begin in shallow habitats, but progressing to deeper habitats with time as indicated before by Claydon et al. (2012) and Andradi-Brown et al. (2017), so we may be face a deeper invasion needed to detailed study in the Mediterranean.

Although clear signs of numerical increase emerged, and raising concerns for an incipient *P. miles* invasion (Dailianis et al., 2016; Kletou et al., 2016; Azzurro and Bariche, 2017), little was known regarding the its biology and ecology in the Mediterranean. Considering literature including experimental, applied studies in western Atlantic and applied risk screening tool for the Mediterranean (Filiz et al., 2017), it is known that it has many biological abilities expected of a successful invader, such as high climate match, tolerance of a wide range of environmental conditions, flexibility in utilising food resources, high fecundity, small size at maturity, high reproductive effort (Azzurro et al., 2017; Filiz et al., 2017) which can be obtained certain critical data such as abundance, dietary habits, predators, and reproduction of *P. miles* are scarce for the Mediterranean.

In spite of all the negativities of the Mediterranean scientists and data obtained from literature, the diving schools seem very happy the occurrence of *P. miles* in the coastal waters in Antalya and Muğla province since the *P. miles* is an attractive marine fish for the divers. A similar point of view was also reported from Cyprus by Jimenez et al. (2017).

The northward occurrence of *P. miles* in the present study, as well as previous reports, may be evidence its accelerating expansion through the Mediterranean Sea and adjacent seas. In conclusion, status of *P. miles* in the Mediterranean and adjacent seas should be monitored closely via formal and citizen sciences. The recent and rapid expansion of the *P. miles* in the Mediterranean is therefore alarming and requires the immediate action of all concerned stakeholders in the area (Bariche et al., 2017). Finally, it is vital that the ecology and distribution of the invasive species is fully understood to design the most effective form of control (Andradi-Brown et al., 2017).

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