ISSN: 2458-8989

Natural and Engineering Sciences

NESciences, 2022, 7(3): 228-239 doi: 10.28978/nesciences.1163001

Food Composition and Dietary Overlap of the Lionfish Species in Iskenderun Bay

Burçin Demirci [1*], Sefa Ayhan Demirhan [2]

[1] Ministry of Agriculture and Forestry, District Directorate of Agriculture and Forestry, Turkey

[2] Iskenderun Technical University, Faculty of Marine Sciences and Technology, Iskenderun, Hatay, Turkey

Abstract

The food composition and dietary overlap of the *Pterois volitans* and *P. miles* were studied in the İskenderun Bay. The main prey groups found in the stomachs of the *P. volitans* and *P. miles* were fishes and crustaceans. The study has shown that the Niche overlap-Pianka's index of these species was 83,2%. Most of the stomach contents for both species were not identified. Fish and shirimps were found in the stomachs contents of both species freqently. However reef parts, moss residuals, molluscs shell parts and crab parts were found in the stomachs content for both species rarely. *Chlorophthalmus agassizi*, *Uranoscopus scaber*, *Helicolenus dactylopterus*, Serranidae, Sparidae and Scorpaenidae members have been identified as stomach contents of *P. volitans*. Similarly C. *agassizi* was identified in the stomach contents of *P. miles*. Conspicuously, juvenile lionfish and body parts of juvenile lionfishes (dorsal fin and spines) were found in 4 specimens stomachs of *P. miles.*

Keywords:
Pterois miles, *Pterois volitans*, lionfish, diet composition, stomach analyses

Article history:
Received 01 April 2022, Accepted 10 Agust 2022, Available online 16 August 2022

Introduction

Lionfish are considered the world's most invasive fish species (Whitfield et al., 2007; Molnar et al., 2008; Morris et al., 2009; Schofield, 2010; Johnston & Purkis, 2014; Poursanidis, 2015). There are lionfish invasions in various seas of the world marine waters (Hare & Whitfield, 2003; Ferreira et al., 2015; Fogg et al., 2019). They may have been introduced into the Atlantic at Biscayne Bay, Florida when several individuals were released from an aquarium during Hurricane Andrew in 1992 (Courtenay, 1995; Hamner et al., 2007). Since their establishment in the Bahamas, they have

*Corresponding Author: Burçin DEMİRCİ, E-mail: burcin.demirci@tarimorman.gov.tr

colonized the western Atlantic and Caribbean region, and populations have grown exponentially at many locations. These species have also been seen in the Mediterranean since 1992 through the Suez Canal (Golani & Sonin, 1992).

The Mediterranean is an important point in terms of biodiversity with an estimated 17000 species (Coll et al., 2010). The ecosystem is highly volatile due to threats such as global climate change, overfishing and the invasion of alien species (Kletou et al., 2012; Doğdu et al., 2016; Dragičević et al., 2019; Turan & Doğdu, 2022). It is reported that the gradual increase in the seawater temperature of the Mediterranean leads to the tropicalization of the community (Gobert et al., 2020). Today, it is known that highest entered and settled alien species into theMediterranean Sea, most of which enter through the Suez Canal (Stamouli et al., 2017;Turan et al., 2018; Ergüden et al., 2019; Crocetta et al., 2021). Fertilized pelagic eggs and larvae of lionfish can spread by currents (Ahrenholz & Morris, 2010; Turan et al., 2017). Similarly, it can be predicted that the fertilized eggs and larvae of lionfish were transported to the Mediterranean by the current crossing the Suez Canal (Yağlıoğlu & Ayas 2016).

Studies since its first detection in 2014 show that the species has increased its density in the Iskenderun Bay (Turan et al., 2014; Gürlek et al., 2016; Dağhan & Demirhan, 2020; Yılmaz & Demirhan, 2020). The spread of lionfish in the Mediterranean continues in the western Mediterranean and the Aegean Sea (Turan & Öztürk, 2015; Dailianis et al., 2016; Mytilineou et al., 2016; Turan, 2020; Turan et al.,2020). This invasive carnivore is a predator of native fish and invertebrates and can also cause detrimental changes in the coral reef ecosystem through competition with native predators, thereby negatively affecting fisheries (Albins & Hixon, 2008). Therefore, this study aimed to understand which species of lionfish exert pressure on the ecosystem and to determine whether there is a nutritional competition between the two species.

Materıal and Methods

Specimens of both species were collected in the Iskenderun Bay by commercial fisheries using trammel nets. Some of the specimens were collected by spearfishing by diving. A total of 96 *P. miles* and 118 *P. volitans* were collected.

Stomachs with contents were placed in numbered plastic bags and frozen for subsequent analysis. In the laboratory, whenever possible, the prey was visually identified to species level and unidentified remains were noted. The stomach contents were weighed.

Stomach contents were analyzed concerning the importance of prey in the diet of the *P. miles* and *P. volitans* by using the methods proposed by Levins (1968), Hureau (1970), Pianka (1971), Hyslop (1980) and Krebs (1989).

Based on prey items, frequency of occurrence (O%) (eq.1), % number (N%) (eq.2) and % weight (W%) (eq.3) were calculated following Hyslop (1980).

$O_i\% = (FO_i/NS)*100$ (eq. 1)

$N_i\% = (N_i/N_p)*100$ (eq. 2)

$W_i\% = (W_i/W_p)*100$ (eq. 3)

where *Oi*% is the percent frequency of occurence of prey *i*, *FOi* is the frequency of occurrence of prey *i*, *NS* is the total number of stomachs examined, *Ni*% is the percent by number of prey *i*, *Ni* is the total number of prey *i*, *Np* is the total number of prey, *Wi*% is the percent by weight of prey *i*, *Wi* is the total weight of prey *i*, *Wp* is the total weight of prey.

The composition of the diet was calculated by the index of relative importance (*IRI*%) following Pianka (1971) (eq. 4). The diet breadth (*B*) was calculated using Levin's index (1968) (eq. 5) and arbitrarily adjusted at the following levels: high (> 0.6), intermediate (0.4 - 0.6) or low (<0.4). The feeding coefficient (*Q*) (eq. 6) and percentage of predominance value (*PVi*%) (eq. 7) were used to evaluate the relative importance of various prey types in the diet and to provide a quantitative description of stomach contents following Krebs (1989).

$I_{RI}\% = 100*((N\% + W\%)*O\%^{-1})(\sum(N\% + W\%)*O\%^{-1})^{-1}$ (eq.4)

Were, N_i , W_i and O_i represent percentages of number, volume and frequency of occurrence prey *i* respectively.

$B = \left(\sum_i^n = 1 p_i^2\right)^{-1}$, (eq. 5)

where *B* = standardized index of niche breadth, *pij* = proportion of the diet of predator *i* on prey *j*, and *n* = total number of items (resources). *Bi* values vary from 0 (species consume a single item) to 1 (species exploits available items in equal proportion). Values of *Bi* are considered high when higher than 0.6, moderate, when between 0.4 and 0.6 and low when below 0.4 (Novakowski et al., 2008).

Results

A total of 96 *P. miles* and 118 *P. volitans* samples were captured during 2019-2020, of the examined stomachs, 24 (25%) *P. miles* and 75 (48%) *P. volitans* stomachs were empty. The main prey groups found in the stomachs were teleosts (65%) for *P. miles* and unidentified items (46%) for *P. volitans* by frequency of occurence (*O*%). Results of the stomach content analysis for *P. miles* and *P. volitans* indicating the percentage frequency of occurrence (*O*%), percentage by number (*N*%), percentage by weight (*W*%), respective percentage of feeding coefficient (*Q*%), respective percentage of Predominancy value (*PV*%), Index of Relative Importance (IRI) and its respective percentage (*IRI*%) for each prey groups identified were summarized in table 1. The dietary breadth is a quantitative measure of the specifics of a species' diet (Krebs, 1989). The estimated value for *P. volitans* (2.36) was a little higher than that of *P. miles* (2.56). Dietary niche overlap (Niche overlap-Pianka's index) between *P. miles* and *P. volitans* was 0.83.

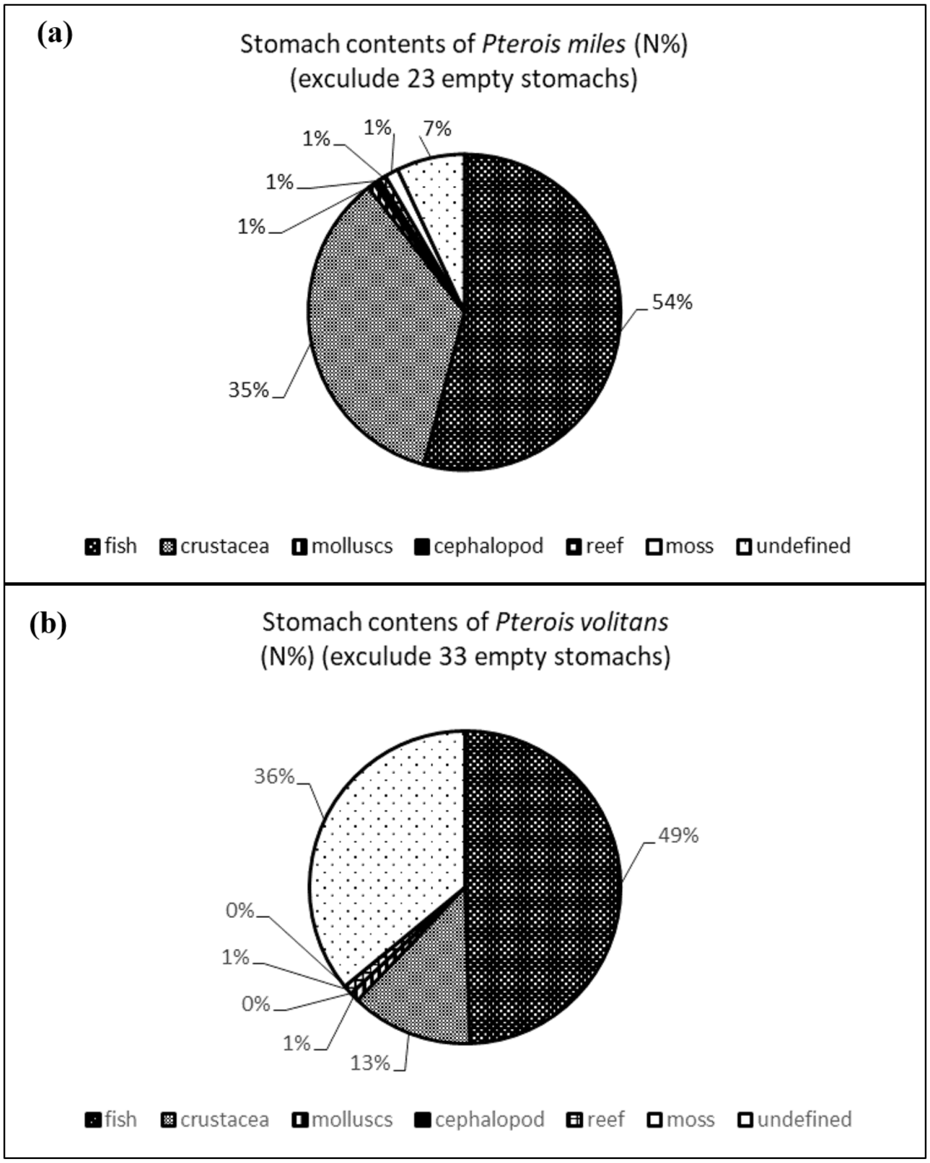

Figure 1. Stomach contens of *P. miles* (a) and *P. volitans* (b)

Table 1. Evaluation of stomach contens of *P.miles* and *P. volitans*

	Pterois miles						*Pterois volitans*					
Groups	**%O**	**%N**	**%W**	**%IRI**	**%Q**	**%PV**	**%O**	**%N**	**%W**	**%IRI**	**%Q**	**%PV**
Fish	64.52	54.23	81.70	89.62	89.99	70.88	41.98	49.51	67.08	61.28	75.75	52.99
Crustacea	18.28	35.21	13.31	9.06	9.52	24.49	9.88	12.62	4.51	2.12	1.30	6.55
Cephalapods	1.08	0.70	0.79	0.02	0.01	0.12	0.00	0.00	0.20	0.00	0.00	0.00
Mollusks	1.08	0.70	0.08	0.01	0.00	0.12	1.23	0.97	0.20	0.02	0.00	0.18
Seaweed	2.15	1.41	0.16	0.03	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00
Reef	1.08	0.70	0.71	0.02	0.01	0.12	1.23	0.97	0.00	0.01	0.00	0.18
Undefined	11.83	7.04	3.25	1.24	0.46	3.94	45.68	35.92	28.01	36.57	22.95	40.10

Chlorophthalmus agassizi, *Uranoscopus scaber*, *Helicolenus dactylopterus* and Serranidae, Sparidae and Scorpaenidae members have identified stomach contents of samples. Although the results show that the diets of the two species have similar characteristics, it was remarkable that a whole juvenile specimen in 4.5 cm total length and parts of *Pterois spp.* were just found in the stomachs of *P. miles*. In addition seaweed and cephalopod parts were found some of both species' stomachs.

Discussion

Two invasive lionfish species, *P. miles* and *P. volitans* were recorded for the first time from Iskenderun Bay, the north-eastern Mediterranean part of Turkey in 2014 and 2016 (Turan et al., 2014; Gürlek et al., 2016). Both species became increasingly common in the area (Dağhan & Demirhan 2020; Yılmaz & Demirhan 2020). According to Turan et al., (2017) these species may cause the reduction of populations of vanikoro sweeper (*Pempheris spp.*), cardinal fish (*Apogon spp.*) and red coat (*Sargocentron rubrum*). Similarly, it will also create predation pressure on the species (*Mullus surmuletus* and *Gobiidae spp*.) found in the stomach of lionfish in Antalya Bay (Özbek et al., 2017). Additionally, both species may cause predation pressure on species found in the stomachs of samples in this study (*C. agassizi*, *U. scaber*, *H. dactylopterius* and Serranidae, Sparidae, Scorpaenidae). Predation can have large effects on prey populations and on community structure of the ecosystem where, there is high fishing pressure on predators such as grouper species (Turan et al., 2017). Managers need this information and should alert stakeholders to the potential ecological and socio-economic impacts that may arise from a lionfish invasion (Kletou et al., 2016).

For these reasons a management strategy used to control the existing lionfish populations must be developed. Encouraging consumption and commercial fishing is an important option in the struggle against lionfish (Ulman et al., 2022; Uyan, 2022). However, many fishermen release these species back into the sea when they catch them due to various injury events. Various competitions are held in the Atlantic as a method of combating lionfish. Additionally, the development of specially designed fishing gear, such as traps, to prevent lionfish will also be an important alternative.

Acknowledgements

This study is produced from Burçin Demirci's Master thesis. Also, abstract of this study was presented at 2th International Symposium on Pufferfish/Lionfish held on 20-22 May 2022 in Turkey.

Author Contributions

B.D. and S.A.D. performed all the experiments and drafted the main manuscript text..

Conflict of Interest

The authors declare there is no conflict of interest in this study.

References

Ahrenholz, D. & Morris, J., (2010). Larval duration of the lionfish, *Pterois volitans* along the Bahamian Archipelago. *Environmental Biology of Fishes*. 88. 305-309. https://doi.org/10.1007/s10641-010-9647-4.

Albins, M. A. & Hixon, M. A., (2008). Invasive Indo-Pacific lionfish Pterois volitans reduce recruitment of Atlantic coral-reef fishes. *Marine Ecology Progress Series*, 367, 233-238. https://doi.org/10.3354/meps07620.

Coll M, Piroddi C, Steenbeek J, Kaschner K, Ben Rais Lasram F, Aguzzi J, Ballesteros E, Bianchi CN, Corbera J, Dailianis T, Danovaro R, Estrada M, Froglia C, Galil BS, Gasol JM, Gertwagen R, Gil J, Guilhaumon F, Kesner-Reyes K, Kitsos MS, Koukouras A, Lampadariou N, Laxamana E, López-Fé de la Cuadra C.M, Lotze H.K, Martin D, Mouillot D, Oro D, Raicevich S, Rius-Barile J, Saiz-Salinas JI, San Vicente C, Somot S, Templado J, Turon X, Vafidis D, Villanueva R, Voultsiadou E. The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. *PLoS One*. 2010 Aug 2;5(8):e11842. https://doi.org/10.1371/journal.pone.0011842.

Courtenay W. R., (1995) *Marine fish introductions in southeastern Florida*. Am Fish Soc Introduced Fish Newsl 14:2–3

Crocetta, F., Al Mabruk, S., Azzurro, E., Bakiu, R., Bariche, M., Batjakas, I., Bejaoui, T., Ben Souissi, J., Cauchi, J., Corsini-Foka, M., Deidun, A., Evans, J., Galdies, J., Ghanem, R., Kampouris, T., Katsanevakis, S., Kondylatos, G., Lipej, L., Lombardo, A., Marletta, G., Mejdani, E., Nikolidakis, S., Ovalis, P., Rabaoui, L., Ragkousis, M., Rogelja, M., Sakr, J., Savva, I., Tanduo, V., Turan, C., Uyan, A., & Zenetos, A. (2021). "New Alien Mediterranean

Biodiversity Records" (November 2021). *Mediterranean Marine Science*, 22(3), 724-746. https://doi.org/10.12681/mms.26668.

Dağhan, H. and Demirhan, S. A., (2020). Some bio-ecological characteristics of lionfish *Pterois miles* (Bennett, 1828) in Iskenderun Bay. *Marine and Life Sciences*, 2(1): 28-40.

Dailianis, T., Akyol, O., Babali, N., Bariche, M., Crocetta, F., Gerovasileiou, V., Chanem, R., Gökoğlu, M., Hasiotis, T., İzquierdo-Muñoz, A., Julian, D., Katsanevakis, S., Lipez, L., Mancini, E., Mytilineou, C., Ounifi Ben Amor, K., Özgül, A., Ragkousis, M., Rubio-Portillo, E., Servello, G., Sini, K., Stamouli, C., Sterioti, A., Teker, S., Tiralongo, F. and Trkov, D., (2016) New Mediterranean biodiversity records (July 2016). *Mediterranean Marine Science*, 17(2): 608- 626. https://doi.org/10.12681/mms.1734.

Doğdu, S. A., Uyan, A., Uygur, N., Gürlek, M., Ergüden, D., & Turan, C. (2016). First record of the Indo-Pacific striped eel catfish, *Plotosus lineatus* (Thunberg, 1787) from Turkish marine waters. *Natural and Engineering Sciences*, 1(2), 25-32. https://doi.org/10.28978/nesciences.286245.

Doğdu, S. A., Sakallı, U., Gürlek, M., & Turan, C. (2019). The first record of the Lesser amberjack Seriola fasciata (Bloch, 1793) in the Çevlik coast of Turkey, Eastern Mediterranean Sea. *Biharean Biologist*, 13(1), 55-57.

Dragičević, B., Anadoli, O., Angel, D., Benabdi, M., Bitar, G., Castriota, L., Crocetta, F., Deidun, A., Dulčić, J., Edelist, D., Gerovasileiou, V., Giacobbe, S., Goruppi, A., Guy-Haim, T., Konstantinidis, E., Kuplik, Z., Langeneck, J., Macali, A., Manitaras, I., Michailidis, N., Michaloudi, E., Ovalis, P., Perdikaris, C., Pillon, R., Piraino, S., Renda, W., Rizgalla, J., Spinelli, A., Tempesti, J., Tiralongo, F., Tirelli, V., Tsiamis, K., Turan, C., Uygur, N., Zava, B., & Zenetos, A. (2019). New Mediterranean Biodiversity Records 2019. *Mediterranean Marine Science*, 20(3), 645-656. doi:http://dx.doi.org/10.12681/mms.20913.

Ergüden, D., Ayas, D., Gürlek, M., Karan, S., & Turan, C. (2019). First documented smoothback angelshark *Squatina oculata* Bonaparte, 1840 from the north-eastern Mediterranean Sea, Turkey. *Cahiers de Biologie Marine*, 60, 189-194. https://doi.org/10.21411/CBM.A.23607FF9.

Ferreira, C. E., Luiz, O. J., Floeter, S. R., Lucena, M. B., Barbosa, M. C., Rocha, C. R., & Rocha, L. A. (2015). First record of invasive lionfish (*Pterois volitans*) for the Brazilian coast. *PloS One*, 10(4), e0123002. https://doi.org/10.1371/journal.pone.0123002.

Fogg, A. Q., Evans, J. T., Peterson, M. S., Brown-Peterson, N., Hoffmayer, E. R., & Ingram Jr, G. W. (2019). Comparison of age and growth parameters of invasive red lionfish (*Pterois* *volitans*) across the northern Gulf of Mexico. *Fishery Bulletin*, 117(3), 1. https://doi.org/10.1371/10.7755/FB.117.3.1.

Gobert, S., Fullgrabe, L., Lejeune, P. and Marengo, M., (2020). Climate Change and Fisheries: The Case Study of Corsica, an Ideal Reference Station in the Mediterranean Sea. 2. 1-2.Golani, D. and Sonin, O., (1992) New records of the Red Sea fishes, Pterois miles (Scorpaenidae) and Pteragogus pelycus (Labridae) from the eastern Mediterranean Sea. *Japanese Journal of Ichthyology*, 39(2): 167-169.

Golani, D., & Sonin, O. (1992). New records of the Red Sea fishes, *Pterois miles* (Scorpaenidae) and *Pteragogus pelycus* (Labridae) from the eastern Mediterranean Sea. *Japanese Journal of Ichthyology*, 39(2), 167-169. https://doi.org/10.11369/jji1950.39.167.

Gürlek, M., Ergüden, D., Uyan, A., Doğdu, S. A., Yağlıoğlu, D., Öztürk, B. & Turan, C., (2016). First record red lionfish *Pterois volitans* (Linnaeus, 1785) in the Mediterranean Sea. *Natural and Engineering Sciences*, 1(3): 27-32. https://doi.org/10.28978/nesciences.286308.

Hamner, R. M., Freshwater, D. W., & Whitfield, P. E. (2007). Mitochondrial cytochrome b analysis reveals two invasive lionfish species with strong founder effects in the western Atlantic. *Journal of Fish Biology*, 71, 214-222. https://doi.org/10.1111/j.1095-8649.2007.01575.x.

Hare, J. A. & Whitfield, P. E., (2003). An integrated assessment of the introduction of lionfish (*Pterois volitans/miles* complex) to the western Atlantic Ocean. NOAA Tech Memo NOS NCCOS 2:1–21.

Hureau J.C., (1970) *Biologie comparée de quelques poissons antarctiques* (Nototheniidae). Bull Inst. Océanogr. Monaco 68(1391), 1-244.

Hyslop, E. J. (1980). Stomach contents analysis-a review of methods and their application. *Journal of fish biolo*gy, 17(4), 411-429. https://doi.org/10.1111/j.1095-8649.1980.tb02775.x.

Johnston M. W., & Purkis S. J. (2014). Are lionfish set for a Mediterranean invasion? Modelling explains why this is unlikely to occur. *Marine Pollution Bulletin*, 88(1-2), 138-147. https://doi.org/10.1016/j.marpolbul.2014.09.013.

Kletou, D., Hall-Spencer, J. M. & Kleitou, P., (2016). A lionfish (*Pterois miles*) invasion has begun in the Mediterranean Sea. *Marine Biodiversity Records*, 9(1), 46. https://doi.org/10.1186/s41200-016-0065-y.

Krebs, C. J., (1989). *Ecological methodology*. New York, NY: Harper and Row Publishers Inc.,654 p.

Levins, R., (1968). *Evolution in changing environments: Some theoretical explorations*. Princeton Univ. Press, Princeton, New Jersey. 120 p.

Molnar, J. L., Gamboa, R. L., Revenga, C. and Spalding, M. D., (2008). Assessing the global threat of invasive species to marine biodiversity. *Frontiers in Ecology and the Environment*, 6(9), 485-492. https://doi.org/10.1890/070064.

Morris, J. A. J., Akins, J. L., Barse, A., Cerino, D., Freshwater, D. W. Green, S., Muñoz R., Paris C., & Whitfield, P. E. (2009). Biology and ecology of the invasive lionfishes, *Pterois miles* and *Pterois volitans*. In: *Proceedings of the 61st Gulf and Caribbean Fisheries Institute*, 61, 1-6.

Mytilineou, C., Akel, E. K., Babalı, N., Balistreri, P., Bariche, M., Boyacı, Y.O., Cilenti, L., Constantinou, C., Crocetta, F., Çelik, M., Dereli, H., Dounas, C., Durucan, F., Garrido, A., Gerovasileiou, V., Kapiris, K., Kebapcioglu, T., Kleitou, P., Krystalas, A., Lipej, L., Maina, I., Marakis, P., Mavrič, B., Moussa, R., Peña-Rivas, L., Poursanidis, D., Renda, W., Rizkalla, S.I., Rosso, A., Scirocco, T., Sciuto, F., Servello, G., Tiralongo, F., Yapici, S. and Zenetos A. (2016) New Mediterranean biodiversity records (November, 2016). *Mediterranean Marine Scien*ce, 17(3): 794-821. http://dx.doi.org/10.12681/mms.1976.

Novakowski, G. C., Hahn, N. S., & Fugi, R. (2008). Diet seasonality and food overlap of the fish assemblage in a pantanal pond. *Neotropical Ichthyology*, 6, 567-576. https://doi.org/10.1590/S1679-62252008000400004.

Özbek, E. Ö., Mavruk, S., Saygu, İ. and Öztürk, B., (2017). Lionfish distribution in the eastern Mediterranean coast of Turkey. *Journal of Black Sea/Mediterranean Environment*, 23(1), 1-16.

Pianka, E. R. (1971). Lizard species density in the Kalahari desert. Ecology, 52, 1024-1029.Poursanidis D., (2015) Ecological Niche Modeling of the the invasive lionfish *Pterois miles* (Bennett, 1828) in the Mediterranean Sea. Eleventh Panhellenic Symposium on Oceanography and Fisheries, Mytilene, Lesvos island, Greece, 13–15 May 2015. Anavyssos Attiki Greece; Hellenic Center for Marine Research, pp. 621–624.

Poursanidis D. (2015). Ecological Niche Modeling of the invasive lionfish *Pterois miles* (Bennett, 1828) in the Mediterranean Sea. In: Ele*venth Panhellenic Symposium on Oceanography and Fisheries*, Mytilene, Lesvos Island, Greece. pp: 621-624.

Schofield, P. J. (2010). Update on geographic spread of invasive lionfishes (*Pterois volitans* [Linnaeus, 1758] and *P. miles* [Bennett, 1828]) in the Western North Atlantic Ocean, Caribbean Sea and Gulf of Mexico. *Aquatic Invasions*, 5(1), 117-122. https://doi.org/10.3391/AI.2010.5.S1.024.

Stamouli, C., Akel, E. H. K., Azzurro, E., Bakiu, R., Bas, A. A., Bitar, G., Boyaci, Y., Cakalli, M., Corsinifoka, M., Crocetta, F., Dragičević, B., Dulčić, J., Durucan, F., Zrelli, R. E., Erguden, D., Filiz, H.,Giardina, F., Giovos, İ., Gönülal, O., Hemida, F., Kassar, A., Kondylatos, G., Macali, A., Mancini, E.,Ovalis, P., Paladini De Mendoza, F., Pavičič, M., Rabaoui, L., Rizkalla, S., Tiralongo, F., Turan, C.,Vrdoljak, D., Yapici, S., & Zenetos, A. (2017). New Mediterranean Biodiversity Records (December 2017). *Mediterranean Marine Science*, 18(3), 534–556. https://doi.org/10.12681/mms.15823.

Turan C., Ergüden D., Gürlek M., Yağlıoğlu D., Uyan A., Uygur N. (2014). First record of the Indo-Pacific lionfish *Pterois miles* (Bennett, 1828) (Osteichthyes: Scorpaenidae) for the Turkish marine waters. *Journal of the Black Sea/Mediterranean Environment*, 20(2), 158-163.

Turan, C., & Öztürk, B. (2015). First record of the lionfish *Pterois miles* (Bennett 1828) from the Aegean Sea. *Journal of the Black Sea/Mediterranean Environment*, 20(2), 334-388.

Turan, C., Uyan, A., Ergüden, D., Gürlek, M., Dogdu, S. A., & Uygur, N. (2015). First record of the moon crab *Ashtoret lunaris* (Forskål 1775) from Turkish waters. *Journal of the Black Sea/Mediterranean Environment*, 21(3), 328-333.

Turan, C., Ergüden, D., Gürlek, M. (2016). Climate change and biodiversity effects in Turkish Seas. *Natural and Engineering Sciences*, 1(2), 15-24. https://doi.org/10.28978/nesciences.286240.

Turan, C., Uygur, N., İğde, M. (2017) Lionfishes Pterois miles and Pterois volitans in the North-eastern Mediterranean Sea: Distribution, habitation, predation and predators. *Natural and Engineering Sciences* 2(1): 35-43. https://doi.org/10.28978/nesciences.292355.

Turan, C., Gürlek, M., Başusta, N., Uyan, A., Doğdu, S.A., Karan, S., (2018). A checklist of the non-indigenous fishes in Turkish marine waters. *Natural and Engineering Sciences*. 3(3), 333-358. https://doi.org/10.28978/nesciences.468995.

Turan, C. (2020). Species distribution modelling of invasive alien species; *Pterois miles* for current distribution and future suitable habitats. *Global Journal of Environmental Science and Management*, 6(4), 429-440. https://doi.org/10.22034/gjesm.2020.04.01.

Turan, C., Uyan, A., Gürlek, M., & Doğdu, S. A. (2020). DNA Barcodes for Identifications of Two Lionfish Species *Pterois miles* (Bennett, 1828) and *Pterois volitans* (Linnaeus, 1758) in the Mediterranean. *FishTaxa*, 16, 29-36.

Turan, C., & Doğdu, S. A. (2022). Preliminary Assessment of Invasive Lionfish *Pterois miles* Using Underwater Visual Census Method in the Northeastern Mediterranean. *Croatian Journal of Fisheries: Ribarstvo*, 80(1), 38-46. https://doi.org/10.2478cjf-2022-0005.

Ulman, A., Ali, F. Z., Harris, H. E., Adel, M., Mabruk, S. A. A. A., Bariche, M., Candelmo, A. C., Chapman, J. K., Cicek, B. A., Clements, K. R., Fogg, A. Q., Frank, S., Gittings, S. R., Green, S. J., Hall-Spencer, J. M., Hart, J., Huber, S., Karp, P. E., Kyne, F. C., Kletou, D., Magno, L., Rothman, S. B. S., Solomon, J. N., Stern, N., & Yildiz T (2022) Lessons From the Western Atlantic Lionfish Invasion to Inform Management in the Mediterranean. *Frontiers in Marine Science*, 9, 865162. https://doi.org/10.3389/fmars.2022.865162

Uyan, A. (2022). A Review on the Potential Usage of Lionfishes (*Pterois spp*.) in Biomedical and Bioinspired Applications. *Natural and Engineering Sciences*, 7(2), 214-227 https://doi.org/10.28978/nesciences.1159313.

Whitfield, P. E., Hare, J. A., David, A. W., Harter, S. L., Munoz, R. C. and Addison, C. M., (2007). Abundance estimates of the Indo-Pacific lionfish *Pterois volitans/miles* complex in the Western North Atlantic. *Biological Invasions*, 9(1), 53-64. https://doi.org/10.1007/s10530-006-9005-9.

Yağlıoğlu D., & Ayas D. (2016). New occurrence data of four alien fishes (*Pisodonophis semicinctus*, *Pterois miles*, *Scarus ghobban* and *Parupeneus forsskali*) from the North Eastern Mediterranean (Yeşilovacık Bay, Turkey). *Biharean Biologist*, 10(2), 150-152

Yılmaz, S. & Demirhan, S. A. (2020). Age, growth parameters and food composition of Invasive Red Lionfish (*Pterois volitans* L., 1758) in İskenderun Bay. *Natural and Engineering Sciences*, 5 (2), 82-91. https://doi.org/10.28978/nesciences.756730.