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Occurrence of Non-Indigenous *Epinephelus malabaricus*, *Abudefduf vaigiensis*, and *Acanthocybium solandri* with Positive View of the Lionfish Expanding, Safety Processing, Nutritional Values, and Further Control Along the Egyptian Mediterranean Coast

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Abstract

This study reported non-indigenous species for the first time along the Egyptian Mediterranean coast, including *Epinephelus malabaricus*, *Abudefduf vaigiensis*, and *Acanthocybium solandri*, as well as filling the gap for two lionfish species (*Pterois miles* and *P. volitans*). Specimens and data were collected from 2021 to 2023 for the first three species and identified morphologically. For lionfish, specimens were collected from 2016 to 2024, along with relevant fisheries data, distribution, safety, processing, consumption precautions, nutritional values, venom treatment, and further control. Lionfish species *P. miles* (13–42cm TL) and the newly reported *P. volitans* (15–35cm TL) are mainly found in trawl and longliner fisheries from Alexandria to Sallum, in sandy-rocky habitats at depths up to 30m, with a minor presence in trammel nets. *P. miles* is more predominant. Consumption is safe when proper handling and processing procedures are followed. Symptoms from lionfish spine stings, such as pain and swelling, were detected but resolved with simple treatment, without fatal effects. The price has increased from 10 to 70 LE per kg, adding a positive socio-economic value. Nutritional values for *P. miles* muscles showed high crude protein (78.97±7.57% for large specimens, 81.46±7.35% for small ones). The amino acid profile included 16 amino acids (8 essential, 8 non-essential), with good levels of omega-3 and omega-6 fatty acids. This study highlighted the benefits of lionfish species and recommends continuous monitoring of non-indigenous species, assessing their positive and negative ecosystem impacts. For lionfish control, fishing by skilled spearfishermen could be aligned with socio-economic and food strategies, without compromising conservation efforts. Additionally, the Malabar grouper (*E. malabaricus*) may be useful in biological control of lionfish. Public awareness is needed regarding the risk of handling both live and dead lionfish due to their venomous spines.

INTRODUCTION

The Mediterranean Sea is still receiving non-indigenous species from various pathways. To date, the global warming and climatic change caused an exceeding rate of new species migration and establishment in the Mediterranean Basin. The recent inventory of non-indigenous species has been reported by **Galanidi *et al*. (2023)**. Three pathways were identified for species migration: the Suez Canal, the Strait of Gibraltar, and ballast water from shipping **(Farrag, 2016; Galanidi *et al*., 2023)**. Positive and negative impacts of non-indigenous species to new ecosystems were detected by several authors **(El Haweet, 2013; Farrag *et al*., 2016; Farrag *et al*., 2018; Katsanevakis *et al*., 2024)**. The ongoing observation of non-indigenous species from the Atlantic Ocean and the Red Sea in the Mediterranean has prompted further monitoring of new species in Egypt, such as the arrow Bullseye (*Priacanthus sagittarius*) **(Farrag *et al.*, 2016)** and five other species including *Abudefduf* sp. **(Al Mabruk *et al*., 2021)**. Detailed studies are needed on these proliferating species, particularly the lionfish.

Recently, the entry of the lionfish species was observed as it appeared in different areas in the Mediterranean Sea along the coast of Egypt **(Personal observations and communications)**. The genus *Pterois* is represented with ten valid species worldwide **(Froese & Pauly, 2016)**. They are mostly found in warm marine waters at depths between 1 and 300 feet on hard and muddy bottoms, mangroves, seagrasses, coral reef, and artificial reefs **(Albins & Hixon, 2008; Ferrieira *et al*., 2015)**. The high feeding rates of the lionfish pose a serious threat to benthic ecosystems (**Morris & Akins, 2009; Kulbicki *et al.*, 2012; Higgs, 2013)**. However, it gained public acceptance in the fish markets and is gradually establishing itself as a commercially viable species, despite its poisonous spines.

The red lionfish *Pterois volitans* (Linnaeus, 1758) is distributed in the Pacific Ocean (North and South), Atlantic Ocean (North and South) and also found in the Indo-West Pacific Ocean **(Whitfield *et al*., 2002; Kimball *et al*., 2004; Frose & Pauly, 2016)**. Another species of the lionfish is the common *Pterois miles* (Bennett, 1828), which is known as the devil firefish; it is a native species in the Indo-Pacific, occurring from the Red Sea to South Africa and eastward to Indonesia **(Fricke 1999; Froese & Pauly 2019)**. In 1991, it was recorded as a single specimen in the eastern Mediterranean Sea off Tel Aviv with no available data on its population establishment **(Golani & Sonin, 1992)**. However, it reappeared two decades later (in 2012) in the region, likely through the arrival of new specimens from the Red Sea **(Bariche *et al.*, 2013, 2015, 2017)**. In the following years, the common lionfish spread further in the Mediterranean Sea, reaching as far as Tunisia and Sicily **(Azzurro *et al.*, 2017)**, and recently it was recorded in Libya **(Al Mabruk & Rizgalla, 2019)**. Then, *P. miles* and *Scarus ghobban* together were observed for the first time from Libya as pictures on the social media **(Al Mabruk *et al.*, 2020)**. Since then, these species have been reported in different countries along the Mediterranean Sea without detailed data from Egypt regarding their distribution, biology, and catchability. The present study aimed to report the occurrence of three non-indigenous species *Epinephelus malabaricus, Abudefduf vaigiensis*, and *Acanthocybium solandri* along the Egyptian Mediterranean coast, updating the inventory of non-indigenous species. It also highlighted the occurrence of two lionfish species *Pterois miles* and *P. volitans,* providing insights into their distribution, socio-economic status, processing, nutritional challenges, further risk avoidance and further control.

MATERIALS AND METHODS

The samples of the present study were collected individually from different locations along the Egyptian Mediterranean coast (Fig. 1). The first species, the Malabar grouper *Epinephelus malabaricus*, was collected from Alexandria at 10m depth during 2021 and Marsa Matrouh at 11m depth during 2022. Both locations were rocky habitats adjacent to sandy habitats. The Indo-Pacific sergeant, *Abudefduf vaigiensis*, was collected from Alexandria coast at a depth of 5m from rocky habitat (Montaza area, Alexandria; 31.28 62° N, 30. 05 50° E). The third species was the wahoo fish *Acanthocybium solandri* that was fished by hook/handline during recreational activity in April 2024 off Alexandria coast (31.35 52° N, 30. 05 50° E) at a 15m depth. The specimens were examined morphologically using the identification keys of **Fischer and Bianchi (1984)**, **Remo *et al*. (2005)**, and **Collette and Graves (2019)** for *A. solandri*. While, keys of identification of **Heemstra and Randall (1993)** and **Schembri and Tonna (2011)** were determined for the Malabar grouper, and **Randall (2007)**, **Froese and Pauly (2015)** and **Vella *et al.* (2016)** for *Abudefduf vaigiensis*. For the identification of the lionfish species, the keys of **Schultz (1986)**, **Paulin (2012)**, **Gürlek *et al*. (2016)**, and **Turan *et al.* (2017)** were used. The identifying features used were total length (T.L), fork length (F.L), standard length (S.L), body depth (B.D), head depth (H.D), eye diameter (ED), post orbital length (Post.O.L), pre-orbital length (Pre.O.L), length of upper jaw (L.U.J), and length of lower jaw (L.L.J).

The lionfish specimens were collected from various sites along the Egyptian coast of the Mediterranean Sea. Historical records were reviewed, and a distribution map was created using the available data. The collection locations, depths, times, and dates are presented in Table (1). The specimens were preserved at -18ºC until they could be identified based on their descriptive features and morphometric measurements. Morphological characteristics were analyzed to distinguish between the two lionfish species, *Pterois miles* and *P. volitans*, using various identification keys **(Schultz, 1986; Allen & Erdman, 2008; Paulin, 2012)**. Fisheries data and economic information were also reported to assess the status of the lionfish and its socio-economic value to fishermen, as well as public acceptance. For processing, the skin of the lionfish samples was carefully separated from the body, and fillets were prepared. Data on poisoning cases from the lionfish stings were collected through a questionnaire distributed to several fishermen. Feedback on the lionfish consumption was also recorded.

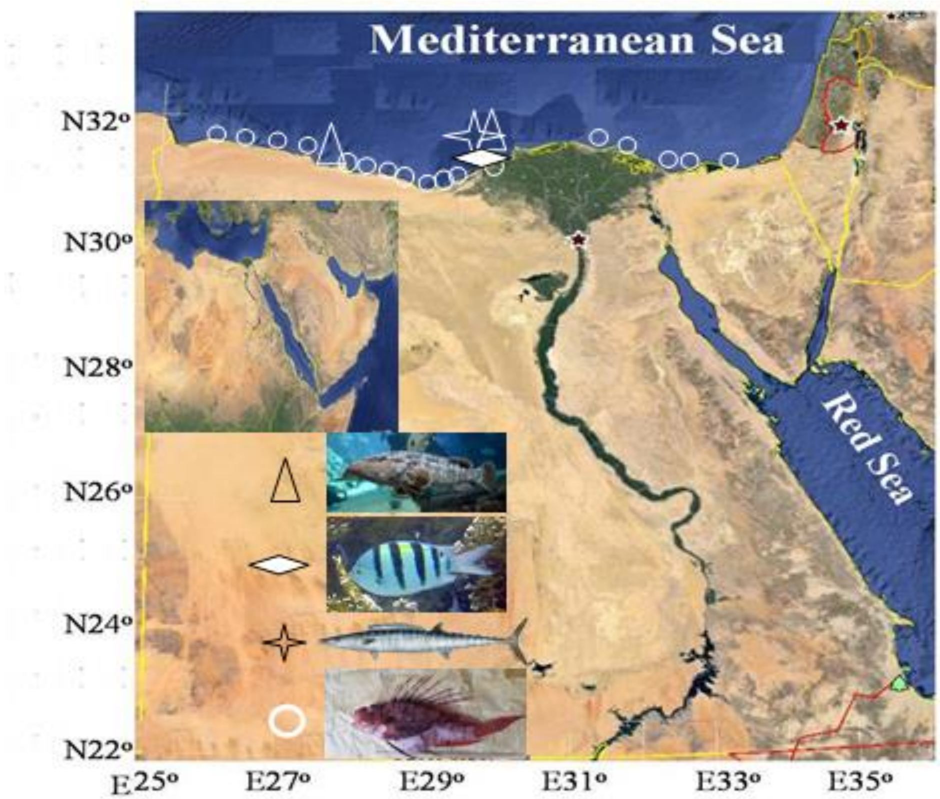

Fig. 1. A Map showing the Egyptian Mediterranean coast, with the locations of the collection sites of the three reported non-indigenous species *(Epinephelus malabaricus, Abudefduf vaigiensis,* and *Acanthocybium solandri),* with the expansion of the lionfish species *Pterois* spp.

Biochemical composition of lionfish

A total of 20 lionfish samples were utilized for the biochemical composition of *P. miles* due to its majority. The fish samples were divided into two groups (larg darker group 25-40 cm and small- medium lighter group 15-30 cm). Composition percentages of fish muscles [Moisture, ash, crude protein, carbohydrates (glycogen), and crude fibers] were measured according to **AOAC (2000)**. The crude lipid content in both large-darker and small-medium lionfish samples was analyzed using the Soxhlet system with ether as a solvent (SRPS ISO 1443:1997). Regarding amino acids and fatty acids in the lionfish, the pooled muscle samples were investigated by high-performance liquid chromatography (HPLC; Agilent Technologies 1200 Series, G1315D DAD) for amino acids. While, the samples were investigated using gas chromatography-mass spectrometry (7890A- 5975B) at the same laboratory for fatty acids. Statistical analysis was performed in the simple way using excel program to obtain the mean and standard error.

RESULTS

The results of the current study presented the collection of four targeted species as first records all of which were non-indigenous fish species.

1- Malabar grouper: *Epinephelus malabaricus* (Bloch & Schneider, 1801)

The Malabar grouper (*Epinephelus malabaricus*) (Fig. 2a, b), family Epinephelidae, was collected on separate occasions by spearfishing from two regions; Alexandria 31.35 52° N, 30. 05 50° E at 10 m depth (45cm TL; 4kg weight) and Marsa Matrouh 31.18 52° N, 27. 58 15° E at a depth of 11m (55cm TL; 6kg weight) from rocky habitats adjacent to sandy habitats. The fish's body had a posteroventral preopercular margin with enlarged serrae. Its color was brownish, with several small blackish spots along the body, mostly dark brown on the upper part of the head. Moreover, the body had irregular whitish blotches ventrally on the head, pectoral and pelvic fins, and tail. Dorsal fin membranes were incised between spines. The caudal fin was slightly rounded as the most grouper fishes. The pectoral fin's middle ray was longer than the length of the longest pelvic fin ray. The lateral side of the body was covered with ctenoid scales. The meristic features of the dorsal fin were counted as XI + 16, anal fin III + 8); pectoral fin 21, and ventral fin I +6.

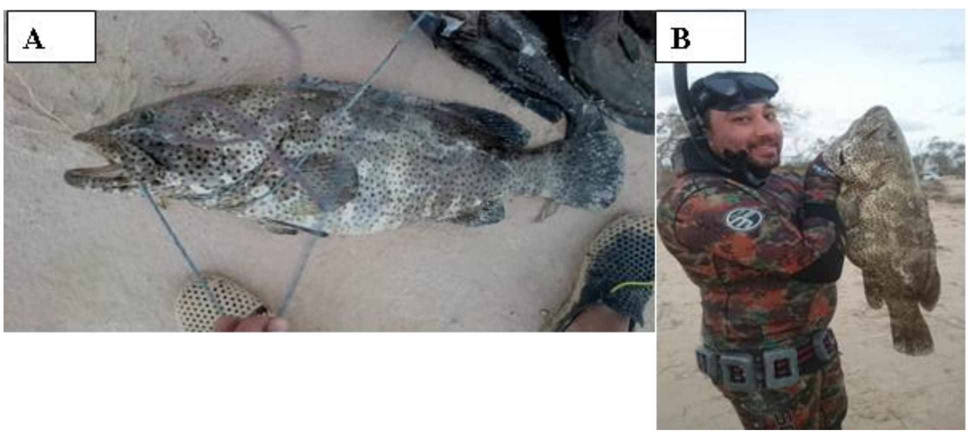

Fig. 2. Photos of the collected Malabar grouper (*Epinephelus malabaricus*) from the Egyptian Mediterranean coast (A: from Alexandria; B; from Matrouh, Egypt)

2- Indo-pacific sergeant, *Abudefduf vaigiensis* (Quoy & Gaimard, 1825)

Indo-pacific sergeant, *Abudefduf vaigiensis*, family Pomacentridae (damselfishes), was collected from Alexandria coast at 5m depth from a rocky habitat (Montaza area, Alexandria; 31.28 62° N, 30. 05 50° E). The body color was blue-green dorsally and slightly silver-white ventrally. There were five bluish-black bars behind the head, with the fifth being narrow and located on the caudal peduncle. The third to fifth bars extended into the dorsal fin. Additionally, the body exhibited a yellow color dorsally between the first and third dark bars. The caudal fin lacked dark bands (Fig. 3).

Morphometric measurements were recorded as follows: Total length (TL) 10.4cm, fork length (FL) 9.5cm, standard length (SL) 8.5cm, body depth (BD) 4.1cm, head depth (HD) 3cm, eye diameter (ED) 1cm, pre-ocular length (Pre.O.L.) 0.4cm, post-ocular length (Post.O.L.) 1cm, length of upper jaw (L.U.J) 0.3cm, and length of lower jaw (L.L.J) 0.4cm.

The meristic features were as follows: 13 dorsal spines, 12–14 dorsal soft rays, 2 anal spines, 11–13 anal soft rays, and 18–19 pectoral soft rays.

Fig. 3. Photo of the recorded Indo-Pacific sergeant, *Abudefduf vaigiensis,* from the Mediterranean Sea, Egypt

3- *Acanthocybium solandri* (Cuvier, 1832)

The wahoo fish species *Acanthocybium solandri*, Family Scombridae, was caught by hook during recreational activity from the Alexandria coast, at a depth of 15m, with a length of 70cm and a weight of 2365g in April 2024 (Fig. 4).

Fig. 4. Photos of the recorded *Acanthocybium solandri* (Cuvier, 1832) from Alexandria (photos by Abd Allah Al Ghandour)

This species belongs to genus *Acanthocybium* and is known by many common names such as wahoo, barracuda, kingfish, malata kingfish, and Pacific kingfish. It is fusiform with an elongated body and pointed head (Fig. 4). It has a beak-like snout, and its body is dark blue on the top side and silver on the bottom, with cobalt vertical dark-blue bars running along its body. The dorsal fin is very long including around 24-27 rays and 14-17 spines. Lateral line is curving abruptly downward below the middle of the first dorsal fin.

4- Lionfish species

***4.1. Pterois miles* (Bennett, 1828) and *P. volitans* (Linnaeus, 1758)**

The present results document the expansion of lionfish species along the Egyptian Mediterranean coast. Both the devil firefish (*Pterois miles*) and the red lionfish (*P. volitans*) were identified in this study. Both species belong to the family *Scorpaenidae* and the genus *Pterois*.

The first observation occurred in 2016 at Alexandria's fish market, where two individuals were identified among the catch of scorpion fish species (personal observation and unpublished data by the authors). These specimens were identified as *P. miles*. In July-August 2018, *P. miles* was reported for the first time in Egypt, specifically from Marsa Matrouh (Marsa Matrouh Governorate) at two sites. A single specimen (40cm TL) was speared at a depth of 27m at Cleopatra Beach (31°22′23.1″N, 27°12′12.9″E). A second specimen (20cm TL) was speared at 7m depth off Ras Alam Al-Rum Beach (approximately 31°19′14.6″N, 27°21′38.6″E). This latter specimen was posted on Facebook and cited by **Al Mabruk *et al*. (2020)**, who identified the fish as *P. miles*.

This study shows that the lionfish specimens have expanded along the Egyptian coast, with occurrences in various locations and depths ranging from 1 to 40m (Table 1 & Fig. 5a, b). The survey reveals that the two lionfish species, *P. miles* and *P. volitans*, have been introduced to the Egyptian Mediterranean coast. The descriptions, morphometric features, and differences between these two species are provided in Table (1) and Fig. (6).

P. volitans is characterized by elongated dorsal-fin spines and pectoral fins, the presence of connective tissue between the spines of the pectoral-fin rays, long tentacles above the eyes, and spotted membranes on all fins. The head and body display cream to red or reddish-brown vertical stripes, and eight small white spots are present on the lateral line.

Table 1. Morphometric measurements of two lionfish specimens from the Egyptian coast of the Mediterranean Sea

Morphometric index	***P. volitans***	***P. miles***
Pectoral fin	Longer extended over the caudal fin	Smaller
Scales rows count	Horizontal	Non
Tentacles above the eyes	Longer	Very small
Anal-fin spines	3	3
Pelvic rays	5	5
Pelvic-fin spines	1	1
Second dorsal rays	10-11	9-10
Tiny brownspots surrounding the eyes	Absence	Presence
Number of 1st dorsal spines	11-13	9- 11
Scale count below lateral line	18-25	17-21
Number of 2nd dorsal rays	11	10
Number of caudal rays	12-14	13
Number of anal rays	7-8	6
Number of pelvic spines (rays)	11	10-11
Number of Pectoral rays	14-15	13-14

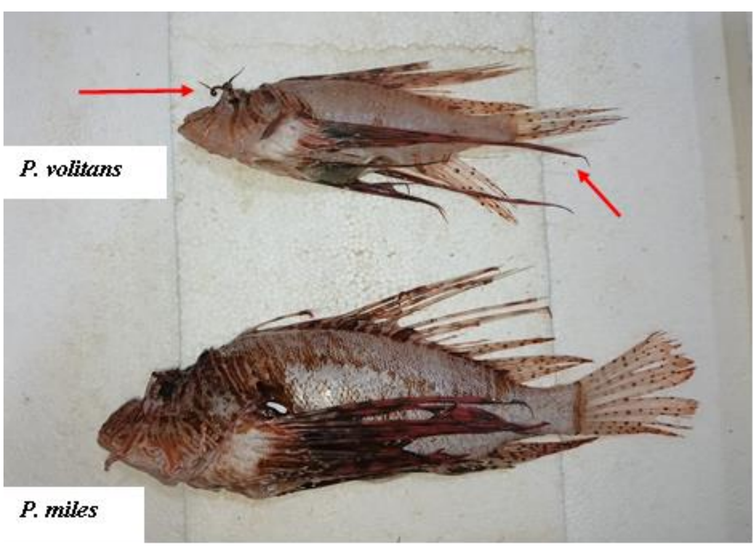

Fig. 6. Two lionfish species above is *Pterois volitans* with longer pectoral extended to caudal fin and longer tentacles above eyes; the lower is *P. miles* with shorter pectoral and very short tentacles above eyes

4.2. Distribution, and fisheries status

As mentioned earlier, the current study shows that the lionfish first appeared as scattered individual specimens in various locations from 2016 to 2020, primarily between Alexandria and Marsa Matrouh (Table 2). Since then, the lionfish sightings have increased in other areas along the coast and have become a well-known fish product in local markets. High densities of lionfish were observed by free divers between Alexandria and Sallum, where sandy-rocky habitats are prevalent, as well as in the Abu-Qir area, extending eastward to Damietta. The species began to appear in moderate numbers further east toward Al-Arish.

The lionfish were caught in various fishing activities, including bottom trawling, longlining, and small-scale fisheries, as well as through recreational and spearfishing activities. The highest catches were recorded on boats operating in the areas from Alexandria to Sallum, with Alexandria's landing site receiving significant quantities of the lionfish (Fig. 7). It is worth noting that the majority of the lionfish catches came from depths ranging from 25 to 40m. The sizes of the caught fish ranged from 13 to 42cm for *P. miles* and 15 to 35cm for *P. volitans*.

Regarding size variation based on fishing gear, the lionfish were predominantly caught in large numbers by bottom trawls and long liners, with moderate catches from trammel nets and smaller catches from gillnets. Recreational fishing also contributed to the catch, targeting specific size criteria. Size variations showed that the fish caught by longlines ranged from 18 to 35cm, with an average length of 27.26 ± 4.12cm. For bottom trawls, the length ranged from 16 to 38cm, with an average of 27.65 ± 4.84cm. The next size category (17 to 25cm) was observed in trammel nets, with an average of 22.09 ± 2.5cm. Occasionally, this size range was also caught by gillnets. The largest specimens, ranging from 25 to 42cm with an average of 29.88 ± 3.83cm, were primarily caught through spearfishing activities. This type of fishing appears to be selective, targeting larger specimens for higher sales or personal consumption.

Table 2. Locations and detailed description of the lionfish records (*Pterois* spp.) from the Egyptian coast of the Mediterranean Sea

City/ Place	Date	Depth	Coordinates	Picture, video or sample	Population	Way	Observer/ Collector
				Lionfish *Pterois spp*			
El Max fish market (Alexandria)	2016	------	------	Samples in bycatch as scorpion	1	-----	Mahmoud Farrag
Alexandria Bahary (Eastward)		3 m	31.2120° N, 29.8832° E	Sample	2		Hamdy Omar
Alamin, Lazordi Bay (North coast)	Jul 2020	3 m	30.9496° N, 28.8284° E	Video and pic	2	Spearfishing	Mohammad Adel

Alexandria, Miami (Westward))	Nov 2020	40 m	31.2351° N, 29.9763° E	Picture	1	Line fishing	Amgad – fisherman
Alexandria, Abu Qir (Westward))	Jan 2021	20 m	31.3233° N, 30.0616° E	Non	20 +	Spearfishing	Osama - Fisherman
Alexandria, Montana (Westward))	Apr 2021	2 m	31.2869° N, 30.0101° E	Video and pic	1	Spearfishing	Mohammad Adel-
Alexandria, Sidi Krir (North coast)	May 2021	14 m	31.0155° N, 29.6373° E	Non	10 +	Spearfishing	Adel wahby – fisherman
Alexandria Montana (Westward))	May 2021	8 m	31.2869° N, 30.0101° E	Video and pic	1	Spearfishing	Mohammad Adel
Alexandria, Asafra (Westward)	Jul 2021	4 m	31.2050° N, 29.9064° E	Video and pic	2	Spearfishing	Mohammad Adel
Marsa Matrouh, Sidi Hinesh (North coast)	Jul 2021	4 m	31.1865° N, 27.6310° E	Video and pic	1	Spearfishing	Mohammad Adel
Alexandria, Montaza (Westward)	Jul 2021	10 m	31.2869° N, 30.0101° E	Non	1	Spearfishing	Mohammad Adel
Alamin, Lazordi Bay (North coast)	Aug 2021	6 m	30.9496° N, 28.8284° E	Sample, video and pic	5 (3+2)	Spearfishing	Mohammad Adel
Alexandria, Sidi Gaber	Sept 2021	7 m	31.2267° N, 29.9371° E	Non	2	Spearfishing	Mohammad Adel
Alexandria, Loran (Westward)	Oct 2021	4 m	31.2541° N, 29.9739° E	Non	6	Spearfishing	Mohammad Adel
Alexandria landing, Abu Qir, Ezbet ElBorg (Westward)	From 2021 - 2023	6m – 35m	Alexandria- Sallum Alexandria to Maddia Damietta- ports aid	Onbaord, landings, & Fish markets	>100	Trawl, longlines, Trammels	Fishers, Mahmoud Farrag

Fig. 7. The catch of lionfish species in the landing site of Alexandria, Egypt

4.3. Socio-economy, precautionary safety for consumption

The present investigation found that fishermen using small-scale fisheries, such as hooks and longlines, faced challenges when handling the lionfish due to the risk of exposure to its venomous spines. However, they became more cautious and adopted safety procedures, using tools like sharp scissors to cut off the spines (Fig. 8). For spearfishing, divers maintained a safe distance while collecting the lionfish specimens, either placing them in large mesh bags or spearing them and cutting off the spines to avoid venom exposure. Additionally, they removed the long spines and rays to collect multiple individuals while minimizing the risk of stings. In contrast, fishers using trawl nets experienced less risk of exposure to the fish's spines.

The lionfish has become an attractive commercial product for traders, with its price increasing from 10 Egyptian Pounds (L.E.) per kg in 2020 to 70 L.E. per kg in 2023. It is now widely sold by fishers. To date, no cases of poisoning have been reported from consuming lionfish.

When preparing the lionfish for human consumption, it is essential to handle the fish carefully, holding it by the abdominal portion or head with gloves to avoid contact with the spines. The spines should then be carefully removed using sharp scissors, starting with the dorsal spine from front to back, ensuring that the venomous glands at the base are eliminated. Afterward, the pectoral spines and other spines should be removed. To avoid other sharp and hard parts, it is recommended to remove the head. Larger and darker specimens tend to have thicker skin, which can be easily removed by hand by gripping a section of the skin behind the head and pulling it toward the rear (Fig. 9).

A survey of 100 individuals, including traders, fishers, and consumers who ate the lionfish during 2023-2024, found that all of them recommended consuming the lionfish meat, noting its delicious taste, provided that the spines were carefully avoided during processing.

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Fig. 8. Lionfish caught by spearfishing and removing its spines directly as a safety precaution

4.4. Poisonous cases, symptoms, and preliminary treatment

The present survey of individuals exposed to the spines of live lionfish species revealed that the highest exposure occurred among longline fishers, followed by fishers using trammel nets, and lastly, spearfishing divers, despite the fact that they directly encounter the lionfish underwater. The symptoms of the lionfish stings were not fatal; however, most individuals experienced varying levels of pain, swelling, a heat sensation, and redness, with fever being a rare occurrence.

Fig. 9. The processing, preparation steps, and safety precautions for consumption of lionfish

In cases of the lionfish stings, the treatment process began with cleaning the wound to ensure that no spine fragments remained. The affected area was then submerged in hot water (50-60°C) for 30-90 minutes. After the heat treatment, ice packs were applied to reduce swelling. Around 70% of individuals exposed to the lionfish stings recovered without the need for hospitalization, highlighting the manageable nature of these injuries when treated promptly.

For those who continued to experience pain and swelling in their hands and fingers, hospital visits were necessary. In these cases, oral non-steroidal anti-inflammatory drugs (NSAIDs), such as ibuprofen, were used for pain relief, and antihistamines were sometimes added to help mitigate pain and swelling. A few cases required a tetanus injection to prevent irritation and additional toxic effects from the lionfish spines.

Over time, fishers and spearfishing divers became familiar with the risks of the lionfish stings and typically used gloves and cutters to handle the spines safely. No fatal poisoning cases have been reported, and most cases resolved within 2-4 hours. As a result, hospitalization has not been required for the lionfish stings.

4.5. Biochemistry and nutritional values of lionfish

The chemical composition of the red lionfish muscles (*P. miles*) showed a promising nutritional profile. Data in Table (3) display the estimate of water content/moisture as 72.32 ± 3.64 and 75.34 ± 4.28% for large and small specimens, respectively. The ash content was 5.59 ± 0.49 and 6.82±0.82% for large darker and small lighter lionfish, respectively. Notably, the high crude protein content (78.97 ± 7.57 and 81.46 ±7.35%) was evaluated for large darker and small lighter lionfish, respectively. The fat content ranged from 12.06 ± 2.04 to 8.55± 2.21% for darker and lighter lionfish, respectively. Additionally, the low carbohydrate (1.69 ± 0.82%) was higher than those in small lighter (1.45 ± 0.31%), while the value of fibers in darker and larger ones was lower than those in lighter and small.

Table 3. Chemical composition in muscles of both larger and smaller lionfish *P. miles* based on dry matter weight

Chem. composition	Darker & larger (Av±SR)	Lighter & smaller (Av±SR)
Moisture %	72.32±3.64	75.34±4.28
Ash%	5.59±0.49	6.82±0.82
Crude protein %	78.97±7.57	81.46±7.35
Fat %	12.06±2.04	8.55±2.21
Carbohydrates %	1.69±0.82	1.45±0.31
Fibers%	1.02±0.26	0.75±0.15

The amino acid profile of the lionfish samples revealed a diverse composition, with notable variations in amino acid concentrations (Table 4). The obtained profile of amino acids gave 16 amino acids (8 Essential + 8 non-essentials). For the essential amino acids, lysine (9.79%) exhibited the highest value followed by leucine (8.21%), while the group of sulfur-containing amino acid groups, which was considered to be a valuable group, was represented here by methionine (3.07%). The profile also includes balanced amounts of other essential amino acids such as threonine (4.96%) and valine (5.46%). Regarding non-essential amino acids, glutamic acid exhibited the highest concentration (14.39%), followed by aspartic acid (10.80%) and lysine (9.79%) and the lowest one was observed for tyrosine (3.51%).

Table 4. Amino acids profile of the lionfish muscles (g/100 g of dry weight)

Essential amino acid	**g/100 g**	**Non-essential amino acid**	**g/100 g**
Leucine	8.21	Alanine	6.07
Isoleucine	4.56	Aspartic acid	10.80
Valine	5.46	Glutamic acid	14.39
Lysine	9.79	Serine	4.63
Threonine	4.96	Glycine	5.82
Phenylalanine	5.01	Proline	3.54
Histidine	2.89	Tyrosine	3.51
Methionine	3.07	Arginine	5.87

Table 5. Fatty acids profile of dried lionfish flesh sample as % of total lipids

Saturated fatty acids (SFA)			**Monounsaturated fatty acids (MUFA)**			**Polyunsaturated fatty acids (PUFA)**		
Palmitic acid	(C16:0)	25.68	**Oleic acid**	(C18:1, n-9)	20.61	**Eicosapentaenoic acid**	**(EPA, C20:5, n-3)**	8.82
Stearic acid	(C18:0)	7.39	**Palmitoleic acid**	(C16:1)	5.48	**Docosahexaenoic acid**	**(DHA, C22:6, n-3)**	12.47
Myristic acid	(C14:0)	4.14	**Vaccenic acid**	**(C18:1, n-7)**	2.91	**Linoleic acid**	**(C18:2, n-6)**	4.69
Myristic acid	**(C14:0)**	4.79	**Gadoleic acid**	**(C20:1)**	1.37	**Alpha-Linolenic acid**	**(C18:3, n-3)**	2.38
Lauric acid	**(C12:0)**	0.54	**Myristoleic acid**	**(C14:1)**	0.52			
Capric acid	**(C10:0)**	0.27						
Caprylic acid	**(C8:0)**	0.18						

The fatty acid profile of the sample demonstrates a notable distribution across saturated, monounsaturated, and polyunsaturated fatty acids, with some important implications for the nutritional and functional properties of the lionfish flesh (Table 5). Among the saturated fatty acids, palmitic acid (C16:0) was the most abundant, comprising 25.68% of the total fatty acids. Stearic acid (C18:0) and myristic acid (C14:0) were also present in significant quantities, at 7.39 and 4.79%, respectively. In terms of monounsaturated fatty acids, oleic acid (C18:1, n-9) was the dominant component, accounting for 20.61% of the total fatty acids. Additionally, palmitoleic acid (C16:1) and vaccenic acid (C18:1, n-7) were present in moderate amounts (5.48 and 2.91%, respectively). The polyunsaturated fatty acids (PUFAs) included important levels of both omega-3 and omega-6 fatty acids. Notably, docosahexaenoic acid (DHA, C22:6, n-3) and eicosapentaenoic acid (EPA, C20:5, n-3) were present at 12.47 and 8.82%, respectively, providing a substantial source of long-chain omega-3s.

4.6. Future vision and conservation

The present survey highlights the establishment of the lionfish along the Egyptian coast, particularly in sandy-rocky habitats at depths of up to 40m. These habitats are most prevalent starting from Alexandria, extending westward along the coast and eastward from Port Said to the Gaza border. This distribution pattern provides valuable insight for future management efforts, helping to identify key hotspots for the lionfish populations.

Given its public acceptance and consumption—unlike other poisonous fish such as the pufferfish—lionfish should be considered in future fisheries management and conservation plans. According to the survey, trawl nets and long liners could play a significant role in reducing lionfish numbers, while also ensuring that biological measures for conservation and sustainability are considered.

Additionally, spearfishing is expected to be a key method in the future management of the lionfish, as it allows for the selective harvesting of larger specimens (Fig. 10). This approach is facilitated by the fish's behavior, including its slow movement, shallow depth habitat, and association with other commercial species in sandy-rocky areas that attract spearfishermen. The present survey illustrated the establishment of the lionfish along the coast, predominantly in sandy-rocky habitats up to 40m depth. These habitats prevailed mostly starting from the city of Alexandria, extending westward along the Egyptian coast and eastward from Port Said to the border with Gaza. These distribution criteria facilitate the inclusion of this species in future management to identify its most important hotspots. Due to its public acceptance and consumption, unlike other poisonous fishes such as the pufferfish, it should be included in future fisheries and management conservation plans. Based on the present survey, trawl nets and long liners could play a significant role in catching the lionfish species to help reduce its numbers in the future, while considering biological measures for its conservation and sustainability. Furthermore, spearfishing activity is expected to have a major role in the future management of this species, as it allows for the selective harvesting of large lionfish specimens (Fig. 10). This is mainly facilitated by the fish's behavior, including its slow movement, presence in shallow depths, and association with other commercial species in sandy-rocky habitats that attract spearfishermen.

Fig. 10. The activities of spearfishing to catch the lionfish

DISCUSSION

The Mediterranean Sea continues to receive non-indigenous species through various pathways, and climate change may exacerbate this phenomenon. The reporting of these non-indigenous species is important to categorize which of them would be considered commercial or hazardous species for further management and better utilization. The present study reported the introduction of three non-indigenous species while confirming the occurrence of two lionfish species and their expansion along the Egyptian coast. Malabar grouper *Epinephelus malabaricus*, is considered a first report in this study. It was mentioned for its first occurrence in the Mediterranean off the coast of Israel as *Epinephelus* sp. by **Ben-Tuvia and Lourie (1969)**, then was identified as *Epinephelus malabaricus* and confirmed by **Randall and Ben-Tuvia (1983)**. Afterward, **Heemstra and Randall (1993)** confirmed that the *Epinephelus* sp. was actually *Epinephelus coioides*. Later, **Golani *et al.* (2002)** and **Mavruk and Avsar (2008)** reported the occurrence of *Epinephelus tauvina*. This caused confusion about the correct classification of the *Epinephelus* species in this area. Recently, the Malabar grouper was caught off the Gaza coast in 2013 **(Jaffa, 2020)**. In the present study, the specimens that were collected by spearfishing were similar to those reported in the Maltese water **(Schembri & Tonna, 2011)**. The latter authors reported that the locality of the capture of the specimens was inside one of the major harbors in Malta, which might be significant since harbors are considered key points of entry for non-indigenous species that are transported particularly by shipping through ballast water and may remain the most likely pathway for introduction of *E. malabaricus* into the Mediterranean Sea.

Based on the information provided above, it was observed that the occurrence of this species was recorded in limited abundance and reports. The observation of this species on the Egyptian coast of the Mediterranean Sea from 2012 to 2022 was confirmed by morphological identification and agrees with those reported by **Heemstra and Randall (1993)** and **Schembri and Tonna (2011)**. Moreover, many researchers have studied ichthyofauna and fish diversity along the Egyptian coast of the Mediterranean Sea **(El-Sayed, 1994; Akel & Karachle, 2017; Farrag *et al.*, 2019; Galanidi *et al*., 2023)** and noted no previous records of *E. malabaricus*, confirming its first occurrence on the Egyptian coast in the present study. This report in the present study will be considered as a positive addition to the groupers' list found on the Egyptian coast of the Mediterranean Sea, particularly the commercial and non-indigenous species. In the Mediterranean Sea, ten groupers have been reported, of which six are native **(Heemstra & Randall, 1993**), and these are *Mycteroperca rubra* (Bloch, 1793), *Epinephelus aeneus* (Geoffroy Saint-Hilaire, 1817), *E. marginatus* (Lowe, 1834), *E. caninus* (Valenciennes, 1843), *E. costae* (Steindachner, 1878), and *E. haifensis* (Ben-Tuvia, 1953). Two species, *E. malabaricus* (Bloch & Schneider, 1801) and *E. coioides* (Hamilton, 1822), are Lessepsian migrants **(Golani *et al*., 2002)**, while one species, *Cephalopholis taeniops* (Valenciennes, 1828), is of Atlantic origin, having entered the Mediterranean Sea through the Strait of Gibraltar **(Guidetti *et al*., 2010)**. The last species is the Indo-Pacific *E. merra* (Bloch, 1793), which was reported once on the French coast and is believed to have been released from an aquarium **(Lelong, 2005)**,

On the other hand, another non-native species that was recorded in the present study is the Indo-Pacific *Abudefduf vaigiensis* (Quoy & Gamard, 1825). It belongs to family Pomacentridae (Bonaparte, 1831), commonly known as the damselfish. In the Mediterranean Sea, this family is represented by a single native species, *Chromis chromis* (Linnaeus, 1758) **(Dulčić, 2005; Froese & Pauly, 2015)**, and seven additional alien or cryptogenic taxa **(Coll *et al.*, 2010; Golani *et al.*, 2014)**. The sapphire devil, *Chrysiptera cyanea* (Quoy & Gaimard, 1825) has been recorded in Italy **(Lipej *et al*., 2014)** and the cocoa damselfish, *Stegastes variabilis* (Castelnau, 1855) was recorded in Malta **(Vella 2014; Vella *et al.*, 2015)**. In the Mediterranean Sea, the majority of the records of the genus *Abudefduf* are of the Atlantic species *A. saxatilis* (Linnaeus, 1758) based on **Pirkenseer (2020)** and **Zenetos and Miliou (2020)**. Nevertheless, *A. vaigiensis* has also been recorded throughout the Mediterranean Sea **(Osca *et al.*, 2020; Pirkenseer, 2020; Zenetos & Miliou, 2020; Dragičević *et al.*, 2021)**. All specimens were generally observed in very shallow waters from 2–4m depth on hard bottoms. This species is native to the Indo-Pacific region, including the Red Sea, and is often considered a Lessepsian migrant **(Gökoglu *et al*., 2003; Bariche, 2010, 2012; Salameh *et al*., 2012; Tsadok *et al*., 2015; Gürlek *et al.*, 2019)**.

The first record of the genus *Abudefduf* in the Mediterranean was in 1957 as *A. vaigiensis*, from the Gulf of Naples in Italy **(Tardent, 1959)**. Then, it was recorded in the

Gulf of Genoa in the Ligurian Sea, Italy **(Vacchi & Chiantore, 2000)**. According to the suggestion of **Occhipinti-Ambrogi *et al*. (2011)**, this alien species has reached the Italian water through shipping activities. In the eastern Mediterranean basin, it was identified and reported later on the coast of Israel in 1997 **(Goren & Galil 1998)**. Since then, it has been established in the same area **(Golani *et al*., 2014)**. Afterward, **Bariche *et al*. (2015)** recorded its occurrence in Lebanon. Meanwhile, there was another close species of the same genus known as *A. saxatilis*, which was reported in the Mediterranean Sea off the coast of Spain in 2009 as a first observation by **Azzurro *et al*. (2013)**. This was followed by records from **Deidun and Castriota (2014)** and **Vella (2014)** in Malta, and **Tsadok *et al.* (2015)** in Israel. *A. saxatilis* is distinguished by the continuous extension of the fifth dark vertical bar on the posterior margin of the dorsal fin. In contrast, *A. vaigiensis* has a gap between the bar and its extension, along with the absence of two black spots on the caudal peduncle, which are present in *A. saxatilis* **(Randall, 1996; Azzurro *et al*., 2013; Froese & Pauly, 2016)**.

To address the possible confusion between these two very similar congeners, **Tsadok *et al.* (2015)** used genetic analyses and found that all the specimens sampled from Israel were identified as *A. saxatilis,* casting doubt on the possible presence of *A. vaigiensis* in the Mediterranean Sea. However, a more recent study by **Bariche *et al.* (2015)** genetically barcoded a specimen of *A. vaigiensis* from Lebanon, confirming its presence in the Levantine Basin. In Egypt, the genus *Abudefduf* (Forsskål, 1775) was reported for the first time by **Al Mabruk *et al.* (2021)** from Alexandria at 3m depth in 2013. Nevertheless, the species identification was not confirmed, whereas the species report was based on an unclear photograph from Facebook. Therefore, the present specimen may be considered the first confirmed record of this species by specimens' confirmation. Further, its features agree with those reported by **Allen (1991)**, **Randall (1996, 2007)** and **Froese and Pauly (2015**), who supported its occurrence in the Egyptian water.

The third reported species in the present study is the wahoo fish, *Acanthocybium solandri*, which belongs to the family Scombridae. *A. solandri* (Genus; Acanthocybium) is a large epipelagic species distributed in tropical and subtropical temperate waters of the Pacific, Indian and Atlantic oceans **(Collette & Nauen, 1983)**. It has been reported recently from the Red Sea **(Williams *et al*., 2022)**. It is not a well-known fish on the Egyptian coast of the Mediterranean Sea.

Its characteristics agree with those detailed in the studies of **Fischer and Bianchi (1984)**, **Collette and Graves (2019)**, **Williams *et al*. (2022)** and **Gökoğlu *et al.* (2024)**. Sometimes, *A. solandri* is confounded with the narrow-barred Spanish mackerel (*Scomberomorus commerson)*. However, it has a longer dorsal fin and a curved lateral line starting at the middle of the first dorsal fin, unlike the lateral line distinctly sloping ventrally below the second dorsal fin in *S. commerson* **(Williams *et al*., 2022)**.

To date, there was no record of such species along the Egyptian coast of the Mediterranean Sea. The comprehensive checklists of the Red Sea fish species and the Ocean Biodiversity Information System (OBIS) showed no evidence of these species in the basin **(Golani & Fricke, 2018; OBIS, 2022a, b)**. In 2012, a school of *A. solandri* was caught and photographed in the southern Red Sea **(GBIF, 2022)**, but its identification was not verified. According to ICCAT (International Commission for the Conservation of Atlantic Tunas), the wahoo fish is one of the thirteen most important species of small scombrid fish in tropical oceans, and its catches are increasingly frequent worldwide. Therefore, it is necessary to recognize its biological and migratory cycles throughout its range **(Brown-Peterson *et al*., 2000; Oxenford *et al*., 2003; Viana *et al*. 2008, 2013)**.

According to **Romeo *et al.* (2005)**, *A. solandri* was firstly recorded in the Mediterranean Sea as a single specimen in 1872 in a tuna trap off the Sicilian coast of Italy, then by harpoon in the Strait of Messina in 1990m, then in June 2004 from the same area with a harpoon used in traditional swordfish fishing. Then, it was reported from the Lebanese coasts in the eastern Mediterranean Basin by **Fatfat *et al.* (2024)**. Afterward, it was recorded from the Turkish water by **Gökoğlu *et al*. (2024)**. In Egypt, this species has not been reported previously, therefore, the present results are considered the first report of such large pelagic species in the area of study adding one to the commercial non-indigenous fish species in Egypt.

The present study also confirmed the introduction and expansion of the lionfish as the famous non-indigenous species in the Mediterranean Sea, Egypt. The lionfish is a tropical species found mostly in the Red Sea and Indo-Pacific regions. In the Mediterranean Sea, a single specimen of the lionfish (*P. miles*) has been reported as the first record from Haifa Bay in 1991 **(Golani & Sonin 1992)**, the Lebanese coast **(Bariche *et al.*, 2013)**, the Cypriot coast **(Evipidou, 2013)**, Turkish marine waters **(Turan *et al.*, 2014; Turan & Ozturk, 2015; Yaglioglu & Ayas, 2016)**, Greece **(Corsinin-Foka & Kondylatos, 2015; Giovos *et al.*, 2018)**, and in both Italy and Tunisia **(Azzurro *et al*., 2017)**. In Egypt, it has been observed as individuals in Alexandria fish market since 2016, in the catch of scorpion fish (present study; direct observation by the author). After that, it has been observed in different regions along the Egyptian coast of the Mediterranean Sea reflecting its expansion with high abundances. Social media showed a high potential of the non-indigenous species detection in accessible areas. Its use began in the Mediterranean Sea a few years ago and showed a modern and unconventional way for detection **(Bariche & Azzurro, 2016; Rizgalla *et al.*, 2016; Giovos *et al.*, 2019)**, especially for species with unmistakable (clear) morphological features **(Rizgalla *et al.*, 2019)**. One limitation is often the absence of a physical specimen to examine, as is the case of the first document from Egypt of *P. miles* and *Scarus ghobban* **(Al Mabruk *et al.*, 2020)**. Hence, the present study has confirmed the presence of the lionfish *P. miles* with an expanding range along the Egyptian Mediterranean coast. Since its introduction, it has expanded commercially and became significant in the socio-economy context of the Egyptian fisheries. Additionally, another species of the lionfish, *Pterois volitans* (red lionfish), has been observed in the Mediterranean Sea. This species is native to the eastern Indian Ocean, Pacific Ocean, and Atlantic Ocean **(Schultz, 1986; Whitfield *et al.*, 2002; Kimball *et al*., 2004; Froese & Pauly, 2016)**. Therefore, it is unlikely to be a

Lessepsian migrant, as it is absent in the Red Sea and western Indian Ocean **(Froese & Pauly, 2019)**.

The red lionfish *P. volitans* has also been reported in the Mediterranean Sea mostly in the Turkish water. Some researchers attributed this localized population to an aquarium release **(Gürlek *et al.*, 2016; Gökoğlu *et al***., **2017; Ayas *et al.*, 2018a)**. *P. miles* and *P. volitans* are very similar; however, some differences are outlined in Table (1). These differences agree with the findings in the studies of **Schultz (1986)** and **Kuiter and Tonozuka (2001)**, who stated that, *P. volitans* has large tentacles above the eyes. Moreover, **Turan *et al.* (2016)** suggested that *P. volitans* from the Turkish water migrated westward to the Mediterranean Sea. In the Turkish water, both species showed expansion similar to the present study. However, the lionfish *P. miles* was firstly observed in different areas of the Turkish water before *P. volitans* **(Turan & Özturk, 2015; Yaglioglu & Ayaş, 2016)**, which concurs with the present findings. In the present survey, it was noticed that the population of *P. miles* has increased nearshore. In many instances, it was caught in the fishermen's nets within the range of a 3m depth as well as with line fishing at a 40m depth. The present survey also illustrated that the spearfishermen have observed these fishes in various areas in highly intensive populations from a depth of one meter to 20 meters, mostly in rocky habitats particularly in the areas from Alexandria westward to Marsa Matruh. These findings support the understanding of its preferred habitat, abundance and catch, which may need further monitoring and management as stated in its distribution (Table 2). The increased abundance of the lionfish may be related to its rapid growth, as mentioned by high fecundity and tolerance to changing environmental conditions **(Whitfield *et al***., **2007; Gardner *et al***., **2015; Johnson & Swenarton, 2016)**. In fact, most tropical species that entered the Mediterranean Sea have established themselves and have been acclimatized in favorable conditions, and this coincides with that reported for pufferfish *lagocephalus sceleratus* **(Farrag, 2014)**. The climate changes helped distribute non-indigenous species whether they are of tropical or Atlantic origin as supported by **Katsanevakis *et al.* (2024)**. Day by day, the lionfish species is shifting from being a hazardous species to the economic species in the fisheries of trawlers and longliners, where it is sold by traders. This criterion was observed for several non-indigenous species, especially lessepsian species, matching the results of **Farrag *et al***. **(2018)** and **Katsanevakis *et al.* (2024)**.

Despite the danger posed by its venomous spines, many people consume lionfish meat after carefully removing the spines. To date, no cases of human toxicity have been reported as a result of its consumption. As a result, the perception of the lionfish among Egyptian fishers and consumers has shifted from negative to positive. This aligns with the suggestions of **Morris and Whitfield (2009)** and **Huseyinoglu and Ozturk (2018)**.

The positive effect has extended to socio-economic, in 2023-2024, the economic value of this species has been detected by the increase of its price from 10 L.E. to 70 L.E. per Kg, which confirmed its socio-economic value among the Egyptian consumers and traders. Its commercial values were reported also by **Carballo-Cardenas and Tobi**

(2016). The removing spines as safe handling, preparing fillets and cooking of the lionfish following the procedures and directions of spines removing agree with **Huseyinoglu and Ozturk (2018)**. The later authors applied different kinds of cooked lionfish as delicious foods adding the positive values in socio-economic field. In the present study, the lionfish specimens were processed for fillets and cooking after removing the spines and head separation due to having a lot of unacceptable small hard parts. After consumption, no poisonous cases were reported. This encourages fishers and traders to consume it, indicating its better utilization.

Regarding the lionfish spines and the fear of poisoning, these spines contain two grooves on its sides. Each groove is connected to a venom gland at the base of spine. When the spine stings and penetrates into the skin and soft tissue, the venom will be discharged from the glands **(de Haro & Pommier, 2003)**. The symptoms related to lionfish stings included weakness and transient muscle paralysis by disturbing neuromuscular conduction; muscle contractions, cell necrosis, and serum CPK (Creatine Phosphokinase) and AST (Aspartate Aminotranspherase), beside cytotoxic, proinflammatory & prothrombotic effects, and the surrounding tissues become pale and cyanotic with blistering edema **(Church & Hodgson, 2002; Church *et al.*, 2003)**. The above-mentioned symptoms match the present findings. Others have mentioned that the venom can retain full potency up to 48 hours even after animal's death **(Resiere *et al.*, 2016)**. This finding was not observed in the present survey after animal's death. This may be due to the tolerance and response of the victim. According to **Haddad *et al.* (2015)** and **Resiere *et al.* (2016)**, the symptoms may extend to respiratory distress and cardiac dysrhythmias in some strong cases, however the cardiovascular shock and death are very rare.

Regarding treatment, the present results indicate that some cases of the lionfish stings were resolved within a few hours with simple treatments such as cleaning the wound, removing any spine fragments, and applying hot water. In more severe cases, individuals visited the hospital and were treated with medications. If possible, elevating the injured area can help reduce swelling. The wound should be cleaned with warm saline or antiseptic solutions, and any surrounding accessories, such as rings and watches, should be carefully removed before swelling occurs **(Vetrano *et al.*, 2002; Atkinson *et al.*, 2006; Resiere *et al*., 2016)**.

Moreover, **Atkinson *et al.* (2006)** and **Hornbeak and Auerbach (2017)** emphasize that warm water immersion is an important method for pain relief. It is also crucial to be aware that burns or scalding may occur with water temperatures above 40-45°C. The venom of the lionfish is a protein with acetylcholine and antigenic properties, which loses its structure at temperatures of 50-60°C **(Kizer *et al.*, 1985)**.

The hospitalization is better to be applied to avoid the delayed allergic or systemic reactions. It was noticed that the symptoms, signs, and treatments may vary among individuals. Usually, the following signs have been monitored: temperature, pulse, blood pressure, respiration rate, central venous pressure, pulse oximeter, lung function, and urine output **(Edmonds, 2002; Diaz, 2015)**. Some of the above- mentioned symptoms have been monitored during the present survey. Usually, the tetanus was taken for most cases, pain relief and temperature and swelling reduction. These treatment procedures coincide with those reported in the studies of **Badillo *et al*. (2011)**, **Haddad *et al*. (2015)**, **Resiere *et al.* (2016)** and **Schult *et al*. (2017)**. For more monitoring in cases of strong action of stings which may reach the bones, the radiological examinations like soft-tissue X-ray, ultrasound can be used to disclose bone injury **(Edmonds, 2002)**. The recovery period may vary from several hours to a few days. From these findings, it was indicated the awareness of the way to avoid the lionfish stings is very important during spearfishing and handling, and the primary precautions are easy and important for all fishers and traders. The spear divers have the experiences to deal with stings in cases of places that are located far away from the hospital, they used hot water and take some pain relief and antihistaminic and analgesic during transportation.

Regarding its acceptability, the chemical composition of the lionfish *(P. miles)* muscles indicates a promising nutritional profile in agreement with **Sikorski *et al*. (2020)**. The ash content was 5.59 ± 0.49 and 6.82±0.82% for larger and small-medium lionfish, respectively. This points to a significant mineral presence, potentially contributing to essential micronutrient intake **(Bogard *et al*., 2015)**. Notably, the high crude protein (78.97 ± 7.57 and 81.46 ±7.35%) for larger and small lionfish, respectively, makes it a rich source of protein, aligning with prior research on protein levels in lionfish. This outcome is in accordance with the study of **Zhang *et al*. (2023)**. The fat content in muscles indicates the higher lipid content (12.06 ± 2.04 %) of larger size compared to small-medium size (8.55±2.21%) of lionfish *P. miles*. The higher fat content in the muscles of the large samples may be due to the fact that most investigated samples were in spawning season and may reflect storing fats in their muscles. Additionally, the low-moderate carbohydrate and fibers contents reflect typical fish nutritional profiles, where energy is primarily derived from proteins and fats rather than carbohydrates or fibers, agreeing with **Li *et al*. (2019)**. The chemical composition of the lionfish *P. miles* was investigated by **Ayas *et al.* (2018b)** from the North-eastern Mediterranean (Yeşilovacık Bay); they found nearly a similar trend of water, crude protein, and fat content to the present results. **Ayas *et al.* (2018b)**, also recommended the consumption of the lionfish after investigation of general profile including fatty and amino acids as well as the mineral. The present nutrient profile underscores the potential of larger size of the lionfish as an underutilized source of high-quality protein, in agreement with **Fernandes *et al*. (2014)**. This finding contributes to sustainable consumption practices and offers an innovative solution for controlling the lionfish population in accordance with **Ayas *et al.* (2018b)** as an acceptable food strategy and the accepted approach to lionfish removal suggested by **Ulman *et al.* (2022)**. This study suggests better utilization and not removal since it became a valuable stock that requires further management and conservation at the same time.

For more positive values, the relatively high levels of glutamic and aspartic acids suggest that the sample could contribute to flavor enhancement due to their role as key flavor precursors, especially glutamic acid **(Dashdorj *et al*., 2015**). Additionally, lysine's substantial presence is nutritionally valuable, as it is often limited in plant-based proteins, indicating that the sample may help fulfill essential amino acid requirements **(Leinonen *et al*., 2019**). This could make the lionfish a valuable addition to plant-based formulations aiming to meet essential amino acid needs. The profile also includes balanced amounts of other essential amino acids such as threonine (4.96%) and valine (5.46%), contributing to the lionfish's potential as a protein source with a well-rounded amino acid composition, making it suitable for human consumption and possibly valuable for nutritional formulations in agreement with **Ayas *et al* (2018b)**. Moreover, the profile of fatty acids indicates the richness of nutritional values and acceptability during the processing and cooking. The domination of palmitic acid in lionfish muscles suggests that the sample may possess high stability during cooking or processing, as saturated fatty acids contribute to oxidative stability, as supported by **Fomena Temgoua *et al.* (2022)**. In addition, the fatty acids profile includes unsaturated fatty acids that are beneficial for cardiovascular health and others such as their positive role in brain function and anti-inflammatory effects, with values comparable to other commonly consumed fish species makes it more acceptable for consumption in accordance with **Lund (2013)** and **Ayas *et al.* (2018b)**. Moreover, fish consumption is a nutritionally valuable food because it is a source of high protein, essential elements and especially n-3 polyunsaturated fatty acids (n-3 PUFAs) **(Daviglus *et al*., 2002; McMichael & Butler, 2005)**. These nutrients, especially docosahexaenoic acid, are beneficial to the development of the brain and visual system in infants and reduce the incidence of paralysis and cholesterol levels in adults and reduce the risk of some heart diseases **(Bouzan *et al*., 2005; Mahaffey, 2011; Oken, 2012)**. These findings resemble the present results of lionfish indicating its positive values for food consumption.

Further control of the expanded lionfish species may include the food consumption among food strategy in accordance with **Ayas *et al.* (2018b)**, and also may use fishing activities particularly spearfishing as acceptable approach for lionfish catching as supported by **Ulman *et al.* (2022)**. Several suggestions were introduced by **Draman (2018)** in **Huseyinoglu and Ozturk (2018)** for control and reduction of lionfish including food consumption and protected areas, restaurants and biological control. The biological control considered safe conservation measure and sometimes included in the healthy community. **Bernadsky and Goulet (1991)** and **Maljković *et al.* (2008)** stated that the cornetfish *Fistularia commersonii* and the groupers *Epinephelus striatus* and *Mycteroperca tigris* have been reported to feed on the lionfish. There is also indication that large groupers may act as biological control agents in the Caribbean **(Mumby *et al.*, 2011)**. In the Mediterranean, the only convincing example of predation is that of an octopus (*Octopus vulgaris*) filmed while catching and carrying a lionfish in Cyprus **(Crocetta *et al.*, 2021)**. The scarce knowledge on lionfish predators limits any conclusions on the importance of relaxed predation as an explanation for the high invasiveness of the lionfish. The present study illustrated the expanding of lionfish and also reported the occurrence of Malabar grouper, and this indicates the grouper may act as biological control in future.

CONCLUSION

In conclusion, the present study investigated the introduction of non-indigenous fish species in the Egyptian Mediterranean waters reporting the first occurrence of three non-indigenous fish species. It also confirmed the expansion of lionfish *Pterois miles* and the occurrence of *P. volitans,* and touched their high socio-economic status, along the coast, while emphasizing some safety precautions during their handling and consumption. Also, this study supported their acceptability and nutritional values, adding positive advantages to their occurrence. The present study recommends continuous monitoring of new non-indigenous species and sheds light on their positive and negative impact. Further studies and further management are required using the up-to-date biological data, as well as imposing control on overfishing activities, particularly among skilled spearfishermen. Additionally, public awareness is needed regarding how to handle both live and dead lionfish to minimize the risk of poisoning by its venomous spines. Also, the obtained data on mapping the intensively exploited areas of lionfish during the management process may be considered at the mitigation level via commercial fishing operations and spearfishing activities.

REFERENCES

Akel, E. H. Kh. and Karachle, P. K. (2017). The Marine Ichthyofauna of Egypt. Egypt. J. Aquat. Biol. Fish., 21(3): 81-116.

Al Mabruk, S. A. A. and Rizgalla, J. (2019) First record of lionfish (Scorpaenidae: Pterois) from Libyan waters. J. Black Sea/Medit. Environ., 25(1): 108–114.

Al Mabruk, S. A. A.; Abdulghani, A.; Nour, O. M.; Adel, M.; Fabio Crocetta, F.; Doumpas, N.; Kleitou, P. and Tiralongo, F. (2021). The role of social media in compensating for the lack of field studies: Five new fish species for Mediterranean Egypt**.** J Fish Biol., 2021:1–6. DOI: 10.1111/jfb.14721

Al Mabruk, S. A. A.; Rizgalla, J.; Giovos, I., and Bariche, M. (2020). Social media reveals the first records of the invasive lionfish Pterois miles (Bennett, 1828) and parrotfish Scarus ghobban Forsskål, 1775 from Egypt (Mediterranean Sea). BioInvasions Records, 9 :574–579.

Albins, M. A. and 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

Allen, G. R. (1991) Damselfishes of the World. Mergus Publishers, Melle, Germany, 271pp. Allen, G.R., Woods, L.P. (1980) A review of the damselfish genus Stegastes from the Eastern Pacific with description of a new species. Records of the Western Australian Museum 8: 171-198.

Allen, G. R. and Erdmann, M.V. (2008). Pterois andover, a new species of scorpionfish (Pisces: Scorpaenidae) from Indonesia and Papua New Guinea. Aqua, Inter. J. Ichthyol., 13 (3-4):127-138.

AOAC Assn. of Official Analytical Chemists (2000). Coffee and tea. In: Official methods of analysis. 17th ed. Gaithersburg, Md.: AOAC.

Atkinson, P.R.T.; Boyle, A.; Hartin, D. and McAuley, D. (2006) Is hot water immersion an effective treatment for marine envenomation? Emerg Med J 23(7): 503-508. Auerbach, P.S. (1991) Marine envenomations. N Engl J Med 15: 486-493.

Ayas, D.; Ağılkaya, G. S. and Yağlıoğlu, D. (2018a) New occurrence of the red lionfish *Pterois volitans* (Linnaeus, 1758) in the northeastern Mediterranean (Yeşilovacık Bay). Düzce Univ. J. Sci. Technol., 4: 871–877. https://doi.org/10.29130/dubited.362703 .

Ayas, D.; Agılkaya, G. S.; Kosker, A. R.; Durmus, M.; Ucar, Y. and, Mısra Bakan, M. (2018b**).** The Chemical Composition of the Lionfish (*Pterois miles*, Bennett 1828), the New Invasive Species of the Mediterranean Sea. Nat. Engin. Sci. (NES), 3(2): 103-115.

Azzurro, E.; Stancanelli, B.; Di Martino, V. and Bariche, M. (2017) Range expansion of the common lionfish *Pterois miles* (Bennett, 1828) in the Mediterranean Sea: an unwanted new guest for Italian waters. BioInvasions Records 6: 95–98, https://doi.org/10.3391/bir.2017.6.2.01

Azzurro, E.; Broglio, E.; Maynou, F. and Bariche, M. (2013). Citizen science detects the undetected: the case of Abudefduf saxatilis from the Mediterranean Sea. Manag. Biol. Invas.,4: 167-170.

Badillo, R.B.; Banner, W.; Morris, J. A. and Schaeffer, S.E. (2011) A case study of lionfish sting-induced paralysis. Aquacult, Aquar, Conserv & Legisl., 5 (1): 1-3.

Bariche, M. (2010). First record of the angelfish *Pomacanthus maculosus* (Teleostei: Pomacanthidae) in the Mediterranean. Aqua, Inter. J. Ichthyol., 16:31–33.

Bariche, M. (2012). Recent evidence on the presence of Heniochus inter medius (Teleostei: Chaetodontidae) and *Platycephalus indicus* (Teleostei: Platycephalidae) in the Mediterranean Sea. BioInv. Records, 1:53–57.

Bariche, M. and Azzurro, E. (2016). Enhancing early detection through social networks: A Facebook experiment. Rapports et procès-verbaux des réunions Commission internationale pour l'exploration scientifique de la Mer Méditerranée, 41, 413.

Bariche, M.; Kleitou, P.; Stefanos, K. and Bernardi, G. (2017) Genetics reveal the identity and origin of the lionfish invasion in the Mediterranean Sea. Sci. Rep., 7: 6782, https://doi.org/10. 1038/s41598-017-07326-1

Bariche, M.; Torres, M. and Azzurro, E. (2013). The presence of the invasive Lionfish Pterois miles in the Mediterranean Sea. Medit. Mar. Sci., 14(2): 292-294.

Bariche, M.; Torres, M.; Smith, C.; Sayar, N.; Azzurro, E.; Baker, R. and Bernardi, G. (2015). Red Sea fishes in the Mediterranean Sea: a preliminary investigation of a biological invasion using DNA barcoding. J, Biogeography doi:10.1111/jbi.12595

Ben-Tuvia, A. and Lourie, A (1969). A Red Sea grouper *Epinephelus tauvina* caught on the Mediterranean coast of Israel. Israel J. Zool., 18: 245–247.

Bernadsky, G. and Goulet, D. (1991) A natural predator of the lionfish, Pterois miles. Copeia 1(1): 230 231. https://doi.org/10.2307/144626

Bogard, J. R.; Thilsted, S. H.; Marks, G. C.; Wahab, M. A.; Hossain, M. A.; Jakobsen, J. and Stangoulis, J. (2015). Nutrient composition of important fish species in Bangladesh and potential contribution to recommended nutrient intakes. J. Food Compos. & Analysis, 42:120-133.

Bouzan, C.; Cohen, J.T.; Connor, W. E.; Kris-Etherton, P. M.; Gray, G. M.; Konis, A., Lawrence, R.S.; Savitz, D. A. and Teutsch, S.M. (2005). A quantitative analysis of fish consumption and stroke risk. American J. Prevent. Medic., 29, 347–352.

Brown-Peterson, N.J.; Franks, J. S. and Burke, A. M. (2000). Preliminary observations on the reproductive biology of wahoo, Acanthocybium solandri, from the northern Gulf of Mexico and Bimini, Bahamas. Proc. Gulf Caribb. Fish. Inst., 51:414–427, http://hdl.handle.net/1834/29311.

Carballo-Cardenas, E.C. and Tobi, H. (2016) Citizen science regarding invasive lionfish in Dutch Caribbean MPAs: Drivers and barriers to participation. Ocean & Coastal Manag., 133: 114-127

Church, J. E. and Hodgson, W.C. (2002) Adrenergic and cholinergic activity contributes to the cardiovascular effects of lionfish (Pterois volitans) venom. Toxicon, 40: 787-779.

Church, J. E.; Moldrich, R. X.; Beart, P. M. and Hodgson, W.C. (2003) Modulation of intracellular Ca+2 levels by Scorpaenidae venoms. Toxicon 41: 679-689.

Coll, M.; Piroddi, C.; Steenbeek, J.; Kaschner, K.; Ben Rais, F.; Aguzzi, J.; Ballesteros, E.; Bianchi, C. N.; Corbera, J.; Dailianis, T.; Danovaro, R.; Estrada, M.; Froglia, C.; Galil, B.S.; Gasol, J. M.; Gertwagen, R.; Gil, J.; Guilhaumon, F.; Kesner-Reyes, K.; Kitsos, M. S.; Koukouras, A.; Lampadariou, N.; Laxamana, E.; Lopez-Fede la Cuadra, C.M.; Lotze, H. K.; Martin, D.; Mouillot, D.; Oro, D.; Raicevich, S.; Rius-Barile, J.; Saiz-Salinas, J. I.; San Vicente, C.; Somot, S.; Templado, J.; Turon, X.; Vafidis, D.;

Villanueva, R. and Voultsiadou, E. (2010) The biodiversity of the Mediterranean Sea: estimates, patterns and threats. PLoS ONE 5: e11842.

Collette, B. B. and Graves, J. E. (2019) Tunas and Billfishes of the World. Baltimore, MD: Johns Hopkins University Press.

Collette, Bruce B. and Nauen, Comelia E. (1983). Scombrids of the world: an annotated and illustrated catalogue of tunas, mackerels, bonitos, and related species known to date. v. 2. Food & Agricult. Organiz. Unit. Nat...

Corsini-Foka, M. and Kondylatos, G. (2015). First occurrence of the invasive lionfish Pterois miles in Greece and the Aegean Sea. Medit. Mar. Sci., 16/3: 692-702.

Crocetta, F.; Shokouros-Oskarsson, M.; Doumpas, N.; Giovos, I..; Kalogeria S.; Langeneck, J.; Tanduo V.; Tiralongo, F.; Virgili, R. and Kleitou, P. (2021) Protect the natives to combat the aliens: Could Octopus vulgaris Cuvier, 1797 be a natural agent for the control of the lionfish invasion in the Medi terranean Sea? J. Mar. Sci. & Engineer., 9 (3): 308. https://doi.org/10.3390/ jmse9030308

Dashdorj, D.; Amna, T. and Hwang, I. (2015). Influence of specific taste-active components on meat flavor as affected by intrinsic and extrinsic factors: An overview. Europ. Food Res. & Technol., 241:157-171.

Daviglus, M.; Sheeshka, J. and Murkin, E. (2002). Health benefits from eating fish. Comm. Toxicol., 8: 345–374.

De Haro, L. and Pommier, P. (2003) Envenomation: a real risk of keeping exotic house pets. Vet Hum Toxicol 45 (4): 214-6.

Deidun, A. and Castriota, L. (2014) First record of *Abdudefduf cfr saxatilis* Linnaeus, 1758 (Perciformes: Pomacentridae) from the Maltese Islands (Central Mediterranean). BioInvas. Records, 3(1): 53-56.

Diaz, J.H. (2015) Marine Scorpaenidae envenomation in travelers: Epidemiology, management, and prevention. J Travel Med 22(4): 251-258.

Dragičević, B.; Fricke, R.; Ben Soussi, J.; Ugarković, P.; Dulčić, J. and Azzurro, E. (2021). On the occurrence of Abudefduf spp. (Pisces: Pomacentridae) in the Mediterranean Sea: a critical review with new records. BioInvas. Records, 10 (1): 188–199.

Dulčić, J. (2005). Biometric properties of damselfish, Chromis chromis (Osteichthyes: Pomacentridae) from the middle Adriatic. Acta Adriatica, 46: 91- 98.

Edmonds, C. (2002) Venomous marine animals. In: Diving and Subaquatic Medicine, Fourth Edition. (eds., Edmonds, C. Lowry, C., Pennefather, J., Walker, R.) Edward Arnold, London, pp. 335-351.

El Haweet, A. A. (2013). Biological studies of the invasive species *Nemipterus japonicus* (Bloch, 1791) as a Red Sea immigrant into the Mediterranean. Egypt. J. Aqua. Res., 39 (4): 267-274.

El Sayed R. S. (1994). Checklist of Egyptian Mediterranean fishes. Bull. Instit. Ocean ogr. & Fish., Alex., Egypt. ix + 77 pp.

Evripidou, S. (2013). Toxic Lionfish makes its way to Cyprus waters. http://www.cyprus mail.com/cyprus/toxic-Lionfishmakes-its-way-cyprus-waters/20130220.

Farrag, M. M. S. (2016). Deep-sea ichthyofauna from Eastern Mediterranean Sea, Egypt: Update and new records. Egypt. J. Aquat. Res., 42 (4): 479–489.

Farrag, M. M. S. (2014) Fisheries and Biological studies on Lessepsian pufferfish, Lagocephalus sceleratus (Gmelin, 1789) (Family: Tetraodontidae) in the Egyptian Mediterranean waters. PhD Thesis, Faculty of science, Al-Azhar University, (Assuit), Egypt.

Farrag, M. M. S.; Aboul Fadl, Kh. Y.; Al-Absawy, A. N., Toutou, M. M.M. and El-haweet. A. A. k. (2018). Fishery biology of lessepsian immigrant Squirrelfishes *Sargocentron rubrum* (Forsskål, 1775), eastern Mediterranean Sea, Egypt. Egypt. J. Aquatic Res., 44 : 307–313.

Farrag, M. M. S.; El-Haweet, A. A. K.; Akel, E. Kh. A. and Moustafa, M. A. (2016). Occurrence of puffer fishes (Tetraodontidae) in the eastern Mediterranean, Egyptian coast - filling in the gap. BioInvas. Records, 5 (1): 47–54 DOI: http://dx.doi.org/10.3391/bir.2016.5.1.09

Farrag, M. M. S.; El-Naggar, H. A.; Abou Mahmoud, M. A.; Alabssawy, A. N.; Hamdy O. A. Abdallah, H. O. A., Abo-Taleb, H. A. and Kostas, K. (2019). Marine biodiversity patterns off Alexandria area, southeastern Mediterranean Sea, Egypt. Environ. Monitor. Assess., (2019) 191:367-394. Doi.org/10.1007/s10661-019-7471-7

Fatfat, S.; Badreddine, A. and Aguilar, R. (2024). Catch of the Day: The Wahoo *Acanthocybium solandri* (Cuvier, 1832) in the Lebanese Waters, Eastern Mediterranean. J. Fish. Livestock Production, 12, 490.

Fernandes, C. E.; da Silva Vasconcelos, M. A.; de Almeida Ribeiro, M.; Sarubbo, L. A.; Andrade, S. A. C. and de Melo Filho, A. B. (2014). Nutritional and lipid profiles in marine fish species from Brazil. Food chemist., 160: 67-71.

Ferreira, C. E. L.; Luiz, O. J.; Floeter, S. R.; Lucena, M. B.; Barbosa, M. C.; Rocha, C. R. and 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

Fischer, W. and Bianchi, G. (1984) Volume IV bony fishes families: Scatophagidae to Trichiuridae. In FAO Species Identification Sheets for Fishery Purposes– Western Indian Ocean (Fishing Area 51). Rome: Food Agric. Organiz. United Nati.

Fomena Temgoua, N. S.; Sun, Z.; Okoye, C. O. and Pan, H. (2022). Fatty acid profile, physicochemical composition, and sensory properties of Atlantic salmon fish (Salmo salar) during different culinary treatments. J. Food Quality, 2022 (1), 7425142.

Fricke, R. (1999) Fishes of the Mascarene Islands (Réunion, Mauritius, Rodriguez): an annotated checklist, with descriptions of new species. Theses Zoologicae 31. Koeltz Scientific Books, Koenigstein, 759 pp

Froese, R. and Pauly, D (2015) FishBase. (http://www.fishbase.us).

Froese, R. and Pauly, D (2016). FishBase. Worldwide electronic publication. http://www.fishbase.org, version (07/2016).

Froese, R. and Pauly, D. (eds) (2019) FishBase. www.fishbase.org

Galanidi, M.; Aissi, M.; Ali, M.; Bakalem, A.; Bariche, M.; Bartolo, A. G.; Bazairi, H.; Beqiraj, S.; Bilecenoglu, M.; Bitar, G.; et al. Validated Inventories of Non-Indigenous Species (NIS) for the Mediterranean Sea as Tools for Regional Policy and Patterns of NIS Spread. Diversity 2023, 15, 962. https://doi.org/10.3390/d15090962

Gardner, P.; Frazer, T. K.; Jacoby, C. A. and Yanong, P. E. (2015). Reproductive biology of invasive lionfish (Pterois spp). Frontiers Mari. Sci., 2 (7): 1-10.

GBIF (2022). Acanthocybium solandri. InGlobal Biodiversity Information Facility Backbone Taxonomy. Checklist Dataset. Accessed via GBIF.org on 30 March 2022.

Giovos, I.; Giacomo, B.; Romanidis-Kyriakidis, G.; Marmara, D. and Kleitou, P. (2018) First records of the fish Abudefduf sexfasciatus (Lacepède, 1801) and Acanthurus sohal (Forsskål, 1775) in the Mediterranean Sea. Bioinvas. Records, 7: 205–210, https://doi.org/10.3391/bir.2018.7.2.14

Giovos, I.; Kleitou, P.; Poursanidis, D.; Batjakas, I.; Bernardi, G.; Crocetta, F.; Doumpas, N.; Kalogirou, S.; Kampouris, T. E.; Keramidas, I.; Langeneck, J.; Maximiadi, M.; Mitsou, E.; Stoilas, V.O.; Tiralongo, F.; Romanidis-Kyriakidis, G.; Xentidis, N. J.; Zenetos, A. and Katsanevakis, S. (2019). The importance of citizen-science in monitoring marine invasions and stimulating public engagement - a case project from the Eastern Mediterranean. Biol. Invas., 21: 3707–3721, https://doi.org/10.1007/s10530-019-02083-w

Gökoglu, M.; Bodur, T. and Kaya, Y. (2003). First record of the Red Sea ban nerfish (*Heniochus intermedius* Steindachner, 1893) from the Mediter ranean Sea. Israel J. Zool., 49: 324–325.

Gökoğlu, M.; Teker, S. and Julian, D. (2017) Westward extension of the lionfish *Pterois volitans* Linnaeus, 1758 along the Mediterranean coast of Turkey. Nat. Engineering Sci., 2: 67–72, https://doi.org/10.28978/nesciences.329313

Gökoğlu, M.; Turan, C.; Yılmaz, M. and Yıldız, A. (2024). First Record of Wahoo *Acanthocybium solandri* Cuvier, 1832 in Turkish Marine Waters. Tethys Environ. Sci., 1(2): 44-49. DOI: 10.5281/zenodo.12739528

Golani, D. and Fricke, R. (2018) Checklist of the Red Sea Fishes with delineation of the Gulf of Suez, Gulf of Aqaba, endemism and Lessepsian migrants. Zootaxa 4509:1–215.

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. Ichthyol. Res., 39 (2), 167-169.

Golani, D.; Orsi-Relini, L.; Massuti, E. and Quignard, J. P. (2002). CIESM atlas of exotic species in the Mediterranean. Volume 1 Fishes. Monaco, CIESM Publications, 254pp

Golani, D.; Orsi-Relini, L.; Massutí, E. and Quignard, J. P. (2014). CIESM - Atlas of Exotic Fishes – List. (http://www.ciesm.org/ atlas/appendix1.html). (Accessed 10.10.2015).

Goren, M. and Galil, B. S. (1998) First record of the Indo-Pacific coral reef fish Abudefduf vaigiensis (Quoy and Gaimard, 1825) in the Levant. Israel J. Zool., 44: 57–59

Guidetti, P.; Giardina, F. and Azzurro, E. (2010). A new record of *Cephalopholis taeniops* in the Mediterranean Sea, with considerations on the Sicily channel as a biogeographical crossroad of exotic fish. Mar. Biodivers. Records, 3: e13, http://dx.doi.org/10.1017/S1755267210000023

Gurlek, M.; Erguden, D.; Atay, B. and Turan, C. (2019). First record of Pom acanthus imperator (Bloch, 1787) from Turkish marine waters. Natural and Engineering Sciences, 4, 231–236. Golani D and Fricke R (2018) Checklist of the Red Sea Fishes with delineation of the Gulf of Suez, Gulf of Aqaba, endemism and Lessepsian migrants. Zootaxa 4509:1–215.

Gürlek, M.; Ergüden, D.; Uyan, A.; Doğdu, S. A.; Yağlıoğlu, D.; Öztürk, B. and Turan, C. (2016). First record red lionfish Pterois volitans (Linnaeus, 1785) in the Mediterranean Sea. Nat. & Engineering Sci., 1 (3): 27-32**.**

Haddad, V.Jr.; Stolf, H.O.; Risk, J.Y.; França, F.O. and Cardoso, J. L. (2015) Report of 15 injuries caused by lionfish (Pterois volitans) in aquarist in Brazil: a critical assessment of the severity of envenomations. J Venom Anim Toxins Incl Trop Dis 21: 8 doi: 10.1186/s40409-015-0007-x.

Heemstra, P. C. and Randall, J. E. (1993). Groupers of the world (Family Serranidae, Subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper and lyretail species known to date. [FAO Fisheries Synopsis No. 125 Vol. 16] Food and Agriculture Organization of the United Nations, Rome, 382 pp

Higgs, N.D. (2013). The feeding habits of the Indo-Pacific lionfish Pterois volitans at artificial lobster habitats in the Bahamas. First published online at www. nickhiggs.com, 2-2.

Hornbeak, K.B. and Auerbach, P.S. (2017) Marine envenomation. Emerg Med Clin N Am 35: 321-337.

Huseyinoglu, M. F. and Ozturk, B. (Eds.) (2018). Lionfish invasion and its management in the Mediterranean Sea. Turkish Marine Research Foundation (TUDAV) publi:49, Istanbul, Turkey, 121 pages.

Jaffa, N. A. B. A. T. M. (2020). Occurrence of the Malabar Grouper (Epinephelus malabaricus Bloch & Schneider, 1801) in Palestinian Waters. Gazelle: The Palestinian Biol. Bull., 182;1-11.

Johnson, E. G. and Swenarton, M. K. (2016). Age, growth, and population structure of invasive lionfish (*Pterois volitans/miles*) in northeast Florida using a length-based, age-structured population model. *PeerJ* 4:e2730 https://doi.org/10.7717/peerj.2730

Katsanevakis, S.; Nikolaou, A.; Tsirintanis, K. and Rilov, G. (2024). Lessepsian migration in the Mediterranean Sea in an era of climate change: Plague or boon?, (2024), https://doi.org/10.1016/j.sctalk.2024.100412

Kimball, M. E.; Miller, J. M.; Whitfield, P. E. and Hare, J. A. (2004). Thermal tolerance and potential distribution of invasive lionfish (*Pterois volitans*/*miles* complex) on the east coast of the United States. Mar. Ecol. Progress Ser., 283-269-278.

Kizer, K.W.; McKinney, H. E. and Auerbach, P.S. (1985) Scorpaenidae envenomation. A five- year poison center experience. JAMA 253(6): 807-10.

Kuiter, R. H. and Tonozuka, T. (2001). Pictorial guide to Indonesian reef fishes. Part 1. Eels Snappers, Muraenidae - Lutjanidae. Zoonetics, Australia.

Kulbicki, M.; Beets, J.; Chabanet, P.; Cure, K.; Darling, E.; Sergio, R. F.; Galzin, R.; Green, A.; Harmelin-Vivien, M.; Hixon, M.; Letourneur, Y.; De Loma, T. L.; McClanahan, T.; McIlwain, J.; Mou Tham, G.; Myers, R.; O'Leary, J. K.; Planes, S.; Vigliola, L. and Wantiez, L. (2012). Distributions of Indo-Pacific lionfishes Pterois spp. in their native ranges: implications for the Atlantic invasion. Mar. Ecol. Prog. Series, 446:189-205.

Leinonen, I.; Iannetta, P. P.; Rees, R. M.; Russell, W.; Watson, C. and Barnes, A. P. (2019). Lysine supply is a critical factor in achieving sustainable global protein economy. Front. Sustain. Food Systms, 3, 27.

Lelong, P. (2005). Capture d'un macabit, *Epinephelus merra* Bloch, 1793 (Poisson, Serranidae), en Méditerranée nordoccidentale. Marine Life, 15(1–2): 63–66.

Li, S.; Li, Z.; Zhang, J.; Sang, C. and Chen, N. (2019). The impacts of dietary carbohydrate levels on growth performance, feed utilization, glycogen accumulation and hepatic glucose metabolism in hybrid grouper (*Epinephelus fuscoguttatus*♀× *E. lanceolatus*♂). Aquaculture, 512, 734351.

Lipej, L.; Mavrić, B. and Dulčić, J. (2014) First record of *Chrysiptera cyanea* (Quoy and Gaimard, 1825) (Perciformes: Pomacentridae) in the Mediterranean Sea. J. Applied Ichthyol., 30: 1053–1055, https://doi.org/10.1111/jai.12472

Lund, E. K. (2013). Health benefits of seafood; is it just the fatty acids? Food chemist., 140 (3); 413-420.

Mahaffey, K.R.; Sunderland, E. M.; Chan, H. M.; Choi, A. L.; Grandjean, P.; Marien, K.; Oken, E.; Sakamoto, M.; Schoeny, R.; Weihe, P.; Yan, C. H. and Yasutake, A. (2011). Balancing the benefits of n-3 polyunsaturated fatty acids and the risks of methylmercury exposure from fish consumption. Nutrit. Rev., 69 (9): 493-508.

Maljković, A.; Van Leeuwen, T. E. and Cove, S. N. (2008) Predation on the invasive red lionfish, Pterois vo litans (Pisces: Scorpaenidae), by native groupers in the Bahamas. Coral Reefs, 27 (3): 501–501. https://doi.org/10.1007/s00338-008-0372-9.

Manacioglu and Manacioglu (2018) in Huseyinoglu M. F., Ozturk, B. (Eds.)2018. Lionfish invasion and its management in the mediterranean Sea, Turkish Marine Research Foundation (TUDAV) publication number:49, Istanbul, Turkey, 121 pages.

Mavruk, S. and Avsar, D. (2008). Non-native fishes in the Mediterranean from the Red Sea, by way of the Suez Canal. Rev. Fish Biol. & Fish., 18: 251–262. http://dx.doi.org/10.1007/s11160-007-9073-7.

McMichael, A. J. and Butler, C. D. (2005). Fish, health, and sustainability. Am. J. Prev. Med., 29: 322–323.

Morris, J. A. and Akins, J. L. (2009). Feeding ecology of invasive lionfish (Pterois volitans) in the Bahamian archipelago. Environ. Biol. Fishes, 86, 389.

Morris, J. A. Jr. and Whitfield, P. E. (2009). Biology, ecology, control and management of the invasive Indo-Pacific lionfish: An updated integrated assessment. NOAA Technical Memorandum, NOS NCCOS 99, 57 pp.

Mumby, P. J.; Harborne, A. R. and Brumbaugh, D. R. (2011) Grouper as a natural biocontrol of invasive lion f ish. PLOS ONE 6(6): e21510. https://doi.org/10.1371/journal.pone.0021510

OBIS (2022a) Acanthocybium solandri. InOcean Biodiversity Information System. Intergovernmental Oceanographic Commission of UNESCO. Accessed on 30 March 2022. Available at www.obis.org.

OBIS (2022b) Kajikia audax. InOcean Biodiversity Information System. Intergovernmental Oceanographic Commission of UNESCO. Accessed on 30 March 2022. Available at www.obis.org.

Occhipinti-Ambrogi, A.; Marchini, A.; Cantone, G.; Castelli, A.; Chimenz, C.; Cormaci, M.; Froglia, C.; Furnari, G.; Gambi, M. C.; Giaccone, G.; Giangrande, A.; Gravili, C.; Mastrototaro, F.; Mazziotti, C.; Orsi-Relini, L. and Piraino, S. (2011). Alien species along the Italian coasts: an overview. Biological Invasions, 13: 215-237.

Oken, E.; Choi, A. L.; Karagas, M. R.; Marien, K.; Rheinberger, C. M.; Schoeny, R.; Sunderland, E. and Korrick, S. (2012). Which fish should i eat? Perspectives influencing fish consumption choices. Environ. Health Persp., 120 (6): 790-798.

Osca, D.; Tanduo, V.; Tiralongo, F.; Giovos, I.; Al Mabruk, S. A. A.; Crocetta, F. and Rizgalla, J. (2020). The Indo-Pacific sergeant Abudefduf vaigiensis (Quoy & Gaimard, 1825) (Perciformes: Pomacentridae) in Libya, south-central Mediterranean Sea. J. Mar. Sci. Engineer., 8, 14.

Oxenford, H. A.; Murray, P. A. and Luckhurst, B. E. (2003). The biology of wahoo (Acanthocybium solandri) in the western central Atlantic. Gulf and Caribbean Research, 15 (1): 33-49.

Paulin, C. D. (2012). Scorpion fishes of New Zealand (Pisces: Scorpaenidae). New Zealand J. Zool., 9 (4): 437-450.

Pirkenseer, C. M. (2020). Alien species in southern Laconia, Kythira Islands and southern Messenia (Greece): New and additional records and updated record maps. Journal of the Black Sea/Mediterranean Environ ment, 26: 145–175.

Randall, J. E. (1996). Caribbean Reef Fishes, Third Edition. TFH Publications, New York, 512 pp.

Randall, J. E. (2007). Reef and shore fishes of the Hawaiian Islands (p. 546). Honolulu: University of Hawaii Press.

Randall, J. E. (2007). Reef and Shore Fishes of the Hawaiian Islands. University of Hawai'i Press Sea Grant College Program, Honolulu, Hawaii.

Randall, J. E. and Ben-Tuvia, A. (1983). A review of the groupers (Pisces: Serranidae: Epinephelinae) of the Red Sea, with description of a new species of Cephalopholis. Bull. Mar. Sci., 33(2): 373–426.

Resiere, D.; Cerland, L.; De Haro, L.; Valentino, R.; Criquet-Hayot, A.; Chabartier, C.; Kaidomar, S.; Brouste, Y.; Mégarbane, B. and Mehdaoui, H. (2016) Envenomation by the invasive *Pterois volitans* species (lionfish) in the French West Indies--a two-year prospective study in Martinique. Clin Toxicol (Phila) 54(4): 313-318.

Rizgalla, J.; Bron, J. E.; Crocetta, F.; Shinn, A. P. and Al Mabruk, S. A. A. (2019). First record of Aplysia dactylomela Rang, 1828 (Mollusca: Gastropoda) in Libyan coastal waters. BioInvasions Records 8: 80–86, https://doi.org/10.3391/bir.2019.8.1.08

Rizgalla, J.; Shinn, A. P.; Ferguson, H. W.; Paladini, G.; Jayasuriya, N. S. and Bron, J. E. (2016). A novel use of social media to evaluate the occurrence of skin lesions affecting wild dusky grouper, Epinephelus marginatus (Lowe, 1834), in Libyan coastal waters. J. Fish Diseases, 40: 609–620, https://doi.org/10.1111/jfd.12540

Romeo, T.; Azzurro, E. and Mostarda, E. (2005). Record of Acanthocybium solandri in the central Mediterranean Sea, with notes on parasites. J. Mar. Biol. Assoc. Unit. King., 85(5): 1295-1296.

Salameh, P.; Sonin, O.; Edelist, D. and Golani, D. (2012). The first substanti ated record of the yellowbar angelfish, *Pomacanthus maculosus* (Actinopterygii: Perciformes: Pomacanthidae) in the Mediterranean. Acta Ichthyol. et Piscatoria, 42:73–74.

Schembri, P. J. and Tonna, R. (2011). Occurrence of the Malabar grouper *Epinephelus malabaricus* (Bloch & Schneider, 1801) (Actinopterygii, Perciformes, Serranidae), in the Maltese Islands. Aquatic Invasions, 6 (1): S129–S132

Schult, R. F.; Acquisto, N. M.; Stair, C. K. and Wiegand, T. J. (2017) A case of lionfish envenomation presenting to an inland emergency department. Case Reports in Emergency Medicine doi: 10.1155/2017/5893563.

Schultz, E.T. (1986). *Pterois volitans* and *Pterois miles*: two valid species. Copeia, 1986 (3): 686–690.

Sikorski, Z. E.; Kołakowska, A. and Pan, B. S. (2020). The nutritive composition of the major groups of marine food organisms. In Seafood (pp. 29-54). CRC Press.

Tardent, P. (1959). Capture d'un Abudefduf saxatilis vaigiensis Q. und G. (Pisces, Pomacentridae) dans le Golfe de Naples. Revue Suisse de Zoologie, 66: 347-351.

Tsadok, R.; Rubin-Blum, M.; Shemesh, E. and Tchernov, D. (2015) On the occurrence and identification of Abudefduf saxatilis (Linnaeus, 1758) in the easternmost Mediterranean Sea. Aquat. Invasions, 10: 101-105.

Turan, C. and Öztürk, B. (2015). First record of the lionfish *Pterois miles* from the Aegean Sea. J. Black Sea/Medit. Environ., 21:334-338.

Turan, C.; Ergüden, D. and Gürlek, M. (2016). Climate change and biodiversity effects in Turkish Seas. Nat. Engineer. Sci., 1(2): 15-24.

Turan, C.; Erguden, D.; Gurlek, M.; Yaglioglu, D.; Uyan, A. and Uygur, N. (2014). First record of the Indo-Pacific lionfish *Pterois miles* (Bennett, 1828) (Osteichthyes: Scorpaenidae) for the Turkish marine waters. J. Black Sea/Medit. Environ., 20 (2): 158 163.

Turan, C.; Uygur, N. and İğde, M. (2017). Lionfishes *Pterois miles* and *Pterois volitans* in the North-eastern Mediterranean Sea: Distribution, Habitation, Predation and Predators. NESciences, 2017, 2 (1): 35-43

Ulman, A.; Ali, F. Z.; Harris, H. E.; Adel, M.; Mabruk. S.A. A.A.; Bariche, M.; Candelmo, A. C.; Chapman, J. K.; C¸ic¸ek, 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. and Yildiz, T. (2022). Lessons from the Western Atlantic Lionfish Invasion to Inform Management in the Mediterranean. Front. Mar. Sci. 9:865162. doi: 10.3389/fmars.2022.865162

UNEP-MAP RAC/SPA (2010) The Mediterranean Sea Biodiversity: state of the ecosystems, pressures, impacts and future priorities. (eds., Bazairi, H., Ben Haj, S., Boero, F., Cebrian, D., De Juan, S., Limam, A., Lleonart, J., Torchia, G., Rais). C. RAC/SPA, Tunis,100 pp.

Vacchi, M. and Chiantore, M. C. (2000) Abudefduf vaigiensis (Quoy and Gaimard, 1825): a tropical damselfish in Mediterranean Sea. Biol. Mar. Medit., 7(1): 841–843.

Vella, A. (2014) Conservation research reports new alien species and declining local species in our sea. The University of Malta Website news: (http://www.um.edu.mt/newsoncampus/researchinitiatives/archive/newaliendeclininglocalspecies). (Accessed 10.05.2015).

Vella, A.; Agius Darmanin, S. and Vella, N. (2015) Morphological and genetic barcoding study confirming the first *Stegastes variabilis* (Castelnau, 1855) report in the Mediterranean Sea. Mar. Medit. Sci., 16 (3): 609-612.

Vella, A.; Agius Darmanin, S. and Vella, N. (2016). The first records of Indo-Pacific sergeant *Abudefduf vaigiensis* (Quoy and Gaimard, 1825) and further notes on the occurrence of sergeant major *A. saxatilis* (Linnaeus, 1758) in Malta: expanding populations of an invasive genus in the Mediterranean Sea. J. Black Sea & Medit. Environ., 22(1): 1–15.

Vetrano, S. J.; Lebowitz, J. B. and Marcus, S. (2002) Lionfish envenomation. J Emerg Med 23(4): 379-382.

Viana, D.; Branco, I. S.; Fernandes, C. A.; Fischer, A. F.; Carvalho, F. C.; Travassos, P. and Hazin, F. H. (2013). Reproductive biology of the wahoo, Acanthocybium solandri (Teleostei: Scombridae) in the Saint Peter and Saint Paul Archipelago. Braz. Int. J. Plant Anim. Sci. 1 :49–57.

Viana, D.; Hazin, F. H.V.; Nunes, D. M.; Carvalho, F. C.; Véras, D. P. and Travassos, P. (2008). Wahoo Acanthocybium solandri fishery in the vicinity of Saint Peter and Saint Paul Archipelago, Brazil, from 1998 to 2006. In: Collective Volume of Scientific Papers, ICCAT. Vol. 62, pp. 1662–1670.

Whitfield, P. E., J. A. Hare, A. W. David, S. L. Harter, R. C. Munoz, and C. M. Addison. (2007). Abundance estimates of the Indo-Pacific lionfish *Pterois volitans*/*miles* complex in the Western North Atlantic. Biol. Invas., 9: 53-64.

Whitfield, P. E.; Gamer, T.; Viues, S. P.; Gilligan, M. R.; Courtenay Jr.; W.R.; Ray, G. C. and Hare J. A. (2002). Biological invasion of the Indo-Pacific lionfish Pterois volitans along the Atlantic coast of North America. Mar. Ecol. Prog. Series, 235: 289–297.

Williams, C. T.; Arostegui, M. C.; Braun, C. D.; Gaube, P.; Shriem, M., and Berumen, M. L. (2022). First records of two large pelagic fishes in the Red Sea: wahoo (*Acanthocybium solandri*) and striped marlin (Kajikia audax). J. Mar. Biol. Assoc. United King., 102(7): 505-508.

Yağlioğlu, D. and Ayas, D. (2016). New occurrence data of four alien fishes (Pisodonophis semicinctus, *Pterois miles*, Scarus ghobban and Parupeneus forsskali) from the Northeastern Mediterranean (Yeşilovacık Bay, Turkey). Biharean Biologist, 10: 150–152

Zenetos, A. and Miliou, A. (2020). Abudefuf cf. saxatilis in the Saronikos gulf, Greece: Unaided introduction or human aided transfer. Annales, Series Historia Naturalis, 30: 227–230.

Zhang, W.; Boateng, I. D. and Xu, J. (2023). Novel marine proteins as a global protein supply and human nutrition: Extraction, bioactivities, potential applications, safety assessment, and deodorization technologies. Trends in Food Sci. Technol., 104283.