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REVIEW ARTICLE

Status of marine alien species along the Libyan coast

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Abstract

The number of marine alien species in Libyan waters has increased from 63 (known until the end of 2013) to 73 in the present study. This work deals with the present status, distribution and characteristics of marine alien species and their impacts along the coast of Libya, almost 2000 km long. The highest percentage was fishes (32.88%), followed by macrophytes (21.92%), molluscs (16.44%), crustaceans (13.70%), and parasites (9.59%). Some of these species have successfully adapted themselves to various topographies and habitats in the Libyan coasts, which resulted in the change in biodiversity in the area. Some fish were accompanied by parasites and others have become hosts for native parasites; seven alien parasite species (*Nybelinia africana, Neoallolepidapedon hawaiins, Allolepidapedon petimba, Glyphidohaptor plectocirra, Tetrancistrum polymorphum, Apounurs sigani* and *Hatschekia siganicola*) were recorded in three lessepsian fish species. Moreover, the toxic effect of poisonous fish (*Lagocephalus sceleratus*) was investigated as it caused fatalities and severe intoxication for some fishermen. Its population has dramatically increased, with high numbers of juveniles and adults reported in some bays especially in the eastern part of Libya. Alien *Siganus* spp. have competed with the native herbivore fish *Sarpa salpa*. Furthermore, some alien fishes have become commercially valuable in Libya. This paper highlights the biological invasion in the Libyan coasts in an attempt to fill the gap of knowledge on the alien species in the southeastern Mediterranean coast.

Keywords: Bioinvasion, migrant species, South Mediterranean, Libya

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Introduction

The Mediterranean Sea is currently a hot spot for marine bio-invasions (Edelist *et al.* 2013; Katsanevakis *et al.* 2014; Nunes *et al*. 2014). In 2018, a total of 824 taxa of marine alien species were considered established in all European Seas (Tsiamis *et al*., 2018), while for the Mediterranean Sea alone, Zenetos *et al*. (2017) reported 613 established and 208 casual alien species. The introduction rate during 2000-2005 to the Mediterranean Sea peaked at more than 20 first records per year, then declined to an average of 16 species per year in 2012-2017, during which the introduction rate dropped for all taxonomic groups with the exception of fish (Zenetos 2019). The main known pathways of species introduction into the Mediterranean Sea are the Suez Canal, followed by ballast water, aquaculture and trade in live marine aquarium species according to a recent evaluation of pathways at a Pan-European level (Katsanevakis *et al.* 2013). The Mediterranean can be considered as a transition zone between the Atlantic Ocean through the Strait of Gibraltar and the Indian Ocean via the Red Sea and the Suez Canal, and suffered, following these disturbances, important flora and fauna changes (Schembri *et al*. 2010). Mediterranean marine ecosystems have been altered at an alarmingly high rate for the past two centuries due to human-mediated arrival of new species (Rilov and Galil 2009), with Lessepsian immigrants at the forefront of these changes. Lessepsian migration refers to the migration of species through the Suez Canal, predominantly from the Red Sea towards the Mediterranean Sea that represents the most important biogeographic phenomenon witnessed in the contemporary oceans (Por 1978). It is estimated that this process has added more than 490 new species to the Mediterranean (Zenetos *et al.* 2012), including 102 species of fishes (Fricke *et al*. 2017); approximately a quarter to half of the world's marine fish invaders (Lockwood *et al*. 2007). It is an ongoing process with new species regularly entering every year (Zenetos *et al.* 2010; 2012; 2017, Tsiamis *et al*. 2018), presenting scientists with unique opportunities to study rapid evolutionary changes (Belmaker *et al*. 2009). Genetic studies focusing on Lessepsian fishes have demonstrated patterns that are mostly consistent in showing a lack of the expected bottle-neck (Sax *et al.* 2005), with little difference in genetic diversity between the native Red Sea populations and the newly established Mediterranean populations (Bernardi *et al*. 2010).

The Libyan coast is about 2000 km long and is characterized by a wide continental shelf that encompasses various habitats and topography (Shakman *et al*. 2017). The geographic location of Libya, in the central and "warm" part of the Mediterranean Sea is interesting as it can host tropical organisms arriving from the east (Indo-Pacific origin) or expanding from the west (Tropical Atlantic origin) (Shakman *et al.* 2017). Although it is clear that migrant Lessepsian species have had an enormous impact on the eastern Mediterranean ecosystem (Corrales *et al*. 2017), evidence-based studies are sparse (Katsanevakis *et al*. (2014) but see Sala *et al*. (2011) for example) and there has been no systematic study to assess this impact (Golani 2002). Many Lessepsian fish species have been recorded in Libyan waters (Stirn 1970; Zupanovic and El-Buni, 1982; Al-Hassan and El-Silini 1999; Ben Abdallah *et al*. 2005; Shakman and Kinzelbach 2006; 2007a, b, c; Bazairi *et al*. 2013; Shakman *et al*. 2017). The objectives of this paper are to present the status, distribution and characteristics of marine alien species in Libya and highlight some of their potential impacts along the Libyan coast, contributing to the knowledge of marine alien species in the Mediterranean Sea.

Review method

The study area (Figure 1) was divided into three main regions (East region, Sirt Gulf, West region) according to the topography and types of habitats (Shakman 2008). Records of marine alien species were based on a compilation of published articles, grey literature and unpublished data collected during surveys and awareness campaigns in the last two decades.

Scientific names in this paper followed the World Register of Marine Species (WoRMS) (http://www.marinespecies.org). The establishment status of each species was assessed according to the terminology used by Zenetos *et al*. (2017) and Tsiamis *et al*. (2018). Information about fish, i.e. whether they have a commercial value or not and their market values, were collected from the fishermen's union as well as from interviews with local fishermen.

Additional data collection

Samples were collected by trammel nets at a depth up to 50 m along the entire Libyan coast during two periods (January 2005 to March 2006 and January 2013 to January 2017). Some samples were immediately washed with fresh water, and identified according to Whitehead *et al*. (1984 -1986) and Golani *et al*. (2002). Some specimens were preserved in a mixed solution of formaldehyde and ethanol, then washed with fresh water and finally stored in 5% formaldehyde. Standard morphometric and meristic measurements were taken. All the specimens were labelled and registered at the Natural History Museum of Zoology Department, Tripoli University.

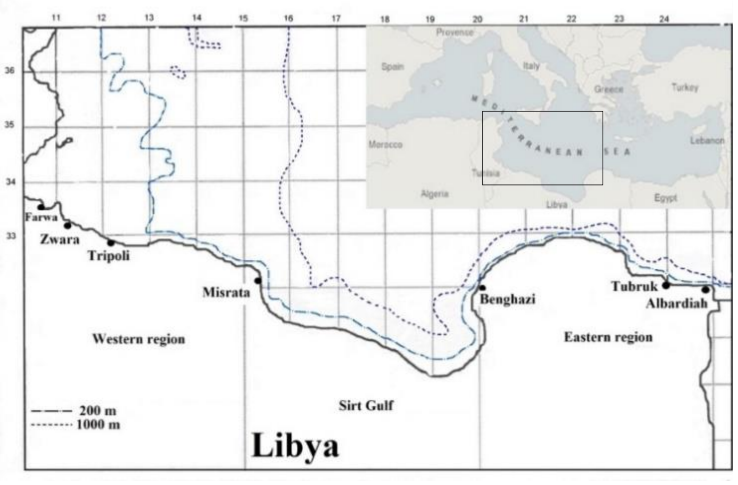

Figure 1. Map of the Libyan coast showing the sampling sites

Composition of alien species

A total of 73 alien marine species have been recorded in Libyan waters (Table 1); fish constituted the highest percentage with more than 32.88%, followed by macrophytes 21.92% and molluscs 16.44%, crustaceans 13.70%, and alien parasites which exceed 9%. (Figure 2).

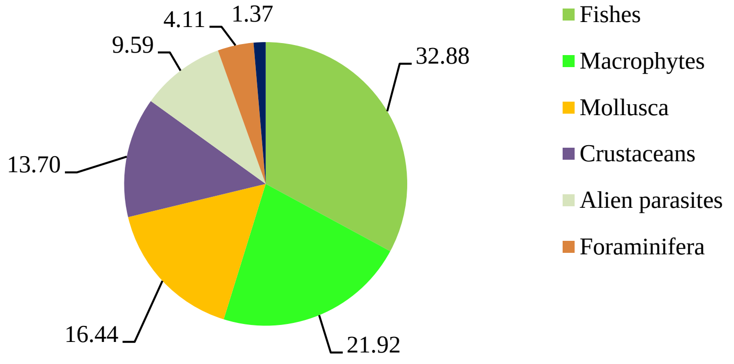

Figure 2. Proportions of alien marine species in the Libyan coast per taxonomic group

There is an increasing trend in the number of alien species in the Libyan coast over the last decades (Figure 3), with a particularly steep slope between the 1990's and 2010's.

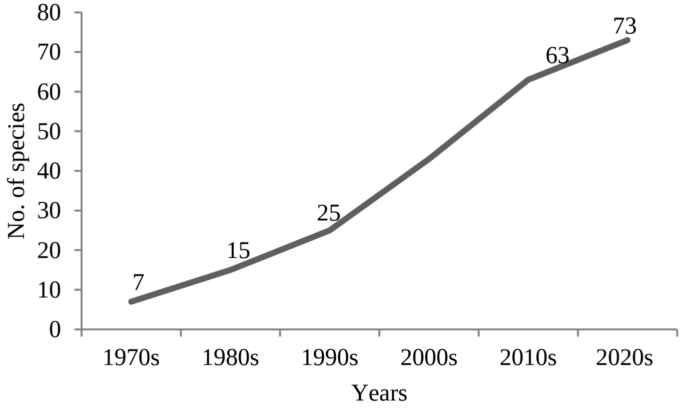

Figure 3. The increasing trend of alien marine species along the Libyan coast

Table 1. Marine alien species recorded in Libyan waters until March 2019. Status, establishment and distribution are shown according to Zenetos *et al*. (2010). (Est.: established, Cas.: casual, Ques.: questionable and Unk.: unknown, A: along the entire coast; E: east region; S+E: Sirt gulf and east region, W: west region, AL= Alien, CR= Cryptogenic)

Species	First record Location and year	Status	Establishment	Distribution	Reference
Foraminifera					
Amphisorus hemprichii Ehrenberg, 1839	E – 2004	AL	Unk	E	Langer 2008
Amphistegina lobifera Larsen, 1976	E – 1979	CR	Est.	E	Blanc-Vernet *et al*. 1979
Coscinospira hemprichii Ehrenberg, 1839	E – 2004	CR	Unk	E	Langer 2008
Phaeophycae					
Padina boergesenii Allender & Kraft, 1983	E – 1974	AL	Est.	A	Nizamuddin 1981
Padina boryana Thivy, 1966	E – 1974	AL	Est.	A	Nizamuddin 1981
Stypopodium schimperi (Kützing) M.Verlaque & Boudouresque, 1991	E – 1977	AL	Est.	A	Nizamuddin 1981
Rhodophyta					
Acanthophora nayadiformis (Delile) Papenfuss, 1968	1888	CR	Est.	A	De Toni & Levi 1888
***Anotrichium furcellatum* (J.Agardh) Baldock, 1976**	2015	CR	Est.	E	Verlaque *et al*. 2015
Chondria coerulescens (J.Agardh) Falkenberg, 1901	W – 1989	CR	Est	W	Godeh *et al*. 1992
Lophocladia lallemandii (Montagne) F.Schmitz, 1893	1918	AL	Est.	A	Petersen 1918
Polysiphonia atlantica Kapraun & J.N.Norris, 1982	E – 1989	CR	Cas.	E	Godeh *et al*. 1992
Chlorophyta					
Caulerpa cylindracea Sonder, 1845	1990	AL	Est.	A	Nizamuddin 1991
Avrainvillea amadelpha (Montagne) A.Gepp & E.S. Gepp, 1908	2012	AL	Est.	E	Verlaque *et al*. 2017

Table 1. Continued.

Cladophora herpestica (Montagne) Kützing, 1849	E – 1986	AL	Ques.	E	Nizamuddin 1988
*Codium fragile subsp. atlanticum (*A.D.Cotton) P.C. Silva, 1955 = *Codium fragile* subsp. *fragile*	1984	AL	Est.	A	Nizamuddin 1991
Codium taylorii P.C.Silva, 1960	1977	AL	Est.	A	Nizamuddin 1991
Ulva fasciata Delile, 1813	1979	CR	Est.	A	Nizamuddin *et al*. 1979
Caulerpa taxifolia var. distichophylla (Sonder) Verlaque, Huisman & Procaccini, 2013	W – 2017	AL	Est.	W	Shakman *et al*. 2017
Magnoliophyta					
Halophila stipulacea (Forsskål) Ascherson, 1867	2009	AL	Est.	A	RAC-SPA 2009
Amphipoda					
Hamimaera hamigera (Haswell, 1879)	E – 1972	AL	Cas.	E	Ortiz & Petrescu 2007
Cirripedia					
Tetraclita squamosa rufotincta Pilsbry, 1916	E – 2007	AL	Cas.	E	Zaouali *et al*. 2007a
Copepoda					
Euchaeta concinna Dana, 1849	E – 1990	AL	Cas	E	Halim 1990
Decapoda					
Percnon gibbesi (H. Milne-Edwards, 1853)	W – 2004	AL	Cas.	W	Elkrwe *et al*. 2008
Plagusia squamosa (Herbst, 1790)	S – 2006	AL	Est.	A	Zaouali *et al*. 2007b
Portunus segnis Forsskål, 1775	E – 2017	AL	Est.	A	Shakman *et a*l. 2017
Eucrate crenata (De Haan, 1835)	1999	AL	Est.	A	Zgozi *et al*. 2002
Isopoda					
Apanthura sandalensis Stebbing, 1900	E – 1976	AL	Est.	E	Negoescu 1981
Paradella dianae (Menzies, 1962)	E – 2001	AL	Cas.	E	Zgozi *et al*. 2002
Stomatopoda					
Erugosquilla massavensis (Kossmann, 1880)	E – 2002	AL	Est.	E + S	Zgozi *et al*. 2002

Table 1. Continued.

Bivalvia					
Malleus regula (Forsskål in Niebuhr, 1775)	2001	AL	Est.	A	Giannuzzi-Savelli, *et al*. 2001
Pinctada imbricata radiata (Leach, 1814)	1913	AL	Est.	A	Monterosato *et al*. 1917
Fulvia fragilis (Forsskål in Neibuhr, 1775)	1997	AL	Est.	A	Zgozi *et al*. 2002
Gastropoda					
Bursatella leachii Blainville, 1817	E – 2000	AL	Cas.	E	Zgozi *et al*. 2002
Cellana rota (Gmelin, 1791)	E – 2007	AL	Cas.	E	Zaouali *et al.* 2007b
Clypeomorus bifasciata (G.B. Sowerby II, 1855)	E – 1994	AL	Cas.	E	Giannuzzi- Savelli *et al*. 1997
Conomurex persicus (Swainson, 1821)	2006	AL	Est.	A	Ben – Souissi *et al*. 2007
Conus fumigatus Hwass in Bruguière, 1792	E – 1976	AL	Cas.	E	Röckel 1986
Erosaria turdus (Lamarck, 1810)	2007	AL	Est.	A	Ben – Souissi *et al*. 2007
***Haminoea cyanomarginata* Heller & Thompson, 1983**	W -2018	AL	Cas.	W	Rizgalla *et al.* 2018
Nerita sanguinolenta Menke, 1829	E – 1994	AL	Cas.	E & S	Giannuzzi- Savelli *et al*. 1994
Cephalopods					
Sepioteuthis lessoniana Férussac, 1831	W – 2015	AL	Cas.	W	Shakman *et al*. 2017
Echinodermata					
Ophiocoma scolopendrina (Lamarck, 1816)	E – 2007	AL	Ques.	E	Zaouali *et al*. 2007b
Fishes					
Siganus luridus Rüppell, 1829	E – 1968	AL	Est.	A	Stirn 1970
Siganus rivulatus Forsskål, 1775	E – 1968	AL	Est.	A	Stirn 1970
Sphyraena flavicauda Rüppell, 1838	E – 1998/	AL	Est.	A	Ben Abdallah *et al*. 2003
Sphyraena chrysotaenia Klunzinger, 1884	E – 1968	AL	Est.	A	Stirn 1970
Herklotsichthys punctatus Ruppell, 1837	E – 2005	AL	Est.	E & S	Shakman & Kinzelbach 2007c
Saurida lessepsianus Russell, Golani, Tikochinski, 2015	1982	AL	Est.	A	Zupanovic & El-Buni, 1982
Hemiramphus far Forsskal, 1775	E – 2006	AL	Est.	A	Shakman & Kinzelbach 2006

Table 1. Continued.

Fistularia commersonii Ruppell, 1838	E – 2004	AL	Est.	A	Ben Abdallah *et al*. 2005
Atherinomorus forskali (Rüppell, 1838)	E – 1929	AL	Est.	A	Norman 1929
Alepes djedaba Forsskal, 1775	E – 1990	AL	Est.	A	Ben Abdallah *et al*. 2005
Upeneus pori Ben-Tuvia & Golani, 1989	E – 1994	AL	Est.	A	Ben Abdallah *et al*. 2005
Upeneus maluccensis Bleeker, 1855	E – 1968	AL	Est.	A	Stirn, 1970
Crenidens crenidens Forsskal, 1775	E – 1999		Ques.	E & S	AL-Hassan & EL-Silini 1999
Pempheris rhomboidea Kossmann and R Cuvier, 1831 *Auber, 1877*	E – 2004	AL	Est.	A	Ben Abdallah *et al*. 2004
Liza carinata Valenciennes, 1836	E – 2005	AL	Est.	A	Shakman & Kinzelbach 2007c
Scomberomorus commerson Lacepède, 1800	E – 2003	AL	Est.	A	Ben Abdallah *et al.* 2003
Stephanolepis diaspros Fraser-Brunner, 1940	E – 1965	AL	Est.	A	Zupanovic & El-Buni 1982
Parexocoetus mento Valenciennes, 1847	E – 1966	AL	Est.	E	Ben Tuvia 1966
Sargocentron rubrum Forsskål, 1775	E – 1968	AL	Ques.	E	Stirn 1970
Lagocephalus suezensis Clark & Gohar, 1953	E – 2009	AL	Est.	A	Kacem-Snoussi *et al.* 2009
Lagocephalus sceleratus Gmelin, 1789	E. – 2009	AL	Est.	A	Kacem-Snoussi *et al.* 2009
***Etrumeus golanii* DiBattista, Randall & Bowen, 2012**	W. – 2017	AL	Est.	A	Shakman *et al*. 2017
***Torquigener flavimaculosus* (Hardy & Randall, 1983)**	E. – 2017	AL	Cas.	E	Al-Mabruk *et al*. 2018
***Pterois miles* (Bennett, 1828)**	E. – 2019	AL	Cas.	E	Al-Mabruk and Rizgalla 2019

Species name in bold are added to the list after Bazairi *et al.* 2013.

Seven alien parasites have been found in three Lessepsian fish species (Table 2), all seven of them of Red Sea/Indo-Pacific origin.

Table 2. Recorded alien parasites in Lessepsian migrants fish species along the western Libyan coast

Parasite	Host	Date & Site	Reference
Nybelinia africana	*Fistularia commersonii*	2016 – West	Salem 2017
Neoallolepidapedon hawaiins	*F. commersonii*	2016 – West	Salem 2017
Allolepidapedon petimba	*F. commersonii*	2016 – West	Salem 2017
Glyphidohaptor plectocirra	*Siganus luridus, S. rivulatus*	2016 – West	Abdelnor *et al*. 2019
Tetrancistrum polymorphum	*Siganus luridus, S. rivulatus*	2016 – West	Abdelnor *et al*. 2019
Apounurs sigani	*Siganus luridus, S. rivulatus*	2016 – West	Abdelnor *et al*. 2019
Hatschekia siganicola	*Siganus luridus, S. rivulatus*	2016 – West	Abdelnor *et al*. 2019

Most of the alien species were established (71.23 %, including parasites), followed by 20.55 % casual, 5.48 % questionable (Figure 4).

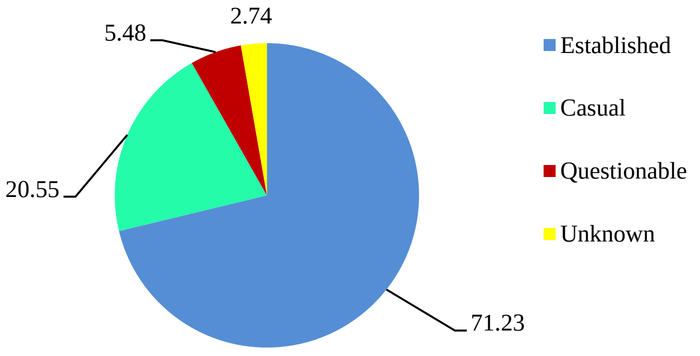

Figure 4. Proportions of establishment success of the alien species along the Libyan coast

Nine of 24 alien fish species (more than 37%) have commercial value in Libya (*Siganus luridus, S. rivulatus, Sphyraena flavicauda, S. chrysotaenia, Hemiramphus far, Fistularia commersonii, Alepes djedaba, Scomberomorus commerson* and *Etrumeus golanii*) and have become regular in Libyan fish markets. Most of the alien species (49.32%) tend to be well adapted and are distributed along the entire Libyan coast, while 28.77% appear only in the eastern region, 16.44% are exclusively recorded from the western region and 5.48% are distributed in the extended area between the east and Sirt gulf (Figure 5). However, during the last survey (June 2018), a population explosion of puffer fish *Lagocephalus sceleratus* (consisting mostly of juveniles) was observed in Tobruk Gulf it the eastern coast of Libya while, on the western coast of Libya, a small number of ghost crab *Portunus segnis* were found in Farwa Lagoon (marine protected area) (Figure 6).

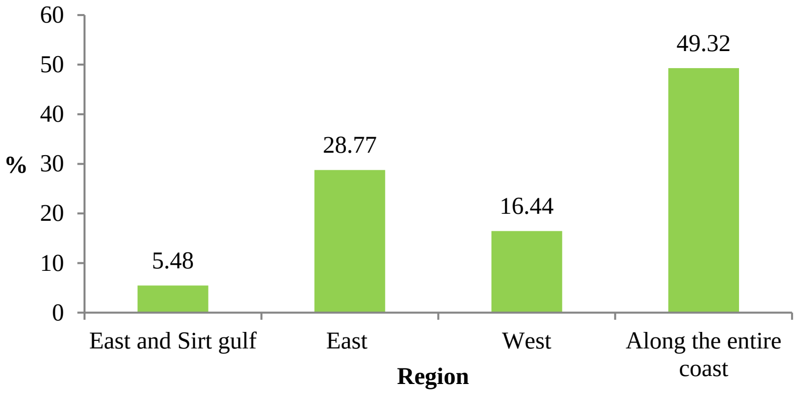

Figure 5. Distribution of alien species along the Libyan coast

Figure 6. Blue crab, *Portunus segnis* (Forskål, 1775), recorded in Farwa Lagoon, Libya

Discussion

Libya has an interesting geographic location in the central and warm part of the Mediterranean Sea; as such, it can host tropical species arriving from the east (Indo-Pacific origin) or expanding from the west (Tropical Atlantic origin). Due to the extensive length of the coast, the records of these species are very few or possibly they prefer the habitats in the eastern Mediterranean rather than the south; however, these results are part of a comprehensive study supported by the Libyan authority for scientific research on the impact of these species along the Libyan coast (Shakman *et al*. 2017). Major groups of alien species in Libya are Macrophytes, Foraminifera, Mollusca, Crustacea, Echinodermata, Fish and alien parasites (Figure 2). The increasing discovery trend (Figure 3) of alien species is largely associated with the increase of scientific interest in monitoring studies and a number of different projects, which have lately been carried out along the Libyan coast to identify alien species. In total, 73 alien marine species were reported in this study, seven species are cryptogenic (*Coscinospira hemprichii* Ehrenberg, 1839; *Amphistegina lobifera* Larsen, 1976; *Acanthophora nayadiformis (*Delile) Papenfuss, 1968*; Anotrichium furcellatum* (J.Agardh) Baldock, 1976; *Chondria coerulescens* (J.Agardh) Falkenberg, 1901; *Polysiphonia atlantica* Kapraun & J.N.Norris, 1982; *Ulva fasciata* Delile, 1813). Direct evidence of their status, i.e. whether they are native or alien in the Mediterranean, is still questionable, thus, they were labeled as "cryptogenic" (Carlton 1996). Nevertheless, these records remain of key importance for studying the early stages of presence of such organisms as well as their spread in the Mediterranean Sea (Shakman *et al*. 2017), and are thus worth reporting in inventories and their updates.

This paper excluded two species although they were mentioned in the inventory of Bazairi *et al.* (2013), one of them was *Asparagopsis taxiformis,* whose status is still debated because the genetic study found two separated populations (Indo-Pacific and Mediterranean) (Anderekis *et al*. 2004). Thus, a comprehensive study needed to clarify the status of this species, as well as for *Cymadusa filosa* which mentioned in 2013 inventory as cryptogenic (Bazairi *et al*. 2013).

The recorded number of alien species in Libya is relatively low compared to other Mediterranean countries. For instance, 136 alien species were recorded in Tunisian waters (Ben Amor *et al*. 2016). This can be explained by the limited research effort, however intensifying in recent years, and by a lack of taxonomic expertise in certain taxonomic groups, such as macrophytes and annelids (Bazairi *et al*. 2013). Another reason could be the geographic position of Libya, which is (i) to the west of the predominant circulation currents that disperse propagules to the north and east from the Suez Canal and (ii) not sufficiently close to the western Atlantic and the Sicily Strait, which is considered a boundary zone between the western and eastern Mediterranean basins and an invasion hotspot (Azzurro *et al*. 2014; Mannino *et al*. 2017). At the same time, the successful invasion of a biological community appears to be the result of the richness of native species and the ability of alien species to adapt and colonize new habitats (Bulleri *et al.* 2008). As an example, the two fish species *Crenidens crenidens* and *Sargocentron rubrum* were not recorded during the surveys which were conducted along the coast of Libya; it is possible that these species could not adapt to the biotic and abiotic conditions of this coast. Indeed, according to Jackson *et al*. (2015) a combination of ecological, physiological and behavioral factors would influence different phases of the invasion process. In this regard, Arndt and Schembri (2015) have recently concluded that the establishment success of Lessepsian fishes is significantly linked to their size and spawning traits and that benthic spawners and species with a tendency to form schools are successful colonizers.

Seven alien parasite species have been added to the national list of Libya; some of these parasites have been previously recorded in many different areas of the south Mediterranean Sea such as Tunisia and Algeria (Boussellaa *et al*. 2018; Ramdane and Trilles 2007). In fact, the success of alien fish species in the Mediterranean does not seem to be related to the liberation from their parasites (Colautti *et al*. 2004). On the contrary, these fishes may have found in their invaded range a rich parasite assemblage that potentially would threaten them more than in their native range (Colautti *et al*. 2004; MacColl and Chapman 2010; Lacerda *et al*. 2013). Some of the alien fishes in Libya were accompanied by several parasites from their place of origin; while others have become hosts for native parasites such as *Siganus luridus*, which was found hosting *Nerocila bivittata* (Shakman *et al*. 2009; Abdelnor *et al*. 2019).

In terms of fisheries, the commercial value of nine fish species from a total of 24 alien species became important in Libya; these species are now found regularly in the Libyan catches. Most of them already have a commercial value in many regions in the eastern and central-south Mediterranean Sea (e. g: Turkey, Israel, Libya and Tunisia (Bilecenoglu and Taskavak 2002; Golani 2002; Shakman and Kinzelbach 2007c; Ben- Amor *et al*. 2016).

The distribution shows that most of the alien species are present in the eastern coasts of Libya (Figure 5), with different abundances for each species. For a better understanding of invasive species migration patterns, more taxonomic and biological investigations are required (Ben Tuvia 1978). It is expected that in some cases the exchange of fauna and flora may have taken place before the opening of the Suez Canal, as a result of the elevation of sea levels and undulations of the Isthmus during the Pleistocene (Ben Tuvia 1978).

Biological invasions have been studied for more than a century in the Mediterranean Sea and more than one thousand alien species are recorded (Katsanevakis *et al*. 2014). However, studies of impacts made by alien species in ecological and socio-economic terms are initiated only recently. Steftaris and Zenetos (2006) prepared a preliminary list of the 100 worst invasive non-indigenous species in the Mediterranean with details on their impacts. Subsequent studies propose impact classification schemes or prioritization approaches (e.g. Davidson *et al.* 2014; Ojaveer *et al.* 2015; Lehtiniemi *et al.* 2015). Alien species can have an impact on biodiversity. According to Crise *et al.* (2015), alien species can perturb the food web structure, displace native species (competition for space and food), modify the genetic pools by hybridization and may also act as pests and cause diseases.

In Libyan waters, a number of studies have started addressing the impact of alien species, particularly fish species. For example, Shakman (2008) and later

Al-Razagi (2017) demonstrated strong competition between *Siganus luridus* and *S. rivulatus* in the central and eastern coast of Libya, which decreases towards the western coast. Moreover, different parasites are coming with the alien fishes to the Libyan coast (Salem 2017; Abdelnor *et al*. 2019), and several venomous and toxic species were recorded in Libya (Milazzo *et al*. 2012). For example *Lagocephalus sceleratus* caused the death of three fishermen who had eaten the gonads of this species; other cases (two fishermen) of high toxicity were reported in the central and eastern part of Libya resulting in more than seven days of hospitalisation in the intensive care (personal communication, a local fisherman). *L. sceleratus* is often caught by fishermen due to its large body, then unknowingly consumed (Golani 2010). Despite national bans on its marketing, along the Mediterranean coasts of Egypt and Turkey, *L. sceleratus* is illegally sold beheaded and eviscerated with subsequent risk of poisoning to the unknowing public (Halim and Rizkalla 2011; Aydin 2011). This species has sharply increased in the eastern part of Libya, where huge numbers of juveniles and adults were recently observed (personal observation by Shakman, July 2018). Therefore, public awareness is urgent and more crucial to reduce the human health risk posed by this species.

Currently, there is no demonstrated impact of *P. segnis* in the Libyan coast, and only a few individuals have been recorded (Shakman *et al*. 2017); this species however has a high socio-economic impact in the Gulf of Gabes in Tunisia (Crocetta *et al.* 2015), which is characterized by similar habitat features as the western coast of Libya. Our point of view is that this species may have arrived to the Gulf of Gabes by ballast water and found a suitable environment in this area, which is the main reason that it has a limited distribution along the south Mediterranean coast concentrated in the Gulf of Gabes. *Pterois miles* has been found in the eastern coast of Libya; this species is expected to continue spreading along the Libyan coast and concerns are expressed regarding its potential environmental impact (Azzurro *et al*. 2017).

This study showed that some of the alien species have successfully adapted to the different topography and environments of Libyan coast and many species have become widespread, some of them already contributing to the commercial fish catch in Libya.

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