Introduction

Marine species have been accidentally or intentionally transferred among the world’s seas for as long as humans have crossed the oceans for exploration, colonization, commerce and war. However, biological invasions are being nowadays recognized as a major agent of global change following the spectacular increase of introductions by non-native marine and estuarine species in various regions of the world (Occhipinti-Ambrogi, 2007). Furthermore, biological invasions can interact with climate change and other components of global change such as increasing deposition of nitrogen and pollutants, and habitat disturbance by human activities (Vitousek et al., 1997; Dukes & Mooney, 1999; Boudouresque & Verlaque, 2010). Many of the marine alien species exhibit aggressive invasive behaviour and represent significant ecological pressures on marine and estuarine communities (Ruiz et al., 1999; Streftaris & Zenetos, 2006; Sala et al., 2011). In addition to alterations in ecosystem functioning and biodiversity loss, alien species can also cause serious economic (fisheries, tourism and aquaculture) and health impacts (Pimentel et al., 2000).

The Mediterranean Sea is highly concerned by species introductions. Based on updated checklists (Zenetos et al., 2010, 2011, 2012), a total of 986 alien species were known in the Mediterranean by December 2012: 775 in the Eastern basin, 308 in the Western basin, 249 in the Adriatic Sea. According to the Mediterranean Action Plan for Invasive Species (UN-EP-MAP-RAC/SPA, 2005), the main known pathway/vector of species introduction into the Mediterranean Sea is the Suez Canal followed by shipping (ballast water and sediments, anchoring and fouling), aquaculture...
(both marine and brackish species) and trade in live marine species (aquarium activities, fishing baits, seafood). This is in agreement with recent evaluation of pathways at Pan European level (Katsanevakis et al., 2013a). Mediterranean biota are driven towards a ‘tropicalization’ as most of the alien species introduced there are of tropical affinity and origin (Bianchi & Morri, 2003). An up-to-date inventory of the alien species in the Mediterranean Sea, apart from its scientific merits, can fulfil the needs of regulatory requirements such as the EU Biodiversity Strategy to 2020 (EU, 2011) and environmental management options (Katsanevakis et al., 2013b).

Libya is located in the Central Mediterranean Basin as adopted and described under the Marine Strategy Framework Directive (MSFD) (EU, 2008). Data regarding alien species are scarce and fragmented due to the lack of long term monitoring survey undertaken in a framework of national initiatives on alien species. It is worth mentioning the inventory of exotic fish reporting 16 introduced species (Ben Abdallah et al., 2005) updated by Shakman & Kinzelbach (2007c).

This work reports on the alien marine species observed in El-Kouf National Park and the neighbouring areas. An updated list of alien marine species recorded from Libya is presented and discussed.

Material and Methods

El-Kouf National Park

El-Kouf National Park (herein: El-Kouf NP) is part of the Libyan coast of Cyrenaica. Located west off the city of El-Beida (N 32.7586, E 21.7484), it occupies an area of 32 000 ha, from the middle of Cyrenaica to Jar-Jar Ummah (Fig. 1). El-Kouf NP was established in 1970 under the supervision of the Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD) and various surveys regarding the geology, wildlife and marine environment were conducted until the mid 1970s (Armsby, 1980). The coastline of El-Kouf NP covers ca. 20 km between Alhanya Village in the east (N 32.8412, E 21.5206) and Alauglah Beach in the west (N 32.7712, E 21.3303). In El-Kouf NP, the marine environment differs from west to east. The western part is formed of open and long sandy beaches with sandy bottoms, rocky patches and seagrass meadows of Posidonia oceanica (L) Delile. The eastern part is more rugged with few sandy lagoons and beaches and a dominance of cliffs and rocky substrata.

Data collection

The presence of marine alien species in El-Kouf NP and the neighbouring areas was assessed through field surveys conducted in October 2010 and two additional surveys conducted in June and September 2012 as part of the local monitoring program. Marine surveys were carried out in the National Park and 9 Km towards the east and 6 Km towards the West. A total of 86 stations were surveyed ranging from 0 to 46 m depth. Investigations were conducted directly from the coast (direct observation mainly in the intertidal area), using a bathyscope, by snorkelling and by scuba diving (Fig. 1). The presence of alien species was recorded. Supplementary data were obtained from professional fishermen. Alien species observed were identified and photographed.

The nomenclature adopted in this paper follows the World Register of Marine Species (WoRMS Editorial Board, 2013) and contributing databases (AlgaeBase, DAISIE, FishBase). The acclimatization (establishment) status of alien species (Established, Casual, Questionable, Cryptogenic or Invasive) in the Central Mediterranean is according to Zenetos et al. (2010). The date of
first sighting in Libya (or of publication when no date of observation/collection was indicated) is also presented as well as the origin of the species.

Finally, scientific literature, websites and unpublished data were analysed to establish an updated list of the alien marine species reported from Libya. Each record has been carefully analyzed, with recourse to the published literature and, where necessary and possible, interviews with the authors.

Results and Discussion

El-Kouf National Park region

Nine alien marine species have been identified in El-Kouf NP and the neighbouring areas; namely, Rhodophyta *Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon, Chlorophyta *Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman & Boudouresque, the crab *Percnon gibbesi* (H. Milne-Edwards, 1853) and the fishes *Fistularia commersonii* Rüppell, 1838, *Lagocephalus sceleratus* (Gmelin, 1789), *Pempheris vanicolensis* Cuvier, 1831, *Siganus luridus* (Rüppell, 1829), *Siganus rivulatus* Forsskål, 1775, and *Sphyraena flavicauda* Rüppell, 1838 (Table 1; Fig. 2).

*Asparagopsis taxiformis* is an alien red alga exhibiting an invasive behaviour on several coasts of the Mediterranean basin (Flagella et al., 2003). First reported from Libya in 1895 (De Toni, 1895), it was largely observed in El-Kouf NP and the neighbouring areas. Two cryptic taxa coexist under the name of *A. taxiformis* in the Mediterranean Sea:

**Fig. 2:** Alien marine species recorded in El-Kouf National Park and neighbouring areas. A: *Asparagopsis taxiformis*; B: *Caulerpa racemosa* var. *cylindracea*; C: *Percnon gibbesi*; D: *Fistularia commersonii*; E: *Pempheris vanicolensis*; F: *Lagocephalus sceleratus*; G: *Siganus luridus*; H: *Siganus rivulatus*; I: *Sphyraena flavicauda*. 

Medit. Mar. Sci., 14/2, 2013, 451-462
Table 1. Alien marine species reported from the El-Kouf National Park (1*) and Libyan waters with the date of first sighting in Libya; world distribution and establishment success in the Central Mediterranean according to Zenetos et al. (2010) amended. Abbreviations: Est = established, Cas = Casual, Cry = Cryptogenic, Ques = Questionable, and Unk = Unknown. 1st sightings in bold indicate species first reported in the CMED from Libya.

| Species | Authority | Distribution | 1st Libyan sighting | Success | Reference |
|---------|-----------|--------------|--------------------|---------|-----------|
| PROTOZOA |           |              |                    |         |           |
| Foraminifera |            |              |                    |         |           |
| Amphistegina lobifera |          | Circumtropical | 1979 | Est | Blanc-Vernet et al. (1979) |
| Foraminifera |            |              |                    |         |           |
| Amphidiscus n. sp. |        | Circumtropical | 1979 | Est | Blanc-Vernet et al. (1979) |
| MACROPHYTES |           |              |                    |         |           |
| Ochrophyta - Phaeophyceae |         |              |                    |         |           |
| Padina boergesenii | Allender & Kraft | Indo-Pacific | 1974 | Est | Langer (2008) |
| Padina boryana | Thivy | Indo-Pacific | 1974 | Est | Langer (2008) |
| Stypopodium schimperi | (Buchinger ex Kützing) Verlaque & Boudouresque | Indo-West Pacific | 1977 | Est | Nizamuddin (1981, as Spatoglossum solieri); Nizamuddin & Godeh (1989, as Stypopodium tubruquense) |
| Rhodophyta |            |              |                    |         |           |
| Acanthophora taxiformis | (Delile) Papenfuss | Indo-Pacific | 1895 | Est | De Toni & Lesi (1888 as A. taxiformis); Muscieri (1910); Nizamuddin et al. (1979) |
| Asparagopsis taxiformis | (Delile) Trevisan de Saint-Léon | Indo-Pacific | 1895 | Est | De Toni & Lesi (1888 as A. taxiformis); Muscieri (1910); Nizamuddin et al. (1979) |
| Chondria coerulescens | (J.Agardh) Falkenberg | East Atlantic | 1989-1990 | Est | Godeh et al. (1992); Nizamuddin & Godeh (1989, as Cystoporina tubruquense) |
| Lophocladia lallemandii | (Montagne) F. Schmitz | Indo-Pacific | 1918 | Est | Nizamuddin et al. (1979) |
| Polysiphonia atlantica | Kapran & J. Morris | N Atlantic/N Pacific | 1990-1990 | Cas | Godeh et al. (1992, as P. macrocarpa) |
| Chlorophyta |            |              |                    |         |           |
| Caulerpa racemosa var. cylindracea | Verlaque, Huisman & Boudouresque | Indo-Pacific | 1990 | Inv | Nizamuddin (1991) |
| Caulerpa columnaris | (Montag) Kützing | NW Pacific | 1984 | Est | Nizamuddin (1991) |
| Codium fragile subsp. fragile | Suringar | NW Pacific | 1984 | Est | Nizamuddin (1991) |
| Codium taylorii | P.C. Silva | Indo-Pacific | 1977 | Est | Nizamuddin (1991) |
| Ulva fasciata | Delile | Warm-temperate seas | 1979 | Est | Nizamuddin (1991) |
| Magnoliophyta |            |              |                    |         |           |
| Halophila stipulacea | (Forsskal) Ascherson | Red Sea | <2009 | Inv | UNEP/MAP-RCSPA (2009); Godeh et al. (2011) |

(continued)
(continued) Table 1.

| Species                        | Authority                          | Distribution     | 1st Libyan sighting | Success | Reference               |
|--------------------------------|------------------------------------|------------------|---------------------|---------|-------------------------|
| **Decapoda**                   |                                    |                  |                     |         |                         |
| Grapsus granulosus            | H. Milne-Edwards, 1853             | Red Sea          | 2006                | Cas     | Zaouali et al. (2007b)  |
| *Percnon gibbesi               | (H. Milne-Edwards, 1853)           | W Atlantic       | 2004                | Inv     | Elkrwe et al. (2008)    |
| Plagusia squamosa             | (Herbst, 1790)                     | Indo-Pacific     | 2006                | Est     | Zaouali et al. (2007b)  |
| Eucrate crenata               | (De Haam, 1835)                    | Indo-Pacific     | 1999                | Est     | Zgozi et al., 2002      |
| **Isopoda**                   |                                    |                  |                     |         |                         |
| Apanthura sandalensis         | Stebbing, 1900                     | Indo-Pacific     | 1976                | Est     | Negoescu (1981)         |
| *Parakeelia diana             | (Menzies, 1962)                    | Indo-Pacific     | 2001                | Cas     | Zgozi et al. (2002)     |
| **Stomatopoda**               |                                    |                  |                     |         |                         |
| Erugoaquilla masavensis       | (Kossmann, 1880)                   | Red Sea-Indian   | 2002                | Est     | Zgozi et al. (2002)     |
| **MOLLUSCA**                  |                                    |                  |                     |         |                         |
| Bivalvia                       |                                    |                  |                     |         |                         |
| Malaxis (Malvaena) regula     | (Forsskål in Niebuhr, 1775)        | Indo-Pacific     | 2001                | Est     | Giannuzzi-Savelli et al. (2001) |
| Pinctada imbricata radiata    | (Leach, 1814)                      | Indo-Pacific     | 1913                | Inv     | Monterosato (1917)      |
| *Pulvia fragilis              | (Forsskål in Niebuhr, 1775)        | Indo-Pacific     | 1997                | Inv     | Zgozi et al. (2002)     |
| **Gastropoda**                |                                    |                  |                     |         |                         |
| Bursatella leachii            | Blainville, 1817                   | Red Sea-Indian   | 2000                | Inv     | Zgozi et al. (2002)     |
| Cellana rota                  | (Gmelin, 1791)                     | Red Sea-Indian   | 2007                | Ques    | Zaouali et al. (2007b)  |
| Clypeomorus bifasciatus       | (G.B. Sowerby II, 1855)            | Indo-Pacific     | 1994                | Cas     | Giannuzzi-Savelli et al. (1997) |
| Conomurex persicus            | (Swainson, 1821)                   | Indian Ocean     | 2006                | Est     | Ben Souissi et al. (2007)as Strombus persicus |
| Conus fumigatus               | Hwass in Bruguère, 1792            | Red Sea          | 1986                | Cas     | Rückel (1986)           |
| Euhorbas tenuis               | (Lamarck, 1810)                    | Red Sea-Indian   | 2007                | Est     | Ben Souissi et al. (2007) |
| Haliospis putatula cruenta    | Reeve, 1846                        | Red Sea-Indian   | 1994                | Cas     | Giannuzzi-Savelli et al. (1994) |
| Monetaria annulus             | (Linneaus, 1758)                   | Indo-Pacific     | 2006                | Ques    | Ben Souissi et al. (2007), as Cypraea annulus |
| Nerita sanguirentina          | Menke, 1829                        | Red Sea          | 1994                | Cas     | Giannuzzi-Savelli et al. (1994) |
| **Polyplacophora**            |                                    |                  |                     |         |                         |
| Acanthopleura gemmata         | (Blainville, 1825)                 | Indo-Pacific     | 2006                | Ques    | Zaouali et al. (2007b)  |
| **ECHINODERMATA**             |                                    |                  |                     |         |                         |
| Ophiocoma scolopendra         | (Lamarck, 1816)                    | Red Sea-Indian   | 2007                | Ques    | Zaouali et al. (2007b)  |
| **FISH**                      |                                    |                  |                     |         |                         |
| Alepes ķedāba                  | (Forsskål, 1775)                   | Indo-Pacific     | 1990                | Est     | Ben Abdallah et al. (2005) |
| Atherinomorus forskydali      | (Rüppell, 1838)                    | Red Sea          | 1929                | Est     | Norman (1929) as Prasenus pinguis |
| Crenidens crenidens           | (Forsskål, 1775)                   | Red Sea-Indian   | 1999                | Est     | Al-Hassan & El-Silini (1999) |
| *Fistularia commersonii       | Rüppell, 1838                      | Indo-Pacific     | 2004                | Inv     | Ben Abdallah et al. (2005) |
| Homomiramus far               | (Forsskål, 1775)                   | Indo-Pacific     | 2006                | Est     | Shakman & Kinzelbach (2006, 2007b,c), Shakman (2008) |
| Herklotsichthys punctatus     | (Rüppell, 1837)                    | Red Sea          | 2005                | Est     | Shakman & Kinzelbach (2007b,c) |
| *Lagocephalus sceleratus      | (Gmelin, 1789)                     | Indo-Pacific     | 2006                | Cas     | Kacem-Snoussi et al. (2009) |
| *Lagocephalus suezensis       | Clark & Gohar, 1953                | Red Sea-Indian   | 2009                | Cas     | Kacem-Snoussi et al. (2009) |
Table 1. *Species* and their **Distribution** in the Mediterranean Sea, according to various authors (continued).

| Species                        | Authority | Reference | Success |
|--------------------------------|-----------|-----------|---------|
| *Liza carinata*                | Valenciennes, 1847 | 1999 | Indo-Pacific |
| *Parexocoetus mento*           | Cuvier, 1831 | 1999 | Indo-Pacific |
| *Pempheris vanicolensis*       | (Forsskal, 1775) | 1994 | Indo-Pacific |
| *Sargocentron rubrum*          | (Forsskal, 1775) | 1994 | Indo-Pacific |
| *Saurida undosquamis*          | (Rüppell, 1838) | 1998 | Indo-Pacific |
| *Scomberomorus commersonii*    | (Rüppell, 1838) | 2004 | Indo-Pacific |
| *Sphyraneus dali*              | (Klunzinger, 1870) | 1999 | Indo-Pacific |
| *Sphyraena chrysotaenia*       | (Klunzinger, 1870) | 1999 | Indo-Pacific |
| *Sphyraena flavicauda*         | (Klunzinger, 1870) | 1999 | Indo-Pacific |

1. When no date of record is mentioned, we report the date of publication.
2. Native and introduced populations probably occur in the Mediterranean Sea.
3. *Described from Libya,* is very close to *Cladophora C. gerloffii* would be a junior synonym of *Cladophoropsis membranacea.*
4. *Sphyraena flavicauda Rüppell, 1838 is considered a synonym of S. obtusata by Doiuchi and Nakabo (2005, 2007).*
5. *Sphyraena chrysotaenia* is considered a synonym of *S. pinguis* by Doiuchi and Nakabo (2005, 2007).*

The bluespotted cornetfish *Fistularia commersonii* is an Indo-Pacific species that invaded the Mediterranean Sea through the Suez Canal. It was first observed in Israel in 1998 (Golani et al., 2001). Since then, it has been spreading throughout the Mediterranean Sea (Azzurro et al., 2012). Reported in Libya since 2004 (Ben Abdallah et al., 2005), *F. commersonii* was not yet abundant in the El-Kouf NP region but it started to appear in local fishing markets.

Originating in the tropical Indo-Pacific Ocean, the alga described in 1813 from Alexandria and confined to the eastern Mediterranean Basin (Egypt, Lebanon, Syria and likely Libya) and a more recently introduced taxon exhibiting an invasive behaviour in the western basin and the Adriatic Sea. Molecular studies showed that the first might be of Atlantic provenance, via the Strait of Gibraltar, whereas the second colonized the Mediterranean from the Indo-Pacific Ocean, probably via the Suez Canal (Lessepsian species) (Ni Chualáin et al., 2004; Andreakis et al., 2007). Identification of *A. taxiformis* spp occurring in El-Kouf NP requires further investigation.
Lagocephalus sceleratus has been listed as one of the 100 “worst invasive species” of the Mediterranean Sea (Streftaris & Zenetos, 2006). Since its first report along the coast of Turkey in 2003 (Akyol et al., 2005), new findings have revealed that this Lessepsian species is now very common along the Levantine coasts of Turkey (Bilecenoglu et al., 2006) and the south Aegean (Corsini et al., 2006; Petrou et al., 2011). In Libya, L. sceleratus was first collected in 2006 (Kacem-Snoussi et al., 2009). Fishermen caught the fish in 2010 inside and outside the Ain Al Ghazala Lagoon and off Ain Al Ghazala (Milazzo et al., 2012). L. sceleratus was not observed in situ in El-Kouf NP but specimens were caught by fishermen working in the area in October 2010.

The sweeper fish Pempheris vanicolensis is an Indo-Pacific species that invaded the Mediterranean Sea through the Suez Canal. It was first recorded in Lebanon in 1979 (Mouneimne, 1979). In Libya where it was first reported in 2004 (Ben Abdallah et al., 2004), P. vanicolensis is frequently observed in relatively high abundance (Shakman & Kinzelbach, 2007a-c). In the surveyed area, the species formed small schools in cracks and underwater caves. Locally, the species has no economic value.

The dusky spinefoot S. luridus and the marbled spinefoot S. rivulatus are widely distributed in the Indian Ocean and the Red Sea, respectively. First observed in the Mediterranean Sea in 1931 and 1924, respectively (Ben-Tuvia, 1964), these two Lessepsian species are considered as invasive in the Eastern and Central Mediterranean basins where they have become common commercial fishes (Golani et al., 2002; Ben Abdallah et al., 2003, Streftaris & Zenetos, 2006; Shakman et al., 2008). Siganus luridus and S. rivulatus were first reported from Libya in 1968 (Štirn, 1970). According to Ben Abdallah et al. (2003), S. luridus appeared in 1973 in commercial catches and became one of the most abundant species in captures by trammel and gill nets, though its abundance decreases towards the west. Since then Siganus spp. have become very common in Libyan waters probably outcompeting the two native herbivorous species Sarpa salpa (Linnaeus, 1758) and Sparisoma cretense (Linnaeus, 1758) (Štirn, 1970; Shakman & Kinzelbach 2007b). Siganus rivulatus is mostly recorded from the eastern littoral of Libya where it is found in small groups in inshore waters close to sandy bottoms covered by seagrasses and caught in small quantities mixed with S. luridus (Ben Abdallah et al., 2003), while S. luridus seems to be more present in central and western parts of the littoral (Shakman & Kinzelbach, 2007c). Both species were abundant in El-Kouf NP, especially S. luridus - numerous schools were observed in different parts of the surveyed area.

Due to their similar morphology, alien barracuda species often cause confusion. According to the distribution of the two species in the CIESM Atlas of exotic species (Golani et al., 2002), the common species in Libya should be S. chrysotaenia collected since 1968 (Štirn 1970); S. flavicauda was collected three decades later (Ben Abdallah et al., 2003). To-date, both species are common (in terms of abundance) and largely distributed in Libyan waters (Shakman & Kinzelbach, 2007b, c). The yellowtail barracuda was not observed in situ in El-Kouf NP but specimens were caught by fishermen working in the area in June 2012.

Inventory of the alien marine species of Libya

A comprehensive inventory of marine alien species for Libyan waters, along with their acclimatization status, origin and date of first sighting (or publication when no date of record is mentioned) was compiled.

Until now 63 marine aliens species have been recorded along the Libyan coastline. These include 3 Foraminifera, 14 macrophytes, 11 Crustacea, 13 Mollusca, 1 Echinodermata and 21 fishes (Actinopterygii) (Table 1, Fig. 3). Among these Non Indigenous Species, 43 are known as established including 8 invasive, 11 casual, 5 questionable, 3 cryptogenic and 1 unknown (Table 1).
Fishes rank first probably because they are the most studied taxon among alien marine organisms, and they highly contribute to local fishery activities (Shakman & Kinzelbach, 2007b). Besides the 16 species recorded by Ben Abdallah et al. (2005), 4 more species were added to the list at a later date: Hemiraphus far (Shakman & Kinzelbach, 2006); Liza carinata (Shakman & Kinzelbach, 2007b, c), L. sceleratus and L. suezensis (Kacem-Snoussi et al., 2009; Ben Abdallah et al., 2011). To these we should add Atherinomorus forskalii reported by Norman (1929) as Prasenus pinguis (Lacepède, 1803). Of the 21 alien fishes, that all are Actinoptygii, 18 have established populations while 3 species (Sargocentron rubrum, Lagoccephalus sceleratus and L. suezensis) are only known from one or two records. However this could be the result of the limited number of studies. For example, L. sceleratus is established in the Central Mediterranean and is expanding its geographic range to the Ionian Sea (Zenetos et al., 2013). Other species such as Cephalopholis taeniops (Valenciennes, 1828), Seriola rivoliana Valenciennes, 1833, Sphoeroides pachygaster (Müller & Troschel, 1848) and Synaptaura lusitanica (Capello, 1868) were not considered in this study as they are of Atlantic origin and it has been argued that their presence in the Mediterranean is due to range expansion. The list of newly introduced fish species in Libya is non-exhaustive. The latest record is that of the Bermuda sea chub Kyphosus sectatrix (Linnaeus, 1758) (Elbarassi et al., 2013). Zupanovic & El-Bini (1982) have reported Pomadasys olivaceum Day, 1975 based on a single specimen collected off Zwaara, Tripolitanian coast. This record has been listed in the DAISIE inventory as Pomadasys stridens (Forsskål, 1775). In the absence of voucher specimens and based on the opinion of local experts who report only its congeneric Pomadasys Incicus, a native Mediterranean species, the record of P. stridens is herein excluded.

Macrophytes rank second on the list. The analysis of literature (Nizamuddin et al., 1979, 1994; Nizamuddin, 1981, 1985, 1991, 1995; Shamel, 1983; Zarmouth & Nizamuddin, 1991; Godeh et al., 1992, 2009; Ribera et al., 1992; Gallardo et al., 1993; Nizamuddin & El Menifi Fathalla, 1993; Babbini & Bressan, 1997; Gómez Garreta et al., 2001; Taskin et al., 2012) gave a list of 240 native marine taxa of macrophytes. Four species not corresponding to valid taxa have been included, i.e. Chaetomorpha urbica (Zanardinii) Kützing, Cladophora catenata (J. Agardh) Hauck, Cladophoropsis pullis (Kütz.) Boegeois and Gracilaria verrucosa var. ramulosa (C. Agardh) M.P. Reis, as well as the nine following alien taxa reported by Nizamuddin (1991) and Godeh et al. (1992, 2009), which we considered as misidentifications (Bryopsis caespitosa Suhr ex Kützing (as Bryopsis caespitosa Suhr in Kützing), Bryopsis pennata var. leprieurii (Kützing) Collins & Hervey (as Bryopsis leprieurii Kützing), Chaetomorpha indica (Kützing) Kützing, Chaetomorpha melagonium (F. Weber & Mohr) Kützing, Chondria oppositieclada E.Y. Dawson, Dasya villosa Harvey, Gastroclonium ovatum (Hudson) Papenfuss, Laurencia laxa (R. Brown ex Turner) Gaill (as Laurencia laxa Kützing) and Ulva taeniata (Setchell & N.L. Gardner). In this study, we have listed a total of 14 alien macrophytes, which represent 5.5% of the Libyan marine macroflora. All these alien species are established except for Cladophora herpetica and Polysiphonia atlantica that are questionable and cryptogenic/questionable, respectively. This group includes one of the most invasive alien species in the Mediterranean, namely Caulerpa racemosa var. cylindracea.

Molluscs are known to be one of the dominant alien groups in the Mediterranean (Zenetos et al., 2012). Here, they rank third on the list, with only six established species, including two invasive bivalves (Pinctada imbricata radiata and Fulvia fragilis) and one invasive gastropod (Bursatella leachii), the remaining ones being casual or questionable. The presence of the limpet Cellana rota and the cowry Monetaria annulus reported by Ben Souissi et al. (2007) is questionable because C. rota can be easily confused with the native limpets, and the majority of old records of M. annulus were based on transported shells (the species was one of the molluscan shells most often carried around, as currency or ornaments) (Gofas & Zenetos, 2003).

Crustaceans with 9 alien species rank fourth. Four species are established and the others are casual or questionable. This group includes one of the most invasive alien species in the Mediterranean, namely the decapod Percnon gibbesi.

Finally, Foraminifera and Echinodermata included 3 and 1 alien species and occupy the fifth and the sixth places, respectively. The absence of taxonomic groups such as the Annelids, one of the major phyla ranking third in terms of contributors to Mediterranean alien biota [with 132 species], is indicative of the lack of taxonomic experts in the area. It is also worth noting the absence or rarity of zoolanktonic species such as Cnidaria and Copepoda.

Up to December 2012, a total of 249 alien species were known from the Central Mediterranean (Zenetos et al., 2012). The majority of alien species in the Libyan waters are of Indo-Pacific origin (53%), followed by Red Sea – Indian Ocean species (16%), Red Sea species (14%), Circum-tropical (3%). Less than 5% of the alien introduced species in Libya originate in the Atlantic as opposed to the Atlantic species expanding their distribution in the Mediterranean (reaching Libya) without human intervention as a result of climate change. Libya, and globally the strait of Sicily, has a special geographical position in the Mediterranean. For approximately 44 of the 63 alien species listed here, the first Libyan record was also the first for the central Mediterranean. This highlights the importance of the region for monitoring introductions in the Mediterranean. This sector is regarded as an area of biogeographical transition (Bianchi, 2007) and it is located at the crossroads between different Mediterranean basins and hydrographic conditions. In this
area, significant changes have occurred in the biological communities and many alien species have appeared in the last few years. Lessepsian migration through the Suez Canal probably has a conspicuous influence on Libyan marine biodiversity, but Libya also seems to harbour alien species arriving from the West (Atlantic). In both cases, a warm temperate or subtropical affinity of most species is evident.

Compared to other Mediterranean regions, the number of alien species recorded in Libya is low: 63 species versus 107 in Tunisia and 232 in Egypt (Katsanevakis et al., 2012; UNEP-MAP-RAC/SPA, 2013). However, this number is certainly underestimated for various reasons. The scientific effort of investigation, including taxonomic expertise availability is limited; small-sized Lessepsian immigrants (macrophytes and invertebrates) have been poorly studied and many species probably remain undiscovered. Moreover, the deep benthic assemblages were not investigated. As an example, the divergence between Tunisia and Libya in numbers is more obvious in Decapoda (17 in Tunisia vs. 4 in Libya), Bivalvia (7 in Tunisia vs. 3 in Libya), Gastropoda (15 in Tunisia vs 9 in Libya) (UNEP-MAP-RAC/SPA, 2013). The difference is also due to the lack of data for several groups in Libya such as Phaeophyceae, Polychaeta, Copepoda, Isopoda, Cephalopoda, Bryozoa, Cnidaria, Hydrozoa, Ascidiaeae, Echinodermata, Platyhelminthes and Elasmobranchii.

Conclusion

Marine protected areas in the Mediterranean have not escaped biological invasions and most of them have been affected by introduced invasive alien species that threaten marine biodiversity (Otero et al., 2013). In El-Kouf National Park, among the nine alien species recorded, C. racemosa var. cylindracea, Siganus spp. and Percnon gibbesi are classified among the major invaders of the Mediterranean. However, no data are available on the environmental impact of these species on the El-Kouf NP.

An in-depth study of marine organisms would substantially increase the number of alien species occurring in Libya, especially the proportion of Indo-Pacific species arriving via the Suez Canal. Monitoring marine assemblages of MPAs provides a valuable opportunity for further in-depth knowledge of native and introduced species.

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