J. Black Sea/Mediterranean Environment
Vol. 16(1): 87-132 (2010)

Alien fish species in the Mediterranean – Black Sea Basin

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Abstract

Alien Fish (Synonyms: non-native, non-indigenous, allochthonous, and exotic) species have been introduced to the Mediterranean-Black Sea Basin via the Suez Canal, Gibraltar or in ballast water. The number of alien fish species increased recently in the Black Sea-Mediterranean Basin because of the opening of the Suez Canal, climate change and international shipping activities. The aim of this review is to compile all relevant data for the alien fish species in both the Black and the Mediterranean Seas. As a result a total of 160 alien fish species have been reported from the Black Sea-Mediterranean Basin. There are 67 species introduced from the Atlantic Ocean via the Gibraltar, three species of which are originated from the Boreal Atlantic, 86 species introduced from the Red Sea via the Suez Canal, four species of which are originated from the Pacific Ocean. The number of alien fish species increased 68.42 % between years 2002-2010.

Some alien fishes mostly in the eastern Mediterranean were well colonized, recently, such as Indo-Pacific species *Atherinomorus forskalii*, *Fistularia commersonii*, *Lagocephalus sceleratus* and *Etrumeus teres* in the western Mediterranean. Regionally, there are 40 species of the Aegean Sea, three species from the Marmara Sea, five species from the Black Sea, 96 species from the eastern Mediterranean Sea, 26 species from the Ionian Sea, 36 species from the Tyrrhenian Sea, 14 species from the Algerian coasts, 43 species from the

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Alboran Sea, 21 species from the Adriatic Sea, six species from the Ligurian Sea, 10 species from the Gulf of Lion and 10 species from the Tunisian coasts were reported in total of 160 alien fish species.

Keywords: Mediterranean, Aegean, Sea of Marmara, Black Sea, Alien Fish Species.

Introduction

Introduction of alien species to new ecosystem is considered to be a major threat to its biodiversity, structure and function (Courchamp et al. 2003, Boudouresque 2005). More than 790 alien species have been introduced to the Mediterranean Sea until today, most of which are benthos and fish species (Zenetos et al. 2007). The majority of them have an Indo-Pacific origin; more than 300 Indo-Pacific species (macrophytes, invertebrates and fish) have migrated from the Red Sea into the eastern Mediterranean Sea since the opening of the Suez Canal in 1869 (Galil 2000). This massive aquatic invasion is called "lessepsian migration" (Por 1978). Marine biologists have justifiably focused on biology and ecology of alien species and their spreading across the Mediterranean coasts, considering the undisputed effects of their invasion on native marine communities and ecosystems as well as on catch composition in commercial fisheries (Goren and Galil 2005, Harmelin-Vivien et al. 2005). With respect to alien species introduction throughout the Mediterranean, Turkey is one of the most influenced countries due to its proximity to the Suez Canal and the dense maritime traffic along its coastline (Cinar et al. 2005).

Zenetos et al. (2008) reported total of 125 alien fish species from the Mediterranean Sea. Movements of species in relation with global warming may increase spatial overlap between exotic and endemic species, which is a critical issue for the conservation of biodiversity. The Mediterranean Sea, which is are ceptacle for exotic species while being a hotspot for endemism, provides exceptional materials for a case study. Ben Rais Lasram and Mouillot (2009) presended the invasion dynamic of exotic fish species in relation with the sea surface temperature series reconstructed from 1810 to 2006 in order to elucidate the correlation between invasion rate and climate change. Due to reported acceleration for successful introduction from the Red Sea and from lower latitudes in the Atlantic in correlation with the increasing temperature of the Mediterranean Sea, endemic fish species are encountering a growing number of exotic species (Ben Rais Lasram and Mouillot 2009).

There is sufficient evidence to warrant the claim that exotic invasion can, at the very least, reduce the abundance of native species, alter disturbance regimes and basic ecosystem processes, impose large economic costs, and introduce new pathogens to indigenous populations. Further native species can be driven to extinction by competitive interactions (e.g. Olden et al. 2006), by predation (e.g. Roemer et al. 2002), or simply by demographic stochasticity when many new individuals enter the community and occupy a part of the carrying capacity of native species (Lande 1993).

The original distributional ranges of aliens in the western Mediterranean are spread over 'the seven seas,' while aliens in the Levantine mostly originate in the tropical Indo-Pacific (Indo-Pacific 46 %, Indian Ocean 23 %, Red Sea 13 %) (Por 1990).

Materials and Methods

This review was carried out on scientific articles which contain information on alien and lessepsian fish species introduced via the Gibraltar and Suez Canal and/or by ship ballast waters to the Black Sea-Mediterranean Sea Basin. The Mediterranean Sea Basin was separated in to two localities; Western Mediterranean and eastern Mediterranean. The Ionian Sea, Tyrrhenian Sea, Liguran Sea, Sicily Strait, Alboran Sea, Gulf of Naples, Lion (Gulf of Lion), Adriatic Sea, Cretan Sea were included in the Western Mediterranean, Levantine, while the Cretan Sea, Libyan Sea, Palestine, were included in the eastern Mediterranean. The Aegean Sea, Marmara Sea and Black Sea were treated as separate seas.

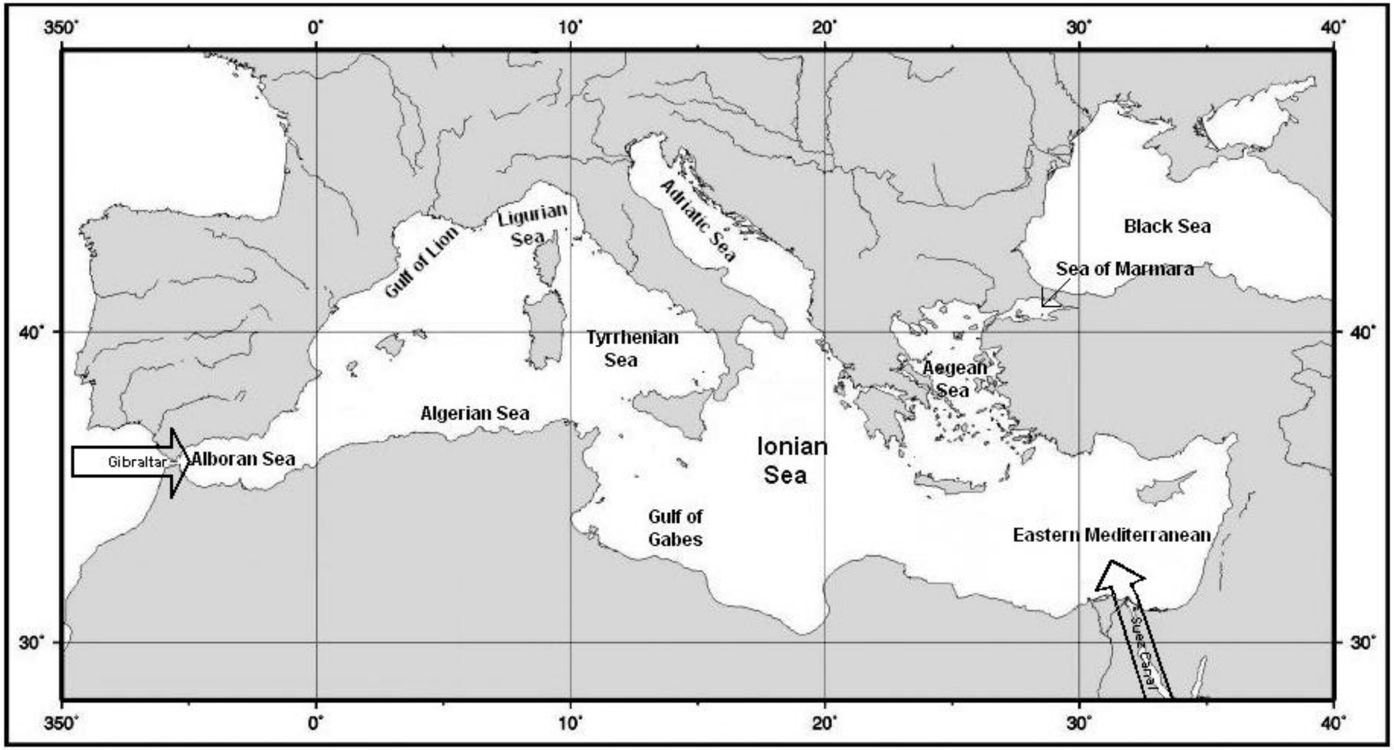

Figure. 1 Geographical location of the Mediterranean Sea and routes of invasion (indicated by arrows).(Ben Rais Lasram and Mouillot, 2009)

Results

Recently a total of 160 alien fish species, from various origins, such as Boreal Atlantic (3 species), Pacific Ocean (4 species), Atlantic Ocean (67 species) and Indo-Pacific (86 species) have been reported for the Mediterranean Sea Basin. From the Aegean Sea, 38 alien fish species were reported, 4 species introduced via the Gibraltar, 1 species from the Pacific Ocean, 33 species from the Indo-Pacific.

Recently in March 2010 two new Indo-Pacific fish species *Priacanthus sagittarius* Starnes, 1988 (Goren et al. 2010) and *Pomacanthus imperator* (Bloch 1787) (Golani et al. 2010) were reported in eastern Mediterranean.

Number and percentage of alien fish species distribution according to seas were two (1.25 %) species from the Sea of Marmara, five (3.13 %) species from the Black Sea, six (3.75 %) species from the Ligurian Sea, 10 (6.25 %) species from the Gulf of Lion, 14 (8.75 %) species from Algerian coasts, 19 (11.18 %) species from Tunisian coasts, 21 (13.13 %) species from the Adriatic Sea, 25 (15.63 %) species from the Ionian Sea, 36 (22.50 %) species from the Tyrrhenian Sea, 38 (23.75 %) species from the Aegean Sea, 43 (26.88 %) species from the Alboran Sea, 95 (59.37 %) species from the eastern Mediterranean Sea.

Distribution of Indo-Pacific fish species according to areas were recorded one species (1.16 %) from the Sea of Marmara, one species (1.16 %) from the Black Sea, one species (1.16 %) from the Algerian coasts, two species (2.33 %) from the Gulf of Lion, three species (3.49 %) from the Ligurian Sea, nine species (10.47 %) from the Tunisian coasts, 13 species (15.12 %) from the Tyrrhenian Sea, 14 species (16.28 %) from the Adriatic Sea, 15 species (17.40 %) from the Ionian Sea, 33 species (38.37 %) from the Aegean Sea and 76 (88,37 %) species from the eastern Mediterranean Sea in total of 86 Indo-Pacific fish species.

Ae	EM	IS	TS	AlgS	AlbS	AdrS	LS	GL	GG
4	17	9	21	13	40	6	3	8	10
5,9701	25,373	13,43	31,343	19,4	59,7	8,955	4,478	11,9	14,93

Fishes introduced via the Gibraltar according to were reported three species (4.48 %) from the Liguran Sea, four species (5.97 %) from the Aegean Sea, six species (8.95 %) from the Adriatic Sea, eight species (11.90 %) from the Gulf of Lion, nine (13.43 %) species from the Ionian Sea, 10 species (14.93 %) from Tunisian coasts, 13 species (19.40 %) from Algerian coasts, 17 (25.37 %) species from eastern Mediterranesn, 21 (3.34 %) species from the Tyrrhenian Sea and 40 species (59.70 %) from the Alboran Sea.

Before 2010, 99 fish species were reported from the eastern Mediterranen, 26 fish species from the Ionian Sea, 36 fish species from the Tyrrhenian Sea, 14 fish species from the Algerian Sea, 43 fish species from the Alboran Sea, 21 fish species from the Adriatic Sea, 19 fish species from the Gulf of Gabes, 10 fish species from the Gulf of Lion, and six fish species from the Ligurian Sea were reported as alien fish species. CIESM atlas presented a total of 92 alien fish species in 2002 and 116 in 2009. Ben Rais Lasram and Mouillot (2009) reported 127 alien fish species in the Mediterranean Sea. Some of fishes excluded in CIESM atlas (2009). These are excluded because some were deep sea fishes, some were described indigenous species in the Mediterranean, and others were given misidentification. Some of the specimens were not preserved and it was impossible to confirm. These species are listed below:

Carcharhinus brevipinna (Müller and Henle,1839), *Carcharhinus melanopterus* (Quoy and Gaimard, 1824), *Squalus megalops* (Macleay, 1881), *Pristis pectinata* Latham, 1794, *Rhinobatos halavi* (Forsskål, 1775), *Clupea kowal* Rüppell, 1837, *Dussumieria acuta* Valenciennes, 1847, *Sardinella sirm* (Wabaum, 1792), *Arius thalassinus* (Rüppell, 1835, *Borostomia antarcticus* (Lönnberg, 1905), *Hemiramphus gamberur* (Rüppell, 1837), *Hemiramphus marginatus* Lesueur, 1821, *Hemiramphus unifasciatus* Ranzani, 1842, *Hyporhamphus dussumieri* (Valenciennes, 1846), *Hyporhamphus xanthopterus* (Valenciennes, 1847), *Demichthys unicolor* (Valenciennes, 1847), *Parexocoetus brachypterus* (Richardson, 1846), *Tylosurus crocodilus* (Péron and Le Sueur, 1821) *Laemonema latifrons* Holt and Byrne, 1908, *Lepidion guentheri* (Giglioli, 1880), *Gaidropsarus granti* (Regan, 1903), *Coryphaenoides guentheri* (Vaillant, 1888), *Melanostigma atlanticum* Koefoed, 1952, *Cataetyx laticeps* Koefoed, 1927, *Aphanius dispar* (Rüppell, 1829), *Sebastapistes nuchalis* (Günther, 1874), *Epinephelus coromandelicus* (Day, 1878), *Epinephelus morrhua* (Valenciennes in Cuvier and Valenciennes, 1833), *Epinephelus tauvina* (Forsskål, 1775), *Serranus melanurus* (Geoffroy St. Hilaire, 1817), *Serranus morrhua* Valenciennes in Cuvier and Valenciennes, 1833, *Apogon (Nectamia) taeniatus* Ehrenberg, 1828, *Therapon jarbua* Forsskål, 1775, *Remora australis* (Bennet, 1840), *Priacanthus hamrur* (Forsskål, 1775), *Caranx gallus* Linnaeus, 1758, *Caranx kiliche* Cuvier in Cuvier and Valenciennes, 1833, *Sargus noct* Valenciennes in Cuvier and Valenciennes, 1830, *Upeneus asymmetricus* Lachner, 1954, *Upeneus barberinus* (Lacepède, 1801), *Upeneus tragula* Richardson, 1846, *Upeneus vittatus* (Forsskål, 1775), *Pempheris molucca* Cuvier, 1829, *Pempheris oualensis* Cuvier, 1829, *Sphyraena viridensis* Cuvier, 1829, *Scarichthys coerulopunctatus* Rüppell, 1835, *Lipophrys pholis* (Linnaeus, 1758), A single record from the Balearic Sea (see Hureau and Monod, 1973) was based on a misidentification (Zander, pers. comm.). *Parablennius pilicornis* (Cuvier, 1829), *Gobius couchi* Miller and El-Tawil, 1974, *Oxyurichthys papuensis* (Valenciennes, 1837), *Ammodytes tobianus* Linnaeus, 1758, *Trichiurus haumela* (Forsskål, 1775), *Istiophorus gladius* (Bloch, 1793), *Bothus pantherinus* (Rüppell, 1830), *Lagocephalus scleratus* (Forster, 1788).

Several migrants have now become common in local fish landings and markets. For example a mixed Mediterranean–Red Sea composition has been seen on the south Lebanon coasts (Golani et al. 2002). The weight percentage (around 37 %) of lessepsian species observed in the south Lebanon coasts was reported in 2002 and new species are now well established for the eastern Mediterranean (Golani et al. 2002).

The success of lessepsian migrant fish in the colonization of the eastern Mediterranean could be the result of occupation of an unsaturated niche and of out-competing local species on resources such as food and shelter (Golani 1998). Invasive species, in fact, may alter the evolutionary pathway of native species by competitive exclusion, niche displacement, predation, and other ecological and genetic mechanisms (Mooney and Cleland 2001).

As stated by Bariche et al. (2004) siganids now represent 80 % of the abundance of herbivorous fish in the eastern Mediterranean coastal waters. Whereas an endemic parrotfish *Sparisoma cretense* and a sparid *Sarpa salpa* represent only 20 % and 0.2 % in the total catch respectively. The presence of the parrotfish, *Scarus ghobban*, recently recorded in the Mediterranean (Goren and Aronov 2002), could have a direct effect on the population of the native co-familial *Sparisoma cretense*; both species, in fact, feed on seaweeds, seagrasses and detritus (Sano et al. 1984, Ochavillo et al. 1992). Similarly, *Apogon pharaonis* has been found to be a successful colonizer affecting the population structure of native Mediterranean *Apogon imberbis* in all the eastern Mediterranean (Gucu et al. 1994). *Apogon pharaonis* is a species with no commercial value and a common by-catch species in standing nets, has showed a steady increase in abundance.

Conversely, trophic separation does not play an important role in resource partitioning between goatfish (Mullidae) and lizardfish (Synodontidae). Co-existence between colonizing (*Upeneus moluccensis*, *Upeneus pori*) and indigenous mullids (*Mullus barbatus*, *Mullus surmuletus*) is presumably linked to spatial segregation (Golani and Galil 1991). Golani (1994) suggested that niche partitioning of eastern Mediterranean mullets is achieved on the bathymetric axis: lessepsian mullets occupy shallow waters (20–30 m) whereas indigenous species dominate greater depths. Ismen (2006) stated that in the north-eastern Mediterranean, 98 % of the total biomass of *Upenus pori* were trawled from waters less than 50 m deep with a marked increase during more recent years. Evidence of niche displacement between indigenous and Red Sea competitors has also been reported for the lessepsian lizardfish *Saurida undosquamis* and the indigenous *Synodus saurus*. Both species are primarily piscivorous, and niche partitioning occurs primarily on a depth basis (Golani 1993). *Saurida undosquamis* may in fact colonize deeper bottoms than their native Mediterranean counterparts. Some lessepsian species, under new environmental conditions, occupy similar ecological niches in the Red Sea and in the

East Mediterranean Basin. This is the case for the nocturnal species *Pempheris vanicolensis*, which occupies overhangs in shallow waters in both the Red Ses and the East Mediterranean seas, and *Sargocentrum rubrum*, which takes shelter in cavities during the day from shallow waters down to 30 m (Golani and Diamant 1991). It is difficult to determine whether the colonizers displaced the local species or whether the latter were occupying the same bathymetric niche prior to its confamilial's colonization.

As reported by Golani (1998), the indigenous meager, *Argyrosomus regius*, was once one of the most common commercial species in Israel; since the 1980s, this species has almost completely disappeared in local catches while, simultaneously, the lessepsian migrant narrow-barred Spanish mackerel *Scomberomorus commerson* has considerably increased its abundance. Both species are mainly piscivorous and may utilize the same resource. Similarly, the expansion of the pelagic round herring *Etrumeus teres* seems to have accelerated in the last decade; this could have a direct effect on the population of native clupeids (*Sardinella maderensis* and *Sardinella aurita*) as well as on local fisheries of these species. Since 1990 *E. teres* is caught in large numbers off the Israeli coast and it is caught regularly in the Gulf of Antalya (Yilmaz and Hossucu 2003).

The Atlantic new comers for the Gulf of Gabes are *Chaunax suttkusi* Caruso, 1949, *Seriola fasciata* (Bloch, 1793), *Seriola carpenteri* Mather, 1971, *Pisodonophis semicinctus* (Richardson, 1848), *Solea senegalensis* Kaup, 1858, *Sphoeroides cutaneus* (Günther, 1870), whereas the Indo-Pacific new comers are *Parexocoetus mento* (Valenciennes, 1846), *Pempheris vanicolensis* Cuvier and Valenciennes, 1831, *Stephanolepsis diaspros* (Fraser-Brünner, 1940), *Siganus luridus* (Rüppell, 1828), *Siganus rivulatus* Forsskål, 1775, *Priacanthus hamrur* (Forsskål, 1775) (Bradai et al. 2004).

Several causes have been put forward to explain the success of lessepsian migrants (Por 1978, Boudouresque 1999, Galil and Zenetos 2002). The eastern Mediterranean Sea is characterized by low fish diversity (Fredj and Meinardi 1989) that could in part explain the success and the steady increase of lessepsian migrants. It is evident that successful colonization can only be established where the overlap between the environmental conditions in the source and target areas is within colonizer tolerance. Since the environment conditions of two seas are not identical, the colonizing population will respond to the new selective pressures by diverging from its mother population, thus becoming better adapted to the new habitat. Evidently, the immigration of Red Sea fish species trough the Suez Canal is a continuous process, and the probability of suitable species of fish entering and colonizing the Mediterranean region increases over time. Recently, tropical migrant, *Nemipterus randalli*, previously unknown by local fishermen, indicates a rapid colonization along the Lebanese coast (Lelli et al. 2008). As reported by this study, the increasing percentage of Red Sea species found in the landing composition of the Lebanese fishery indicates that at least some resistant species have established viable populations.

The ecological role of such newly settled species within the coastal ecosystem and their impact on local populations need to be the object of future research.

Discussion

The majority of the farthest spread species are early settlers, nine fish species recorded in Tunis, Malta, or Sicily *Parexocoetus mento* (Valenciennes, 1847), *Hemiramphus far* (Forsskål, 1775), *Fistularia commersonii* Rüppell, 1835, *Leiognathus klunzingeri* (Steindachner, 1898), *Pempheris vanicolensis* Cuvier, 1831, *Sphyraena chrysotaenia* Klunzinger, 1884, *Siganus rivulatus* Forsskål, 1775, *S. luridus* (Rüppell, 1829), *Stephanolepis diaspros* Fraser-Brunner, 1940, 61 years ago, as compared with an average Mediterranean residence of 43 and 33 years respectively for decapods and fish that are recorded only within the Levantine Sea (Galil 2006).

Bella (2000) and Galil and Zenetos (2002) reported overall 25 Lessepsian species, representing 17 families and contributing to 37 % in weight to the total landings in the area. The colonization of the Mediterranean by Indo-Pacific and Red Sea species, known as Lessepsian migration, is an ongoing process that began in 1869, following the opening of the Suez Canal (Por 1978, Golani 1998) since then, more than 70 % of non-indigenous decapods and about 63 % of exotic fish occurring in the Mediterranean have made their way into the Mediterranean through the Suez Canal.

More than 270 Aquatic Alien Species (AAS) including 66 fish species are reported from Greek waters (Marine, Estuaries and Inland waters) (Zenetos et al. 2009). Besides the introductions via the Suez Canal, the most important vectors of introduction are imports for aquaculture purposes and trade (Zenetos et al. 2009).

Some species such as *Pristis pectinata* is the most wide-ranging species but its range is highly disjunct. *P.pectinata* once occurred in the Mediterranean Sea (now extirpated), but still may be found (although it is extremely rare if not extirpated) in some North African countries (Adam et al. 2006).

Stephanolepis diaspros Fraser-Brunner, 1940; *Siganus luridus* Rüppel, 1828 and *Siganus rivulatus* Forsskål, 1775, plus other two species whose occurrence was supported by weaker data: *Leiognathus klunzingeri* (Steindachner, 1898) and *Sphyraena chrysotaenia* Klunzinger, 1884 (Golani et al. 2002).

Coastal fisheries are disrupted for the inability of sort catches. Coastal tourism and fishing industries are affected across Turkey, Egypt, Cyprus and Israel. Herbivorous Mediterranean sea bream (*Sarpa salpa*) eat *Caulerpa*, but they accumulate toxins from the plant in their flesh, making them inedible. Even species that at first may seem ‘harmless’ may become invasive given the right change in local conditions. This could include the introduction of another alien species, environmental changes or other factors which give it biological advantage. Because such changes can occur either after a long time lag, or quite suddenly, any new introductions into the local environment should be subject to close scrutiny. Considering the devastation caused by those alien species that do become invasive, it is necessary to treat all alien species with caution. Any alien species should be considered ‘guilty unless proven innocent’ (De Poorter et al. 2010).

Galil (2000) reported; in the late 1940s the immigrant gold-band goatfish, *Upeneus moluccensis* (Bleeker, 1855), made up 10-15 % of the total mulled catches off the Israeli coast. Following the exceptionally warm winter of 1954-1955, this fraction increased to 83 % (Oren 1957). This fish has since declined to 30 % of the catch (Ben-Tuvia 1973). Following that same winter, the brush tooth lizardfish, *Saurida undosquamis* (Richardson, 1848), became a commercially important fish in the southeast Levantine Basin, and its proportion in trawl catches rose to 20 % in the late 1950s. The population has since diminished and catches have stabilized at about 5 % of the total trawl catch (Ben Yami and Glazer 1974).

According to Oren (1957), populations of red mullet (*Mullus barbatus*) and hake (*Merluccius merluccius*) have been forced to migrate to deeper waters by the aliens *Upeneus moluccensis* and *Saurida undosquamis*, respectively. However, Golani (1998) argues the evidence of such displacement as ‘it is difficult to determine whether the colonisers displaced the local species or whether the latter occupied the same bathymetric niche prior to its confamiliar colonisation’.

According to Golani (1998) there are two cases that deserve further study. The populations of narrow-barred Spanish mackerel *Scomberomorus commerson* and the dragonet *Callionymus filamentosus* have dramatically increased at a time when the indigenous meager *Argyrosomus regius* (once of the most common commercial species in Israel) and three other confamilial to the *C. filamentosus* species, have almost completely disappeared.

Along the Lebanese rocky coasts, the Lessepsian migrants represent 13 % of the species richness and 19 % of the total abundance of individuals (Harmelin-Vivien et al. 2005), while almost half of the trawl catches on the Mediterranean coast of Israel consist of alien fish species (Golani and Ben Tuvia 1995). Similarly invading species have been found to comprise 62 % of the demersal fish biomass in the Gulf of Iskenderun, Turkey (Gücü and Bingel 1994).

As stated by Verlaque and Fritayre (1994), marine biological invasions are becoming a reality with sometimes devastating effects. At the same time, it is important to study the genotypic changes of new populations driven by natural selection through the interactions with indigenous populations and in response to the new abiotic environment.

Records of the Indo-Pacific and Atlantic fish species from the Mediterranean areas increase continuously. In this new environment population to creat of what will cause a positive or negative effects in species diversity have not yet gained certainty. How quickly can be chancy, and after effects of this transition to the species abundance, diversity and to ecosystem must be continuously monitored.

Table 1 shows the distribution of alien fish species to basins and localities in the Mediterranean Sea basin and the Black Sea Basin.

Table 1. Species number and distribution of alien fishes. Indo-Pacific (IP), Atlatntic (A), Boreal Atlantic (BA) and Pacific Ocean (PO) to the Mediterranean-Black Sea Basin. Y: Yes. Include in CIESM Atlas 2009 (online)

Species	O	Ae	MA	BS	EM	IS	TS	AlgS	AlbS	AdrS	LS	GL	GG	CIESM
Acanthurus monroviae Steindachner, 1876	A				+			+	+					Y
Aluterus monocerus (Linnaeus, 1758)	A								+					Y
Anarhichas lupus Linnaeus, 1758	A						+							
Arius parkii Günther, 1864	A				+									Y
Beryx splendens Lowe, 1934	A										+			Y
Carcharhinus altimus (Springer, 1950)	A				+			+						Y
Carcharhinus brachyurus (Günther, 1870)	A						+	+	+					
Carcharhinus falciformis (Müller & Henle, 1839)	A				+		+	+	+					Y
Cephalopholis taeniops (Valenciennes, 1828)	A								+					Y
Chaunax pictus Lowe, 1846	A						+					+		
Chaunax suttkusi Caruso, 1989	A						+						+	Y
Cheilopogon furcatus (Mitchill, 1815)	A												+	Y
Cyclopterus lumpus Linnaeus, 1758	A									+				Y
Diodon hystrix (Linneaus, 1758)	A						+							Y
Diplodus bellottii (Steindachner, 1882)	A					+			+					Y
Enchelycore anatina (Lowe, 1839)	A	+			+									Y
Entelurus aequoraeus (Linnaeus, 1758)	A					+				+				
Ephippion guttifer (Bennett, 1831)	A								+					
Fistularia petimba Lacepède, 1803	A								+					Y
Gaidropsarus granti (Regan, 1903)	A				+		+							
Galeocerdo cuvier (Peron and LeSueur, 1822)	A						+		+					Y
Galeoides decadactylus (Bloch, 1795)	A							+						
Galeus atlanticus (Vaillant, 1888)	A								+					
Gephyroberyx darwini (Johnson, 1866)	A				+			+						Y
Gobius couchi Miller & El-Tawil, 1974	A								+	+				
Halosaurus ovenii Johnson, 1863	A				+		+	+						Y
Hyperoglyphe perciformis (Mitchill, 1818)	A								+			+		
Laemonema latifrons (Holt & Byrne, 1908)	A								+			+		
Lampanyctus intricarius Tåning, 1928	A								+					
Lepidion guentheri (Giglioli, 1880)	A								+					
Lesueurigobius sanzi (de Buen, 1918)	A								+					
Lipophrys pholis (Linnaeus, 1758)	A								+					
Microchirus (Zevaia) hexophthalmus (Bennett,	A						+							Y
Microchirus azevia (de Brito Capello, 1867)	A								+					
Microchirus boscanion Chabanaud, 1926	A								+					Y
Mycteroperca rubra (Bloch, 1793)	A				+					+				
Nerophis lumbriciformis (Jenyns, 1835)	A								+					
Pagellus bellottii Steindachner, 1882	A				+			+	+				+	Y
Parablennius pilicornis (Cuvier, 1829)	A								+			+		
Parapristipoma octolineatum (Valenciennes, 1833)	A								+					

Species	O	Ae	MA	BS	EM	IS	TS	AlgS	AlbS	AdrS	LS	GL	GG	CIESM
Pinguipes brasilianus Cuvier and Valenciennes, 1829	A						+				+			Y
Pisodonophis semicinctus (Richardson, 1848)	A					+	+						+	Y
Pomadasis incisus (Bodwich, 1825)	A	+			+							+		
Pontinus kuhli (Bowdich, 1825)	A								+					
Pristis pectinata Latham, 1794	A				+				+					
Psenes pellucidus Lütken, 1880	A				+		+	+	+					Y
Pseudupeneus prayensis (Cuvier, 1829)	A								+					Y
Rhizoprionodon acutus (Rüppell, 1837)	A					+	+		+			+		Y
Scorpaena stephanica Cadenat, 1943	A								+					Y
Selene dorsalis (Gill, 1862)	A					+								Y
Seriola carpenteri Mather, 1971	A						+						+	Y
Seriola fasciata (Bloch, 1793)	A	+			+	+	+						+	Y
Seriola rivoliana Cuvier, 1833	A						+						+	Y
Serranus atricauda Günther, 1874	A								+					
Serrivomer brevidentatus Roule & Bertin, 1929	A								+					
Solea senegalensis Kaup, 1858	A							+	+			+	+	Y
Sphoeroides marmoratus (Lowe, 1839)	A						+		+					Y
Sphoeroides pachygaster (Müller and Troschel, 1848)	A	+			+	+	+	+	+	+	+	+	+	Y
Sphoeroides spengleri (Bloch, 1785)	A								+					
Sphyraena viridensis Cuvier, 1829	A				+	+		+		+			+	
Sphyrna mokarran (Rüppell, 1837)	A						+							Y
Squalus megalops (Macleay, 1881)	A							+	+					
Synaptura lusitanica (Capello, 1868)	A					+			+					Y
Tetrapturus georgei Lowe, 1841	A						+		+					
Torpedo fuscomaculata Peters, 18551	A				+									
Trachyscorpia cristulata *echinata* (Koehler, 1896)	A								+					Y
Umbrina canariensis Valenciennes, 1843	A								+					
Centrolabrus exoletus (Linnaeus, 1758)	B								+					Y
Gymnammodytes semisquamatus (Jourdain, 1879)	B					+	+		+					Y
Syngnathus rostellatus Nilsson, 1855	B				+				+					Y
Abudefduf vaigensis (Quoy ann Gaimard, 1825)	IP				+		+				+			Y
Alepes djedaba (Forsskål,1775)	IP	+			+									Y
Apogon fasciatus (White, 1790)	IP				+									
Apogon pharaonis Bellotti, 1874	IP	+			+									Y
Apogon queketti Gilchrist, 1903	IP				+									Y
Apogon smithi (Kotthaus, 1970)	IP				+									Y
Atherinomorus lacunosus (Forster in Bloch and Schneider, 1861)	IP	+			+	+								Y
Callionymus filamentosus Valenciennes, 1837	IP	+			+									Y
Champsodon nudivittis (Ogilby, 1895)	IP				+									
Coryogalops ochetica (Norman, 1927)	IP				+									Y
Crenidens crenidens (Forsskål,1775)	IP				+	+								Y

Species	O	Ae	MA	BS	EM	IS	TS	AlgS	AlbS	AdrS	LS	GL	GG	CIESM
Cyclichthys spilostylus (Leis and Randall, 1982)	IP				+									Y
Cynoglossus sinusarabici (Chabanaud, 1931)	IP				+									Y
Decapterus russelli (Rüppell,1830)	IP				+									Y
Dussumieria elopsoides Bleeker, 1849	IP				+									Y
Epinephelus coioides (Hamilton, 1822)	IP				+		+			+				Y
Epinephelus malabaricus (Bloch and Schneider,	IP				+									Y
Equulites klunzingeri (Steindachner, 1898)	IP	+			+	+				+			+	Y
Etrumeus teres (Dekay, 1842)	IP	+			+		+							Y
Fistularia commersonii Rüppell, 1835	IP	+			+	+	+	+		+			+	Y
Glaucostegus halavi (Forsskål, 1775)	IP				+									Y
Hemiramphus far (Forsskål,1775)	IP	+			+					+				Y
Heniochus acuminatus (Linnaeus, 1758)	IP			+										
Heniochus intermedius Steindachner, 1893	IP				+					+				Y
Herklotsichthys punctatus (Rüppell, 1837)	IP				+									Y
Himantura uarnak (Forsskål,1775)	IP				+									Y
Hippocampus fuscus Rüppell, 1838	IP				+									Y
Hyporhamphus affinis (Günther, 1866)	IP				+									Y
Iniistius pavo (Valenciennes, 1840)	IP	+			+									Y
Lagocephalus sceleratus (Gmelin, 1789)	IP	+												Y
Lagocephalus spadiceus (Linnaeus, 1758)	IP	+	+		+									Y
Lagocephalus suezensis Clark and Gohar, 1953	IP	+			+									Y
Liza carinata (Valenciennes, 1836)	IP				+					+				Y
Lutjanus argentimaculatus (Forsskål,1775)	IP				+									Y
Makaira indica (Cuvier, 1832)	IP						+				+			Y
Monotaxis grandoculis Forsskål, 1775	IP				+									
Muraenesox cinereus (Forsskål,1775)	IP				+									Y
Nemipterus japonicus (Bloch, 1791)	IP				+									
Nemipterus randalli Russell, 1986	IP				+									Y
Omobranchus punctatus (Valenciennes, 1836)	IP				+									Y
Oxyurichthys papuensis (Valenciennes, 1837)	IP	+			+									Y
Pampus argenteus (Euphrasen, 1788)	IP									+				
Papilloculipes longiceps (Ehrenberg in Valenciennes, 1829)	IP				+									Y
Parexocoetus mento (Valenciennes, 1846)	IP	+			+	+				+			+	Y
Parupeneus forsskåli (Fourmanoir & Guézé, 1976)	IP				+									
Pelates quadrilineatus (Bloch, 1790)	IP				+									Y
Pempheris vanicolensis Cuvier, 1831	IP	+			+	+							+	Y
Petroscirtes ancylodon Rüppell, 1838	IP	+			+									Y
Platax teira (Forsskål, 1775)	IP	+												Y
Platycephalus indicus (Linnaeus, 1758)	IP				+		+							Y
Plotosus lineatus (Thunberg, 1787)	IP				+									Y
Pomadasys stridens (Forsskål,1775)	IP				+		+							Y

Species	O	Ae	MA	BS	EM	IS	TS	AlgS	AlbS	AdrS	LS	GL	GG	CIESM
Priacanthus hamrur (Forsskål, 1775)	IP												+	
Pteragogus pelycus Randall, 1981	IP	+			+									Y
Pterois miles (Bennet, 1803)	IP				+									Y
Rachycentron canadum (Linnaeus, 1766)	IP				+									Y
Rastrelliger kanagurta (Cuvier, 1816)	IP				+									Y
Rhabdosargus haffara (Forsskål,1775)	IP				+									Y
Rhynchoconger trewavasae BenTuvia, 1993	IP				+									Y
Sargocentron rubrum (Forsskål,1775)	IP	+			+	+								Y
Saurida undosquamis (Richardson, 1848)	IP	+			+	+	+			+				Y
Scarus ghobban Forsskål, 1775	IP				+									Y
Scomberomorus commerson (Lacapede, 1800)	IP	+			+									Y
Siganus luridus (Rüppell, 1828)	IP	+			+	+	+			+		+	+	Y
Siganus rivulatus Forsskål,1775	IP	+			+	+	+			+			+	Y
Silhouetta aegyptia (Chabanaud, 1933)	IP				+									Y
Sillago sihama (Forsskål,1775)	IP	+			+									Y
Sorsogona prionota (Sauvage, 1873)	IP				+									Y
Sphyraena chrysotaenia Klunzinger, 1884	IP	+		+	+	+	+			+			+	Y
Sphyraena flavicauda Rüppell, 1838	IP	+			+									Y
Sphyraena obtusata Cuvier, 1829	IP			+	+									
Sphyraena pinguis Günther, 1874	IP	+			+									
Spratelloides delicatulus (Bennett, 1831)	IP				+									Y
Stephanolepis diaspros Fraser Brunner,1940	IP	+			+	+	+			+			+	Y
Synagrops japonicus (Doderlein, 1884)	IP						+				+			Y
Terapon puta (Cuvier, 1892)	IP				+									Y
Terapon theraps Cuvier, 1829	IP									+				Y
Tetrosomus gibbosus (Linnaeus, 1758)	IP				+									Y
Torquigener flavimaculosus Hardyand Randall,	IP	+			+									Y
Tylerius spinosissimus (Regan, 1908)	IP	+			+									Y
Tylosurus choram (Rüppell, 1837)	IP				+									Y
Tylosurus crocodilus (Péron & Lesueur, 1821)	IP	+												
Upeneus moluccensis (Bleeker, 1855)	IP	+			+	+								Y
Upeneus pori BenTuvia and Golani, 1989	IP	+			+	+								Y
Vanderhorstia mertensi Klausewitz, 1974	IP				+									
Zenopsis conchifer (Lowe, 1852)	IP					+						+		Y
Elates ransonnetti (Steindachner, 1877)	PO						+							Y
Liza haematocheila (Temminck and Schlegel,	PO	+	+	+										Y
Pagrus major (Temminck and Schlegel, 1843)	PO									+				Y
Tridentiger trigonocephalus (Gill, 1859)	PO			+	+									

(Ae: Aegean Sea, MA: Marmara Sea, Bs: Black Sea, EM: Eastern Mediterranean Sea, IS: Ionian Sea, TS: Tyrrhenian Sea, AlgS: Algerian Coasts, AlbS: Alboran Sea, AdrS: Adriatic Sea, LS: Liguran Sea, GL: Gulf of Lion, GG: Gulf of Gabes)

Acknowledgements

I would like to thank my colleague Prof.Dr. Bayram ÖZTÜRK for his contributions in various ways to this work.

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Received: 10.10.2009
Accepted: 13.12.2009