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Aquatic Invasions Records

Rapid assessment of the marine alien megabiota in the shallow coastal waters of the Greek islands, Paros and Antiparos, Aegean Sea

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Abstract

The shallow seabed off the Greek islands Paros and Antiparos was surveyed for the presence of alien megabiota during July 2011. Fourteen sites were surveyed by snorkeling at depths between 0 and 10 m. Eight alien species were recorded: *Caulerpa racemosa* var. *cylindracea*, *Halophila stipulacea*, *Pinctada radiata*, *Percnon gibbesi*, *Cassiopea andromeda*, *Aplysia dactylomela*, *Siganus luridus* and *Fistularia commersonii*. The first four species are new records for the islands; all eight species established populations in the study area. *Siganus luridus* was present in high numbers in all sites and may be considered as highly invasive. *Cassiopea andromeda* reappeared in the Aegean Sea after a hiatus of 55 years, reaching densities >20 individuals/m^2 at one site.

Key words: eastern Mediterranean, lessepsian invasions, biological invasions, Greece

Introduction

There is an uncontested increase in the number of alien marine species, most of which are Lessepsian migrants, in the Aegean Sea during the last decades (Zenetos et al. 2011). By December 2010, the number of recorded alien marine species in Greek waters was 237, of which 76 have been reported from the south Aegean, excluding the Dodekanisos area (Zenetos et al. 2011). With the exception of the Saronikos Gulf and Rhodes Island, which are systematically monitored for alien species, information on the occupancy and spatial distribution of alien marine species in the Aegean Sea is scattered. I report the results of a rapid assessment survey conducted in July 2011, with the aim to record the presence and establishment success of shallow-water aliens in Paros and Antiparos Islands (Kyklades Archipelago, south Aegean Sea).

Methods

Fourteen sites were randomly selected along the coastlines of Paros and Antiparos Islands (Figure 1) and surveyed for the presence of any alien species between 7 and 17 July 2011. Each site was surveyed by snorkeling during standardized one-hour transects along the coastline at depths between 0 and 10 m, and the presence of alien megabiota was recorded.

The establishment success of each species was assessed based on both the present survey and on previous records (Zenetos et al. 2009, 2011; ELNAIS 2011). Specifically, alien species were considered as established in Paros Island if at least two records had been reported on the island spread over time and space (at least three records for fish). Casual species are those which have been recorded only once (or no more than twice for fish) and are presumed to be non-established in the island. Invasive species were defined as those established aliens that have overcome biotic and abiotic barriers and are able to disseminate away from their area of initial introduction through the production of fertile offspring with noticeable impact, such as threat to the diversity or abundance of native species, the ecological stability of infested ecosystems, economic activities dependent on these ecosystems, and human health (Zenetos et al. 2005).

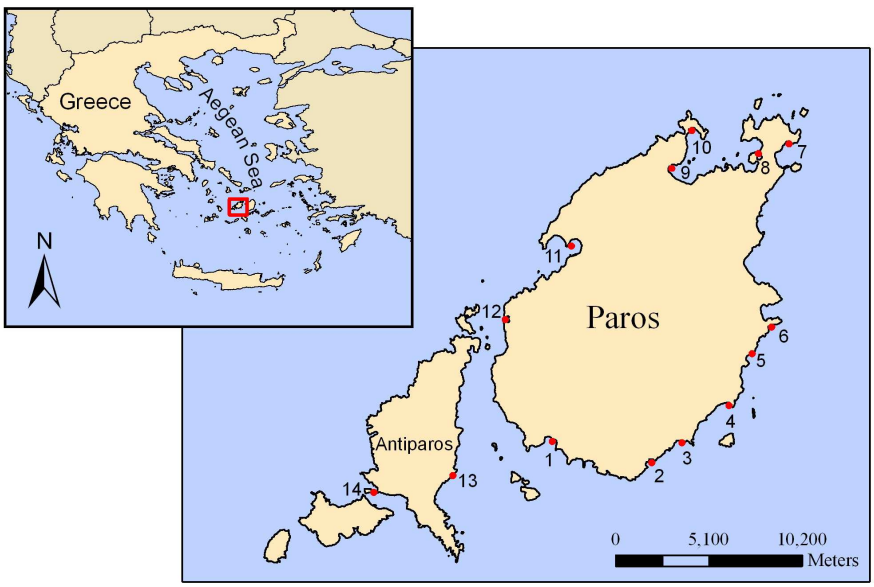

Figure 1: Map of the study area. The 14 survey sites are indicated with red dots.

Results and discussion

Eight alien marine species were recorded: the coarse sea grape *Caulerpa racemosa* var. *cylindracea*, the Halophila seagrass *Halophila stipulacea*, the upside down jellyfish *Cassiopea andromeda*, the rayed pearl oyster *Pinctada radiata*, the spotted sea hare *Aplysia dactylomela*, the sally lightfoot crab *Percnon gibbesi*, the dusky spinefoot *Siganus luridus*, and bluespotted cornetfish *Fistularia commersonii* (Table 1, Appendix 1). Among these, *C. racemosa* var. *cylindracea*, *H. stipulacea*, *P. radiata*, and *P. gibbesi* constitute first records from Paros and Antiparos Islands.

Caulerpa racemosa var. *cylindracea* invaded nearly the entire Mediterranean Sea within the last 20 years. Its high rate of expansion and threat to biodiversity are well known (Klein and Verlaque 2008; Katsanevakis et al. 2010a). However, in the shallow waters off Paros and Antiparos Islands, the species was present in 4 of the surveyed sites, and in 3 of them in very low abundance and low stolon size (Table 1).

Halophila stipulacea is one of the oldest Lessepsian migrants into the Mediterranean Sea, mainly found in the eastern basin but also in the southern Tyrrhenian Sea (Fritsch 1895; Lipkin 1975; Rindi et al. 1999). It is widely distributed and occasionally abundant in the South Aegean Sea but absent from the N. Aegean Sea, probably due to the lower seawater temperature (Tsiamis et al. 2010). The species is established in Paros and Antiparos Islands; patches of the species were recorded in six sites (Table 1), usually co-occurring with the native seagrass *Cymodocea nodosa* (Ucria) Ascherson. The closest records of the species in the southern Aegean are from the islands of Syros, Kimolos, Kythnos, and Tinos (>35 km away) (Tsiamis et al. 2010).

Cassiopea andromeda was the first Lessepsian scyphomedusan, first reported from Cyprus in the early 20th century (Maas 1903). Subsequently, Schäfer (1955) reported the presence of very young specimens on Neokameni, a small volcanic island near Santorini, Aegean Sea, where the medusae flourished in rocky pools with water temperatures reaching up to 36°C due to volcanic activity. After a hiatus of 55 years, it was recorded in Paros and S. Evvoikos (Zenetos et al. 2011). We observed it in two sites off Paros, including the site reported by Zenetos et al. (2011). In the latter site, the species was abundant, at places attaining densities of over 20 individuals/m^2. Gelatinous plankton outbreaks in the Mediterranean have become common, often with important impact on ecosystems and the economy, and thus monitoring initiatives are essential (Boero et al. 2009). The outbreak of *Cassiopea andromeda* in Paros should be closely

Table 1. Records of alien marine species from Paros and Antiparos Islands. Site coding corresponds to that of Figure 1. Establishment success refers specifically to the study area.

Species	Taxon	Sites (as in Figure 1)	Origin	Mode of introduction	Establish-ment success	Remarks
Caulerpa racemosa var. *cylindracea* (Sonder) Verlaque, Huisman et Boudouresque	Chlorobionta	8,9,10,14	SW Australia	aquarium	established	not very abundant except in site 8, stolon size was generally very small; first record in Paros/Antiparos
Halophila stipulacea (Forsskål) Ascherson	Streptobionta	1,5,10,11, 12,14	Red Sea	Suez	established	first record in Paros/Antiparos
Cassiopea andromeda (Forsskål, 1775)	Cnidaria: Scyphozoa	10,11	Indo-Pacific	Suez	invasive	there was an outbreak at site 11 with densities exceeding locally 20 individuals/m^2; previously reported by Zenetos et al. (2011)
Pinctada radiata (Leach, 1814)	Mollusca: Bivalvia	9,10,11,12, 14	Indo-Pacific	Suez	established	only six individuals in five sites; first record in Paros/Antiparos
Aplysia dactylomela Rang, 1828	Mollusca: Gastropoda	8	Circum-tropical	unknown	established	three individuals in one site; previously reported by Zenetos et al. (2007)
Percnon gibbesi (H. Milne Edwards, 1853)	Crustacea	2,5,6,12,13	Atlantic	Gibraltar/ aquarium	established	17 individuals in five sites; first record in Paros/Antiparos
Siganus luridus (Rüppell, 1829)	Osteichthyes	in all sites	Indo-Pacific	Suez	invasive	very abundant; previously reported by Lefkaditou and Petrakis (2010)
Fistularia commersonii (Rüppell, 1835)	Osteichthyes	2	Indo-Pacific	Suez	established	only two individuals in one site; previously reported by Lefkaditou and Petrakis (2010)

monitored. The species has also been reported from the eastern Mediterranean Sea (Galil et al. 1990; Özgür and Öztürk 2008) and Malta (Schembri et al. 2010).

Pinctada radiata has been present in the Mediterranean since 1874 (Antit et al. 2011). It is very abundant in the Levantine basin and in many sites of the south Aegean Sea (ELNAIS, 2011), being locally invasive. Although established in Paros and Antiparos (Table 1), it is rare (only six individuals were recorded).

The sea hare *Aplysia dactylomela* was first recorded in the Mediterranean in Lampedusa Island in 2002 and spread across the central and eastern Mediterranean (Pasternak and Galil 2010). In the Aegean Sea, it was first recorded from Rhodes in 2005, Paros Island in 2006, and later from other sites (Zenetos et al. 2007).

Since its first record in the Mediterranean Sea in 1999, *Percnon gibbesi* has expanded rapidly (Katsanevakis et al. 2011). The species was first observed on the Ionian coast of Greece in 2004 (Thessalou-Legaki et al. 2006), and subsequently spread widely, becoming locally invasive (Katsanevakis et al. 2010b, 2011). In the present study, it was found in 5 sites (Table 1).

The rabbitfish *Siganus luridus* was first reported in Greece in 1968 in the southern Dodecanese island of Tilos (Kavalakis 1968). It is very abundant in many areas of the south Aegean Sea but is not present in the northern Aegean (Katsanevakis and Tsiamis 2009). In the study area it constituted the dominant herbivore fish at all 14 sites. *S. luridus* is considered a high-impact invasive species in the eastern Mediterranean Sea (Katsanevakis et al. 2009; Zenetos et al. 2010). It has become dominant in many coastal areas, outcompeting the main native herbivores, *Sparisoma cretense* (Linnaeus, 1758) and *Sarpa salpa* (Linnaeus, 1758) (Bariche et al. 2004), and altering the community structure and the native food web of the rocky infralittoral zone (Sala et al. 2011). Based on a caging experiment, Sala et al. (2011) concluded that *Siganus luridus* and the congeneric alien *S. rivulatus* were able to create and maintain

barrens (rocky areas almost devoid of erect algae) and contribute to the transformation of the ecosystem from one dominated by lush and diverse brown algal forests to another dominated by bare rock. Extensive barrens were observed along the coastlines of Paros and Antiparos Islands, being the dominant status of all shallow rocky areas. Benthic algae was usually abundant on the uppermost wave-washed infralittoral zone and thus low nutrient concentration should be excluded as a plausible explanation for the existence of these barrens, leaving out overgrazing as the most plausible cause. The high abundance of *S. luridus* but also the high abundance of the sea urchins *Paracentrotus lividus* (Lamarck, 1816) and *Arbacia lixula* (Linnaeus, 1758) seem to be the main reasons for such overgrazing.

Fistularia commersonii was nicknamed the "Lessepsian sprinter" for its rapid spread and successful establishment in the Mediterranean Sea, within a decade of its first record (Karachle et al. 2004; Bodilis et al. 2011). The species is well established in the south Aegean Sea, including Paros (Lefkaditou and Petrakis 2010).

Four alien species recorded off Paros and Antiparos Islands were not found in the present survey: *Metasychis gotoi* (Izuka, 1902) (A. Zenetos, pers. comm.), *Etrumeus teres* (DeKay, 1848) (Kallianiotis and Lekkas 2005), *Lagocephalus sceleratus* (Gmelin, 1789) (Lefkaditou and Petrakis 2010; Zenetos et al. 2011) and *Stephanolepis diaspros* Fraser-Brunner, 1940 (Lefkaditou and Petrakis 2010; Zenetos et al. 2011).

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Appendix 1. Locations of the eight recorded alien species in Paros and Antiparos Islands. All sites were surveyed during July 2011.

Site No (as of Figure 1)	Geographic coordinates (WGS84)		Species
	Latitude, N	Longitude, E	
1	36.995	25.134	*H. stipulacea, S. luridus*
2	36.984	25.194	*P. gibbesi, S. luridus, F. commersonii*
3	36.993	25.211	*S. luridus*
4	37.008	25.244	*S. luridus*
5	37.033	25.259	*H. stipulacea, P. gibbesi, S. luridus*
6	37.048	25.271	*P. gibbesi, S. luridus*
7	37.137	25.289	*S. luridus*
8	37.132	25.268	*C. racemosa, A. dactylomela, S. luridus*
9	37.129	25.220	*C. racemosa, P. radiata, S. luridus*
10	37.142	25.232	*C. racemosa, H. stipulacea, C. andromeda, P. radiata, S. luridus*
11	37.092	25.149	*H. stipulacea, C. andromeda, P. radiata, S. luridus*
12	37.058	25.107	*H. stipulacea, P. radiata, P. gibbesi, S. luridus*
13	36.980	25.070	*P. gibbesi, S. luridus*
14	36.976	25.022	*C. racemosa, H. stipulacea, P. radiata, S. luridus*