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Records of alien marine species in the shallow coastal waters of Chios Island (2009)

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Abstract

The shallow coastline of Chios Island was surveyed for the presence of any alien marine benthic species, during August 2009. Fourteen randomly selected sites were surveyed by snorkeling during standardized one-hour transects at depths between 0 and 10 m, and the presence of all identified alien benthic species was recorded. Six alien species were identified: Asparagopsis taxiformis, Caulerpa racemosa var. cylindracea, Stypopodium schimperi, Halophila stipulacea, Percnon gibbesi, and Siganus luridus. The green alga C. racemosa var. cylindracea was found in high densities in all the surveyed sites and was characterized as invasive in the island. The brown alga S. schimperi, the crab P. gibbesi, and the fish S. luridus sustain established populations in the area. For three of the recorded marine alien species (S. schimperi, P. gibbesi, and S. luridus), Chios Island seems to be the northernmost margin of their geographical range in the Aegean Sea.

Keywords: Alien marine species; Biological invasions; Chios Island; Eastern Mediterranean; Geographical range.

Introduction

Biological invasions in marine habitats represent a recognized global threat with a strong impact on biodiversity and local economies (PIMENTEL *et al.,* 2005; EEA, 2007). In the Mediterranean Sea, alien marine species are a growing concern, with at least 925 alien taxa having being recorded by March 2009 (ZENETOS, 2009). Many of them exhibit aggressive invasive behaviour, resulting in alterations to ecosystem balance and food chains, biodiversity loss, and a negative impact on human activities such as fisheries, tourism, and aquaculture (STREFTARIS & ZENETOS, 2006). Fouling and ballast water transportation along shipping lines, aquaculture, and the aquarium trade seem to favour alien species introduction into the Mediterranean Sea, although for the Eastern Basin the opening of the Suez Canal in 1869 seems to be the main vector for alien immigration (STREFTARIS *et al.,* 2005). In Greece, there has been an uncontested increase of alien marine species during recent decades, most of which are Lessepsian immigrants (PANCUCCI-PAPADOPOULOU *et al.,*

2006). For most of them the geographical range continues to expand, a phenomenon which could be attributed to global warming and the tropicalization scenario (BIANCHI, 2007; OCCHIPINTI-AMBROGI, 2007).

Consequently, in recent years there has been a strong interest from the scientific community and international organisations in monitoring biological invasions in the Mediterranean Sea, assessing their impact on the native flora and fauna populations and on local economies, investigating the causes and patterns of alien introductions, and proposing management measures (CBD, 2000; EC, 2006, 2008; EEA, 2006). Towards that direction, this study aims to provide data on the occurrence of marine alien species in the island of Chios (Aegean Sea, Greece). Chios Island is located in the North Aegean, near the border between the North Aegean basin and the Central Aegean plateau. These two subareas of the Aegean Sea have many geological, hydrological, and ecological dissimilarities (ARVANITIDIS *et al.,* 2002), and thus Chios Island has its importance as a transitional area.

Methods

Fourteen sites were randomly selected on the coastline of Chios Island (Fig. 1) and surveyed for the presence of any alien marine benthic species during August 2009. Each site was surveyed by snorkeling dur-

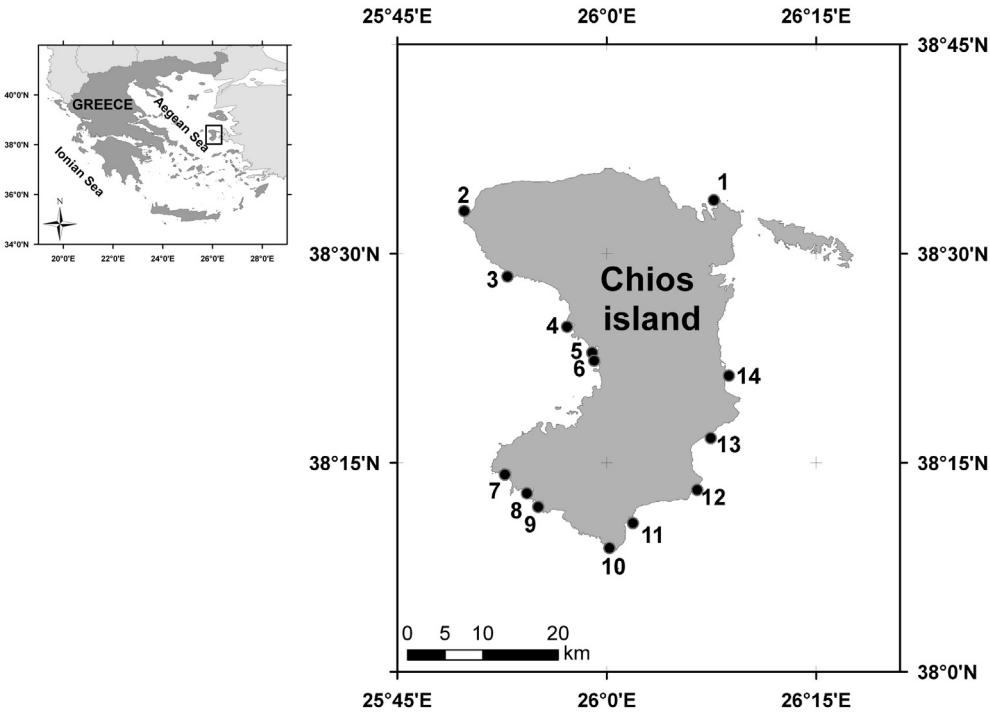

Fig. 1: Map of Chios Island with the fourteen survey sites indicated.

ing standardized one-hour transects along the coastline at depths between 0 and 10 m, and the presence of all identified alien benthic species was recorded.

The establishment success of each species was assessed based on both the present survey and on previous records (ZENETOS *et al.,* 2009) and is given according to the terminology proposed in ZENETOS *et al.* (2006). Specifically, alien species were considered as *established* in Chios 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 having been recorded only once (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.

Results and Discussion

Six alien marine species were identified: *Asparagopsis taxiformis, Caulerpa racemosa* var. *cylindracea, Stypopodium schimperi, Halophila stipulacea, Percnon gibbesi,* and *Siganus luridus* (Table 1).

Caulerpa racemosa var. *cylindracea* was found in all sites and was locally very abundant, forming extensive mats in soft-bottom areas or completely covering large surfaces on rocky bottoms. *C. racemosa* var. *cylindracea* has exhibited an excessive rate of proliferation and has invaded the entire basin of the Mediterranean Sea within the last 18 years; the rate of expansion for this taxon appears to be among the most significant ever recorded for an invasive species (KLEIN & VERLAQUE, 2008). It has stolons that can quickly elongate, and easily overgrow other macroalgal (PIAZZI *et al.,* 1997) or invertebrate species (KRUŽIĆ *et al.,* 2008; BALDACCONI & CORRIERO, 2009) and poses a substantial threat to biodiversity. Due to its high abundance in Chios Island and its noticeable impact on the diversity and abundance of native species, it was characterized as an invasive species in the island.

Asparagopsis taxiformis is an alien red alga with a heteromorphic diplohaplontic life cycle, exhibiting invasive behaviour on several coasts of the Mediterranean basin (FLAGELLA *et al.,* 2003). At least two cryptic taxa seem to coexist under the name of *A. taxiformis* in the Mediterranean Sea (NÍ CHUALÁIN *et al.,* 2004; ANDREAKIS *et al.,* 2007), with the Greek populations probably originating from the Indo-Pacific Ocean, although their precise origin and status is under molecular examination (N. ANDREAKIS, pers. com.). In Greece, it was first reported in 2006 (TSIAMIS & PANAYOTIDIS, 2007); however, since then, there have been numerous records from various coasts of both the Aegean and Ionian Sea (TSIAMIS *et al.,* in press), occasionally exhibiting invasive behavior (TSIAMIS *et al.,* 2009). However, in Chios Island there was only one thallus of the gametophytic phase recorded. The tetrasporophytic phase is microscopic and should have been overlooked during the survey.

The Indo-Pacific brown alga *Stypopodium schimperi* was introduced into the Mediterranean Sea in the early 90's (VERLAQUE & BOUDOURESQUE, 1991), occasionally exhibiting invasive behavior on the Levantine coasts (BOUDOURESQUE & VERLAQUE, 2002). First found in Greece by SARTONI & DE BIASI (1999) in the

Table 1
Records of alien marine species from Chios Island. Site coding corresponds to that of Figure 1. Establishment success refers specifically to Chios Island and not to the whole Aegean Sea.

Species	Taxon	Sites	Origin	Mode of introduction	Establishment Success	Remarks
Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon	Rhodobionta	9	Indo-Pacific	Suez/shipping	Casual	only a single patch
Caulerpa racemosa var. *cylindracea* (Sonder) Verlaque, Huisman et Boudouresque	Chlorobionta	in all sites	SW Australia	aquarium	Invasive	locally very abundant at all kind of substrates
Stypopodium schimperi (Buchinger ex Kützing) Verlaque *et* Boudouresque	Chromobionta	4, 5, 6, 9, 10	Red Sea	Suez	Established	quite abundant in site 4
Halophila stipulacea (Forsskål) Ascherson	Streptobionta	5	Red Sea	Suez	Casual	a single patch in one site
Percnon gibbesi (H. Milne Edwards, 1853)	Crustacea	5, 10	W Atlantic	Gibraltar	Established	two individuals in two sites
Siganus luridus (Rüppell, 1829)	Osteichthyes	9, 10, 12	Indo-Pacific	Suez	Established	one individual in each of sites 9 and 10, eight individuals in site 12

South Aegean Sea, it has presented a rapid expansion along Greek coasts during recent years (BARDAMASKOS *et al.,* 2008), and invasive behavior has even been recorded (TSIAMIS *et al.,* in press). In Chios Island several thalli have been detected which correspond to the northernmost records of the species in Greece, indicating a range expansion towards the North Aegean Sea.

Halophila stipulacea is one of the oldest Lessepian immigrants in the Mediterranean Sea, known since the end of the 19th century (FRITSCH, 1895). This seagrass is mainly restricted to the eastern basin, although there are several records of gradual expansion towards the western basin (LIPKIN, 1975; RINDI *et al.,* 1999). In Greece, it presents a broad distribution in the South Aegean Sea, occasionally through high abundances (HARITONIDIS, 1989), although it is absent from the far N. Aegean Sea, probably due to the lower seawater temperature. In Chios Island there was only one single patch found on a sandy bottom.

Percnon gibbesi is a primarily algivorous crab of the shallow infra-littoral rocky shores. It is a widely distributed species, its range extending from California to Chile, Florida to Brazil, and Madeira to the Gulf of Guinea (MANNING & HOLTHUIS, 1981). It was first observed in the Mediterranean Sea in 1999 in Linosa Island, Sicily Strait (RELINI *et al.,* 2000), most probably transported by ship-

ping (GALIL *et al.,* 2002), although larval drift/adult movement has also been suggested as a vector of arrival of the species (PIPITONE *et al.,* 2001). Its further spreading in the Mediterranean basin is probably mainly via larval transport by currents, although vessels may also contribute to its dispersal (CANNICCI *et al.,* 2006; THESSALOU-LEGAKI *et al.,* 2006; CROCETTA & COLAMONACO, 2008). In Greece, it was first found on the NE coast of the Messiniakos Gulf at distances ranging from 2 to 8 km from the port of Kalamata, in March 2004 (THESSALOU-LEGAKI *et al.,* 2006) and was subsequently (in 2005) observed in Crete, Antikythira, and Rhodes Island (CANNICCI *et al.,* 2006; THESSALOU-LEGAKI *et al.,* 2006). It was also recently observed (summer 2009) in many sites in the eastern Saronikos Gulf (pers. obs.). The present study records the range extension of the species northwards and provides evidence of its further expansion and establishment in the Aegean Sea. *P. gibbesi* was found in two sites in Chios Island (Table 1), which are the northernmost known sites of occurrence of the species in the Aegean Sea. *P. gibbesi* is considered as the most invasive decapod species introduced into the Mediterranean Sea. Its population in the Mediterranean Sea expands rapidly and it has the ability to establish itself in large numbers in both anthropogenically impacted areas, such as ports, and in natural habitats (CANNICI *et al.,* 2006; THESSALOU-LEGAKI *et al.,* 2006).

The dusky spinefoot *Siganus luridus* is a herbivorous fish that feeds mainly on coarse brown algae, and thrives in rocky shallow habitats covered with vegetation (GOLANI *et al.,* 2002; BARDAMASKOS *et al.,* 2008). It was first reported in the Mediterranean Sea in 1931 (GRUVEL, 1931), and in Greece in 1968 in Tilos Island (KAVALAKIS, 1968). It has become dominant in many eastern Mediterranean coastal areas, competes with the main native herbivores, *Sparisoma cretense* (Linnaeus, 1758) and *Sarpa salpa* (Linnaeus, 1758) (BARICHE *et al.,* 2004), and has altered the community structure and the native food web along the Levantine rocky infralittoral zone (GALIL, 2007). *S. luridus* is considered invasive in other parts of the Mediterranean Sea, especially in the Levantine Sea (STREFTARIS & ZENETOS, 2006), where, together with *S. rivulatus* (Forssk å l, 1775), it belongs among common commercial fish (GOLANI, 1993). Although it presents high abundance in several areas of the Greek Seas (BARDAMASKOS *et al.,* 2008) low population densities were observed in Chios Island, and thus the species was not classified as invasive in the island. The species was previously reported from Chios Island (BEN-TUVIA, 1977) and from Izmir (BEN-TUVIA, 1972), which is at approximately the same latitude as Chios Island. No records at higher latitudes in the Aegean Sea have been reported, and consequently this seems to be the northernmost margin of the geographical range of the species in the Aegean Sea.

For three of the recorded marine alien species (*Stypopodium schimperi, Percnon gibbesi,* and *Siganus luridus*), Chios Island seems to be the northernmost margin of their geographical range in the Aegean Sea. However, similar surveys in other northern sites (e.g., Lesvos and Limnos Islands) are missing and further research is needed to properly assess the range of expansion of marine alien species in the Aegean Sea. A large-scale similar survey covering the whole Aegean Sea would be useful, as it would uncover the current status of alien invasions and would constitute a baseline for assessing the rates of expansion of the occupancy of marine alien species.

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