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Backdating the confirmed presence of *Siphonaria pectinata* (Gastropoda: Siphonariidae) along the northern Mediterranean shores, with a discussion on its status in the basin

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Abstract

Background: The known historical range of *Siphonaria pectinata* in the Mediterranean basin is unclear so far. Confirmed records come from the Strait of Gibraltar, the African coastline up to Algeria and the Spanish coastline up to Murcia/Valencia area, whilst all those published from additional Mediterranean areas are affected by a high degree of uncertainty. In addition, this taxon occurs in Tunisia (northern shores up to Cap Bon area), Greece (Saronikos Gulf) and Croatia (Split area), where it has been sighted only recently. The three latter records were widely discussed in the current literature due the possible rationale at the basis of the absence of past sightings, and there is a general agreement in considering that the Greek and Croatian records are the result of a human induced introduction.

Results: A literature overview on the Mediterranean distribution and alien status *sensu lato* of the striped false limpet *Siphonaria pectinata* is here provided for the first time. Concomitantly, the presence of this taxon in Croatia is here shown to date back to 1978 on the basis of material preserved in private collections, and at least to 1960–70 on the basis of local knowledge of Croatian malacologists and shell sizes of specimens collected in 1978. The findings reported in the present paper overall backdate by ca. 30–40 years the presence of this taxon in the Adriatic Sea, and also constitute the first confirmed record of the striped false limpet from the entire northern Mediterranean shores.

Conclusions: The present note corroborates the key role of citizen scientists in observing and recording variations in local biodiversity, as well as in contributing new and past distributional data, and concomitantly suggests the necessity of further work in the Mediterranean area to assess the local species distribution and pattern of spread before its designation as alien *sensu lato*.

Keywords: *Siphonaria pectinata*, Mollusca, Croatia, Adriatic sea, Citizen science, Alien species *sensu lato*

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Background

Specimens belonging to the complex of the striped false limpet *Siphonaria pectinata* (Linnaeus, 1758) *sensu lato* are marine gastropods of the family Siphonariidae Gray, 1827. They are characterized by an oval, limpet-like external shell with several radial brown stripes and a white to cream-tan color. Examined from above, the apex of their shells is slightly off-center, while the underside exhibits a C-shaped muscle scar (sometimes indistinct) opening to one side. Originally described from the Mediterranean Sea (see White and Dayrat, 2012), *S. pectinata* has been often considered to be distributed along the western and eastern Atlantic shores, with sporadic records from the western Pacific (e.g. Voss, 1959; Puizina et al., 2012 among others). However, Giribet and Kawauchi (2016) have recently shown that the former *S. pectinata sensu auctores* was a complex of three different species: *S. naufragum* Stearns, 1872, occurring in Florida and the Gulf of Mexico, *S. placentula* Menke, 1853, only known from the Cape Verde Archipelago, and *S. pectinata*, restricted to the eastern Atlantic up to Gabon and the Mediterranean Sea.

The known historical range of *S. pectinata sensu stricto* in the Mediterranean basin is unclear and widely debated. It included the Strait of Gibraltar, the African coastline up to Algeria (Monterosato, 1877, as *Siphonaria algesirae*; Pallary, 1900, as *Siphonaria mouret*) and the Spanish coastline up to Murcia/Valencia area (Hidalgo, 1917; Nicolay, 1980; Gofas, 2011), although its presence in wider areas has been often stated by other authors (see below). Unfortunately, the presence of unsubstantiated records in the old literature (usually from 1700 to around 1980) is well known to taxonomists and conservation biologists, and even some highly cited species in the literature may have never lived in the area where they have been (sometimes widely) recorded in the past. As an example, this may be the case of Locard (1886), who reported *S. pectinata* from the Mediterranean France (Port-Vendres), and later on Germain (1913) accepted that record while reviewing molluscan fauna from France. No recent records of *S. pectinata* from France exist, and previous records should be considered as doubtful. Another example is that of Pallary (1912), who recorded a *Siphonaria* sp. from Alexandria (Egypt), suggesting its possible identification as *S. algesirae* (= *S. pectinata*). However, the absence of *Siphonaria* material from the Pallary's collection led Nicolay (1980) to conclude that it may have been most likely the alien *Siphonaria laciniosa* (Linnaeus, 1758), considered by the author as widespread along the eastern Mediterranean shores. Voss (1959) subsequently suggested an overall distribution of *S. pectinata sensu lato* limited by the 55 °F isocryme, and reported its presence in the Mediterranean from Spain up to Barcelona area and along the northern African shores up to Alexandria (Egypt). Few later, Morrison (1972) excluded its presence at the east of Algiers (Algeria), but did not discuss Pallary (1912)

and Voss (1959) statements. No confirmed or recent records are known from the Mediterranean Sea east of Cap Bon area in Tunisia (see below), and the careful analysis of concrete materials from areas of original records may shed light on these questionable distribution data. On the contrary, among very recent confirmed records, Enzeroß and Enzeroß (2001) first recorded this species in Tunisia, soon followed by Antit et al. (2008). *Siphonaria pectinata* overall distribution in Tunisia seems to be now restricted to the country northern shores up to Cap Bon area (Enzeroß and Enzeroß, 2001; Antit et al., 2008; Tlig-Zouari et al., 2010; Boukhicha et al., 2015) but, as a matter of fact, known records from the area are all quite recent. Whilst Tunisian records seems to be more or less in continuity with the known historical distribution of the taxon, *S. pectinata* is also known in the Mediterranean Sea from two very distant geographic spots: the Saronikos Gulf (Greece), where its confirmed presence dates back >30 years (1979: Nicolay, 1980) and the Split area (Croatia), where its first record occurred in 2003 (Despalatović et al., 2008).

Records from these three latter countries have been widely discussed in the recent years, mostly due to uncertainties regarding possible rationale at the basis of the absence of past sightings. Range expansion from the nearby coastlines was originally suggested to explain its occurrence in Tunisia (Antit et al., 2008), although Gofas (2011) considered it later as “introduced”. Boukhicha et al. (2014) also listed it first among alien molluscs from Tunisia, but then considered it as a “non-native” species (Boukhicha et al., 2015), despite the fact that they considered it as arrived in Tunisia through a natural progression enhanced by climate change rather than a ship transport or other anthropogenic factors. Being “non-native” widely considered a synonym of “alien”, and therefore implying a human-mediated introduction (see Occhipinti-Ambrogi and Galil, 2004), the use of this term in defining this taxon seems inappropriate, at least in the context used by Boukhicha et al. (2015). Finally, Ounifi-Ben Amor et al. (2016) considered again Tunisian records as a range expansion. Several authors also concluded that the recent records from Greece (Gofas and Zenetos, 2003; Antit et al., 2008; Zenetos et al., 2010; Gofas, 2011; Boukhicha et al., 2015) and Croatia (Gofas and Zenetos, 2003; Antit et al., 2008; Despalatović et al., 2008; Zenetos et al., 2010; Puizina et al., 2012; Pećarević et al., 2013; Boukhicha et al., 2015; Marchini et al., 2015) may be the result of a human induced introduction rather than to a natural occurrence. As a matter of fact, the Cap Bon area (Strait of Sicily) constitutes a major hydrodynamical, biogeographical and geological transition zone within the Mediterranean Sea, and the major West–East transition zone (Bianchi, 2007; Azzurro et al., 2014). In addition, no fossil records are known from the European area, the species inhabits

the intertidal attached to hard substrates, therefore suggesting its being easy to spot, and finally possesses a short larval stage (Ocana and Emson, 1999). To this, it should be added that historically known eastern Mediterranean populations, and even the recently discovered Tunisian one(s), are indeed too far away for natural range extension to operate for the Greek and Croatian records.

During my research on alien and native molluscan species in the Mediterranean Sea, I had the opportunity to analyze two potentially interesting *S. pectinata* lots from Croatia preserved in two Italian private collections. The aim of the present note is therefore to publish such distributional and temporal data as to backdate the first confirmed record of this taxon from Croatia and the northern Mediterranean shores, and to discuss its alien status *sensu lato* in the abovementioned countries in the light of the bibliographic researches held and the unpublished data reported herein.

Methods

Alien status *sensu lato* and taxonomy

The definition of *alien species* (non-native, non-indigenous, exotic) used herein follows the European Commission (EC, 2008): “a species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce”. Alien species were often divided from native Mediterranean species considered to have been transferred by human activities to new Mediterranean localities, and these species were labelled as *intra-Mediterranean transfers* (see Gofas and Zenetos, 2003), *intra-Mediterranean introductions* (see Zenetos et al., 2010), *Mediterranean translocations* (see Crocetta et al., 2013) and *local*

introductions (see Marchini et al., 2015), among the most well known definitions in the Mediterranean area.

The taxonomy has been updated following the World Register of Marine Species (WoRMS (World Register of Marine Species) Editorial Board, 2016).

Published and unpublished data

Indexed and grey literature was surveyed for Mediterranean records, particularly that concerning faunistics, taxonomy and biogeography. The unpublished data reported in the present paper were searched in private collections of Mediterranean malacologists, and are based on specimens collected manually during holidays or shelling trips to the sampling localities. Once potentially interesting lots from Croatia were located in two Italian private collections (see below), additional details/unpublished data were also asked to local (Croatian) malacologists as a confirmation of the abovementioned records. Voucher specimens were measured to the nearest millimeter using vernier calipers (sizes reported in mm as maximum height × maximum width), and are shown in Fig. 2.

Results

As mentioned above, two noticeable lots of *Siphonaria pectinata* (Linnaeus, 1758) from Croatia were found in two Italian private malacological collections. Two specimens were sampled at sea level on rocks in Mljet Island (Croatia; ca. 42°44'N, 17°36'E) by Stefano Pace (Stefano Pace collection - Pescara, Italy) in August 1978 (Figs. 1, and 2). The presence of further specimens cannot be excluded, as the author did not give a particular importance to the finding. In August 1985, more than 200 specimens were sampled at sea level on rocks in Brač Island (43°23'06"N, 16°33'15"E) and Hvar Island (43°10'10"N, 16°26'29"E) by Carlo Smriglio (Carlo Smriglio collection - Rome,

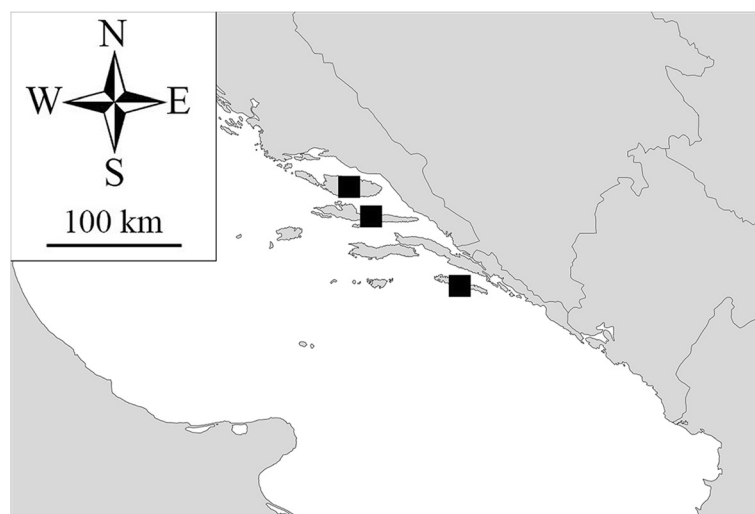


Fig. 1 The Adriatic Sea, with the three Croatian localities (black squares) where *Siphonaria pectinata* (Linnaeus, 1758) was found in 1978 and 1985

Italy) (Figs. 1, and 2), who soon identified this species in the field. The latter malacologist, who recognized the importance of this record, collected a large number of specimens for possible morphometric comparisons between the Croatian and the other Mediterranean populations, which were unfortunately never carried out. Additional details were further asked to three Croatian malacologists (Jakov Prkić and Neven Lete - Split, and Alen Petani - Zadar), who confirmed records held by the two Italian malacologists and declared the species as common and widely distributed in Split and Makarska (Croatia) since at least 1960–70, having collected local shells when young. Taking also into account shell growth of the species (see Ocana, 1997, 2003), specimens found in 1978 should have settled there around a decade before, therefore confirming previous statements. According to local knowledge of the three Croatian malacologists mentioned above, *S. pectinata* is now widely distributed from Šibenik to Makarska, as well as in the main Dalmatian Islands of the Split area.

Discussion

Main result of findings held in the two abovementioned private collections is that unpublished data hereby reported first backdate by ca. 30–40 years the first confirmed presence of *S. pectinata* in Croatia, furthermore

making 1960–70 the first confirmed record from the whole northern Mediterranean shores. This fits quite well the results reported by previous authors: in fact, while recording this species since 2003, Despalatović et al. (2008) hypothesized that it likely inhabited the whole area since previous years, mostly based on the local abundance noticed during the surveyed period. The sightings hereby reported also confirm that *S. pectinata* specimens may be easily overlooked by non molluscan-specialists due to similarities with *Patella* specimens. This has been already shown by Boukhicha et al. (2015) for Tunisian shores on the basis of both careful literature search and shell sizes, and in this view, even first records of *S. pectinata* from Greece and Tunisia come from amateurish activities (Nicolay, 1980; Enzeroß and Enzeroß, 2001).

No ecological studies on *Siphonaria pectinata* (Linnaeus, 1758) have been made along the northern Mediterranean shores so far, although Despalatović et al. (2008) reported an increasing abundance of this species in the Split area during 2003–2008, dominating over other native *Patella* species. The same holds for specimens collected in 1978 (S. Pace, pers. comm.) and for empirical observations held by the Croatian malacologists, who only stated its common status and wide distribution in the area. However, in 1985, a conspicuous number of egg mass ribbons was noticed

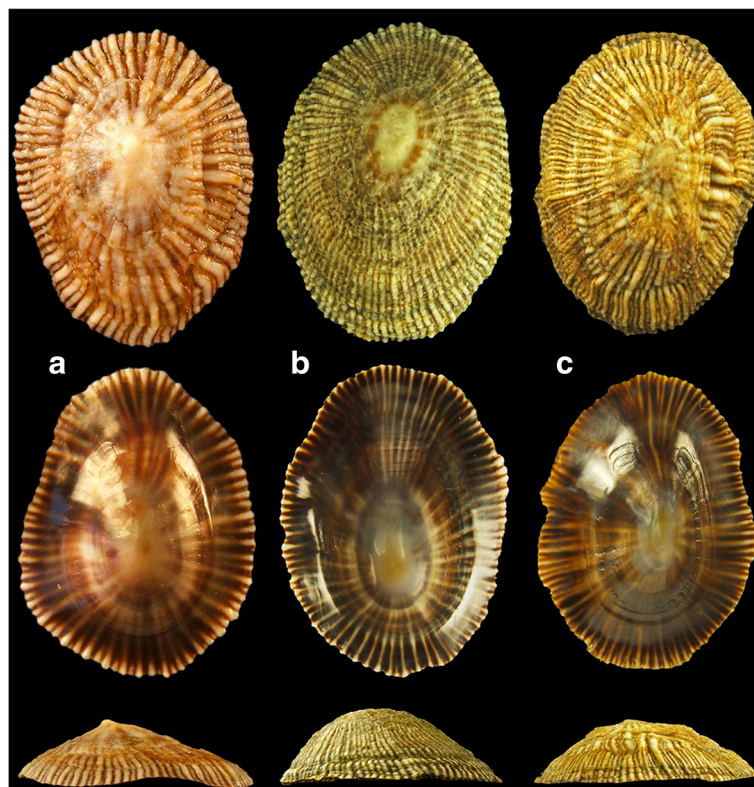


Fig. 2 a-c Top: dorsal, middle: ventral, bottom: lateral views of shells of *Siphonaria pectinata* (Linnaeus, 1758) (not to scale). **a** Mljet Island (17.9 × 13.5 mm) - 1978. **b** Brač Island (31.9 × 29.5 mm) - 1985. **c** Hvar Island (24.6 × 18.1 mm) - 1985

attached to *Siphonaria* shells and neighbourings in August (C. Smriglio, pers. comm.), therefore suggesting that spawning period of Croatian specimens may match that already reported from other areas in the eastern Atlantic-Mediterranean Sea (e.g. Ocana and Emson, 1999). However, Puizina et al. (2012) stated that *S. pectinata* may be able to replace local *Patella* populations. On the contrary, empirical observations carried out in Croatia suggest that *S. pectinata* is able to co-occur at least for decades with *Patella* species, as already known from other Mediterranean and Atlantic areas, and that further studies are therefore needed to understand niche partitioning in these morphologically similar species.

The new records reported here immediately raise questions about the correct timing of appearance and origin of this taxon in Croatia. Indeed Croatian shores have not been widely explored in the past by malacologists as for other Mediterranean countries, and therefore an earlier presence of this taxon in the eastern Adriatic Sea may have simply gone overlooked. However, a well-known local malacologist, Spiridione Brusina, widely wrote on Croatian molluscan fauna in the past, and never recorded the striped false limpet from the area. A careful study of specimens held at the Croatian Natural History Museum confirmed the absence of *S. pectinata* in his former collection, even misidentified as a *Patella* species (Jakov Prkić, unpublished data). Unfortunately, Brusina mostly sampled in the Zadar area, where the species does not seem to be present even now (Alen Petani & Jakov Prkić, pers. comm.), and therefore the absence of this taxon in his collection cannot be considered conclusive with regards to the very recent confirmation from Croatia.

Puizina et al. (2012) also tried to examine the Croatian population using molecular techniques, whilst no such studies have been carried out so far on specimens from Greece and Tunisia. The authors found wide genetic variability within the analyzed Croatian population, contrarily to what one could usually expect for recently introduced taxa, and explained it with the possibility of a larger founder population or the presence of several successful introduction events. Indeed the Split and Saronikos areas may be easily considered as possible hotspots of alien species introduction in the Mediterranean Sea due to the presence of harbors and sheltered areas. However, although a human mediated introduction in the Adriatic may be possible, it may indeed have happened earlier than the recent records reported by Despalatović et al. (2008), and at least in 1960–70s.

Conclusions

The key role of amateur malacologists in observing and recording variations in local biodiversity, as well as in contributing to new distribution data, is still central in the Mediterranean Sea (e.g. see Crocetta, 2011, 2012; Crocetta

and Tringali, 2015), and is here confirmed by the present paper. However, as highlighted in the literature review carried out, the true Mediterranean distribution of this species still remains unknown or partially questionable, and lack of past and recent field studies along the Mediterranean shores of Libya and Egypt, as well as under-sampling along the northern Tunisian coastline, have also widely contributed to the statements discussed in the introduction. In this view, even the arrival of the species in the Aegean and Adriatic Sea throughout natural dispersal may be possible and cannot be ruled out at all, especially when its presence in the area is backdated as in the present study and when wide areas of the Mediterranean Sea remain unexplored. Before the definitive assignment of the species as an alien *sensu lato* in Tunisia and the whole northern Mediterranean shores, there is therefore a definite need of further field investigation to assess the species current distribution, and of molecular studies to evaluate the origin and possible vectors of introduction of *S. pectinata* along the Mediterranean shores, particularly its northern parts.

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Competing interests

The author declares that he has no competing interests.

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