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Marine alien Mollusca in the Gulf of Trieste and neighbouring areas: a critical review and state of knowledge (updated in 2011)

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The state of knowledge on marine alien molluscan species from the Gulf of Trieste and neighbouring areas is presented based on a critical review of records compiled from an extensive literature survey and from unpublished data obtained from 2006 to 2011, and enriched by older material preserved in private collections. Based on the IUCN definition of 'alien', 13 valid alien molluscan taxa (3 Gastropoda and 10 Bivalvia) are reported here, for each of which the following information (collected up to August 2011) is provided: published and unpublished records from the coastal and offshore territorial seawaters of the Gulf of Trieste and neighbouring areas, including lagoons; establishment status; vector(s) of introduction. The area was characterized by the presence of eight established alien species, while another four were considered as casual and one was, with caution, considered not established. Specimens of Anadara transversa *(Say, 1822) and* Limnoperna securis *(Lamarck, 1819) are first reported here from the Gulf of Trieste, thus reaching the extreme northern point of the Mediterranean Sea. Old distribution data on* Mercenaria mercenaria *(Linnaeus, 1758) and* Mya arenaria *Linnaeus, 1758 are considered unreliable, also according to the recent literature. Accurate analysis of bibliographic data as well as re-identification of specimens preserved in private collections or collected from the same published sampling sites led to the exclusion of A*ssiminea grayana *Fleming, 1828 and* Conomurex persicus *(Swainson, 1821) from the resident fauna of the Gulf of Trieste. Concerning* Arcuatula senhousia *(Benson in Cantor, 1842), its first record from Slovenia came from bibliographic misreading, so that the original record of this bivalve from the area is considered more recent. Finally, natural dispersal accounts for 46% of the plausible vectors of introduction, while shipping/maritime transport and aquaculture for 23%.*

Key words: Mediterranean Sea, Adriatic Sea, Gulf of Trieste, Marine Mollusca, Alien species

INTRODUCTION

Biological pollution is recognized worldwide as one of the main threats to biodiversity, the economy and human health (ELLIOTT, 2003). The opening of the Suez Canal in 1869 has led to the colonization of the Mediterranean Sea by a large number of tropical/subtropical species that have established viable populations along the Levantine coast and subsequently spread into the central Mediterranean Sea, in part by natural dispersal and in part by the transport of larvae, juveniles or adult specimens by shipping. The increase in human activities, aquaculture and leisure boating in the past century has contributed to the introduction of alien species in the Mediterranean Sea. Natural and/or anthropic introduction of alien species contributes to the

alteration of autochthonous communities and could disrupt the delicate equilibrium between native biota and their physical and biological environments (GOFAS & ZENETOS, 2003). Given the difficulties in controlling invasions, a careful analysis of the present situation may help to correctly understand the ongoing phenomenon.

Several recent papers focus on alien Molluscan species both in the Gulf of Trieste and in the northern Adriatic Sea (DE MIN & VIO, 1998; VIO & DE MIN, 1999; ORLANDO-BONACA, 2001), yet critical reviews of the bibliography are needed. The aim of the present work is to a) provide a critical review of the Molluscan species from the Gulf of Trieste and neighboring areas that were recorded, suspected or interpreted as alien, b) list their published and unpublished records from the area, c) evaluate their establishment status and d) analyze their known or hypothetical vectors of introduction.

Description of the area

The Gulf of Trieste is the northernmost gulf of the Adriatic Sea, an enclosed basin of the Mediterranean Sea, part of a paleoalluvial plain which was flooded during a postglacial transgression (PERVESLER & DWORSCHAK, 1985). Approximately rectangular in shape and bordered by a shoal connecting Grado Island (Italy) and Punta Salvore (Croatia), it has an average depth of about 20 m (the maxima water depth in the central part of the Gulf does not exceed 25 m), a surface area of about 600 km² and a volume of 9.5 km³ (MALEJ *et al.*, 1995). In the northwest, between Grado and Duino, the Gulf is bordered by a shallow water zone, where the 10 m isobaths lie as far as 3 km offshore. This area is influenced by the freshwater inflow of the Isonzo River, the main tributary of the area that accounts for a daily flow ranging between 90 to 130 m³/s with peaks of over 1000 m³/s during rainy periods, mainly in spring and autumn (MOZETIČ *et al.*, 1998). The steeper coast between Duino and Trieste is a spur of karst, and there the 10 m isobaths lie 250 m offshore. The steep coast in the southeastern part of the Gulf is interrupted by shallow bays, and the rivers flowing into this area are the Dragonja and the Risano. The southern coast has an approximate annual flow rate of 5-10 m³/s with peaks up to 100 m³/s (MOZETIČ *et al.*, 1998). The main sediments of the Gulf of Trieste are sandy pelites and pelites of terrigenous origin, which are dispersed uniformly off the mouths of the rivers and accumulated in the protected basin of the Gulf (BRAMBATI & VENZO, 1967; BRAMBATI *et al.*, 1983). Hydrodynamic conditions are forced by a wind regime characterized by pulses of strong wind (Bora), by interactions with the general circulation of the north Adriatic Sea, and by the seasonal alternation of mixing and stratification processes of the water column. Mean surface temperatures in summer months are well above 20ºC, with maximum values above 26ºC in July and August, while minima in February-March are below 10ºC. The southeastern part of the Gulf shows variability in surface salinities ranging from slightly above 32‰ (in late spring and late autumn) to values close to 38‰ in winter and late summer (SHIGANOVA & MALEJ, 2009).

The eastern part of the Gulf is characterized by the presence of Trieste Harbor, one of the biggest in the entire Adriatic Sea with an area of about 2.304.000 mq² and a maximum depth of 18 m. Due to its vicinity to Central Europe, Trieste Harbor constitutes a main hub for communication with all continents: from Australia and New Zealand to Africa, Asia, North and South America.

MATERIAL AND METHODS

Distribution data and records were obtained from past and recent bibliography on the benthic and molluscan fauna mainly from the Gulf of Trieste and neighboring areas, although papers on the entire Adriatic Sea from about 1850 to 2011 were also included in this study. Moreover, during the last 5 years (2006-2011), several sites were directly investigated, as well as several photographic portfolios of SCUBA divers and private collectors' collections (see for each species under Material examined). Results obtained were enriched by the study of older material preserved in private collections.

The definition of alien species used here follows the one proposed by the IUCN (International Union for Conservation of Nature): "(non-native, non-indigenous, foreign, and exotic). Means a species, subspecies, or lower taxon occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and includes any part, gametes or propagule of such species that might survive and subsequently reproduce".

Each paper or identification encountered was analyzed and several categories of records were excluded as follows:

- species only recorded on the basis of shells;
- species not correctly classified;
- species whose published geographical distribution is incorrect or speculative;
- species with a complex/unclear taxonomy;
- very old records of exotic species unless supported by clear images, direct examination of specimens or finding of living specimens;
- possible cryptogenic (CARLTON, 1996) or vagrant species (see also CROCETTA, 2010, for further discussions on the topic);
- purely brackish water species;
- translocations of native Mediterranean species in an area where they previously did not occur.

The following data are provided for each species recorded, suspected or reviewed as alien from the Gulf of Trieste and neighbouring areas:

- site of description/first Mediterranean record/first Mediterranean site impacted;
- records and history from the area;
- its inclusion (or not) among alien species (with bibliographic references);
- material examined;

On the basis of the data collected herein, the following data are also summarized in Table 1:

- establishment status (updated in 2011), based on the following terminology:

• established (E): an alien for which, during the surveyed period, at least a self-maintaining population is currently known to occur in the wild (including new recorded species);

• not established (NE): an alien that was able to survive and reproduce for a period of time, but for which no self-maintaining population is presently known to occur in the wild;

• casual (C): an alien that never spread or reproduced in the area or one recorded on the basis of a single or few specimens, as well as an alien whose field record(s) was closely related to the aquarium trade, live imports (e.g. related to fish markets) or as ship fouling biota.

When a species has been included with doubt in one of the three categories (as a consequence of lack of knowledge due to difficulties in sampling or identification and lack of specific field research), its questionable status is indicated by a question mark;

- most plausible vectors of introduction, divided into the following categories:

• shipping/maritime transport (S/MT): includes introductions via ballast water and transfers of specimens attached as fouling to ship hulls or petroleum platforms and similar structures;

• trade (T): includes imports of non-target species and subsequent discard in the field of live adult specimens from markets or pounds, or aquarium escape/introduction of target species;

• natural dispersal (ND): active dispersal from an area where the species is considered not native;

• aquaculture-not intentional (AQ (NI)): non-target species or gametes unintentionally introduced in the field together with target species imported for aquaculture purposes;

• aquaculture-intentional (AQ (I)): species intentionally introduced for aquaculture purposes;

• unknown (U).

Abbreviations used: SA, Stefano Ambroso (Verona, Italy); CC, Claudia Canzi (Trieste, Italy); LC, Leonardo Cherici (San Benedetto del Tronto, Italy); FC, Fabio Crocetta (Naples, Italy); WG, Walter Gasperi (Trieste, Italy); DP, Diego Poloniato (Trieste, Italy); SR, Stefania Rismondo (Trieste, Italy); when a P follows the abbreviation, the material is stored in a private collection.

The list and the data reported are based on valid species records collected up to August

2011, while taxonomy follows WoRMS (World Register of Marine Species available at http://www.marinespecies.org/index.php - last accessed on 1st November 2011). Where nomenclature problems still exist, a full list of synonyms is offered.

RESULTS

A review of bibliographic data has led to the discovery of sixteen species recorded or reported as alien or non indigenous in the Gulf of Trieste and neighbouring areas, of which all are listed and commented upon in "Notes on the species". A full list of synonyms is given for *Assiminea gittembergeri*. A brief summary of the data is reported in Table 1.

Notes on the species:

Family LITTORINIDAE Children, 1834

[1] *Littorina saxatilis* (Olivi, 1792)

Site of description: Italy - Venice Lagoon area (OLIVI, 1792).

Records and history from the area: only reported from the Grado & Marano Lagoons (Italy) (TORELLI, 1981; VIO & DE MIN, 1996).

Alien: considered by ORLANDO-BONACA (2001) as a non indigenous species. Included among the "List of excluded species" by ZENETOS *et al.* (2004) following REID (1996), who considered it as a cryptogenic species as no certainties were obtained about an its recent introduction. OCCHIPINTI-AMBROGI *et al.*, (2011) (data updated to 2009), CROCETTA (2011) (data updated to 2010) and ZENETOS *et al.*, (2011) (data updated to 2010) did not include it among aliens or list it as a cryptogenic species. However, recently, PANOVA *et al.*, (2011), using sequence variation in a fragment of the mitochondrial cytochrome b gene, concluded that the outlying monomorphic Venetian population is likely a recent anthropogenic introduction from northern Europe and not a remnant of an earlier wider distribution in the Mediterranean Sea. As populations of this species from the Gulf of Trieste area may be presumably connected with those from the nearby Venetian shores, *L. saxatilis* is included here among the aliens.

Material examined: no specimens were recorded during the present field studies.

Family ASSIMINEIDAE (Adams H. & A., 1856)

[2] *Assiminea gittembergeri* Van Aartsen, 2008

Assiminea sp. CESARI (1988);

Assiminea cfr. *grayana* CESARI (1994); MIZZAN (1996); VIO & DE MIN (1996); GIANNUZZI-SAVELLI *et al.* (1997); DE MIN & VIO (1997);

Assiminea grayana DE MATTIA (2004); OLIVERIO *et al.,* (2008).

First Mediterranean record: Italy - reported by CESARI (1988) from the Venice Lagoon area.

Records and history from the area: first reported from the Italian (Miramare and Punta Sottile) and Croatian (Punta Salvore) shores by VIO & DE MIN (1996). Then listed for the entire Slovenian shore by DE MIN & VIO (1997), again reported from Miramare and the Grado Lagoon (GIANNUZZI-SAVELLI *et al.*, 1997) and recently from Muggia (DE MATTIA, 2004), Grado and Trieste (Italy) (VAN AARTSEN, 2008).

Alien: considered by OLIVERIO *et al.* (2008) as an alien species. Here it is excluded from aliens following VAN AARTSEN (2008), who described Mediterranean specimens of "*Assiminea grayana*" as *A. gittembergeri*. The main differences with respect to *Assiminea grayana* Flemin, 1828 are blunter protoconch, bigger embryonic whorls, smaller shell dimensions and distinct radular features.

Material examined: Santa Caterina (Slovenia), on the beach, winter 1997, *legit* DV: 8 shells (DVP); Fossalon (Grado - Italy), under stones, 04/2000, *legit* DV: around 50 specimens (DVP); Rio Ospo (Muggia - Italy), under stones, 04/2000, *legit* DV: around 40 specimens (DVP); Santa Caterina (Slovenia), under stones, 2005, *legit* DV: 13 specimens (DVP); Punta Grossa (Slovenia), under stones, 2006, *legit* DV: 30 specimens (DVP); Punta Grossa (Slovenia), under stones, 07/2008, *legit* FC: 10 specimens (FCP).

Family STROMBIDAE (Rafinesque, 1815)

[3] *Conomurex persicus* (Swainson, 1821)

First Mediterranean site impacted: Turkey (ZENETOS *et al.*, 2004).

Table 1. Marine molluscan species recorded, suspected or interpreted as alien or non indigenous from the Gulf of Trieste and neighbouring areas.

Phylum Mollusca	N	Main bibliographic references on the presence/absence in the Gulf of Trieste and neighbouring areas	2011 update	Vectors
Classis Gastropoda				
Fam. LITTORINIDAE				
Littorina saxatilis (Olivi, 1792)	[1]	Torelli, 1980; Vio & De Min, 1996	Not established?	U
Fam. ASSIMINEIDAE				
Assiminea gittembergeri (Van Aartsen, 2008)	[2]	Vio & De Min, 1996; De Min & Vio, 1997; De Mattia, 2004; Van Aartsen, 2008	Native	
Fam. STROMBIDAE				
Conomurex persicus (Swainson, 1821)	[3]	Vio & De Min, 1996	Rejected	
Fam. MURICIDAE				
Rapana venosa (Valenciennes, 1846)	[4]	Present paper; Cucaz, 1983; Vio & De Min, 1996; De Min & Vio, 1997	Established	ND
Fam. APLYSIIDAE				
Bursatella leachii (Blainville, 1817)	[5]	Present paper; Jaklin & Vio, 1989; Lipej *et al.*, 2008; Crocetta *et al.*, 2009	Established	ND
Classis Bivalvia				
Fam. ARCIDAE				
Anadara transversa (Say, 1822)	[6]	Present paper	Established	ND
Anadara kagoshimensis (Tokunaga, 1906)	[7]	Present paper; Di Massa, 1993; Vio & De Min, 1996; De Min & Vio, 1997; Mavrič *et al.*, 2010	Established	ND
Fam. MYTILIDAE				
Brachidontes ustulatus (Lamarck, 1819)	[8]	Vio & De Min, 1996; Crocetta *et al.*, 2009	Casual	S/MT
Perna perna (Linnaeus, 1758)	[9]	Vio & De Min, 1996	Casual	S/MT
Arcuatula senhousia (Benson in Cantor, 1842)	[10]	Present paper; Dondi *et al.*, 2004; Zenetos *et al.*, 2004; Mavrič *et al.*, 2010	Established	ND
Limnoperna securis (Lamarck, 1819)	[11]	Present paper; De Min & Vio, 1998; Dondi *et al.*, 2004	Established	ND
Fam. PTERIIDAE				
Pinctada imbricata radiata (Leach, 1814)	[12]	Vio & De Min, 1996; Crocetta *et al.*, 2009	Casual	S/MT
Fam. OSTREIDAE				
Crassostrea gigas (Thunberg, 1793)	[13]	Present paper; Valli, 1980; Vio & De Min, 1996; Vio & Valli, 2010	Established	AQ (I)
Fam. VENERIDAE				
Mercenaria mercenaria (Linnaeus, 1758)	[14]	Poutiers, 1987; Turolla, 2006	Casual	AQ (NI)
Ruditapes philippinarum (Adams & Reeve, 1850)	[15]	Present paper; Vio & De Min, 1996; Zentilin *et al.*, 2007; Bettoso *et al.*, 2010	Established	AQ (I)
Fam. MYIDAE				
Mya arenaria (Linnaeus, 1758)	[16]	Bussani & Zuder, 1976; Poutiers, 1987; Crocetta & Turolla, 2011	Rejected	

Records and history from the area: only a few empty shells were found off Muggia (Trieste - Italy) (VIO & DE MIN, 1996; DE MIN & VIO, 1998; VIO & DE MIN, 1999). Photos included in the papers excluded a misidentification. It was reported among the alien species of the northern Adriatic shores by DE MIN & VIO (1998), listed by ORLANDO-BONACA (2001) as "occasional" and by ZENETOS *et al.,* (2004) as "local record", while OLIVERIO *et al.*, (2008) did not list this species for the Italian seas.

Alien: uniformly considered a Mediterranean alien species.

Material examined: no specimens were recorded during the present field studies.

Family MURICIDAE (Rafinesque, 1815)

[4] *Rapana venosa* (Valenciennes, 1846)

First Mediterranean site impacted: Italy - off Ravenna-Cattolica area - 1973 (GHISOTTI, 1974; POGGIANI *et al.*, 2004).

Records and history from the area: after its first record from the Italian shores of the Gulf of Trieste (CUCAZ, 1983), the species was mainly recorded in Slovenian waters (VIO & DE MIN, 1996).

Alien: uniformly considered a Mediterranean alien species.

Material examined: Piran (Slovenia), from local fishermen, 10/2008, *legit* FC: 2 specimens on a boat (material not preserved).

Family APLYSIIDAE (Lamarck, 1809)

[5] *Bursatella leachii* (Blainville, 1817)

First Mediterranean site impacted: probably from Palestine, although the absence of labels led us to speculate that the specimen came from the Red Sea (O'DONOGHUE & WHITE, 1940).

Records and history from the area: after the first records (JAKLIN & VIO, 1989), *Bursatella leachii* likely disappeared from the Gulf of Trieste, where it was recently recorded again (LIPEJ *et al.*, 2008; CROCETTA *et al.*, 2009). The same situation was noted in several Adriatic Sea sites (CROCETTA *et al.*, 2009).

Alien: uniformly considered a Mediterranean alien species.

Material examined: Miramare (Trieste - Italy), 2 m depth, 11/2007, *legit* DP: photo of one specimen (FCP); Punta Olmi (Muggia - Italy), 2 m depth on mud, summer 2010, *legit* WG: one specimen not preserved; Filtri (Trieste - Italy), 3 m depth, 08/2010, *legit* FC: one specimen not preserved.

Family ARCIDAE (Lamarck, 1809)

[6] *Anadara transversa* (Say, 1822)

First Mediterranean site impacted: Turkey (ZENETOS *et al.*, 2004).

Records and history from the area: the species has never been recorded in the deep northern Adriatic Sea (CROCETTA *et al.*, 2008; PEHARDA *et al.*, 2010).

Alien: uniformly considered a Mediterranean alien species.

Material examined: Grado (Italy), from local fishermen, 10/2002, legit DV: 6 specimens and complete shells (DVP); Santa Caterina (Slovenia), on the beach, 2003, legit DV: 6 specimens and complete shells (DVP); Grado (Italy), from local fishermen, winter 2003, legit DV: 12 specimens and complete shells (DVP); Grado (Italy), from local fishermen, 11/2006, legit DV: 1 specimen (DVP); Muggia (Trieste - Italy), 3m depth on mud, 07/2008, *legit* FC: 4 specimens (FCP); Pirano (Slovenia), from local fishermen, 10/2008, *legit* FC: 2 specimens (FCP); Golometto (Grado - Italy), 7/8 m depth on mud with *Cymodocea*, 03/2009, *legit* FC and DP: 4 specimens and 2 shells (FCP); Punta Grossa (Slovenia), 1m, summer 2009, legit DV: 1 specimen (DVP); Punta Olmi (Muggia - Italy), 1 m byssed on rocks, 07/2011, legit DV: 1 specimen (DVP).

[7] *Anadara kagoshimensis* (Tokunaga, 1906)

First Mediterranean site impacted: Italy - Adriatic Sea - around 1966 (PARENZAN, 1976).

Records and history from the area: reported for the whole area (DI MASSA, 1993; VIO & DE MIN, 1996; DE MIN & VIO, 1997).

Alien: uniformly considered a Mediterranean alien species.

Material examined: Fossalon (Grado - Italy), on the beach, 04/1997, *legit* DV: 5 complete shells (DVP); Grado (Italy), from local fisher-

men, winter 1997, *legit* DV: 1 specimen (DVP); Muggia (Trieste - Italy), 3m depth on mud, 07/2008, *legit* FC and SA: 1 specimen (FCP); Grado (Italy), on the beach, 11/2008, *legit* FC: 1 specimen (FCP).

Family MYTILIDAE (Rafinesque, 1815)

[8] *Brachidontes ustulatus* (Lamarck, 1819)

First Mediterranean site impacted: Egypt (ZENETOS *et al.*, 2004).

Records and history from the area: several specimens were found beached (with soft parts) at Punta Salvore (Croatia) (VIO & DE MIN, 1996; DE MIN & VIO, 1998). ORLANDO BONACA (2001) listed it as "occasional" and no follow-up is known from the area (DESPALATOVIĆ *et al.*, 2008; CROCETTA *et al.*, 2009).

Alien: uniformly considered a Mediterranean alien species.

Material examined: no specimens were recorded during the present field studies.

[9] *Perna perna* (Linnaeus, 1758)

First Mediterranean site impacted: Italy - at the end of the 1980's (CROCETTA, 2011).

Records and history from the area: few living specimens were found byssed on a platform translocated in Trieste Harbor from Senegal (DE MIN & VIO, 1998; VIO & DE MIN, 1999).

Alien: listed as alien or non indigenous species for the Gulf of Trieste or for Italian seas by VIO & DE MIN (1996), ORLANDO-BONACA (2001), OCCHIPINTI-AMBROGI (2002) and SCHIAPARELLI (2006), although is not included among the alien Mediterranean species of the CIESM Atlas (ZENETOS *et al.*, 2004), for reasons specified in GOFAS & ZENETOS (2003) who consider it as an exotic taxon. Also, it was not listed as alien by SCHIAPARELLI (2008) and OCCHIPINTI-AMBROGI *et al.* (2011). Only recently it was included among alien species by CROCETTA (2011) since specimens cited fit with the concept of "*lower taxon occurring outside of its dispersal potential*" according to the IUCN definition, while further Mediterranean specimens (*e.g.* those reported from Sicilian shores) could have arrived via natural dispersal from the autochthonous African populations.

Material examined: no specimens were recorded during the present field studies.

[10] *Arcuatula senhousia* (Benson in Cantor, 1842)

First Mediterranean site impacted: Israel (ZENETOS *et al.*, 2004).

Records and history from the area: cited for Slovenia in ZENETOS *et al.* (2004) referring to DE MIN & VIO (1997). This record was then reported by several papers (*e.g.* BACHELET *et al.*, 2008; GALIL & BOGI, 2009), and web databases (for example GLOBAL INVASIVE SPECIES DATABASE; FAO), all referring to DE MIN & VIO (1997) or ZENETOS *et al.* (2004). While the species is not reported in DE MIN & VIO (1997; 1998) nor in VIO & DE MIN (1996; 1999), *A. senhousia* is truly present in the area as currently established in the Grado and Marano Lagoon area (CROCETTA *et al.*, 2010) and along the Slovenian shore (MAVRIČ *et al.*, 2010).

Alien: uniformly considered a Mediterranean alien species.

Material examined: Salvore (Croatia), from local fishermen, winter 2003, legit DV: 1 specimen (DVP); Grado Lagoon (Italy), 50cm depth, 06/2008, *legit* FC: 5 specimens (FCP).

[11] *Limnoperna securis* (Lamarck, 1819)

First Mediterranean site impacted: Italy - Venice Lagoon area - 1991 (MIZZAN, 1999), as the specimen figured in CESARI (1994) as *Modiolus adriaticus* (Lamarck, 1819) clearly belongs to *L. securis* (CROCETTA, 2011).

Records and history from the area: only recorded from off Porto Buso (from fishermen) (Grado and Marano Lagoon area) by DE MIN & VIO (1998) and by DONDI *et al.,* (2004) from the Natissa river mouth.

Alien: uniformly considered a Mediterranean alien species.

Material examined: Fossalon (Grado-Italy), on the beach, 12/1998, legit DV: 5 complete shells (DVP); Grado Lagoon (Italy), low depth, 06/2004, *legit* DV: 20 specimens (DVP); Grado Lagoon (Italy), 50 cm under rocks, 03/2008, *legit* FC: 3 specimens (FCP); Villaggio del Pescatore (Trieste - Italy), on floating objects among *Myti-*

lus galloprovincialis Lamarck, 1819, 11/2010, *legit* LC: 2 specimens and 1 loose valvae (FCP). Common among other Mytilidae (LC, personal communication). Villaggio del Pescatore (Trieste - Italy), on floating objects among *M. galloprovincialis*, 11/2010, *legit* SR and CC: 3 specimens (FCP).

Family Pteriidae (Gray, 1847)

[12] *Pinctada imbricata radiata* (Leach, 1814)

First Mediterranean site impacted: Egypt (ZENETOS *et al.*, 2004).

Records and history from the area: a few live specimens of *P. imbricata radiata* were found byssed to an oil platform transported to Trieste Harbour from the Sicily Channel (VIO & DE MIN, 1996). The species was listed as "occasional" by ORLANDO BONACA (2001) and as local record by ZENETOS *et al.* (2004). No follow-up is known from the area (DESPALATOVIĆ *et al.*, 2008; CROCETTA *et al.*, 2009).

Alien: uniformly considered a Mediterranean alien species.

Material examined: no specimens were recorded during the present field studies.

Family Ostreidae (Rafinesque, 1815)

[13] *Crassostrea gigas* (Thunberg, 1793)

First Mediterranean site impacted: Tunisia (DANTAN & HELDT, 1932).

Records and history from the area: the species is widely distributed and invasive in the Gulf of Trieste and neighbouring areas (VALLI, 1980; VIO & DE MIN, 1996; VIO & VALLI, 2010).

Alien: quite uniformly considered a Mediterranean alien species, but not included among aliens by SCHIAPARELLI (2008). As also convincingly argued by PARENZAN (1989), the native presence of a so large a species may not have been undetected in the Adriatic Sea until so recently.

Material examined: A large number of specimens was sighted all over the Gulf of Trieste and neighbouring areas (F. Crocetta, unpublished data). Muggia (Italy), on *Mytilus galloprovincialis* Lamarck, 1819, 09/2006, *legit* FC: 2 specimens (FCP); Muggia Harbour (Italy), low depth, 2008, *legit* FC: 10 specimens (FCP); Grado (Italy), on the beach, 02/2008, *legit* FC and SR: 11 specimens (FCP).

Family Veneridae (Rafinesque, 1815)

[14] *Mercenaria mercenaria* (Linnaeus, 1758)

First Mediterranean site impacted: France (ZENETOS *et al.*, 2004)

Records and history from the area: POUTIERS (1987) reports it for the northern Adriatic Sea: "Quelques tentatives d'introduction… …en Adriatique. Espèce draquée activement en haute Adriatique où elle apparaît assez régulièrement sur les marchés et est utilisée fraîche", but such a sentence was confuted by TUROLLA (2006). An isolate specimen came from Marano Lagoon where it was presumably introduced via unintentional aquaculture (TUROLLA, 2006).

Alien: uniformly considered a Mediterranean alien species.

Material examined: no specimens were recorded during the present field studies.

[15] *Ruditapes philippinarum* (Adams & Reeve, 1850)

First Mediterranean site impacted: France (ZENETOS *et al.*, 2004)

Records and history from the area: probably impacted due to a voluntary anthropic introduction into Grado Lagoon (ZENTILIN *et al.*, 2007). Then recorded for the entire area (VIO & DE MIN, 1996; BETTOSO *et al.*, 2010).

Alien: uniformly considered a Mediterranean alien species.

Material examined: a large number of specimens was sighted in the Grado and Marano Lagoons (Italy) and just outside the lagoons (FC, unpublished data), even if no material was preserved from there. Punta Sottile (Muggia -Italy), 4 m on mud, 05/2009, *legit* FC: 2 complete shells (FCP).

Family Myidae (Lamarck, 1809)

[16] *Mya arenaria* (Linnaeus, 1758)

First Mediterranean site impacted: France (CROCETTA & TUROLLA, 2011).

Records and history from the area: old recor-

ds from the area (BUSSANI & ZUDER, 1976; POUTIERS, 1987) were recently critically analyzed, revealing that its declared occurrence in the Gulf of Trieste was due to speculation (CROCETTA & TUROLLA, 2011).

Alien: uniformly considered a Mediterranean alien species.

Material examined: no specimens were recorded during the present field studies.

CONCLUSIONS

Ten years after the last review dealing with the molluscan species considered as alien or non indigenous in the Gulf of Trieste and neighboring areas (ORLANDO-BONACA, 2001), a critical update is provided. Results obtained here show an alien assemblage similar to the one known for the Italian northern Adriatic shores, suggesting a local general uniformity. For instance, recent sightings of *Anadara transversa* (Say, 1822) and *Limnoperna securis* (Lamarck, 1819) in the deep northern Adriatic Sea are not surprising, with both species being well established and common on the nearby Venetian shores and *A. transversa* recently being recorded as empty complete shells from the Adriatic Croatian shores (PEHARDA *et al.*, 2010). In addition, *L. securis*, only locally recorded in November 2010 at Villaggio del Pescatore (Trieste), seems to be present in the area for many years, as also suggested by its local abundance (L. CHERICI, personal communication). A lack of previous records of *L. securis* may be due to the paucity of recent studies on the faunal benthic biocenosis in the area and on the local molluscan fauna after studies published in the 1990's (VIO & DE MIN, 1996; DE MIN & VIO, 1998; VIO & DE MIN, 1999). Further, *Arcuatula senhousia* (Benson in Cantor, 1842) was never recorded in the extreme northern Adriatic Sea up to recently, even though its presence north of Grado and Marano Lagoons was plausible. Results of samplings carried on during 2005-2006, but only recently published (MAVRIČ *et al.*, 2010), confirmed this speculation. The sightings of five more alien species, in addition to the three previously cited, confirm their stable presence in the Gulf of Trieste and neighbouring areas. Among them, *Ruditapes philippinarum* (Adams & Reeve, 1850) and *Crassostrea gigas* (Thunberg, 1793) need to be cited. The first one is very common, mainly in the Grado and Marano Lagoons and neighbouring area due to local aquaculture, while *C. gigas* has almost entirely colonized the mesolittoral and infralittoral fringes of the Gulf of Trieste, becoming invasive and mainly competing with *Mytilus galloprovincialis* Lamarck, 1819. Four species were considered in the present work as casual and one was considered with caution as not established. *Brachidontes ustulatus* (Lamarck, 1819) and *Pinctada imbricata radiata* (Leach, 1814) do not seem to have been able to survive the local cold winters. Indeed, these Mediterranean aliens are actually established and invasive mainly along warmer shores (CROCETTA, 2011; ZENETOS *et al.*, 2004). The same is assumed for *Perna perna* (Linnaeus, 1758). Regarding *Mercenaria mercenaria* (Linnaeus, 1758), only a single specimen was recorded in the Grado and Marano Lagoons to date (TUROLLA, 2006), while *Littorina saxatilis* (Olivi, 1792) was, with caution, considered not established. Although no specimens were recorded during the present field studies, old conspicuous records from the area suggest that the species may be present but undetected at several sites (TORELLI, 1981 - see Addendum). Records of *Mya arenaria* Linnaeus, 1758 and *Conomurex persicus* (Swainson, 1821) from the Gulf of Trieste should be rejected. The ones regarding *M. arenaria* (in BUSSANI & ZUDER, 1976; POUTIERS, 1987) as based on wrong distribution data or probable misidentifications (CROCETTA & TUROLLA, 2011). Moreover, further records listed by BUSSANI & ZUDER (1976), in addition to that of *M. arenaria* (*e.g. Lacuna parva* (da Costa, 1778), *Petricola pholadiformis* (Lamarck, 1818), etc.), are not to be taken in account because of uncertainties regarding native and non-native species (see CROCETTA & TUROLLA, 2011). Moreover, the record of *C. persicus* is based on empty shells only (VIO & DE MIN, 1996; DE MIN & VIO, 1998; VIO & DE MIN, 1999) and, since this species is actually used as sea-food in eastern Mediterranean fish markets (MIENIS, 1999), an accidental discharge of imported specimens can be considered.

Finally, one species recently listed among aliens, *Assiminea gittembergeri* Van Aartsen, 2008, is now included among native Mediterranean species (VAN AARTSEN, 2008).

Concerning plausible vectors of introduction of alien species in the studied area, results listed in Table 1 suggest that six recorded alien species (46%) arrived by natural dispersal. This could be linked to the very near presence of the Venice Lagoon, a hot spot for the arrival of alien species to Italian seas and the entire Adriatic Sea. This hypothesis is confirmed by sightings of the listed alien species first in the Venice area and then in the Gulf of Trieste area. A plausible vector of 23% of the recorded alien species is constituted by shipping/maritime transport since three species (*B. ustulatus*, *P. imbricata radiata* and *P. perna*) arrived in the area as fouling due to the presence of Trieste Harbor and its neighboring industries. The arrival of the remaining three species (25%) is associated with aquaculture. *C. gigas* and *R. philippinarum* were in fact intentionally introduced *in situ* as the Grado and Marano Lagoons are exploited for molluscan farming, while the finding of a single specimen of *M. mercenaria* could be due to incorrect clam seedings. A similar case could be hypothesized also for the recent findings of *M. mercenaria* in the Sacca di Goro Lagoon, where the species does not seem to have survived (TUROLLA, pers. comm.).

Finally, it should be underlined that the disturbance of the ecological balance by accidental or deliberate introduction of alien species is recognized worldwide as one of the major threats to biodiversity, the economy and human health. While constant monitoring of the ongoing phenomenon is required, it is also necessary to invest in effective prevention policies.

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REFERENCES

BACHELET, G., H. BLANCHET, M. COTTET, C. DANG, X. DE MONTAUDOUIN, A. DE MOURA QUEIRÓS, B. GOUILLIEUX & N. LAVESQUE. 2008. A round-the-world tour almost completed: first records of the invasive mussel *Musculista senhousia* in the North-east Atlantic (southern Bay of Biscay). Marine Biodiversity Records, 2: e119.

BETTOSO, N., I.F. ALEFFI, L. FARESI, P. ROSSIN, G. MATASSI & P. CRIVELLARO. 2010. Evaluation on the ecological status of the macrozoobenthic communities in the Marano and Grado Lagoon (Northern Adriatic Sea). Annals for Istrian and Mediterranean Studies, 20: 193-206.

BRAMBATI, A. & G.A. VENZO. 1967. Recent sedimentation in the Northern Adriatic Sea. Studi Tridentini di Scienze Naturali, Sezione A, 44: 202-274.

BRAMBATI, A., M. CIABATTI, G.P. FANZUTTI, F. MARABINI & R. MAROCCO. 1983. A new sedimentological textural map of the Northern and Central Adriatic Sea. Boll. Oceanol. Teor. Appl., 1: 1-5.

BUSSANI, M. & A. ZUDER. 1976. Molluschi del Parco Marino di Miramare (Nota preliminare). Annuario 1976 del WWF Italia, Parco Marino di Miramare, 5: 17-29.

CARLTON, J.T. 1996. Biological invasions and cryptogenic species. Ecology, 77(6): 1653-1655.

CESARI, P. 1988. La Malacofauna della Laguna veneta. Gasteropodi terrestri, dulciacquicoli e salmastri dei litorali di Pellestrina, Lido e Cavallino. Mollusca Prosobranchia e Pulmonata. Boll. Mus. Civ. Stor. Nat. Venezia, 38: 7-42.

CESARI, P. 1994. I molluschi della laguna di Venezia. Arsenale editrice. Venezia, 189 pp.

CROCETTA, F. 2010. Nozioni base di nomenclatura sulle invasioni biologiche, ovvero… quali specie sono da considerarsi come aliene? Notiziario S.I.M., 28: 27-28.

CROCETTA, F. 2011. Marine alien Mollusca in Italy: a critical review and state of the knowledge. J. Mar. Biol. Ass. U. K., in press: doi:10.1017/S002531541100186X.

CROCETTA, F., W. RENDA & G. COLAMONACO. 2008. New distributional and ecological data of some marine alien molluscs along the southern Italian coasts. Marine Biodiversity Records, 2: e23.

CROCETTA, F., W. RENDA & A. VAZZANA. 2009. Alien Mollusca along the Calabrian shores of the Messina Strait area and a review of their distribution in the Italian Seas. Boll. Malacol., 45: 15-30.

CROCETTA, F., A. VAZZANA & W. RENDA. 2010. The infralittoral mobile bottom molluscs of Gizzeria harbour (Catanzaro). Marine Biodiversity Records, 3: e15.

CROCETTA, F. & E. TUROLLA. 2011. *Mya arenaria* Linné, 1758 (Mollusca: Bivalvia) in the Mediterranean: its distribution revisited. Journal of Biological Research, 16: 188-193.

CUCAZ, M. 1983. *Rapana venosa* (Valenciennes, 1846) vivente nel Golfo di Trieste. Boll. Malacol., 19: 261-262.

DANTAN, J.L. & H. HELDT. 1932. L'ostréiculture en Tunisie. Résultats acquis dans le lac de Porto Farina. Bull. Stat. Océanogr. Salammbo, 30: 1-30.

DE MATTIA, W. 2004. I molluschi terrestri, salmastri e d'acqua dolce della Valle delle Noghere a Muggia presso Trieste. Hydrores Inf., 21 (26): 45-51.

DE MIN, R. & E. VIO. 1997. Molluschi conchiferi del litorale sloveno. Annals for Istrian and Mediterranean Studies, 11: 241-258.

DE MIN, R. & E. VIO. 1998. Molluschi esotici nell'Alto Adriatico. Annals for Istrian and Mediterranean Studies, 13: 43-54.

DESPALATOVIĆ, M., I. GRUBELIĆ, V. NIKOLIĆ, B. DRAGIČEVIĆ, J. DULČIĆ, A. ŽULJEVIĆ, I. CVITKOVIĆ & B. ANTOLIĆ. 2008. Allochthonous warm water species in the benthic communities and ichthyofauna of the eastern part of the Adriatic Sea. CIESM, 2008. Climate warming and related changes in Mediterranean marine biota. CIESM Workshop Monographs N° 35. In: F. Briand (Editor). Monaco, pp. 51-58.

DI MASSA, D. 1993. I Molluschi della Baia di Muggia. Borgolauro, Riv. Storia, Lettere, Arti Fameia Muiesana, 1-68.

DONDI, G., A. MARCHINI & R. SCONFIETTI. 2004. La foce fluviale come gradiente d'ecotono: l'esempio del Fiume Natissa nel Nord-Adriatico. Studi Tridentini di Scienze Naturali, Acta Biologica, 80: 237-244.

ELLIOTT, M. 2003. Biological pollutants and biological pollution - an increasing cause for concern. Mar. Pollut. Bull., 46: 275-280.

FAO http://www.fao.org/fishery/introsp/8065/en (last research 1/08/2011).

GALIL B.S. & BOGI C. 2009. *Mytilopsis sallei* (Mollusca: Bivalvia: Dreissenidae) established on the Mediterranean coast of Israel. Marine Biodiversity Records, 2: e73.

GHISOTTI, F. 1974. *Rapana venosa* (Valenciennes) nuova ospite Adriatica? Conchiglie, 10(5-6): 125-126.

GIANNUZZI-SAVELLI, R., F. PUSATERI, A. PALMERI & C. EBREO. 1997. Atlante delle conchiglie marine del Mediterraneo, vol 2 (Caenogastropoda, parte 1: Discopoda-Heteropoda). La Conchiglia Edizioni, 1-258.

GLOBAL INVASIVE SPECIES DATABASE. http://www.invasivespecies.net/database/species/ecology.asp?si=1031&fr=1&sts=&ver=print&prtflag=false (last research 1/08/2011).

GOFAS, S. & A. ZENETOS. 2003. Exotic molluscs in the Mediterranean Basin: current status and perspectives Oceanogr. Mar. Biol. Ann. Rev., 41: 237-277

JAKLIN, A & E. VIO. 1989. *Bursatella leachii* (Gastropoda, Opistobranchia) in the Adriatic Sea. J. Molluscan Stud., 55: 419-420.

LIPEJ, L., Z. DOBRAJC, B. MAVRIČ, S. ŠAMU & S. ALAJBEGOVIČ. 2008. Opisthobranch Mollusks (Mollusca: Gastropoda) from Slovenian coastal waters (Northern Adriatic). Annals for Istrian and Mediterranean Studies, 18(2): 1-14.

MALEJ, A., P. MOZETIC, V. MALACIC, S. TERZIC & M. AHEL. 1995. Phytoplankton responses to freshwater inputs in a small semi-enclosed gulf (Gulf of Trieste). Mar. Ecol. Prog. Ser., 120: 111-121.

MAVRIČ, B., M. ORLANDO-BONACA, N. BETTOSO & L. LIPEJ. 2010. Soft-bottom macrozoobenthos of the southern part of the Gulf of Trieste: faunistic, biocoenotic and ecological survey. Acta Adriat., 51: 203-216.

MIENIS, H.K. 1999. *Strombus persicus* on the fish-market of Yafo, Israel. De Kreukel, 35(7):112.

MIZZAN, L. 1996. In memoria di Paolo Cesari. I molluschi lagunari e costieri del Veneziano. Boll. Mus. Civ. Stor. Nat. Venezia, 45: 71-122.

MIZZAN, L. 1999. Le specie alloctone del macrozoobenthos della Laguna di Venezia: il punto della situazione. Boll. Mus. Civ. Stor. Nat. Venezia, 49: 145-177.

MOZETIČ, P., S. FONDA UMANI, B. CATALETTO & A. MALEJ. 1998. Seasonal and interannual plankton variability in the Gulf of Trieste (northern Adriatic). ICES J. Mar. Sci., 55: 711-722.

O'DONOGHUE, C.H. & WHITE, K.M. 1940. A collection of marine molluscs, mainly opisthobranchs, from Palestina. Proceedings of the Malacological Society of London, 24: 92-96.

OCCHIPINTI-AMBROGI, A. 2002. Current status of aquatic introductions in Italy. In: Leppakoski E, Gollasch S, Olenin S(Editors). Invasive Aquatic species of Europe. Distribution impacts and management. Kluwer Academic Publishers, Dordrecht, Boston, London: 311-324.

OCCHIPINTI-AMBROGI, A., A. MARCHINI, G. CANTONE, A. CASTELLI, C. CHIMENZ, M. CORMACI, C. FROGLIA, G. FURNARI, M.C. GAMBI, G. GIACCONE, A. GIANGRANDE, C. GRAVILI, F. MASTROTOTARO, C. MAZZIOTTI, L. ORSINI & S. PIRAINO. 2011. Alien species along the Italian coasts: an overview. Biological Invasions, 13: 215-237.

OLIVERIO, M., R. GIANNUZZI-SAVELLI, F. GIOVINE, G. MANGANELLI, F. PUSATERI, B. SABELLI & G. SPADA. 2008. Checklist della flora e della fauna dei mari italiani (Parte I). Gastropoda Prosobranchia. Relini Ed. Biologia Marina Mediterranea, 15 (suppl.): 235-278.

OLIVI, G. 1792. Zoologia Adriatica ossia catalogo ragionato degli animali del Golfo e delle Lagune di Venezia; preceduto da una dissertazione sulla storia fisica e naturale del Golfo; e accompagnato da memorie, ed osservazioni di fisica storia naturale ed economia. Bassano: 1-334.

ORLANDO-BONACA, M. 2001. A survey of the introduced non-indigenous species in the northern Adriatic Sea. Annals for Istrian and Mediterranean Studies, 11: 149-158.

PANOVA, M., A.M.H. BLAKESLEE, A. WHITMAN MILLER, T. MÄKINEN, G.M. RUIZ, K. JOHANNESSON & C. ANDRÉ. 2011. Glacial history of the North Atlantic marine snail, *Littorina saxatilis*, inferred from distribution of mitochondrial DNA lineages. Plos One, 6(3): e17511PARENZAN, P. 1976. Carta d'identità delle conchiglie del Mediterraneo, 3. Bivalvi parte seconda. Bios - Taras, Taranto.

PARENZAN P. 1989. Storia della *Crassostrea gigas* (Thunb.) spontanea nel Mediterraneo. Thalassia Salentina, 19: 39-48.

PEHARDA, M., D. EZGETA-BALIĆ, N. VRGOČ, I. ISAJLOVIĆ & D. BOGNER. 2010. Description of bivalve community structure in the Croatian part of the Adriatic Sea - hydraulic dredge survey. Acta Adriat., 51(2): 141-158.

PERVESLER, P. & P.C. DWORSCHAK. 1985. Burrows of *Jaxea nocturna* Nardo in the Gulf of Trieste. Senckenb. Marit., 17(1/3): 33-53.

POGGIANI, L., G. MATTIOLI & P. MICALI. 2004. I molluschi marini conchiferi della Provincia di Pesaro & Urbino. Provincia di Pesaro e Urbino. Assessorato Beni ed Attività Ambientali. Quaderni dell'Ambiente, 17: 1-178.

POUTIERS, J.M. 1987. Bivalves. In Fischer W, Schneider M, Bauchot M-L (Editors). Fiches FAO d'identification des espèces pour les besoins de la pêche. - Méditerranée et Mer Noire. Zone de pêche 37. Révision 1. CEE, FAO, pp. 369-512.

REID, D.G. 1996. Systematics and evolution of *Littorina*. London: The Ray Society, pp. 1-463.

SCHIAPARELLI, S. 2006. Checklist della flora e della fauna dei mari italiani. Bivalvia. http://www.sibm.it/CHECKLIST/17%20BIVALVIA/bivalvi.htm.

SCHIAPARELLI, S. 2008. Checklist della flora e della fauna dei mari italiani (Parte I). Bivalvia. Relini Editor. Biologia Marina Mediterranea, 15 (suppl.): 296-314.

SHIGANOVA, T. & A. MALEJ. 2009. Native and non-native ctenophores in the Gulf of Trieste, Northern Adriatic Sea. J. Plankton Res., 31: 61-71.

TORELLI, A.R. 1981. Notizie preliminari sulla presenza di Littorina saxatilis (Olivi) (Gastropoda, Prosobranchia) nella laguna di Grado Marano. Boll. Mus. Civ. Stor. Nat. Venezia, 31: 79-83.

TUROLLA, E. 2006. Considerazioni sul ritrovamento di esemplari adulti di *Mercenaria mercenaria* (Linnaeus, 1758) in due lagune del Delta del Po. Boll. Malacol., 42: 1-4.

VALLI, G. 1980. Riproduzione ed accrescimento di alcune specie di molluschi eduli nelle lagune di Grado e Marano. Nova Thalassia, 4: 49-65.

VAN AARTSEN, J.J. 2008. The Assimineidae of the Atlantic-Mediterranean seashores. Basteria, 72: 165-181.

VIO, E. & R. DE MIN. 1996. Contributo alla conoscenza dei Molluschi marini del Golfo di Trieste. Atti Mus. Civ. Stor. Nat. Trieste, 47: 173-233.

VIO, E. & R. DE MIN. 1999. Ritrovamenti malacologici nel Golfo di Trieste. Hydrores Inf., 16: 29-34.

VIO, E. & G. VALLI. 2010. Note sulla malacofauna di alcuni sollevamenti morfologici marini del Golfo di Trieste (Alto Adriatico). Atti Mus. Civ. Stor. Nat. Trieste, 54: 303-317.

WORMS - World Register of Marine Species - http://www.marinespecies.org/index.php.

ZENETOS, A., S. GOFAS, G. RUSSO & J. TEMPLADO. 2004. CIESM Atlas of exotic species in the Mediterranean. In F. Briand (Editor) *Molluscs*, Monaco, CIESM Publishers. Vol. 3: 1-380.

ZENETOS, A., S. GOFAS, M. VERLAQUE, M.E. ÇINAR, J.E. GARCIA RASO, C.N. BIANCHI, C. MORRI, E. AZZURRO, M. BILECENOGLU, C. FROGLIA, I. SIOKOU, D. VIOLANTI, A. SFRISO, G. SAN MARTIN, A. GIANGRANDE, T. KATAĞAN, E. BALLESTEROS, A. RAMOS-ESPLÀ, F. MASTROTOTARO, O. OCAÑA, A. ZINGONE, M.C. GAMBI & N. STREFTARIS. 2011. Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. Mediterranean Marine Science, 11: 381-493.

ZENTILIN, A., G. OREL & R. ZAMBONI. 2007. L'introduzione in Europa di *Tapes philippinarum* (Adams & Reeve, 1852), la vongola verace filippina. Annals for Istrian and Mediterranean Studies, 17: 227-232.

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Alohtone vrste mekušaca u Tršćanskom zaljevu i susjednim područjima: kritički osvrt i dosadašnja saznanja (ažurirano u 2011.)

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Dosadašnja saznanja o alohtonim vrstama mekušaca u Tršćanskom zaljevu i susjednim područjima prikazana su na temelju detaljnih pregleda zapisa sadržanih u literaturi i iz neobjavljenih podataka dobivenih u razdoblju između 2006. – 2011. godine, te je dodatno nadopunjeno podacima o starijim nalazima koji su sačuvani u privatnim zbirkama.

Na temelju IUCN definicije 'strana vrsta', 13 svojti mekušaca (3 Gastropoda i 10 Bivalvia) je izneseno u ovom radu, a za svaku od njih su date slijedeće informacije (prikupljene do kolovoza 2011.): objavljeni i neobjavljeni zapisi iz obalnih i teritorijalnih obalnih voda u Tršćanskom zaljevu i susjednim područjima, uključujući lagune; utvrđeni status, kao i vektor(i) unosa. Područje karakterizira nazočnost osam uspostavljenih stranih vrsta, dok su ostale četiri povremene, te jedna koja se zbog opreza ne smatra uspostavljenom vrstom. U ovom radu se po prvi put iznose podaci o prikupljenim primjercima vrsta *Anadara transversa* (Say, 1822) i *Limnoperna securis* (Lamarck, 1819) u Tršćanskom zaljevu, što predstavlja najsjevernije nalaze ovih vrsta u Sredozemnom moru.

Prema recentnoj literaturi stari podaci o raspodjeli vrsta *Mercenaria mercenaria* (Linnaeus, 1758) i *Mya arenaria* (Linnaeus, 1758) se ne smatraju pouzdanim. Precizna analiza bibliografskih podataka, re-identifikacija uzoraka sačuvanih u privatnim zbirkama, kao i ponovno uzorkovanje faune, doveli su do isključenja vrsta *Assiminea grayana* Fleming, 1828 i *Conomurex persicus* (Swainson, 1821) iz popisa faune Tršćanskog zaljeva. Glede vrste *Arcuatula senhousia* (Benson u Cantor, 1842), njezin prvi nalaz u slovenskim vodama je proizišao iz pogrešnog tumačenja bibliografije, tako da se tek noviji zapisi ovog školjkaša smatraju izvornim.

Na kraju, smatramo da je prirodna disperzija u 46% slučajeva bila vektor unosa, a u 23% to su bili pomorski promet i akvakultura.

Ključne riječi: Sredozemno more, Jadran, Tršćanski zaljev, mekušci, strane vrste