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Mieniplotia scabra (Müller, 1774), another gastropod invasive species in Europe and the status of freshwater allochthonous molluscs in Greece and Europe

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Abstract

Mieniplotia scabra (Müller, 1774), a freshwater gastropod originating from the Indo-Pacific area, has proved to be a successful invader spreading to other parts of East Asia, Middle East, the Pacific Islands, North America and West Indies. This paper reports the first record of *M. scabra* from Europe, where it has become naturalized in Kos Island in Greece. This new trans-continental introduction brings the number of alien freshwater mollusc species to nine in Greece and to 30 in Europe. This paper provides an updated snapshot of the presence of the numerous non-native freshwater species in Europe (divided by nation) - an account that is currently lacking in literature and in the specific databases.

Keywords: *Mieniplotia scabra*, Europe, Greece, Kos Island, aquatic alien molluscs, distribution, Greek and European alien-list.

Introduction

Mieniplotia scabra (Müller, 1774) is a freshwater gastropod belonging to the Thiaridae Troschel, 1857, a family that in Europe includes another alien invasive species: *Melanoides tuberculata* (Müller, 1774). The original distribution includes a large area of the Indo-Pacific coasts and adjacent islands, from central-east Africa to south Asia and north-east Australia (Davis & Yamaguchi, 1969; Pace, 1973; Brandt, 1974; Starmühlner, 1976, 1979; Brown, 1980; Burch, 1980; Starmühlner, 1982, 1983, 1984; Subba Rao, 1989; Nesemann *et al.*, 2007; Glaubrecht *et al.*, 2009; Dunga *et al.,* 2010; Nesemann *et al.,* 2011; Budha, 2012; Glöer & Pešić, 2012; GBIF, 2014). In Africa, the species lives in eastern South Africa, Kenya, Tanzania (Wami and Kingani rivers, Zanzibar, Pemba Island), Madagascar, Comore Islands, Seychelles Islands, Reunion, Mauritius (Rodriguez Island included). In Asia, the species has been recorded from Afghanistan, India, Sri Lanka, Nepal (Indo-Gangetic Plane), Bangladesh, Myanmar, Andaman Islands, Thailand, Malaysia, Laos, Vietnam, south China, Japan (Ryukyu Islands), Taiwan, Philippines, Indonesia (Borneo, Sulawesi, Sumatra, Java, Moluccas), East Timor. In addition, the species has been recorded from north and north-east Australia (Northern Territory and Queensland).

However, given its high propensity to invasiveness (Nasarat *et al.*, 2014), it is difficult to be certain if this species is actually native throughout these regions. Nevertheless, for the Asian region, *M. scabra* has likely been introduced in the United Arab Emirates, in Oman and Yemen (including Socotra Island) in south-eastern Arabia (Brown & Gallagher, 1985; Al-Safadi, 1990; Neubert, 1998; Feulner & Green, 1999; Glaubrecht *et al.,* 2009; Budha, 2012).

In the Pacific area, the species has now spread in many west Pacific Islands; Starmühlner (1983) considered the species native to this area, even if he affirmed that it was one of the commonest species in west Pacific Islands and hypothesized a possible human introduction with rice and aquatic plants. More recent papers tend to consider the species in this area as cryptogenic (Cowie, 2000, 2002; Glaubrecht *et al.,* 2009) or invasive (Bogan, 2012; Budha, 2012). In particular, it has been recorded from Guam Island, Palau, Federated States of Micronesia (Kosrae, Pohnpei, Truk, Yap Islands), Papua New Guinea including Bismarck Archipelago (Manus, New Ireland, New Britain, Long Island), Solomon Islands (Guadalcanal, Malaita), Vanuatu (Espiritu Santo Island and Éfate Island), New Caledonia, Fiji Islands (Viti Levu and Vanua Levu) and Samoa (Pace, 1973; Brandt, 1974; Starmühlner, 1976, 1983; Haynes, 1984; Starmühlner, 1984; Haynes, 1985, 1990, 1993; Cowie, 2000; Haynes, 2000; Cowie, 2002; Glaubrecht *et al.,* 2009; Glaubrecht & Podlaka, 2010; Prasad, 2010; Budha, 2012; GBIF, 2014).

Recently *M. scabra* has also been introduced into North America, in Florida and in the West Indies, such

as Antilles, Jamaica and Montserrat (Thompson *et al.,* 2009; GBIF, 2014).

It has also been introduced in the Mediterranean area recently: in Israel (Mienis, 2008; Mienis & Mienis, 2008a, 2008b; Roll *et al.,* 2009; Mienis, 2011; Heller *et al.,* 2014) and Jordan (Nasarat *et al*., 2014).

M. scabra is considered one of the most successful invasive species in many parts of the world (Thompson *et al.*, 2009) and its recent and very rapid diffusion in some Middle East countries (Israel and Jordan) confirms the high level of invasiveness (Mienis & Mienis, 2008a, 2008b; Nasarat *et al*., 2014).

To date, no record exists from Europe, and the discovery of a population in the Kos Island, Greece, is the first data from this continent.

Materials and Methods

Specimens were collected by hand. The collection data are listed as follows: locality, altitude, UTM coordinates, collectors and dates; number of specimens, collection and, if present, number of collections in parentheses. Names of the localities and UTM coordinates were taken from Google Earth and converted in ED 50. The examined material is preserved in the following collections: Museo di Storia Naturale dell'Università di Firenze, sezione di Zoologia "La Specola", Via Romana 17, Florence, Italy (MZUFC); Marco Bodon, Via delle Eriche 100/8, Genoa, Italy (MBC); Simone Cianfanelli, Via Monferrato 3, Florence, Italy (SCC); Enrico Talenti, Piazza Parri 4, Incisa, Florence, Italy (ETC).

Sampling was performed at five sites in Greece, South Aegean, Dodekanisos, Kos Island, municipality of Kos (Table 1); *M. scabra* was found in sites 1 and 2.

1. Lake Pyli, small lake feds by springs, 1.2 km SSE of Marmari, 22 m ca. a.s.l., 35S 05143 40800, E. Talenti leg. 01/07/2013 (1 spec., 1 juv. spec., MZUFC GC/44740; 1 spec., MBC; 1 spec., SCC 44740/18955; 2 spec., 7 juv. spec., ETC).

2. Small canal feds by springs, along the main road, 900 m S-SE of Marmari, 15 m ca. a.s.l., 35S 05141 40803, E. Talenti leg. 01/07/2013 (2 juv. spec., ETC).

3. Tributary canal of the Lake Aliki, west shore, 0 m a.s.l., 35S 05146 40819, E. Talenti leg. 04/07/2013.

4. Lake Aliki, west shore, debris, 0 m a.s.l., 35S 05146 40820, E. Talenti leg. 04/07/2013.

5. Lake Aliki, southern shore, debris, 0 m a.s.l., 35S 05152 40818, E. Talenti leg. 10/07/2013.

The updated distribution of alien species in Europe (Table 2) and the data processing (Figs. 2-4) are the result of a meticulous research utilizing books, texts and scientific journals, including journals of regional relevance, from national checklists (Gittenberger *et al*., 1998; Angelov, 2000; Falkner *et al*., 2002; Korniushin *et al*., 2002; Reischütz, 2002; Albuquerque de Matos & Kolouch, 2003; 2004; Killeen *et al*., 2004; Anderson, 2005; Glöer & Zettler, 2005; Zettler *et al*., 2005; Gloer & Sirbu, 2006; Gollasch & Nehring, 2006; Cejka *et al*., 2007; Hubenov, 2007; Jungbluth & Knorre, 2008; Byrne *et al*., 2009; Fehér & Eross, 2009; Fontaine *et al*., 2010; Kantor *et al*., 2009; De Oliveira *et al*., 2010a, 2010b; Horsák *et al*., 2010; Koralewska-Batura *et al*. 2010; Munjiu & Shubernetski, 2010; Sîrbu *et al*., 2010; Sokolka & Preda, 2010; Boschi, 2011; Gargominy *et al*., 2011; Proschwitz, 2011; Welter-Schultes *et al*., 2011; Zettler, 2014) to records or monographs on alien species (especially recent works, i.e. Reischutz, 2002; Anderson, 2003, 2004; Horsák *et al.,* 2004; Nienhuis, 2004; Vimpère, 2004; Beran & Gloer, 2006; Zettler *et al*., 2006; Majoros *et al.,* 2008; López Soriano *et al*., 2009; Son, 2008; van der Velde *et al*., 2010; Verween *et al*., 2010; Marrone *et al*., 2011; Soes *et al*., 2011; Butkus *et al*., 2014; Marrone *et al*., 2014; Quiñonero-Salgado & López-Soriano, 2014); furthermore, various online databases were checked, such as Fauna Europea (Araujo, 2013; Bank, 2014), GBIF (2014), GISP (2014), IUCN (2014) and AnimalBase (2015).

Results

Identification and taxonomy

M. scabra is a medium size operculate gastropod, with a dextral shell (Fig. 1 A-F). The shell is ovoid-conical, 10-32 mm in height, with a rather short spire (less than last whorl in height), consisting of 7-9 whorls (even if usually early juvenile whorls are worn away) with fine spiral ridges and more strong axial ribs with rising, in the upper part of the whorls, as nodules and spines. Sometimes the spines may be very developed, extending the suture of the whorl (*Melania spinulosa* Lamark, 1822, taxa of uncertain taxonomic status, considered synonym by some authors as Brandt, 1974). The ground colour is tawny with vertical, rust-coloured flames and blotches alternating with the nodules and spines (Benthem-Jutting, 1956; Brandt, 1974; Starmühlner, 1976; Muley, 1978b; Glaubrecht *et al.,* 2009; Nasarat *et al.,* 2014). *M. scabra* has a horny, paucispiral operculum smaller than aperture, with eccentric nucleus (Pace, 1973; Starmühlner, 1976, 1983; Gomez *et al*., 2011).

In the case of the Thiaridae family, the anatomy of the genital tract is quite uniform and anatomical details are irrelevant for the recognition of the species (Riech, 1937; Abbot, 1948; Pace, 1973; Brandt, 1974; Starmühlner, 1974, 1976; Muley, 1977, 1978a).

M. scabra may be confused for the apparent morphological similarity of the shell with some untypical forms of *Melanoides tuberculata*, which usually is easily distinguishable for the more elongated and conical shape, the on average bigger size, the absence, in the upper part of the whorls, of the more or less developed nodules or stout spines.

M. scabra is variable and includes many synonyms or infraspecific taxa of uncertain validity (Benthem-Jutting, 1956; Brandt, 1974; Starmühlner, 1976, 1983, 1984).

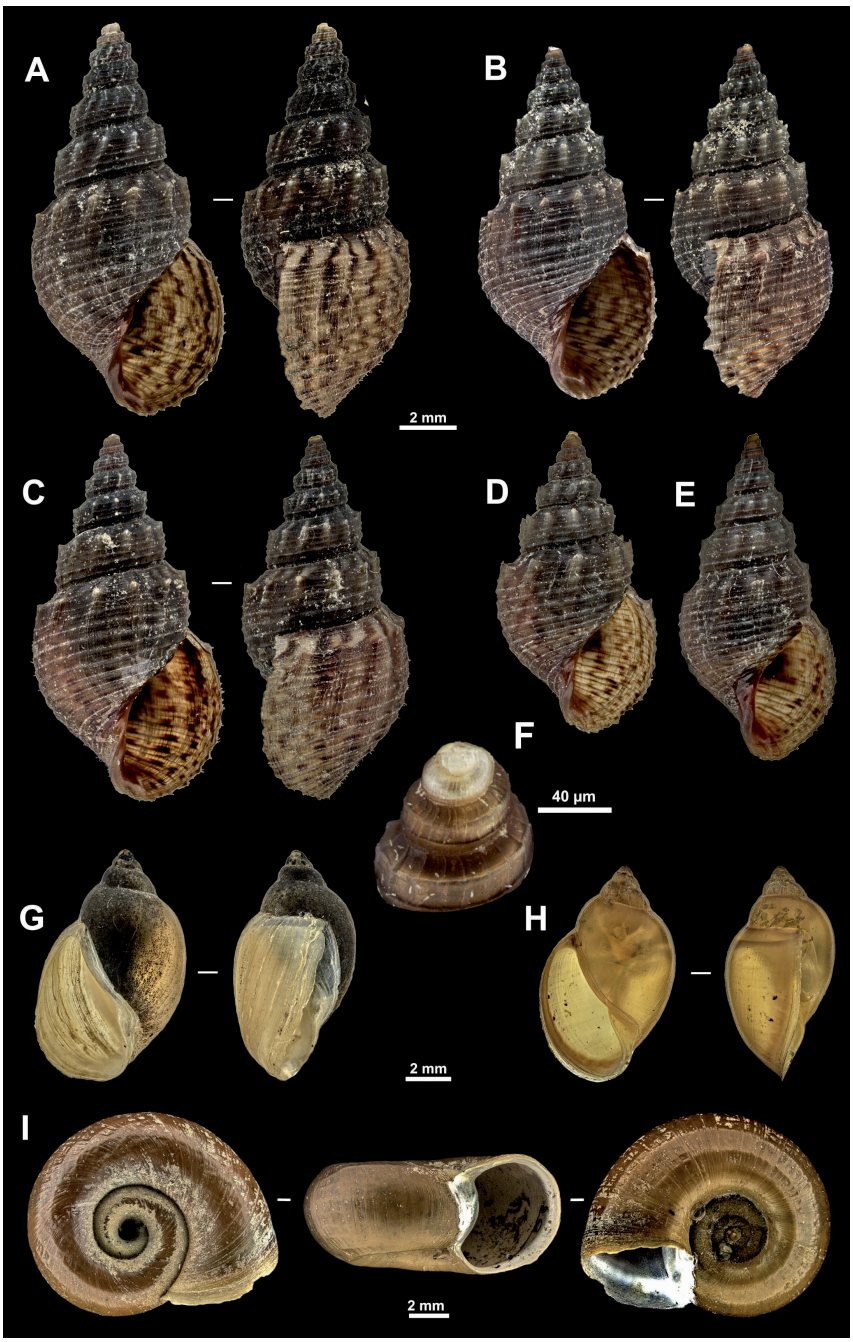

Fig. 1: Non-native Gastropods from Kos Island. A-F) *Mieniplotia scabra* (Müller, 1774), frontal view, lateral view and magnification of the protoconch in subapical view; Lake Pyli, 1.2 km SSE of Marmari, E. Talenti leg. 01/07/2013 (A, F: MZUFC GC/44740; B: SCC; C: MBC; D-E: ETC). G-H) *Physella acuta* (Draparnaud, 1805), frontal view and lateral view; tributary canal of the Lake Aliki, west shore, E. Talenti leg. 04/07/2013 (MZUFC GC/44741). I) *Helisoma duryi* (Wetherby, 1879), upper view, frontal and lower view; tributary canal of the Lake Aliki, west shore, E. Talenti leg. 04/07/2013 (MZUFC GC/44738).

Even the systematic recognition at genus level is controversial; the species is often attributed to *Thiara* Röding, 1798, and, even recently, some authors are continuing to consider valid the attribution to this genus (Roll *et al.,* 2009; GBIF, 2014); other authors (Mienis, 2012; Mienis & Rittner, 2013; Nasarat *et al*., 2014) place the species in the genus *Pseudoplotia* Forcart,1950; while Glaubrecht *et al*. (2009), Glaubrecht & Podlaka (2010), Budha (2012) and Bogan (2012) place the species in the genus *Plotia* Röding, 1798. The generic attribution has been recently reviewed by Low & Tan (2014) that have established the new monospecific genus *Mieniplotia*, already adopted by Bouchet (2015). Considering that the genetic analysis confirms *M. scabra* as rather distant from all other Thiaridae (Glaubrecht *et al*., 2009), its inclusion in a monospecific genus is acceptable.

Distribution on Kos Island

At sites 1 and 2 (Table 1), the populations of *Mieniplotia scabra*, sampled in 2013, were abundant and with

Table 1. List of the freshwater (F) and brackish water (B) molluscs of Kos Island, based on the literature and the collections of the authors; the asterisk (*) highlights the alien species.

Family	Species	Habitat	Literature	Collecting sites				
				1	2	3	4	5
Neritidae	*Theodoxus anatolicus* (Récluz, 1844)	F	Gambetta 1929; Schütt 1986; Bank and Neuteboom 1988; Bank 2006		X			
Thiaridae	*Mieniplotia scabra* (Müller, 1774)*	F		X	X			
Melanopsidae	*Melanopsis buccinoidea* (Olivier, 1801)	F	Gambetta 1929; Fuchs and Käufel 1936; Bank and Neuteboom 1988; Bank 2006	X	X	X		X
Bithyniidae	*Pseudobythinia gittenbergeri* Glöer & Maassen, 2009	F				X	X	X
Hydrobiidae	*Pseudamnicola* sp.	F	Bank and Neuteboom 1988					
Hydrobiidae	*Radomaniola* sp.	F	Schütt 1980 (*Belgrandiella seminula*); Bank and Neuteboom 1988 (*Belgrandiella* n. sp.); Bank 2006 (*Belgrandiella seminula*); Georgiev 2013 (*Radomaniola seminula*)					
Cochliopidae	*Eupaludestrina* sp.	F/B						X
Bythinellidae	*Bythinella kosensis* Schütt, 1980	F	Schütt 1980; Bank and Neuteboom 1988; Bank 2006					
Truncatellidae	*Truncatella subcylindrica* (Linnaeus, 1767)	B						X
Valvatidae	*Valvata saulcyi* Bourguignat, 1853	F						X
Physidae	*Physella acuta (*Draparnaud, 1805)*	F	Bank and Neuteboom 1988; Bank 2006	X	X	X		X
Lymnaeidae	*Galba truncatula* (Müller, 1774)	F	Bank and Neuteboom 1988; Bank 2006					X
Planorbidae	*Planorbis intermixtus* (Mousson, 1874)	F				X		X
Planorbidae	*Helisoma duryi* (Wetherby, 1879)*	F				X		
Ancylidae	*Ancylus fluviatilis* Müller, 1774	F	Gambetta 1929; Bank and Neuteboom 1988; Bank 2006					
Sphaeriidae	*Pisidium casertanum* (Poli, 1791)	F	? Bank and Neuteboom 1988 *(Pisidium* sp.)					X

specimens of all sizes, demonstrating that naturalization of this alien species occurred in Kos Island. At all sites, except 4, also other alien species were found.

Discussion

At present, there are no reliable data on the date and causes of the introduction of *M. scabra* in Kos Island; the findings are recent but there have not been any reports in the previous years from the same locality. Only Bank & Neuteboom (1988) sampled the area near Pyli, in 1978, 1979 and 1987 and *Melanopsis buccinoidea* (Olivier, 1801) was collected, but no *M. scabra*. One reliable hypothesis can be the natural introduction through avian carriers, given the recent invasion of *M. scabra* in Israel, observed since 2006 (Mienis, 2008; Mienis & Mienis, 2008a, 2008b; Mienis & Rittner, 2013); the Kos Island is, in effect, near one of the major bird migration routes that transit from Europe to the Middle East (BLI, 2015; WID, 2015). However, an involuntary introduction for anthropogenic causes, by means of the transport and trade of aquatic ornamental plants or by means of aquariophily, as has been suggested by Roll *et al.* (2009) for the aquatic species introduced in Israel or by Nasarat *et al*. (2014) for the introduction of *M. scabra* in Jordan, cannot be excluded.

Kos Island has not been the subject of recent research on freshwater and brackish water species and only nine have been cited in literature (Gambetta, 1929; Schütt,1980, 1986; Bank & Neuteboom, 1988; Georgiev, 2013; see Table 1). From the summarily research carried out in 2013, with the sampling of 5 sites, 12 aquatic species were identified, some of which are new for the island: 11 gastropod and 1 bivalve species. The preliminary list of the malacological fauna from Kos has therefore been updated to 16 species (Table 1). Nevertheless, this checklist is certainly incomplete, as few aquatic habitats have been sampled in Kos. Besides *M. scabra,* two other alien freshwater species were identified: *Physella acuta* (Draparnaud, 1805) (Fig. 1 G-H) (already reported in Bank & Neuteboom, 1988 and in Bank, 2006) and *Helisoma duryi* (Wetherby, 1879), a new record for the island (Fig. 1 I).

With *M. scabra,* the number of allochthonous freshwater molluscs found in Greece rises to 9 (Economou *et al.,* 1991; Petridis & Sinis, 1993; Conides *et al.,* 1995; Bank,

Table 2. Checklist of alien freshwater molluscs in Europe, with the continent of origin and distribution for each country. X: allochthonous in the indicated country; *: native in the indicated country (species whose area of origin is practically non-European or very invasive species with marginal native range).

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	Total
	Species \ Distribution	Native area	Albania	Andorra	Austria	Belarus	Belgium	Bosnia and Herzegovina	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	Estonia	European Russia	European Turkey	Finland	France	Germany	Great Britain	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Liechtenstein	Lithuania	Luxembourg	Macedonia	Malta	Moldova	Montenegro	Norway	Poland	Portugal	Romania	Serbia and Kosovo	Slovak Republic	Slovenia	Spain	Sweden	Switzerland	The Netherlands	Ukraine	
1	*Marisa cornuarietis* (Linnaeus, 1758)	N America																								X																				1
2	*Pomacea bridgesii* (Reeve, 1856)	S America			X							X?														X													X							4
3	*Pomacea maculata* Perry, 1810	S America																																							X					1
4	*Pomacea* cf. *paludosa* (Say, 1829)	C-S America			X																																								1
5	*Bellamya chinensis* (Gray, 1834)	Asia																																										X		1
6	*Melanoides tuberculata* (Müller, 1774)	Africa and Asia			X						X	X						X	X	X		X		X	X	X					*				X				X		X	X		X		15
7	*Mieniplotia scabra* (Müller, 1774)	Africa and Asia																			X																								1
8	*Potamopyrgus antipodarum* (Gray, 1843)	Oceania		X	X	X	X		X	X	X?	X	X	X	X		X	X	X	X	X	X		X	X	X		X	X			X		X	X	X	X		X	X	X	X	X	X	34
9	*Physella acuta* (Draparnaud, 1805)	N America	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	43
10	*Physella gyrina* (Say, 1821)	N America			X															X				X																X					4
11	*Physella pomilia* (Conrad, 1834)	N America			X																																								1
12	*Galba cubensis* (Pfeiffer, 1839)	N America			X																																								1
13	*Radix javanica* (Mousson, 1849)	Asia			X																																								1
14	*Radix rubiginosa* (Michelin, 1831)	Asia																		X				X																					2
15	*Pseudosuccinea columella* (Say, 1817)	C-S America			X							X						X	X		X	X			X	X										X	X		X		X	X	X	X		15
16	*Gyraulus chinensis* (Dunker, 1848)	Asia			X							X						X	X	X	X			X	X								X		X									13
17	*Gyraulus parvus* (Say, 1817)	N America			X							X						X	X		X	X	*						X									X?			X	X	X		11
18	*Menetus dilatatus* (Gould, 1841)	N America										X						X	X	X															X	X							X	X	8
19	*Biomphalaria glabrata* (Say, 1818)	C-S America											X						X																										2
20	*Biomphalaria tenagophila* (d'Orbigny, 1835)	S America																																		X									1
21	*Helisoma anceps* (Menke, 1830)	N America																	X?																										1
22	*Helisoma duryi* (Wetherby, 1879)	N America	X		X							X	X					X	X	X	X	X		X	X	X?				X	X				X	X	X		X		X	X		X		21
23	*Helisoma nigricans* (Spix, 1827)	N America																				X																					X		2
24	*Ferrissia fragilis* (Tryon, 1863)	N America	X		X	X	X		X			X	X		X			X	X	X	X	X		X	X	X		X	X		X	X		X	X	X	X	X	X	X	X	X	X	X	31
25	*Sinanodonta woodiana* (Lea, 1834)	Asia			X		X		X	X		X			X			X	X		X	X			X							X	X		X		X	X	X	X	X		X	X	22
26	*Dreissena polymorpha* (Pallas, 1771)	Ponto-Caspian		X	X	*	X	X	X	X		X	X	X	*	X	X	X	X	X		X		X	X	X		X	X			X	X		X	X	X	X	X	X	X	X	X	X	*	32
27	*Mytilopsis leucophaeata* (Conrad, 1831)	N America					X								X		X	X	X	X															X					X			X	X	10
28	*Musculium transversum* (Say, 1829)	N America																X	X	X																								X		4
29	*Corbicula fluminalis* (Müller, 1774)	Asia					X											X	X			X			X				X						X	X		X					X	X	X	12
30	*Corbicula fluminea* (Müller, 1774)	Asia			X		X		X	X		X						X	X	X		X		X	X				X			X			X	X	X	X	X		X		X	X	X	22
		Total	3	3	17	3	8	2	6	5	3	13	6	3	5	2	4	15	17	13	9	12	1	10	11	9	1	4	7	2	3	6	3	3	11	10	9	6	11	5	13	10	8	17	8	

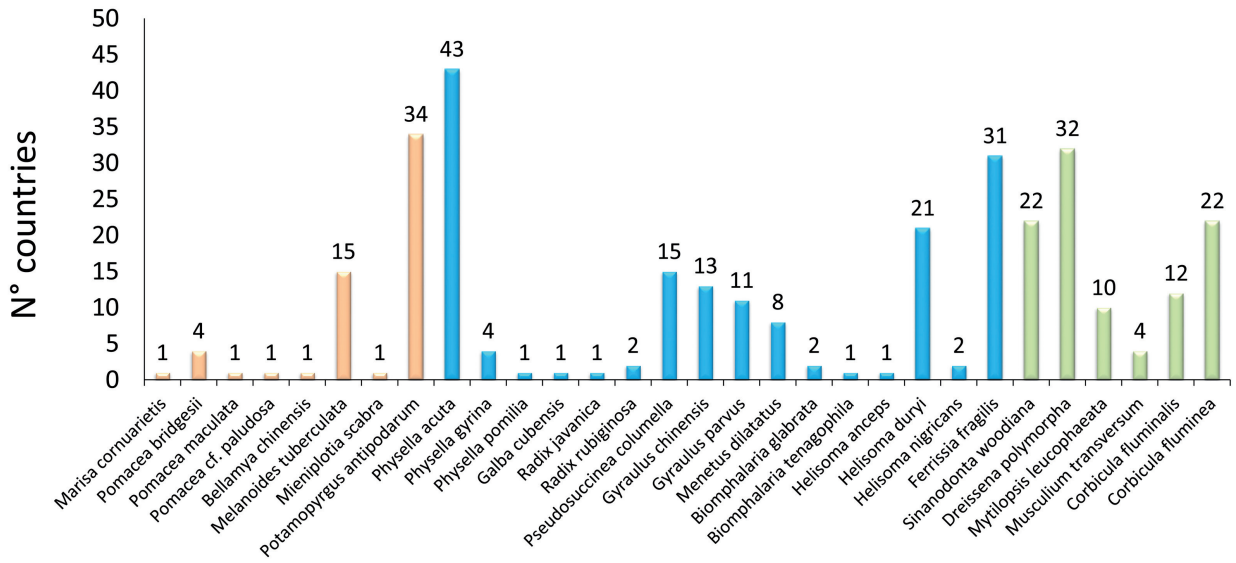

Fig. 2: Number of European countries where the presence of species of allochthonous freshwater molluscs has been reported: many species are particularly invasive, being now present in many countries, while others may be dormant or not invasive, being present in only a few European states and only in artificial environments.

2006; Radea *et al*., 2008; Zenetos *et al.,* 2009; Bank, 2011, 2013); *Helisoma anceps* (Menke, 1830), recorded by Erőss *et al*., 2005 from Prespa Lake, is here referred to *Helisoma duryi*, according to Bank, 2011, 2013, while the doubtful records of *Dreissena polymorpha* from Greece (Zenetos *et al*., 2009) have not been confirmed by genetic data (Wilke *et al*., 2010).

Molluscs are, at the European level, a taxon with many allochthonous species representing about 10 % of the total amount of introduced freshwater alien species (Gherardi *et al.,* 2008; DAISIE, 2009). Currently the freshwater molluscs of extra-European origin, present in European countries, amount to 30 species (Table 2). In the list of introduced species, taxa of extra-European origin or present, in origin, only marginally in the continent (taking the eastern geographic borders proposed in UNSC, 2014 and in INSTAT, 2014, thereby excluding Turkey to the south of the Bosphorus and the Georgia) have been considered. A very invasive species, which has its original origin in Eastern Europe at the turn with the Asian continent: *Dreissena polymorpha* (Pallas, 1771) was also included, while *Dreissena rostriformis bugensis* (Andrusov, 1897) being native to Ukraine has been regarded as of European origin (van der Velde *et al.,* 2010) and therefore not included. Finally, two other taxa have been considered as non-European, with the exception of a single European nation, where the species are considered autochthonous (*Melanoides tuberculata* in Malta and *Gyraulus parvus* (Say, 1817) in Iceland). Allochthonous species include both species acclimated in nature and those known from the literature as species present in artificial environments such as pools, greenhouses, intensive crops, nurseries, gardens and botanical gardens, sometimes not naturalized. It is in fact known that some species, spread by means of aquariophily, such as *Melanoides tuberculata* or *Helisoma duryi*, species distributed in tropical areas, remain confined to artificial and semi-natural environments or hot and thermal waters in colder countries in central Europe (Glöer, 2002), while, in the Mediterranean countries, these species spread more easily in natural environments and become invasive.

In Europe, among the major invasive continental molluscs there are several aquatic species that have found a quick and easy route of spreading along the drainage systems, also thanks to anthropical interventions (Ricciardi, 2001; Gherardi *et al*., 2008). Among the 30 alien freshwater species of molluscs, these are the most alarming invaders, such as *Physella acuta* (Draparnaud, 1805), present in all the 43 European countries, *Potamopyrgus antipodarum* (Gray, 1843) present in 34 countries, *Dreissena polymorpha*, present in 32 countries, *Ferrissia fragilis* (Tryon, 1863), present in 31 countries, *Corbicula fluminea* (Müller, 1774) and *Sinandodonta woodiana* (Lea, 1834), present in 22 countries (Table 2; Fig. 2). However the data reported in Table 2 are still provisional, since the phenomenon of biological introductions is extremely dynamic, and the number of species is exponentially growing; also the level of knowledge is very different from one country to another, and many of the small alien entities are not easily detected except through specific research, which sometimes is not carried out in depth in all the European countries.

In Europe, the wide range of habitats and climatic diversity facilitate the acclimatization of alien species from different continents, and these are mainly found in the central and Mediterranean areas (Fig. 3). The allochthonous species come from Oceania (*Potamopyrgus antipodarum*), Africa and Asia (*Melanoides tuberculata, Mieniplotia scabra*), Central and South America (*Pseu-*

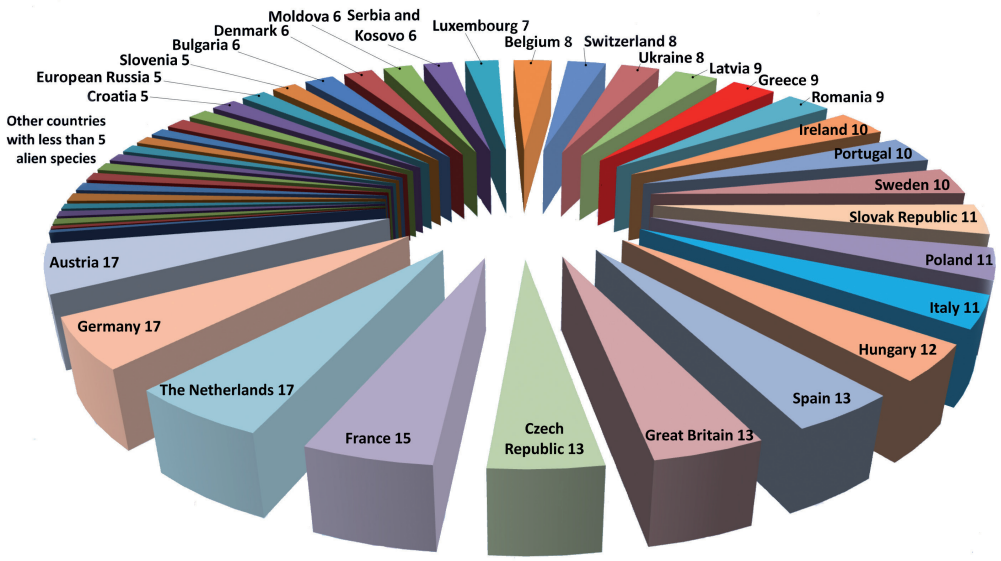

Fig. 3: Number of alien freshwater molluscs by country: central European nations have the largest number of introduced species (17 in Austria, in The Netherlands and in Germany: 15 in France, etc.), but the numbers are also high in the Mediterranean areas, such as in Spain (13), in Italy (11) and in Greece (9).

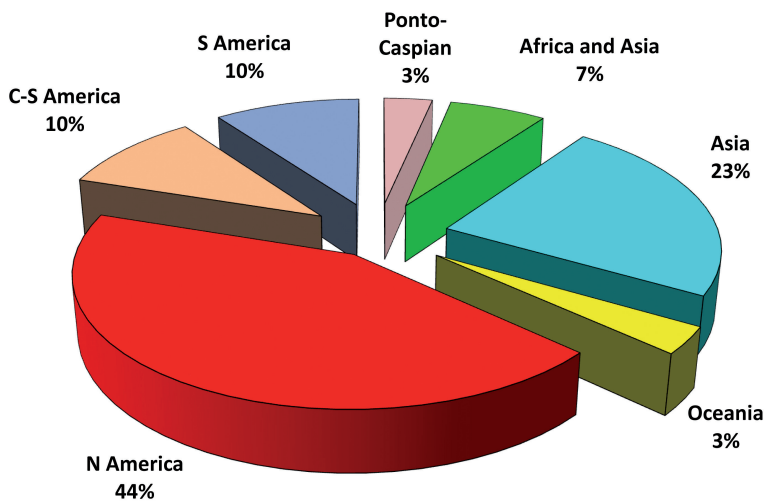

Fig. 4: Percentage of allochthonous freshwater molluscs introduced in Europe according to the continent of origin.

dosuccinea columella Say, 1817) and species of the genus *Helisoma* Swainson, 1840), Asia (with *Corbicula fluminalis* and particularly invasive species such as *Sinanodonta woodiana* and *Corbicula fluminea* (Müller, 1774)), but the largest number of alien species (13 species, 44 %, Fig. 4) is native to North America, with *Physella acuta*, the more prevalent alien in Europe and other species such as *Ferrissia fragilis* at present very frequent, while species such as *Menetus dilatatus* (Gould, 1841) and *Gyraulus parvus* are less widespread.

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