Biodiversity Journal, 2013, 4 (4): 571-580

On the presence of *Dreissena polymorpha* Pallas, 1771 and *Sinanodonta woodiana woodiana* (Lea, 1834) in Sicily (Bivalvia)

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ABSTRACT In this paper we report on the presence of two non-native and invasive species of bivalve mollusks in Sicily: *Sinanodonta woodiana woodiana* (Lea, 1834) (Bivalvia Unionidae) native to East Asia and *Dreissena polymorpha* (Pallas, 1771) (Bivalvia Dreissenidae) native to the Ponto-Caspian area, with a particular focus on how the presence of these alien species can lead to imbalances in the delicate equilibrium of Sicilian freshwater invertebrates and, above all, does threaten the existence of *Unio elongatus gargottae* Philippi, 1836 an island's native bivalve suffering from strong rarefaction.

KEY WORDS invasive species; bivalve mollusks; aquatic biotopes; Sicily.

Received 28.11.2013; accepted 20.12.2013; printed 30.12.2013

INTRODUCTION

The problem of non-native and invasive species, and particularly those who have settled in the Euro-Mediterranean area, has become in recent years extremely interesting in relation to the large number of species that have been reported.

All habitats and all groups of animals and plants are affected by this phenomenon and the impact on native ecosystems is almost always devastating (Bogan, 1993; Lydeard et al., 2004).

The sicilian aquatic biotopes are not an exception, with an increasing colonization by allochthonous organisms observed both in historical times that during the last few decades, for the freshwater mollusks:

- *Haitia acuta* (Draparnaud, 1805): Cianfanelli et al., 2007)
- *Radix auricularia* (Linnaeus, 1758): Liberto et al., 2010
- *Corbicula fluminea* (Müller, 1774): Mienis, 1991
- *Anodonta* sp.: Zettler & Richard, 2003
- *Potamopyrgus antipodarum* (J.E. Gray, 1843): Zettler & Richard, 2003; Bodon et al. 2005; Cianfanelli et al., 2007
- *Melanoides tuberculatus* (O.F. Müller, 1774): Reitano et al., 2007
- *Helisoma duryi* (Wetherby, 1879): Manganelli et al. 1995; Reitano et al., 2007
- *Ferrissia fragilis* (Tryon, 1863): Marrone et al., 2011.

Recently, some observations have indicated to us the presence in Sicily of *Sinanodonta woodiana woodiana* (Lea, 1834) (Bivalvia Unionidae) (personal observations; Distefano, 2013; Firrito, 2013) one of the most invasive aquatic macroinvertebrate species. Subsequent research carried out in the field allowed to highlight the presence of another allochthonous: *Dreissena polymorpha* (Pallas, 1771) (Bivalvia Dreissenidae).

ACRONYMS. The materials used for this study are deposited in the following private collections: R. Grasso collection, Dipartimento di Scienze Biologiche, Geologiche ed Ambientali, Università degli Studi di Catania, Italy (CGR); S. Giglio collection, Cefalù, Italy (CGS); F. Liberto collection, Cefalù, Italy (CL); A. Reitano collection, Tremestieri Etneo, Italy (CR); I. Sparacio collection, Palermo, Italy (CS).

MATERIALS AND METHODS

All specimens were collected by sight directly in the field. Photographs were taken with a digital camera. Voucher specimens were stored in collections indicated below. Toponyms (place-names) are reported following the Portale Cartografico Nazionale (PCN, http://www.pcn.minambiente.it /PCN/), Map IGM 1:25000. Taxonomical references are based on the checklist of "Fauna Europaea", version 2.0 (Araujo 2009a, 2009b) available at: http://www.faunaeur.org.

RESULTS

BIVALVIA
DREISSENIDAE

Dreissena polymorpha Pallas, 1771
Zebra mussel

EXAMINED MATERIAL. Italy, Sicily, Ragusa, Lago di Santa Rosalia, 385 m, 36°59'19"N 14°46'47"E, 29.IX.2012, 3 specimens with soft tissues (CR) (Figs. 1, 2).

DESCRIPTION. Mytiliform bivalve (25–35 mm in size) with relatively flattened ventral margins, roundend dorsal margins and pointed umbo. Brownish-yellowish in color with dark and light coloured zigzag banding. Viewed from the inside, the shell has a large septum to which the anterior adductor and retractor muscles are attached (Killeen et al., 2004) (Figs. 3–7).

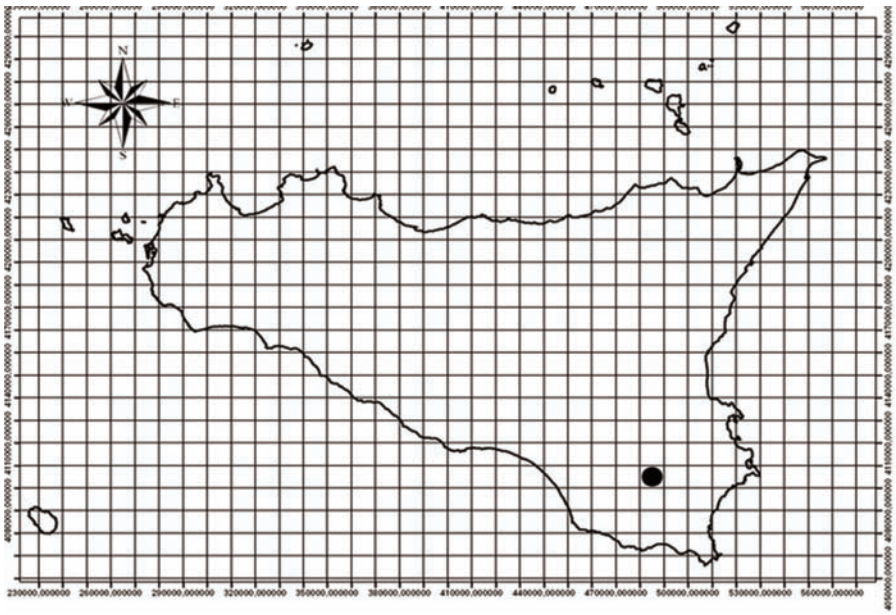


Figure 1. Current geographic distribution of *Dreissena polymorpha* and *Sinanodonta woodiana* in Sicily. Dot: Ragusa, Lago di Santa Rosalia.

Figure 2. Sicily, Ragusa: Lago di Santa Rosalia. Figures 3–7. *Dreissena polymorpha* from Sicily, Lago di Santa Rosalia.

DISTRIBUTION AND BIOLOGY. *D. polymorpha* is native to the Ponto-Caspian Region of Eastern Europe. Its invasion history dates back to the late 18th century in Russia and during the 19th century the species spread out in most of inner water systems of central and western Europe (Kinzelbach, 1992; Strayer & Smith,1993; Minchin et al., 2002); it has been reported also in Spain, in the southern part of the Ebro river (Araujo & Halcon, 2001; Araujo et al., 2004) and in Northern Ireland (Millane et al., 2008). In 1988, it first appeared in the Great Lakes of North America and rapidly spread along the Mississippi River (Strayer, 1991; Strayer et al., 1994; Strayer & Smith, 1996; Strayer et al., 1998; May et al., 2006). It was found for the first time in Italy in 1969 in Lake Garda (Giusti & Oppini, 1973; Franchini, 1976). Subsequently, *D. polymorpha* has been reported for several lakes of Northern Italy (Bianchi et al., 1974; Camusso et al., 2001; Morpurgo & Thaler, 2002; Dalfreddo & Maiolini, 2003, Roncaglio & Borsani, 2005) and central Italy (Spilinga et al., 2000; Bodon et al., 2005; Lori & Cianfanelli, 2006).

D. polymorpha is characterized by a high fecundity, ranging from about 30,000 to 40,000 eggs/female per year. Veliger larvae lead a planktonic life for, usually, 8-10 days, then settle and attach to the bottom by byssal filaments. The average life span is 3-6 years. Adults anchored to the substratum can reach a high density, in the order of thousands per square meter. Hence, filtrating capacity of zebra mussels usually cause severe damages at both local and system-levels, including changes in species composition and density of native benthic invertebrates; decreases in phytoplankton and zooplankton densities, in chlorophyll concentration and suspended matter; increase in water transparency with a consequent growth of macrophytes (Mackie et al., 1991; Therriault et al., 2013).

REMARKS. In September 2013 a population of *D. polymorpha* was found in the artificial Lake Santa Rosalia (Ragusa, Sicily, Italy), which is the first record of *D. polymorpha* in Sicily. Water discharge due to introduction of fish was probably the main vector that made it possible the spread of *D. polymorpha* in the lake. As noted, the species seems to be successfully established in the lake basin with large aggregations (druses) and it is likely that a future further increase in its spreading rate and diffusion will occur leading these organisms to colonize the basin of Irminio river and other basins. Indeed, Lake Santa Rosalia is connected to Scicli by a 16 km aqueduct and two other pipelines will be built to connect the Lake to Marina di Ragusa and Santa Croce Camerina (Ragusa), which might behave as highways for the diffusion of the species.

According to the Global Invasive Species Database of IUCN (2006) *D. polymorpha* is one of the 100 World's Worst Invasive Alien Species, and its negative impacts on the ecosystem and especially its economical damage are well known.

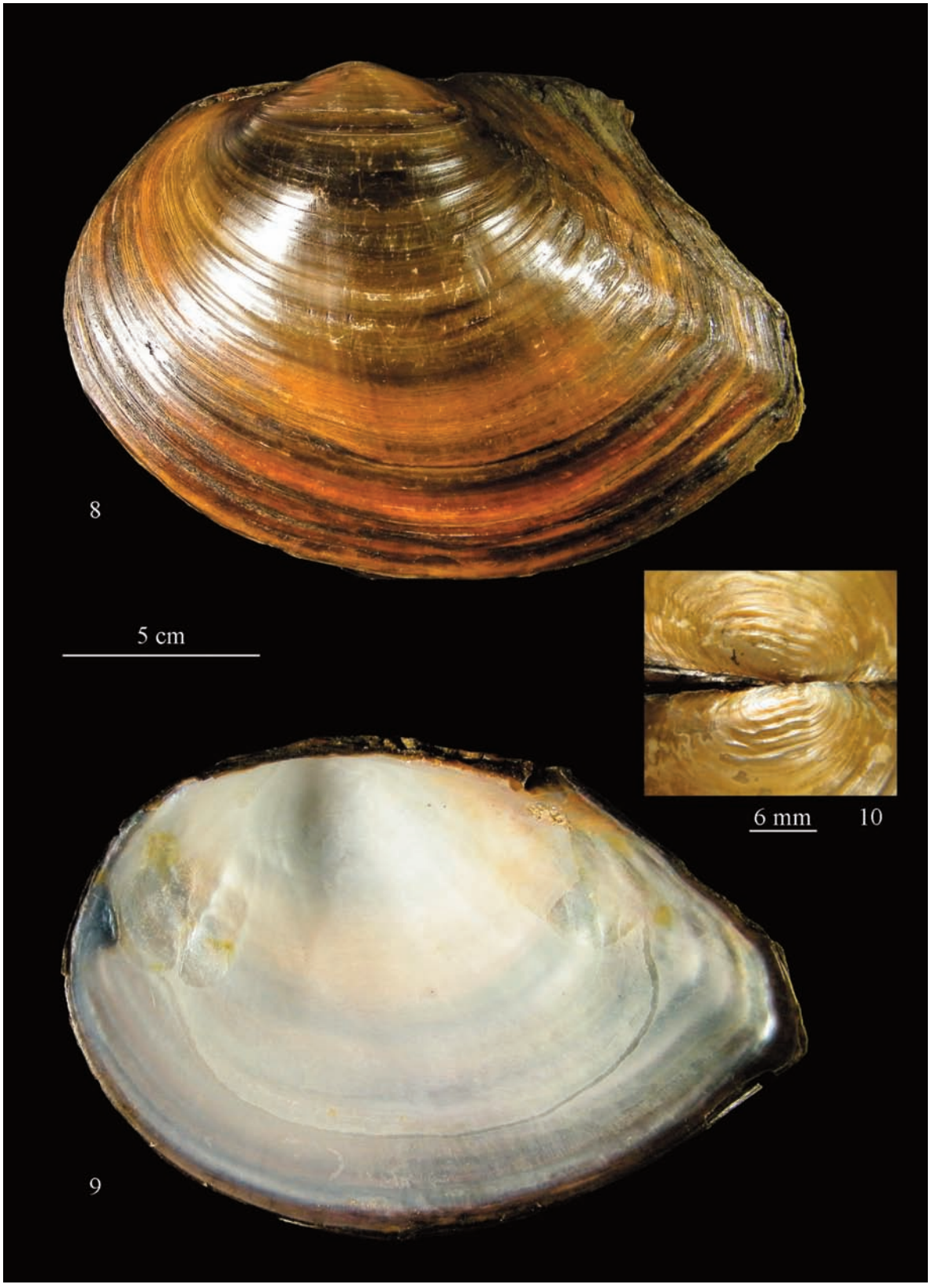
UNIONIDAE

Sinanodonta woodiana woodiana (Lea, 1834)
Chinese pond mussel

EXAMINED MATERIAL. Italy, Sicily, Ragusa, Lago di Santa Rosalia, 36°59'13"N 14°46'50"E, 385 m, 21.VII.2012, 1 specimen (CGR); Italy, Sicily, Ragusa, Lago di Santa Rosalia, 36°59'19"N 14°46'47"E, 385 m, 29.IX.2012, 4 specimens (CR); idem, legit Reitano A., 3 specimens (CL); idem, legit Reitano A., 3 specimens (CGS); idem, legit Reitano A., 3 specimens (CS) (Figs. 8–10).

DESCRIPTION. From a morphological standpoint, *S. woodiana* collected in Sicily show typical characters of the species: wide shell (maximum length ca. 300 mm), with deeply rounded ventral margin, surface irregularly rippled to corrugated, umbonal rugae prominent widely spaced, subconcentric or slightly transverse ripples without prominent nodules, posterior pedal retractor scar very narrow; hinge without teeth. The size of some specimens exceed 190 mm in length.

DISTRIBUTION AND BIOLOGY. *S. woodiana* is a species of East Asia (Baba, 2000) that has recently been reported as being invasive worldwide. The expansion of *S. woodiana*'s range began in the second half of the twentieth century. To date, *S. woodiana* can be found in the Indonesian islands (Djajasasmita, 1982), Central America (Watters, 1997), Europe (Hungary: Petró, 1984; Romania: Sárkány-Kiss, 1986; France: Girardi & Ledoux, 1989; Slovakia: Košel, 1995; Czech Republic: Beran, 1997; Austria: Reischutz, 1998; Poland: Bohme, 1998; Ukraine: Yurishinets & Korniushin, 2001; Germany: Glöer & Zettler, 2005; Serbia:



Figures 8–10. *Sinanodonta woodiana woodiana* from Sicily, Lago di Santa Rosalia.

Paunovic et al., 2006; Montenegro: Tomović et al., 2013; see also Sárkány-Kiss et al., 2000; Kraszewski, 2007; Douda et al., 2012), and North America (Benson, 2011).

It was first reported in Italy in 1996 (Manganelli et al., 1998), and in about 15 years it formed colonies in many Italian regions: Emilia-Romagna and Latium (Manganelli et al., 1998; Fabbri & Landi, 1999; Lodde et al., 2005a; 2005b; Albano, 2006), Tuscany and Veneto (Niero, 2003; Lori & Cianfanelli, 2006), Marche, Piedmont, Umbria and Lumbardy (Solustri & Nardi, 2006), and Campania (De Vico et al., 2007); in Sicily, *Anodonta* sp. was recorded by Zettler & Richard (2003) and, recently, the presence of *S. woodiana* was reported in some web pages from Ragusa, Lago di Santa Rosalia (Distefano, 2013; Firrito, 2013).

S.woodiana larvae, like all Unionidae (Castagnolo et al., 1980; Aldridge & McIvor, 2003), go throught an obligatory parasitic stage (known as glochidium); glochidia larvae parasitize, by clinging with a kind of hook, the fins or gills of fish for several days to weeks; afterwards they detach from the host and fall to the bottom where mature and start to conduct a free life. The great success of *S. woodiana* has been attributed to the worldwide introduction for commercial purposes of its sympatric fish hosts (mainly carp species from East Asia) (Watters, 1997). *S. woodiana* is a broad generalist, and it may parasitize even on novel native hosts (Kiss,1995; Watters, 1997; Sárkány-Kiss et al., 2000; Douda et al., 2012), in addition both juveniles and adults of *S. woodiana* can successfully cope with a wide range of environmental conditions.

Thermal conditions, water flow and substrate characteristics mostly determine the distribution and density of *S. woodiana* (Kraszewski & Zdanowski, 2007). According to Demayo et al. (2012), this species prefers habitats with higher temperatures (the optimal thermal conditions vary within 10 and 35ºC).

REMARKS. The presence of *S. woodiana* in Lake Santa Rosalia, an artificial basin for irrigation built in 1980 on Irminio river (Ragusa, South-eastern Sicily), may have been caused by the introduction of several species of fish from farms to promote sport fishing. The discovery in 2012 of specimens larger than 190 mm, aged more than 8 years, allows us to hypothesize that the entrance of *S. woodiana* in the lake took place at least 10 years ago.

According to the Global Invasive Species Database of IUCN (2006), *S. woodiana* is one of the 100 World's Worst Invasive Alien Species.

DISCUSSION AND CONCLUSIONS

Generally, the introduction of alien species in a given territory produces nearly always negative effects on the presence and population dynamics of native species. Particularly, the filtrating capacity of *D. polymorpha* and *S. woodiana* may affect organic matter pathways within the sediment and the water column with serious consequences for the surrounding ecosystem (Vaughn & Hakenkamp, 2001; Kraszewski & Zdanowski, 2007).

In Sicily, the increase in population density of these species and the diffusion to other lakes and rivers can be expected to produce a negative impact on native sedentary benthic invertebrates. For example, native unionid mussels may be threatened by competition for food, space and hosts, as has already been observed in other Italian regions (Fabbri & Landi, 1999; Niero, 2003).

In Sicily, the presence of the genus *Unio* Philipson, 1788, the only major bivalve native to the island is particularly critical. According to Bodon et al. (2005) and Prie et al. (2012) two species of *Unio* are present in Italy, *Unio pictorum* in the Isonzo Basin and *Unio elongatus* (Pfeiffer, 1825) in the rest of the Italian territory, including Sicily (the latter previously reported also as *U. mancus* Lamarck, 1819). *Unio* populations from Sicily are considered by Zettler & Richard (2003) and Araujo (2009a) as belonging to the endemic subspecies *U. elongatus gargottae* Philippi, 1836.

In the second half of the nineteenth century, many taxa were described or reported for the genus *Unio* in major rivers and lakes of Sicily (see for example: Philippi, 1836- 1844; Benoit, 1875, 1882; Monterosato, 1896; Castagnolo et al., 2002).

During the twentieth century the records of *Unio* in Sicily were rare (Naselli-Flores et al., 1996; personal observations), thus indicating a dramatic decline in the distribution and abundance of *Unio* populations mainly caused by pollution and improper wetland management (drainage, channel alterations, water intake, cementification of riverbanks, or total destruction of habitats). However, some observations in the field have allowed

to testify the presence of *U. elongatus gargottae* in a few basins of western Sicily with small but stable populations monitored successfully since 2003 to 2007. Now, this survival strategy of the native *Unio* could be threatened by the presence and strong invasiveness of *S. woodiana*.

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