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THE FIRST RECORD OF THE CHINESE POND MUSSEL *SINANODONTA WOODIANA* (LEA, 1834) IN MONTENEGRO

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Abstract - Sinanodonta woodiana (Lea, 1834), Chinese pond mussel (Bivalvia: Unionoida: Unionidae) is one of the most invasive aquatic macroinvertebrate species found in Europe. We report the Chinese pond mussel for the first time in Montenegro, in August 2012, in Lake Šasko (Adriatic part of the Central Mediterranean subarea). One specimen of the Chinese pond mussel was observed in a habitat with a predominantly silt-clay substrate. The main pathway of species introduction was evaluated to be via fish stocking.

Key words: Alien species, biological invasions, nonindigenous species, Montnegro

INTRODUCTION

The aim of this paper is to present the first finding of the nonindigenous invasive species *Sinanodonta woodiana* (Lea, 1834) or the Chinese pond mussel, (Bivalvia: Unionoida: Unionidae), one of the most invasive freshwater mussel species (Lowe et al., 2000), in Montenegro.

Aquatic biotopes are ecosystems most predisposed to bio-invasions. Increasing colonization by allochthonous organisms has been observed during the last few decades due to their unique features. Once these species are established in a new environment, they multiply, spread over large areas, compete with native organisms, modify local habitats and affect ecosystem functioning. In other words, they cause biological invasions that have recently been recognized as one of the major driving forces of global change (Occhipinti-Ambrogi, 2008).

Some species of freshwater mussels, such as *S. woodiana* and *Dreissena polymorpha* (Pallas, 1771), were found to be among the most prominent invaders of freshwater ecosystems (Paunovic et al., 2006; Zaiko, 2009; Lajtner and Crnčan, 2011).

The native distribution areas of *S. woodiana* include the basin of the Amur River, Hanka Lake, China, Hong Kong, Taiwan, Kampuchea, Thailand and Japan (Popa et al., 2007). It was recorded in Europe for the first time in Romania in 1979 (Sárkány-Kiss, 1986). The species has been subsequently observed in Hungary (Petró, 1984; Sárkány-Kiss, 1986), France

(Girardi and Ledoux, 1989), Slovakia (Košel, 1995), Czech Republic (Beran, 1997), Austria (Reischutz, 1998), Poland (Bohme, 1998), Ukraine (Юришинец and Корнюшин, 2001), Italy (Manganelli, et al., 1998; Lodde at al., 2005), Germany (Glöer and Zeittler, 2005), Serbia (Paunovic et al., 2005a), Moldova (Munjiu and Shubernetski, 2008), Spain (Pou-Rovira et al., 2009), Croatia (Lajtner and Crnčan, 2011) and most recently in the United States (Bogan et al., 2011). The presence of the Chinese pond mussel was also recorded in some Indonesian islands, the Dominican Republic and Costa Rica (Watters, 1997). The species is dispersed along lowland rivers, associated wetlands and manmade canals. Heavily modified and artificial aquatic habitats with high silting rates were found to be especially suitable for population by *S. woodiana* (Paunovic et al., 2006).

MATERIAL AND METHODS

Field research was conducted at two lakes in Montenegro (Lakes Skadar and Šasko) that are connected in a system by the Bojana River (Fig.1). Sampling was done in August 2012. Material was collected at four sampling sites (two on the Šasko and two on the Skadar Lake – Fig.1), using a benthic hand net (mesh size was 500 μm) by the kick and sweep technique (EN 27828:1994), from all of the available substrates represented by more than 5% of the total habitat area, as well as by free diving.

The bottom of all sampling sites was dominated by the silt-sand substrate, but stony substrate (small to medium size stones, from 5 to 30 cm in diameter) was found to be mosaically distributed within limited areas.

Three linear shell distances (shell length, height and width) were measured in the laboratory using a digital caliper to the nearest 0.01 mm. The coordinates of the sampling points were measured by GPS ("Garmin Etrex"), and charted by ArcView software (map 1:300,000; system WGS_1984).

For the presentation of general characteristics of the water quality of Lake Šasko, the data on physical and chemical parameters measured by Institute of Marine Biology, Kotor, were used. The oxygen concentration was measured at the same depth and similar distance from the shore as where the Chinese pond mussel was recorded.

Both investigated systems are shallow karstic lakes of tectonic origin. Lake Skadar is the largest natural lake on the Balkan Peninsula (depending on the water level, its surface area varies between 370 and 530 km^2). This transboundary lake is shared between Albania and Montenegro, and was declared a Ramsar site (No. 784) and granted National Park status in Montenegro. The Bojana River (Adriatic Sea Basin) flows out of Lake Skadar and into the Adriatic Sea near the settlement of Ulcinj. The Bojana River is connected with Lake Šasko by a side channel.

Lake Šasko is about 3 km long and 1.5 km wide. Depending on the current hydrological status of the lake, the Bojana River can flow into Lake Šasko. The lake is located in the southeastern part of Montenegro (Ulcinj Field), i.e. the Adriatic part of the Central Mediterranean subarea, according to the FAO classification of geographical units (FAO, 1990-2012).

RESULTS AND DISCUSSIONS

One adult specimen of Chinese pond mussel (Fig. 3) was observed at a sampling site located on the northern shore of Lake Šasko (Fig. 2) (Site 1; N 41°58'35.71"; E 19°20'19.47"), within the habitat with a predominantly silt-clay substrate (grains are visible by eye; diameter <0.125 mm). Besides Chinese Pond mussel, abundant occurrence of the invasive mussel species *D. polymorpha* was detected at the same locality, but only in stony habitats without dense development of aquatic vegetation. Therefore, the presence of only two mussel species were registered in Lake Šasko, both nonindigenous, while three native mussel species were found in Lake Skadar: *Anodonta anatina* (Linnaeus, 1758), *Unio pictorum* (Linnaeus, 1758) and *Unio tumidus* (Philipsson, 1788).

The mussel was collected at a depth of 2.5 m, at a distance of about 40 m from the shore, outside an

Fig. 1. Sampling sites at Lakes Skadar and Šasko

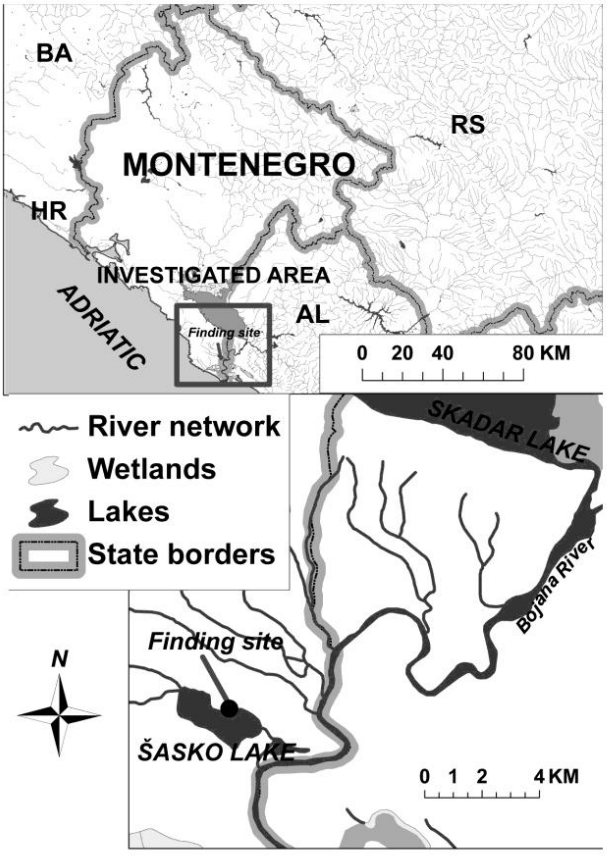

Fig. 2. Investigated area and finding site.

area with a dense covering of aquatic macrophytes (*Myriophyllum* sp., *Najas marina* and *Potamogeton pectinatus*).

Based on the measurements on sites 1 and 2 (Site 2; southern shore of Lake Šasko: N 41°58'22.50"; E 19°19'16.67") for a four-year period (2008-2011) provided by the Institute for Marine Biology, Kotor, Šasko Lake is characterized by a range of pH values between 7.1 and 7.8, oxygen concentration between 7.8 and 11.5 ml L^{-1} and salinity between 0.48 and 0.58 ‰. A higher variation of salinity has been observed within the area of southern shore of Lake Šasko (site 2), during the drought summer period.

The temperature regime of Lake Šasko could be described based on the results of continuous measurement during 15 months (hourly measurement during 2003-2004) on site 1 by automatic station – Institute for Marine Biology, Kotor (all together 10,335 measurements). The mean monthly temperature and mean temperature for measuring period are presented in Fig. 4.

Thermal conditions, water flow and character of the substrate mostly determine the distribution and density of Chinese pond mussel (Kraszewski and Zdanowski, 2007). According to Demayo et al. (2012), *S. woodiana* prefers habitats with higher temperatures (the optimal thermal conditions vary within 10 and 35°C). It could be assumed that in Lake Šasko, the high water temperature with recorded mean monthly values that exceed 20°C during fifth month period could favor the establishment and fur-

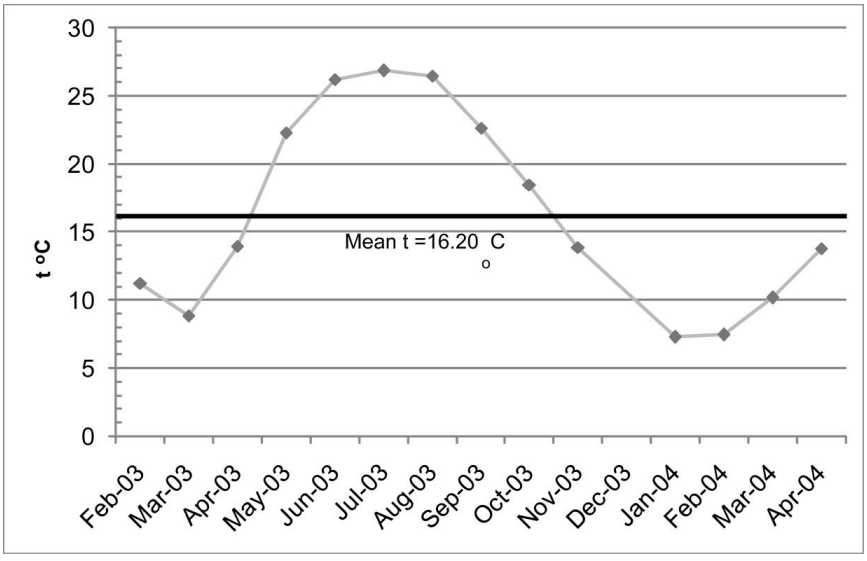

Fig. 3. The mean measured temperature for a 15-month period.

ther dispersal of thermophilous species *S. woodiana* along the lake system. Kraszewski and Zdanowski (2007) reported that Chinese pond mussels prefer sandy substrate and moderate water flow, but according to recent investigations in the southeastern Europe (Paunovic et al., 2006; Lajtner and Crnčan, 2011), the species prefers slow current conditions or absence of flow, and muddy and sand-silt dominated substrate.

Accompanying species of Chinese Pond mussel in Lake Šasko were only the Ponto-Caspian species

Fig. 4. *S. woodiana* – specimen collected from Lake Šasko.

D. polymorpha Pallas 1771 (Zebra Mussel). Zebra mussel was found to be tolerant to salinity up to 0.07 ‰ (DAISIE, 2006). Having in mind that other limiting factors were not identified for other mussel species, based on available data (no oxygen deficit recorded, favourable substrate type for other mussel species is observed, other mussel taxa were identified in the Skadar Lake, fish species known as mussel glochidia hosts in the lakes and in the Bojana River are present – *Ctenopharyngodon idella* (Valenciennes, 1844), *Hypophthalmichthys molitrix* (Valenciennes, 1844), *Hypophthalmichthys nobilis* (Richardson, 1845), *Cyprinus carpio (Linnaeus,1758) Carassius gibelio* (Bloch, 1782), etc.) could indicate that salinity is a limiting factor for other mussel species, as well as that Chinese Pond Mussel could tolerate a higher degree of salinity in comparison to other mussel taxa characteristic for the region (*U. tumidus, U. pictorum* and *A. anatina* (this article and Paunovic et al., 2004, 2006; Lajtner and Crnčan, 2011)).

Considering the lack of relevant data about the distribution of Unionidae species (unionids) in the lake systems in Montenegro, further research is necessary, especially study on the dependence of the unionid communities on the physicochemical envi-

ronmental parameters. The autecological characteristics of species (salinity tolerance, temperature and life history) should be taken into the consideration, since there is no available data about local unionid populations.

This report represents the first finding of Chinese pond mussel in Montenegro and the Southern Adriatic region (the Central Mediterranean subarea, according to FAO (1990-2012) classification of geographical units). The presence of *S. woodiana* in the Adriatic Sea Basin was only reported in Lake Vrana in Croatia (in the Central Adriatic Region) by Lajtner and Crnčan (2011). It is important to emphasize that the authors presumed that findings of empty shells of this species on the lakeshore was a consequence of sport fishing. In fact, Vrana Lake is known as an important destination for sports anglers who bring bivalves from continental Croatia with them for use as bait. Malacological research carried out in the Vrana Lake during 2011 years did not confirm the presence of this species in the lake ecosystem (Lajtner et al., 2012). Based on the foregoing, it can be concluded that the finding of live specimens of *S. woodiana* in Lake Šasko was the first in this part of Europe. During our investigation, the Chinese pond mussel was not recorded in Lake Skadar.

The linear dimensions of the examined specimen were as follows: length (L) = 110 mm; height (H) = 68 mm; width across the valves (W) = 39 mm. Taking into account the known data about the growth of the shell of this species (Dudgeon and Morton, 1983; Afanasyev et al., 2001), we can estimate that the specimen is about 3-4 years old.

While *S. woodiana* has been discovered in most European countries, recently the Chinese pond mussel has become widely distributed across freshwater ecosystems in Europe and worldwide, as noted in the Introduction.

The rapid spread and mass occurrence of *S. woodiana* has been reported in several recipient areas within the Western Balkans (Paunovic et al., 2005a, 2006; Lajtner and Crnčan, 2011).

The introduction and spread of the Chinese pond mussel to Europe seems to be closely correlated with the introduction of fish from China and other Far-East countries, described as the Chinese fish complex, comprising the Grass Carp *C. idella* (Valenciennes, 1844), Prussian Carp *C. gibelio*, Silver Carp *H. molitrix* and Bighead Carp *H. nobilis*, Richardson, 1844 (Paunovic et al., 2006). These species were imported to the Western Balkans for fish stocking in the sixties and mid-seventies (Cakic and Hristic, 1987) of the 20th century, which suggests that the Chinese pond mussel was introduced at about the same time. The increasing colonization of inland waters of the Balkan Peninsula by allochthonous organisms has already been reported, and alien aquatic species have been identified among plants, vertebrates and invertebrates (reviewed in: Paunovic et al., 2004, 2005b). The inland waters of Montenegro are no exception. Therefore, an investigation of the distribution of *S. woodiana*, as well as other aquatic neobiota in Montenegro, is necessary in order to identify the distribution and assess the impact of biological invasions on native communities, and to provide effective prevention measures for mitigating the introduction and dispersal of invasive species. Since Lake Šasko is connected to Lake Skadar (via the Bojana River), monitoring the further spread of the Chinese pond mussel is of special concern in view of its potential negative influence on native biota of this, according to its native biodiversity, important ecosystem. Further spread of the Chinese pond mussel is of particular importance if we bear mind that the species is listed in the IUCN register of "100 of the World's Worst Invasive Alien Species" (IUCN, 2000). Considering the invasive characteristics of *S. woodiana*, an impact on autochthonous bivalves via competition is to be expected (Essl and Rabitch, 2002). It is known that the Chinese pond mussel is a direct competitor for food, habitat and fish hosts (Rashleight, 1995; Fabbri and Landi, 1999). Dudgeon and Morton (1983) have stated that *S. woodiana* reproduces two to three times year, unlike native species, which typically reproduce only once a year. The invasive potential of *S. woodiana* has been attributed to its ability to spread rapidly during its free-living larval stage or glochidia (Douda et al., 2012). The fact that *S. woodiana* is

so widespread implies that both juvenile and adult *S. woodiana* individuals can cope with a wide range of environmental conditions. The species is biologically more successful compared to native species, especially unionids, because of its better tolerance to increasing pollution and decreasing oxygen concentration (Sîrbu et al., 2005).

Furthermore, a transitional type of ecosystem (freshwater-to-brackish lakes), due to its salinity regime and high level of human activity (pollution, hydromorphological degradation, nuisance activities, navigation, etc.) may serve as an "acclimatization chamber" for potentially euryhaline species, enabling them to colonize inland waters.

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