

# Range Expansion of the Introduced Species *Sinanodonta woodiana* (Lea, 1834) in the Sava River (Slovenia)

Maja Raković<sup>1</sup>, Jelena Tomović<sup>1</sup>, Nataša Popović<sup>1</sup>, Katarina Zorić<sup>1</sup>, Tea Zuliani<sup>2</sup>, Maja Sever<sup>3</sup> and Momir Paunović<sup>1</sup>

<sup>1</sup> Institute for Biological Research “Siniša Stanković”, University of Belgrade, Bulevar Despota Stefana 142, Belgrade, Serbia; E-mail: [rakovicmaja@ibiss.bg.ac.rs](mailto:rakovicmaja@ibiss.bg.ac.rs)

<sup>2</sup> Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia

<sup>3</sup> Slovenian Environment Agency, Vojkova 1b, SI-1000 Ljubljana, Slovenia

## Abstract

The Chinese pond mussel *Sinanodonta woodiana* (Lea, 1834) (Bivalvia: Unionoida: Unionidae), is one of the most invasive aquatic macroinvertebrate species registered in flowing and standing waters throughout most of Europe. During the September 2015 Sava River survey, conducted within the GLOBAQUA project, findings were reported on the most upstream alien species *S. woodiana* in the Sava River (locality Čatež, Slovenia).

**Keywords:** Chinese pond mussel, biological invasions, alien species, Slovenia.

## Introduction

The Chinese pond mussel, *Sinanodonta woodiana*, is one of the most invasive freshwater mussel species (Lowe et al., 2000). The native distribution areas of *S. woodiana* are East and South–East Asia, primarily the Amur and Yangtze River basins (Soroka, 2005; Kraszewski and Zdanowski, 2007). The introduction and proliferation of this species is reported in Cambodia, Taiwan, Thailand, Malaysia, Japan, Hong Kong (South and Southeast Asia) as well as in the Dominican Republic and Costa Rica (South America) (WATTERS, 1997).

In the last few decades this bivalve has already successfully invaded Europe. For the first time it was discovered in Romanian fish farms at Cefa-Oradea in 1979 (Sárkány-Kiss, 1986), subsequently it has become widely distributed across Europe – Hungary, (Petró, 1984; VITUIKI, 2001), France (Girardi and Ledoux, 1989), Slovakia (Košel 1995; Halgoš, 1999), the Czech Republic (Beran, 1997), Austria (Reischutz, 1998), Poland (Bohme, 1998), Ukraine (Urishients and Korniuшин, 2001), Italy (Manganelli et al., 1998; Lodde et al., 2005), Germany (Glöer and Zeittler, 2005), Serbia (Paunovic et al., 2005), Sweden (von Proschwitz, 2006), Moldova (Munjiu and Shubernetski, 2008), Spain (Pou-Rovira et al.,

2009), Croatia (Lajtner and Crnčan, 2011), Slovenia (Klenovšek et al., 2012) and Montenegro (Tomović et al., 2013).

The primary pathway of introduction and spread of the Chinese pond mussel to Europe seems to be closely correlated with the introduction of Asian fish species (the Chinese fish complex) from China and other Far East countries (Paunovic et al., 2006). This fish complex was imported to the Western Balkans for fish stocking in the sixties and mid-seventies (Cakic and Hristic, 1987) of the 20<sup>th</sup> century, which suggests that the Chinese pond mussel was introduced at about the same time (Tomović et al., 2013).

*S. woodiana* was found to be among the most prominent invaders of freshwater ecosystems (Paunovic et al., 2006; Zaiko, 2009; Lajtner and Crnčan, 2011). It prefers silt and clay substrates, turbid conditions with water temperatures between 30-33° C and it could be found in either standing or slow-flowing water (Soroka, 2005; Zettler and Jueg, 2006). Heavily modified and artificial aquatic habitats with high silting rates were found to be especially suitable for *S. woodiana* (Paunovic et al., 2006).

The aim of this paper is to present the first record of the non-indigenous invasive species *S. woodiana* in the Slovenian stretch of the Sava River.

## Material and Methods

The investigation was conducted during the GLOBAQUA survey in September 2015 on 15 sampling sites, covering the entire length of the Sava River, from Mojstrana (Slovenia) to Belgrade (Serbia) (Figure 1). Various techniques were used for collecting samples - kick and sweep technique (EN 27828:1994) with a benthic hand net (mesh

size was 500 µm), benthic dredging and free diving (up to a depth of 5 m). 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 sites were measured by GPS ("Garmin Etrex") and charted using ArcView software (map 1:300,000, system WGS\_1984).

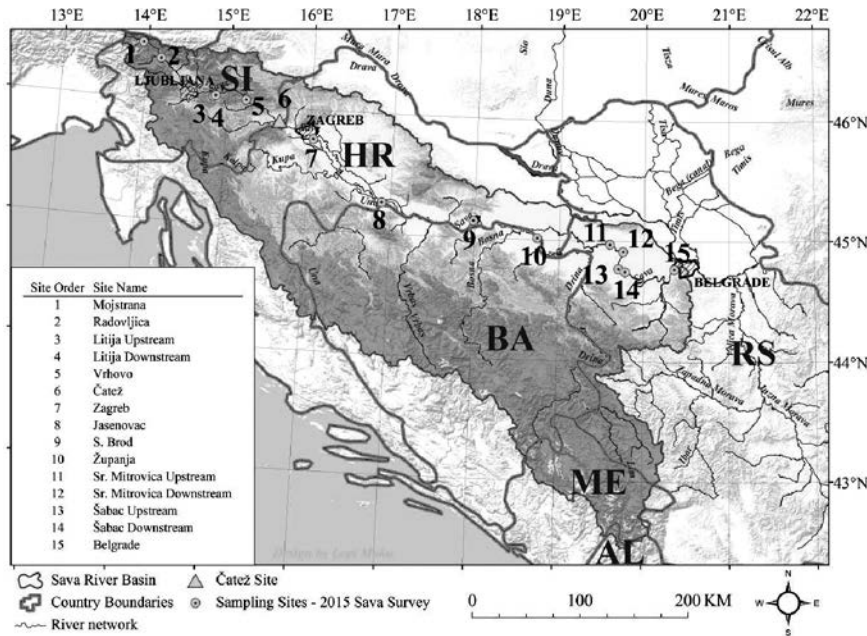


Figure 1: Map of the Sava River with sampling sites.

## Results and Discussions

During our investigation of the Sava River, *S. woodiana* was recorded at sampling site Čatež (N 45°51'37.27"; E 15°41'31.77") located on the right river bank, in the Municipality of Brežice (Eastern Slovenia). Eight adult specimens of *S. woodiana* were found with native bivalve species from the Unionidae family: *Unio tumidus* Philipsson, 1788, *Unio pictorum* (Linnaeus, 1758), *Anodonta anatina* (Linnaeus, 1758) (Figure 2). This was the most

upstream finding of *S. woodiana* in the Sava River. This bivalve species occurs mainly in slow-flowing lowland rivers, canals, large ponds and wetlands, particularly places with a predominant silt-clay substrate (Lajtner and Crnčan, 2011).

The first report of this species in Slovenia dated from May 2011. Six adult specimens of *S. woodiana* (up to 85 cm of total length) were found in a drained fish pond Priložje near Metlika (Southeast Slovenia) (Klenovšek et al., 2012).

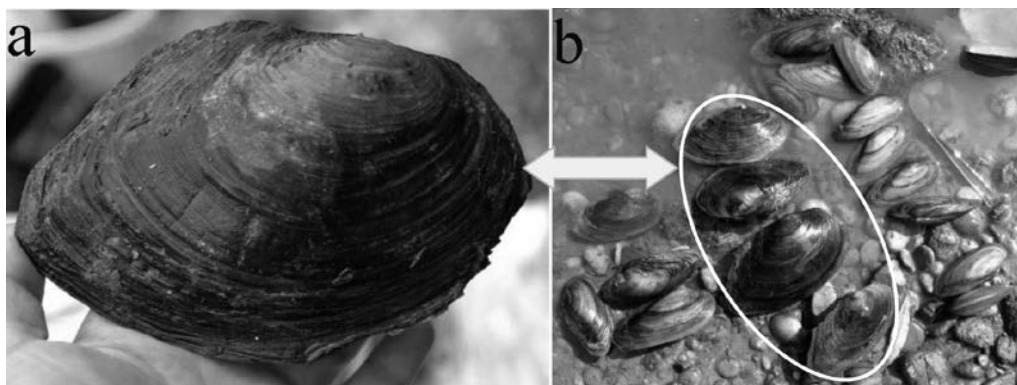


Figure 2: *Sinanodonta woodiana*  
 a. Specimen collected in the Sava River, Slovenia;  
 b. Specimens *S. woodiana* together with native Unionidae species.

In our study the shell length (L) ranged from 118.06 mm to 162.32 mm, height (H) from 67.44 mm to 110.30 mm, while the width ranged between 38.54 mm and 64.89 mm (Table 1). According to previous data on shell growth (Dudgeon and Morton, 1983; Afanasyev et al., 2001; Spyra et al., 2016), we can estimate that the specimens were in different age classes. The largest individual can be estimated as 8 years old.

Table 1: Morphometric parameters of *S. woodiana* collected in Čatež site.

No of spec.	Length (L, mm)	Height (H, mm)	Width (W, mm)
1	126.95	71.70	39.44
2	128.34	72.39	42.85
3	126.02	78.34	43.81
4	126.46	81.38	41.41
5	140.91	85.43	51.80
6	162.32	110.30	64.89
7	126.14	82.33	45.11
8	118.06	67.44	38.54

Based on the recorded data we could conclude that the *S. woodiana* expanded its distribution area along the Sava River at least eight years ago. During the previous survey in the same area (GLOBAQUA survey in September 2014) this species was not recorded at the Čatež study site, which is probably the consequence of heavy rainfall and high water levels during sampling.

Previous investigation of watercourses in the region indicated that the Chinese pond mussel is well adapted to large lowland rivers (Paunovic et al., 2006). It was found along the entire Serbian stretch of the Danube and the Tisza River, as well as downstream sectors of the Sava and Velika Morava Rivers (Paunovic et al., 2006). Also, the species is widespread in Croatia, mostly within the Pannonian-Peripannonian region (Lajtner and Crnčan, 2011).

This alien species was recorded at sites characterised by slow water flow and fine substrate. According to recent investigations in southeastern Europe (Paunovic et al., 2006; Lajtner and Crnčan, 2011), it was confirmed that *S. woodiana* prefers slow current conditions or the absence of flow, also muddy and sand-silt dominated substrate.

The Sava River Basin lies within the territories of several countries (Bosnia and Herzegovina, Croatia, Serbia, Slovenia, Montenegro and Albania) and is highly heterogeneous concerning overall environmental conditions (Lucić et al., 2015). More than 50% of the Sava watercourse is navigable, suited for large boats from Belgrade (Serbia) to Slavonski Brod (Croatia, 377 river km) and smaller boats to Sisak (Croatia, 583 river km).

Since the Sava River is considered to be an important bio-invasion trajectory, a part of the Southern Invasive Corridor of Europe (Paunović et al. 2008), it is expected that the introduced species *S. woodiana* would expand due to the presence of suitable habitat conditions in this river.

This paper presents a contribution towards a better understanding of the distribution and spread of the invasive species *S. woodiana*. It should be noted that, hydromorphological modifications on the river sector have facilitated the establishment and increase in local population densities. The spread of this mussel species is closely correlated with the introduction and spread of a fish species known as the obligate mussel glochidia hosts. Host fish directly affect the mussel's reproductive success and dispersal (Douda et al., 2012), and enable its rapid spread upstream and downstream of the river. It should be underlined that extensive field work is needed in order to collect additional data on the distribution of freshwater mussels within the aquatic ecosystems of Slovenia, especially in order to determine the relation of native and nonindigenous bivalve species, characterized as invasive.

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**Conflict of interest disclosure:** There are no conflicts of interest.

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