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Research article

Distribution of *Anodonta (Sinanodonta) woodiana* (Rea, 1834) in inland waters of Serbia

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Abstract

Aquatic biotopes are, due to their unique features, among the most disposed ecosystems to bioinvasions. Serbian waters are not an exception, with a increasing colonization by allochthonous organisms observed there during the last few decades. Non-indigenous aquatic species were found among plants, vertebrates and invertebrates. One of the most invasive aquatic macroinvertebrate species found in the region is the Chinese pond mussel *Anodonta (Sinanodonta) woodiana* (Rea, 1834). 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 *A. woodiana*. A mass occurrence of Chinese mussel was observed among these habitats, particularly where bottom substrata were characterised by the domination of silt-clay.

Key words: *Anodonta (Sinanodonta) woodiana*, biological invasions, Chinese pond mussel, non-indigenous species, Serbia

Introduction

The Chinese pond mussel, (the Eastern Asiatic freshwater clam or swan-mussel) *Anodonta (Sinanodonta) woodiana* (Rea, 1834) (Bivalvia: Unionida: Unionidae) originates from Eastern Asia (Watters 1997).

Recently, it was discovered far outside its natural areal, in several European countries - Hungary, (Petró 1984), Romania (Sárkány-Kiss 1986), France (Girardi and Ledoux 1989), Slovakia (Košel 1995), Czech Republic (Beran 1997), Austria (Reischutz 1998), Poland (Bohme 1998), Ukraine (Urishients and Korniushin 2001), Italy (Manganelli et al. 1998, Lodde at al. 2005), Germany (Glöer and Zeittler 2005), as well as outside of Europe - some Indonesian islands, the Dominican Republic and Costa Rica (Watters 1997).

Rapid spread, frequent findings and mass occurrence of *A. woodiana* were reported from several recipient areas in the Danube Basin - Slovakia (Halgoš 1999), Hungary (VITUKI 2001) and Serbia (Paunovic et al. 2005a). Recently, the species has been reported as frequent along the Middle Danube (ICPDR 2002).

The aim of this paper is to present the current distribution of Chinese pond mussels in Serbian waters. Investigations on the distribution of Chinese pond mussel should be continued, due to the invasive character of *A. woodiana*, its mass occurrence in the region, as well as possible impact to the autochthonous bivalves via competition (Essl and Rabitch 2002).

Materials and Methods

Special attention has been focused on collecting data on the distribution of non-native fauna within Serbian waters during macroinvertebrate surveys performed in the period 1998-2006. These investigations comprehended trans-boundary rivers (sectors of the Danube which are shared with Croatia and Romania), as well as the bordering region with Hungary (the Danube and the Tisza River). Along with other information, datasets on the distribution of *A. woodiana* were gathered during these surveys.

Benthic samples were collected by various techniques - benthic hand nets, hydraulic polyp sampler, Van Veen (0.027 m^2) and Eckman (0.0225 m^2) grabs and benthological dredge. Diving was also performed to collect mussels. The mussels were gathered in periods of low water conditions at depths between 0.4 and 7 m.

The coordinates of the sampling points were measured by GPS ("Garmin Etrex") and charted by using ArcView software (map 1:300,000, system WGS_1984).

For some sampling sites, the abundance of mussels has been evaluated by collecting and counting individuals within randomly selected square areas of 0.5 m^2 by diving. A diver sampled all mussel specimens from chosen quadrant and removed it to the shore for identification.

Results and Discussion

We are presenting the findings of *A. woodiana* (Figure 1) on 44 sampling stations in Serbia. Geo-referenced records are reviewed in Annex and mapped on Figure 2. Our investigations indicated that Chinese pond mussel is well adapted to large lowland rivers in Serbia. The distribution is limited to the northern, lowland part of the country. The species has been found along entire Serbian stretches of the Danube and the Tisza River (Figure 2, Annex). *A. woodiana* has also been recorded in the downstream sectors of the Sava and Velika Morava Rivers (Figure 2, Annex), as well as in the armband of the Sava River, Cukaricki rukavac (Figure 2, Annex, Record No. 42).

According to Csányi et al. (2005) the Chinese pond mussel has a dense population in the Danube River, at the inflowing stretch of the Iron Gate Reservoir. Our investigations confirmed that

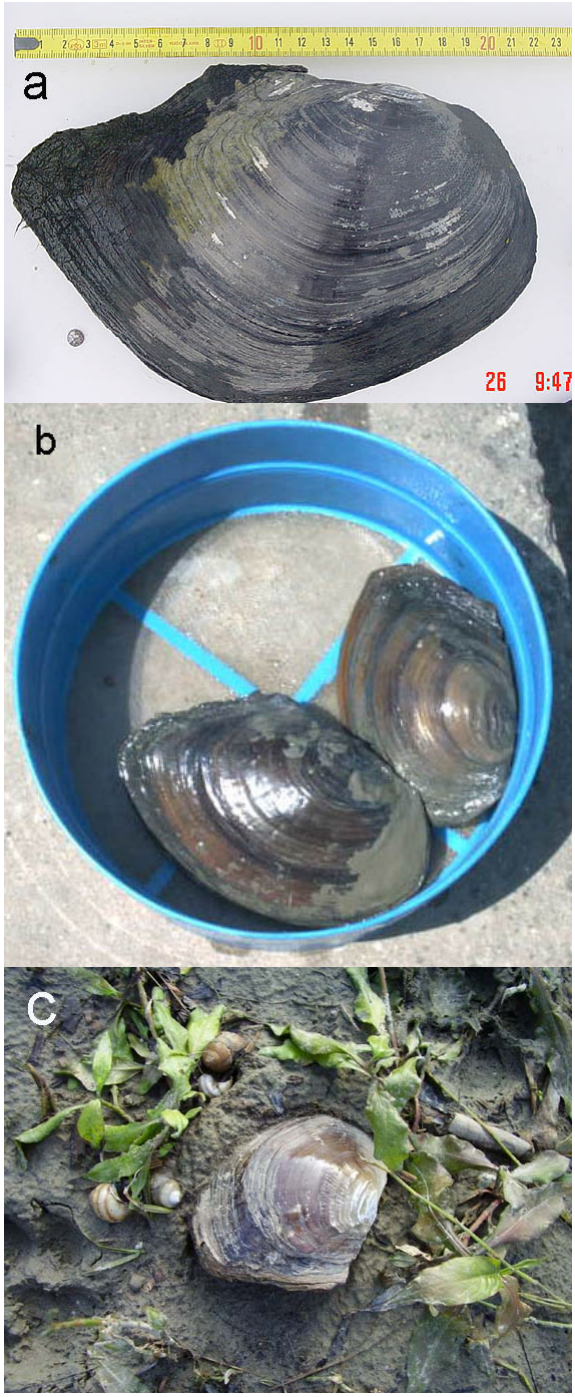

Figure 1. *Anodonta woodiana*: a) specimen collected in the Tisza River, 26.08.03, record No. 34; b) specimens collected in the Danube River, near to the confluence of the Sava River, 06.06.02, record No. 10; c) *A. woodiana*, 26.08.06, Danube, Gornji Milanovac, record No. 44 - bank region, after rapid decline of water level (photo by M. Paunovic)

statement. Abundant population of *A. woodiana* was observed at section between r.km 1077 and 1081 (Annex, Records No. 21, 22 and 26).

In addition, we found abundant populations on other sampling stations along the Danube (Figure 2, Annex, Records No. 10, 13, 19, 30 and 32), as well as in the main tributaries - the Tisza (Figure 2, Annex, Record No.35), the Sava (Figure 2, Annex, Record No.42) and the Velika Morava (Figure 2, Annex, Record No. 43). Mass occurrence has been observed at the Begej River (large tributary of the Tisza River, near to the confluence to the Tisza - Figure 2 and 3, Annex, Record No. 40).

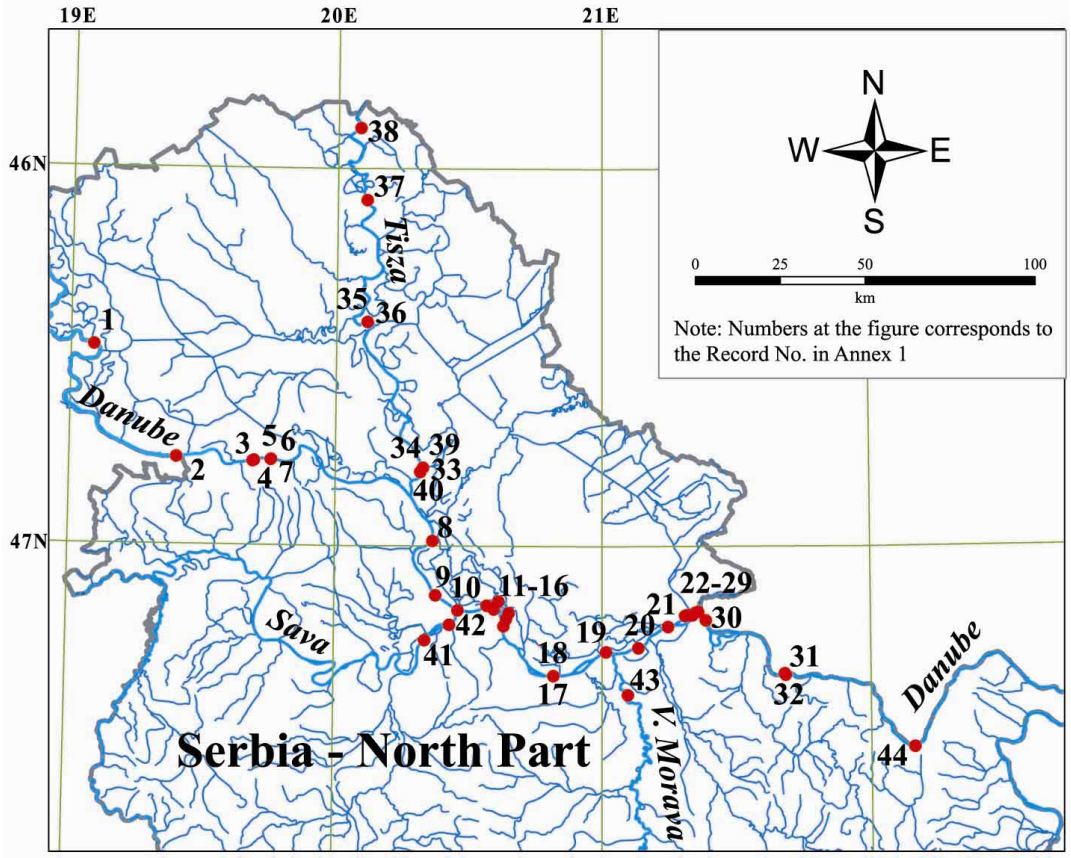

Figure 2. Sampling sites for *Anodonta woodiana* in Serbia

During our investigations, the Chinese pond mussel was observed within habitats with a predominantly silt-clay substrate, together with native mussel species - *Unio pictorum* (Linnaeus, 1758), *U. crassus* (Philipsson, 1788), *U. tumidus* (Philipsson, 1788), *Pseudanodonta complanata* (Romässler, 1835) and *Anodonta anatina* (Linnaeus, 1758), as well as other molluscan species - *Viviparus acerosus* (Bourguignat, 1862) and *Viviparus viviparus* (Linnaeus, 1758). In some cases, *A. woodiana* was found to be the dominant mussel (Figure 2, Annex, Records No. 10, 26, 40, 42 and 43). Thus, at the Velika Morava River (Figure 2, Annex, Record No. 43) *A. woodiana* was found together with *U. pictorum* in a ratio of 5:1 specimens, respectively. During the 2003 Tisza expedition (August 25-29), we had the opportunity to count mussels along the bank region of the Begej River due to an extremely low water level (Figure 2, Annex, Record No. 40). At this location, an abundant population of *A. woodiana* was observed, with a mean number of six individuals per square meter; compared to all other mussel taxa confirmed, *A. woodiana* dominated by a 2:1 ratio (Figure 3). Observed domination of *A. woodiana* in comparison with native mussel taxa infers that Chinese pond mussel could have an impact on autochthonous bivalves via competition (Essl and Rabitch 2002).

Figure 3. Mussels recorded in the bank region of the Begej River, near to the confluence to the Tisza River (26.08.03, record No. 40) - photos taken during extremely low water conditions (photo by M. Paunovic)

The introduction and spread of the Chinese pond mussel seems to be closely correlated with the introduction of the Grass Carp *Ctenopharyngodon idella* (Valenciennes, 1844), the Prussian Carp *Carassius auratus gibelio* Bloch, 1783, the Silver Carp *Hypophthalmichthys molitrix* (Valenciennes, 1844) and the Bighead Carp *Arstichthys nobilis* Richardson, 1844 from China and other Far East countries into Serbian waters and neighboring regions. These species, belonging to the so-called Chinese complex, were introduced into Serbian waters in the sixties and mid-seventies (Cakic and Hristic 1987) of the XX century, which suggests that the Chinese pond mussel was introduced at the same time. Rapid spread and mass occurrence of *A. woodiana* have been reported from several recipient areas in the Danube Basin - Slovakia (Halgoš 1999), Hungary (VITUKI 2001) and Serbia (Paunovic et al. 2005a). Stefek et al. (2004) reported that, since 1999, *A. woodiana* has been expanding from the Danube River to other larger rivers in Slovakia. Our investigations indicated a similar trend - the Chinese pond mussel has been found in the downstream stretches of the Sava and the Velika Morava River, which suggests that it has spreads to those rivers from the Danube. With regard to the Tisza River, the situation is not as clear, because the Chinese pond mussel has been found 419km upstream of its confluence with the Danube at Kisköre Reservoir - Hungarian part of the Tisza River (Csányi 2002). This situation could indicate that *A. woodiana* has expanded into the Tisza River not only from the Danube River, but also from other sources in the Middle Stretch - via the introduction of fish species from China and Far East.

Recent international surveys (ICPDR 2002) indicated that the Chinese pond mussel is dispersing from the middle Danube to the upper and the lower stretches. The spread of non-indigenous species along the Danube (in both directions, upstream and downstream), as well as the expansion of neobiota from the Danube to its tributaries, indicates that the Danube River is an important invasion corridor (lower part of the so called "Southern Invasion Corridor" sensu Bij de Vaate et al. (2002)).

The growing colonization of allochthonous organisms in Serbian waters has already been

observed and aquatic alien species have been found among plants, vertebrates and invertebrates (literature review in Paunovic et al. 2004, 2005b). Large lowland rivers in the region of the Middle Danube are under particular pressure by neobiota (Cakic et al. 2004, Simonovic et al. 1998, 2001, Csányi 1999, Paunovic et al. 2004, 2005a, b; Paunovic 2004, Pavlovic et al. 2006). This has been confirmed by the distribution of *A. woodiana* in this research.

Further, investigations on the distribution of *A. woodiana*, as well as on other aquatic neobiota in Serbia, are needed in order to provide effective prevention measures for the introduction and dispersal of invasive species.

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Annex

Records *of Anodonta woodiana* in Serbia 1998-2006*

Record No (Map Ref.)	Location (River, river-kilometer)	Record coordinates		Record date	Abundance	Collector
		Latitude, °N	Longitude, °E			
1	Danube River, 1367	45,5323	19,0740	01.09.2001		Csanyi and Paunovic
2	Danube River, 1300	45,2274	19,3621	01.09.2001		Csanyi and Paunovic
3	Danube River, 1260	no data	no data	24.08.1999		Csanyi
4	Danube River, 1259	45,2267	19,8395	02.09.2001		Csanyi and Paunovic
5	Danube River, 1252	45,2617	19,8871	02.09.2001		Csanyi and Paunovic
6	Danube River, 1252	45,2594	19,8934	28.08.2004		Csanyi and Paunovic
7	Danube River, 1252	no data	no data	24.08.1999		Csanyi
8	Danube River, 1200	45,0323	20,3563	29.08.2004	1	Csanyi and Paunovic
9	Danube River, 1175	44,8715	20,3741	15.06.1998	1	Paunovic
10	Danube River, 1171	44,8314	20,4553	06.06.2002	7	Paunovic
11	Danube River, 1162	44,8315	20,5569	06.06.2002		Paunovic
12	Danube River, 1159	44,8430	20,5633	30.08.2004		Csanyi and Paunovic
13	Danube armlet, 1159	44,8395	20,5889	06.06.1998	4	Paunovic
14	Danube River, 1154	no data	no data	25.08.1999		Csanyi

Annex
(continued)

Record No (Map Ref.)	Location (River, river-kilometer)	Record coordinates		Record date	Abundance	Collector
15	Danube River, 1151	44,8174	20,6495	30.08.2004		Csanyi and Paunovic
16	Danube River, 1148	44,7990	20,6356	18.05.1999		Paunovic
17	Danube River, 1126	44,6559	20,8237	14.09.1998	4	Paunovic
18	Danube River, 1126	44,6611	20,8148	13.05.1999		Paunovic
19	Danube River, 1107	44,7140	20,9973	31.08.2004	7	Csanyi and Paunovic
20	Danube River, 1097	44,7373	21,1252	31.08.2004		Csanyi and Paunovic
21	Danube River, 1081	44,7832	21,2068	14.06.2000	6	Paunovic
22	Danube, 1077	44,8169	21,3344	01.09.2004	5	Paunovic
23	Danube, 1077	no data	no data	26.08.1999		Csanyi
24	Danube, 1077	no data	no data	26.08.1999		Csanyi
25	Danube, 1077	44,8274	21,3236	13.06.2000		Paunovic
26	Danube, 1078	44,8251	21,3152	13.06.2000	7	Paunovic
27	Danube, 1078	44,8233	21,3143	11.07.2002		Paunovic
28	Danube, 1077	44,8134	21,3240	14.06.2000	3	Paunovic
29	Danube, 1076	44,8180	21,3338	14.06.2000		Paunovic
30	Danube, 1071	44,7967	21,3896	01.09.2004	9	Csanyi and Paunovic
31	Danube, 1040	44,6611	21,6773	02.09.2004		Csanyi and Paunovic
32	Danube, 1040	44,6598	21,6770	06.09.2001		Csanyi and Paunovic
33	Tisza, 10	45,1921	20,3105	29.09.2001		Csanyi and Paunovic
34	Tisza, 10	45,1968	20,3114	26.08.2003		Paunovic
35	Tisza, 0,5	45,2106	20,3240	29.09.2001	7	Csanyi and Paunovic
36	Tisza, 69	45,5957	20,1096	27.08.2003	2	Paunovic
37	Tisza, 72	45,5955	20,0638	30.09.2001		Csanyi and Paunovic
38	Tisza, 120	45,9041	20,1143	28.08.2003		Paunovic
39	Tisza, 155	46,1106	20,0788	28.08.2003		Paunovic
40	Begej, 0,4	45,2102	20,3209	26.08.2003	6	Paunovic
41	Sava, 8	44,7809	20,3631	18.08.2003		Paunovic
42	Sava armlet, 4	44,7937	20,4271	20.08.1998	7	Paunovic
43	Velika Morava	44,5860	22,1275	08.07.2004	5	Paunovic
44	Danube River, 991	44,4666	22,1576	12.06.2006		Stojanovic and Paunovic

*Full reference to the data: Paunovic M, Csányi B, Simic V, Stojanovic B and Cakic P (2006) Distribution of *Anodonta (Sinanodonta) woodiana* (Rea, 1834) in inland waters of Serbia. Aquatic Invasions 1(3): 154-160