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INVASIVENESS ASSESSMENT OF THE CHINESE MITTEN CRAB *ERIOCHEIR SINENSIS* (H. MILNE EDWARDS, 1853) IN THE SERBIAN SECTION OF THE RIVER DANUBE

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Abstract – The Chinese mitten crab *Eriocheir sinensis* is listed in The Global Invasive Species Database and the IUCN Register as one of "100 of the world's worst invasive alien species". It has been reported in Serbia since 1995 in the Danube River, suggesting a predominantly human-aided dispersal. The risk of invasiveness posed by the Chinese mitten crab to aquatic ecosystems in Serbia, assessed using the FI-ISK (Freshwater Invertebrate Invasiveness Scoring Kit, v1.19), revealed a final score of 37. This shows a high potential of invasiveness, mainly due to its versatile ecological and biological features in a climate similar to that in the donor area. FI-ISK assessment revealed the alleged environmental impact of Chinese mitten crab in Serbia to be of much greater impact on aquaculture than previously assumed.

Key words: *Eriocheir sinensis*, Serbia, Danube River, invasiveness risk, biological contamination rate

INTRODUCTION

The Chinese mitten crab (Fig. 1) is listed in The Global Invasive Species Database and the IUCN Register, as one of "100 of the world's worst invasive alien species" (IUCN, 2000; http://issg.org/database). Considering that the first reports on their finding in the downstream Danube River section in Romania dates from 1997 (Otel, 2004) and in the upstream section in Hungary from 2003 (Paunović et al., 2004), as well as in subsequent records (Fig. 2, Table 1), it seems that the Chinese mitten crab has been successfully introduced into the Serbian section of the Danube River.

Chinese mitten crabs are carnivorous. Gastropods and bivalves are their dominant food, but their diet also includes detritus, invertebrates, fishes and fish eggs (Hymanson et al., 1999). In this way, native species (particularly rare or endangered ones) that share habitat and diet with Chinese mitten crab could be negatively affected by their abundant populations (Rudnick et al., 2000).

Chinese mitten crabs have so far been introduced into North America and Europe. In Europe, they were first introduced in 1912, into Germany from China (Panning, 1939), and then they spread into the Baltic Sea countries (Panning, 1938) and other European countries, e.g., Czech Republic, Netherlands, Belgium, France and England. Their impact throughout European waters became especially strong from the late 1920s and early 1930s, when they occurred in mass and became a true pest (Peters, 1933). The further dispersal of this animal within the continent has been mainly by three routes: the Northern invasion corridor (Volga River and Baltic Sea); the Central invasion corridor (Dnieper-Vistula-Oder-Elbe-Rhine rivers); and the Southern invasion corridor (Danube River connection with the Rhine basin) (Holdrich and Pöckl, 2007). The greatest abundance is currently in the Elbe, Weser and Thames rivers, and it also lives on the Atlantic seaboard of Europe and in the Mediterranean (Cohen and Carlton, 1995) and Black (Zaitsev and Öztürk, 2001; Gomui et al., 2002) Seas.

The main introducing vectors of the Chinese mitten crab are shipping (usually through ballast tanks and the hull fouling of vessels, but they have even been found in empty cirriped shells on ship hulls), import for aquarium and pet trade purposes, import for human consumption (being a commercially important aquaculture species in China), natural dispersal of planktonic larvae by river current drift to new locations and the active migration of adults through rivers and canals (Marquard, 1926; Peters, 1933; Holdrich and Pockl, 2007). Assessment of their pathways of introduction could help in deciding on the measures that should be undertaken for the control and monitoring of the spread of Chinese mitten crab in the Serbian section of the Danube River.

MATERIALS AND METHODS

The Serbian part of the Danube River is 588 km long. Since reports on the Chinese mitten crab encompass localities situated in the upstream section from the Hungarian border, as well as those in the downstream section to the Bulgarian border, it seems that the whole Serbian part of the Danube River could be considered as one assessment unit after (Panov et al., 2009). The incidence of crabs caught in the Serbian waterway has been explored for over 15 years (since the first report by Paunović et al., 2004), except the period after 1999 due to the closure of the Danube River as an international waterway in the area of the city of Novi Sad brought about by NATO bombing. However, circumstances that occurred in the period of recording of Chinese mitten crab catches in the Serbian section of the Danube River influenced the biological contamination rates assessed through that period. Specimens were caught in the Danube River by fishermen using deep-running drifting seine nets and standing gillnets, and stored as voucher collections, preserved in either 4% formaldehyde or 70% ethanol.

Assessment of the Chinese mitten crab invasion potential in the Serbian section of the Danube River was worked out using FI-ISK (Freshwater Invertebrate Invasiveness Scoring Kit, v1.19) that Tricarico, Vilizzi, Gherardi and Copp (2010) developed as an assessment tool for invasiveness risk identification of non-native invertebrate species already occurring in inland waters of the United Kingdom, or those assumed as potential invaders (Vilizzi et al., 2007), following the FISK (Fish Invasiveness Scoring Kit) of Copp, Garthwaite and Gozlan (2005). Both screening kits were developed using the semi-quantitative approach of Pheloung et al. (1999). Assessment toolkits were promoted first as tools for the implementation of the codes of practice (CoP) for responsible fisheries management (ICES 1995, 2004), primarily for the purpose of intentional introductions of fish (Kohler and Stanley, 1984; Kahn et al., 1999). Subsequently, the risk assessment tools were developed for the non-native fish already occurring, or those most likely to be imported, as well as for intentionally introduced fish species (Kolar and Lodge, 2002). The FI-ISK assessment toolkit identifies the risk by evaluating features of biogeography and history of invasiveness of alien invertebrate species, as well as those aspects that are important for their biology and ecology (undesirable or persistence traits, feeding guild, reproduction, dispersal mechanisms and tolerance attributes). The FI-ISK initially included confidence (certainty/uncertainty) rankings by the assessor to each response. It was subsequently calibrated by Tricarico et al. (2010) with the statistically appropriate threshold scores being 0 (low risk, accept), 1-15 (medium risk, evaluate) and ≥16 (high risk, reject).

RESULTS

The history of Chinese mitten crab records of catch (Fig. 2, numbers in open squares) reconstructed from previously published reports reveals that their occurrence in the Danube River drainage area of Serbia is still occasional and low in number (Table 1), suggesting low abundance. The biological contamination rate in the Serbian section of the Danube River as an assessment unit calculated from the records 2-9 presented in Table 1 is 0.56 for the whole recording

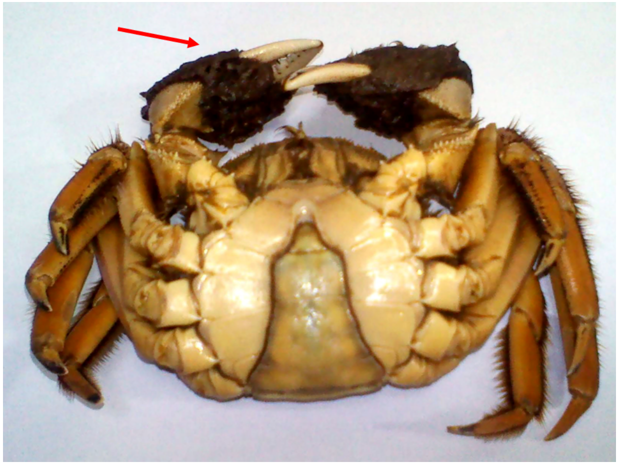

Fig. 1. Chinese mitten crab caught in Serbia: arrow indicates the dense mat of fine hair on the claws and on the leading edges of the legs that are especially well developed in males (the scientific name *Eriocheir sinensis* is derived from the Greek and means "woolen hand of the Chinese").

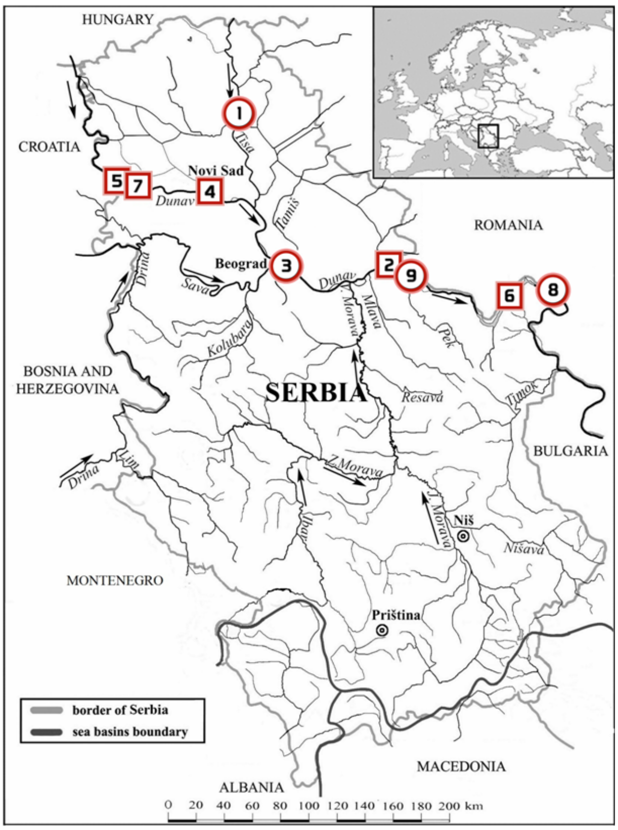

Fig. 2. Map of the localities of Chinese mitten crab catch: open circles denote recently caught individuals; open squares denote previously published data (numbers are the same as in Table 1).

period. Considering the particular sections of the Serbian stretch of the Danube River, the overall biological contamination rate in the upstream section (from the Hungarian border to the city of Novi Sad) is 0.15, and in the downstream section (from the city of Novi Sad to the Bulgarian border) is 0.32. During 1995-1999 (the first record), when water traffic was at a standard level, the overall biological contamination rate was 0.20; during 2000-2005, when water traffic was lower, it was 0.67; for the period 2006-2011, when water transportation was reestablished, it was 0.50. In the upstream section during the first period, the biological contamination rate was 0 upstream and 0.2 downstream; during the second period in the upstream section it was 0.25 and downstream it was 0.42; in the most recent period, in the upstream section it was 0.17 and in the downstream section it was 0.33.

The Chinese mitten crab gained a score of 37 using the FI-ISK assessment toolkit, which is a high value score of its invasiveness in Serbia. In the score partition, their score for biogeography was 17, for undesirable attributes it was 9, whereas the score for biology/ecology was 11. Considering the questions answered, the score for biogeography was 10, for undesirable attributes it was 12, and for biology/ecology it was 23, giving a total of 45. According to the assessment, the environmental sector was much more affected (having a score of 33) by their introduction than the sector of aquaculture (a score of 25), with no nuisance (score of 0) observed.

DISCUSSION

Although there are two possible routes of introduction of the Chinese mitten crab into Serbia via the Danube River, the identification of the Chinese mitten crab at Stara Palanka (Site 2, Fig. 2) and Kladovo (Site 8) indicates that the more likely pathway was from downstream sections, with either actively migrating juveniles and adults, or passively introduced by the ballast waters of shipping vessels. This is in agreement with the higher biological contamination rate values for the section of the Danube River downstream of the city of Novi Sad when compared

Table 1. Records of Chinese mitten crab in waters of the Danube River basin in Serbia (the vertical columns refer to: the reported date of catch; the sites where the Chinese mitten crabs were caught; the names of the locality and Danube River section; 4, coordinates of the locality; 5, number of individuals caught; their gender; carapace lengths of individuals (in mm); reference of reported catch record).

No	1	2	3	4	5	6	7	8
1	May 1973	Tisa	Novi Bečej	45°35'36"N 20°07'56"E	1	♂	70.0	Karaman and Machino (2004), this paper
2	June 1995	Danube, km 1084	Stara Palanka,	44°49'20"N 21°19'40"E	1	♂	56.9	Paunovic et al. (2004)
3	Nov. 2001	Danube, km 1174	Belgrade	44°51'30"N 20°25'10"E	1	♂	56.6	Paunovic et al. (2004), this paper
4	Unknown, 2002	Danube, km 1255	Novi Sad	45°13'33"N 19°49'38"E	1	♀	55.0	Karaman and Machino (2004)
5	Oct. 2003	Danube, km 1319	Bačko Novo Selo	45°17'07"N 19°08'17"E	1	♂	55.0	Karaman and Machino (2004)
6	Mar. 2004	Danube, km 972	Pećka bara, Iron Gate	44°35'36"N 22°15'55"E	1	♂	66.6	this paper
7	Dec. 2006	Danube, km 1298	Bačka Palanka	45°14'03"N 19°24'12"E	1	n/a	n/a	oral report, unpublished
8	Jan. 2007	Danube, km 933	Kladovo, Iron Gate	44°36'42"N 22°37'15"E	1	♀	66.14	this paper
9	Nov. 2011	Danube, km 1059	Veliko Gradište	44°46'04"N 21°31'51"E	1	♂	60.7	this paper

to those for the upstream section. After the NATO air strikes in 1999, the collapsed bridges in Novi Sad (Pannonian Serbia) completely blocked river traffic. Shipping vessels started to operate again in 2005 when river traffic was normalized.

The irregularity in dates of recording and spotted pattern of Chinese mitten crab distribution in the Serbian section of the Danube River suggests that their dispersal was aided by humans, with only a limited role played by natural means of dispersal. However, the strong domination of males caught in Serbia that is in accordance with data from other European regions (Czerniejewski et al., 2007) questions the mode of human-aided dispersal, and implies the presence of either different survival rates of females compared to males, or different behavioral patterns in females that render them less susceptible to detection and catch.

The Chinese mitten crab gained a very high score in assessment of its invasiveness using the FI-ISK assessment tool. Since they are not used as a food in Serbia, they are not imported, so that chances of their expansion in Serbia and their impact on the environment or aquaculture are minimal. Their ecological and other biological features, e.g. catadromy and capability to withstand various degrees of dryness and salinities (Rudnick et al., 2003), have contributed greatly to the total score, as well as their biogeography. The contribution of undesirable attributes, e.g. their competitive nature (Rudnick et al., 2003), to the score was much lower. However, with these undesirable traits, the Chinese mitten crab affects the environment via its broad feeding spectrum, habitat, biocenosis and economy (i.e. reduced catches in commercial fishing) (Cohen and Carlton, 1995).

Considering the long-term period of introduction in the Danube River section of Serbia, records of their occurrence remain scarce. Contradictory reports about frequent catches were obtained from commercial fishermen in order to warn the authorities in Serbia about this alien aquatic species.

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