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Invasive Crayfish on Land: *Orconectes limosus* (Rafinesque, 1817) (Decapoda: Cambaridae) Crossed a Terrestrial Barrier to Move from a Side Arm into the Danube River at Szeremle, Hungary

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Abstract: Non-indigenous crayfish species have successfully invaded many European lentic and lotic ecosystems in the past 120 years. *Orconectes limosus* (Rafinesque, 1817) has one of the largest distribution areas from among these taxa. Its invasion front has recently reached the Lower Danube while it has also been gradually colonising Middle Danubian tributaries and adjacent areas in the Carpathian Basin. A further characteristic with invasion implications was observed along the Danube River at Szeremle, Hungary. On 28th September, 2011, at 3.15 pm an adult individual of *O. limosus* was observed walking from the Szeremle dead arm towards the Danube River. The river and the Szeremle arm are separated by a dike during low and medium water levels. The individual crossed successfully the dike and covered a distance of approximately 20 metres between the two separate water bodies. It is the first record of *O. limosus* in the Danube River catchment crossing on land from one water body into another. This behaviour definitely helps the colonisation of new water bodies when only small stretches of land separate inhabited and non-inhabited water bodies. It may also help the exchange of individuals between neighbouring populations, as well as to allow the use of terrestrial escape routes in case of desiccation or pollution of the water body.

Introduction

Mainly due to intensive transport of goods and people to and from other continents in the previous centuries, Europe is a continent where more than 11 000 alien species exist (DAISIE). Their taxonomic composition is really diverse, including species from bacteria to mammals. About 15% of these alien species cause economic damage and 15% of them cause harm to biological diversity. According to a recent estimate this damage is valued at over 260 million euros in Ireland and Northern Ireland alone, without estimating *e.g.* the regulating and supporting ecosystem services offered through biodiversity (Kelly *et al*. 2013).

The introduction of aquatic alien species has been known in Europe for a long time. The number of established aquatic species is lower than, for example, that of terrestrial plants (DAISIE). However, aquatic alien species may threaten equally seriously the biodiversity and may cause damage. As an example, fighting a long-established invasive decapod, *Eriocheir sinensis* (Edwards, 1853), cost 80 million euros in a hundred years in Germany alone (Gollasch 2011). This species is also present in the Danube River from Romania and Bulgaria up to Austria and Hungary (Gomui *et al*. 2002, Kutsarov, Trichkova 2013, Puky *et al*. 2005, Rabitsch, Schiemer 2003).

Crayfish are an important freshwater macroinvertebrate group playing a key role in many ecosystems (Reynolds, Souty-Grosset 2012). The

introduction of non-indigenous species to Europe sometimes was owing to a deliberate human activity including mainly North-American species. Non-indigenous crayfish species have invaded successfully European lentic and lotic ecosystems. *Orconectes limosus* (Rafinesque, 1817) has been on the continent for over 120 years, while other taxa have just recently arrived (Souty-Grosset *et al*. 2006, Holdich *et al.* 2009). Predominant species, such as *Pacifastacus leniusculus* (Dana, 1852), have already colonised at least twenty countries and are still spreading.

The present paper reports the first description of *O. limosus* crossing on land from one water body into another water body in the Danube River catchment, which may play a role in spreading this species at its invasion front, as well as in its survival strategy in areas where its populations have already been established.

Material and Methods

The Szeremle Danube side arm is situated on the left side of the main arm of the Danube River, between rkm 1478.8 and 1469.1. In 1994 a transverse dike was constructed at its lower end. It is situated at 85.6 m a.s.l. and it includes a built-in 800 mm culvert which, at present, is not in use. The Danube River reaches the top of the dike when the water level at Baja is around 510 cm. In the last 15-20 years the water level overtopped the dike in approximately 15% of the days.

A previously unreported characteristic with invasion implications was detected at the dike at low water level. On 28th September, 2011, at 3.15 pm. an adult individual of *O. limosus* was observed walking from the Szeremle Danube side arm towards the Danube River.

Results and Discussion

An *Orconectes limosus* individual successfully crossed a dike (Fig. 1) and covered a distance of approximately 20 metres between the two separated water bodies. Though it stopped several times at suitable places and hid in crevices between the rocks, especially while climbing the dike, its movement was basically unidirectional. *Orconectes limosus* has been reported earlier to be found on land, *e.g.* there are four records from the Netherlands when it was forced to walk directly after dredging or dehydrating. An observation from Poland even recorded it several hundred metres from the water at night after rainfall (Soes, Koese 2010). Its first record in the wild in the United Kingdom was also from land, from the lawn of a garden, and therefore it was considered to be moving on land (Holdich, Black 2007). However, these publications did not describe the animals moving from one water body into another one.

Orconectes limosus has one of the largest distribution areas among non-indigenous crayfish species in Europe (Souty-Grosset *et al*. 2006). Its invasion front has recently reached the Lower Danube River (Pârvulescu *et al*. 2009). Moreover, it is also gradually colonising Middle Danubian tributaries and adjacent areas in the Carpathian Basin. It was introduced to Hungary from Germany for farming in the late 1950s (Thuránszky 1960). Until 1985, however, it was not detected in natural Hungarian water bodies. Thuránszky, Forró (1987) first recorded this species in the wild in a large secondary branch of the Danube River. In less than 30 years it colonised the Hungarian stretch of the river and established abundant and spreading populations in side arms and tributaries of the river such as the Dráva River, the Ipoly River, the Tisza River (including the River Körös) and several small water courses and canals (Bódis *et al*. 2012, Györe *et al*. 2013, Hudina *et al*. 2009, Puky 2009, Puky, Schád 2006, Sallai, Puky 2008, Szepesi, Harka 2011).

Several biological characteristics assist the spread of *O. limosus*. Among them are the potential shift of its mating regime towards facultative parthenogenesis (Buřič *et al.* 2013); its high tolerance to environmental conditions and good adaptability to a wide range of water types and water bodies with different water quality (Holdich, Black 2007). Moreover, *O. limosus* has high tolerance towards crayfish plague, a fungal disease caused by *Aphanomyces astaci,* which is lethal for European crayfish (Souty-Grosset *et al*. 2006). The first characteristic allows multiplication when in low abundance, the second enables migrating individuals to use less favourable waters, which may serve as barriers for other crayfish (*e.g.* stepping stone habitats), while the latter is a key factor when coming into contact with indigenous crayfish in Europe. As *O. limosus* is often a carrier of the crayfish plague (*e.g.*

Fig. 1. *Orconectes limosus* crossed this transverse dike to reach another water body on the other side at Szeremle side arm, Hungary (Photo: Miklós Puky)

Kozubikova *et al*. 2010), it infects native populations, which are usually wiped out fast by the disease thus creating crayfish-free habitats for the invasive species (Reynolds, Souty-Grosset 2012). There are some exceptions: when the prevalence of *A. astaci* is very low in the carrier populations, and indigenous and non-indigenous crayfish populations co-exist for long periods (Schrimpf *et al*. 2013). *Orconectes limosus* may outcompete native crayfish even in the absence of the crayfish plague agent because it has many features that enhance its survival, giving it an advantage over the native European species. *Orconectes limosus* is able to endure heavy pollution and low oxygen concentrations (Souty-Grosset *et al*. 2006); it has a rapid population growth, which is associated with a high somatic growth rate (Kozák *et al*. 2007). Besides, the fecundity of *O. limosus* is also higher (Ďuriš *et al*. 2006) and its sexual maturation is also earlier than that of European crayfish, *e.g. Astacus astacus* (Souty-Grosset *et al*. 2006, Buřič *et al*. 2013).

Orconectes limosus is known or, in some instances, suspected to spread through different means. A recent finding south of Lake Balaton, the largest lake in the Carpathian Basin, was made in a fishpond system connected to an inflow of the lake at least 50 km away from any known populations, which suggests strongly that it got there with the intentional or unintentional help of man (Ferincz *et al*. 2014).

The described phenomenon, the first record of O. *limosus* crossing on land from one European waterbody into another, is a movement on a very different scale. However, this behaviour definitely helps the colonisation of new water bodies if only small stretches of land separate inhabited and non-inhabited waters and may also help the exchange of individuals between neighbouring populations, as well as using terrestrial escape routes in case of the drying out or pollution of water bodies.

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