Status, distribution and infection rate of the invasive crayfish species, *Orconectes limosus*, in the river Danube and its tributaries in Hungary

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1 Introduction

The introduction of non-indigenous species is one of the most important anthropogenic impacts on freshwater ecosystems with many direct and indirect effects on native taxa. Introduced species can cause the degradation of natural habitats, alter species assemblages and trophic structure, displace or decimate native species (Aldridge et al. 2004; Gratton & Denno 2005). Simultaneous interactions such as competition and predation significantly influence the process of degradation (Mills et al. 2004). Among other invasive groups, such as plants, mussels and fish, also crayfish have important ecological impacts on aquatic ecosystems. Despite this, they have been often introduced outside their native ranges, either by deliberate stocking or even by bait bucket releases (Hobbs et al. 1989). Non-indigenous crayfish species (NICS) in Europe now outnumber indigenous crayfish species (ICS) by 2:1, and it has been predicted that they may dominate completely in the next few decades unless efficient methods of control are established to mitigate or stop their spread (Holdich et al. 2009). A decline in stocks of ICS has been recorded in many countries due to habitat loss, deteriorating water quality, overfishing, climate change, and most importantly from NICS and crayfish plague. The threat to ICS is so great in some countries that “ark” sanctuary sites are being established (Holdich et al. 2009). One of the three most widely-spread NICS in Europe is the North American spiny-cheek crayfish, *Orconectes limosus* (Rafinesque, 1817).

Orconectes limosus was introduced to Europe in 1890. By today, it is recorded from 20 countries in that continent (Holdich et al. 2009). It is particularly common in Western, Central and Eastern Europe. A proven vector of crayfish plague, caused by the fungus-like organism *Aphanomyces astaci* Schikora, this species is thought to have been responsible for the demise of many populations of ICS in Europe (Holdich et al. 2006). According to Puky & Schád (2006) it tends to inhabit the lower stretches of rivers and their tributaries. In consequence, populations of ICS in the upper stretches might be safe and not affected. *O. limosus* is less sensitive to land use changes and human activities than ICS (Schulz et al. 2002), and it can withstand habitats unfavourable to the ICS such as soft substrates, turbid and muddy waters, polluted canals and organically enriched ponds and lakes (Puky 2009). *O. limosus* can spread rapidly in different parts of Europe with strikingly different environmental conditions such as the Baltic region (Burba 2008, Holdich et al. 2009) as well as Central and Eastern Europe along the River Danube and its tributaries (see e.g. Hudina et al. 2009 for Croatia, Jansky & Kautman 2007 and Puky 2009 for Slovakia, and Pârvulescu 2009 and Pârvulescu et al. 2009 for Romania).

This article summarises the current knowledge on the status, distribution and also on the infection rate of *Orconectes limosus* by the crayfish plague pathogen in Hungary.

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2 Material and methods

The distribution of *O. limosus* was investigated in several sections of the River Danube, Tisza and Ipoly and the Sió canal. Active diurnal searches by turning stones and checking holes and trapping were used to prove the presence of the species. Besides crayfish-oriented surveys, valuable observations or collections were also made during the study trips of the Hungarian Danube Research Station staff along the River Danube and its backwaters. Several crayfish specialists were interviewed and other experts (e.g. ichthyologists) were contacted to incorporate their observations into the data base together with the available literature. In those investigations crayfish were caught by hand, netting, diving and dredging and also by electrofishing during ichthyological surveys (for more details see Puky et al. 2005).

Individuals collected for testing the presence of crayfish plague pathogen were kept separately while transported to the laboratory and stored deep-frozen at -80 °C. We used molecular method according to Oidtmann et al. (2006) to detect latent infection with *A. astaci* in some crayfish. DNA was extracted from soft abdominal cuticle of each tested individual and semi-nested PCR protocol was followed to amplify a species-specific fragment of ITS (internal transcribed spacer) in the rDNA region.

3 Results and discussion

It has been estimated that between one-third and one-half of the world's crayfish species are threatened with population decline or extinction (Taylor 2002). In Europe, NICS play an important role in decline of local species, especially as they carry and spread the crayfish plague pathogen, which is listed in the top 100 of the "World's Worst" invaders by the International Union for Conservation of Nature (IUCN) (Lowe et al. 2000).

Table 1. *Abundance and infection rate of O. limosus along different rivers in Hungary*

	Distribution	Abundance	Infection rate	Literature
River Danube	present from the Danube Bend to the southern border, also in tributaries, canals	high at some localities	The presence of *A. astaci* was proved, ratio of infected individuals varied	Puky et al. (2005), Puky & Schád (2006), Thuránszky & Forró (1987)
River Ipoly	gradually spreading north	low	No infection was proved	Jansky & Kautman (2007), Puky (2009)
River Tisza	present in the middle stretch	low	No investigation was carried out	Sallai & Puky (2008)
River Dráva	present in the Karasica stream	most abundant decapod	No investigation was carried out	Horvai et al. (2010)

The occurrence of *O. limosus* has been proved in the River Danube, River Ipoly, River Tisza, the Sió canal and canals in the Great Hungarian Plain (Table 1.). The species is known to be present in the River Danube since 1985 (Thuránszky & Forró 1987). *O. limosus* has established dense and successfully reproducing populations in Danubian side arms and even on dikes. In the River Tisza *O. limosus* is known to be present from the late 2000s along the middle stretch near the Kisköre reservoir (Sallai & Puky 2008). The Sió canal plays a special role in the Carpathian Basin connecting Lake Balaton to the River Danube. *O. limosus* moved there upstream from the river but no records are known from Lake Balaton so far. *O. limosus* exists in a large number of individual canals in the Great Hungarian Plain, some connected to the River Danube, others in the aquatic system of the River Tisza. The localities are spread over a large area with at least 250 km between the populations furthest from each other.

Aphanomyces astaci is present in populations of *O. limosus* along the Hungarian stretch of the River Danube. The highest infection rate was detected south of the Danube Bend, close to the site of the first record of the species for the country. No information is available on the potential infection by *A. astaci*, or population densities in the River Tisza or in the canals.

Large rivers such as the Danube or the Elbe function as natural migration corridors for freshwater invasive species such as *O. limosus*, which colonised the catchments of both rivers (Petrusek et al. 2006). The presence of this invasive species is suspected to be related to recent crayfish plague outbreaks affecting NIC populations in the Czech Republic (Kozubíková et al. 2008). Kozubíková et al. (2009) found that a high percentage, but not all individuals were infected in recent mortalities of indigenous species. This

phenomenon may also be true for Hungary. It is likely that the rapid spread of this species in the River Danube and elsewhere in Hungary may be enhanced by deliberate introductions making the colonisation process faster and less predictable. Though ICS have been found co-existing with *O. limosus* in large rivers in Austria where the habitat diversity, discharge and current velocity was high and crayfish density was low (Pöckl & Pekny 2002), their protection is urgently needed. This would require practical measures including stricter regulation and control of introductions together with an information campaign.

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