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Distribution of crayfish species in Hungarian waters

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HIGHLIGHTS

- Occurrence of native and non-native crayfish species in Hungary in the last 20 years.
- The known distribution of *Orconectes limosus* spread further to Eastern Hungary in the last five years.
- The area occupied by *Astacus leptodactylus* shifted from the main rivers Danube and Tisza to their tributaries, because of the strong expansion of *O. limosus*.
- *Pacifastacus leniusculus* threatens the native *Astacus astacus* population in Western Hungary.

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ABSTRACT

Three native crayfish species, i.e. *Astacus astacus*, *Astacus leptodactylus* and *Austropotamobius torrentium*, occur in Hungary. Lately, however, non-indigenous crustaceans have also invaded the country Their most recent distribution and impact on the occurrences of the native species is not clear. Consequently, the first object of the present study was to investigate the present-day distribution and habitat preference of the native and invasive crayfish and crab species in Hungary according to water types and surface water velocity values. The second aim was to investigate the changes in the distribution patterns of all species over the last 20 years and to identify potential risks for native species in Hungary. Although *A. astacus* was discovered on several new locations the overall distribution of the species is decreasing. The rarest crayfish is *A. torrentium* which was found only at three locations, making this the most endangered crayfish in Hungary. Although *A leptodactylus* used to occur especially in the main branches of the Danube and Tisza Rivers it shifted towards its tributaries after *O. limosus* appeared here. Despite their overlapping habitat preference and the fact that *O. limosus* is a carrier of the lethal crayfish plague, both species still co-occur at a few locations in Hungary *Pacifastacus leniusculus* is invading the country from the West and although it is not present in large numbers yet, it has replaced the local *A. astacus* populations and may further impact its distribution when it further increases its range in the future. Although occurrences of the Chinese mitten crab (*Eriocheir sinensis*) the marbled crayfish (*Procambarus fallax* f. *virginalis*) and the red swamp crayfish (*Procambarus clarkii*) have been reported in the literature, these species were not encountered during the survey Thus indicating that their occurrence in Hungary is not widespread yet. The increasing distribution of the invaders forms a constant threat to native crayfish populations in Hungary To ensure the survival of the native species it is important to keep track of the ongoing changes in crayfish distributions. Nevertheless,

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additional protection measures will be required to safe-guard the survival of the native crayfish populations in Hungary.

1. Introduction

The native European crayfish fauna is represented by taxa belonging to the genus *Astacus* and *Austropotamobius* (Kozák et al., 2015) whose populations are nowadays under pressure or even disappearing (Kouba et al., 2014). As one of the main causes for their decline has been put forward the arrival of crayfish originating from the North-America that carry the oomycete *Aphanomyces astacii* (Schikora, 1903) causing crayfish plague (Diéguez-Uribeondo et al., 1997). While the invaders are resistant to this disease, it is extremely lethal for the native crayfish species (Thuránszky and Forró, 1987). These invaders comprise several American crayfish species i.e., the spiny-cheek crayfish, *Orconectes limosus* (Rafinesque, 1817), the signal crayfish, *Pacifastacus leniusculus* (Dana, 1852), *the* marbled crayfish, *Procambarus fallax* f. *virginalis* (Martin et al., 2010), the red swamp crayfish (*Procambarus clarkii* Girard, 1852) and the catadromous Chinese mitten crab (*Eriocheir sinensis* H. Milne-Edwards, 1853) (Puky et al., 2005; Puky and Schád, 2006a,b). Although the *E. sinensis* discovered in Europe (Germany) in 1912 (Veilleux and De Lafontaine, 2007), originates from Asia it also seems to be resistant to the crayfish plague and even may act as its carrier (Schrimpf et al., 2014; Svoboda et al., 2014). Invasive crayfish species arrived in Hungary in different periods with the *O. limosus* already present for 30 years and the *P. leniusculus* being first recorded in Hungary in 1998 (Kovács et al., 2005). More recent arrivals comprise *P. fallax f. virginalis* and *P. clarkii*. For instance, *P. fallax* f. *virginalis* was caught in 2013 in Páhoki-canalbelt (Kovács et al., 2015), in several waters in the West Balaton region in 2014 (Lökkös et al., 2016), and in warm water lakes of the capital city and at the effluent of these lakes into the Danube (Weiperth et al., 2015). On the other hand, *P. clarkii* was found in Lake Városliget were in 2015 only one specimen was caught (Weiperth et al., 2015). Both *P. fallax* f. *virginalis* and *P. clarkii* are popular in the pet trade and have established populations in nearby countries like Slovakia, Croatia, Ukraine and Austria (Samardžić et al., 2014; Keller et al., 2014; Novitsky and Son, 2016; Lipták et al., 2016; Petutschnig, 2008). These invasive pecies may colonize new areas quickly because they spread actively through canals and rivers and passively during floods and through human activities (Holdich and Pöckl, 2007). According to Bernardo et al. (2011), the colonization rate in the river Maçãs (Portugal) by *P. leniusculus* ranged from 0.8 to 2.6 km yr^{-1}. In contrast, the downstream dispersal rate of *O. limosus* in the Mura river, Croatia, was 18–24.4 km yr^{-1} (Hudina et al., 2009), while a rate of 13 km yr^{-1} has been observed in the River Danube in Hungary (Puky and Schád, 2006b). This latter river used to be inhabited by *Astacus astacus* in the 1990s, but it is now dominated by *O. limosus* (Holdich and Pöckl, 2007).

Despite the arrival of the invasive crustacean species, the three native species, the noble crayfish *Astacus astacus* (Linneaus, 1758), the narrow-clawed crayfish *Astacus leptodactylus* (Eschscholtz, 1823) and the stone crayfish *Austropotamobius torrentium* (Schrank, 1803) are still present in Hungary (Puky et al., 2005). However, their current distribution is unclear since the last comprehensive overview of crayfish occurrences in Hungary published in 2013 (Györe et al.) was mainly based on literature data containing observations till 2006 for native species and observations till 2012 for non-native species. In addition, the overview of Györe et al. (2013) presented information on crayfish distribution in large sized grids of 50 km and consequently lacked details on for instance crayfish occurrence per water type Our present investigation contains data from very detailed field monitoring studies spanning more than two decades, from 1995 up to 2016 and includes exact geographical positions of the sampled sites together with information on environmental conditions (e.g., water type, dimensions of waterbodies, water flow). The aim of this present study is two-fold. Firstly it aims to investigate the present-day distribution and habitat preference of the native crayfish species *A. astacus, A. leptodactylus* and *A. torrentium* and the distribution of the invasive crayfish and crab species *O. limosus P. leniusculus, P. fallax* f. *virginalis, P. clarkii* and *E. chinensis* Secondly it aimed to investigate changes in the distribution patterns of all species over the last 20 years to identify potential risks for native species in Hungary

2. Material and method

2.1. Sampling

For our research we used existing data from different short- and long-term projects between 1995 and 2015 (BioAqua Pro Ltd., http://www.bioaquapro.hu/hu/referenciak). In total 1268 water systems comprising 4043 sampling sites have been sampled.

Crayfish were sampled according to the 'multi habitat sampling' procedure for macro-invertebrates (Juhász et al., 2009). Different microhabitats were sampled in proportion to their percentage presence which was determined prior to the sampling. The "kick and sweep" technique (Juhász et al., 2009) with a standard dip net (with a 950 μm mesh fabric and a 25 × 25 cm metal frame) was applied to collect the animals. Complementing the sampling, additional qualitative (faunistical) samples were taken following Nieuwenhuis (2005).

Each sampling location was categorized as being 'lowland' or 'upland–hilly' and 'calcic' or 'siliceous' type. Furthermore, the size of the waterbody was categorized as 'extra small', 'small', 'medium', 'large' and 'extra large', following the Water Framework Directive water body typology Furthermore, all standing water bodies were assigned to the category 'lakes' In Hungary, extra large lakes do not occur, so these kinds of waters were not included in the database In addition, the surface water velocity was estimated by measuring the distance travelled of a plastic cap in 10 s.