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The distribution of crayfish (Decapoda: Astacidae, Cambaridae) population in Cris and Mures rivers crossing the Romanian-Hungarian border

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Abstract. The crayfish (Decapoda) fauna of the Mures/Maros, Crisul Repede/Sebes-Körös, Crisul Negru/Fekete-Körös and Crisul Alb/Fehér-Körös rivers was surveyed in 16 sampling areas in 2012. The crayfish assemblages of the sampling areas were sampled using LiNi traps, hand collection and electric fishing. A total of 56 individuals of 3 crayfish species, two indigenous (*Astacus astacus, Astacus leptodactylus*) and one exotic (*Orconectes limosus*), were registered in the four rivers. The individuals of the spiny-cheek crayfish were caught in the Körösladány section of the Sebes-Körös river, making this site the easternmost border of the current Hungarian range of the species. The extremely rapid colonization in the Tisza watershed questions the hypothesis that the species has spread to the Tisza from the Danube. It was probably introduced into the eastern part of the country accidentally during fish stocking events or intentionally, as a live bait.
Key Words: crayfish fauna, distribution, *Astacus astacus*, *Astacus leptodactylus*, *Orconectes limosus*.

Kivonat. 2012-ben 16 mintaterületen felmértük a Maros, Sebes-Körös, Fekete-Körös és a Fehér-Körös folyók Decapoda rákfaunáját. A mintaterületek rákegyütteseit LiNi típusú rákvarsákkal, kézi egyeléssel, elektromos halászattal mintáztuk. A négy folyón 3, két natív (*Astacus astacus, Astacus leptodactylus*) és egy idegenhonos (*Orconectes limosus*) rákfaj összesen 56 egyedét regisztráltuk. A cifrarák egyedeit a Sebes-Körös körösladányi szakaszán fogtuk, amely lelőhely jelenleg a faj magyarországi elterjedési területének keleti határa. A Tisza vízrendszerén való igen gyors kolonizációja megkérdőjelezi a faj Duna felőli térnyerését a Tiszában. Valószínűsíthető, hogy az ország keleti felébe haltelepítés során véletlenül, ill. halcsaliként szándékosan kerültek.
Kulcsszavak: rákfauna, elterjedés, *Astacus astacus*, *Astacus leptodactylus*, *Orconectes limosus*.

Introduction. Freshwater crayfish belong to the monophyletic suborder Reptantia of the order Decapoda. A total of 593 taxa (species and subspecies) have been described in the world to date (Souty-Grosset et al 2006), which can be classified into 3 families (Astacidae, Cambaridae, Parastacidae). They naturally occur in all continents except Africa (although some species are known from Madagascar), Antarctica and the Indian subcontinent. The highest species diversity can be found in North America and Australia. A total of 14 species of Astacidae, 409 of Cambaridae and 170 of Parastacidae are known on Earth. Five indigenous [*Astacus astacus* (Linnaeus, 1758), *Astacus leptodactylus* Eschscholtz, 1823, *Astacus pachypus* Rathke, 1837, *Austropotamobius pallipes* (Lereboullet, 1858), *Austropotamobius torrentium* (Schrank, 1803)] and 8 exotic [*Pacifastacus leniusculus* (Dana, 1852), *Cherax destructor* Clark, 1936, *Orconectes immunis* (Hagen, 1870), *Orconectes limosus* (Rafinesque, 1817), *Orconectes virilis* (Hagen, 1870), *Orconectes rusticus* (Girard, 1852), *Procambarus clarkii* (Girard, 1852), *Procambarus sp.*] species occur in Europe.

With the exception of *Astacus astacus*, their taxonomic status is extremely unclear, e.g. the species *Astacus leptodactylus* and *Austropotamobius pallipes* are considered species complexes (Holdich 2002; Pöckl et al 2006). There have been five taxonomic revisions in the last half-century. Several nomenclatures have not been

universally accepted, mainly because they described too many species, subspecies, varieties, races etc with few new proofs (Holdich 2002).

In the last 150 years, the populations of European indigenous crayfish species were decimated by industrial, agricultural and communal pollutions, river regulations, hydrological constructions and the crayfish plague spread by the introduced North American crayfish. The species-conservation-based management of the indigenous crayfish stocks required an up-to-date distribution map of the indigenous and introduced species living in Europe. The logistic support to this task was provided by the CRAYNET project (Souty-Grosset et al 2006). The project focused on special topics, such as the monitoring of indigenous species, the interactions of indigenous and exotic species, following the spreading of introduced species, habitat restoration, restoring the stock size and, if possible, restocking of indigenous species, organizing education and elaborating the relevant legislation.

Currently, the presence of three indigenous (*A. astacus*, *A. leptodactylus*, *A. torrentium*) and two exotic species (*O. limosus*, *P. leniusculus*) is known in Hungary (Borza & Puky 2012). The same indigenous species occur in Romania, currently with only one exotic species, *O. limosus* (Pârvulescu 2012).

Our insufficient knowledge on the status, distribution and stock size of decapod populations in the Mures/Maros and Cris/Körös rivers crossing the Hungarian-Romanian border require general data collection, some conservational interventions and, if possible, restocking for a long-term preservation of the indigenous species.

Material and Method. A total of 16 sampling areas were designated on the Crisul Repede/Sebes-Körös, Crisul Negru/Fekete-Körös, Crisul Alb/Fehér-Körös and Mures/Maros rivers, four in Hungary and twelve in Romania (Table 1). In Hungary, sampling areas were designated on the Maros at Apátfalva, on the Fekete-Körös downstream of Gyula-Városerdő, and on the Sebes-Körös near Körösladány and Körösszakál, one sampling area at each place. In Romania, the Mures sampling areas were chosen to be at Periam Port, Pecica, Neudorf, Ususău and Petriş. Sampling areas were designated on the Crisul Alb at Chisineu Criş and Ineu, on the Crisul Negru near Tinca and Petrani and on the Crisul Repede near Oradea, Fughiu and Urvind.

A boat was needed on the Mures/Maros river at Apátfalva, Periam Port and Pecica, and on the Fekete-Körös at Gyula-Városerdő because of the large distances. The other sampling areas were waded in waterproof waders. Crayfish were collected with spring-loaded LiNi traps and/or hand collection, as well as electric fishing. The diameter of the crayfish traps was 0.30 m and 0.45 m, their length, 0.85 m and 0.90 m, the mesh size was 5 mm, and the diameter of the entrance, 15 cm and 18 cm. Before placing them into the water, a numbered table tennis ball mounted on a plastic line of about 2 m was attached to each trap. The numbered balls helped to subsequently find and identify the fully submerged traps. Each trap was baited with about 5-10 g dry dog feed. Depending on the size of the sampling area (length of the designated section, width of the river channel), 14-60 traps were set. The size of the placed traps was determined by the water depth of the sampled habitat. The traps were anchored in the riverbed near the bank using two hooked stainless steel wires. The mounted balls were tied to the riverbank vegetation. Depending on the characteristics of the riverbank, 5-15 m intervals were left between two traps. In sections with very gravelly or rocky bottom and strong current, big stones were placed into the traps in addition to/instead of anchoring with wires in order to prevent them from being swept away. The traps were set in late afternoon and checked after an exposition of at least 12 hours, the next morning. The catch or the emptiness of each trap was registered. Sampling was also done by hand collection, by night in one sampling area and during the day in two (Table 1). Electric fishing was also done in two sampling areas. The caught crayfish were identified on the spot, the data were registered. In order to confirm the field identification later, all crayfish were photographed from different angles, then released in their original habitats (except the individuals of *O. limosus*). The identification was done using the keys of the „Atlas of crayfish in Europe" (Souty-Grosset et al 2006).

Table 1

Location, code and coordinates of the sampling areas

Water course	*Location*	*Sampling area code*	*Sampling method*	*Coordinates (N/E)*
Maros Mureş	Apátfalva (HU)	C 01	crayfish trapping, direct hand sampling	46º09'16.82"/20º35'21.15"
	Periam Port (RO)	C 02	crayfish trapping	46º04'38.01"/20º54'09.78"
	Pecica (RO)	C 03	crayfish trapping	46º09'02.86"/21º03'55.26"
	Neudorf (RO)	C 04	crayfish trapping	46º06'00.19"/21º38'31.17"
	Ususău (RO)	C 05	crayfish trapping	46º05'17.67"/21º50'53.45"
Fehér-Körös Crişul Alb	Petriş (RO)	C 06	crayfish trapping	46º00'26.11"/22º24'43.29"
	Chişineu Criş (RO)	C 07	crayfish trapping	46º31'34.70"/21º30'26.80"
	Ineu (RO)	C 08	crayfish trapping	46º25'53.90"/21º51'36.60"
Fekete-Körös Crişul Negru	Gyula-Városerdő (HU)	C 09	crayfish trapping, direct hand sampling, electric fishing	46º42'11.03"/21º20'08.28"
	Petrani (RO)	C 10	crayfish trapping	46º40'48.55"/22º15'06.19"
	Tinca (RO)	C 11	crayfish trapping	46º46'15.46"/21º56'58.44"
Sebes-Körös Crişul Repede	Körösladány (HU)	C 12	crayfish trapping, direct hand sampling, electric fishing	46º58'45.65"/21º06'42.00"
	Körösszakál (HU)	C 13	crayfish trapping	47º00'51.48"/21º37'27.43"
	Fughiu (RO)	C 14	crayfish trapping	47º03'57.21"/22º03'45.57"
	Urvind (RO)	C 15	crayfish trapping	47º03'44.30"/22º16'56.57"
	Oradea (RO)	C 16	crayfish trapping	47º03'41.81"/21º55'30.96"

Results. Samples were collected in Romania between 19-23 June and 25-30 June 2012 in 12 sampling areas of 12 different locations, and in Hungary, in the period of 16-18 July 2012, on 12 September 2012 and between 20-21 September 2012 in four sampling areas of four different locations. A total of 56 individuals of three crayfish species, two indigenous (*Astacus astacus, Astacus leptodactylus*) and one exotic (*Orconectes limosus*), were registered in the four rivers (Table 2, Figure 1).

Table 2

Number and sex ratio of the crayfish species caught and observed in the individual sampling areas

River	Location	Crayfish species	Caught (ind.) ♂	Caught (ind.) ♀	+Observed (ind.)
Maros Mures	Apátfalva (HU)	*Astacus leptodactylus*	2	3	0
	Neudorf (RO)	*Astacus leptodactylus*	1	3	0
	Petriş (RO)	*Astacus leptodactylus*	2	5	0
Sebes-Körös Crişul Repede	Körösladány (HU)	*Orconectes limosus*	5	3	2
	Oradea (RO)	*Astacus leptodactylus*	6	8	12
Fekete-Körös Crişul Negru	Gyula-Városerdő (HU)	*Astacus leptodactylus*	1	0	2
	Tinca (RO)	*Astacus astacus*	1	0	0

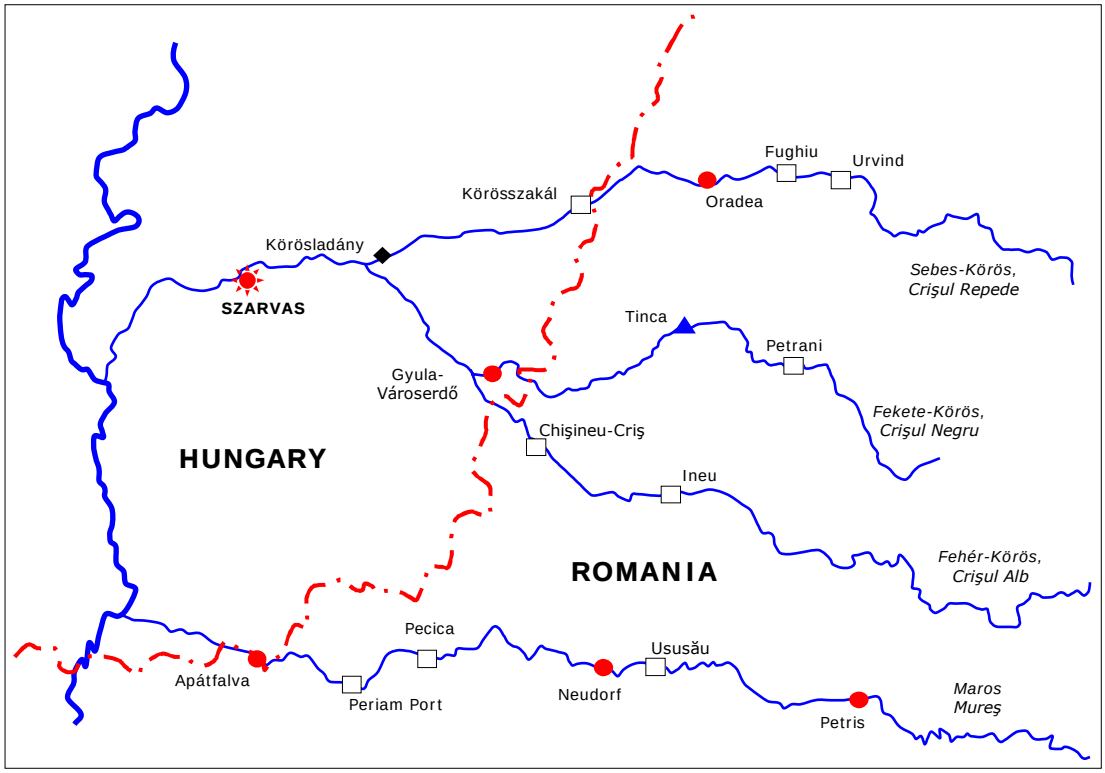

Figure 1. Occurrences of crayfish in the studied water courses;
(□ = no crayfish, ● = *Astacus leptodactylus*, ▲ = *Astacus astacus*, ◆ = *Orconectes limosus*).

Discussion and Conclusions. The two indigenous crayfish species, *A. astacus* and *A. leptodactylus*, have a wide European distribution. The distribution range of the nominate subspecies of noble crayfish includes Central Europe with the rivers Elbe and Oder, and the watersheds of the rivers flowing into the North Sea and the Baltic Sea. The race *A. a. astacus* natio *canadziae* inhabits the Croatian, Serbian and Romanian tributaries of the Danube, including River Drava. *A. a. balcanicus* occurs in Albania, Greece and Macedonia, while *A. a. colchicus* only lives in Georgia. The natural eastern border of the species' distribution range passes through Belarus, Ukraine and Georgia. The range of the species includes the Netherlands, Belgium, Luxembourg, France and Switzerland, but the general consensus is that it was introduced to these countries due to human activity, similarly to the way it appeared in Norway and Sweden in the Middle Ages (Souty-Grosset at al 2006). *A. astacus* is currently the crayfish species with the largest distribution range in Europe, its presence was indicated from 39 countries. *A. leptodactylus* was originally a crayfish species of the Ponto-Caspian region, but it has widely spread in Europe by now. It is absent from Scandinavia, its occurrence have not yet been reported from the Iberian Peninsula, Ireland and some countries of the Balkans.

Literature data on the distribution of the two species in Hungary are very scarce. The first paper having a scientific value was by Entz (1912), it contained data on crayfish in Hungary. The study summarized the earlier literature data on our three indigenous crayfish and reported several new occurrences. The next important publication, which appeared more than 80 years later, reported the processing of the crayfish material of the Natural History Museum of Hungary collected between 1910-1960 and the study material collected by Thuránszky between 1956-1960 (Thuránszky & Forró 1987). Of the papers reporting numerous occurrences of several of our crayfish species, the studies by Kovács et al (2005), Juhász et al (2006), Szepesi & Harka (2011) and Hegedűs (2007) deserve to be mentioned. There are no recent proofs from the last 25 years on the occurrences of noble crayfish in the Hungarian parts of the Maros and Körös watersheds. If taking into account the 1909 distribution data as well, the species inhabits 40 of the 58 50x50 km UTM squares covering the area of Hungary (Figure 2). The shrinking and reduction of the distribution range of the species have been noted by many, quoting the

drying habitats, pollution and often unknown factors as the main causes (Pintér & Thuránszky 1983). Populations of the spiny-cheek crayfish inhabit an area corresponding to 29 UTM squares (Figure 2). In the geographic region of our study, it was recently reported from the Berettyó river (at Szeghalom), the Öcsöd section of the Hármas-Körös river, the Hortobágy-Berettyó river near Mezőtúr (Juhász et al 2006), the mouth area of the Hármas-Körös, the mouth of the Kurca river at Magyartés and the Újiráz section of the Sebes-Körös river (Kovács et al 2005), as well as the Kákafok oxbow lake (Sallai & Puky 1998).

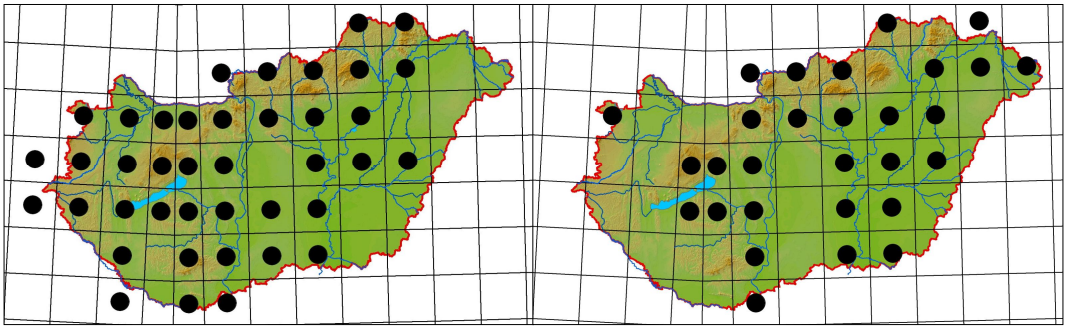

Figure 2. Distribution of *Astacus astacus* (left) and *Astacus leptodactylus* (right) in Hungary (black circle: occurrence in the given 50x50 km quadrat is proven) (Puky & Schád 2006).

Orconectes limosus is the second most widespread exotic crayfish species in Europe after *Pacifastacus leniusculus*. The species is endemic to the north-western states of the US (Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia) and the south-western part of Canada (New Brunswick, Québec) (Adams et al 2010). It was brought to Europe by Max von den Borne in 1894, who introduced it into the catchment area of the Oder river (Seligo 1895). Its first introduction to Hungary took place in September 1959 in Pilisvörösvár, Szigetszentmiklós and Szigetbecse (Thuránszky 1960). It is surprising that the further fate of the nearly 10,000 stocked individuals of spiny-cheek crayfish is unknown, e.g. the specimen found in a tributary of the Újpest reach of the Danube in 1985 was not considered a descendant of the individuals imported from Germany (Thuránszky & Forró 1987). However, in our view, this opinion is untenable as the species only appeared in the Austrian reach of the Danube in 1991 (Nesemann et al 1995). In the 1980s, two disjunct populations could be identified in the upper and middle reaches of the Danube. The first spiny-cheek crayfish stock was detected in the Bavarian reach of the Danube near Ingolstadt. It has since spread downstream as far as the town of Donaustauf (Nesemann et al 1995). The second Danube population was registered from Hungary. Specimens of the species were frequently caught in the main channel of the Danube between Leányfalu (1673 rkm) and Dunaföldvár (1562 rkm) in 1991, indicating its progressive spreading in the years after 1985. The two distinct core areas suggest that the 1985 specimen was a descendant of the stock introduced in 1959. The first spiny-cheek crayfish population of the Austrian reach of the Danube was registered only in September 1991 near Vienna (Ölhafen). The colonization of that isolated habitat was explained by the introduction of the crayfish species by boats (Pöckl 1999; Pöckl & Pekny 2002).

The species *Orconectes limosus* occurs in about 16 UTM squares in the faunal area of Hungary (Figure 3). The proof of its easternmost occurrence in Hungary has been provided by the survey of the present HURO project. The resolution of the distribution map based on 50x50 km UTM squares in accordance with the CRAYNET programme is too low, hiding the series of real occurrences, especially in the Danube-Tisza Interfluve. An adequate representation of the UTM system suggests that, following the Danube, the species has also colonized the Tisza watershed by natural dispersal.

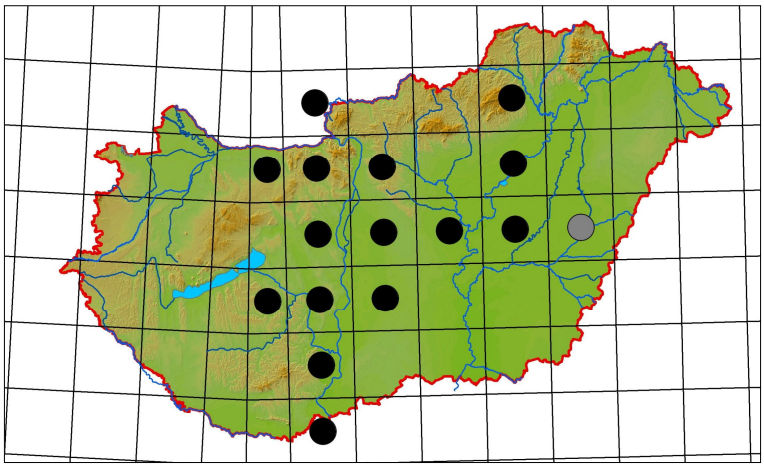

Figure 3. Distribution of *Orconectes limosus* in Hungary;
(grey circle = the occurrence of the species in the given UTM square was first proven by the present survey).

If representing the 60+ occurrence data in Hungary with dots (Figure 4), it becomes clear that the individuals of the species could not get from the Danube to the Tisza via natural waters, as there is no direct connection between the two major rivers in the Danube-Tisza Interfluve. Colonization of the Tisza was predicted (Puky & Schád 2006). Sallai & Puky (2008) considered it possible that the colonization would happen from the Serbian reach of the Danube. This is contradicted by the fact that the first occurrence of the species in the Tisza Lake (Tiszanána-Dinnyéshát) was reported already in 2005 by Zoltán Müller (Juhász et al 2006); moreover, there are data suggesting that anglers found occasional specimens of *O. limosus* even in 2003-2004 (Szepesi & Harka 2011).

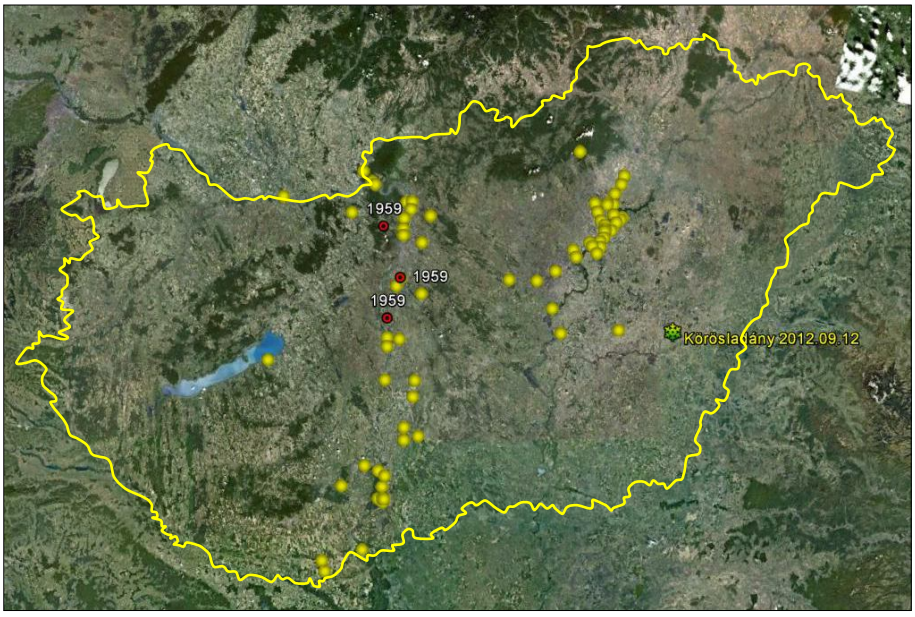

Figure 4. The 66 known occurrences of *O. limosus* in Hungary shown on a Google Earth map
(red dots show the locations of the 1959 introduction).

At the same time, the species was found in the faunal area of Croatia, in a marsh by the Danube (Kopacki rit), only in 2003 (Maguire & Gottstein-Matoveč 2004), and in the Serbian reach of the Danube, at Smederevo, near the mouth of the Tisza, only in 2004 (Pavlović et al 2006). The exotic crayfish, having an average downstream spreading rate of 15 km/year (Puky & Schád 2006), could not appear in the Tisza Lake earlier than it

was observed near the mouth of the Tisza. Its appearance in the Tisza Lake was probably due to human activity, e.g. accidental introduction while stocking fish or intentional introduction as fish bait. The specimen detected in the Felsőtárkány Pond can be explained by similar human activities (Fitala 2009). Tributaries flowing into the Tisza Lake were colonized naturally. There were also predictions concerning its further spreading, its appearance in tributaries of the Tisza was also expected (Sallai & Puky 2008; Szepesi & Harka 2011). A young specimen of spiny-cheek crayfish was caught in 2008 in a reach of the Hortobágy-Berettyó river downstream of Túrkeve, at the mouth of the Nagykunság Main Channel (Sallai 2010), which occurrence proved the further eastern spreading of the species very soon.

Studies on the crayfish fauna in the Romanian part of the watersheds of the studied rivers date back to the beginning of the 20th century. The above-mentioned paper by Entz (Entz 1912) reported detailed data on contemporary crayfish occurrences in the Transylvanian water courses. Another paper, which also included extensive distribution data, was published by Băcescu (1967). During the cataloging of the crayfish material collected by the author between 1935-1974 and stored in the „Grigore Antipa" Museum of Bucharest, some occurrences of the species *Astacus astacus* (Ciucea), *Astacus leptodactylus* (Tămăşeelu, Ciucea) and *Austropotamobius torrentium* (Meziad) in the rivers Crisul Repede and Crisul Negru could be confirmed (Petrescu & Petrescu 2010). A survey by Parvulescu (2012) in the catchments of the tributaries of the Tisza aimed at confirming and complementing these data of over 30 years before. Faunal research in the Mures basin included only the tributaries. Occurrence of *Astacus astacus* was confirmed in 11 of the 25 sampling areas. According to the results, seven tributaries of the Crisul Alb river were inhabited by noble crayfish, while two, by stone crayfish. A sampling area was also designated in the main river channel near Dieci, but no crayfish was found here. Mostly *Austropotamobius torrentium* individuals occurred in the mountain brooks of the Crisul Negru watershed, noble crayfish was proven only from three water courses. No crayfish were detected in the Poienii and Cristior branches of the river. Stone crayfish was also dominant in the tributaries of the Crisul Negru, noble crayfish could be confirmed only in an upland creek. The first Romanian occurrence and spreading of spiny-cheek crayfish was reported by Pârvulescu et al (2009, 2012). Upon summarizing the occurrence data of the above-mentioned crayfish, it was Pârvulescu (2010) who published the distribution of the three indigenous crayfish species and the exotic *Orconectes limosus* in Romania. Stone crayfish and noble crayfish only occur with high probability in the mountainous parts of the Mures and Cris watersheds, but they are rare in the hilly and lowland areas studied by us. In contrast, the narrow-clawed crayfish is frequent in these latter river reaches. After confirming the occurrence of spiny-cheek crayfish in the Danube and the brooks flowing into the Danube reach in question, further possible detection of the species was predicted in Transylvania, in the Upper Tisza and Mures rivers. However, the results of the present project suggest that the appearance of *Orconectes limosus* should be rather expected in the Romanian reaches of the Cris rivers.

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