HOW TO FIND A STONE CRAYFISH *AUSTROPOTAMOBIUS TORRENTIUM* (SCHRANK, 1803): A BIOGEOGRAPHIC STUDY IN EUROPE

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Reçu le 2 février 2005 *Received February 2, 2005*
Accepté le 6 Juillet 2005 *Accepted July 6, 2005*

ABSTRACT

The stone crayfish *Austropotamobius torrentium* (Schrank, 1803) is widely distributed in Southeastern and Central Europe. However, this information has not been verified until recently because of:

- ignorance about biogeographic notion and hydrography and
- ignorance of data in the literature.

Overcoming these problems during the last decade, the distribution pattern of the stone crayfish has now become apparent in Europe. It is known from Luxembourg and Germany to the west, from Turkey to the east, from Germany and the Czech Republic to the north and from Greece to the south. It is absent in the northeastern part of the Pannonian basin as well as in Poland and Ukraine. Its presence in Luxembourg and the Czech Republic may be related not to natural distribution but to introduction by humans through history. The discovery of the stone crayfish in Italy and Turkey as well as its re-discovery in France during the 1990s proves the biogeographic conception that this animal belongs to the Danubian fauna. It probably originates from the southwestern part of the Pannonian basin.

Key-words: crayfish, Astacidae, *Austropotamobius torrentium*, biogeography.

COMMENT TROUVER UNE ÉCREVISSE DES TORRENTS *AUSTROPOTAMOBIUS TORRENTIUM* (SCHRANK, 1803) : UNE ÉTUDE BIOGÉOGRAPHIQUE EN EUROPE

RÉSUMÉ

L'écrevisse des torrents *Austropotamobius torrentium* (Schrank, 1803) est largement répandue en Europe centrale et en Europe du sud-ouest. Mais cette information n'a pas été vérifiée jusqu'à récemment à cause de :

- la négligence sur la notion biogéographique et l'hydrographie.
- la négligence sur les données dans la litérature.

Surmontant ces problèmes durant la dernière décennie, la mode (« pattern ») de répartition de l'écrevisse de torrent est enfin devenue visible en Europe. Cette écrevisse est connue au Luxembourg et en Allemagne à l'ouest, en Turquie à l'est, en Allemagne et

Article available at http://www.kmae-journal.org or http://dx.doi.org/10.1051/kmae:2005010

en République tchèque au nord et en Grèce au sud. Elle est absente dans la partie nord-est du bassin Pannonien et également absente en Pologne et Ukraine. Sa présence au Luxembourg et en République Tchèque pourrait être liée non à la répartition naturelle mais à des introductions artificielles faites par les hommes. La découverte de l'écrevisse de torrent en Italie et en Turquie et sa redécouverte en France durant les années 1990 prouvent la conception biogéographique que *A. torrentium* appartient à la faune danubienne. Cette espèce est probablement d'origine de la partie sud-ouest du bassin Pannonien.

Mots-clés : écrevisse, Astacidae, *Austropotamobius torrentium*, biogéographie.

INTRODUCTION

The stone crayfish *Austropotamobius torrentium* (Schrank, 1803) is widely distributed throughout Central and Southeastern Europe (LAURENT, 1988). Although the global and general view of its geographical distribution seems to be known (LAURENT, 1988; HOLDICH, 2002), details and exact regional or local patterns are quite hazy. Many people believe or feel that such information does not exist. Biologically and biogeographically this species is believed to be much less known than the noble crayfish *Astacus astacus* (Linnaeus, 1758), the narrow-clawed crayfish *Astacus leptodactylus* Eschscholtz, 1823 and the white-clawed crayfish *Austropotamobius pallipes* (Lereboullet, 1858). This is one of the reasons why the 4th Craynet Meeting Innsbruck 2004 was focused on the stone crayfish.

Since 1994 we have been studying the stone crayfish at the European level. We quickly understood that the stone-crayfish information existed in the literature as well as on the local level in every country. Although it was believed that such information did not exist because most likely people had not looked for it; we herein prove the contrary: in tracking important information and verifiying it, we show how to find stone crayfish in Europe. By indicating our crayfish hunting techniques and considering a standard protocol for crayfish searching, we present new data on the distribution pattern and give some ecological notes of this poorly known European crayfish species. Majority of the information mentioned below comes from our crayfish studies and observations carried out between 1994 and 2004.

METHODS, RESULTS and DISCUSSION

Historic of our stone-crayfish hunting

Austria - Tyrol: When we started our crayfish studies in 1994 in Tyrol (Austria), we did not know how and where to find the stone crayfish in Tyrol. There was no published information available at all. We began with Lake Plansee because we knew there were crayfish, which were revealed to be *A. pallipes* (FÜREDER and MACHINO, 1995). And later near Lake Plansee, we had information about crayfish of the River Archbach. The crayfish of the lower part of the Archbach has been shown to be *A. torrentium* (FÜREDER and MACHINO, 1996). This was our first stone crayfish. At that time we looked for it in all kinds of waters rather randomly because we did not know the exact methodology, as the correct information was not available in the literature then.

Austria - Carinthia: In 1994 we also began the crayfish study in western Carinthia but we targeted waters very randomly, as we had very little information about Carinthian crayfish in the literature then.

We started developing experiences on the local level, *i.e.*, Austria (Tyrol and Carinthia), in 1994 and quickly these were extended at the European level. The next remarks were noticed since.

Remarks

A general view on the distribution pattern of *A. torrentium* was given by LAURENT (1988). It clearly indicates that the species belongs to the Danubian fauna. Thus biogeographic notion can be indicative: where they live and where they expand. Also the biogeographic pattern of other aquatic animals is very important. As *A. torrentium* is a member of the Danubian fauna, its presence is always accompanied by other representatives of the Danubian fauna. This is a very important indication, particularly when it is present in hydrographic basins beyond the Danube system.

The paper of HART and CLARK (1987) belongs to the most important crayfish-literature data. But this seems not to have been exploited by the European scientists. When this paper is exploited well, many important references become apparent and the crayfish distribution pattern in Europe appears in detail, *e.g.*, in Hungary, Romania and Bulgaria. Thus the *A. torrentium* distribution pattern in southern Europe becomes obvious and the presence of *A. torrentium* in several Greek territories and even in Turkey has to be expected.

The taxonomic confusion between *A. torrentium* and *A. pallipes* occurred until the beginning of the 1920s although the former was described in 1803 and the latter in 1858. The confusion was corrected by ENTZ (1909, 1914) and CARL (1920).

Other shortcomings appear when investigating the distribution of crayfish. Although local information on crayfish presence always exists, usually not many scientists look for that information. In addition, as it requires administrative authorizations for catching crayfish, which are generally not easily obtained, it is difficult to study indigenous crayfish in some countries.

Standard protocol for the crayfish hunting

These experiences and remarks enabled us to learn the importance and usefulness of the topographic as well as hydrographic information. We always look for the topographic maps before the crayfish observation. Moreover, both the literature data and the local information appear to be the most efficient sources for finding crayfish waters. We start our crayfish observation with the next steps :

Step 1 - Analyzing many references on the biogeography of the Danubian fauna. This is a difficult task, as there are so many Danubian animals, *i.e.*, it is almost impossible to read all the papers. So, we followed some particular classes of the animals in order to have the biogeographic notion of these particular animals. Especially, the fish biogeography (*e.g.*, BERG, 1932; THIENEMANN, 1950; BANARESCU, 1990/1995) helped a lot in our case.

Step 2 - Analyzing HART and CLARK (1987) for extracting all important references on the stone crayfish.

Step 3 - Analyzing all the references on the stone crayfish found in HART and CLARK (1987) and other stone-crayfish references found in elsewhere.

Step 4 - Analyzing the crayfish references, treating every aspect of the crayfish biogeography in Europe. These included documents on human history, geography, fisheries, zoology, etc.

Step 5 - Analyzing the hydrographic situation using maps.

The steps 1 to 5 allow us to know the possible stone-crayfish situation of every corner in Europe, *i.e.*, where to go and do the crayfish observation. The next steps are:

Step 6 - Analyzing the topographic situation after topographic maps and ecological situation at the sites.

Step 7 - Looking for local information from local people and institutions. Local farmers, hunters, fishermen, policemen, professors, teachers, fishing guards, forest guards, town/village mayors and children are asked.

The steps 6 to 7 enable us to target waters and places. The next steps are:

Step 8 - Before the night observation, a daytime pre-observation is necessary. This allows us to find most likely the crayfish spots.

Step 9 - Crayfish catching by hand (daytime and/or night-time).

Step 10 - Nighttime observation with a lamp.

Step 11 - Crayfish catching by crayfish traps.

Thus once all the information and situations had been analyzed, we targeted waters and places where we were most likely to find crayfish. Then we try to catch the stone crayfish. This method became our standard protocol for geographical distribution studies of the indigenous crayfish.

Application of the protocol: searching for *A. torrentium*

Czech Republic

A. torrentium is known only from the Elbe drainage (*i.e*. Bohemia) and seems to be absent in the Danube drainage (*i.e*. Moravia) (LOHNISKY, 1984a, 1984b, 1990; POLICAR and KOZÁK, 2000; DURIS *et al*., 2001; KOZÁK *et al*., 2002). The distribution pattern in the Elbe drainage (*i.e.* no logical biogeographic pattern) allows us to "suppose" that this may be an introduction by man (MACHINO and HOLDICH, *in press*).

France

For the French *A. torrentium*, the important paper is LEREBOULLET (1858). Some taxonomic confusion seems to have occurred between *A. torrentium* and *A. pallipes*, however, only the specimens studied by LEREBOULLET were verifiable. These *A. torrentium* were from a population near Strasbourg. But the population has already disappeared (probably in the 19th century).

Till the 1980s, nobody looked for *A. torrentium* in Alsace and Lorraine. Since the 1990s, three populations of *A. torrentium* have been found (two in Lorraine and one in Alsace) (FRANCKHAUSER and MACHINO, 2000, 2001; HORNIER *et al.*, 2002). Two are still present, but one from Lorraine is probably extinct (FRANCKHAUSER and MACHINO, 2001; CHANGEUX, 2003).

Germany

Austropotamobius torrentium has been known only from the Middle and Upper Rhine drainages and the Danube drainage as well as the headwaters of the Eger River (=Ohře; Elbe drainage) (BERG *et. al*., 1989; SCHANZ and FROEHLICH, 1991; STEINBERG, 1992; SCHADT, 1993; TROSCHEL and DEHUS, 1993; BOCK *et al.*, 1996; DEHUS, 1997; KAPPUS *et al.*, 1999; REPA, 1999; BOHL, 2000; BOHL *et al*., 2001; KLOS and KROTTEN, 2001; MEINEL and MOCK, 2001).

Greece

Austropotamobius torrentium has been known from northern Greece (BOTT, 1972; KINZELBACH, 1986), but searching for it in other parts of Greece, the crayfish information from Bulgaria (*e.g.*, BULGURKOV, 1961) is important. In 1996 the information allowed us to find several *A. torrentium* populations in eastern Greece (Struma drainage, Mesta drainage and one isolated karstic hydrography) (MACHINO and HOLDICH, *in press*).

Italy

No historical papers on *A. torrentium* existed. The biogeographic conception was neglected, and nobody suspected the *A. torrentium* presence in the Italian Danubian water (Slizza drainage). DE LUISE (1988, 1991) reported "*A. pallipes*" there by identification error. MACHINO (1996) corrected the error, it is *A. torrentium*. Up to now, we have found three populations in the Slizza drainage near Tarvisio, but one of them probably extinct already (MACHINO and HOLDICH, *in press*).

Luxembourg

Very few papers existed for the historical crayfish data. TROSCHEL and BARTL (1998), MACHINO (2000, 2001) and FRANCKHAUSER and MACHINO (2002) are useful. ATTEN (1987) indicates that *A. torrentium* is not indigenous. Also the crayfish data from German provinces of Saarland and Rheinland-Pfalz (Machino, *unpub. data*) indicate that *A. torrentium* is non-indigenous to Luxembourg.

Poland

Up to now, no *A. torrentium* has been found in Poland. There are a few papers mentioning its presence in Poland (*e.g.*, STAROBOGATOV, 1995), but no verifiable data and papers on the Polish *A. torrentium* are available.

Turkey

Nobody seemed to have suspected the presence of *A. torrentium* in Turkey. But the information on the Bulgarian crayfish (BULGURKOV, 1961) provides such possibility. Also the biogeographic information on other freshwater fauna indicates this country may/ should have *A. torrentium*. Indeed, one population was found in the European part of Turkey in 1996, *i.e.*, in the Velika River (Rezovska drainage).

Ukraine

Up to now, no *A. torrentium* has been found in Ukraine. The reported presence of *A. torrentium* in the headwaters of the Stokhod River in Ukraine (Dniepr drainage) (KARAMAN, 1962) seems to be an error on the sampling location (MACHINO and HOLDICH, *in press*).

Some ecological notes on stone crayfish

Mostly stone crayfish live in running waters, but they can also exist in stagnant waters like Lake Haldensee in Austria (MACHINO and FÜREDER, 1998) or Lake Blejsko jezero in Slovenia (BUDIHNA, 2004 pers. com.). Except this high preference for rheophilic waters and the avoidance of muddy areas, the habitats of stone crayfish are very similar to those of two other European crayfish (*A. pallipes* and *A. astacus*). We here indicates some remarks on its habitat and ecology. As references on the stone-crayfish ecology are rather recent and still relatively rare (*e.g.*, SCHULZ and KIRCHLENER, 1984; BOHL, 1989, 1999; PETUTSCHNING, 1993; BITTERMANN, 1998; KAPPUS *et al.*, 1999; RENZ and BREITHAUPT, 2000; MAGUIRE *et al*., 2002; STREISSL and HÖDL, 2002), most of the remarks come from our observations on the fields:

- Steepness: difficult to say. If very steep brooks, the water flow must be low for a good spot for stone crayfish. They like stable grounds. Typical torrents are generally not good for them.

- Width of rivers and brooks: Generally less than 10 or 15 m wide, but it can be much wider. One of us (Y.M.) saw stone crayfish in the Lim River (Montenegro) with 40 or 50 m width. In another large river in Montenegro (the Tara River), stone crayfish are

present in hyporhithron a few kilometers below the town Kolašin, while they are absent in metarhithron above Kolašin. In brooks, they generally occur in metarhithron, and they can occur in epirhithron if the water flow is low. In another sentence, the epirhithron is generally not a good habitat for stone crayfish.

• Bottom: stones and gravels, but not sand nor mud. The bottom must be stable. Stone crayfish often make burrows like other European crayfish species. With sand, they cannot dig burrows.

• Temperature: variable, but the data for the temperature limits are not available to us. All the stone-crayfish rivers we know offer a nice temperature for people to swim in summer.

• Vegetation: prairie or deciduous forests. Coniferous forests are not inducive to crayfish survival. Probably because coniferous trees tend to make the soil acid and their leaves seem not to be used by the crayfish as food.

• Water pollution: stone crayfish are very sensitive to water pollution. In Western Europe, the presence of houses with detergents and agricultural activities with pesticides is indicative for the absence of stone crayfish. Wider presence of these animals in large rivers in Eastern Europe would be related to relative absence of these pollutants. Also eutrophication of water by human activities decreases or destroys the habitat of the stone crayfish. Presence of large areas of riparian vegetation as well as water plants within brooks or rivers is one of very important factors for survival strategies of stone-crayfish populations that live in such badly polluted waters.

Origin of *A. torrentium*

The crayfish papers from Bulgaria (ARNDT, 1943; BULGURKOV, 1961; SUBCHEV and STANIMIROVA, 1998), Romania (SCRIBAN, 1908; ENTZ, 1909, 1914; CALINESCU, 1929; MARCU, 1930; BACESCU, 1967), Hungary (ENTZ, 1909, 1914; WOLSKY, 1934; THURÁNSZKY and FORRÓ, 1987; PUKY, 2000), Slovakia (ORTVAY, 1902; ENTZ, 1909, 1914; MATIS, 1971; HALGOS, 1972; JANSKY, 1987) and the Czech Republic (see above) are not used sufficiently by the scientists from Western Europe. These papers reveal that *A. torrentium* is almost absent in the northeastern areas of the Pannonian basin as well as in the Lower Danube drainage (below the Olt drainage in Romania) (Fig. 1). Our prospection in the Danube drainage of several countries (Ukraine, Poland, the Czech Republic, Slovakia, Hungary and Romania) supports this opinion.

On the other hand, *A. torrentium* would have originated from somewhere in the southwestern part of the Pannonian basin, where Slovenia, Croatia, Bosnia and Herzegovina and Serbia lie today. The species is widely distributed within this area and recent studies based on Cytochrome Oxydase I (COI) sequence analyses support this opinion (TRONTELJ *et al*., 2005). From the original distribution area, then through the evolution history, *A. torrentium* reached river basins of the Aegean Sea (Greece, Macedonia, Serbia, Bulgaria), Black Sea (Bulgaria, Romania, Turkey) and Upper Danube drainage (Germany, Austria), thus allowing them to extend the geographical distribution to the Rhine drainage (France, Switzerland, Germany, Austria) as well as the Drin drainage (Montenegro, Albania, Serbia, Macedonia and Greece) (BOTT, 1972; ALBRECHT, 1982; MACHINO and DURIS, 2004).

ACKNOWLEDGEMENTS

We heartly thank the unknown referees and the editors. Their helps were precious.

Figure 1
Geographical distribution of *Austropotamobius torrentium* in Europe.

Figure 1
Répartition géographique d'*Austropotamobius torrentium* en Europe.

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