A remarkable assemblage of riffle beetles (Coleoptera: Dryopoidea: Elmidae) from the Aisne river, northern France, with records of *Potamophilus acuminatus* (Fabricius, 1792) and *Limnius muelleri* (Erichson, 1847)

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Abstract. In 2009 a remarkable assemblage of riffle beetles (Elmidae) was discovered in the Aisne, a small river in France's Champagne-Ardenne region. Amongst a batch of rare species, *Potamophilus acuminatus* was found for the first time in northeastern France, and the even rarer *Limnius muelleri*, believed to be extinct in most parts of its range, was rediscovered. It is shown that the Aisne harbours an exceptional potamophilous elmid fauna and that this richness is best explained by a combination of good water quality and high structural diversity. The importance of this river for the conservation of potamophilous insect communities is stressed.

Keywords. Aquatic Coleoptera, Elmidae, faunistics, Aisne river, France, rivers.

1. Introduction

Riffle beetles are characteristic inhabitants of the bottom of streams and rivers in most parts of the world. In Europe the familiy Elmidae is represented with 54 taxa, 44 of which are currently granted species level. The richest elmid faunas are found in the southwestern parts of the continent, in the Mediterranean and Submediterranean regions in France and Spain with 39 taxa, and in Italy, including the Tyrrhenian islands, with 33 taxa. The Balkans and eastern parts of the Mediterranean regions have a slightly poorer fauna with a total of 30 taxa, but as a rule the Mediterranean is much richer in species than the rest of Europe, with numbers sharply declining to the north: 29 taxa in central Europe, 13 in the British Isles, 10 in Scandinavia and none in Iceland (Fauna Europaea, www.faunaeur.org).

Throughout most parts of western and central Europe each major type of stream has its own typical assemblage of elmid beetles. While the faunas are rather well preserved in upland regions, although they may have suffered from acidification locally, the situation is dramatically different for those restricted to larger rivers in lowland areas of central and western Europe. In those regions, manmade habitat loss caused by channelizing, alteration of the flow regime, extraction of sediments, destruction of alluvial forests, further worsened by rampant water pollution, has brought most of the characteristic species to the brink of extinction in the course of the twentieth century (Jäch 1992)

Though the Elmid fauna of France is generally well known, there is only few and scattered information available for every single region of the country and this is especially true for the northern and northeastern parts, with available information on riffle beetles being particularly scarce.

With this background in mind, several stretches of the river Aisne have been visited in late summer of 2009 in order to sample their water beetle fauna, with a special focus on elmids and hydraenids. This led to the

discovery of a very rich and remarkably well-preserved assemblage of riffle beetles displaying all the species expected in that type of river, including those that have vanished from so many river basins of western and central Europe.

The aim of the present paper is to present the elmid fauna of the upper stretches of the Aisne upstream of Attigny and to explain the possible causes of its richness.

2. Methods and study sites

The river was sampled using a fine-meshed (1 mm) sturdy net whose contents were then searched for adult beetles and their larvae in a white tray. Insects were killed and preserved in a solution of isopropanol (40%), water (50%), ethylacetate (5%) and acetic acid (5%) and later mounted on cards. The male aedeagi were extracted and glued next to the beetle.

Efforts were made to sample as many microhabitats as possible, but particular attention was devoted to larger chunks of submerged wood in both fast flowing sections and lenitic backwaters; the system of fine willow rootlets found on steeper banks overgrown by riverine trees, and the gravel and stones in riffles where the classic „kick sampling" could be employed.

The beetles were identified with Jäch (1992), Drost et al. (1992) and Olmi (1976).

The Aisne river has been visited twice in late summer (on 26.08.2009 and 09.09.2009), when the water level was at its lowest and most parts of the river channel were readily accessible.

The sampled locations lie in the departement of Ardennes on the northern fringe of the Paris Basin (Fig. 1), the first one immediately east of Attigny (Fig. 2), the second one several kilometres upstream, some 7 km south of Vouziers, near the village of Olizy-Primat, and the third one a further kilometre upstream north of Brécy-Brières (Fig. 3). The geographical coordinates are 49°28'54" N 4°35'30"E, 49°20'30"N 4°45'19"E and 49°19'54"N 4°46'22"E respectively, the respective elevations being 78, 99 and 99 m a.s.l.

The Aisne river flows through an alluvial plain whose width varies roughly between 600 and 1200 m and which is carved in the limestones of the Upper Jurassic and both the Lower and Upper Cretaceous. This geology accounts for the well mineralized nature of the river's water, and although water hard-

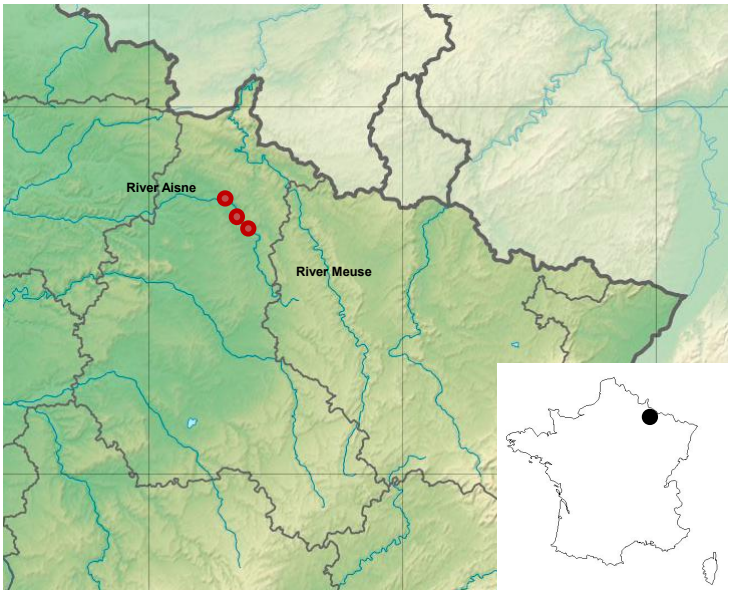


Fig. 1. Sampling sites on the River Aisne on the northern fringe of the Paris Basin, France.



Fig. 2. Sampling site east of Attigny (F-08) with a gravelly riffle in the foreground where *Limnius muelleri* was found in September 2009.



Fig. 3. The Aisne north of Brécy-Brières (F-08) where larvae of *Potamophilus acuminatus* and adults of *Macronychus quadrituberculatus* were found in August 2009.

ness has not been measured, the electric conductivity was 466 µS/cm near Attigny.

The width of the river channel varies between 15 and 50 m but at most places the river is ca. 20 to 25 m wide with a characteristic succession of meanders and an alternating pattern of shallow, gravelly riffles and deeper pools. The banks are generally steep as the river has deeply cut into its alluvial deposits and, although the floodplain is used for agricultural purposes, there are still many patches of gallery forest and even isolated groups of larger hardwood trees, mainly ash (*Fraxinus excelsior*) and oak (*Quercus robur*), along with huge willow pollards (*Salix* sp.). The presence of trees is important in this context as it is a rich source of dead submerged wood required by some of the rarer elmids. The Aisne is a tributary of the river Oise which itself joins the Seine west of Paris. It rises in the hilly Argonne slightly south of Sainte-Ménéhould.

3. Results

During the two visits in late summer of 2009 a total of 10 elmid and 1 dryopid species were recorded (Tab. 1). This number was unexpectedly high, the more so as several species generally common in northeastern France and in Luxembourg went unrecorded.

Table 1. Species recorded from the Aisne river. Site I = Attigny, site II = Olizy-Primat, site III = Brécy-Brières.

Species	Site I	Site II	Site III
Elmidae			
Larinae			
Potamophilus acuminatus (F., 1792) larvae	×	×	×
Elminae			
Stenelmis canaliculata (Gyllenhal, 1808)	×	×	×
Elmis obscura (Müller, 1806)		×	
Esolus parallelepipedus (Müller, 1806)	×		×
Esolus pygmaeus (Müller, 1806)	×		×
Oulimnius major (Rey, 1889)		×	
Limnius muelleri (Erichson, 1847)	×		×
Normandia nitens (Müller, 1817)	×	×	
Riolus cupreus (Müller, 1806)	×	×	×
Macronychus quadrituberculatus Müller, 1806	×	×	×
Other aquatic Coleoptera			
Dytiscidae			
Laccophilus hyalinus (Degeer, 1774)		×	
Hydraenidae			
Hydraena riparia Kugelann, 1794			×
Hydraena reyi Kuwert, 1888			×
Hydrophilidae			
Anacaena bipustulata (Marsham, 1802)			×
Laccobius striatulus (F., 1801)			×
Dryopidae			
Pomatinus substriatus (Müller, 1806)		×	×
Number of species	8	9	12

Among those missing are such widely distributed species as *Elmis maugetii* Latreille, 1798 and *Elmis aenea* (Müller, 1806), *Limnius volckmari* (Panzer, 1793) and *Oulimnius tuberculatus* (Müller, 1806), all of which can be found in the River Meuse some 35 km further east (Gerend, unpublished records). Whether those species are genuinely absent from the Aisne, or just went unnoticed, must be left to further investigation.

Along with the Elmidae 6 other species of water beetles were recorded (Tab. 1), a figure that amounts most probably only to a fraction of the river's actual coleopteran fauna.

Potamophilus acuminatus (Fabricius, 1792)

This is a widespread European species that occurs from the Iberian Peninsula throughout much of western and central Europe and along the northern shores of the Mediterranean Sea to the plains of Belarus and the Ukraine. It is absent from the British Isles and Asia Minor, as well as from the islands of the Mediterranean Sea and there are no confirmed records from Scandinavia (www.faunaeur.org).

The species is exceedingly rare and very localized with recent records published only from Germany (Upper Bavaria, Gerber 1993), Austria (Burgenland, river Raab, Jäch et al. 2001), Hungary (Kovács et al. 1999) and France (Allier river near Auzon, Beauger 2008). Old French records were provided by Bertrand (1967), who lists captures from the Adour (19th century: Dufour leg.), the Sauldre, the Loire (Abbé Rullier leg.) and, again, the Allier near Puy-Guillaume (in IX.1935).

Bertrand (1967) notes that larvae of *Potamophilus acuminatus* commonly cooccur with those of *Macronychus quadrituberculatus*,

a fact corroborated by our data, as indeed both species coexist in stretches of the Aisne, although larvae were not actually found in close vicinity.

So far no adults of *P. acuminatus* have been found in the Aisne river, only larvae of different developmental stages (Fig. 4). A total of at least 20 larvae were found in the three localities, the greatest number having been recorded just north of Brécy-Brières on 26.08.2009. It would probably have been easy to find more larvae but we refrained from searching too assiduously in order not to inflict any damage upon the local population.

The larvae were found in both fast and slow-flowing sections of the river, some even in backwaters on the submerged roots of large ash or willow trees (Fig. 5). Others were found on willow branches of quite small diameter (3-5 cm) in fast-flowing water; still more were found clinging to a big snag washed up on a shingle bank, in company with some adult *Macronychus* and many *Pomatinus substriatus* (adults).

With no published records available, this seems to be the first time *P. acuminatus* has ever been found in northeastern France.

Limnius muelleri (Erichson, 1847)

This is a rather enigmatic species which has vanished from most parts of its previous range during the twentieth century. There are indeed no recent records from the western part of Europe and the species has recently only been found in one place in northwestern Hungary, in the Kisalföld-area close to the border with Austria (Kalman et al., 2009). The last record from Germany is from the Danube near Vilshofen and goes back to 1918; since the specimens are housed in the „Zoologische Staatssammlung München", their identity could be confirmed (Schulte 1994). The same author has thoroughly re-examined all the available information on its distribution and comes to the conclusion that *Limnius muelleri* should be considered a missing species. According to Berthélemy (1964a) the species occurred in the Paris Basin, the Massif Central, the Aquitaine Basin and the departement of Basses-Pyrénées, though no detailed records are given in the paper. Since then no-one seems to have recorded this species in France or at least no records have been published for several decades.

Limnius muelleri has been found in the gravel of fast-flowing stretches of the Aisne in two different localities: 10 adults (2 males, 8 females) and an indefinite number of larvae north of Brécy-Brières (Fig. 6) on 26 .08.2009; 11 adults and again several larvae east of Attigny on 09.09.2009.

They were easily collected with the usual kick-sampling technique in shallow, fast-flowing riffles where adults and larvae seemed to be hiding amongst coarse calcareous gravel or under the occasional flat stone. No aquatic macrophytic vegetation was encountered and the river bed was not shaded by trees. The gravelly bottom was devoid of any kind of slimy deposit and there was no excessive siltage nor any black-coloured layers under stones which, generally, betray anaerobic conditions. The water was clean, though a very slight turbidity was detectable which may be explained by the chalky sediments of the river substrate.

In the field, the captured *Limnius* immediately attracted attention by their small size, which ruled out the larger and widely distributed *Limnius volckmari,* which is known from several river basins of northeastern France (personal data), and their fairly slender shape, which did not match the other small *Limnius* species, i.e., *Limnius opacus*. A closer inspection in the lab and the extraction of the aedeagi of the first two males confirmed the premonition that these *Limnius* were in fact something exceptional. The identification was later kindly confirmed by Dr Manfred A. Jäch (Vienna).

Elmis obscura (Müller, 1806)

This species has recently been found by the author in one locality on the Meuse river near the town of Stenay, though it seems to be rare in that site, as only one single male could be obtained, despite repeated visits to the place (Gerend, unpublished). *Elmis obscura* seems to be absent from Luxembourg (Gerend 2003) and it is very localized in western Germany, with extant populations only known from



Fig. 4. Full-grown larva of *Potamophilus acuminatus* from the Aisne. The mesh size is 1 mm.

the lower Sieg near Bonn (Hadulla 2004) and the Lauter (Gerend, unpubl. record), a small tributary of the Rhine marking the border between France (Alsace) and Germany. The current status in France remains unclear, as no records were published in recent years.

In 2009 two specimens have been obtained from the Aisne, at the Olizy-Primat locality. They were, typically, sampled from fine, submerged roots of willows growing on a steep bank. As the water level of the river was rather low at that time of the year, there was no perceptible flow at that place, which was, moreover, shielded from the main current by a shingle bank. Along with *E. obscura,* several specimens of *Oulimnius major* and *Normandia nitens* could be found among the rootlets. This seems to be the normal type of habitat for both *E. obscura* and *O. major*, which were previously found to co-occur in the Meuse in similar conditions (Gerend, unpubl.).

Normandia nitens (Müller, 1817)

N. nitens is restricted to hardwater streams and seems to favour well-oxygenated stretches of warmer, larger rivers (Drost, 1992). Hence its sensitivity to habitat degradation, as rivers most suited tend to flow through intensely farmed countryside. *N. nitens* has never been recorded from Luxembourg (Gerend, 2003) nor is it currently known from Lorraine (Gerend, unpubl.) or Alsace. There seems to be but one old record from the Netherlands (Drost, 1992) and nothing is known about its current status in Belgium.

The species was found in two different locations in the Aisne river. While one male was obtained from the pebbles of a fast-flowing stretch, two more females were found clinging to rootlets in a backwater with no perceptible current at that moment.

Macronychus quadrituberculatus Müller, 1806

M. quadrituberculatus was found in all the localities sampled in the course of this survey and may therefore be considered quite a common species in this river. This should not distract from the fact that *Macronychus* is generally a rare and localized species that has sharply declined in numbers or even vanished from so many parts of its former range (Jäch 1992). Compared to the situation in so many parts of northwestern Europe, including western Germany, Belgium, Luxembourg



Fig. 5. Backwater of the Aisne with willow roots. Habitat of *Potamophilus* larvae.



Fig. 6. River Aisne north of Brécy-Brières. In this riffle with gravelly bottom both adults and larvae of *Limnius muelleri* were discovered in August 2009, together with *Esolus parallelepipedus*, *Esolus pygmaeus*, *Stenelmis canaliculata*, *Hydraena reyi*, *Hydraena riparia* and *Laccobius striatulus*.

and The Netherlands, the species seems to do quite well in France's Paris Basin, with extant populations known from the Meuse, Aire and Saône (Gerend, unpubl.).

4. Discussion

As with most small insect species, the question remains whether *Limnius muelleri* is genuinely rare or has merely been overlooked in other similar rivers. It should be pointed out that the capture of the individuals was very easy and did not require any new or sophisticated method. In fact, the first specimens were found in the first locality searched for water beetles that day, and after only a few moments of collecting. They were not found in huge quantities but, then, no attempt was made to make a population estimate and only a part of the gravelly riffle was surveyed. Having confirmed the identification at home, a second trip to the river ten days later, again, immediately yielded almost a dozen specimens, once a suitable spot on the river had been found. With these facts in mind, it seems improbable that the species was overlooked in previous years when water beetles were collected in other rivers, some of them quite similar, in Lorraine or Champagne-Ardenne. Also, no individuals of *Limnius muelleri* have ever been found in the Meuse river, which was visited and surveyed repeatedly by the author during the past two decades, and which yielded many interesting species. The same applies to the near-by Aire, a tributary of the Aisne, where water beetles were collected twice in previous years.

Of course, some of these rivers, especially their gravelly riffles, will be revisited, as it is always possible that a species present in low density may have gone unnoticed after all, though, again, this seems rather improbable.

As with most elmids, the enigmatic *Limnius muelleri* is very likely to have suffered from habitat degradation caused by communal waste-water and nutrient enrichment due to an input of agricultural fertilizers. In fact, species of the interstitial habitat are negatively affected by clogging of the spaces between the sedimentary particles where they live. The clogging is likely to make oxygen levels decrease and might change other ecologically important parameters, such as composition of algal communities, that are vital for scrapers. The rich elmid assemblage of the upper Aisne river may be best explained by the fact that this river has not yet been submitted to any serious modifications of its course or flow regime. There are still no dams and the banks have not been artifically stabilized, so that in many places they still display the full range of habitat structures typical for meandering rivers with shingle banks, steep eroded banks on the outside of bends, backwaters etc. Most important in this context is the presence of a significant number of riparian trees and shrubs providing wooded debris as well as shelter amongst their network of submerged

roots. This habitat feature is utterly important for those species whose larvae cling to or burrow in submerged wood, either dead or decaying, and feed on the wood itself or on algae colonizing its surface. Again, the quality of the water seems to play a vital role, as the presence of wooded debris alone does not ensure the survival of species like *Potamophilus* or *Macronychus*. In fact, it may be assumed that their populations were wiped out by widespread water pollution in the first place and could only subsist in rivers being spared both deterioration of their water quality and loss of structural diversity, including riverine arboreal vegetation.

Hence the crucial importance of rivers such as the Aisne which, owing to the sparse human population, the low level of industrialization and a rather small-scale agriculture in their catchment area, probably never lost their original aquatic faunas completely. The position of the Aisne basin in a previously much embattled region of Europe may have played its role, for that matter. From a conservational vantage point this means that this small river must be preserved at all cost, as it seems to be one of the last strongholds of a diverse potamophilous fauna, including some exceedingly rare dragon-, may- and caddisflies (Coppa, pers. comm.), that has all but vanished from most of the area's major rivers. While writing these lines, a project to construct several dams in order to regulate the river's flow regime is looming large. Together with changing agricultural practices, i.e. abandoning pasture for the sake of large-scale maize cultivation, this is very likely to wreak havoc on the habitats of the alluvial plain and ultimately to cause the loss of the most valuable species.

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