Notes on diversity and conservation of the European fauna of Plecoptera (Insecta)

ROMOLO FOCHETTI1 & JOSÉ MANUEL TIERNO DE FIGUEROA2

1Dipartimento di Scienze Ambientali, Università della Tuscia, Viterbo, Italy, and 2Departamento de Biología Animal y Ecología, Facultad de Ciencias, Universidad de Granada, Spain

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Abstract

Plecoptera are one the most endangered groups of insects in running waters. Due to their strict ecological needs and to the growing pollution of water courses, many species are in fact reduced to small isolated populations and many others have already become extinct. With the aim of compiling the taxonomic and faunistic lists of European Plecoptera (within the project Fauna Europaea, ref. EVR1-CT-1999-2001), we catalogued a total of 426 species included in 35 genera and seven families and reviewed their present diversity and conservation status. Historical knowledge and geographical information on Plecoptera diversity in Europe are presented. Data on the conservation status of the European stonefly fauna are discussed as well. The whole Plecoptera fauna of lowland rivers in Europe can be considered threatened. The situation is particularly critical for several species, known from a small number of individuals and/or from restricted areas, and that of relict species. Despite this situation, no European Plecoptera species are included on any official lists of threatened species.

Keywords: Endemic species, extinction, freshwater ecosystems, relict species, running waters, stoneflies

Introduction

Freshwater species and ecosystems are a major component of biodiversity that is highly endangered. In fact, the extinction rates reported for freshwater organisms in North America are five times greater than those seen in terrestrial animals (Ricciardi and Rasmussen 1999). Plecoptera constitute a numerically and ecologically significant component in running waters of all sizes, all over the world (Zwick 2004). They are probably one of the most endangered groups of insects. In fact, due to the growing organic pollution of water courses and to the strict ecological needs of Plecoptera, many European stonefly species are reduced to small isolated populations and some others have already become extinct (Fochetti and Tierno de Figueroa 2004).

Plecoptera is a small hemimetabolous insect order distributed over all continents except Antarctica. It presently includes more than 2000 described species (Zwick 2000), but the last
count dates from more than 30 years ago: the number of described species can today be estimated to more than 3400 (R. Fochetti and J. M. Tierno de Figueroa, unpublished data).

Stonefly nymphs live mainly in cold, well-oxygenated running waters; some species can also be found in high-altitude lakes, and others are adapted to terrestrial life in Sub-Antarctic areas [such as some Gripopterygidae species of the genera Megandiperla Illies, 1960 in Patagonia and Apteryoperla Wisely, 1953 in New Zealand (Illies 1960, 1963)]. Adults are terrestrial or sub-aerial, with the exception of Capnia lacustra Jewett, 1965, whose adults are aquatic and have been collected at a depth of 60–80 m in Lake Tahoe (USA) (Jewett 1963). Only Perlidae, among the known families, include species adapted to tropical environments; the remaining families prefer mountain streams in temperate and cold areas.

Their ecological requirements greatly limit the nymph’s dispersal capacity. Moreover, adults show a reduced activity and poor flight ability. Hence, Plecoptera shows a high percentage of endemism in more or less restricted areas, and widely distributed species are not common. Species such as Arcynopteryx compacta (McLachlan, 1872), distributed throughout the Holarctic region (Zwick 1973), or Leuctra fusca (Linnaeus, 1758), that spreads from Western Europe to the Russian far east (Zwick 2004), are exceptions.

**European Plecoptera diversity**

A total of 426 Plecoptera species, belonging to 35 genera, have been described or listed for the European continent (Fauna Europaea Web Service 2004) (Table I). Thirteen genera (37% of the total) are monospecific, whereas the four most diverse ones (Leuctra, Protonemura, Nemoura, and Isoperla) include approximately 69% of the European stonefly species.

From a historical taxonomic perspective, Phryganea bicaudata (now Diura bicaudata), Phryganea nebulosa (now Taeniopteryx nebulosa), and Phryganea fusca (now Leuctra fusca) were the first three named species of Plecoptera (Linnaeus 1758). Since then a first description peak occurred in the decade 1832–1842 (mainly due to Pictet), a second one extended from the last decade of the 19th century to the first decade of the 20th century (mainly due to the Plecopterists Klapálek, Kempny, and Ris), and a third period of intense taxonomic activity occurred from 1952 to the present (mainly due to authors such as Aubert, Zwick, Ravizza, Vinçon, etc.) (Figure 1). In the last 25 years, a mean of 2.6 Plecoptera species per year were described in Europe. This relatively high rate of discovery of new taxa is offset by the loss of diversity due to local taxa extinctions. However, extinction is difficult to demonstrate, particularly in areas where no taxonomic or faunistic research has been carried out in the past, or where no relevant studies were conducted in recent decades (this is the case, for instance, of Belgium, studied only by Aubert in 1956 and 1957).

When describing the species distribution (Figure 2), we had to consider political units (as used in the Fauna Europaea) and that made it more difficult to infer general patterns; however it appears that:

1. Very high species richness and endemism exist in Mediterranean peninsular countries (particularly Spain and Italy) mainly due to: (1) presence of mountain regions (Pyrenees, Betic system, Apennines, Italian Alps), which represent an optimal environment for stoneflies, and (2) the effect of glaciations, that favoured isolation and speciation processes (as demonstrated by the high number of endemic species). Nevertheless, species richness generally decreases in these countries from North to South (Sánchez-Ortega and Tierno de Figueroa 1996; Fochetti et al. 1998) due to the well-known peninsular effect (Simpson 1964).
2. Species richness is high in mountainous Central Europe countries (Alpine or Carpathic). Again, this can be explained by the preference of stoneflies for well-oxygenated high mountain streams. The scarcity of endemics is a consequence of the generally small size of these countries, of the unnatural political boundaries used in analyses, and of the post-glacial recolonisation of these countries by widespread species.

3. Low species richness occurs in Northern Europe, also due to Pleistocene glaciation, even though the stonefly fauna can be unusual in some countries (e.g. the UK has an endemic species).

4. Plecoptera species are absent from the Atlantic islands (Azores, Madeira, Selvagens, Canaries) as a consequence of their distance or isolation from the continent, and the poor ability of stoneflies to disperse. Other islands (Balearic, North Aegean, Cyclades, Crete, etc.) which are closer to the continent or have been joined to continental Europe, have a stonefly fauna, even though it is often numerically reduced.
5. Plecoptera species are apparently reduced or even absent in several areas, such as the Republic of Moldova; this could be the consequence, in several cases, of lack of studies.

A detailed analysis of European Plecoptera distribution can be found in Illies (1953, 1967, 1978), Raušer (1962, 1971), and Zwick (1980, 1981).

The high number of endemic species (approximately 33% of the total, according to the political areas considered by the project Fauna Europaea) increases the risk of species disappearance. While widely distributed species can survive in more or less dispersed rifugia in case their range is fragmented, species with restricted distribution cannot. Moreover, several endemic species are still known only from the type localities and from a low number of individuals, as is the case for many species described in the last two decades. Thus, although conclusions must be carefully drawn (waiting for instance for new surveys that quantify the real population size or the real distribution area), in many cases it can be stated that species are in fact rare and potentially threatened.

**Conservation status**

Due to the increasing pollution of running waters—mainly from sewage, agricultural, and industrial waste—to habitat fragmentation of streams, and to the alteration of water courses and their banks, including channel modifications, and the narrow ecological requirements
of stoneflies, many species are vulnerable or threatened with extinction. Several of them are in fact reduced to small isolated populations and several others have already gone extinct (see for instance Ravizza and Nicolai 1983; Zwick 1992; Sánchez-Ortega and Tierno de Figueroa 1996).

In Europe the entire stonefly fauna of lowland rivers can be considered threatened. *Taeniopteryx araneoides* (Klapálek, 1902) and *Oemopteryx loewi* (Albarda, 1899), once common in large Central European rivers, are now extinct (they have not been collected in the last 100 years) (Zwick 1992, 2004). *Isogenus nubecula* (Newman, 1839) was exceedingly common in major European rivers, but it was considered extinct from Western and Central Europe in the second half of the 20th century (Zwick 1992). Luckily enough, there are new recent records of this species from Hungary, Austria, and Slovakia (Juhasz et al. 1998; Kovács et al. 2001; Derka et al. 2002), although these populations appear to be isolated and endangered. *Agnetina elegantula* (Klapálek, 1905) is almost extinct in Central Europe as well; this species is presently known from very few localities (Graf 1997; Kovács and Ambrus 2000). *Marthamea vitripennis* (Burmeister, 1839) is today extinct in most of its former geographical range (Zwick 1984a, 2004). Its congener, *M. selysii* (Pictet, 1841), is a rare West European species of lowland rivers, threatened throughout its range; it has been collected recently only in a few localities in Spain (Luzón-Ortega and Tierno de Figueroa 2004). Several other species [e.g. *Brachyptera trifasciata* (Pictet, 1832), *Isoperla obscura*...
(Zetterstedt, 1840), and Brachyptera braueri (Klapálek, 1900)] have become rarities (Zwick 1992).

Many Plecoptera species have been described from very limited areas and/or from a small number of individuals. This is the case, for instance, of Leuctra bidula Aubert, 1962, recorded only three times (Aubert 1962, 1963; Tierno de Figueroa et al. 1996) and known from a total of 19 adults and 10 nymphs collected in 1960 and 1994 in some tributaries of River Genal (Sierra Bermeja, southern Spain). The case of Helenoperla malickyi Sivec, 1997 is more significant; this is the only species of the genus, recently described but already threatened, as it is known only from two rivers in Epirus, Greece (Zwick 2004). Many species endemic to Italy are known only from two or three populations. This is the case of Isoperla hylea Consiglio, 1961, I. ivana Consiglio, 1958, I. oenotriae Consiglio, 1967, Taeniopteryx mercury Fochetti and Nicolai, 1996, Nemoura lucana Nicolai and Fochetti, 1991, N. oropensis Ravizza and Ravizza Dematteis, 1980, Protonemura helenae Nicolai, 1985, P. hirpina (Consiglio, 1958), P. italica (Aubert, 1954), P. julia Nicolai, 1983, Leuctra annae Consiglio, 1975, L. canavensis Ravizza and Ravizza Dematteis, 1992, L. cyrnea Consiglio and Giudicelli 1965 (Corsica), L. fraterma Morton 1930, L. ravizzai Ravizza Dematteis and Vinçon, 1994, L. silana Aubert, 1953, and L. vesulensis Ravizza and Ravizza Dematteis, 1984. Particularly T. mercury, N. lucana, N. oropensis, P. helenae, P. hirpina, P. italica, P. julia, L. canavensis, L. cyrnea, L. ravizzai, L. silana, and L. vesulensis, are known only from the type locality.

The relict and isolated populations of once widely distributed species are particularly threatened. The distribution area of some Northern and Central European species expanded during glaciations. Later, during the warm period, they became isolated as small populations on some high peaks in Southern Europe. This seems to be the case of Perlodes microcephalus (Pictet, 1833) and Perla grandis Rambur, 1842 populations in Sierra Nevada (southern Spain) (Tierno de Figueroa et al. 2003a) and of P. microcephalus in Central Italy Apennines.

The risk of disappearance of whole stonefly faunas is shown by a few examples of endangered Plecoptera from some European countries: 22 species out of 144 are considered threatened with extinction in Italy, islands included (Fochetti 1994), and some species, such as Brachyptera trifasciata, Isogenus nubecula, Isoperla obscura, and Perla abdominalis Burmeister, 1839 are considered already extinct in this country (Fochetti et al. 1998); 23 species from a total of 142 are considered threatened in the Iberian Peninsula and Balearic Islands (Tierno de Figueroa et al. 2003b): five of them, endemics for the Peninsula or for the Balearic Islands (Leuctra besucheti Aubert, 1962, L. bidula Aubert, 1962, L. estrela Aubert, 1962, L. wilmae Illies, 1954, L. balearica Pardo and Zwick, 1993), are in danger of extinction; 14 of the 24 species from the Netherlands are thought to be extinct (Claessens 1981) in this country. Forty-four species were listed in the “Red List of German stoneflies” by Zwick (1984b) but the number has now risen to 57, with 15 species reported as extinct in the country (Reusch and Weinzierl 1998): among them Oemopteryx loewii and Taeniopteryx araneoides, the only known cases (already reported in this paper) of Plecoptera species globally extinct. As regards the Czech Republic, six of the 110 species reported can be considered belonging to the category of “extinct species” in the country, 14 to that of “critically endangered species”, 14 to the “endangered species” and four to “vulnerable species” (Landa et al. 1998). Half the species in the industrial and agricultural regions of Switzerland have become extinct since 1949 (Aubert 1984). Finally, regarding Great Britain, that has a stonefly fauna composed of 33 species, Isoperla obscura is considered extinct in the country and Rhabdiopteryx acuminata Klapálek, 1905, Brachyptera
*putata* (Newman, 1838), *Nemoura dubitans* Morton, 1894, are considered Nationally notable (=Nationally scarce) (Bratton 1990). It must be noted that *B. putata* is also endemic to the country.

This situation is in clear contrast to what is globally known about insect conservation risks. As stated by Dunn (2005), the study of insect extinctions has been highly neglected in the past. Only 70 modern insect extinctions have been documented, whereas the same author reports that, according to a rough estimate, more than 44,000 insect extinctions may have occurred in the past 600 years (Dunn 2005). In this respect, also considering the risks to their conservation reported above, it is astonishing to see how few Plecoptera species (or other aquatic insect taxa), compared with that of birds or mammals or vertebrates in general, are included in the lists of threatened species (cf. IUCN red data lists, www.redlist.org) despite the widely held view that Plecoptera are highly sensitive to habitat alteration and pollution (they are considered very good bioindicators of environmental quality, see for instance Hellawell 1986). The authors strongly recommend reassessment of this situation, and the careful consideration of Plecoptera, and other threatened insect orders of importance as environmental indicators, as additions to red data lists.

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