

Current distribution of mayflies (Insecta: Ephemeroptera) in German Federal Waterways

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Abstract

German Federal Waterways are larger rivers and canals, affected by human activities for centuries. Industrial and communal effluents result in a decrease of oxygen budget, hydraulic engineering results e.g. in a change of flow regimes. Insect fauna was heavily affected by these impacts. For about 20 years water pollution and effects of hydraulic engineering are slightly decreasing, and 56 mayfly species have been currently recorded. Today, number of immigrating non-indigenous species (esp. Crustacea and Mollusca) increases and results in a drastic change in macroinvertebrate communities in many large rivers. Effects of these main factors on certain mayflies are briefly discussed.

Keywords: faunistics, species list, large rivers, environmental impact, alien species.

Introduction

Federal Waterways (FWW) are waters in property and administration of the Federal Republic of Germany. These are mainly large rivers and canals which have often been used for centuries as traffic routes, water and energy supplier, or simply as receiving streams for waste water.

For more than 40 years, the Department Fauna and Ecology of the Federal Institute of Hydrology (BfG) has studied, among others, the occurrence and ecology of macroinvertebrate communities in water ways. This study describes briefly the occurrence and distribution of some Ephemeroptera species in German Federal Waterways and names the main impacts on mayfly fauna in large rivers in Germany. Main ecological impacts on mayflies are briefly discussed.

Material and Methods

Samples were taken from a ship by means of a dredger and an orange-peel grab. With this technique (Tittizer and Schleuter, 1986) sampling is nearly independent from the water level, and samples can be taken from several depth zones (0.3 to 5.0 m) and different substrate types (silt, gravel, stone, rock). Species were kept in 90% ethanol and determined in our laboratory.

Results and Discussion

About 30.000 samplings from nearly all Federal Waterways throughout Germany have been carried out so far. In total, 56 species were recorded in FWWs with the BfG sampling-technique (Table 1). This represents about 50 % of all mayfly species known so far in Germany (Haybach and Malzacher, 2002).

We cannot exclude that fast swimming species (e.g. most Baetidae), or species living in special habitats like aquatic plants or on dead wood are under-represented in our study. Some additional species have been recorded (for details see Haybach, 1998) in large Rivers in Germany like *Prosopistoma pennigerum* (MÜLLER, 1785), *Rhithrogena beskidensis* ALBA-TERCEDOR & SOWA, 1987 or *Caenis pusilla* NAVÁS, 1913 but haven't been recorded by us. However, also rare and endangered species as *Electrogena affinis*, *Ephemerella notata*, *Ephemera lineata* or *Choroterpes picteti* (Fig. 1) could be found. These stenoeconomic species were recorded more frequently (but not exclusive) in the Danube

Table 1 - Alphabetical list of mayfly species recorded in Germany's federal waterways by BfG. t = species from tributaries, only by chance recorded in rivers, LT = species captured by light traps only

1	<i>Baetis buceratus</i> EATON, 1870	
2	<i>Baetis fuscatus</i> (LINNAEUS, 1761)	
3	<i>Baetis liebenauae</i> KEFFERMÜLLER, 1974	
4	<i>Baetis lutheri</i> MÜLLER-LIEBENAU, 1967	
5	<i>Baetis niger</i> (LINNAEUS, 1761)	
6	<i>Baetis rhodani</i> (PICTET, 1843-45)	t
7	<i>Baetis scambus</i> EATON, 1870	t
8	<i>Baetis vardarensis</i> IKOMONOV, 1962	
9	<i>Baetis vernus</i> CURTIS, 1834	
10	<i>Brachycercus harrisella</i> CURTIS, 1834	
11	<i>Caenis beskidensis</i> SOWA, 1973	
12	<i>Caenis horaria</i> (LINNAEUS, 1758)	
13	<i>Caenis luctuosa</i> (BURMEISTER, 1839)	
14	<i>Caenis macrura</i> STEPHENS, 1836	
15	<i>Caenis pseudorivulorum</i> KEFFERMÜLLER, 1960	
16	<i>Caenis rivulorum</i> EATON, 1884	
17	<i>Caenis robusta</i> EATON, 1884	
18	<i>Centroptilum luteolum</i> (MÜLLER, 1776)	
19	<i>Choroterpes picteti</i> (EATON, 1871)	
20	<i>Cloeon dipterum</i> (LINNAEUS, 1761)	
21	<i>Cloeon simile</i> EATON, 1870	
22	<i>Ecdyonurus dispar</i> (CURTIS, 1834)	
23	<i>Ecdyonurus insignis</i> (EATON, 1870)	
24	<i>Ecdyonurus torrentis</i> KIMMINS, 1942	t
25	<i>Ecdyonurus venosus</i> (FABRICIUS, 1775)	t
26	<i>Electrogena affinis</i> (EATON, 1883)	
27	<i>Epeorus assimilis</i> EATON, 1885	t
28	<i>Ephemera danica</i> MÜLLER, 1764	
29	<i>Ephemera glaucops</i> PICTET, 1843-45	LT
30	<i>Ephemera lineata</i> EATON, 1870	
31	<i>Ephemera vulgata</i> LINNAEUS, 1758	
32	<i>Ephemerella mucronata</i> (BENGTSSON, 1909)	t
33	<i>Ephemerella notata</i> EATON, 1887	
34	<i>Ephoron virgo</i> (OLIVIER, 1791)	
35	<i>Habroleptoides confusa</i> SARTORI & JACOB	t
36	<i>Habrophlebia fusca</i> (CURTIS, 1834)	
37	<i>Habrophlebia lauta</i> EATON, 1884	
38	<i>Heptagenia coeruleans</i> ROSTOCK, 1878	
39	<i>Heptagenia flava</i> ROSTOCK, 1878	
40	<i>Heptagenia longicauda</i> (STEPHENS, 1835)	
41	<i>Heptagenia sulphurea</i> (MÜLLER, 1776)	
42	<i>Kageronia fuscogrisea</i> (RETZIUS, 1783)	
43	<i>Oligoneuriella rhenana</i> (IMHOFF, 1852)	
44	<i>Leptophlebia marginata</i> (LINNÉ, 1767)	
45	<i>Leptophlebia vespertina</i> (LINNAEUS, 1758)	
46	<i>Paraleptophlebia cincta</i> (RETZIUS, 1783)	
47	<i>Paraleptophlebia submarginata</i> (STEPHENS, 1836)	
48	<i>Potamanthus luteus</i> (LINNAEUS, 1767)	
49	<i>Procloeon bifidum</i> (BENGTSSON, 1912)	
50	<i>Procloeon pennulatum</i> (EATON, 1870)	
51	<i>Raptobaetopus tenellus</i> (ALBARDA, 1878)	
52	<i>Rhithrogena semicolorata</i> (CURTIS, 1834)	
53	<i>Serratella ignita</i> (PODA, 1761)	
54	<i>Siphonurus aestivalis</i> (EATON, 1903)	
55	<i>Siphonurus lacustris</i> (EATON, 1870)	
56	<i>Torleya major</i> (KLAPÁLEK, 1905)	t

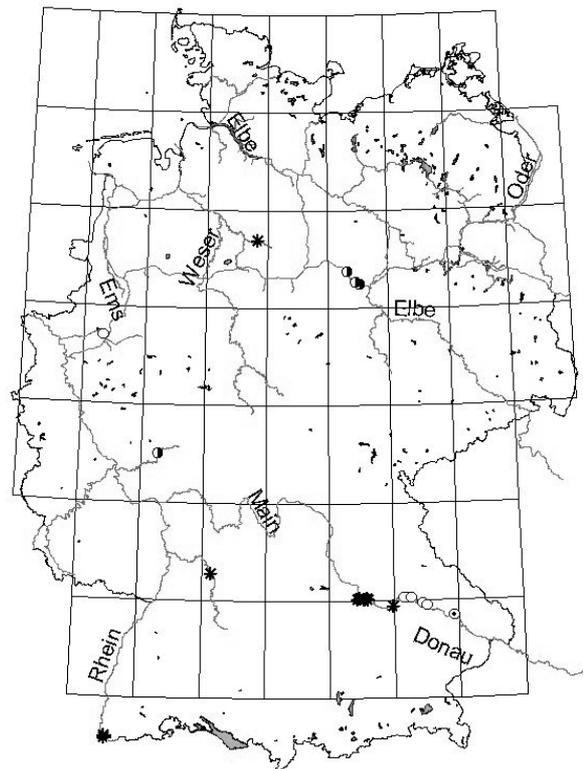


Fig. 1 - Records of rare mayflies in Germany's federal waterways by BfG. *Choroterpes picteti* (spotted circle), *Ephemera lineata* (open circle), *Electrogena affinis* (half filled circle), *Ephemerella notata* (star).

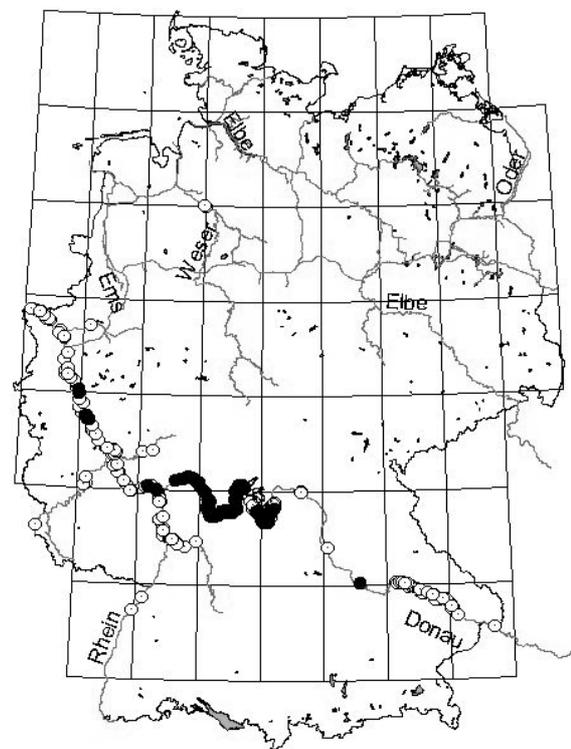


Fig. 2 - Records of *Ephoron virgo* in Germany's federal waterways by BfG. Full circle = records from 1980 – 1989, open circles = records after 1989, showing expansion of *Ephoron virgo* during the last decade.

catchment area, which was historically only slightly impaired by waste waters from industry or domestic sewage in comparison with other big rivers in Germany, esp. the River Rhine or the Rivers Elbe and Weser.

In our opinion the following factors are most responsible for occurrence and distribution of mayflies in Germany's Federal Waterways.

- 1) **Water pollution** – keyword: organic (oxygen budget) and inorganic, partly toxic impact, by industrial and communal effluents. These impacts result in a decline of all Ephemeroptera species. Currently the pollution of FWWs remains on a constant (low) level or is even decreasing. With the improved oxygen budget after the 1980s, the settlement of mayflies in Federal Waterways in general is not limited by water quality any longer. A good example is the recolonisation of most rivers by *Ephoron virgo* (Fig. 2) in consequence of water quality improvement.
- 2) **Hydraulic engineering** – keyword: impoundment regulation => decline of rheobiont species and passive filter feeders (e.g. *Baetis* spp., *Heptagenia* spp., *Rhithrogena* spp., *Oligoneuriella rhenana*, *Isonychia ignota*); promotion of pelophilic species, e.g. *Caenis luctuosa*, in canals also *C. robusta* which are also more tolerant to suction and wave surge caused by travelling ships. Keywords: bank constructions, maintenance and repair of riparian banks, weed control => decline of phytophilic species and inhabitants of dead wood, e.g. *Leptophlebia* spp., *Cloeon* spp., *Kageronia fuscogrisea* or *Electrogena affinis*.
- 3) **Alien species** (Neozoa) – keyword: Increased immigration of non-indigenous species, mainly Crustacea and Mollusca. The main impacts are: a) *Competition* between filtering Bivalvia and Crustacea when occurring in very high numbers result in a decrease of Chironomidae. *Raptobaetopus tenellus*, feeding mainly on Chironomidae, may be indirectly affected. b) Habitat modification (mud accumulation) by *Corophium curvispinum* when in high densities. These accumulations on stones results in a general change of the macroinvertebrate community towards a mud community with a reduction of grazing species like *Baetis* spp. or *Heptagenia sulphurea*. c) Pressure by predators: Large predatory species like *Dikerogammarus villosus* feed on a wide range of Insecta,

Crustacea and Oligochaeta. Currently decreasing numbers of *Ephoron virgo* are suspected to be correlated with increasing numbers of *D. villosus*.

- 4) **Zoogeographic reasons** – keyword: ice ages, retreat and resettlement of Central Europe. The most western River Mosel catchment lacks some typical river species like *Heptagenia flava*, resettling Germany postglacial from the East via the northern lowlands and the Southeast via Danube River.

Conclusions

By now 56 species of mayflies have been recorded in German Federal Waterways (FWW) by the BfG. Besides biogeographic reasons, water pollution, and hydraulic engineering have major influence on the occurrence of mayflies in FWWs. Currently the increasing change of the macroinvertebrate communities of big rivers by alien species becomes more and more important. While water pollution is decreasing, and effects of hydraulic engineering are compensated increasingly by more favourable constructions and measures for ecological compensation, the number of alien species is increasing. Their ecological impact on the macroinvertebrate fauna of large rivers and canals in general, and in particular on the mayflies should be thoroughly observed in the future.

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