Ferrantia

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Proceedings of the first conference on faunistics and zoogeography of European Trichoptera

Luxembourg
2nd - 4th September 2005

Marc Meyer
Peter Neu
(editors)

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First conference on faunistics and zoogeography of European Trichoptera

Luxembourg
2nd - 4th September 2005

Organising institution:	Musée national d'histoire naturelle, Luxemburg
Venues:	Musée national d'histoire naturelle, Luxemburg Cocoon Hotel Belair, Bourscheid-Plage
Administrative responsibility:	Georges Bechet. Director
Scientific responsibility:	Marc Meyer, Conservator of dept. Zoology of Invertebrates.
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Preface of the editors

It was Peter Neu who had the idea to organise a first European conference on caddisflies (Trichoptera). He asked the author if this event could be held in Luxemburg. With the support of the Director of our Museum and the funding of the National Research Fund (FNR) the project could start. The aim of this initiative was to create a communication platform for Trichopterologists on a continental level.

The conference had a good success, with a total of 62 participants from 19 nations, 16 lectures and 11 posters. The fact that the venue was a Conference-Hotel in the north of Luxemburg, near the river Sure, one of the less polluted flowing water in Central Europe gave the opportunity for the participants to collect caddisflies, particularly with the use of light traps set around the venue.

Unanimously the participants agreed to produce a publication with the proceedings of the conference. After a long and somehow time-consuming task, we are pleased to publish these proceedings in this volume of our monographic series, Ferrantia.

The first chapter brings the programme of the conference.

The scientific contributions follow in alphabetic order of the authors' names.

Acknowledgments

First, we have to thank Georges Bechet, Director of the MnhnL for the support, the financial help and the superb social programme. The organisers thank the National Research Fund (FNR) for the substantial funding, which allowed us to invite keynote speakers not funded by institutions or State Authorities in their countries.

The editors are very grateful to Isabel Schrankel who took care of the biggest part of the organising task. We are grateful that numerous colleagues from our Museum assumed many important tasks, like the running of the reception desk, the services for participants, the technical support and, last not least, the arranging of an excellent buffet on the first evening. We are also very grateful towards Simone Backes, head of our museographers service, for the conceptual design of the logo and the conference documents.

We also thank the authors for their contributions and the anonymous reviewers for the competent and constructive comments and critics.

We are indebted to Thierry Helminger for the configuration and Romain Bei for the layout of this issue

Marc Meyer and Peter Neu, 21.03.2008

Conference programme

Friday, 2nd September 2005

Über den Stand der Faunistik und Zoogeografie der Trichopteren in Europa (Hans Malicky)

First interim report on the atlas of distribution of the European Trichoptera (Michael Malicky, Peter J. Neu)

Overall distributional patterns of European Trichoptera (Peter WibergLarsen)

The Trichoptera of the Grand Duchy of Luxembourg (Isabel Schrankel et al.)

Specific caddisfly assemblages characterizing different ecological areas in Luxembourg: from geographical distributions to bioindication (Alain Dohet et al.)

Distribution of caddisflies in The Netherland: use and pitfalls (Bert Higler)

Saturday, 3rd September 2005

Zoogeographic division of Slovenia based on caddisfly distribution (Urbanic Gorazd)

Limes Norrlandicus - a natural biogeographical border for caddisflies (Trichoptera) in Sweden (Bo Gullefors)

Zoogeographical characteristics of the Trichoptera Fauna of Turkey (Füsun Sipahiler)

State of knowledge of investigations on Trichoptera in Ukraine (Elena Dyatlova

The first electronically database of the Romanian Trichoptera, with an annotated list of the species (Lujza Ujvarosi)

Sunday, 4th September 2005

Variability and distribution of species belonging to the Chaetopteryx villosa group (Trichoptera; Limnephilidae) in Europe (Katarzyna Majecka)

First record of the species Hydropsyche incognita in Romania, with special reference on its ecological requirements (Miklos Balint)

Phylogeography of the montane caddisfly *Drusus discolor* (Rambur, 1842) (Trichoptera: Limnephilidae, Drusinae) (Steffen Pauls et al.)

Investigations on Wormaldia occipitalis PICTET 1834 (Peter J. Neu)

Caddis larvae in urbanization gradient (Lech Pietrzak, Stanisław Czachorowski)

Extra-mediterranean centres of areas of Trichoptera of the European Dinodal (Hans Malicky)

Posters

The larva of *Micrasema cenerentola* SCHMID, 1952 (Trichoptera: Brachycentridae) (Marcos Gonzalez et al.)

Trichoptera of Landscape Park Wzgôrza Dylewskie (Dylewskie Hills) (Marta Monko et al.)

Caddisflies (Insecta: Trichoptera) of Mazovia and Podlasie (Poland) - state of knowledge (Witold Szczepanski)

Towards a Red Data Book of the Swiss caddisfly fauna (Insecta, Trichoptera) (Verena Lubini - Ferlin, Heinrich Vicentini)

History and results of Trichoptera research of caddisfly fauna in the Czech Republic (Pavel Chvojka, Petr Komzâk)

Light-trapping of Trichoptera at the March, a lowland river in Eastern Austria (Johann Waringer, Wolfram Graf)

The caddisflies of Vorarlberg (Austria): a meeting place for various zoogeographic elements (Wolfram Graf, Johann Waringer)

Trichoptera (Insecta) of the Ban stream, Bükk Mts., northern Hungary (Otto Kiss)

Rhyacophila Pictet, 1834 in Italy (Fernanda Cianficconi et al.)

The caddisflies (Trichoptera) of Suwalki Lakeland (N-E Poland) - contemporary data (Janusz Majecki, Bronislaw Szczesny)

Trichopterological investigations in the SW Ukraine (Elena Dyatlova)

www.freshwaterecology.info - A database for bioindicators of aquatic ecosystems (Astrid Schmidt-Kloiber et al.)

The history and present state of Trichoptera research in the Czech Republic

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Abstract

The history of the trichopterological research within the territory of the present Czech Republic is summarized. The first data on Trichoptera in Bohemia, Moravia and the southern part of Silesia date back to the middle of the 19th century (Kolenati, Stein). This and all subsequent important periods and personalities of trichopterological research are briefly presented.

According to our present knowledge, 252 species were recorded from the territory of the Czech Republic (243 and 211 from Bohemia and Moravia, respectively) during the last 150 years. However, 9 species have not been found since the middle of the 20th century, therefore they are considered to be regionally extinct (RE). Of extant species, 31 % are qualified as threatened (19 are critically endangered - CR, 26 endangered - EN, and 30 vulnerable - VU).

The actual checklist of Czech Trichoptera (including new records of Rhyacophila laevis Pictet and Hydroptila vichtaspa Schmid) is presented and the threat categories RE, CR, EN, VU are indicated.

History

The first data on Trichoptera within the territory of the present Czech Republic date back to the middle of the 19th century. In his publications (1848, 1858a, b, 1859a, b, 1860) Kolenati lists more than 70 species of Trichoptera from Bohemia and Moravia (including the southern part of Silesia, i.e. former Österreichisch Schlesien). Stein (1873, 1874) added another 9 species from the Jeseníky Mts. More detailed knowledge of the caddisfly fauna of Bohemia was obtained at the end of the 19th century due to the work of F. Klapálek, who also published the first list of Bohemian Trichoptera (1890). He subsequently complemented it (Klapálek 1891-1903) and during this period the number of species known from Bohemia and Moravia increased from 150 to 189. Three other species were mentioned from Bohemia by Šámal (1920).

A further important period were the 1930s, when K. Mayer published his faunistic contributions and the checklist of Trichoptera of the former Czechoslovakia (Mayer 1939) with 204 species from Bohemia and Moravia. In the second half of the 20th century, F. Krkavec, K. Novák, S. Obr, F. Petruška, E. Sedlák and J. Sýkora considerably extended the knowledge of caddisfly distribution in the Czech Republic. Further data, based on caddis larvae, resulted from numerous hydrobiological studies (see e.g. Obr 1969). New national and regional records were included in the updated list of Czechoslovak Trichoptera (Novák & Obr 1977); a total of 224 species were mentioned from Bohemia and Moravia.

Intensive field samplings conducted mainly in nature protection areas were carried out in the 1990s, and several papers with new records of Trichoptera for the territory of Bohemia and/or Moravia were published (Sukop 1990, Chvojka 1996, Sedlák 1999). New findings and results of the revision of earlier data were summarized by Chvojka & Novák (2001). The latest new records of caddisflies were obtained from Moravia (Komzák 2001, Němcová 2001, Sedlák 2001, Komzák & Chvojka 2005, Komzák, Kroča & Bojková 2006), since trichopterological research was focused on some parts of Moravia which were omitted in the past.

Results

According to our present knowledge, 252 species were recorded from the territory of the Czech Republic (243 and 211 from Bohemia and Moravia, respectively) during the last 150 years (Tab. 1). However, 9 species have not been collected since the middle of the 20th century, therefore they are considered to be regionally extinct. Of extant species, 31 % are qualified as threatened (19 are critically endangered, 26 endangered, and 30 vulnerable) (Chvojka, Novák & Sedlák 2005).

Table 1. Checklist of Trichoptera of the Czech Republic (Taxa are listed according to Malicky 2005). B = Bohemia, M = Moravia

	Threat category	**Czech Republic**	
Rhyacophilidae			
Rhyacophila dorsalis persimilis McLachlan, 1879		B	
Rhyacophila evoluta McLachlan, 1879		B	
Rhyacophila fasciata Hagen, 1859		B	M
Rhyacophila glareosa McLachlan, 1867		B	M[1]
Rhyacophila hirticornis McLachlan, 1879	VU	B	
**_Rhyacophila laevis_ Pictet, 1834	EN	B	
Rhyacophila mocsaryi Klapálek, 1898	VU		M
Rhyacophila nubila (Zetterstedt, 1840)		B	M
Rhyacophila obliterata McLachlan, 1863		B	M
Rhyacophila pascoei McLachlan, 1879	RE	B	
Rhyacophila philopotamoides McLachlan, 1879	VU	B	M
Rhyacophila polonica McLachlan, 1879		B	M
Rhyacophila praemorsa McLachlan, 1879		B	
Rhyacophila pubescens Pictet, 1834		B	M[2]
Rhyacophila torrentium Pictet, 1834	VU	B	M
Rhyacophila tristis Pictet, 1834		B	M
Rhyacophila vulgaris Pictet, 1834		B	M
Glossosomatidae			
Glossosoma boltoni Curtis, 1834		B	M
Glossosoma conformis Neboiss, 1963		B	M
Glossosoma intermedium (Klapálek, 1892)		B	M
Agapetus delicatulus McLachlan, 1884	CR	B	M
Agapetus fuscipes Curtis, 1834		B	M
Agapetus laniger (Pictet, 1834)	EN	B	M
Agapetus ochripes Curtis, 1834		B	M
Synagapetus armatus (McLachlan, 1879)	VU		M[2]

	Threat category	Czech Republic	
Synagapetus iridipennis McLachlan, 1879		B	M
Synagapetus moselyi (Ulmer, 1938)	VU	B	M
Ptilocolepidae			
Ptilocolepus granulatus (Pictet, 1834)		B	
Hydroptilidae			
Hydroptila angulata Mosely, 1922		B	M[2]
Hydroptila angustata Mosely, 1939	CR	B	
Hydroptila forcipata (Eaton, 1873)		B	M
Hydroptila lotensis Mosely, 1930			M[2]
Hydroptila martini Marshall, 1977	VU	B	
Hydroptila occulta (Eaton, 1873)	CR	B	
Hydroptila pulchricornis Pictet, 1834		B	M
Hydroptila simulans Mosely, 1920		B	
Hydroptila sparsa Curtis, 1834		B	M
Hydroptila taurica Martynov, 1934	CR	B	
Hydroptila tineoides Dalman, 1819	CR	B	
Hydroptila valesiaca Schmid, 1947	EN	B	
Hydroptila vectis Curtis, 1834	VU	B	M
***Hydroptila vichtaspa* Schmid, 1959	CR		M
Ithytrichia lamellaris Eaton, 1873		B	M
Orthotrichia angustella (McLachlan, 1865)	RE	B	
Orthotrichia costalis (Curtis, 1834)		B	M
Orthotrichia tragetti Mosely, 1930	EN	B	M[2]
Allotrichia pallicornis (Eaton, 1873)	CR	B	M[3]
Agraylea multipunctata Curtis, 1834		B	M
Agraylea sexmaculata Curtis, 1834		B	M
Tricholeiochiton fagesii (Guinard, 1879)	VU	B	M
Oxyethira falcata Morton, 1893	EN	B	
Oxyethira flavicornis (Pictet, 1834)		B	M
Oxyethira frici Klapálek, 1891	CR	B	M[2]
Oxyethira simplex Ris, 1897	EN	B	
Oxyethira tristella Klapálek, 1895	RE	B	
Philopotamidae			
Wormaldia copiosa (McLachlan, 1868)	EN	B	M[4]
Wormaldia occipitalis (Pictet, 1834)		B	M
Wormaldia pulla (McLachlan, 1878)	VU	B	M
Wormaldia subnigra McLachlan, 1865	CR	B	M
Philopotamus ludificatus McLachlan, 1878		B	M
Philopotamus montanus (Donovan, 1813)		B	M
Philopotamus variegatus (Scopoli, 1763)		B	M
Chimarra marginata (Linnaeus, 1767)	RE	B	M

	Threat category	Czech Republic	
Ecnomidae			
Ecnomus tenellus (Rambur, 1842)		B	M
Polycentropodidae			
Holocentropus dubius (Rambur, 1842)		B	M
Holocentropus picicornis (Stephens, 1836)		B	M
Holocentropus stagnalis (Albarda, 1874)	VU	B	M
Cyrnus crenaticornis (Kolenati, 1859)	EN	B	M
Cyrnus flavidus McLachlan, 1864		B	M
Cyrnus insolutus McLachlan, 1878	VU	B	
Cyrnus trimaculatus (Curtis, 1834)		B	M
Polycentropus flavomaculatus (Pictet, 1834)		B	M
Polycentropus irroratus (Curtis, 1835)	VU	B	M
Neureclipsis bimaculata (Linnaeus, 1758)		B	M
Plectrocnemia brevis McLachlan, 1871		B	M
Plectrocnemia conspersa (Curtis, 1834)		B	M
Plectrocnemia geniculata McLachlan, 1871	VU	B	M
Psychomyiidae			
Lype phaeopa (Stephens, 1836)		B	M
Lype reducta (Hagen, 1868)		B	M
Psychomyia pusilla (Fabricius, 1781)		B	M
Tinodes dives (Pictet, 1834)	EN	B	
Tinodes kimminsi Sýkora, 1962	CR	B	
Tinodes maclachlani Kimmins, 1966	CR	B	
Tinodes pallidulus McLachlan, 1878		B	M
Tinodes rostocki McLachlan, 1878		B	M
Tinodes unicolor (Pictet, 1834)		B	M
Tinodes waeneri (Linnaeus, 1758)		B	M
Hydropsychidae			
Cheumatopsyche lepida (Pictet, 1834)		B	M
Hydropsyche angustipennis (Curtis, 1834)		B	M
Hydropsyche botosaneanui Marinković-Gospodnetić, 1966	VU	B	
Hydropsyche bulbifera McLachlan, 1878		B	M
Hydropsyche bulgaromanorum Malicky, 1977		B	M
Hydropsyche contubernalis McLachlan, 1865		B	M
Hydropsyche dinarica Marinković-Gospodnetić, 1979	VU	B	
**Hydropsyche exocellata* Dufour, 1841	VU	B	M
**Hydropsyche fulvipes* (Curtis, 1834)	EN	B	M
Hydropsyche guttata Pictet, 1834	VU	B	
Hydropsyche incognita Pitsch, 1993		B	M
Hydropsyche instabilis (Curtis, 1834)		B	M
Hydropsyche modesta Navás, 1925			M
Hydropsyche pellucidula (Curtis, 1834)		B	M

	Threat category	Czech Republic	
Hydropsyche saxonica McLachlan, 1884		B	M
Hydropsyche silfvenii Ulmer, 1906		B	
Hydropsyche siltalai Döhler, 1963		B	M
Hydropsyche tenuis Navás, 1932	EN	B	
Phryganeidae			
Agrypnia obsoleta (McLachlan, 1865)	VU	B	M
Agrypnia pagetana Curtis, 1835	VU	B	M
**Agrypnia varia* (Fabricius, 1793)		B	M
Hagenella clathrata (Kolenati, 1848)	EN	B	M
Oligostomis reticulata (Linnaeus, 1761)	VU	B	M
Oligotricha striata (Linnaeus, 1758)		B	M
Trichostegia minor (Curtis, 1834)		B	M
Phryganea bipunctata Retzius, 1783		B	M
Phryganea grandis Linnaeus, 1758		B	M
Brachycentridae			
Brachycentrus maculatus (Fourcroy, 1785)	VU	B	M
Brachycentrus montanus Klapálek, 1892		B	M
Brachycentrus subnubilus Curtis, 1834		B	M
Micrasema longulum McLachlan, 1876		B	M
Micrasema minimum McLachlan, 1876		B	M
Micrasema setiferum (Pictet, 1834)	EN	B	M
Goeridae			
Goera pilosa (Fabricius, 1775)		B	M
Lithax niger (Hagen, 1859)		B	M
Lithax obscurus (Hagen, 1859)	VU	B	M
Silo nigricornis (Pictet, 1834)		B	M
Silo pallipes (Fabricius, 1781)		B	M
Silo piceus (Brauer, 1857)		B	M
Lepidostomatidae			
Lepidostoma basale (Kolenati, 1848)		B	M
Lepidostoma hirtum (Fabricius, 1775)		B	M
Crunoecia irrorata (Curtis, 1834)		B	M
Limnephilidae			
Dicosmoecinae			
Ironoquia dubia (Stephens, 1837)		B	M
Apataniinae			
Apatania fimbriata (Pictet, 1834)		B	M
Apatania muliebris McLachlan, 1866	RE	B	
Drusinae			
Anomalopterygella chauviniana (Stein, 1874)		B	M

	Threat category	**Czech Republic**	
Ecclisopteryx dalecarlica Kolenati, 1848		B	M
Ecclisopteryx guttulata (Pictet 1834)		B	
Ecclisopteryx madida (McLachlan, 1867)		B	M
Drusus annulatus (Stephens, 1837)		B	M
Drusus biguttatus (Pictet, 1834)	EN	B	M
Drusus discolor (Rambur, 1842)		B	M
Drusus trifidus (McLachlan, 1868)		B	M
Limnephilinae: Limnephilini			
Anabolia brevipennis (Curtis, 1834)		B	M
Anabolia furcata Brauer, 1857		B	M
Anabolia nervosa (Curtis, 1834)		B	
Glyphotaelius pellucidus (Retzius, 1783)		B	M
Grammotaulius nigropunctatus (Retzius, 1783)		B	M
Grammotaulius nitidus (Müller, 1764)	EN	B	M
Limnephilus affinis Curtis, 1834		B	M
Limnephilus algosus (McLachlan, 1868)	EN	B	
Limnephilus auricula Curtis, 1834		B	M
Limnephilus binotatus Curtis, 1834	CR	B	M
Limnephilus bipunctatus Curtis, 1834		B	M
Limnephilus centralis Curtis, 1834		B	M
Limnephilus coenosus Curtis, 1834		B	M
Limnephilus decipiens (Kolenati, 1848)		B	M
Limnephilus elegans Curtis, 1834	VU	B	M
Limnephilus extricatus McLachlan, 1865		B	M
Limnephilus flavicornis (Fabricius, 1787)		B	M
Limnephilus fuscicornis Rambur, 1842	VU	B	M
Limnephilus germanus McLachlan, 1875	EN	B	
Limnephilus griseus (Linnaeus, 1758)		B	M
Limnephilus hirsutus (Pictet, 1834)		B	M
Limnephilus ignavus McLachlan, 1865		B	M
Limnephilus incisus Curtis, 1834	VU	B	M
Limnephilus lunatus Curtis, 1834		B	M
Limnephilus nigriceps (Zetterstedt, 1840)		B	M
Limnephilus politus McLachlan, 1865		B	M
Limnephilus rhombicus (Linnaeus, 1758)		B	M
Limnephilus sericeus (Say, 1824)		B	
Limnephilus sparsus Curtis, 1834		B	M
Limnephilus stigma Curtis, 1834		B	M
Limnephilus subcentralis Brauer, 1857		B	M
Limnephilus vittatus (Fabricius, 1798)		B	M
Nemotaulius punctatolineatus (Retzius, 1783)	CR	B	
Rhadicoleptus alpestris (Kolenati, 1848)		B	M
Limnephilinae: Chaetopterygini			
Annitella obscurata (McLachlan, 1876)		B	M
Annitella thuringica (Ulmer, 1909)	VU	B	M

	Threat category	Czech Republic	
Chaetopterygopsis maclachlani Stein, 1874		B	M
Chaetopteryx fusca Brauer, 1857			M[2]
Chaetopteryx major McLachlan, 1876		B	M
Chaetopteryx polonica Dziędzielewicz, 1889	VU		M
Chaetopteryx villosa (Fabricius, 1798)		B	M
Pseudopsilopteryx zimmeri (McLachlan, 1876)		B	M
Psilopteryx psorosa psorosa (Kolenati, 1860)		B	M
Psilopteryx psorosa bohemosaxonica Mey & Botosaneanu, 1985		B	
Limnephilinae: Stenophylacini			
Acrophylax vernalis Dziędzielewicz, 1912	EN	B	
Acrophylax zerberus Brauer, 1867	EN	B	
Allogamus auricollis (Pictet, 1834)		B	M
Allogamus uncatus (Brauer, 1857)		B	M
Halesus digitatus (Schrank, 1781)		B	M
Halesus radiatus (Curtis, 1834)		B	M
Halesus rubricollis (Pictet, 1834)		B	M
Halesus tessellatus (Rambur, 1842)		B	M
Hydatophylax infumatus (McLachlan, 1865)		B	M
Melampophylax nepos (McLachlan, 1880)		B	M
Micropterna lateralis (Stephens, 1837)		B	M
Micropterna nycterobia McLachlan, 1875		B	M
Micropterna sequax McLachlan, 1875		B	M
Micropterna testacea (Gmelin, 1789)		B	M
Parachiona picicornis (Pictet, 1834)		B	M
Potamophylax carpathicus (Dziędzielewicz, 1912)	VU		M
Potamophylax cingulatus cingulatus (Stephens, 1837)		B	M
Potamophylax cingulatus alpinus Tobias, 1994		B	M
Potamophylax cingulatus depilis Szczęsny, 1994			M
Potamophylax latipennis (Curtis, 1834)		B	M
Potamophylax luctuosus (Piller & Mitterpacher, 1783)		B	M
Potamophylax nigricornis (Pictet, 1834)		B	M
Potamophylax rotundipennis (Brauer, 1857)		B	M
Stenophylax permistus McLachlan, 1895		B	M
Stenophylax vibex (Curtis, 1834)	VU	B	M
Sericostomatidae			
Oecismus monedula (Hagen, 1859)		B	M
Sericostoma personatum (Spence, 1826)		B	M
Sericostoma schneiderii (Kolenati, 1848)		B	M
Notidobia ciliaris (Linnaeus, 1761)		B	M
Odontoceridae			
Odontocerum albicorne (Scopoli, 1763)		B	M

	Threat category	Czech Republic	
Molannidae			
Molanna angustata Curtis, 1834		B	M
Molanna nigra (Zetterstedt, 1840)	CR	B	
Molannodes tinctus (Zetterstedt, 1840)	EN	B	M
Beraeidae			
Beraea maurus (Curtis, 1834)		B	M
Beraea pullata (Curtis, 1834)		B	M
Beraeodes minutus (Linnaeus, 1761)		B	M
Beraeamyia hrabei Mayer, 1937	EN		M
Ernodes articularis (Pictet, 1834)		B	M
Ernodes vicinus (McLachlan, 1879)	EN	B	M[2]
Leptoceridae			
Adicella filicornis (Pictet, 1834)		B	M
**Adicella reducta* (McLachlan, 1865)		B	M
Triaenodes bicolor (Curtis, 1834)		B	M
Ylodes simulans (Tjeder, 1929)	RE	B	M
Erotesis baltica McLachlan, 1877	CR	B	
Mystacides azurea (Linnaeus, 1761)		B	M
Mystacides longicornis (Linnaeus, 1758)		B	M
Mystacides nigra (Linnaeus, 1758)		B	M
Athripsodes albifrons (Linnaeus, 1758)		B	M
Athripsodes aterrimus (Stephens, 1836)		B	M
Athripsodes bilineatus (Linnaeus, 1758)		B	M
Athripsodes cinereus (Curtis, 1834)		B	M
Athripsodes commutatus (Rostock, 1874)		B	M
Athripsodes leucophaeus (Rambur, 1842)	CR	B	M
Ceraclea albimacula (Rambur, 1842) (incl. *C. alboguttata* (Hagen, 1860))		B	M
Ceraclea annulicornis (Stephens, 1836)		B	M
Ceraclea dissimilis (Stephens, 1836)		B	M
Ceraclea fulva (Rambur, 1842)	EN	B	M
Ceraclea nigronervosa (Retzius, 1783)	EN	B	M[5]
Ceraclea riparia (Albarda, 1874)	RE	B	
Ceraclea senilis (Burmeister, 1839)	EN	B	M
Setodes punctatus (Fabricius, 1793)	RE	B	M
Setodes viridis (Fourcroy, 1785)	RE	B	
Leptocerus interruptus (Fabricius, 1775)	CR	B	M
Leptocerus tineiformis Curtis, 1834		B	M
Oecetis furva (Rambur, 1842)		B	M
Oecetis lacustris (Pictet, 1834)		B	M
Oecetis notata (Rambur, 1842)		B	M[2]
Oecetis ochracea (Curtis, 1825)		B	M

	Threat category	Czech Republic	
Oecetis struckii Klapálek, 1903	CR	B	M
Oecetis testacea (Curtis, 1834)	EN	B	
**Oecetis tripunctata* (Fabricius, 1793)	CR	B	M

Explanatory notes:

B - Bohemia, M - Moravia (including southern part of Silesia); threat categories: RE - regionally extinct, CR - critically endangered, EN - endangered, VU - vulnerable species.

** - New species for the fauna of the Czech Republic:

Rhyacophila laevis Pictet, 1834. Bohemia mer., Velká niva ESE Lenora (7048-49), 750 m a.s.l., light trap, 22.-24.vi.2004, 1 ♂, J. Jaroš et K. Spitzer leg., K. Novák det., coll. National Museum, Prague.

Hydroptila vichtaspa Schmid, 1959. Moravia mer., the Kazivec brook SW Horní Němčí (48°54‘19‘‘ N, 17°36‘41‘‘ E) (7071), 466 m a.s.l., 1.vii.2005, 91 ♂ 86 ♀, P. Chvojka leg. et det., coll. National Museum, Prague.

[+] ***Ceraclea ramburi*** Morse, 1975. This species is not included in the total number, although one male labeled „Bohemia, Moldau, 26.5., Kolenati“ is deposited in Naturhistoriches Museum Wien (Malicky 2005). A specimen with such a label was mentioned by Kolenati (1859) under *Ceraclea nervosa* Coquebert.

* - Species for the first time recorded from Moravia:

Hydropsyche exocellata Dufour, 1841. Moravia mer.: the Morava river 800 m SE Spytihněv (6871), 7.ix.2005, 1 ♂ pupa; 12.vi.2006, 2 ♂; the Morava river SE Hodonín (7168), 12.vi.2006, 4 ♂; all P. Komzák leg., det. et coll.

Hydropsyche fulvipes (Curtis, 1834). Moravia bor., Štramberk, botanical garden (6474), light trap, viii.2001, 1 ♂, P. Pavlík leg., P. Komzák det. et coll.; Moravia or., right tributary of the Zápechová stream NE Nedašova Lhota (6874), 10.vi.2005, 2 ♂, P. Chvojka leg. et det., coll. National Museum, Prague.

Agrypnia varia (Fabricius, 1793). Moravia mer.: Tasov (7070), at light, 27.vii.2005, 1 ♂, P. Chvojka leg. et det., coll. National Museum, Prague; Hnanice (7161), light trap, 30.vii.2004, 1 ♂, J. Šumpich leg., P. Komzák det. et coll.

Adicella reducta (McLachlan, 1865). Moravia bor., the Huntava stream 700 m NW Valšovský Důl (49°50‘34‘‘ N, 17°12‘34‘‘ E) (6169), 15.iv.2003, 1 larva, K. Brabec leg., P. Komzák det., coll. Masaryk University, Brno.

Oecetis tripunctata (Fabricius, 1793) - Moravia mer., gamekeeper’s lodge Doubravka 4 km S Lanžhot (7367), light trap: 24.vii.2004, 1 ♂; 31.vii.2004, 1 ♂; 3.viii.2004, 1 ♂; all J. Šumpich leg., P. Komzák det. et coll.

Recently published records (additions to Chvojka & Novák 2001):

[1] - Sedlák 2001, [2] - Komzák & Chvojka 2005, [3] - Němcová 2001, [4] - Komzák, Kroča & Bojková 2006, [5] - Komzák 2001

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The genus *Rhyacophila* Pictet, 1834 in Italy

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Abstract

The list of Italian *Rhyacophila* species has been updated to 2005 thanks to the specimens caught in Italian running waters after the year 2000.

The list includes 35 species and 4 subspecies: 1 of them is new to science (*Rhyacophila dorsalis pantinii* Valle, 2001); 3 of them are new to the Italian fauna (*Rhyacophila polonica* McLachlan, 1879; *R. schmidinarica* Urbanic, Krusnik & Malicky, 2000; *R. dorsalis persimilis* McLachlan, 1879) and 8 are recorded for the first time in several Italian Regions.

The number of species in the Peninsula decreases from north to south. 8 species of central-European origin are found only in the Alps and not along the Apennines. The most widespread species in the Italian Regions are *Rhyacophila simulatrix* McLachlan, 1879 and *R. tristis* Pictet, 1834. 8 species and 3 subspecies are endemic to Italy and their percentage increases in the Peninsula from north to south.

Food habits of larvae and the presence of symbionts are investigated. At the last instar the larvae are carnivorous. The symbionts, Nematomorpha, Gregarinida and Acarina are observed. Cysts of Nematomorpha are the most widely distributed. In the digestive tract of the larvae, three species of gregarine of genus *Asterophora* are present. Only one adult of *Rhyacophila intermedia* was parasitized by larvae of Hydracarina.

Résumé

La liste des espèces italiennes de *Rhyacophila* a été mise a jour jusqu'a 2005 grace aux exemplaires capturés dans les eaux courantes d'Italie depuis l'année 2000.

La liste comprend 13 espèces et 4 sous-espèces parmi lequelles 1 est nouvelle pour la science (*Rhyacophila dorsalis pantinii* Valle, 2001), 3 sont nouvelles pour la faune italienne (*Rhyacophila polonica* McLachlan, 1879; *R. schmidinarica* Urbanic, Krusnik & Malicky, 2000 ; *R. dorsalis persimilis* McLachlan, 1879) et 8 ont été mentionnées pour la première fois in plusieures regions italiennes.

Le nombre des espèces diminue dans la Peninsule du nord au sud. 8 espèces d'origine centre-europeenne ont été trouvées seulement dans les Alpes et non pas dans les Appennines. Les espèces les plus repandues dans les regions italiennes sont *Rhyacophila simulatrix* McLachlan, 1879 and *R. tristis* Pictet, 1834. 8 espèces et 3 sousespèces sont endemiques pour l'Italie et leur pourcentage augmente dans la Peninsule du nord au sud.

Le regime alimentaire des larves ainsi que leurs symbiontes ont été etudiés. Les larves de dernier stade sont carnivores. On a observé les symbiontes Nematomorpha, Gregarinida et Acarina. Les kystes de Nematomorpha sont les plus repandus. Dans le tube digestive des larves 3 espèces de gregarine du genre *Asterophora* ont été relevées. Un seul adulte de *Rhyacophila intermedia* a été parasité par la larves de Hydracarina.

Zusammenfassung

Die Liste der Italienischen Arten der Gattung *Rhyacophila* ist bis 2005 der neubearbeitet worden, dank der nach dem Jahr 2000 in den italienischen Fließgewässern gefundenen Exemplaren.

Die Liste umfasst 35 Arten und 4 Unterarten ein. Eine Art ist für die Wissenschaft neu (*Rhyacophila dorsalis pantinii* Valle, 2001), 3 Arten sind für die Italienische Fauna neu (*Rhyacophila polonica* McLachlan, 1879; *R. schmidinarica* Urbanic, Krusnik & Malicky, 2000; *R. dorsalis persimilis* McLachlan, 1879), und 8 Arten sind zum ersten Mal in vielen italienischen Regionen notiert worden. Die Artenzahl verringert sich von Norden in Richtung Süden .

8 Arten mitteleuropäischen Ursprungs wurden nur in den Alpen, aber nicht im Appennin gefunden. Die verbreitesten Arten in den italienischen Regionen sind *Rhyacophila simulatrix* McLachlan, 1879 und *R. tristis* Pictet, 1834. 8 Arten und 3 Unterarten sind endemisch in Italien, ihr Bestand erhöht sich von Nord nach Süd der Halbinsel. Man hat die Ernährungsgewohnheiten der Larven und die Anwesenheit von Symbionten untersucht. Die Larven des letzten Stadiums sind karnivor. Man hat die Symbionten Nematomorpha, Gregarinida und Acarina beobachtet. Die Zysten von Nematomorpha sind die häufigsten. In dem Verdauungstrakt von Larven sind 3 Arten der Gregarinida aus dem Genus *Asterophora* gefunden worden. Nur ein adultes Exemplar von *Rhyacophila intermedia* wurde von Larven der Hydracarina parasitiert.

Introduction

The family Rhyacophilidae is one of the most widespread of the Trichoptera in running waters in Italy. In the third list of Italian Trichoptera updated to the year 2000 (Cianficconi 2002), 35 species and 2 subspecies of *Rhyacophila* genus were listed. This derived from research carried out over many years (1884-2000) in sampling sites located in the Alps (McLachlan 1884; Moretti 1937; Cianficconi & Moretti 1985a, 1987, 1992; Cianficconi, Corallini & Moretti 1999), Prealps (Cianficconi, Moretti & Valle 1993), Apennines (Campadelli, Cianficconi & Moretti 1990; Cianficconi, Corallini, Moretti & Salerno 1994; Cianficconi, Moretti & Papagno 1991; Cianficconi, Moretti & Tucciarelli 1986) and in the islands Sicilia (Cianficconi, De Pietro, Gerecke & Moretti 1999), Sardegna (Moretti & Cianficconi 1983; Cianficconi, Corallini, Moretti & Azara 1996), Elba (Moretti, Gianotti, Taticchi & Viganò 1981).

The aim of this work is to update the *Rhyacophila* list with findings by Malicky (2002, 2004, 2005, *in litt.* 2002) and by Valle (2001) along the Peninsula, as well as to analyse the present distribution and the ecological and chorological aspects. In addition, symbionts and parasites of some species have also been observed (Moretti & Sorcetti Corallini 1976; Moretti & Corallini Sorcetti 1981; Corallini Sorcetti 1984, Cianficconi *et al.* 1993; Cianficconi *et al.* 1995; Moretti *et al.* 1997; Cianficconi *et al.* 1998; Cianficconi *et al.* 1999).

Material and methods

The *Rhyacophila* were sampled as larvae, pupae and adults, in more than 1500 sampling sites by researchers and undergraduate students of the Istituto di Zoologia, Università di Perugia. The adults were collected in daylight and sometimes during the night with light traps. Some larvae were reared in captivity in order to study the biological cycles of the respective species.

For the symbiont study, the larvae were dissected. For light microscopy the gut was fixed in formol 4 %. For scanning and trasmission electron microscopy the gut was fixed in Karnovsky medium in cacodylate buffer (pH 7.2).

Observations and discussion

Ecological remarks

The aquatic instars inhabit lotic biozones from crenal (Cianficconi, Corallini & Moretti 1998) to iporithral, preferably epirithral, with a substrate of gravel and stones (Fig. 1). Some species (e.g. *R. pubescens*, *R. tristis*) often live in hygropetric habitats, covered with mosses (*Fontinalis antipyretica, Fissidens crassipes, Cratoneuron filicinum*) (Cianficconi *et alii* 2005).

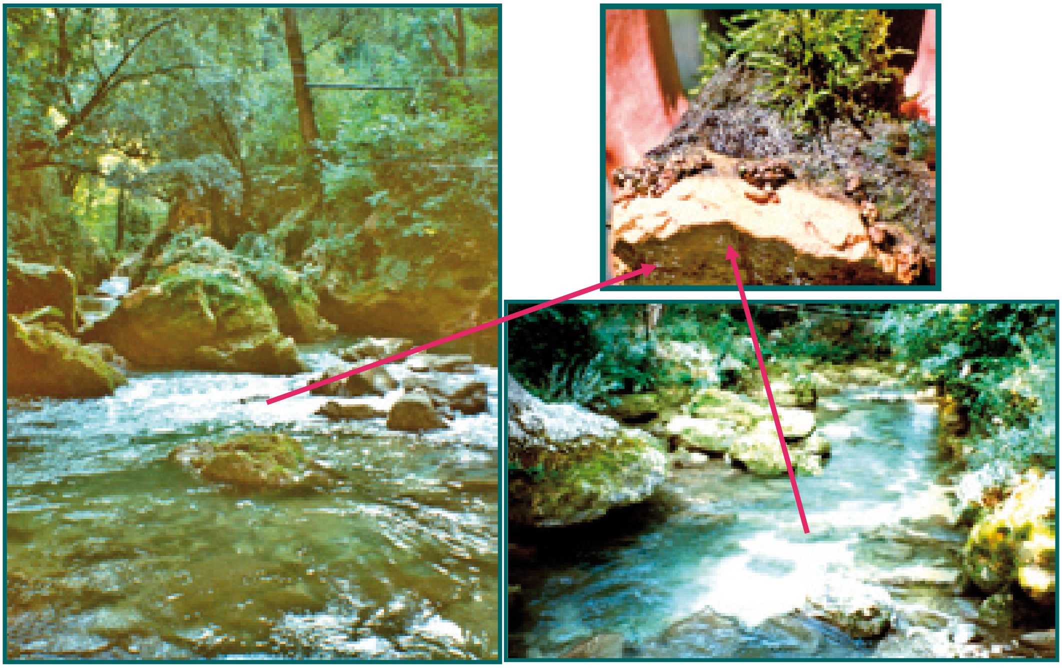


Fig. 1: Preferred habitat of *Rhyacophila* aquatic instars.

The biozones are located at different altitudes (from 1 to 2600 m a.s.l.) and the highest number of species was found at medium and high altitudes. The most significant physico-chemical parameters are: clear, cool waters, concentration of O_2 usually near saturation point, various flow rates, various levels of hardness (from 5-7 French degrees on granitic substrate in the western Alps, Calabria and Sardegna to 10-30 Fr. dgr. on calcareous substrate) and of pH (from 5.5-6.5 on granitic substrate to 7-8 on calcareous substrate).

Only the larvae of *R. dorsalis acutidens* seem to adapt to slightly polluted waters (as in Tiber river) (Moretti & Cianficconi, 1984).

A few species (e.g. *R. vulgaris*, *R. intermedia*, *R. rougemonti*) are occasionally found as adults in caves (Moretti & Gianotti 1967; Cianficconi & Moretti, 1985).

List and distribution updated to 2005

In Table 1 the species found in the 18 Italian regions and 3 islands are listed as in the checklist of Italian Trichoptera (Moretti & Cianficconi 1995) and their chorotypes are shown.

To date 35 species and 4 subspecies have been found. Compared to the previous list, 2 species are new findings: *R. polonica* found in Friuli Venezia Giulia (Malicky 2005) and *R. schmidinarica* found in Trentino Alto Adige (Malicky *in litt*. 2002). 2 taxa have a new status because *R. dorsalis* (Curtis, 1834) was transferred to subspecies *R. dorsalis persimilis* (Malicky, 2002) and *R. nubila* (Zetterstedt, 1840) to the recently described subspecies *R. dorsalis pantinii* (Valle, 2001).

Eight species extended their distribution in the Peninsula. Among these *R. dorsalis acutidens* extended from central southern Apennines to north-western Italy (Malicky 2002), *R. orobica* from Lombardia to Trentino Alto Adige and Veneto (Malicky 2005) and *R. vallei* from Calabria to Molise, Campania and Basilicata (Valle 2001).

The list shows a significant difference between the Alps, the Apennines and the Islands. In the central Alps the highest number of species was found in Lombardia and Trentino Alto Adige (19), in the central Apennines in Toscana (12, including the Apuanian Alps) and in the southern Apennines in Calabria (9). 2 species were found in Sicilia, 2 in Sardegna and 1 subspecies in Elba.

Tab. 1: List and distribution of italian *Rhyacophila* updated to 2005:

● = taxa included in the third list; ■ = new finding in Italy (Malicky); ◣ = new to science (Valle); ▲ = new finding in the Region (Malicky); ◆ = new finding in the Region (Valle). Chorotype names: APPE = Apennine endemic; CEU = Central-European; ALSW = SW-Alpine endemic; APPS = S-Apennine endemic; EUR = European; APPC = Central-Apennine endemic; WEU = W-European; SACO = Sardo-Corsican endemic; EME = E-Mediterranean; AWNA = W-Alpine-N-Apennine endemic. (**Vigna Taglianti** *et a* 1999).

	TAXA / REGIONS AND ISLANDS		Piemonte	Valle d'Aosta	Liguria	Lombardia	Trentino A.Adige	Veneto	Friuli V.Giulia	Emilia Romagna	Toscana	Umbria	Marche	Lazio	Abruzzo	Molise	Campania	Puglia	Basilicata	Calabria	Sicilia	Sardegna	Elba	Total	Chorotypes
	Rhyacophilidae																								
1	*Rhyacophila albardana* , McLachlan, 1879		●	●	●	●			●			●	●		●		◆		●	●				11	CEU
2	*R. appennina* McLachlan, 1898	E			●						●													2	APPE
3	*R. aquitanica* McLachlan, 1879		●			●	●	●	●															5	CEU
4	*R. arcangelina* Navas, 1932	E	●		●																			2	ALSW
5	*R. aurata* Brauer, 1857					●	●	●	●															4	CEU
6	*R. bonaparti* Schmid, 1947					●	●																	2	CEU
	R. dorsalis acutidens McLachlan, 1879	E	▲		▲					●	●	●	●	●	●	●	●	●		●				12	APPE
	R.dorsalis pantinii Valle, 2001	E														◣	◣							2	APPS
	R. dorsalis persimilis McLachlan, 1879					■	■	■	■															0	CEU
7	*R. fasciata* Hagen, 1859							●	●															2	EUR
8	*R. foliacea* Moretti, 1981	E									●	●	●	●	●	●	●		●	●				9	APPC
9	*R. glareosa* McLachlan, 1867		●	●		●	●																	4	CEU
10	*R. hartigi* Malicky, 1971	E														●			●	●	●			4	APPS
11	*R. hirticornis* McLachlan, 1879					●	●	●	●															4	EUR
12	*R. intermedia* McLachlan, 1868		●	●	▲	●	●		●	●	●													8	EUR
13	*R. italica* Moretti, 1981	E								●	●	●	●											4	APPC
	R. italica ilvana Moretti, 1981	E																					●	1	
14	*R. kelnerae* Schmid, 1971		●		●						●													3	WEU
15	*R. laevis* Pictet, 1834					●	●	●			●													4	EUR
16	*R. meyeri* McLachlan, 1879		●			●				●	●		●		●									6	CEU
17	*R. orobica* Moretti, 1991					●	▲	▲																3	CEU
18	*R. pallida* Mosely, 1930																					●		1	SACO
19	*R. palmeni* McLachlan, 1879								●															1	EME
20	*R. pascoei* McLachlan, 1879		●	●			●							●										4	EUR
21	*R. polonica* McLachlan , 1879								■															1	CEU
22	*R. praemorsa* McLachlan, 1879		●			●	▲			▲														4	CEU
23	*R. producta* McLachlan, 1879					●	●		●															3	CEU
24	*R. pubescens* Pictet, 1834		●		●		●				●	●	●	●	●				●	●				10	EUR
25	*R. ravizzai* Moretti, 1991	E	●		▲																			2	AWNA
26	*R. rectispina* McLachlan, 1884		●		●	●								●										4	CEU
27	*R. rougemonti* McLachlan, 1880	E										●	●	●	●	●	●	●	●	●	●			10	APPS
28	*R. schmidinarica* (Urbanic-Krusnik -Malicky 2000)						■																	1	CEU
29	*R. simulatrix* McLachlan, 1879		●		●	●	●	●	●	●	●	●	●	●	●	●	●		●	●				16	CEU
30	*R. stigmatica* (Kolenati, 1859)		●			●	●	●	●															5	CEU
31	*R. torrentium* Pictet, 1834		●	●		●	●	●	●	▲														7	CEU
32	*R. trifasciata* Mosely, 1930																					●		1	SACO
33	*R. tristis* Pictet, 1834		●	●	●	●	●	●	●	●	●	●	●	●	●				●	●				15	EUR
34	*R. vallei* Moretti, 1997	E														◆	◆		◆	●				4	APPE
35	*R. vulgaris* Pictet, 1834		●	●	●	●	●	●	●	●	●			●										10	CEU
	Total		18	7	12	18	19	12	15	9	12	8	9	9	8	7	7	2	8	9	2	2	1		

The most widespread species are *R. simulatrix* (16 Regions) and *R. tristis* (15), the rarest are *R. palmeni, R. polonica, R. schmidinarica* found only in one Region.

Chorological remarks

In Italy, the genus *Rhyacophila* represents 31% of the species and 25 % of the subspecies known in Europe (Malicky 2004).

The zoogeographical balance shows a predominance of species with Central - European distribution (41 %), followed by those with European (18 %) and Western Mediterranean (5,1 %) distribution. 8 species and 3 subspecies (marked E in Tab. 1) are endemic to the Italian fauna.

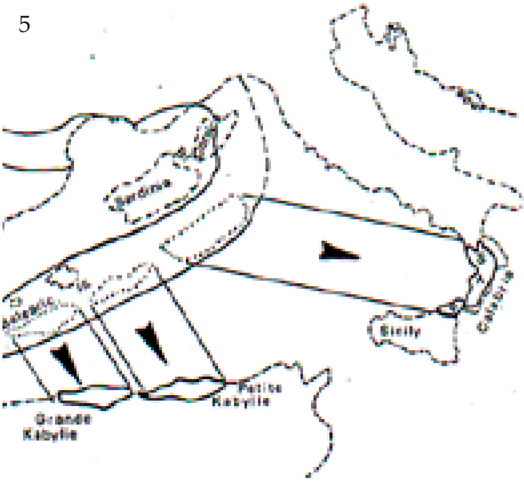
It is noteworthy that among the species of Central- European origin, some are limited to the Italian Alps (*R. aquitanica, R. aurata, R. bonaparti, R. glareosa, R. hirticornis, R. polonica, R. producta, R. stigmatica*), others are vicariated along the peninsula by similar species. *R. vulgaris* is vicariated in the central Apennines by *R. foliacea* and in the southern Apennines and Sicilia by *R.*

Fig. 2: Distribution of 3 vicariant species of *Rhyacophila* gr. *vulgaris*: ● = *R. vulgaris*; ▲ = *R. foliacea*; ★ = *R. hartigi*

Fig, 3: Distribution of 3 vicariant subspecies of *R. dorsalis:* ■ = *R. dorsalis persimilis*; ▲ = *R. dorsalis acutidens*; ● = *R. dorsalis pantinii*.

4

5



Figs. 4, 5: Distribution of *Rhyacophila* gr. *rougemonti* in the W- Mediterranean region.
■ = *R. italica*; ☾ = *R. italica ilvana*; ✦ = *R. rougemonti*; ● = *R. pallida*; ▲ = *R. trifasciata*. *R. vallei* (✸) is similar to Corsican *R. tarda* (⚡) 5) W- Mediterranean microplates in the Oligocene (by Alvarez, Cocozza and Wezel 1974).

Fig. 6: Total number of species found in each region and number of Italian endemic species (encircled number).

hartigi (Fig. 2). The subspecies *R. dorsalis persimilis* is vicariated in the western Alps and central Apennines by *R. dorsalis acutidens* and in southern Apennines by *R. dorsalis pantinii* (Fig. 3).

Among the species of Western Mediterranean distribution the Sardo-Corsican *R. pallida* and *R. trifasciata* are vicariated in the southern Apennines and Sicily by similar species *R. rougemonti* and in the central Apennines by *R. italica*. Moreover *R. vallei* of the southern Apennines is similar to Corsican *R. tarda* Giudicelli, 1968. (Fig. 4).

These distributions could confirm the hypothesis that the original colonization of *Rhyacophila* in the Peninsula occurred mainly via the Alps in the north and with the translation of the continental Sardo-Sicilian-Calabrian microplate in the west (Cianficconi & Moretti 1990) (Fig. 5).

It is interesting to note that in the northern regions (Valle d'Aosta, Lombardia, Trentino Alto Adige, Veneto, Friuli Venezia Giulia) there are no endemic species and that the percentage of endemic species increases in the Peninsula from the north west to the south (Apulia, and Sicily 100%, Molise (85%) and Campania (71%) (Fig.6).

Feedings and symbionts

The feeding regime and the presence of symbionts are investigated in 14 species of *Rhyacophila* (Tab. 2). These belong to 4 subgenera sensu Döhler: Hyporhyacophila (*R. pubescens*, *R. tristis*); Pararhyacophila (*R. intermedia*, *R. italica*, *R. pallida*, *R. rougemonti*, *R. trifasciata*); Hyperrhyacophila (*R. torrentium*); Rhyacophila s str. (*R. dorsalis acutidens*, *R. dorsalis persimilis*, *R. foliacea*, *R. hartigi*, *R. simulatrix*, *R. vulgaris*).

Tab. 2: Species of *Rhyacophila* examined and their Symbionts.

	Gregarinida	Nematomorpha	Hydracarina
R. dorsalis acutidens	*Asterophora mucronata* Lèger, 1892	*Gordius* sp. (cyst)	larvae
R. dorsalis persimilis	*Asterophora mucronata* Lèger, 1892	*Gordius* sp. (cyst)	
R. foliacea	*Asterophora mucronata* Lèger 1892	*Gordius* sp. (cyst)	
R. hartigi	*Asterophora heerii* Kőlliker, 1848	*Gordius* sp. (cyst)	
R. intermedia			
R. italica	*Asterophora mucronata* Lèger, 1892		
R. pallida	*Asterophora heerii* Kőlliker, 1848	*Gordius* sp. (cyst)	
R. pubescens	*Asterophora mucronata* Lèger, 1892	*Gordius* sp. (cyst)	
R. rougemonti	*Asterophora mucronata* Lèger, 1892	*Gordius* sp. (cyst)	
R. simulatrix	*Asterophora mucronata* Lèger, 1892	*Gordius* sp. (cyst)	
R. torrentium	*Asterophora capitata* Boudoin, 1967	*Gordius* sp. (cyst)	
R. trifasciata	*Asterophora heerii* Kőlliker, 1848	*Gordius* sp. (cyst)	
R. tristis	*Asterophora mucronata* Lèger, 1892	*Gordius* sp. (cyst)	
	Asterophora mucronata Lèger, 1892		
R. vulgaris	*Asterophora heerii* Kőlliker, 1848	*Gordius* sp. (cyst)	
	Asterophora mucronata Lèger, 1892		

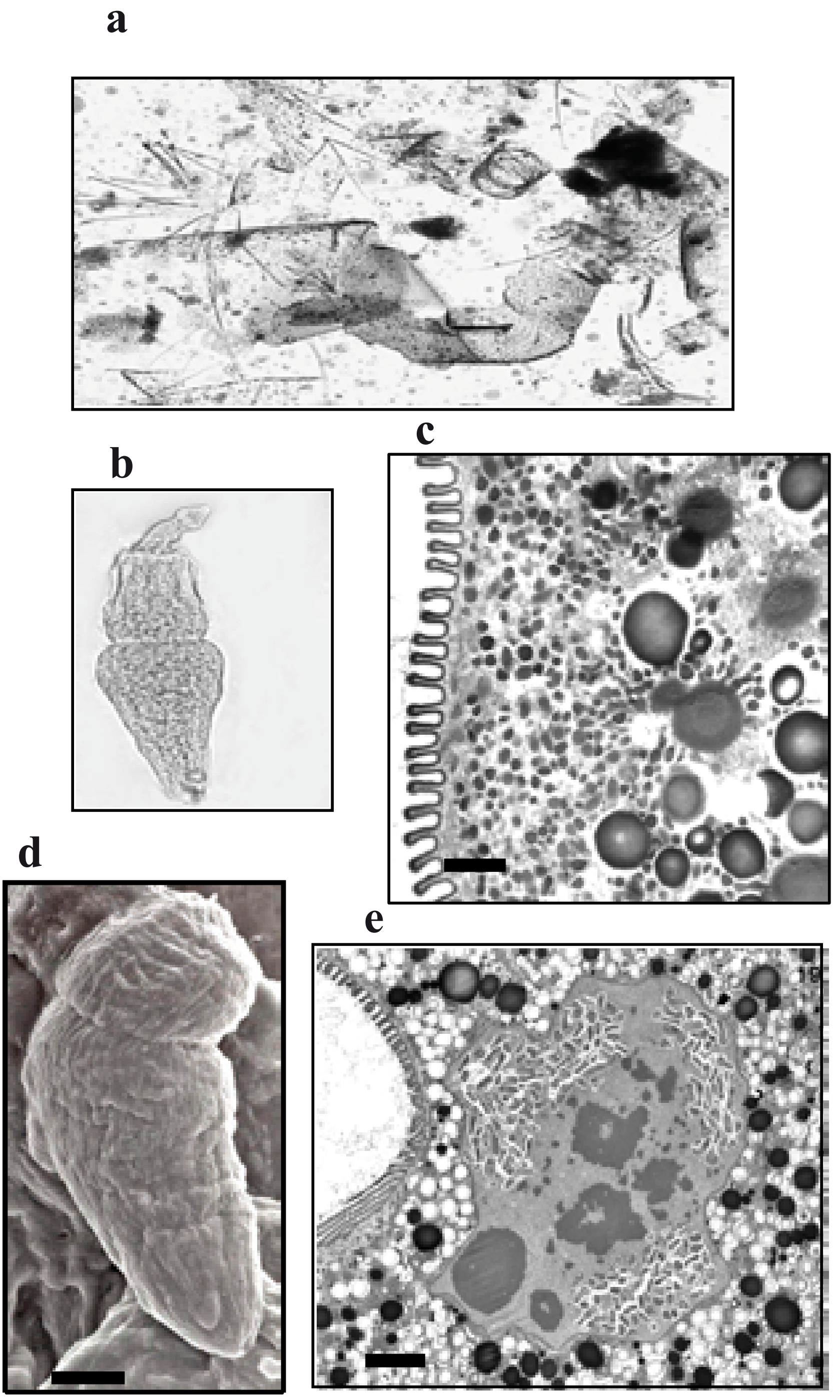


Fig. 7: a) Gut content of the *Rhyacophila* larva b) *Astherophora mucronata*: Trophozoite c) *A. mucronata*: Transverse section, trophozoite showing epicyte folds (TEM bar =1 µm) d) *A. mucronata*: Gamont, surface arranged in longitudinal epycite folds (SEM bar =10 µm) e) *A. mucronata*: Longitudinal section, nucleus of gamont including bacteria (TEM bar = 0,5 µm).

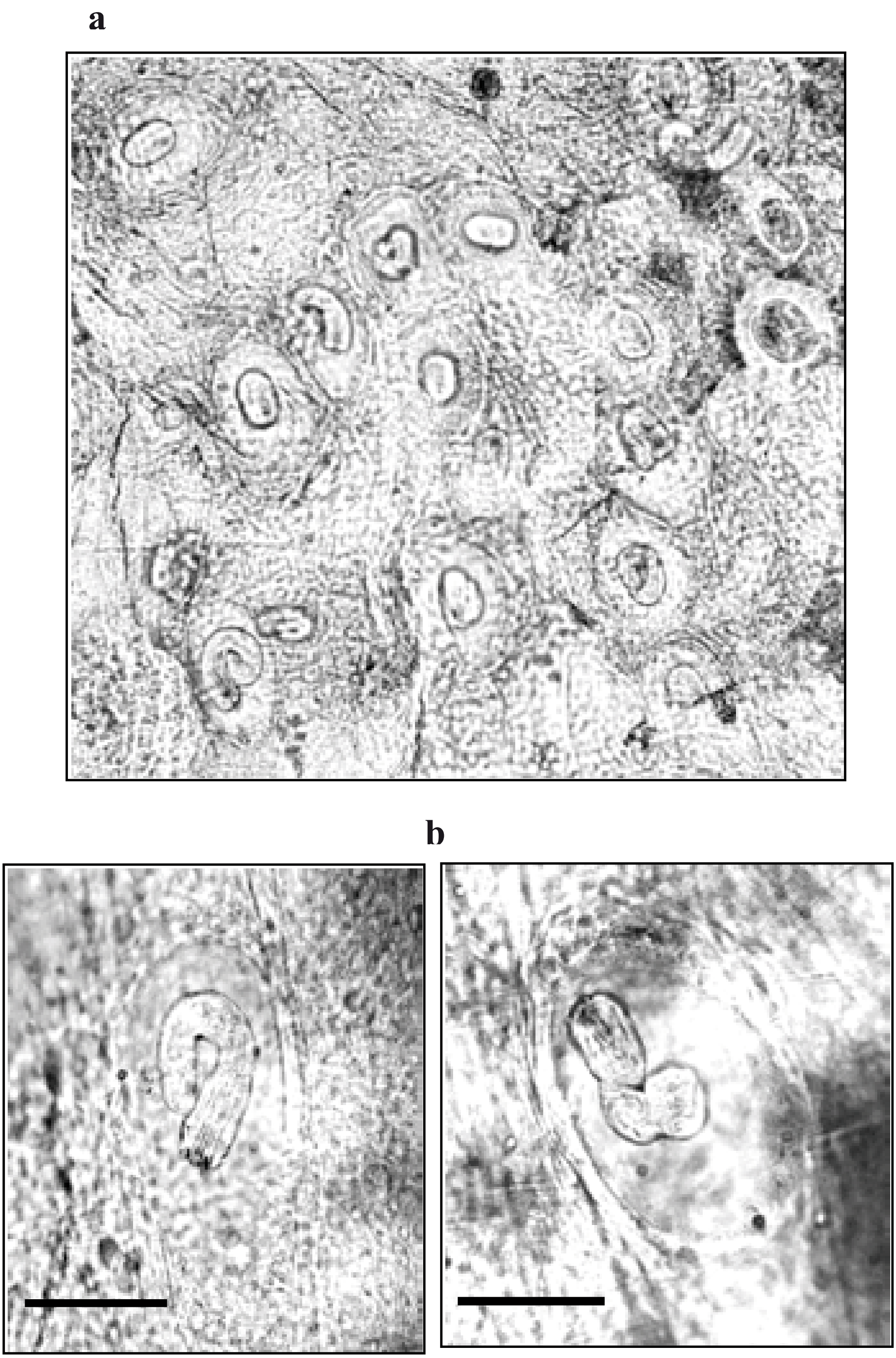


Fig. 8: Nematomorpha immature stages are internal parasites of *Rhyacophila* larvae, pupae and adults: a) Several cysts in muscular layers of the midgut wall b) Cyst of Nematomorpha larva (bar = 35 µm).

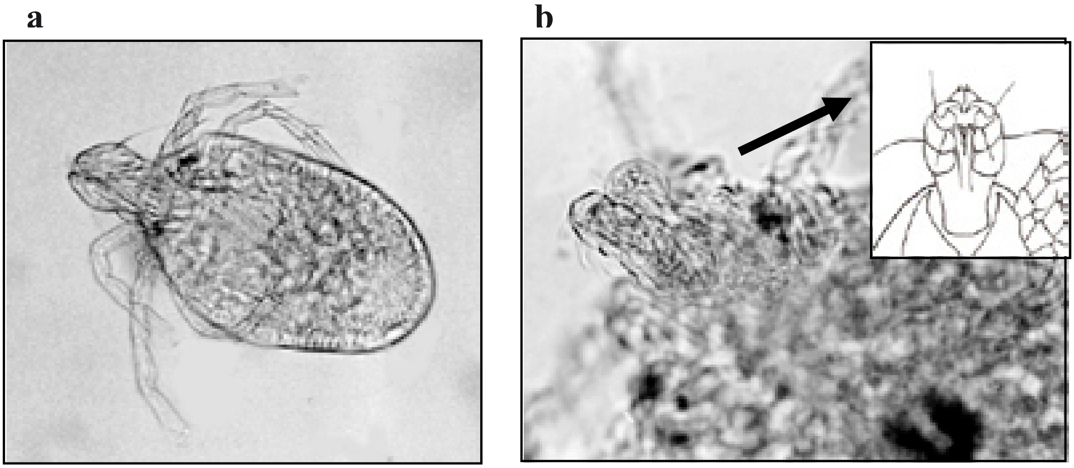


Fig. 9: Hydracarina indet. (suborder Trombidiformes) ectoparasite on *Rhyacophila* adults:
a) Hydracarina larva b) Gnatosoma. Inset: detailed drawing.

The larvae at the last instars are typically carnivorous predators, which feed above all on larvae of other aquatic insects, including Trichoptera. Several fragments of cuticle have been observed (Fig. 7a).

The digestive tract consists of three regions: foregut, midgut and hindgut. The foregut of the larvae is particularly long and has cuticular structures, mainly spines which characteristically point towards the buccal cavity (Corallini Sorcetti & Catapano 1988; Spinelli Batta & Corallini Sorcetti, 1988).

The presence of symbionts is frequently observed.

Reviewing the Protozoa Eugregarinida present in the midgut of *Rhyacophila*, three species of the genus *Asterophora* were observed. *A. mucronata* is the most widespread, in some cases 60-65 % of the larvae were infested. Trophozoites gamonts, syzygy and gametocysts were observed (Corallini 1997). The trophozoite is 40 – 100µm long (Fig. 7b), the gamont 80 – 140µm. The gamont surface is arranged in an epicyte fold along the cell body (Fig. 7d). The pellicle has three cortical membranes, the epicyte folds have filaments localized to the distal tip (Fig. 7c). In the cytoplasm mitochondria, endoplasmic reticulum, free ribosomes, Golgian vesicles, paraglycogen granules (Fig. 7c) and electron dense bodies. were observed. The gamont has bacteria inside the nucleus (Fig. 7e). *A. capitata* is present only in Val d'Aosta and *A. heeri* only in Sardinia.

Nematomorpha of the genus *Gordius*, are the most widely distributed and are found as cysts in the larvae, pupae and adults. (Fig. 8a-b).

After hatching the larva of *Gordius* immediately penetrates an aquatic animal, preferably an insect. The larva continues its development only if the host is suitable.

The larvae ingested by an unsuitable host dies or encysts in the tissues instead of developing further, as happens when this host is eaten by another suitable insect.

Rhyacophila is not a suitable host for *Gordius.*

An adult of *R. intermedia* was parasitized by larvae of Hydracarina (Fig. 9a-b) attached to the thorax, abdomen and legs.

The Hydracarina larvae, after a short free-swimming period, become attached to aquatic insects with their gnatosoma and assume a parasitic existence.

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Caddisfly assemblages characterizing different ecological areas in Luxembourg: from geographical distributions to bioindication

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Abstract

Traditionally, the Grand Duchy of Luxembourg is divided into two main ecological areas, which are characterized by specific geo-morphological and climatic conditions. The Oesling in the north covering one-third of the territory is a homogeneous schistous Hercynian massif with a mean altitude approaching 450 m. The Gutland in the south is characterized by Triassic and Jurassic layers on a Devonian base. The altitude varies between 250 m and 400 m. Within the Gutland, two sub-ecoregions may be further distinguished: the Minette basin and the Moselle valley. These regions are restricted respectively to the southwest and southeast of the country.

A database of caddisflies sampled in 239 sites distributed over three out of the four ecological areas (no sites were sampled in the Moselle valley area) is used to verify if these geographic areas correspond to distinct caddisfly assemblages. The ability of this landscape classification to explain variation in caddisflies, was compared to that of a river typology determined on the basis of selected abiotic variables. Ordination methods were used to illustrate the site separation according to biological data.

Although there was some overall difference in caddisfly composition among the two main ecological areas (i.e. Oesling and Gutland), the different classes were not well separated on the ordination diagram, indicating a great overlap between species assemblages in the two ecological areas. Possible reasons for the relative poor correlation observed between caddisfly assemblages and the geographic classes included unaccounted-for longitudinal zonation of rivers and unaccounted-for perturbation gradient in the dataset. Indeed, the use of the classification based on the river typology, which can be assimilated to a partition of these two main ecological areas nested by the catchment's size gradient, and the selection of sites characterized by low anthropogenic disturbance, improve greatly the separation of classes on the reduced multidimensional space. Discrete clusters indicating distinct caddisfly assemblages are present in the ordination diagram. The indicator value method was then used to identify caddisfly species characteristic of the different clusters. For instance, *Glossosoma conformis*, *Philopotamus ludificatus*, *Oecismus monedula*, *Sericostoma personatum/schneideri*, *Hydropsyche instabilis* and *Odontocerum albicorne* show high indicator values for headwater streams in the Oesling when anthropogenic disturbances are minimal. *Plectrocnemia conspersa*, *Drusus annulatus* and *Potamophylax cingulatus* do the same for headwater streams in the Gutland. *Polycentropus flavomaculatus*, *Brachycentrus maculatus*, *Mystacides azureus*, *Allogamus auricollis*, *Silo piceus*, *Athripsodes bilineatus* and *Ceraclea annulicornis* are the best indicator species for larger and less impacted streams in the Oesling. The proportions and identities of the Trichoptera species, which are characteristic of the different river types are discussed in relation to human-induced alterations that especially affect large lowland rivers in Central Europe.

Introduction

The classification of streams has a long tradition in Europe and has always been a matter of strenuous discussions between scientists. It is not the objective of this paper to discuss the advantages and disadvantages of the different theories (especially the zonation system and the River Continuum Concept) proposed so far. Interesting discussions can be found in numerous published works (e.g. Huet 1949; Illies & Botosaneanu 1963, Pennak

1971, Verneaux 1973, Persoone 1979, Vannote *et al.* 1980, Wright *et al.* 1984, Statzner & Higler 1986, Botosaneanu 1988, Wasson 1989).

Classification of waterbodies is a necessary step for aquatic biological assessment and is recommended for water resource and conservation management. Indeed, the use of ecoregions as a geographic framework (i.e., "a priori" classifications) on which to base catchment management is especially attractive to water quality programs that depend on assessments of multiple biological elements to measure attainment of water quality goals (e.g. fish, periphyton, macrophytes, benthic invertebrates or phytoplankton). Indeed, these biological elements respond to different environmental factors and the classifications based on communities (i.e., "a posteriori" classifications) are not always concordant across taxonomic groups (Paavola *et al*. 2003). Consequently, such an approach would request specific typologies for each taxonomic group investigated and would be inappropriate for water managers. Ecoregions also help managers to develop and implement management strategies that address how the causes of degradation may interact with the landscape, as well as to communicate those relationships to the public (Hawkins *et al*. 2000).

Ecoregions are classified by mapping geographical regions within which climatological and landscape attributes, such as topography, geology, and land cover are homogeneous and distinctive compared to other regions (Snelder *et al*. 2004). The resultant classes are expected to explain variation in ecological characteristics (*e.g.* assemblage structure) and to predict, to some extent, the ecological attributes of those areas (Feminella 2000). However, the strength of the relationships between landscape features and site-specific biota is poorly known (Hawkins *et al.* 2000). Consequently, a rigorous evaluation of the extent to which those a priori regionalizations of the landscape are able to capture a significant part of the natural variation associated to the biota is necessary.

In Europe, the 25 European ecoregions defined by Illies (1978) are frequently used as a framework for national typologies, particularly for applied purposes like the implementation of the EU Water Framework Directive (WFD) (EU 2000) (Lorenz *et al*. 2004). The Grand Duchy of Luxembourg is completely included in the north-east part of ecoregion 8 (Western Sub-alpine Mountains), comprising regions like the Eifel, the Hunsruck, the Ardennes, the Plateau Lorrain, the Vosges and the Massif central. Nevertheless, on the basis of specific geo-morphological and climatic conditions, the country is traditionally divided into two main ecoregions, the Oesling in the north and the Gutland in the south. Within the Gutland, which is characterized by a more heterogeneous geology in comparison to the Oesling, two sub-ecoregions may be further distinguished: the Minette basin and the Moselle valley (Administration des Eaux et Forêts 2003).

Among freshwater macroinvertebrates, the caddisflies (Trichoptera) constitute one of the most diversified groups. Only aquatic Diptera approach or exceed the Trichoptera in number of species or genera. Thus, the Trichoptera display ecological and behavioural specialisations which enable them to successfully colonise a vast range of lotic and lentic waters (e.g. Mackay & Wiggins 1979, Stroot 1989). This high taxonomical diversity of Trichoptera concurrently induces a high diversity of life history strategies that make this group one of the most suited to appraise the structure and functioning of aquatic ecosystems (Morse 2003). Although caddisflies are present in a wide range of aquatic habitats, numerous species have very strict environmental requirements (Resh & Unzicker 1975, Malicky 1981, Stroot 1989, Resh 1993, Dohet 2002). For this reason and because of the usual high species diversity and density of caddisflies in unpolluted surface waters on one hand, and their distributions all along the stream continuum on the other hand, assemblages of Trichoptera appear as ideal indicators to test the idea that an a priori regionalization of the landscape can be used to classify biotic communities.

In this study, the ability of a landscape classification to explain variation in caddisfly samples collected from about 230 sites distributed over the whole country, was compared to that of a river typology determined on the basis of selected abiotic variables (Ferréol *et al*. 2005). Furthermore, a reference condition approach was used in order to decrease the high heterogeneity that is likely to appear if patterns were derived from mixtures of reference and nonreference sites. Indeed, classification should rely on characteristics that are intrinsic, or natural, and are not the result of human activities (Gerritsen *et al*. 2000). One of the primary purposes of classification for water resource management is to develop appropriate expectations of biological conditions, that is, to predict the natural or undisturbed reference condition (Hawkins & Norris 2000, Hawkins *et al.* 2000).

Our main purpose is to compare the degree to which distribution patterns of caddisflies within Luxembourg classified by large scale ecological areas compared with a classification by stream types at a smaller spatial scale. We addressed the following specific questions: 1) Do the traditional ecological regions observed in Luxembourg correspond to distinct caddisfly assemblages? 2) Does a stream typology enable or not to capture more variation in caddisflies communities? 3) What are the implications of the results from questions 1 and 2 for the design and use of biological assessments in aquatic ecosystem management? 4) What is the proportion and what are the Trichoptera species, which are characteristic of the different landscape units resulting from the most robust classification?

Material and methods

Site selection and field sampling

A dataset, comprising physio-geographical, physical, chemical and land use variables measured at 239 sampling sites distributed all over the country was used. These 239 sites were selected in order to provide a relevant and representative hydrological and geographical coverage. Although different degrees of human impact were considered, a particular effort was made to find streams with minimal disturbance. The complete list of variables measured at sampling sites can be found in Ferréol *et al*. (2005).

Benthic invertebrates were sampled at each station twice a year (spring and summer-autumn seasons) from the different microhabitats (riffles, depositional zones, different types of vegetation). The sampling procedure was described in Dohet *et al*. (2002). Concerning taxonomic resolution, all invertebrate taxa collected were identified mainly to species level. The total number of taxa recorded from the 239 sites was 966.

Ecological areas in Luxembourg

According to the topoclimate and landscape features such as topography, geology, and land cover, two large ecological areas, which are characterized by specific geo-morphological and climatic conditions, can be recognized in the Grand Duchy of Luxembourg (Fig. 1a). The Oesling in the north covering one-third of the territory is a homogeneous schistous Hercynian massif with a mean altitude approaching 450 m. The remaining of the territory is characterized by Triassic and Jurassic layers on a Devonian base. The altitude varies between 250 m and 400 m. Because of the different altitudinal ranges between these to main ecological areas, rivers flowing in the northern part are characterized by deeper valleys in comparison to the rivers flowing in the southern part. Minette basin and Moselle valley, which can be assimilated as two sub-ecoregions pertaining to the Gutland main ecoregion, are restricted respectively to the southwest and southeast of the country. The Minette basin also called "red soils" is characterized by marns and sandstones covered with ferrous sediments. This area is an old mining district. Lastly, the Moselle basin is restricted to the southeast and occupies only 1% of the land surface of the country. This area takes advantage of a clearly drier and sunnier climate and is also characterized by a high proportion of vineyards, which represent about 36% of the surface area of this region. In the southern part of the country, layers of sandstones and marns alternate with clays involving more mineralized stream water in comparison to the north part. Moreover, the differences in topology, geology and climate also involve different land uses in the country and enhance the partition between the two main ecological areas (i.e., Oesling and Gutland). Indeed, the north being essentially a forested area is generally less influenced by anthropogenic disturbances in comparison to the south where big cities, industries and intensive agriculture are concentrated.

Even if the 239 sites are distributed over the whole country, unfortunately no one is included in the Moselle basin ecological area (Fig. 1a). Actually, the Moselle is a very wide river and requires a specific sampling procedure that was not compatible with the one used for the streams investigated in this study.

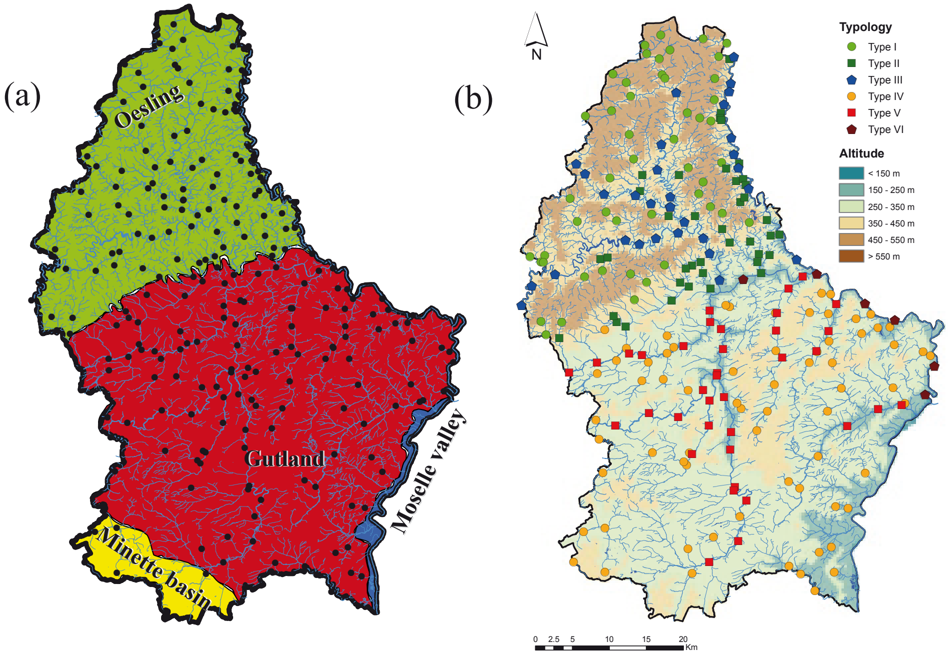

Fig. 1: (a) Map of Luxembourg showing the four ecological areas of the country: the Oesling (in green), the Gutland (in red), the Minette basin (in yellow) and the Moselle valley (in blue). The 239 sampling sites are superposed on the landscape classification. (b) Stream typology of the Grand-Duchy of Luxembourg on the basis of abiotic variables. Type I, small high-altitude streams in the Oesling; Type II, small mid-altitude streams in the Oesling; Type III, mid-sized mid-altitude streams in the Oesling; Type IV, small-sized mid-altitude streams in the Gutland; Type V, mid-sized low and mid-altitude streams in the Gutland; Type VI, large lowland streams.

Typology

In the context of the WFD implementation (EU 2000), an optimal "a priori" classification of streams in Luxembourg was defined and validated upon physio-geographical variables (Ferréol *et al*. 2005). Only mesological data were considered so as to preserve the independence between biotic and abiotic data. In short, both classical and more complex statistical tools were used in order to identify an optimal separation of stream types on the basis of mesological variables related to geology, elevation and longitudinal stream gradient. This resulted in the definition of six stream types for the whole country (Fig. 1b). Typological keys were principally the global size of the stream, the altitude and the water mineralization. The latter was well correlated to the geological difference between the calcareous and non-calcareous areas of the country. Some threshold values of relevant environmental variables obtained from a boxplot graphical analysis performed on the different stream types, are given in table 1. According to the mineralization of water (e.g. carbonate hardness, conductivity), stream types I, II and III (low mineralization) can be clearly separated from types IV, V and VI (high mineralization). In each of these two subgroups, the size gradient (e.g. catchment area, distance to source, width of the river) enables to split stream types I, II and IV (small stream types) from types III and V (intermediate stream types) and type VI (large stream type). Finally, stream types I and II can be discriminated upon the elevation values: sites of the stream type I being situated at higher altitudes than sites of the stream type II.

Tab 1: Threshold values of relevant environmental variables for the different stream types.

Variables \ Types		Type I	Type II	Type III	Type IV	Type V	Type VI
Catchment area (km^2)	25%	2.9	2.8	182.7	3.2	80.1	3105.6
	Median	5.0	9.6	346.9	9.1	117.4	3236.0
	75%	11.7	31.9	431.3	19.4	263.7	4000.0
Stream width (m)	25%	1.0	1.5	9.2	1.0	6.8	36.5
	Median	1.5	2.0	13.7	2.0	8.5	39.9
	75%	2.1	3.5	21.9	3.0	11.8	44.1
Altitude (m)	25%	372	254	247	235	218	153
	Median	390	282	274	265	240	165
	75%	431	310	330	278	260	177
Slope (m.km^{-1})	25%	0.8	2.3	2.7	0.8	2.3	1.3
	Median	1.7	5.0	4.3	1.9	4.2	1.5
	75%	2.3	6.6	6.2	3.1	6.9	2.3
pH	25%	7.0	7.2	7.6	7.7	7.5	8.1
	Median	7.2	7.5	7.8	7.9	7.8	8.2
	75%	7.4	7.8	8.0	8.1	8.1	8.3
Total hardness (méq.L^{-1})	25%	1.1	1.2	1.0	5.4	5.2	5.0
	Median	1.3	1.5	1.2	6.2	5.6	5.1
	75%	1.5	2.0	1.5	7.6	6.7	5.2
Conductivity (µS.cm^{-1})	25%	147	172	145	575	534	477
	Median	184	215	177	664	600	483
	75%	221	283	252	806	728	531
DBO$_5$ (mg.L^{-1})	25%	0.7	0.5	1.8	0.9	2.0	2.5
	Median	1.4	0.9	2.0	1.9	2.8	2.9
	75%	2.6	1.4	3.4	3.4	10.6	3.2

Reference conditions

The dataset was filtered by the criteria specified in table 2 to test the influence of the perturbation gradient on the robustness of the classification (i.e., the degree to which the caddisfly communities are distinct along the different landscape classifications).

To restrict the data to samples of near-natural conditions, a step by step procedure was used. A first selection of sites was made on the basis of instream nutrient concentrations (*i.e.*, ammonium, nitrites, soluble reactive phosphorous and DBO$_5$ or summarized in the organic pollution index (I.P.O., Leclercq & Maquet 1987)). Second, the anthropogenic land use in the surroundings of the sites was evaluated by drawing buffer strips along the stream of each site, according to Townsend *et al.* (2003). Each strip was delimited by a distance on either side of the stream centre line (from 50 to 400 m) and by a distance downstream (from 60 to 130 m) and upstream (from 540 to 1270 m) of the study site. Land use proportions were then estimated from a GIS. Land-use data were obtained from the Ministry of the Environment and originated

Tab 2: Criteria used to restrict the dataset to near-reference samples.

Filter criterion	Reason, comment	Threshold values					
		Type I	Type II	Type III	Type IV	Type V	Type VI
Instream nutrient concentration: I.P.O.	Exclusion of polluted (organic pollution) sites	>= 3.5	>= 3.5	>= 3.5	>= 3.5	>= 3.5	>= 3.5
Land use: L.U.I.	Exclusion of sites with degraded catchment	<= 0.40	<= 0.40	<= 0.60	<= 0.40	<= 0.90	<= 0.90
Biotic index: (I.B.G.N.)	Exclusion of degraded sites	>= 14	>= 14	>= 14	>= 12	>= 12	>= 12
Hydromorphology: SEQ physique	Exclusion of hydromorphologically degraded sites	>= 60%	>= 60%	>= 60%	>= 60%	>= 60%	>= 60%

from the EU CORINE program. A Land Use Index (L.U.I.) was calculated according to Hering *et al.* (2004) and Feld (2004) by summing 4 times urban land, 2 times crop land and 1 time pasture land use, assuming that urban land use has a greater impact than crop land and pastures. Then, the physical habitat of these pre-selected streams was evaluated in the field by the SEQphysique method (Agence de l'eau Rhin-Meuse 1998), which allows an easy and fast characterization of the physical quality of river beds and banks (Charrier *et al.* 2002, Raven *et al.* 2002). Finally, the data were checked with the biotic index I.B.G.N. (AFNOR 2004), in order to eliminate severely impaired sites according to benthic invertebrate communities.

This procedure enables to restrict the dataset to 62 near-natural sites. As some stream types (e.g. stream types V and VI) did not hold sites with a sufficient high quality, they must be considered as the highest ecological potential available for their respective types. Actually, even if the same methodology was used to select the best ecological quality sites, the thresholds values for some parameters (e.g. land use index) were different for fast flowing mountain streams in comparison to slow-flowing lowland streams for instance (Tab. 2).

Statistical analysis

Multivariate statistical techniques like PCA (Principal Component Analysis) were used to illustrate the site separation derived from the distance matrix. These gradient analyses enable to visually assess the relative strength of the different classifications by comparing the distinctness of their patterns in the ordination plots (Waite *et al*. 2000). In brief, these techniques quantify the difference between any two communities by comparing the abundance of each taxon present in each of the two communities, and aggregating this set of comparisons into a distance measure. An ordination of this distance matrix will show compositionally very similar communities close together in the ordination space, whereas very different communities will be spread across the plot. In the ordination plan, the superposition of an inertia ellipse based on the average plotting position of each landscape class, enables to differentiate strong classifications (each class is well separated in the ordination space and corresponds to distinct communities) from weak ones (great overlap between the classes, absence of discrete clusters).

Rare species, whose occurrence is usually more a matter of chance than an ecological indication (Gauch 1982), were not retained for these multivariate analyses. Caddisfly species that occurred in <5% of all sites and that were represented by less 10 specimens were removed from the distance matrix. As a consequence, among these rare species, only those which were euryceous (present in several sites at low densities) were eliminated. Stenoecious species, absent from most sites but sometimes abundant in particular environmental conditions, were maintained. The latter species were certainly valuable in such an analysis (Stroot 1989). In order to reduce the effect of a few highly abundant species, the PCA analyses were computed from log-transformed abundance data for caddisflies.

To identify indicator species or species assemblages characterizing groups of sites, the IndVal method was used (for background information and advantages of the method, see Dufrêne & Legendre 1997). In short, IndVal is a very simple but efficient method that combines a species relative abundance with its relative frequency of occurrence in the various groups of sites. The index is maximum when all individuals of a species are found in a single group of sites and when the species occurs in all sites of that group. The statistical significance of the species indicator values can be evaluated using a randomisation procedure. To determine whether a species is a robust indicator of a particular stream type, two criteria were used: (1) the indicator value should be statistically significant ($p \leq 0.05$) and (2) the indicator value should be ≥ 25. This arbitrary threshold level of 25 for the index supposes that a characteristic species is present in at least 50% of one site group and that its relative abundance in that group reaches at least 50%. If one of the two values reaches 100%, the other is always greater than or equal to 25%. In the tables (Tab. 3 and 4) presented below, species that comply with these two criteria were marked in bold characters.

Results

Trichoptera communities

Among a total of 966 invertebrate taxa identified over the 239 sampling sites, 132 belong to Trichoptera. With a mean taxonomic richness of 16 taxa per site (SD = 8.3), the Trichoptera is the most diverse group after Diptera (mean = 24 taxa per site, SD = 9.3). The most widespread caddisflies are the complexes *Rhyacophila fasciata/dorsalis*-Gr. and *Sericostoma schneideri/personatum* and the species *Hydropsyche siltalai* Döhler, 1963, *Chaetopteryx villosa* (Fabricius, 1798), which occur in more than 60% of the sites. *Halesus radiatus* (Curtis, 1834), *H. digitatus* (Schrank, 1781), *Hydropsyche saxonica* McLachlan, 1884, *H. instabilis* (Curtis, 1834), *Lepidostoma hirtum* (Fabricius, 1775), *Silo piceus* Brauer, 1857 and *Odontocerum albicorne* (Scopoli, 1763) are also very common species, occurring in more than 30% of the sites. Some less widespread species like *Brachycentrus maculatus* (Fourcroy, 1785) or *Agapetus fuscipes* Curtis 1834 are among the most abundant taxa, occurring with a mean relative abundance of 29% and 9%, respectively. The mean relative abundance of *H. siltalai*, *L. hirtum* or *Hydroptila* spp. exceeds also 5% but 114 taxa occur with mean relative abundances of <1%, emphasizing the dominance of a few taxa in the fauna and highlighting the frequency with which rare taxa are found. The frequency of rare taxa supports our decision to remove all taxa that were collected at <5% of sites and represented by less than 10 specimens, for most ordination analyses.

Ordination

Ecological areas

The ordination of sites based on their caddisfly assemblages is mainly explained by the two first axes (respectively 9.32% and 4.78% of the inertia; Fig. 2).

The two main ecological regions (Oesling in green and Gutland in red) tend to separate to some extent indicating that there were some overall differences in caddisfly composition between these two ecological regions. However, discrete clusters are not present and there is a great overlap between the Oesling and Gutland main ecoregions. Moreover, the few sites of the Minette basin (yellow ellipse) are completely included in the Gutland area and cannot be distinguished on the basis of their caddisfly communities.

The first idea that comes to mind to explain this relative poor correlation is that longitudinal variation and perturbation gradient in the dataset

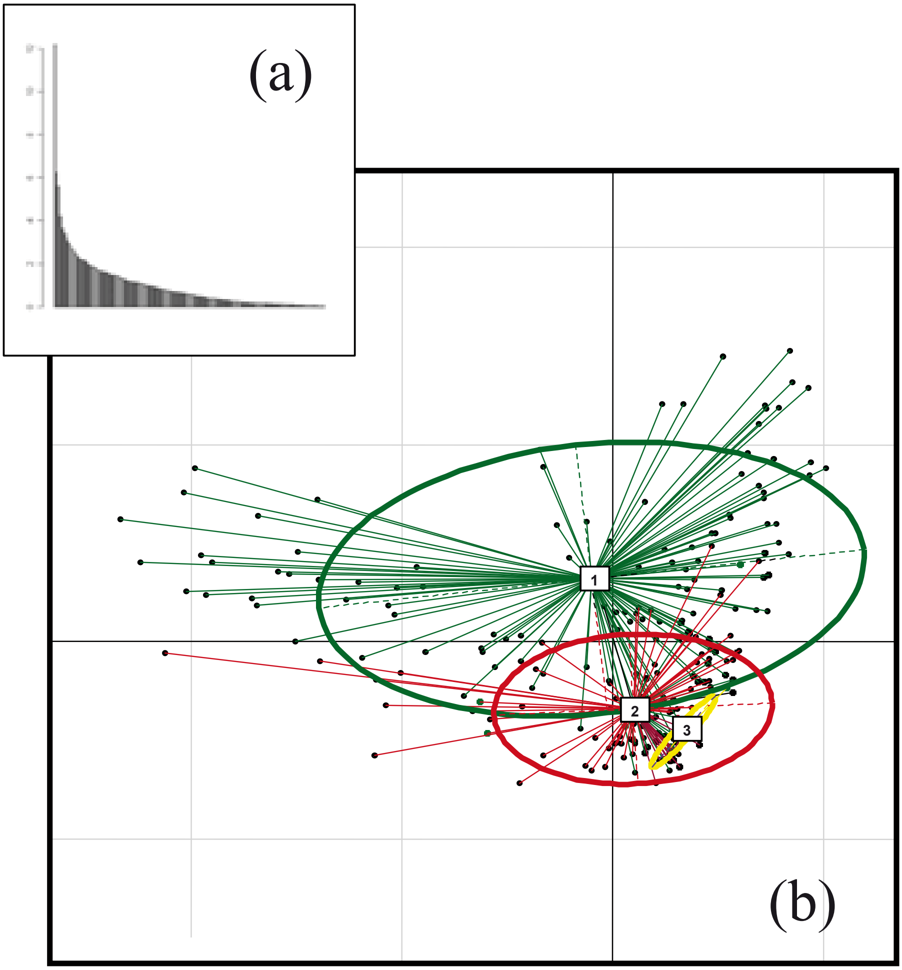

Fig. 2: Ordination of sites and ecological areas by principal component analysis (PCA1). (a) Histogram of eigenvalues ; (b) distribution of 239 samples (small dots) and the three ecological areas (open circles) on the plane of the first two axes (C1 first eigenaxis; C2 second eigenaxis). Ecological areas are positioned at the weighted average of samples representing them (1: Oesling; 2: Gutland; 3: Minette basin).

are not taken into account in this broad landscape classification. Obviously, these gradients are likely to influence significantly caddisfly assemblages.

Stream typology

The two first eigenvalues are identical to those of the previous ordination (i.e., respectively 9.32% and 4.78% of the inertia; Fig. 3). The reason is that sites are distributed in the ordination space on the basis of the same caddisfly communities than in the first PCA. Only the classification, indicated by new inertia ellipses, has changed in comparison to the PCA1. Stream types I and II can not be distinguished and there is still some overlap between stream types IV and V on one hand and between stream types IV + V and I + II on the other hand. Nevertheless, clusters are generally better separated than in the previous ordination based on ecological areas alone (PCA1). In particular, larger rivers belonging to stream types III and VI (respectively, mid sized mid altitude streams in the Oesling and large lowland streams) are

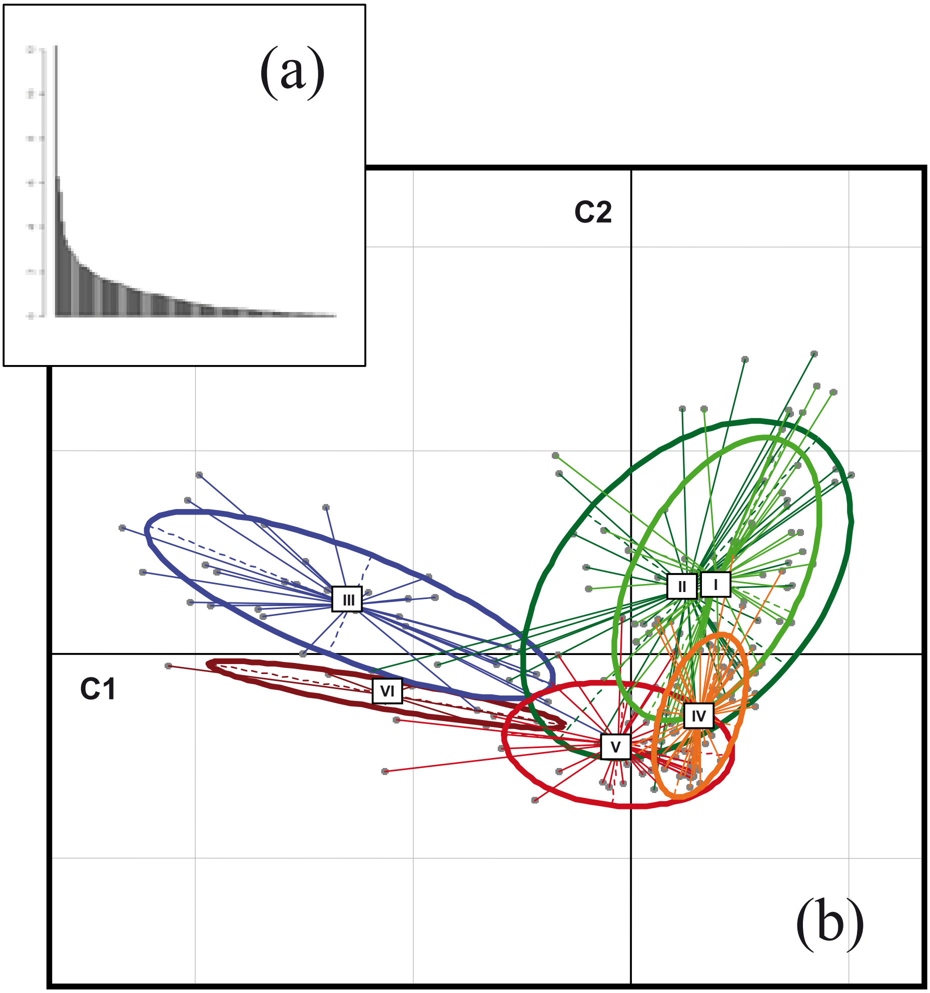

Fig. 3: Ordination of sites and stream types by principal component analysis (PCA2). (a) Histogram of eigenvalues ; (b) distribution of 239 samples (small dots) and the six stream types (open circles) on the plane of the first two axes (C1 first eigenaxis; C2 second eigenaxis). Stream types are positioned at the weighted average of samples representing them (numbers refer to stream type codes in table 1).

well separated in the ordination diagram and correspond to specific caddisfly assemblages.

Stream typology and reference condition

When sites considered to be more or less impacted are removed from the dataset, only about 35% of sites are still available to test the influence of the perturbation gradient on the relation between stream types and Trichoptera distributions. In particular, this selection eliminates numerous sites belonging to the stream types V and VI (mid sized low and mid altitude streams in the Gutland and large lowland streams). For the latter stream type, no sites can be considered as "reference" so far. Consequently, the stream type VI was omitted from this new ordination (PCA3; Fig. 4)

If the analysis is restricted to near-reference sites in the different stream types (Fig. 4), some clusters are noticeably better separated. The eigenvalues are noticeably higher in this ordination (C1:

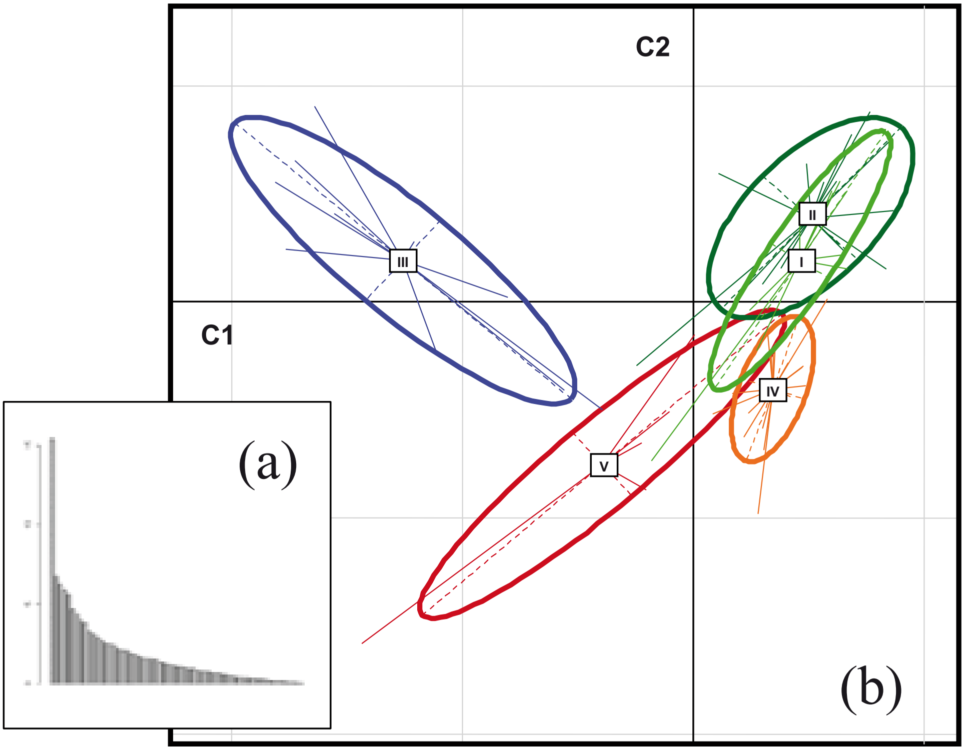

Fig. 4: Ordination of sites in "reference condition" and stream types by principal component analysis (PCA3). (a) Histogram of eigenvalues; (b) distribution of 62 samples (small dots) and the five stream types (open circles) on the plane of the first two axes (C1 first eigenaxis; C2 second eigenaxis). Stream types are positioned at the weighted average of samples representing them (numbers refer to stream type codes in table 1).

13.64% and C2: 6.00%, Fig. 4) indicating that a higher amount of biotic variation is captured by the classification when only near-natural sites are selected. In comparison to the previous ordination (PCA2), the separation is obviously improved for stream types IV and V (respectively, small sized mid altitude streams in the Gutland and mid sized low and mid altitude streams in the Gutland) indicating now distinct caddisfly assemblages. Overall, there is a better separation of the stream types belonging to the two main ecological areas, the Oesling (stream types I, II and III) and the Gutland (stream types IV and V). However, even in near-reference condition, stream types I and II (respectively, small high altitude and small mid altitude streams, both in the Oesling) can still not be distinguished on the basis of their Trichoptera communities.

Identification of characteristic caddisfly assemblages

Characteristic caddisfly species are identified for clusters (stream types) observed in PCA2 (ordination of all sites of our dataset) and PCA3 (ordination of sites in "near-reference condition"). The lists of indicator species for different stream types are provided in table 3 for all sites and table 4 for sites considered as "near-reference".

Since, stream types I and II cannot be distinguished on the basis of their caddisfly fauna, they were merged before the computation with the INDVAL method. Species are sorted according to the groups they are indicative for (ascending) and by observed indicator value (descending). For each species, indicator values are given for the stream type with the highest affinity but also for all other stream types. Species that are considered as robust indicators of a particular stream type (p ≤ 0.05 and indicator value ≥ 25) are marked in bold characters (Tab. 3 - 4).

Nine caddisfly species (*Sericostoma personatum/schneideri*, *Glossosoma conformis* Neboiss 1963, *Hydropsyche instabilis*, *Odontocerum albicorne*, *Agapetus fuscipes*, *Philopotamus ludificatus* McLachlan, 1878, *Potamophylax cingulatus* (Stephens, 1837), *Oecismus monedula* (Hagen, 1859) and *Silo pallipes* (Fabricius, 1781)) can be considered as significant indicators for the stream type I+II (small high altitude and mid altitude streams in the Oesling), when all sites of the database are selected (Tab. 3). If the analysis is restricted to sites identified as "reference", six species remain significant indicators (*G. conformis*, *P. ludificatus*, *S. personatum/schneideri*, *H. instabilis*, *O. monedula* and *O. albicorne*) for the stream type I+II.

Numerous species (15) are characteristic of the stream type III (mid sized, mid altitude streams in

Tab. 3: List of indicator species for different stream types according to the PCA2. The "Avg" and "Max" columns refer to the indicator values for the given species (average and maximum value); "MaxGrp" is the type identifier for the group with the highest indicator value. The statistical significance of the observed indicator value is tested with a randomization (Monte Carlo) procedure: "SD" is the Standard Deviation; "P" evaluates the statistical significance of the maximum indicator value recorded for given species. The probability of type I error is the proportion of times that the maximum indicator value from the randomized data set equals or exceeds the maximum indicator value from the actual data set. Species are ordered according to the groups they are indicative for (ascending) and by observed indicator value (descending). Significant indicators for a particular stream type (IndVal ≥ 25.0 and p ≤ 0.05) are marked in bold characters.

	Types			I+II	III	IV	V	VI	Observed IndVal	IndVal from randomized groups		P
	Number of items			89	32	66	36	6				
	Avg	Max	Max-Grp							Mean	SD	
Sericostoma personatum/schneideri	**17**	**55**	**I+II**	**55**	**24**	**4**	**0**	**0**	**55,3**	**21,0**	**5,49**	**0,002**
Glossosoma conformis	**9**	**45**	**I+II**	**45**	**0**	**0**	**0**	**0**	**44,8**	**10,4**	**5,38**	**0,002**
Hydropsyche instabilis	**9**	**41**	**I+II**	**41**	**0**	**1**	**5**	**0**	**40,9**	**14,2**	**6,30**	**0,010**
Odontocerum albicorne	**9**	**39**	**I+II**	**39**	**0**	**4**	**4**	**0**	**38,6**	**13,6**	**5,34**	**0,008**
Agapetus fuscipes	**7**	**33**	**I+II**	**33**	**0**	**3**	**0**	**0**	**33,1**	**16,3**	**5,97**	**0,014**
Philopotamus ludificatus	**6**	**31**	**I+II**	**31**	**0**	**0**	**0**	**0**	**31,5**	**8,0**	**4,81**	**0,005**
Potamophylax cingulatus	**8**	**29**	**I+II**	**29**	**0**	**13**	**0**	**0**	**29,1**	**13,0**	**5,34**	**0,027**
Oecismus monedula	**5**	**27**	**I+II**	**27**	**0**	**0**	**0**	**0**	**27,0**	**7,4**	**4,75**	**0,011**
Silo pallipes	**6**	**25**	**I+II**	**25**	**0**	**4**	**0**	**0**	**25,2**	**10,5**	**5,30**	**0,027**
Hydropsyche saxonica	8	20	I+II	20	0	15	5	0	20,4	14,7	5,22	0,106
Philopotamus montanus	4	20	I+II	20	0	0	0	0	19,6	6,9	4,74	0,045
Halesus digitatus	6	18	I+II	18	3	11	1	0	18,2	14,2	6,08	0,157
Hydropsyche fulvipes	4	17	I+II	17	0	4	0	0	17,0	8,7	5,04	0,077
Rhyacophila praemorsa	3	13	I+II	13	0	1	0	0	13,1	6,5	4,54	0,066
Potamophylax latipennis	4	12	I+II	12	4	1	0	0	12,0	8,6	4,91	0,159
Hydatophylax infumatus	2	9	I+II	9	0	0	0	0	9,5	5,8	4,26	0,091
Anomalopterygella chauviniana	3	9	I+II	9	7	0	0	0	9,2	7,0	4,99	0,171

	Types			I+II	III	IV	V	VI	Observed	IndVal from randomized groups		P
	Number of items			89	32	66	36	6	IndVal			
	Avg	Max	Max-Grp							Mean	SD	
Crunoecia irrorata	2	8	I+II	8	0	0	0	0	7,9	4,4	4,29	0,117
Hydropsyche silfvenii	1	7	I+II	7	0	0	0	0	6,7	4,0	3,32	0,105
Wormaldia occipitalis/subnigra	1	7	I+II	7	0	1	0	0	6,6	5,1	4,00	0,168
Limnephilus fuscicornis	1	6	I+II	6	0	0	0	0	5,8	4,6	3,98	0,173
Diplectrona felix	1	6	I+II	6	0	0	0	0	5,6	3,9	3,00	0,152
Silo nigricornis	1	6	I+II	6	0	0	0	0	5,6	3,8	3,84	0,149
Limnephilus extricatus	1	5	I+II	5	0	1	0	0	5,0	4,9	3,91	0,322
Agapetus delicatulus	1	4	I+II	4	0	0	0	0	4,5	3,3	3,23	0,198
Philopotamus variegatus	1	4	I+II	4	0	0	0	0	4,5	3,6	3,91	0,179
Micropterna lateralis	1	4	I+II	4	0	0	0	0	4,5	3,6	3,71	0,208
Adicella reducta	1	4	I+II	4	0	0	1	0	4,3	4,1	3,76	0,273
Notidobia ciliaris	1	4	I+II	4	0	1	0	0	3,9	4,6	3,46	0,489
Plectrocnemia geniculata	1	3	I+II	3	0	0	0	0	3,4	3,2	3,54	0,267
Limnephilus rhombicus	1	3	I+II	3	0	0	0	0	3,1	4,3	3,51	0,517
Enoicyla pusilla	0	2	I+II	2	0	0	0	0	2,2	2,7	3,03	0,470
Synagapetus iridipennis	0	2	I+II	2	0	1	0	0	1,8	3,5	3,97	0,643
Limnephilus centralis	1	2	I+II	2	0	1	0	0	1,8	3,4	3,36	0,618
Tinodes cf. dives	0	1	I+II	1	0	0	0	0	1,1	2,3	2,77	1,000
Micrasema longulum	0	1	I+II	1	0	0	0	0	1,1	2,2	2,49	1,000
Limnephilus flavicornis-Gr.	0	1	I+II	1	0	0	0	0	1,1	2,2	2,69	1,000
Apatania muliebris helvetica	0	1	I+II	1	0	0	0	0	1,1	2,2	2,49	1,000
Beraea pullata	0	1	I+II	1	0	0	0	0	1,1	2,2	2,49	1,000
Lepidostoma hirtum	**19**	**83**	**III**	**1**	**83**	**0**	**3**	**7**	**82,7**	**18,5**	**7,30**	**0,001**
Oecetis testacea	**17**	**80**	**III**	**1**	**80**	**0**	**0**	**2**	**79,9**	**10,1**	**5,39**	**0,001**
Brachycentrus maculatus	**14**	**71**	**III**	**0**	**71**	**0**	**0**	**0**	**71,1**	**9,8**	**5,26**	**0,001**
Mystacides azureus	**17**	**69**	**III**	**1**	**69**	**0**	**0**	**17**	**68,5**	**12,6**	**5,61**	**0,001**
Silo piceus	**14**	**60**	**III**	**4**	**60**	**0**	**4**	**0**	**59,8**	**15,8**	**6,11**	**0,003**
Polycentropus flavomaculatus	**18**	**55**	**III**	**0**	**55**	**0**	**1**	**32**	**54,5**	**11,8**	**5,41**	**0,002**
Lasiocephala basalis	**12**	**54**	**III**	**1**	**54**	**0**	**5**	**0**	**54,4**	**15,1**	**7,21**	**0,003**
Brachycentrus subnubilus	**10**	**49**	**III**	**0**	**49**	**0**	**0**	**0**	**49,3**	**6,2**	**4,38**	**0,002**
Hydropsyche siltalai	**17**	**44**	**III**	**9**	**44**	**1**	**18**	**14**	**44,2**	**20,1**	**5,31**	**0,005**
Athripsodes cinereus	**12**	**36**	**III**	**0**	**36**	**0**	**2**	**24**	**35,7**	**8,2**	**4,59**	**0,004**
Psychomyia pusilla	**10**	**33**	**III**	**0**	**33**	**0**	**1**	**14**	**33,4**	**7,7**	**4,75**	**0,007**
Allogamus auricollis	**6**	**31**	**III**	**0**	**31**	**0**	**0**	**0**	**30,7**	**6,2**	**4,20**	**0,009**
Ceraclea annulicornis	**12**	**30**	**III**	**0**	**30**	**0**	**0**	**28**	**30,2**	**7,3**	**4,50**	**0,004**
Anabolia nervosa	**7**	**29**	**III**	**5**	**29**	**0**	**0**	**0**	**28,7**	**8,2**	**4,41**	**0,009**

	Types			I+II	III	IV	V	VI	Observed	IndVal from randomized groups		P
	Number of items			89	32	66	36	6	IndVal			
	Avg	Max	Max-Grp							Mean	SD	
Micrasema setiferum	**6**	**28**	**III**	**0**	**28**	**0**	**0**	**0**	**28,1**	**4,8**	**4,05**	**0,005**
Athripsodes bilineatus	6	21	III	7	21	0	0	0	21,0	9,7	5,34	0,032
Potamophylax luctuosus	4	20	III	0	20	0	0	0	19,7	6,2	4,57	0,032
Halesus tesselatus	4	19	III	0	19	0	0	2	19,2	6,2	4,22	0,023
Agapetus ochripes	3	14	III	0	14	0	0	0	14,4	5,8	3,87	0,042
Goera pilosa	5	13	III	2	13	2	0	6	13,3	8,9	5,74	0,114
Leptocerus tineiformis	3	13	III	0	13	0	0	0	12,5	3,3	3,47	0,047
Leptocerus interruptus	2	9	III	0	9	0	0	0	9,4	2,9	3,25	0,069
Setodes argentipunctellus	1	6	III	0	6	0	0	0	6,2	2,6	2,94	0,061
Chaetopteryx major	2	6	III	0	6	5	0	0	5,8	6,0	4,44	0,329
Cyrnus trimaculatus	1	5	III	0	5	0	1	0	4,8	3,1	3,63	0,144
Beraeodes minuta	2	4	III	4	4	3	0	0	4,3	7,0	4,51	0,776
Chaetopteryx villosa	12	37	IV	13	9	37	2	0	37,1	26,6	8,15	0,080
Plectrocnemia conspersa	**7**	**31**	**IV**	**5**	**0**	**31**	**0**	**0**	**31,4**	**11,9**	**5,72**	**0,018**
Tinodes unicolor	**6**	**31**	**IV**	**0**	**0**	**31**	**0**	**0**	**30,6**	**8,3**	**4,89**	**0,007**
Drusus annulatus	**7**	**26**	**IV**	**10**	**0**	**26**	**0**	**0**	**25,5**	**12,0**	**5,92**	**0,035**
Tinodes cf. rostocki	3	16	IV	0	0	16	0	0	16,5	5,4	4,31	0,026
Halesus radiatus	8	15	IV	11	6	15	5	2	15,5	15,5	6,02	0,345
Potamophylax latipennis/luctuosus	5	12	IV	3	7	12	3	0	11,6	11,6	5,33	0,366
Rhyacophila tristis	2	10	IV	0	0	10	0	0	10,3	5,2	3,97	0,066
Limnephilus lunatus	3	10	IV	2	0	10	0	1	10,3	8,5	4,63	0,237
Lithax obscurus	2	8	IV	0	0	8	0	0	7,6	4,0	3,54	0,079
Micropterna sequax	1	6	IV	1	0	6	0	0	6,1	4,4	3,44	0,215
Synagapetus dubitans	1	5	IV	0	0	5	0	0	4,5	3,1	3,18	0,154
Melampophylax mucoreus	1	4	IV	0	0	4	0	0	4,0	3,9	3,67	0,286
Mystacides cf. longicornis	1	3	IV	0	0	3	0	0	3,0	2,7	2,95	0,282
Tinodes cf. pallidulus	0	2	IV	0	0	2	0	0	1,5	2,2	2,73	0,613
Ironoquia dubia	0	2	IV	0	0	2	0	0	1,5	2,3	2,57	0,663
Limnephilus affinis-Gr.	0	2	IV	0	0	2	0	0	1,5	2,1	2,17	0,616
Limnephilus bipunctatus	0	2	IV	0	0	2	0	0	1,5	2,2	2,49	0,599
Micropterna nycterobia	0	2	IV	0	0	2	0	0	1,5	2,3	2,57	0,663
Lithax niger	0	2	IV	0	0	2	0	0	1,5	2,2	2,50	0,600
Glyphotaelius pellucidus	0	1	IV	0	0	1	0	0	0,9	2,9	3,67	1,000
Stenophylax permistus	0	1	IV	0	0	1	0	0	0,9	2,9	3,63	1,000
Hydropsyche pellucidula	**9**	**37**	**V**	**3**	**2**	**0**	**37**	**4**	**37,5**	**12,2**	**5,57**	**0,008**
Hydropsyche angustipennis	**4**	**22**	**V**	**0**	**0**	**0**	**22**	**0**	**21,5**	**8,1**	**4,58**	**0,016**
Hydroptila sp.	8	15	V	0	0	13	15	11	15,0	20,8	7,73	0,789
Mystacides nigra	3	12	V	0	4	0	12	2	11,9	6,3	4,45	0,064
Hydroptila vectis	3	11	V	0	0	4	11	0	10,7	5,9	3,99	0,095
Mystacides longicornis/nigra	4	9	V	1	7	0	9	4	9,2	7,7	5,00	0,200
Lype reducta	2	7	V	0	3	1	7	0	7,2	5,8	4,12	0,198

	Types			**I+II**	**III**	**IV**	**V**	**VI**	**Observed**	**IndVal from**		
	Number of items			**89**	**32**	**66**	**36**	**6**	**IndVal**	**randomized groups**		**P**
	Avg	**Max**	**Max-Grp**							**Mean**	**SD**	
Ithytrichia lamellaris	1	7	V	0	0	1	7	0	6,6	4,3	3,54	0,121
Brachycentrus montanus	2	6	V	3	0	0	6	0	5,8	5,0	4,24	0,241
Annitella obscurata	2	5	V	0	1	2	5	0	5,4	5,3	3,36	0,345
Tinodes waeneri	1	3	V	2	1	0	3	0	2,7	4,9	3,54	0,765
Hydropsyche incognita	**19**	**72**	**VI**	**0**	**22**	**0**	**1**	**72**	**71,9**	**11,3**	**5,40**	**0,001**
Hydropsyche contubernalis	**16**	**72**	**VI**	**0**	**0**	**0**	**7**	**72**	**71,7**	**6,6**	**4,86**	**0,001**
Oecetis notata	**13**	**65**	**VI**	**0**	**0**	**0**	**0**	**65**	**65,1**	**5,6**	**3,66**	**0,001**
Allotrichia pallicornis	**9**	**44**	**VI**	**0**	**0**	**0**	**1**	**44**	**44,3**	**4,3**	**3,68**	**0,001**
Cheumatopsyche lepida	**15**	**42**	**VI**	**0**	**33**	**0**	**0**	**42**	**41,7**	**7,7**	**4,77**	**0,001**
Rhyacophila fasciata/dorsalis-Gr.	**18**	**35**	**VI**	**8**	**25**	**4**	**19**	**35**	**35,1**	**22,6**	**4,64**	**0,028**
Athripsodes albifrons	**10**	**35**	**VI**	**0**	**12**	**0**	**4**	**35**	**34,7**	**8,7**	**4,77**	**0,006**
Ceraclea dissimilis	**9**	**34**	**VI**	**0**	**12**	**0**	**2**	**34**	**33,7**	**7,5**	**4,67**	**0,005**
Ceraclea cf. fulva	3	17	VI	0	0	0	0	17	16,7	2,3	2,77	0,034
Ceraclea nigronervosa	3	14	VI	0	1	0	0	14	14,3	3,2	3,18	0,050
Agraylea sp.	3	14	VI	0	0	0	0	14	14,0	2,8	3,14	0,057
Hydropsyche dinarica	2	5	VI	0	0	0	4	5	5,3	5,3	3,90	0,350

the Oesling) in the full range of the quality gradient. This number decreases to only seven species (*Polycentropus flavomaculatus* (Pictet, 1834), *Oecetis testacea* (Curtis, 1834), *Brachycentrus maculatus*, *Mystacides azureus* (Linnaeus, 1761), *Allogamus auricollis* (Pictet, 1834), *Athripsodes bilineatus* (Linnaeus, 1758) and *Ceraclea annulicornis* (Stephens, 1836)) when "reference" sites are selected. However, among the latter species, an increase in the indicator value is only observed for *A. bilineatus* when the most degraded sites are removed.

The number of species in caddisfly assemblages that are characteristic of stream types belonging to the Gutland ecoregion is noticeably reduced (stream types IV and V in particular). Indeed, only *Plectrocnemia conspersa* (Curtis, 1834), *Tinodes unicolor* (Pictet, 1834) and *Drusus annulatus* Stephens, 1837 show relative high affinities for the stream type IV (small sized, mid altitude streams in the Gutland) and only *Hydropsyche pellucidulla* (Curtis, 1834) and *H. angustipennis* (Curtis, 1834) are indicators of the stream type V (mid sized, low and mid altitude streams in the Gutland). If the impacted sites are removed from the analysis, *P. conspersa* and *D. annulatus* show higher indicator values for stream type IV. *P. cingulatus*, which was considered as a characteristic species of the stream type I+II in the Oesling (all sites selected), becomes an indicator species for the best quality sites pertaining to the stream type IV. Only two species (*Lype reducta* (Hagen, 1868) and *Hydroptila vectis* Curtis, 1834) have relative high affinities for the stream type V when the most impacted sites are removed from the selection.

Finally, some species (e.g. *Hydropsyche incognita* Pitsch, 1993, *H. contubernalis* McLachlan, 1865, *Oecetis notata* (Rambur, 1842), *Allotrichia pallicornis* (Eaton, 1873), *Cheumatopsyche lepida* (Pictet, 1834), *Athripsodes albifrons* (Linnaeus, 1758)) have relative high indicator values for the stream type VI (large lowland streams). Nevertheless, these high values have to be weighted by the relative few number of sites available for this stream type. Actually, only six sites belong to the stream type number VI. Among the significant indicator species pointed out for these larger rivers, only *H. contubernalis*, *O. notata* and *A. pallicornis* can be considered as robust indicators for this type since they have high and specific affinities for it. Species like *H. incognita* or *C. lepida* are not specific for these large lowland rivers. Indeed, even if they are predominantly found in the stream type VI, *H. incognita* and *C. lepida* occur also significantly in the stream type III (mid sized, mid altitude streams in the Oesling).

Tab. 4: List of indicator species for different stream types in "reference condition" according to the PCA3. The "Avg" and "Max" columns refer to the indicator values for the given species (average and maximum value); "MaxGrp" is the type identifier for the group with the highest indicator value. The statistical significance of the observed indicator value is tested with a randomization (Monte Carlo) procedure: "SD" is the Standard Deviation; "P" evaluates the statistical significance of the maximum indicator value recorded for given species. The probability of type I error is the proportion of times that the maximum indicator value from the randomized data set equals or exceeds the maximum indicator value from the actual data set. Species are ordered according to the groups they are indicative for (ascending) and by observed indicator value (descending). Significant indicators for a particular stream type (IndVal ≥ 25.0 and p ≤ 0.05) are marked in bold characters.

	Types			I+II	III	IV	V	Observed	IndVal from randomized groups		P
	Number of items			27	10	20	5	IndVal			
	Avg	Max	Max-Grp						Mean	SD	
Glossosoma conformis	**7**	**61**	**I+II**	**61**	**0**	**0**	**0**	**61,2**	**9,8**	**5,61**	**0,001**
Philopotamus ludificatus	**7**	**61**	**I+II**	**61**	**0**	**0**	**0**	**60,6**	**7,7**	**4,63**	**0,001**
Sericostoma personatum/schneideri	**10**	**50**	**I+II**	**50**	**16**	**7**	**0**	**50,2**	**15,3**	**4,56**	**0,001**
Hydropsyche instabilis	**7**	**49**	**I+II**	**49**	**0**	**1**	**2**	**49,0**	**11,8**	**5,31**	**0,001**
Oecismus monedula	**5**	**43**	**I+II**	**43**	**0**	**0**	**0**	**43,0**	**7,4**	**4,70**	**0,001**
Odontocerum albicorne	**7**	**41**	**I+II**	**41**	**0**	**10**	**0**	**40,7**	**11,1**	**4,76**	**0,001**
Philopotamus montanus	3	23	I+II	23	0	0	0	22,5	7,6	5,20	0,030
Hydropsyche fulvipes	3	19	I+II	19	0	2	0	19,1	8,6	5,53	0,048
Rhyacophila praemorsa	2	18	I+II	18	0	1	0	17,6	7,1	4,88	0,047
Philopotamus variegatus	2	15	I+II	15	0	0	0	14,8	5,2	4,11	0,032
Brachycentrus montanus	2	13	I+II	13	0	0	0	13,1	6,1	4,90	0,074
Crunoecia irrorata irrorata	1	8	I+II	8	0	0	0	7,7	5,7	4,31	0,208
Hydatophylax infumatus	1	6	I+II	6	0	2	0	5,9	6,2	4,16	0,426
Potamophylax latipennis	2	6	I+II	6	5	1	0	5,7	7,9	4,65	0,615
Wormaldia occipitalis/subnigra	1	4	I+II	4	0	2	0	4,3	5,8	4,03	0,547
Limnephilus flavicornis-Gr.	0	4	I+II	4	0	0	0	3,7	4,0	3,80	0,406
Synagapetus iridipennis	1	3	I+II	3	0	3	0	2,8	5,2	4,41	0,575
Silo nigricornis	1	3	I+II	3	0	0	0	2,6	5,3	4,26	0,730
Stenophylax permistus	0	2	I+II	2	0	0	0	2,3	4,3	3,89	0,731
Polycentropus flavomaculatus	**10**	**49**	**III**	**0**	**49**	**0**	**0**	**49,3**	**10,1**	**4,88**	**0,001**
Oecetis testacea	**10**	**47**	**III**	**0**	**47**	**0**	**0**	**46,6**	**9,4**	**5,15**	**0,002**
Brachycentrus maculatus	**8**	**44**	**III**	**0**	**44**	**0**	**0**	**43,7**	**10,5**	**6,39**	**0,003**
Mystacides azureus	**10**	**41**	**III**	**0**	**41**	**0**	**0**	**40,6**	**11,1**	**5,59**	**0,004**
Allogamus auricollis	**4**	**37**	**III**	**0**	**37**	**0**	**0**	**37,1**	**7,1**	**5,27**	**0,003**
Silo piceus	**7**	**36**	**III**	**1**	**36**	**0**	**5**	**36,0**	**13,5**	**6,42**	**0,020**
Athripsodes bilineatus	**5**	**30**	**III**	**0**	**30**	**0**	**0**	**30,2**	**10,3**	**6,45**	**0,020**
Ceraclea annulicornis	**6**	**30**	**III**	**0**	**30**	**0**	**0**	**30,1**	**7,8**	**5,25**	**0,009**
Rhyacophila fasciata/dorsalis-Gr.	10	22	III	2	22	4	17	21,7	15,3	3,58	0,060
Halesus tesselatus	3	21	III	0	21	0	0	20,6	6,8	4,64	0,022
Athripsodes cinereus	6	20	III	0	20	0	5	20,1	7,7	4,63	0,030
Setodes argentipunctellus	2	20	III	0	20	0	0	20,0	4,7	4,50	0,006
Anabolia nervosa	4	18	III	1	18	0	0	18,0	8,0	4,88	0,044
Potamophylax luctuosus	3	17	III	0	17	0	2	16,9	6,6	4,77	0,043

	Types			I+II	III	IV	V	Observed	IndVal from randomized groups		
	Number of items			27	10	20	5	IndVal			P
	Avg	Max	Max-Grp						Mean	SD	
Anomalopterygella chauviniana	3	17	III	2	17	0	0	16,6	7,2	4,79	0,051
Agapetus ochripes	1	9	III	0	9	0	0	9,0	7,2	5,33	0,214
Chaetopteryx major	2	9	III	0	9	8	0	8,8	6,3	4,87	0,169
Plectrocnemia conspersa	**7**	**54**	**IV**	**2**	**0**	**54**	**0**	**53,7**	**11,2**	**5,78**	**0,001**
Drusus annulatus	**6**	**47**	**IV**	**5**	**0**	**47**	**0**	**46,9**	**10,6**	**5,50**	**0,002**
Chaetopteryx villosa	8	39	IV	5	7	39	2	39,4	23,2	9,84	0,062
Potamophylax cingulatus	**6**	**27**	**IV**	**19**	**0**	**27**	**0**	**26,6**	**11,3**	**5,37**	**0,026**
Rhyacophila tristis	3	23	IV	0	0	23	0	22,9	6,2	4,64	0,011
Potamophylax latipennis/luctuosus	4	21	IV	1	1	21	3	20,8	10,5	6,00	0,059
Tinodes cf. rostocki	3	21	IV	0	0	21	0	20,6	6,5	4,97	0,028
Tinodes unicolor	4	19	IV	0	0	19	1	18,9	8,4	4,94	0,046
Halesus radiatus	5	15	IV	4	4	15	4	15,2	12,6	5,31	0,217
Synagapetus dubitans	2	15	IV	0	0	15	0	15,0	5,0	4,60	0,063
Melampophylax mucoreus	1	8	IV	0	0	8	0	8,2	5,0	3,88	0,153
Beraeodes minuta	2	6	IV	0	6	6	4	6,1	7,7	4,95	0,508
Tinodes cf. pallidulus	1	5	IV	0	0	5	0	5,0	3,9	3,65	0,177
Lithax niger	1	5	IV	0	0	5	0	5,0	3,9	3,59	0,173
Glyphotaelius pellucidus	0	3	IV	2	0	3	0	2,9	4,6	4,26	0,569
Lype reducta	**3**	**28**	**V**	**0**	**0**	**0**	**28**	**27,9**	**6,8**	**4,87**	**0,006**
Hydroptila vectis	**4**	**26**	**V**	**0**	**0**	**0**	**26**	**26,2**	**6,6**	**4,66**	**0,008**
Hydropsyche saxonica	5	19	V	12	0	3	19	19,0	12,5	5,36	0,106
Annitella obscurata	2	14	V	0	0	0	14	14,1	6,9	4,89	0,088
Mystacides longicornis-Gr.	3	13	V	0	3	0	13	12,9	7,6	5,29	0,105
Tinodes waeneri	2	11	V	0	0	0	11	11,0	5,9	4,43	0,096

Discussion

Correspondence between ecological areas and caddisfly assemblages

The broad landscape classification tested in this study, even at the scale of a small country like Luxembourg, only captures a slight amount of variation in the composition of caddisflies. Indeed, traditional ecological areas of Luxembourg (i.e., the Oesling and Gutland main ecoregions and the Minette basin sub-ecoregion) were not well separated on the ordination (PCA1, Fig. 2). However, the separation between the average plotting positions of the correlation circles corresponding to the Oesling and Gutland classes was evident. The mean plotting position of the Minette basin ellipse was slightly separated from the other ones but all sites of this geographical class are included in the Gutland region. In consequence, only the separation between the two main ecological areas in Luxembourg (i.e. Oesling and Gutland) can be considered as meaningful according to caddisfly assemblages. The relative low performance of the stratification by ecoregions was also observed in several countries all over the world (e.g. Gerritsen *et al*. 2000, Marchant *et al*. 2000, Sandin & Johnson 2000, Feminella 2000, Snelder *et al*. 2004). On the contrary, Moog *et al*. (2004) consider that the ecoregion concept was confirmed as a valuable tool for the prediction of Austrian river faunas. Nevertheless, the authors suggest to divide large ecoregions into smaller geographic units, which based on ecological knowledge and theory, are expected to differ in their species composition. According to Hawkins *et al*. (2000), Snelder *et al*. (2004) and Lorenz *et al*. (2004), the unaccounted-for zonation of rivers and the unaccounted-for causes of biological variation at different spatial scales are among the more likely reasons explaining the relative poor performance of ecoregion classifications.

Performance of the stream typology relative to the classification based on the ecological areas

Stream dimension, elevation and geology are the three key typological descriptors, which enable to clearly distinguish the six stream types defined in Luxembourg based upon a combination of classification and ordination procedures (Ferréol *et al*. 2005). The particularity of this typology is the coincidence between environmental gradients such as the mineralization of the water (related to the geological distinction between the north and the south of the country), the elevation and the two main ecological regions (i.e., Oesling and Gutland). In consequence, the stream typology of Luxembourg can be assimilated to a partition of these two main ecological areas nested by the catchment's size gradient. Thus, there is a close correspondence between traditional geographical areas of Luxembourg on the one hand, and the stream typology on the other hand. Therefore, the clear enhancement of the performance of the stream typology in comparison to the ecological area classes (compare Fig. 3 and Fig. 2), in terms of the variation in caddisfly compositions captured by the classification, is not surprising. Indeed, the importance of the longitudinal zonation in streams has not to be demonstrated any more (e.g. Illies & Botosaneanu 1963, Vanotte *et al*. 1980, Wright *et al*. 1984, Botosaneanu 1988, Wasson 1989, Wiberg-Larsen *et al*. 2000). In Germany, Lorenz *et al*. (2004) considered the size gradient expressed as catchment size, stream width, or distance to source, as a prevailing "typologically relevant" parameter to complement ecoregions and explain the composition of stream fauna. In the heterogeneous landscape of the Mid-Atlantic Highlands (USA), Waite *et al*. (2000) observed that classification strengths by ecoregions increased if sites were previously stratified by stream order. They concluded that the macroinvertebrates seemed to respond primarily to slope and stream order and then to the landscape factors summarized by ecoregions. Wiberg-Larsen *et al*. (2000) found that Trichoptera species richness and assemblage composition in Danish streams primarily show a strong association with stream order, width and slope, and secondarily with presence / absence of riparian forest. These results suggest that landscape-scale classifications can only provide a general representation of the spatial patterns in invertebrate assemblages and cannot be used reliably to predict characteristics for a specific site because instream physical habitat becomes homogeneous and distinctive at relatively small spatial scales (Snelder *et al*. 2004).

Despite the comparatively small number of near-reference sites available, relatively distinct clusters can be distinguished according to their caddisfly assemblages (PCA3: Fig. 4). Besides the overall better separation of clusters with these selected sites, the improvement of the classification is especially obvious for the stream types IV and V (respectively, small sized mid altitude streams in the Gutland and mid sized low and mid altitude streams in the Gutland). The latter stream types are included in the Gutland ecological area where human-induced perturbations are more likely to occur (i.e., more densely populated area, more pressures from industry and agriculture). Thus, these results suggest that the mixing of reference and nonreference sites in the previous ordination (PCA2: Fig. 3) was the principal reason explaining the absence of distinct caddisfly assemblages between these two stream types. Although Waite *et al*. (2000) and McCormick *et al*. (2000) analyzing respectively invertebrate and fish assemblages, in the Mid-Appalachian Highlands (USA) have shown similar classification strength results from either randomly selected sites or only reference sites, a perturbation gradient is likely to mask real discontinuities and typical invertebrate assemblages present in different classes (Stroot 1991, Verdonschot 1995, Lorenz *et al*. 2004). Therefore the improvement of the relationship between caddisfly assemblages and the classification based on the stream typology and the selection of near-reference sites, as observed in our results, is not really surprising.

However, despite the selection of the near-reference sites, stream types I and II (respectively, small high altitude and small mid altitude streams, both in the Oesling) can still not be distinguished according to their caddisfly communities. The elevation gradient, which enables to separate these two stream types on the basis of mesological variables (see Tab. 1), does not involve distinct caddisfly assemblages. According to Rundle *et al*. (1993) and Brewin *et al*. (1995) who analyzed macroinvertebrate communities in the Himalaya (Nepal), the altitude was the most important factor explaining the separation of stream assemblages. Obviously, the altitudinal range of Luxembourg (i.e., 150 – 550 m.) is not in the same size order than those of the Nepalese Himmalaya (i.e., 600 – 3800 m.). The elevation gradient observed in Luxembourg is most likely not sufficient to induce different adaptations of caddisfly species and moreover the appearance of distinct communities. This trend is not exclusive to Trichoptera since communities composed of other benthic invertebrate groups were also rather similar within these two stream types (Dohet, unpublished results). Thus, according to the benthic invertebrate assemblages, the merging of the stream types I and II could be proposed in order to achieve greater accuracy and precision and, hence, more reliable assessments of the biological conditions.

Implications for the design and use of biological assessments in aquatic ecosystem management

The usefulness of macroinvertebrate assemblages for monitoring water quality and biological integrity depends in part on our ability to distinguish human impacts from natural variability (Waite *et al*. 2000). Classification is thus a critical component in many bioassessment program designs to assess the health of streams (Hawkins *et al*. 2000). However, synthesizing the results that emerged from several papers describing variation in aquatic biota at landscape spatial scales, Hawkins *et al*. (2000) concluded that large-scale regionalizations, if used alone to specify expected conditions, will likely have limited use in biotic assessment, where it is critical to specify expected conditions as accurately and precisely as possible. We agree with this opinion, but our results also suggest that a broad scale classification based on geographical areas can account for sufficient variation among biotic data, if this classification is nested by a stream size gradient (e.g. stream order, catchment size, distance to source). Waite *et al*. (2000) also argued that ecoregion/catchment in combination with other variables such as stream order, stream gradient, or other physical stream features may be useful tools to help partition the variance of biological assemblages and thus to improve our understanding and interpretation of stream systems. We also acknowledge their arguments that environmental classifications may need to account for the striking shift that often occurs from headwaters to mid-order streams in stream characteristics and resulting biological assemblages.

The results of this investigation also suggest that an iterative process, which consists in using relevant information, including prior knowledge and classification, measured data, and exploratory statistical analysis, is an appropriate strategy to achieve the most effective classifications (Gerritsen *et al*. 2000). Thus, besides classifications that can be done either with physical features (a priori) or by analysis of biological data without physical features (a posteriori), a 3rd alternative consists to test and refine physically derived classes with subsequent analysis of biological data (Gerritsen *et al*. 2000). This 3rd alternative, adopted in this study, is probably the best-suited strategy to attain water quality goals and fulfill the requirements of the EU water framework directive.

Characteristic indicator species of Trichoptera in the different stream types

The most robust classification that emerged from our results (i.e., stream typology with the stream types I and II merged together) was used to identify characteristic caddisfly communities by the means of the INDVAL method.

The species that show high preferences for small high and mid altitude streams in the Oesling (i.e., *Sericostoma schneideri/personatum*, *Glossosoma conformis*, *Hydropsyche instabilis*, *Odontocerum albicorne*, *Agapetus fuscipes*, *Philopotamus ludificatus*, *Potamophylax cingulatus*, *Oecismus monedula* and *Silo pallipes*) are all common inhabitants of small headwater streams in continental Europe (e.g. Verneaux 1973, Botosaneanu & Malicky 1978, Stroot 1984, Higler & Solem 1986, Pitsch 1993, Edington & Hildrew 1995). However, species like *O. albicorne* or *S. pallipes* are often considered as eurytopic species (Verneaux 1973, Botosaneanu & Malicky 1978, Stroot 1984, Dohet *et al*. 2002). In our dataset, despite a higher affinity for the small high and mid altitude streams in the Oesling, the latter species are not exclusive for this stream type and show some affinities for other stream types as well (see Tab. 3). Larvae of *Sericostoma schneideri* Schneider, 1845 and *S. personatum* (Spence in Kirby & Spence, 1826) are difficult to distinguish from each other, especially early instars larvae. On the contrary, the adults can be identified relatively easily. Since, our analyses are based on larval identification, the two *Sericostoma* species were not separated. However, some captures of adults tend to indicate that *S. personatum* is more restricted to headwater streams whereas *S. schneideri* predominantly occurs in lower reaches (small to middle-sized streams). This succession of the two *Sericostoma* species along the longitudinal gradient is confirmed in the literature (e.g. Pitsch 1993, Robert 1996, Gerecke *et al*. 2005). This trend is revealed by the different allocations of the indicator values of the complex *S. schneideri/personatum* for the stream type I+II on the one hand and the stream type III on the other hand (Tab. 3). Among the species that remain significant indicators of the stream type I+II when only near-reference sites are selected, only *P. ludificatus*, *O. monedula* and to a lesser extent *G. conformis* are characterized by higher indicator values. Indeed, the indicator values for *P. ludificatus* and *O. monedula* significantly increase from 31 to 61 and 27 to 43, respectively (Tab. 3 and 4). Thus these species must be considered as true indicators of the small high and mid altitude streams in the Oesling in the absence of anthropogenic alterations. Pitsch (1987, 1993) and Moog (1995) consider these taxa as very sensitive to organic pollution and other disturbances.

In the same stream size class, but in the other main ecological area (i.e., the Gutland), the species that have high affinities for the stream type IV, are rather scarce. Actually, only *Plectrocnemia conspersa*, *Tinodes unicolor* and *Drusus anulatus* are significant indicators and among them, only *T. unicolor* is present exclusively in this stream type. However, similarly to the small stream type in the Oesling, the indicator value of *P. conspersa* and *D. annulatus* clearly increases when only near-natural sites are selected (i.e. from 31 to 54 and from 26 to 47 for *P. conspersa* and *D. annulatus*, respectively). Unexpectedly, *P. cingulatus*, which showed a high preference for small high and mid altitude streams in the Oesling when the whole set of data was used, becomes a significant indicator of small mid altitude streams in the Gutland when the dataset is restricted to near-reference sites. Whatever, these three species (i.e., *P. conspersa*, *D. annulatus* and *P. cingulatus*) may be considered as important indicators of minimally disturbed small mid altitude streams in the Gutland area. Concerning *D. annulatus*, Moog (1995) attributes a saprobic valence range (reflecting the tolerance an organism has for organically rich substances) qualified as xenosaprobic to oligosaprobic. *P. conspersa* has a relative higher range of tolerance to organic pollution (from xenosaprobic to α-mesosaprobic zone). *P. cingulatus* has affinities for the xenosaprobic to β-mesosaprobic zone. Compared to other *Potamophylax* species, Higler & Solem (1986) consider that *P. cingulatus* has a preference for smaller upper courses and more stenotherm conditions.

When considering mid sized, mid altitude streams in the Oesling (stream type III), we notice a clear decrease in the number of significant indicator species in parallel with a clear decrease of their indicator values, when we restrict the data to near-natural sites. The only exception to this general trend is *Athripsodes bilineatus*, which shows a higher index when best quality sites are selected in comparison to the combination of reference and nonreference sites (compare Tab. 3 and 4). Graf *et al*. (2006) assign *A. bilineatus* to hyporhithral and epipotamal zones along the longitudinal stream gradient. However, this taxon is not considered as a sensitive species. According to Moog (1995), *A. bilineatus* is categorized as a "β-mesosaprobic" species. An analogous observation can be made for the stream type V (mid sized, mid altitude streams in the Gutland). Indeed, *H. pellucidula* and *H. angustipennis*, which are typical species of the stream type V in the whole range of anthropogenic disturbances are replaced by *Hydroptila vectis* and *Lype reducta* if the best quality sites available for these stream type are selected. Both species are categorized as "β-mesosaprobic" species and *L. reducta* is considered as a habitat specialist (xylobiontic) species (Moog 1995, Graf *et al*. 2006). More generally, the decrease of characteristic species and associated indicator values observed in large stream types (i.e. types III in the Oesling and type V in the Gutland) in comparison to small stream types (i.e. types I+II in the Oesling and type IV in the Gutland) is likely to be a consequence of the multiple anthropogenic pressures that affect large parts of European rivers for decades. Human-generated disturbances such as intensive agriculture, industry or deforestation more particularly concern large streams flowing in the lowlands and often are associated with more densely populated areas. In those regions, anthropogenic disturbance is widespread and pristine catchments or sub-catchments are consequently extremely difficult to find (e.g. Wasson 2001, Lorenz *et al*. 2004, Nijboer *et al*. 2004). Straightening of streams, dam construction, the disconnection of the stream from its floodplain and alteration of riparian structure and vegetation led to a loss of several habitat types and associated species (Zwick 1992). Therefore, it is not so surprising that we found a comparatively lower number of characteristic species in the large stream types (i.e., types III and V), particularly when indicator species analyses are restricted to best available quality sites for the different stream types. These findings have probably to be compared to the extinction rate of numerous species characteristic of the lower reaches, over the last decades. Indeed, Stroot (1989), examining the preferred habitats of the most threatened Trichoptera species, has shown that besides different types of ponds and swamps with rich vegetation, and spring sources, the lower reaches and the large lowland rivers, accounted for the most endangered habitats. In comparison, the situation of species inhabiting small and mid sized streams was relatively less critical, at least at the scale of the European community. In this context, it should be emphasized that species like *Agapetus laniger* (Pictet, 1843), *Tricholeiochiton fagesii* (Guinard, 1879), *Chimarra marginata* (Linnaeus, 1767), *Ecnomus tenellus* (Rambur, 1842), *Cyrnus flavidus* McLachlan, 1864, *Neureclipsis bimaculata* (Linnaeus, 1758), *Micrasema longulum* McLachlan, 1876, *M. minimum* McLachlan, 1876, *Limnephilus sparsus* Curtis, 1834, *Stenophylax permistus* McLachlan, 1895, *Athripsodes leucophaeus* (Rambur, 1842), *Ceraclea nigronervosa* (Retzius, 1783), *Leptocerus interruptus* (Fabricius, 1775), *L. tineiformis* Curtis, 1834 or *Setodes argentipunctellus* McLachlan, 1877, which were considered as relatively abundant and/or widespread species in the lower part of Luxembourg's rivers (Hoffmann 1970, Schrankel *et al*. 2002) are really endangered species or even have completely disappeared during the last decades. Among them, some species were probably very sensitive to human-induced alterations. Trichoptera assemblages observed at the present time in large lowland rivers from Luxembourg are mainly composed of relatively euryecious species that have resisted until now to the overall anthropogenic pressures of different types that predominantly affect this kind of ecosystems. By definition, those species have relative broad environmental requirements and are not likely to be exclusive for one or another stream type (i.e., their indicator values will be very low).

For similar reasons, no sites belonging to the largest stream type described in Luxembourg (stream type VI) can be considered as near-reference. Species that appear as characteristic of this large lowland river system must be weighted by the fact that only a few sites were sampled for this stream type (see Tab. 3). Taking into account this reservation, we may notice that several species occurring in this large lowland river are not found elsewhere. This is particularly the case for *Hydropsyche contubernalis*, *Oecetis notata* and *Allotrichia pallicornis*, which are practically exclusive for this stream type in Luxembourg. *Hydropsyche incognita*, *Cheumatopsyche lepida*, *Athripsodes albifrons* and *Ceraclea dissimilis* (Stephens, 1836) may be considered as indicators of the lower sections of rivers, whatever they are in one or another ecoregion. Indeed, those species have high affinities for both largest stream types in the Oesling and the Gutland geographical areas (Tab. 3).

It was already pointed out that many species are rare in the sense that they are present in only a small % of collections or represent a very low proportion of the total abundance measured at the whole community level. In contrast, there are also several common taxa that are characterized by broad geographic distributions and that occur in a wide variety of streams. Among the most widespread species of the Trichoptera assemblages observed in Luxembourg, *Hydropsyche siltalai*, *Chaetopteryx villosa* and *Rhyacophila dorsalis/fasciata*-Gr. show affinities (i.e., indicator values > 0) for most of the stream types described in the present study. The eurytopic features of those species were also demonstrated in different biocenotic investigations (e.g. Verneaux 1973, Stroot 1984).

Conclusions

Hawkins and Norris (2000) synthesized the results of a dozen of papers describing variation in aquatic biota at a landscape spatial scale. They concluded that even if ecoregion classifications accounted for significantly more variation in biotic assemblages than would be expected by chance, the amount of biotic variation related to landscape features was often rather weak. These authors put forward the following explanations for this poor relationship: (1) taxa can vary independently and continuously over environmental gradients; consequently, classifications can create artificial discontinuities that do not exist in reality; (2) there can be a large within-class biological heterogeneity, not accounted for by the classifications (incomplete sampling, high heterogeneity among sites, proximity or dispersal effects, local habitat features,…); (3) biotic assemblages are composed of many common species, which occur nearly everywhere and will potentially mask real biological differences among sites. On the contrary, many species are very rare. They are restricted to very specific ecological conditions and contribute little to the discrimination of groups.

The results presented in this paper confirm that the concept of ecoregion classification, even at the scale of a small country like Luxembourg, is not sufficiently strong to warrant its use alone as a classification tool for the evaluation of the biological assemblages (exemplified here by the Trichoptera communities). However, if these geographical classes are nested with variables expressing the longitudinal stream gradient (e.g. stream order, catchment area, distance to source), a clear improvement of the separation of classes can be observed on the reduced multidimensional space, indicating distinct Trichoptera assemblages in the ordination diagram. The relationship between the classification used in the present study (i.e., typology of streams) and other groups of invertebrates or other biological elements (e.g. phytobenthos, macrophytes, fish) has to be verified in order to allow for sensitive and accurate bioassessments. We consider that robust physical classifications are necessary for water management purposes especially because they are easily understood and communicated. The relationship between a priori classifications and biological assemblages might be improved if we focus on those taxa, which have both narrow ecological requirements and intermediate abundances (i.e, not the too rare or the too common species). The present study suggests that those species are few. However, if they are selected for bioassessment, an improvement of the discrimination between physical classes along with a decrease of the heterogeneity within physical classes might be expected.

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Spatial and temporal distribution of Trichoptera larvae in the Mirusha River (Kosova)

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Abstract

In this paper the spatial and temporal distribution of Trichoptera larvae in the Mirusha River (Kosova) was studied. Surber samples were taken at six selected stations two times per month during a one-year period.

The abundance of Trichoptera larvae varied greatly in space and time. Three different families of Trichoptera were found (Rhyacophilidae, Hydropsychidae and Limnephilidae) with 10 taxa in total. The percentage of Trichoptera in overall macrozoobenthos invertebrate density and 'standing crop' biomass was calculated as well.

Introduction

Trichoptera, or caddisflies, comprise one of the most diverse aquatic insect orders. The larval stages are found in lakes, rivers, and streams and are important components of food webs in these freshwater ecosystems (Resh and Rosenberg 1984). Almost 12,000 caddisfly species, belonging to 45 families and about 600 genera, have been described from all faunal regions, but it has been estimated that the world fauna may contain as much as 45,000 species (Schmid 1984).

Trichoptera investigations in Kosova are mainly sporadic and mostly included within general studies of benthic macroinvertebrates.

The Mirusha River catchment is located in the western part of Kosova. The total length of the river is about 29 km, situated along the borders of the Black Sea, Aegean and Adriatic Sea catchments.

The aim of this study was to explore spatial and temporal distribution patterns along the river and throughout the year. The percentage of Trichoptera larvae with respect to the overall macroinvertebrate fauna was also determined at selected stations.

Material and Methods

Quantitative samples were taken with a Surber sampler (30 x 20 cm, 600 cm^2) during 1989 - 1990. Additional samples were taken during 2001. The criteria for choosing sampling stations were: type and slope of the river bad, altitude and vegetation structure. The collected material was preserved in 4 % formaldehyde. In the laboratory, the material was sorted out and the larvae of Trichoptera were identified and transferred to 75% ethanol. The material was determined at the Department of Biology (University of Prishtina - Kosova) with continuous assistance by experts from Institute of Zoology of the Bulgarian Academy of Sciences.

Results

The investigations at six selected stations along the Mirusha River yielded 10 taxa of Trichoptera belonging to three families (Table 1).

At station M1 seven taxa of Trichoptera were found. The most frequent taxa per surface unit for this station is *Hydropsyche sp*., which is present mostly

Table 1. Distribution of species of Trichoptera (larvae) at six selected stations of the Mirusha River.

	Stations					
Taxa	*M1*	*M2*	*M3*	*M4*	*M5*	*M6*
Rhyacophilidae						
Rhyacophila nubila	+	+				+
Rhyacophila sp. (gr. *vulgaris*)	+	+				+
Rhyacophila sp.						+
Hydropsychidae						
Hydropsyche sp. (gr. *guttata*)	+	+	+	+	+	+
Hydropsyche sp. (gr. *pellucidula*)	+	+		+	+	
Hydropsyche sp. (gr. *instabilis*)	+	+		+	+	+
Hydropsyche sp.	+	+	+	+	+	
Limnephilidae						
Limnephilidae gen. sp.		+				
Stenophylax sp.		+				
Potamophylax sp.	+	+				

in summer – autumn. *Hydropsyche sp.* (gr. instabilis) was present throughout all seasons but it showed the greatest density during July. *Rhyacophila nubila,* (Zetterstedt, 1840) *and Rhyacophila sp*. (gr. vulgaris) are present at low densities during winter-spring.

At station M2 *Rhyacophila sp.* (gr. vulgaris) and *Rhyacophila nubila* are present in all seasons but in small numbers. *Hydropsyche sp.* (gr. guttata) reaches high abundances during spring. *Hydropsyche sp.* (gr. pellucidula) and *Limhephilidae gen. sp.* were found only two times at this station in March and April. *Hydropsyche sp.* (gr. instabilis) is present in all seasons but most frequently during summer. Dense populations of *Hydropysche sp.* are reached during the end of the summer and during the autumn. *Stenophylax sp.* and *Potamophylax sp.* were found only once in very small numbers per surface unit.

Only two taxa were found at station M3 during summer and autumn: *Hydropsyche sp.* (gr. guttata) and *Hydropsyche sp.*.

At station M4 four taxa of family Hydropsychidae are present. *Hydropsyche sp.* (gr. instabilis) is scarce. *Hydropsyche sp.* (gr. guttata) is sub-dominantly present during all seasons. *Hydropsyche sp.* (gr. pellucidula) and *Hydropsyche sp.* are present almost in equal numbers but they differ in their seasonal distribution. The first one is present during winter-spring, the second during summer-autumn.

Four taxa of Trichoptera were found at station M5. *Hydropsyche sp.* (gr. guttata) and *Hydropsyche sp.* are both subdominant whereas *Hydropsyche sp* (gr. guttata) is present continually during the whole year except March. *Hydropsyche sp.* (gr. pellucidula) is present during the end of the winter, during the summer and during spring. *Hydropsyche sp.* (gr. instabilis) and *Hydropsyche sp.* were not found in spring.

Six taxa were found at station M6. *Rhyacophila nubila* is present at low abundances during all seasons except winter. *Rhyacophila sp.* (gr. vulgaris) is present during May and October, and *Rhyacophila sp* during June, October and December. *Hydropsyche sp*. (gr. guttata) is the most abundant Trichoptera taxon at this station. *Hydropsyche sp.* (gr. instabilis) is present at low densities during spring-summer whereas *Hydropsyche sp*. is present exclusively during autumn.

The mean percentage of Trichoptera with respect to overall macrozoobenthos density of the Mirusha river sampling sites was 14.1 % with specific stations ranging from 0.85 % (station M3) to 42.28 % (station M5) (Fig.1).

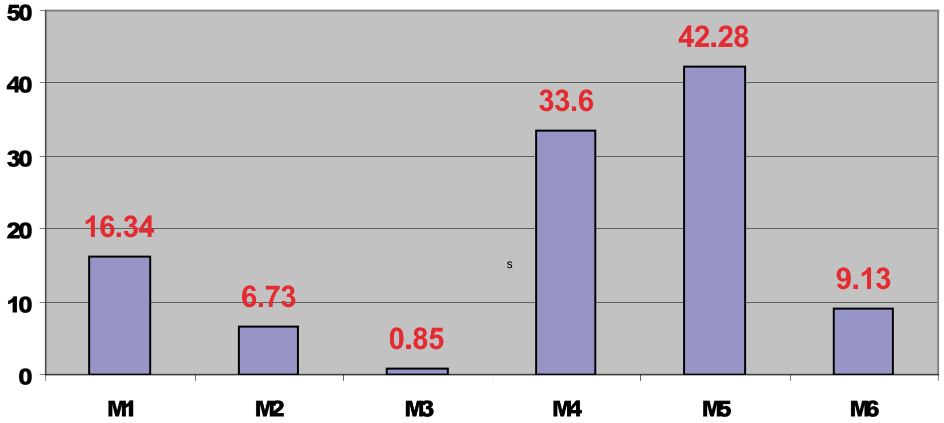

Fig. 1: The percentage of Trichoptera larvae with respect to overall macrozoobenthos density at six selected stations of the Mirusha River.

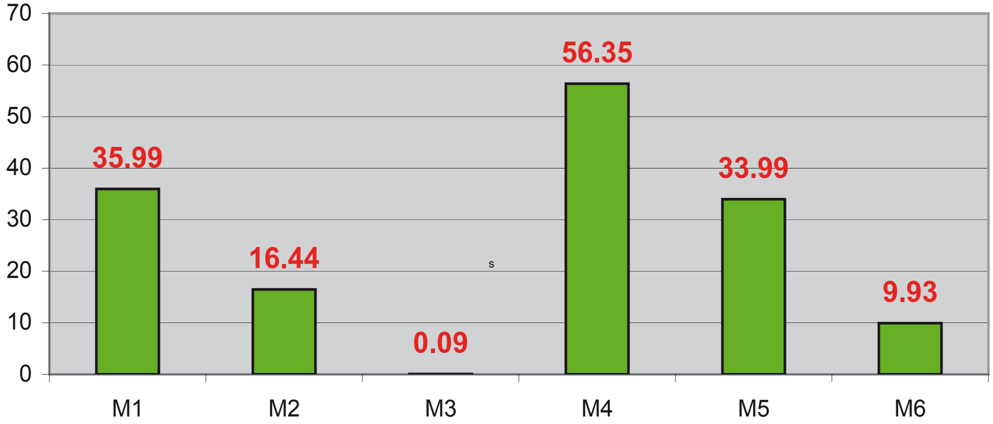

Fig 2: Percentage of Trichoptera larvae in terms of 'standing crop' biomass of overall macrozoobenthos at six selected stations of the Mirusha River

The mean percentage in terms of 'standing crop' biomass of overall benthic invertebrates was 16.8 % with stations ranging from 0.09 % (station M3) to 56.35 % (station M4) (Fig. 2).

Discussion and Conclusions

In the present study the contribution of Trichoptera within overall macrozoobenthos was up to 14.1 % in terms of density and 16.8 % in terms of 'standing crop' biomass. This is in agreement with other similar studies. For example, Micha (1970) reported that in a Belgian river Trichoptera constituted about 20% of total biomass of all invertebrates per surface unit. The percentage of 16.8 % for Trichoptera in Mirusha River would be even higher when Gastropoda were omitted which were measured with shell.

Among taxa identified genus Hydropsyche made up the most important fraction of macrozoobenthos. Species of this genus were present all over the year, which is in agreement with other similar investigations (Avdyli, 1988, Filipovic, 1968).

Highest taxa richness was observed at station M2 (nine taxa) while at station M3 only two taxa were found. The structure of other benthic invertebrate groups at station M3 was very poor as well. The reason for this are uniform climate conditions during the year and especially relatively constant water temperature (23 – 25 ºC) throughout all the seasons.

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Limes norrlandicus - a natural biogeographical border for caddisflies (Trichoptera) in Sweden

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Abstract

Of the 222 known Trichoptera species in Sweden most species are found all over the country, 25 species have a southern distribution while 53 are mainly in the north. The border "Limes Norrlandicus" is mainly used for botanical purpose but can also be regarded as a natural northern border for caddisflies from southern areas and a natural southern border for caddisflies living in the northern part of Sweden.

Introduction

H. D. J. Wallengren was the first person who tried to give a complete compilation of what was known about the caddisflies in Sweden at the end of the 19th century. He knew 166 species in Scandinavia, i.e. Sweden and Norway together. Wallengren (1884, 1890, 1891) already described some of the Swedish caddisflies as living in the south of Sweden while others were found only in the northern parts of the country.

We didn't get a checklist of the Swedish caddisflies until 1942, when K.-H. Forsslund and Bo Tjeder listed the 208 species distributed in the 30 Swedish fauna provinces. Forsslund (1953) supplemented their check-list and the number of known Swedish Trichoptera increased to 211 species.

Svensson & Tjeder (1975) revised the Swedish check-list including all Trichoptera species known in NW Europe. The Trichoptera species known in Sweden were at that time 216. The known Swedish Trichoptera species had 1988 increased to 219 when the distribution in the northern Swedish provinces also was presented (Gullefors 1988). Today the number of Swedish caddisfly species is 222 (Gullefors 2002).

The knowledge of the distribution areas for some species is not complete but the checklist of today shows a clear pattern for most of the 222 species. The majority of the Swedish caddisflies (151) can be found almost all over the country. Twenty five species have been collected mainly in the southern provinces. Fifty three species have a northern distribution (Tabs. 1-3), of those are, however, 13 species widely distributed in other parts of Europe. The northern distribution in Sweden of these species must be further investigated. They might be overlooked or the southern provinces may not have suitable habitats for these species. Several of the species must be regarded as genuine northern species and are also reported from a few countries on the continent.

Limes norrlandicus

The pattern that can be distinguished for the southern living species shows that their northern peripheral zone usually doesn't cross the border called Limes norrlandicus (Fig. 1). This border was originally invented by botanists identifying the distribution of Swedish plants. Limes norrlandicus has its counterpart in the Limes labradoricus in Canada.

Limes norrlandicus divides the northern boreal forests and alpine areas from the southern part of the country mainly consists of agricultural land and mixed forests. Limes norrlandicus isn't a sharp border but should be regarded as a transition zone. Limes Norrlandicus starts in Oslo in Norway and goes through the southern part of the province of

Fig. 1

Fig. 2

Fig. 3

Fig. 4

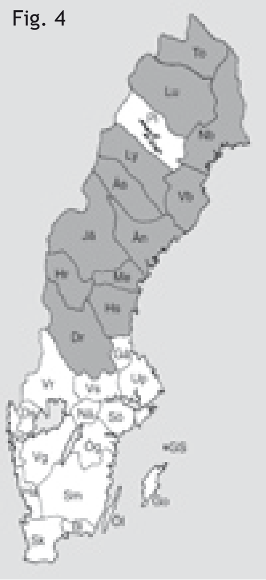

Fig. 1: The border Limes norrlandicus in Sweden divides the northern boreal forests and alpine areas from the southern part of the country mainly consists of agricultural land and mixed forests.

Fig. 2: The Limes norrlandicus acts as a northern border for the distribution area of Trichoptera species *Ecnomus tenellus*.

Fig. 3: The distribution area of Trichoptera species *Leptocerus tineiformis*.

Fig. 4: The Trichoptera species *Anabolia concentrica* can be regarded as a characteristic species for those living north of the Limes norrlandicus.

Värmland, the provinces of Närke, Västmanland and southern Dalarna to the province of Gästrikland (Sjörs 1967, 1999).

Whether Limes norrlandicus also crosses the province of Hälsingland isn't clear, but many southern species follow the Swedish coast into the province of Hälsingland. Limes norrlandicus is also a southern border for northern species.

For some of the Trichoptera species Limes norrlandicus clearly act as a border between northern and southern living species, i.e. for example the southern species *Ecnomus tenellus* (Fig. 2) and *Leptocerus tineiformis* (Fig. 3) and the northern species *Anabolia concentrica* (Fig. 4).

Discussion

Limes norrlandicus is a pronounced climatological and biogeographical border for many plants from the south *(Quercus robur* (Oak), *Fraxinus excelsior* (Ash) and *Corylus avellana* (Hazel)) and birds *(Strix aluco* (Tawny owl) and *Picus viridis* (Green woodpecker). The plants *Lactuca alpina, Betula nana* and *Sparganium hyperboreum* and the birds *Fringilla montifringilla* (Bramling), *Lanius excubitor* (Great grey shrike) and *Lagopus lagopus (Willow* grouse) have Limes norrlandicus as a southern border. Svensson (1992) has in his study of adult gyrinids (Coleoptera) shown that the border is also valid for the northern living species *Gyrinus opacus* Sahlberg. The distribution areas of the two studied southern species, G. *natator* and G. *substriatus*, cross the Limes norrlandicus.

The distribution of the listed caddisflies is based on the findings in Sweden. I believe that some species could be missing or at least not recorded in the south of Sweden due to activities in the landscape concerning land use, changes of air- and water conditions, influences by human activities etc. or do they simply lack suitable habitats for their development? Some of the species that Wallengren (1891) didn't record at all or only recorded as rare at some small local

Tables 1-3: Caddisfly species with their main distribution areas in North and South Sweden and data about their distribution in Europe. Data from Sweden are taken from Gullefors (2002, 2003, 2004, 2005) and data about European distribution are from Wiberg-Larsen (2004).

Table 1: Forty species with a northern distribution in Sweden:

Country designations: SE = Sweden, NO = Norway, Fl = Finland, EE = Estonia, LA = Latvia, DK = Denmark, UK = United Kingdom, DE = Germany, PL = Poland, A = Austria, BU = Bulgaria, SLK = Slovakia, CZ = Czech Republic, RO = Romania, SLN = Slovenia, FR = France

Species	**Distribution in Europe:**
Glossosoma nylanderi McLachlan 1879	SE, NO, FI
Oxyethira boreella Svensson & Tjeder 1975	SE, FI
Oxyethira ecornuta Morton 1893	SE, FI, LA
Oxyethira klingstedti Nybom 1983	SE, FI
Oxyethira mirabilis Morton 1904	SE, NO, FI, LA, UK, FR
Plectrocnemia conjuncta Martynov 1914	SE, FI, EE, PL
Arctopsyche ladogensis (Kolenati 1859)	SE, NO, FI, LA
Agrypnetes crassicornis McLachlan 1878	SE, FI, EE, UK
Agrypnia colorata Hagen 1873 / *Agrypnia principalis* (Martynov 1909)	SE, FI
Agrypnia czerskyi (Martynov 1924)	SE, FI
Agrypnia sahibergi (McLachlan 1880)	SE, NO, FI
Micrasema gelidum McLachlan 1876	SE, NO, FI, EE
Apatania dalecarlica (Forsslund 1930)	SE
Apatania forsslundi Tobias, 1981	SE
Apatania hispida (Forsslund 1930)	SE, NO, FI
Chaetopteryx sahibergi McLachlan 1876	SE, NO, FI, EE, PL, RO
Brachypsyche sibirica (Martynov 1924)	SE, FI
Anabolia concentrica (Zetterstedt 1840)	SE, NO, FI, EE, LA, RO
Anabolia laevis (Zetterstedt 1840)	SE, NO, FI, EE, LA, PL, RO, FR
Arctopora trimaculata (Zetterstedt 1840)	SE, NO, FI, EE
Asynarchus contumax McLachlan 1880	SE, NO, FI
Asynarchus impar McLachlan 1880	SE, NO, FI
Asynarchus lapponicus (Zetterstedt 1840)	SE, NO, FI, A, BU, RO
Asynarchus thedenii (Wallengren 1879)	SE, NO, FI
Grammotaulius signatipennis McLachlan 1876	SE, NO, FI, EE, LA, PL
Lenarchus bicornis (McLachlan 1880)	SE, FI, EE, PL
Lenarchus productus (Morton 1896)	SE, NO, FI
Limnephilus algosus (McLachlan 1868)	SE, NO, FI, DE, A, SLK, CZ
Limnephilus diphyes McLachlan 1880	SE, NO, FI, EE, SLK, CZ
Limnephilus dispar McLachlan 1875	SE, NO, FI, EE, LA, DK, DE, PL
Limnephilus externus Hagen 1861	SE, NO, FI, LA, DE, PL
Limnephilus femoralis Kirby 1837	SE, NO, FI
Limnephilus feinoratus (Zetterstedt 1840)	SE, NO, FI, EE
Limnephilus fenestratus (Zetterstedt 1840)	SE, NO, FI, EE, ICE
Limnephilus picturatus McLachlan 1875	SE, NO, FI, EE, ICE
Limnephilus subnitidus McLachlan 1875	SE, NO, FI
Molanna nigra (Zetterstedt 1840)	SE, FI, EE, DE, CZ
Molanna submarginalis McLachlan 1872	SE, FI, EE
Ceraclea excisa (Morton 1904)	SE, FI, PL
Triaenodes unanimis McLachlan 1877	SE, NO, FI, EE, LA, DE

Table 2: Thirteen species which are mainly found in the northern part of Sweden but are widely distributed in Europe:

Species	**Found in No of European countries**
Rhyacophila obliterata McLachlan 1863	19
Glossosoma intermedium Klapalek 1892	13
Hydroptila lotensis Mosely 1930	15
Hydroptila occulta (Eaton 1873)	19
Hydroptila simulans Mosely 1920	22
Hydroptila vectis Curtis 1834	21
Oxyethira distinctella McLachlan 1880	9
Oxyethira falcata Morton 1893	18
Oxyethira frici Klapalek 1891	12
Oxyethira simplex Ris 1897	11
Stactobiella risi (Felber 1908)	11
Micrasema setiferum (Pictet 1834)	17
Apatania muliebris McLachlan 1965	14

Table 3: Twenty five species with a southern distribution in Sweden:

Species	**Found in No of European countries**
Agapetus fuscipes Curtis 1834	17
Ithytrichia clavata Morton 1905	7
Orthotrichia angustella (McLachlan 1865)	19
Orthotrichia costalis (Curtis 1834)	20
Orthotrichia tragetti Mosely1930	14
Tricholeiochiton fagesii (Guinard 1879)	19
Wormaldia occipitalis Pictet 1834	23
Lype reducta (Hagen 1868)	24
Tinodes pallidulus McLachlan1878	19
Ecnomus tenellus (Rambur 1842)	24
Cyrnus crenaticornis (Kolenati 1859)	19
Anabolia furcata Brauer 1857	12
Grammotaulius nitidus (O.F. Müller 1764)	18
Limnephilus hirsutus (Pictet 1834)	22
Limnephilus luridus Curtis 1834	11
Limnephilus tauricus Schmid 1964	7
Potamophylax rotundipennis (Brauer 1857)	18
Beraea maura (Curtis 1834)	23
Ernodes articularis (Pictet 1834)	20
Notidobia ciliaris (Linnaeus 1761)	20
Odontocerum albicorne (Scopoli 1769)	20
Leptocerus tineiformis Curtis 1834	23
Setodes argentipunctellus McLachlan 1877	11
Setodes punctatus (Fabricius 1793)	19
Ylodes reuteri (McLachlan 1880)	11

places, e.g. *Ecnomus tenellus,* are 50 years later described with a wide distribution (Forsslund & Tjeder 1942). Nor Wallengren (1884, 1890, 1891) or Forsslund & Tjeder (1942) did mention *Leptocerus tineiformis*. Forsslund (1953) was the first to report Leptocerus tineiformis from Sweden (from the two provinces Södermanland and Uppland). Fifty years later it is recorded from 21 different places in eight provinces (Gullefors 2002, 2003, 2004, 2005) and was collected in an enormous quantity at the lake Krankesjön in the province of Skåne in 2003 and 2004 (Gullefors unpublished). Why were those two examples found so late and in scattered places? Have the species dispersed or are earlier only badly investigated?

My classification in southern and northern species has to be considered as a first attempt to describe the pattern of the spreading of the caddisflies in Sweden and will undoubtedly be modified with increasing knowledge.

The enlarged distribution area for some species can depend on spreading, due to climatical changes, at least towards the north. Both *Ecnomus tenellus* and *Leptocerus tineiformis* are species progressing northwards. Northern species rarely spread towards the south. The northern boundary of a species depends on the climate, while the southern boundary depends more on the competition of the species (Angelstam & Svensson 1996).

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Distribution of caddisflies in The Netherlands

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Abstract

1. There is no trustworthy overview of the distribution of caddisflies in The Netherlands.

2. The present knowledge of over 50.000 observations is mainly based on larvae, many of which have probably not been identified properly.

3. Old records (before the Second World War) of adults suffer from lack of modern literature and are mainly based on observations near home and from excursions to entomological hot spots.

4. Recent observations of adults show an increase of several species, indicating either the effects of climate change or a change in habitat use by the larvae *(Oecetis notata, Ceraclea dissimilis).*

5. Red lists have to consider the total geographical range of species instead of national boundaries. "Rare" species from the southernmost part of The Netherlands are very common in Central Europe: common species from Dutch standing waters are rare in surrounding countries.

Introduction

In preparing a distribution atlas of Dutch Trichoptera, I am collecting data from literature and reports, including a database of species collected by Water Authorities. Moreover, several Museum collections have been scrutinized (Botosaneanu 2005), Tilburg Natural History

Museum (Higler et al. 2005) and old material from research for the institute where I used to work (at present Alterra) has been re-identified. Some 50.000 data have been collected and provisionally mapped by European Invertebrate Survey, where the total database is maintained.

Results

The maps are a great help for the interpretation of distribution patterns, which are related to abiotic parameters such as current velocity, pH, geographical variation and history of historical events. It also enables to trace probable errors in identification.

The Netherlands, although a small country without mountains, harbours a great variety of standing and running waters, the latter including the lower reaches of the rivers Meuse and Rhine. The division of Holocene and Plistocene is reflected by the presence of ditches, lakes and marshes on clay and peat soils in the Holocene and sources, streams and oligotrophic moorland pools on sandy soils in the Plistocene part of the country. In general, the oligotrophic moorland pools have a low pH which is enhanced by acid rain. The following distribution patterns can be discerned.

1. Species that occur all over the country but often with the exception of the Wadden Isles and the islands of the Province of Zeeland. The Wadden Isles have a lower diversity of water types and probably they are not easy to reach with the prevailing western winds. The islands of the province of Zeeland have been flooded by the sea in 1953 and very few species have reached this area afterwards. (Fig. 1)
2. Species that are restricted to the Plistocene part of the country. They live in sources, lowland streams or oligotrophic moorland pools. (Fig. 2)

Fig. 1: Distribution of Triaenodes bicolor in The Netherlands

Fig. 3: Distribution of *Cyrnus insolutus* in The Netherlands

Fig. 2: Distribution of *Hydropsyche angustipennis* in The Netherlands

Fig. 4: Distribution of *Ernodes articulons* in The Netherlands

Fig. 5: Distribution of *Hydropsyche contubernalis* in The Netherlands

3. There are no species restricted to the Holocene, but some have highest concentrations in the peaty marsh areas on the transition from Plistocene to Holocene. (Fig. 3)
4. Species that are restricted to the most southern part of The Netherlands. These are species that need small, fast running streams, probably lime-rich. (Fig. 4)
5. Species with a distribution pattern along the large rivers. These are species living in the rivers and (sometimes) tributaries. (Fig. 5)

Problems with the data

There are several types of problems with the data.

- Old records, based on adult identifications, sometimes suffer from more recent taxonomical changes. Especially in the genus Hydropsyche, this may lead to a wrong picture. *Hydropsyche guttata* and *H. ornatula* have been recorded from The Netherlands (Fischer 1934), but they certainly do not occur here.
- The entomologists in the beginning half of the twentieth century collected near their homes or they traveled by train (in suits with hat) to yearly organized meetings in well known hot spots of beautiful nature or entomological richness. There were no highways and not many cars. The majority of waters were hardly or not accessible and the so-called ordinary water types as ditches or ponds were obviously not interesting because of their superfluous presence. Their ideas about abundance and rareness of species are based on these experiences.
- Identifications of larvae are very unreliable, because the literature was scarce, incomplete and sometimes incorrect. Only since the Seventies, trustworthy keys have been produced.
- Despite the presence of very good foreign keys, larval identifications are often questionable. The major part of the recent data is from larvae and by controlling "strange" data, identifications proved always to be false. One can have questions about the more common species.
- Most recent data are *from* Water Authorities (they only collect larvae) with fixed sampling stations. Therefore; species are missed, that occur in places outside these spots. So called rare species have not been found, although they may occur in many sites. Examples are wet terrestrial habitats, sources and places away *from* bridges and from other places, where cars cannot park.
- Recently, adult caddisflies have been collected and they show another picture than that presented by the larval distribution. Although not all species can be captured by light, it is a great help to evaluate the presence in The Netherlands nowadays. There are several species that seem to increase *(Oecetis notata, Ceraclea dissimilis)* and if so, the question is why. A possibility is climate change, but it sometimes looks like a change in habitat preference.

It is my firm impression that there is not a trustworthy overview of the distribution of the Dutch Trichoptera. The most common species are probably represented well, but there are many questions about a majority of species, which results in strange consequences. It looks like that ideas about presence and abundance are changing during years and that the knowledge of autecology is insufficient.

Consequences for national and international legislation

The Dutch Red List is mainly based upon the data from Water Authorities. There are three criteria for admittance in the Red List.

- The species is rare in The Netherlands.
- The species is decreasing in numbers or occupied localities
- The species has an international importance for maintenance of its population.

Two out of three of these criteria are sufficient for admittance to the Red List. It resulted in a list with 84 (!) species which is more than half of the present Dutch species. What is the practical use of such a list with species that have been recorded once or 50 or 100 years ago for the last time, some of that perhaps wrongly identified? Bureaucratic nonsense!

Many of these species have been included in the reference situations that are being used for the standards of the European Water Framework Directive. This has very strange implications for water managers, who have to comply with the European rules in 2015.

In many cases it is impossible to improve conditions in such a way, which mentioned species are returning.

It is unwise to restrict oneself to the national borders. The rare species in the southern part of the country are often very common in central Europe and the very common Dutch species of standing waters are often very rare in adjoining countries. What is needed is an international, a European, Red List. The type of distribution-maps as proposed by Thomas Pitsch (Pitsch, 1981) could be used and it must be easy to make a European Red List by some of us with a good overview of the situation in Europe. Of course, there is the internet site http://www.faunaeur.org , but the information is not complete and only deals with the presence or absence in countries as political units.

Conclusion

Knowledge on the distribution of Trichoptera is necessary and useful for scientific, practical and political purposes. Pitfalls as indicated before are dangerous and harmful for the applicability in water management and European politics.

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State of knowledge of investigations on Trichoptera larvae in Kosova

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Abstract

The fauna of Trichopteara in Kosova is poorly studied and the investigations are neither detailed nor complete. There are no data about adult Trichoptera and the details about larvae of Trichoptera are yet to be obtained from the greatest part of the country. This paper presents a summary of some of the former studies and records from Kosovo.

According to the present data in Drini i Bardhë River 37 taxa of Trichoptera larvae are recorded, in Bistrica e Prizrenit River 19 taxa are recorded, in Mirusha River 10 taxa are recorded.

Ongoing investigations on macrozoobenthos fauna including larvae of Trichoptera are carried over in several other streams in Kosova

Introduction

There are four river Basins in Kosova flowing into 3 distinct catchments (Black, Aegean and Adriatic Sea) and although the net of streams and rivers is very well developed they are poorly investigated. Especially the fauna of Trichopteara is poorly studied and most of the investigations are carried over within the general studies of macrozoobenthos fauna, being concentrated usually on larvae. Investigations on macrozoobenthos fauna are not so old in Kosova and some authors who mention Kosova's rivers and watercourses in their studies have also analyzed specific aspects of some animal groups (taxonomy, distribution of some species, ecology of smaller groups, than issues related to saprobiology and biogeography).

Radovanovic (1931) is among the first ones who investigated larvae of Trichoptera in Bistrica e Prizrenit River. So far detailed studies on taxonomy and distribution of larvae of Trichoptera were done in Drini i Bardhë River and Bistrica e Prizrenit River. Less detailed studies of macrozoobenthos fauna including larvae of Trichoptera were also done in Mirusha River and Llapi River. The faunistic material of some of these studies is deposited in Department of Biology – Faculty of Natural Sciences in Prishtina.

Below is a fragmental list of Trichoptera larvae species found in Kosova's rivers and the data are mostly taken from MSc and PhD thesis of respective authors who investigated them.

Results

Trichoptera of Bistrica e Prizrenit River

Confluence of Bistrica e Prizrenit River is mainly located in north-west lowlands of Sharr Mountains. The approximate surface of this confluence is about 262.5 km^2. Radovanovic (1931) is the first one who has contributed investigations of larvae of Trichoptera of this river. Thorough investigations on larvae of Trichoptera in Bistrica River were done later by A Shukriu (1979). Here are the results of these findings:

Limnephilidae

Chaetopterygopsis sp.
Drusus sp.
Glyphotaelius pellucidus Retzius, 1783
Stenophylax permistus McLachlan, 1895

Goeridae

Goera pilosa Fabricius, 1775

Hydropsychidae

Hydropsyche pellucidula Curtis, 1834
Hydropsyche sp.
Cheumatopsyche lepida Pictet, 1834

Brachycentridae

Micrasema minimum Mc Lachlan, 1876
Oligoplectrum maculatum Fourcroy, 1785

Philopotamidae

Philopotamus montanus, Donovan, 1813

Rhyacophilidae

Rhyacophila armeniaca Guerin-Meneville, 1843
Rhyacophila loxias Schmid, 1970
Rhyacophila laevis Pictet, 1834
Rhyacophila obliterata McLachlan, 1863
Rhyacophila tristis Pictet, 1834
Rhyacophila sp. (group *vulgaris*)

Sericostomatidae

Sericostoma personatum Kirby & Spence, 1826
Sericostoma sp.

Trichoptera of Drini i Bardhë River

The source of Drini i Bardhë River is located in northern part of Peja town in altitude of 567m. Throughout all of its flow until Vërbnica village when it passes in the Republic of Albania, Drini i Bardhë mainly has got characteristics of field river. Detailed studies on Trichoptera larvae were done by Avdyli (1988). 12 families with 37 species in total were found during these investigations. Additional studies were also done by Grapci-Kotori (2002).

Rhyacophilidae

Rhyacophila obliterata McLachlan, 1863
Rhyacophila dorsalis Curtis, 1834
Rhyacophila tristis Pictet, 1834

Glossosomatidae

Glossosoma discophorum Klapalek, 1902
Agapetus laniger Pictet, 1834

Philopotamidae

Wormaldia subnigra McLachlan, 1865

Polycentropodidae

Plectrocnemia conspersa Curtis, 1834
Polycentropus flavomaculatus Pictet, 1834
Neureclipsis bimaculata Linne, 1758

Hydropsychidae

Hydropsyche angustipennis Curtis, 1834
Hydropsyche pellucidula Curtis, 1834
Hydropsyche sp.
Cheumatopsyche lepida Pictet, 1834

Limnephilidae

Grammotaulius sp.
Limnephilus rhombicus Linne, 1758
Limnephilus lunatus Curtis, 1834
Limnephilus sp.
Anabolia laevis Zetterstedt, 1840
Potamophylax latipennis Curtis, 1834
Potamophylax nigricornis Pictet, 1834.
Halesus digitatus Schrank, 1781
Halesus radiatus Curtis, 1834
Micropterna lateralis Stephens, 1837
Chaetopteryx villosa Fabricius, 1798
Annitella obscurata Mc Lachlan, 1876
Drusus discolor Rambur, 1834
Drusus trifidus McLachlan, 1868

Goeridae

Goera pilosa Fabricius, 1775
Silo pallipes Fabricius, 1781

Lepidostomatidae

Lepidostoma hirtum Fabricius, 1775

Brachycentridae

Brachycentrus montanus Klapalek, 1891
Brachycentrus subnubilus Curtis, 1834

Odontoceridae

Odontocerum albicorne Scopoli, 1763

Lepptoceridae

Athripsodes aterrimus Stephens, 1836
Athripsodes cinereus Curtis, 1834

Sericostomatidae

Notidobia ciliaris Linnaeus, 1761
Sericostoma personatum Kirby & Spence, 1826

Less detailed studies on Trichoptera were done in some other rivers (Mirusha River, Llapi River and some other smaller river and streams), mostly within general investigations of macrozoobenthos invertebrates.

Trichoptera of Mirusha River

Mirusha River basin is located in western part of Kosova and the total length of the river is about 29 km. River position is important because it is placed in dividing line of: Black Sea, Aegean and Adriatic Sea catchments. Studies on larvae of Trichoptera as a part of general investigations of benthic macrofauna were done by Gashi (1993). 10 taxa belonging to three families were identified.

Rhyacophilidae

Rhyacophila nubila Zetterstet, 1840
Rhyacophila sp. (group *vulgaris*)
Rhyacophila sp.

Hydropsychidae

Hydropsyche sp (group *guttata*)
Hydropsyche sp. (group *pellucidula*)
Hydropsyche sp. (group *instabilis*)
Hydropsyche sp.

Limnephilidae

Limnephilidae gen. sp
Stenophylax sp.
Potamophylax sp.

Conclusions

Investigations on Trichoptera in Kosova are relatively new and incomplete. Beside very few detailed studies, the inventories are mostly a result of general investigations on benthic macroinvertebrates. These families of Trichoptera are identified in larval stage so far in these studies: Rhyacophilidae, Glossosomatidae, Philopotamidae, Polycentropodidae, Hydropsychidae, Limnephilidae, Goeridae, Lepidostomatidae, Brachycentridae, Odontoceridae, Leptoceridae and Sericostomatidae. Ongoing studies are on the process in Sitnica River, Prishtina River and several other streams and rivers, and they show presence of very rich Trichoptera fauna.

There are intentions to continue further with these studies including adult stages of Trichoptera in the near future.

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The Trichoptera (Insecta) of the Bán Stream, Bükk Mts., northern Hungary

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Keywords: caddis larvae, Bán stream, water quality, functional feeding groups, Hungary

Abstract

Larvae of Trichoptera were collected monthly at five sampling sites along the Bán stream from April to late September, 2004. The physical, chemical and biological parameters as well as the geographic description of the sampling sites are given. The longitudinal distribution of larvae along the eucrenon, hypocrenon and epirhithron zones as well as functional feeding group composition of the collected trichopteran species are presented. Both the chemical and biological water quality assessments revealed the water of the spring and the first order section of the stream being of quality class one, i.e. drinking water quality.

Introduction

Earlier data on the Trichoptera fauna of the Bán Valley in the Bükk Mountains were published by Sátori (1938, 1939), Ujhelyi (1974) and Nógrádi et al. (1996). The objective of my investigations was partly to contribute to the detailed knowledge of the fauna by surveying the larval assemblages of Trichoptera and the accompanying faunal elements and partly to include some additional viewpoints, such as the differentiation of the longitudinal (eucrenon, hypocrenon, epirhithron) zones of the stream – as made for other streams of the Bükk Mountains (Kiss 1977a, 1978 1979, 1982-83, 1984a, 1984b, 1987, 1991a, 2002; Kiss & Schmera 1996; Kiss et al. 1998, 1999, 2000a, 2003; Schmera 1999, 2004; Schmera & Kiss 2000) – and the assessment of the chemical and biological water quality of the stream section studied, demonstrating the importance of environmental protection of this area.

Material and methods

The study area (B1-B5: sampling sites, Fig. 1) is located at elevations of 310-528 m at 48°06'N and 20° 28'E, N of Bálvány peak on the northern edge of the Bükk plateau in the Bükk Mountains, Hungary. Five sampling sites were chosen within the 5 km long 1st order section of the stream, starting from the spring. At a 5 km distance from the spring, where the Bán stream takes a NE turn, the Szilvás stream flows into it, and from this point the Bán stream can be considered as 2nd order stream. The geographical positions were determined with a

Fig. 1: Map of study area with sampling sites (B1-5).

Garmin type GPS. Exploratory measurements of chemical parameters were taken with a Multiline P4 type electrometric device. The caddis larvae and the accompanying faunal elements were sampled monthly from April to late September 2004, using the methods of Kamler & Riedel (1960) and Macan (1958).

The imagines were caught by netting along the stream.

For the identification of the trichopteran larvae Waringer & Graf (1997) and Hickin (1967) were used. The trichopteran imagines were identified using Malicky (1983). For the identification of the other macroinvertebrates the Hungarian translation of Bährmann (2000) and the work of Pöckl (1988) were used. Diptera larvae were identified at family level, based on Biró (1981).

Results and discussion

Results are summarized in Tab. 1.

Sampling site B1, a 2 to 4 m long section of the spring region beginning with the rheocrene karst spring at an elevation of 528 m at 48°06'N and 20°28'E, is located within layers of Middle Triassic limestone.

The water temperature range is 8.0-8.7 °C, the pH values vary between 6.86 and 7.7, conductivity is 480 µS/cm and the dissolved oxygen concentration is 9.2 mg/l (83.1%). The hornbeams (*Carpinus betulus* L.) provide such a dense canopy near the spring that the area is fully shaded. The width of the spring region is 50-60 cm with large stones as bottom substrate. It is a typical eucrenon region.

Larvae of *Rhyacophila fasciata* Hagen, 1859, *Agapetus fuscipes* Curtis, 1834 *and Ecclisopterix madida* McLachlan, 1867 were collected at this site. The dominant elements of the accompanying fauna were *Crenobia alpina* Dana , *Sadleriana pannonica* Frfl. and *Gammarus fossarum* Koch.

Sampling site B2 is situated 400 m downstream, at an elevation of 498 m. It is a hypocrenon zone of the first order stream section with high velocity water rushing down a dam, and continuing its way swiftly over the large stones of the streambed. The stream width beneath the dam is 180 cm, water depth is 7 cm. It is a half-shaded area with stony substrate. Beyond the dam, the streambed widens and is covered with fine sediments. On the banks, the vegetation consists of *Petasitetum hybridi* Dost and common nettle (*Urtica dioica* L.). The water temperature range is between 9.0 °C and 10.3 °C, the pH is 8.34, conductivity ranges from 471 to 477 µS/cm and the dissolved oxygen concentration is 8.55 mg/l (77.2 %). *Rhyacophila fasciata, Rhyacophila pubescens* Pictet, 1834 and *Agapetus fuscipes* were dominant among the seven trichopteran species collected here. Larvae of *Wormaldia occipitalis* Pictet, 1834 were rare. The dominant elements of the accompanying fauna were *Crenobia alpina* and *Sadleriana pannonica*, although Chironomidae and Simulidae larvae were also common, even *Gordius aquaticus* L. occurred.

Sampling site B3 is situated about 450 m from the spring and downstream of a bridge at an elevation of 478 m. Here, the stream width is 100 cm, the water depth is 8 cm, the bottom substrate consists of large stones, and the water is fast-flowing. On the half-shaded banks, common alder (*Alnus glutinosa* L. Gartn.) and stands of *Petasitetum hybridi* Dost are found. The water temperature ranges between 9.2 °C and 10.5 °C, the pH is 8.3, conductivity is 467-468 µS/cm and the dissolved oxygen concentration is 8.77 mg/l (79.2%). Of the seven species of Trichoptera collected, the dominant ones were *Rhyacophila fasciata, Agapetus fuscipes*, and *Ecclisopteryx madida.* The accompanying fauna was represented by *Crenobia alpina, Dugesia gonocephala* Dug. and *Sadleriana pannonica*.

Sampling site B4, approximately 800 m downstream of the spring and after a roadbend, is located at an elevation of 474 m. The right bank of the streambed is boggy, its left bank is steep. The bottom substrate ranges from small sections of large and small stones to sand and fine sediment accumulations. The area is fully shaded by hornbeam (*Carpinus betulus* L.) and common alder (*Alnus glutinosa* L. Gartn.). Thick stands of *Urtica dioica* L., *Petasitetum hybridi* Dost, and *Sambucus nigra* L. are found. The stream width varies from 85 to 120 cm, the water depth is 8-9 cm. The water temperatures fluctuate between 9.5 °C and 11.1 °C, the pH is between 6.55 and 8.3, conductivity is between 456 µS/cm and 484 µS/cm and the dissolved oxygen concentration is 8.56 mg/l (78.2%). Of the ten species found here the dominant ones were *Agapetus fuscipes*, *Hydropsyche instabilis* Curtis, 1834, and *Ecclisopteryx*

Tab. 1: Zonal distribution of the trichopteran larvae and the accompanying fauna in a 3.6 long section of the Bán stream, Bükk Mts; functional feeding groups of the trichopteran larvae; water quality indices of the trichopteran species of the Bán stream given by Moog (1995). Legend: *=1-2 specimens, **=3-6 specimens, ***= over 6 specimens; sh=shredders, c=collectors, f=filterers, p=predators, d=detritivores, h=herbivores; x=xenosaprobic, o=oligosaprobic, ß=beta-mesosaprobic, α=alpha-mesosaprobic, p=polysaprobic.

	Species of the trichopteran larvae	**Sampling sites**					**Functional feeding groups**	**Water quality**				
		Eucrenon	**Hypocrenon**			**Epirhithron**						
		B1	**B2**	**B3**	**B4**	**B5**		**x**	**o**	**β**	**α**	**p**
1	Rhyacophila fasciata	***	***	***	***	***	p	2	4	4		
2	Rhyacophila obliterata		*	**	*	**	p		4	6		
3	Rhyacophila pubescens		***	***		***	p	7	3			
4	Rhyacophila tristis				*	*	p	2	3	4	1	
5	Agapetus fuscipes	***	***	***	***	***	s	4	5	1		
6	Synagapetus moselyi		*	*			s	8	2			
7	Wormaldia occipitalis		**				c,f	8	2			
8	Silo pallipes					*	s	1	4	5		
9	Plectrocnemia conspersa		**	**	**	**	p	1	3	4	2	
10	Hydropsyche instabilis				***	***	c,f ,p	1	4	5	+	
11	Hydropsyche pellucidula				*	**	c,f, p		2	5	3	
12	Halesus digitatus					**	sh, h		5	4	1	
13	Ecclisopteryx madida	***		***	***	***	sh, d	4	4	2		
14	Grammotaulius nitidus				*	*	sh,d,p	-	-	-		
15	Potamophylax rotundipennis					**	s, d		4	4	2	
16	Stenophylax permistus					*	s, d	-	+	+		
17	Limnephilus affinis					**	s, d, h	-	+	+		
18	Limnephilus lunatus					*	s, d, h		+	+		
19	Limnephilus vittatus					*	s, d, h		+	+		
20	Sericostoma personatum				**	**	s	3	4	3		
21	Odontocerum albicorne					**	s, d, h	1	6	3		
	Species of the accompanying fauna											
	Nemathelminthes/Turbellaria											
	Crenobia alpina	***	***	***								
	Dugesia gonocephala		*		***	***						
	Nematomorpha											
	Gordius aquaticus		*		*	*						
	Parachordodes tolosanus					*						
	Gastropoda											
	Planorbarius corneus		*	*								
	Sadleriana pannonica	***	***	***	***	***						
	Crustacea/Amphipoda											
	Gammarus fossarum	***	***	***	***	***						
	Diptera											
	Chironomidae		**	**	**	**						
	Tipulidae			*	*							
	Simulidae		**	**	**							
	Thaumaleidae	*										
	Dixidae				*							
	Megistoceridae					*						

madida. Trichopteran larvae with a preference for lotic waters comprised *Rhyacophila tristis* Pictet, 1834 (a subalpine species), *Rhyacophila fasciata*, *Odontocerum albicorne* Scopoli, 1763, *Hydropsyche instabilis, Plectrocnemia conspersa* Curtis, 1834 and *Ecclisopteryx madida*. In addition, larvae with a preference for lentic waters were sampled, e.g. *Halesus digitatus* Schrank, 1781 and *Potamophylax rotundipennis* Brauer, 1857. With respect to the accompanying fauna, *Dugesia gonocephala* was common, but *Gordius aquaticus* and Tipulidae larvae also occurred.

Sampling site B5, 3600 m downstream of the spring, is situated near the railroad-crossing where the valley widens at an elevation of 310 m above sea level at 48°08'N and 20°27'E. At the sampling site the stream width is 150 cm and the water depth is 9 cm. The banks are shaded by *Petasitetum hybridi* Dost, *Sambucus nigra* L. and *Carpinus betulus* L. The water temperatures fluctuate from 9.5 °C to 14.1 °C, the pH value is 8.42, the conductivity ranges from 456 µS/cm to 484 µS/cm and the dissolved oxygen concentration is 8.72 mg/l (87.7%). Of the 19 trichopteran species collected here the dominant ones were *Rhyacophila fasciata*, *Agapetus fuscipes*, *Hydropsyche instabilis*, and *Ecclisopteryx madida*. Abundant lotic species comprised *Odontocerum albicorne*, *Hydropsyche instabilis*, *Ecclisopteryx madida, Agapetus fuscipes, Rhyacophila fasciata*, and *Rhyacophila tristis*, but *Halesus digitatus,* a lentic species, was also found. In addition, *Dugesia gonocephala, Parachordodes tolosanus* Duj. and *Megistocera sp*. (Diptera) were collected.

A total of 226 individuals belonging to 21 species of Trichoptera were collected, together with 6 species of Diptera, two species of Nemathelminthes/ Turbellaria, two species of Nematomorpha, two species of Gastropoda, and one species of Crustacea/Amphipoda (Tab. 1). This species inventory is typical for the faunal composition of a 1st order stream in a typical mountain range of medium height. Species richness and abundance increase downstream from the spring due to the varied substrates and the availability of a wider range of food resources. In winter, the stream is not frozen due to the almost constant water temperature and provides suitable living conditions for the benthic communities.

The characteristic trichopteran species were *Rhyacophila tristis* and *Rhyacophila pubescens, Wormaldia occipitalis, Agapetus fuscipes* and *Ecclisopteryx madida.* Other characteristic macrozoobenthic elements comprised *Crenobia alpina, Sadleriana pannonica*, and *Parachordodes tolosanus*.

Fuctional feeding groups (Tab. 1)

Although the majority of the trichopteran larvae are collectors, ten species of the caddis larvae in this study area were shredders, feeding on macrophytes and/or CPOM. Three species, *Wormaldia occipitalis* and young instars of *Hydropsyche instabilis* and *Hydropsyche pellucidula* Curtis, 1834 belong to the group of filtering collectors, with FPOM as their main food resource. Three species, *Agapetus fuscipes*, *Synagapetus moselyi* Ulmer, 1938 and *Silo pallipes* Fabricius, 1781, represented the scrapers. Predators were represented by a relatively large number of species: 4 *Rhyacophila* species, one *Plectrocnemia* species and the larvae of two *Hydropsyche* species from instar 3 onwards.

Water quality

Based on the chemical parameters and in compliance with the qualification specifications (Dévai et al. 1992; MKOSZ. 1989) it can be stated that the water in the 3600 m long reach of the Bán stream is of first class, i.e. of drinking water quality. In macroinvertebrates, the frequency values of the Trichoptera, Gastropoda and Amphipoda are of special significance in the different saprobic categories for the assessment of the biological water quality (Moog 1995). Although several indicator species of Trichoptera accumulate in the same saprobic category, they also occur in other saprobic categories (Kiss et al. 2002). Ten trichopteran species with high frequency values (4 or over 4) indicate oligosaprobic waters. Six of these 10 species overlap with 6 of 9 indicator species with high frequency values in the β-mesosaprobic category. Five indicator species, three of them with rather high values (7-8), prefer xenosaprobic waters. Several species with low frequency values (1-3) occur in all four saprobic categories (Tab. 1).

Based on the bioindicator species we state that the biological water quality is of first class, i.e. it is in accordance with the chemical water quality.

These findings indicate the importance of nature conservation and environmental protection of the stream within the Bükk National Park.

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Glacial refugia of the montane caddisfly *Drusus discolor* (Rambur, 1842)

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(Extended Abstract)

Introduction

In central Europe the legacy of the Pleistocene ice ages and their effects on the European Biota have been subject to much study over the last few decades. More recently a plethora of studies have focussed on examining population genetic structure using a variety of fingerprinting methods to infer the Pleistocene history of European species (see Hewitt 2004a, b; Schmitt 2007 for recent reviews). Most of these studies have focussed on terrestrial species and have shown that there are several common patterns. For many temperate species examined to date these patterns suggest Pleistocene survival in climatically favourable regions on one or more of the southern European peninsulas. A common scenario in the literature suggests post-glacial re-colonisation of central Europe where unfavourable climate conditions prevailed throughout much of the Pleistocene (see Hewitt 2004a, b; Schmitt 2007 for recent reviews).

Other hypotheses of Pleistocene persistence have suggested glacial fringe species (e.g. Thienemann 1950), glacial relicts (e.g. Thienemann 1950), and nunatuks (e.g. Merxmüller 1952). These latter hypotheses are thought to be relevant for very cold-hardy species. For very few arboreal species cryptic northern refugia have been suggested. These are pockets of habitat with favourable microclimates in regions with otherwise harsh climatic conditions in central Europe where small refugial populations survived (reviewed by Stewart & Lister 2001).

Unfortunately over the years, little attention has been given to aquatic organisms. There is a critical lack of knowledge in this area of study as aquatic organisms are subject to very different physical conditions than terrestrial species and presumably climate change has different effects on aquatic than terrestrial ecosystems. This is especially true for mountain streams, which have permanent turbulent flow and water temperatures, which are regulated by fluvial regime and highly dependent on groundwater influx. Based on these ecosystem considerations and the distribution of endemics Malicky (1983) proposed that cold-water tolerant, mountain stream-dwelling caddisfly species may have survived the Pleistocene on the slopes of mountains in permanently flowing streams in central Europe. The hypothesis of Pleistocene survival is based on the fact that the species can survive extremely cold aquatic habitats today. If streams were permanently flowing throughout the Pleistocene they would not have cooled below 0°C. Thus cold-tolerant aquatic organisms would have been subject to much less severe temperature decreases than their terrestrial counterparts (Malicky 1983; Pauls, Lumbsch & Haase 2006). So, although their present-day distribution suggest that montane stream-dwelling insects form part of the arboreal biome, their reaction to climate change was vastly different: instead of surviving in southern European refugia, they simply moved locally to permanently flowing, turbulent mountain streams in the central European periglacial. Malicky (1983, 2000) proposes the biome-type dinodal to group all aquatic species, which reacted in this manner to Pleistocene cooling.

Population structure and glacial refugia of *Drusus discolor*

We wanted to test this hypothesis by studying the phylogeography of a species, which fulfils the distributional and ecological requirements of a dinodal species. We therefore studied the genetic population structure and phylogeography of the montane caddisfly *Drusus discolor* across its entire range (Pauls, Lumbsch & Haase 2006). The species is restricted to cold turbulent flowing streams in mountain regions in central and southern Europe (Schmid 1956; Malicky 1983; Pauls 2004). The distribution is insular from the Cantabrian Mts in northern Spain in the southwest to the northern Rhodopi Mts in Bulgaria in the southeast. Pauls, Lumbsch & Haase (2006) studied samples from 71 populations spanning the entire range and generated and analysed mitochondrial sequence data (cytochrome oxidase I, mtCOI) for 254 individuals. Population genetic and phylogeographic analyses included Bayesian (Huelsenbeck et al. 2001) and statistical parsimony (Templeton, Crandall & Sing 1992; Clement, Posada & Crandall 2000) phylogenetic inferences, to analyse relationships between haplotypes and haplotype distribution; analysis of molecular variance (AMOVA) to partition total observed variation among different geographic hierarchies (Excoffier, Smouse & Quattro 1992); estimates of F_{ST} (Wright 1951) and exact tests of population differentiation (Raymond & Rousset 1995) to reveal population genetic structure; tests of selective neutrality Fu's F (Fu 1997) and Tajima's D (Tajima 1989) and mismatch distributions (Rogers & Harpending 1992) to infer recent demographic history of populations and clades. Details on materials and methods are published in Pauls, Lumbsch & Haase (2006).

For *D. discolor* Pauls, Lumbsch & Haase (2006) show little molecular variance within populations and regions, but distinct genetic structure between various mountain ranges across Europe. Most populations are significantly differentiated based on F_{ST} and exact tests of population differentiation, and most haplotypes are private to a single mountain range. Phylogenetic analyses reveal deep divergence between geographically isolated lineages. Combined, these results suggest that past fragmentation is the prominent process structuring the populations across Europe. Tests of selective neutrality and mismatch distributions suggested recent demographic expansion of those populations with haplotype overlap. The high level of genetic differentiation between mountain ranges and estimates of demographic history provide evidence that at least eleven independent refugia existed over different lengths of time over the Pleistocene. In particular refugia are hypothesised in the north-western ranges on the Iberian Peninsula; in the vicinity of the Pyrenees; the Massif Central; the south-western Alps; the region northwest of the Alps near the Jura and Vosges Mountains and the Black Forest; in the central German highlands; in the ranges south-east of the Alps; in the Sudety Mountains; in the vicinity of the Tatra ranges; in the Carpathians; and the ranges on the southern Balkan Peninsula. Many of these regions have been considered important refugial centres for other species as well (e.g. Hewitt 2004a, b; Pauls 2004). Also, many of these regions are hypothesised areas of diversification based on the large number of caddisfly and other endemic species occurring here (Pauls 2004, Malicky 2006). However, some of these areas, in particular the northern regions, are of particular interest and have not been considered as refugial centres in the past. This is true for the region northwest of the Alps and the central German highlands. The unique and endemic genetic lineages found in these regions and evidence for secondary contact in the Erzgebirge of previously separated lineages strongly suggests that there were glacial refugia in these regions in which populations of *D. discolor* survived since well before the last glacial maximum (Pauls, Lumbsch & Haase 2006).

Independent of direct location, Malicky (1983, 1988) proposes that in the vicinity of glaciers there must have been precipitation and thus also some streams, which could have served as refugia. He therefore suggests glacial refugia in mountains or hills in the vicinity of glaciers. Most of the refugia suggested for *D. discolor* fit this pattern. All of them are located near mountain regions, which were glaciated. Glaciations are known from high elevations of the Cantabrian Mountains, the Pyrenees, Massif Central, Alps, Vosges Mts., Jura Mts., Black Forest, the Carpathian ranges and the northern Rhodopi Mts. (Holdhaus & Lindroth 1939; Pletsch 1997). The central German highlands were all more or less close to the northern glacial fringe; some regions were very close (e.g. Harz Mts.). Although stream density may have been much lower during drier Pleistocene glaciation periods, water was presumably always running somewhere in the periglacial region (Thienemann 1950; Malicky 1983). Also, fossil remains from aquatic Coleoptera found throughout the last 140,000 years from the Grand Pile peat bog in the Vosges Mts. (Ponel 1994), suggest that suitable conditions for running-water species occurred throughout the cold periods (~ 140,000 to ~ 30,000 years ago) in the highlands between the northern and southern inland ice sheets.

In general, caddisfly species are known to adapt their life cycle to water temperature during different development stages (e.g. Enders & Wagner 1996; Fischer 2003). Among the Drusinae, very slow, but successful egg development has even been observed at temperatures between 2°C and 3.5°C in *Drusus rectus rectus* (Décamps & Pujol 1975), while *D. annulatus* showed plasticity in adult weight and body size dependent along a gradient of water temperature (Wagner 2005). *Chaetopteryx villosa* also shows plasticity in adult size and weight along a temperature gradient (Wagner 2005) and the life cycle was prolonged to a two-year cycle in colder climates (Andersen & Tysse 1984). *C. villosa* completed its life cycle successfully at 2°C water temperature (Wagner 1986, 1990) and even close to 0°C water temperature (Wagner, personal communication). As *D. discolor* is a species which is not restricted to, but capable of surviving in extremely cold water habitats (e.g. Lavandier 1992), its persistence would presumably not have been limited by low temperatures, but by occurrence of permanently, turbulently flowing water bodies, where it would have found suitable and sufficiently oxygenated habitats. Constantly running water over hard substrates would have presumably been sufficient habitats for *D. discolor* to survive its larval stage.

Only little is known about the adult phase and behaviour of *D. discolor*. We therefore cannot imply specific habitat requirements of the species for successful courtship, mating and oviposition. However, larvae and adults of the species occur in habitats well above the tree line in both the Alps and the southern European mountain ranges (Malicky 1988, Lavandier 1992, Pauls 2004). It also occurs in the floodplains of large Alpine rivers, like the Isar (Hering 1995), which are naturally free of tree vegetation. It thus seems plausible that the species was able to survive in a tundra or steppe like environment with little or only low riparian vegetation, and does not require trees as swarming or congregation landmarks or habitat.

Conclusions

The study of mitochondrial population structure in *D. discolor* shows that this aquatic organisms reacted differently to Pleistocene cooling than many terrestrial species. It persisted in numerous refugia over multiple glacial cycles, allowing many local endemic clades to form. Some of these refugia lie in central Europe. The hypotheses based on these results complement theories founded mainly on terrestrial species, which claim that glacial refugia were located only in the southern European regions.

The knowledge of persisting aquatic insects in central European highlands on the one hand and the plasticity in life history traits of several caddisfly species related to water temperature on the other hand, suggest that the pattern observed in *D. discolor* might not be unique, but that other cold-tolerant aquatic insects may also have survived in these regions. The evidence collected for *D. discolor* is a first molecular indication for the existence of a group of animals, which reacted similarly to Pleistocene climate cooling and Malicky (1983) defined as elements of the dinodal biome type.

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The Indicator Database for European Freshwater Invertebrates

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Abstract

Many river assessment systems currently developed to implement the European Water Framework Directive are based on metrics using autecological information on macroinvertebrate taxa. The EU funded AQEM and STAR projects have compiled a list of aquatic macro-invertebrate taxa and an associated ecological database, comprising information like feeding behaviour, preferences for longitudinal zones or saprobic conditions on 9146 European macroinvertebrate species. The database is now further extended within the EU funded project Euro-limpacs, particularly by parameters, which might be sensitive to direct or indirect impacts of climate change (e.g. altitudinal and temperature preferences or life history traits). Focus is also given on the ecoregional distribution of species according to Illies (1978). First targeted invertebrate group are Trichoptera.

Introduction

The temporal and spatial distributions of freshwater organisms are tightly connected to aspects of zoogeography plus their physiological and behavioural responses to varying levels of environmental factors. The comparatively good knowledge of their environmental needs and of responses to various environmental factors has led to a frequent use as (bio)indicators in water management and in applied ecology (see Rosenberg & Resh 1993, Davis & Simon 1995).

The main goal of the aquatic macro-invertebrate taxalist and its associated ecological database presented here is to provide a tool for the ecological assessment of water bodies in compliance with the needs of the Water Framework Directive (EC 2000/60; WFD).

Since data on autecology and distribution are scattered about thousands of sources, the database aims at making this manifold information available to the interested public in an easily accessible form.

Methods – Development of the database

The macro-invertebrate taxalist published on http://www.freshwaterecology.info is a "living document" that was first set up for the purposes of the EU funded AQEM project (www.aqem.de). The aim of this project was the development and testing of an integrated system for the assessment of the ecological quality of streams and rivers throughout Europe using benthic macro-invertebrates. The eight project member countries (Austria, Czech Republic, Germany, Greece, Italy, The Netherlands, Portugal, Sweden) developed multi-metric assessment systems for different stream types, which are applicable through a computer software (ASTERICS, formerly AQEM River Assessment Programme, to be downloaded at www.aqem.de). As the assessment systems require ecological knowledge of the taxa it was essential to collect information on both occurrence of taxa within the partner countries, and ecological information for a consistent and reliable database. To achieve this goal the macro-invertebrate taxalist builds on the scientific expertise of many scientists from different zoological fields, universities, organisations and societies.

In the succeeding EU funded STAR project (www.eu-star.at) that aimed for the standardisation of river classifications, the taxa and autecology database was extended with national checklists from Denmark, France, Great Britain, Latvia, Poland and Slovakia.

The steps taken towards the development of the www.freshwaterecology.info database under the above mentioned two projects were:

- Designation of persons responsible for the national checklists: from each partner country at least one person was selected to be responsible for providing information on national records of the targeted invertebrate groups (see country checklists www.freshwaterecology.info).
- Quality control: species validity, species nomenclature and synonymy were checked by acknowledged and approved experts (see taxonomic experts on www.freshwaterecology.info).
- Compiling the database: the data were combined into a MS Access database, using the proven structure of the Austrian software ECOPROF that has been developed for data storage and evaluation (www.ecoprof.at).
- Compiling the autecological information: as a basic data source, existing ecological classifications were critically reviewed and adopted. In order of prioritisation we used (1) the Fauna Aquatica Austriaca (Moog 1995, 2002), (2) the Bavarian List (Schmedtje & Colling 1996) and (3) other national lists. If possible, selected species were assigned to experts and project partners for amendment of their classifications.
- Coding the new autecological information: depending on the parameter, data were given a numerical code using either a 10 points system or a single category assignment.

The database is now further improved within the EU funded project Euro-limpacs (www.eurolimpacs.ucl.ac.uk), which deals with the evaluation of climate change impacts on European freshwater ecosystems. The focus within Euro-limpacs lies on ecological parameters relevant for assessing the impact of climate change on freshwater organisms. These cover data on ecoregional distribution (e.g., taxa in high mountain areas may be particularly sensitive), life cycle parameters (e.g., increased water temperature may particularly effect the timing of emergence), temperature preferences and current preferences (e.g., current resistance might be an important assessment feature, if discharge patterns will change in future). This information is compiled for selected invertebrate groups, starting with Trichoptera (caddisflies). Chironomidae (non-biting midges), Plecoptera (stoneflies) and Ephemeroptera (mayflies) will follow.

Results

Taxonomical and autecological information

The freshwaterecology.info database currently holds information on a total of 9146 European benthic invertebrate species, categorised into 1411 genera, 300 families and 33 higher taxonomic groups (mostly orders). Including "working taxa" like species-groups the list contains 12191 taxa.

36 ecological parameters and indices, with varying numbers of classified taxa, are included into the database. Generally, the six ecological parameters, on which most information is available, are oxygen demand (saprobic indices), stream zonation preferences (expected distribution of a species within the longitudinal gradient of a stream from the source to the mouth), current and substrate (microhabitat) preferences, functional feeding and locomotion types. For Trichoptera information is already additionally available regarding ecoregional distribution (see below), endemism and habitat specialists.

Since most of the relevant information in literature is recorded in narrative form, two different methods (10 points system, single category assignment system) were used to transform the ecological knowledge into numerical values. This numerical information offers the opportunity to be processed for ecological quality assessment.

A comprehensive overview of the database, a discussion and some examples for the use of ecological parameters are given by Schmidt-Kloiber et al. (2006).

Ecoregional distribution

The ecoregion concept of Illies (1978) was adopted by the WFD as base for typology and the development of assessment methodologies (annex 11). Therefore, the compilation of the ecoregional information on taxa within the freshwaterecology.info database is one of the major goals of Euro-limpacs. This information is now available for Trichoptera. The database can be queried for different ecoregions and the results can either be displayed as tables or as distribution maps. As an example Figure 1 demonstrates the ecoregional distribution of *Plectrocnemia kisbelai* Botosaneanu, 1967 in the Alps and in the Carpathians.

Discussion and outlook

A sound understanding of benthic invertebrate ecology is a prerequisite for the implementation of biological approaches to European aquatic ecosystem management. The development of assessment systems for the ecological status of freshwaters has enormously increased in recent years, primarily to meet the requirements of the WFD. Ranging from traditional saprobic water quality monitoring to the evaluation of various stressors and their impact on benthic invertebrates, these assessment methodologies have become more and more complex and sophisticated.

Fig. 1: Ecoregional distribution of *Plectrocnemia kisbelai* Botosaneanu, 1967 in the Alps and in the Carpathians; source of map (modified): European Environment Agency (www.eea.eu.int)

The main purpose of the aquatic macroinvertebrate taxalist and its associated ecological database is to provide a basic tool for the ecological assessment of water bodies that should be available for the scientific public at a comparatively early stage of its development. Therefore, the species inventories and the ecological rankings are in different stages of completeness for most of the targeted countries and taxonomic groups. Consequently, the taxa inventory does not necessarily represent the state of the art of a country's recorded species: these lists have to be understood as an operational tool for bio-monitoring projects under the auspices of the Water Framework Directive. Nevertheless, besides its operational character, the final product should represent a numerically transformed, state of the art database of European zoogeographic and ecological knowledge on benthic invertebrates.

The future aims of the database development are defined as:

- Completion of national benthic invertebrate taxa inventories (checklists) for all European countries and adjustment with the findings of the Fauna Europaea group (www.faunaeur.org).
- Filling the gaps in our knowledge of the ecological parameters treated so far.
- Inclusion of additional ecological parameters such as temperature preference, resistance to droughts, hydrological preference, reproductive cycles and life cycle duration, altitude preference, and others. A special focus will be on wetland-groundwater-interactions with the river corridor as an entity of aquatic systems in the sense of lateral and vertical connectivity.

While the development of assessment systems come to the fore, the performance of autecological studies, which often form the base of these systems, seems to be decreasing due to the fashion for "up-to-date" sciences. The gap between our basic knowledge of indicators and the number of different so-called indicator-based assessment systems is, in fact, becoming greater, which seems to be contradictory. Fundamental and applied sciences need to develop synchronously. Therefore, it is important to fill as many as possible of the taxonomic and autecological gaps within the freshwaterecology.info database. The more ecologically classified species are included into an assessment methodology, the more likely the model will become both quantitatively powerful and increasingly sensitive to the full range of possible environmental influences. Effective assessment programmes to evaluate the ecological status of freshwater systems can contribute to the overall health of the aquatic environment.

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Checklist of the Trichoptera of the Grand Duchy of Luxembourg - First revision

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A first checklist of the Trichoptera of Luxembourg was published in 2002 (Schrankel et al. 2002) including 178 species.

Due to new investigations 7 species can be added.

Wormaldia occipitalis (Pictet, 1834) and *Wormaldia mediana* McLachlan, 1878 of the first list are replaced by *Wormaldia occipitalis* type 1 and *Wormaldia occipitalis* type 2. *Wormaldia mediana* McLachlan, 1878 is expected to occur in Luxembourg too, but no adults could be found yet.

Glossosoma boltoni Curtis, 1834 was wrongly identified and turned out to be *Glossosoma conformis* Neboiss, 1963 and *Ceraclea alboguttata* Hagen, 1860 is now a synonym of *Ceraclea albimacula* (Rambur, 1877) (Malicky 2005).

Systematical and nomenclatorical changes after Robert (2004) have been taken into consideration. Thus, the actualised checklist includes 183 species.

Bold = New species in comparison with the list of Schrankel et al. (2002)

* = Systematic or nomenclatural changes after Robert (2004)

Rhyacophilidae Stephens, 1836

1 *** *Rhyacophila dorsalis dorsalis* (Curtis, 1834)**
2 *Rhyacophila fasciata* Hagen, 1859
3 *Rhyacophila laevis* Pictet, 1834
4 *Rhyacophila obliterata* McLachlan, 1863
5 *Rhyacophila philopotamoides* McLachlan, 1879
6 *Rhyacophila praemorsa* McLachlan, 1879
7 *Rhyacophila pubescens* Pictet, 1834
8 *Rhyacophila tristis* Pictet, 1834

Glossosomatidae Wallengren, 1891

9 *Glossosoma conformis* Neboiss, 1963
10 *Synagapetus iridipennis* McLachlan, 1879
11 *Agapetus delicatulus* McLachlan, 1884
12 *Agapetus fuscipes* Curtis, 1834
13 *Agapetus* cf. *laniger* (Pictet, 1834)
14 *Agapetus ochripes* Curtis, 1834

Hydroptilidae Stephens, 1836

15 *Ptilocolepus granulatus* (Pictet, 1834)
16 *Agraylea multipunctata* Curtis, 1834
17 *Agraylea sexmaculata* Curtis, 1834
18 *Allotrichia pallicornis* (Eaton, 1873)
19 *Hydroptila angulata* Mosely, 1922
20 *Hydroptila forcipata* (Eaton, 1873)
21 *Hydroptila simulans* Mosely, 1920
22 *Hydroptila sparsa* Curtis, 1834
23 *Hydroptila vectis* Curtis, 1834
24 *Oxyethira flavicornis* (Pictet, 1834)
25 *Tricholeiochiton fagesii* (Guinard, 1879)
26 *Orthotrichia costalis* (Curtis, 1834)
27 *Ithytrichia lamellaris* Eaton, 1873

Philopotamidae Stephens, 1829

28 *Philopotamus ludificatus* McLachlan, 1878
29 *Philopotamus montanus* (Donovan, 1813)
30 *Philopotamus variegatus* (Scopoli, 1763)
31 ***Wormaldia occipitalis* type1**
32 ***Wormaldia occipitalis* type2**
33 *Wormaldia subnigra* McLachlan, 1865
34 *Chimarra marginata* (Linnaeus, 1767)

Psychomyiidae Curtis, 1835

35 *Psychomyia pusilla* (Fabricius, 1781)
36 *Tinodes assimilis* McLachlan, 1865
37 *Tinodes dives* (Pictet, 1834)
38 *Tinodes pallidulus* McLachlan, 1878
39 *Tinodes rostocki* McLachlan, 1878
40 *Tinodes unicolor* (Pictet, 1834)
41 *Tinodes waeneri* (Linnaeus, 1758)
42 *Lype phaeopa* (Stephens, 1836)
43 *Lype reducta* (Hagen, 1868)

Ecnomidae Ulmer, 1903

44 *Ecnomus tenellus* (Rambur, 1842)

Polycentropodidae Ulmer, 1903

45 *Cyrnus crenaticornis* (Kolenati, 1859)
46 *Cyrnus flavidus* McLachlan, 1864
47 *Cyrnus insolutus* McLachlan, 1878
48 *Cyrnus trimaculatus* (Curtis, 1834)
49 *Holocentropus dubius* (Rambur, 1842)
50 *Holocentropus picicornis* (Stephens, 1836)
51 *Neureclipsis bimaculata* (Linnaeus, 1758)
52 *Plectrocnemia brevis* McLachlan, 1871
53 *Plectrocnemia conspersa* (Curtis, 1834)
54 *Plectrocnemia geniculata* McLachlan, 1871
55 *Polycentropus flavomaculatus* (Pictet, 1834)
56 *Polycentropus irroratus* Curtis, 1835

Hydropsychidae Curtis, 1835

57 *Cheumatopsyche lepida* (Pictet, 1834)
58 *Hydropsyche angustipennis* (Curtis, 1834)
59 *Hydropsyche botosaneanui* Marinkovic-Gospodnetic, 1966
60 ***Hydropsyche bulgaromanorum* Malicky, 1977**
61 *Hydropsyche contubernalis* McLachlan, 1865
62 *Hydropsyche dinarica* Marinkovic, 1979
63 *Hydropsyche exocellata* Dufour, 1841
64 *Hydropsyche fulvipes* (Curtis, 1834)
65 *Hydropsyche incognita* Pitsch, 1993
66 *Hydropsyche instabilis* (Curtis, 1834)
67 ***Hydropsyche modesta* Navas, 1925**
68 *Hydropsyche pellucidula* (Curtis, 1834)
69 *Hydropsyche saxonica* McLachlan, 1884
70 *Hydropsyche silfvenii* Ulmer, 1906
71 *Hydropsyche siltalai* Döhler, 1963
72 *Diplectrona felix* McLachlan, 1878

Phryganeidae Leach, 1815

73 *Trichostegia minor* (Curtis, 1834)
74 *Agrypnia pagetana* Curtis, 1835
75 *Agrypnia varia* (Fabricius, 1793)
76 *Oligotricha striata* (Linnaeus, 1758)
77 *Phryganea bipunctata* Retzius, 1783
78 *Hagenella clathrata* (Kolenati, 1848)

Brachycentridae Ulmer, 1903

79 *Brachycentrus maculatus* (Fourcroy, 1785)
80 *Brachycentrus montanus* Klapalek, 1892
81 *Brachycentrus subnubilus* Curtis, 1834
82 *Micrasema longulum* McLachlan, 1876
83 *Micrasema minimum* McLachlan, 1876
84 *Micrasema setiferum* (Pictet, 1834)

Lepidostomatidae Ulmer, 1903

85 *Lepidostoma hirtum* (Fabricius, 1775)
86 *Lasiocephala basalis* (Kolenati, 1848)
87 *Crunoecia irrorata* (Curtis, 1834)

Limnephilidae Kolenati, 1848

Dicosmoecinae Schmid, 1955

88 *Ironoquia dubia* (Stephens, 1837)

Drusinae Banks, 1916

89 *Anomalopterygella chauviniana* (Stein, 1874)
90 *Drusus annulatus* (Stephens, 1837)
91 *Ecclisopteryx dalecarlica* Kolenati, 1848

Limnephilinae Kolenati, 1848

Limnephilini Kolenati, 1848

92 *Anabolia nervosa* (Curtis, 1834)
93 *Glyphotaelius pellucidus* (Retzius, 1783)
94 *Grammotaulius nigropunctatus* (Retzius, 1783)
95 *Grammotaulius submaculatus* (Rambur, 1842)
96 *Limnephilus affinis* Curtis, 1834
97 *Limnephilus auricula* Curtis, 1834
98 *Limnephilus binotatus* Curtis, 1834
99 *Limnephilus bipunctatus* Curtis, 1834
100 *Limnephilus centralis* Curtis, 1834
101 *Limnephilus decipiens* (Kolenati, 1848)
102 *Limnephilus extricatus* McLachlan, 1865
103 *Limnephilus flavicornis* (Fabricius, 1787)
104 *Limnephilus fuscicornis* Rambur, 1842
105 *Limnephilus griseus* (Linnaeus, 1758)
106 *Limnephilus hirsutus* (Pictet, 1834)
107 *Limnephilus ignavus* McLachlan, 1865
108 ***Limnephilus italicus* McLachlan, 1884**
109 *Limnephilus lunatus* Curtis, 1834
110 *Limnephilus marmoratus* Curtis, 1834
111 *Limnephilus rhombicus* (Linnaeus, 1758)
112 *Limnephilus sparsus* Curtis, 1834
113 *Limnephilus stigma* Curtis, 1834
114 *Limnephilus vittatus* (Fabricius, 1798)
115 ***Phacopteryx brevipennis* (Curtis, 1834)**

Stenophylacini Schmidt, 1955

116 *Allogamus auricollis* (Pictet, 1834)
117 *Enoicyla pusilla* (Burmeister, 1839)
118 *Halesus digitatus* (Schrank, 1781)
119 *Halesus radiatus* (Curtis, 1834)
120 *Halesus tessellatus* (Rambur, 1842)
121 *Hydatophylax infumatus* (McLachlan, 1865)
122 *Melampophylax mucoreus* (Hagen, 1861)
123 *Micropterna lateralis* (Stephens, 1837)
124 *Micropterna nycterobia* McLachlan, 1875
125 *Micropterna sequax* McLachlan, 1875
126 *Micropterna testacea* (Gmelin, 1790)
127 *Parachiona picicornis* (Pictet, 1834)
128 ******Potamophylax cingulatus cingulatus* (Stephens, 1837)**
129 *Potamophylax latipennis* (Curtis, 1834)
130 *Potamophylax luctuosus* (Piller & Mitterpacher, 1783)
131 *Potamophylax nigricornis* (Pictet, 1834)
132 *Potamophylax rotundipennis* (Brauer, 1857)
133 *Stenophylax mitis* McLachlan, 1875
134 ***Stenophylax mucronatus* McLachlan, 1880**
135 *Stenophylax permistus* McLachlan, 1895
136 *Stenophylax vibex* (Curtis, 1834)

Chaetopterygini Hagen, 1858

137 *Annitella obscurata* (McLachlan, 1876)
138 *Chaetopteryx major* McLachlan, 1876
139 *Chaetopteryx villosa* (Fabricius, 1798)

Apataniidae Wallengren, 1886

140 *Apatania fimbriata* (Pictet, 1834)

Goeridae Ulmer, 1903

141 *Goera pilosa* (Fabricius, 1775)
142 *Lithax niger* (Hagen, 1859)
143 *Lithax obscurus* (Hagen, 1859)
144 *Silo nigricornis* (Pictet, 1834)
145 *Silo pallipes* (Fabricius, 1781)
146 *Silo piceus* Brauer, 1857

Leptoceridae Leach, 1815

147 *Athripsodes albifrons* (Linnaeus, 1758)
148 *Athripsodes aterrimus* (Stephens, 1836)
149 *Athripsodes bilineatus* (Linnaeus, 1758)
150 *Athripsodes cinereus* (Curtis, 1834)
151 *Athripsodes commutatus* (Rostock, 1874)
152 *Athripsodes leucophaeus* (Rambur, 1842)
153 *Ceraclea albimacula* (Rambur, 1877)
154 *Ceraclea annulicornis* (Stephens, 1836)
155 *Ceraclea dissimilis* (Stephens, 1836)
156 ***Ceraclea fulva* (Rambur, 1842)**
157 *Ceraclea nigronervosa* (Retzius, 1783)

158 *Ceraclea senilis* (Burmeister, 1839)
159 *Leptocerus interruptus* (Fabricius, 1775)
160 *Leptocerus tineiformis* Curtis, 1834
161 *Adicella filicornis* (Pictet, 1834)
162 *Adicella reducta* (McLachlan, 1865)
163 *Triaenodes bicolor* (Curtis, 1834)
164 *Oecetis furva* (Rambur, 1842)
165 *Oecetis lacustris* (Pictet, 1834)
166 *Oecetis notata* (Rambur, 1842)
167 *Oecetis ochracea* (Curtis, 1825)
168 *Oecetis testacea* (Curtis, 1834)
169 ***Setodes argentipunctellus* McLachlan, 1877**
170 *Setodes punctatus* (Fabricius, 1793)
171 ***Mystacides azureus* (Linnaeus, 1761)**
172 *Mystacides longicornis* (Linnaeus, 1758)
173 ***Mystacides niger* (Linnaeus, 1758)**

Molannidae Wallengren, 1891

174 *Molanna angustata* Curtis, 1834

Odontoceridae Wallengren, 1891

175 *Odontocerum albicorne* (Scopoli, 1763)

Sericostomatidae Stephens, 1836

176 *Notidobia ciliaris* (Linnaeus, 1761)
177 *Oecismus monedula* (Hagen, 1859)
178 ***Sericostoma schneideri* Kolenati, 1848**
179 *Sericostoma personatum* (Spence in Kirby & Spence, 1826)

Beraeidae Wallengren, 1891

180 *Beraea maura* (Curtis, 1834)
181 *Beraea pullata* (Curtis, 1834)
182 *Beraeodes minutus* (Linnaeus, 1761)
183 *Ernodes articularis* (Pictet, 1834)

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Zoogeographical characteristics of the Trichoptera Fauna of Turkey

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Abstract

Zoogeographical analysis of the Trichoptera fauna of Turkey in two geographical regions, in northeastern and northwestern Anatolia and some distribution patterns are presented. The Caddisfly fauna of Turkey is represented by 402 taxa, (389 species and 13 subspecies) belonging to 80 genera in 22 families. The dominance of the European species is the characteristic feature of the fauna (42 %); 91 species are widely distributed in Europe (22.6 %), 62 species (15.5%) show southeastern Mediterranean type of distribution; 15 species distribute holarctic or palearctic. One of the important characteristics of the fauna, is the dominance of Caucasian fauna in northeastern Turkey. 15 % of the species are found in the Caucasus. Sixteen of the known 402 species/subspecies are found only in Turkey and Iran. 6 % of the species with a widespread distribution (Palearctic or Holarctic) 35 % of the known species are endemic, which is the highest rate of endemism within the Mediterranean countries. Excluding the endemics, which are found in northeastern Turkey, almost all the relatives of the endemic species are also European. Even in northeastern Anatolia 20 % of the endemics have their close relatives in Europe. The Trichoptera fauna of northeastern Turkey is related to Caucasian/Transcaucasian fauna; 60 species (15 %) distribute in the Caucasus or through Iran; 44 species (10.9 %) of which are found only in Turkey and the Caucasus.

The similarities with the Iranian fauna are less prominent; 70 species (17 %) that occur in Turkey are also found in Iran; 16 species distribute only in both countries. One of the characteristics of the Turkish Trichoptera fauna is the high rate of the endemism. Analysis of the endemics and their relatives indicates the centres of endemism in northeastern Anatolia and the fauna of the region is not the extending part of the Caucasian fauna but shows its own characteristics. Several types of the distribution of Turkish Trichoptera are figured and discussed.

Introduction

The studies on the Trichoptera fauna of Turkey have begun in the 19. Century. In the Synopsis of Trichoptera of the European Fauna, 65 species are cited from Asia Minor (McLachlan, 1874-1880). The species described by McLachlan from Turkey were few, remaining also the endemics today; these are *Tinodes manni* McLachlan, *Limnephilus ponticus* McLachlan and *Sericostoma mesopotamicum* McLachlan. In addition, *Drusus concolor* Kempny, 1908, described on the beginning of the 20. Century from Keşiş Dagh (Uludağ) (Malicky, 1988: 1) is an endemic species found in a small area in the Bursa province (Malicky & Sipahiler, 1993). After 1970's, the number of studies increased; in 1978, 114 species for Turkey were listed (Botosaneanu & Malicky, 1978). In 1984, the first list included 201 species, was published (Malicky & Sipahiler, 1984). Later, in 1987, the number of the known species reached to 235, in 1993 to 291 and in 1995 to 313 (Sipahiler & Malicky, 1987; Malicky & Sipahiler, 1993; Sipahiler, 1996). In the last decade, many new species and records were published, increasing the number of known species/subspecies to 386 (Sipahiler, 2005). In the present study, the latest records were added, so that the known species of the fauna increases to 402 species/subspecies belonging to 80 genera in 22 families. *Oecetis notata* Rambur, 1842 is a new record for the Turkish fauna, discovered recently in northwestern Turkey.

In this study, general outlines of the zoogeography of Turkish Trichoptera and the faunistic analysis of northeastern and northwestern Anatolia regions are given.

Turkey is a mountainous country, divided to 8 geographical regions (Fig.1). Northern Anatolia, called the Black Sea Region, is bordered in the south with the plates of the eastern and central Anatolia regions. Pontus mountain range (Karadeniz Mountains) extent parallels to the coast and becomes higher through the east. Kackar Mountains in the Rize province is the highest part (3917 m) of the mountain range. These mountains are the extensions of the Caucasus but are separated from these mountains by Rioni-Kura valley in Georgia. This separation is also evident in the composition of the Trichoptera fauna of northeastern Anatolia; the region has its own endemics and the Caucasian invasions are more or less limited. On the other hand, some genera like *Cerasma* and *Martynomyia*, which were described first from the Caucasus, have more species in the region. Valleys, extending vertically along the coast, separate the Pontus mountain ranges. In the western part of the region, the mountains are less high and the valleys are sometimes very large like a plain. In the east of the region, two valleys separate the mountains from each other. One of them is the Çoruh valley, separates the highest part of the mountains deeply to Kaçkar and Karchal Mountains. This separation caused a zoological isolation of the northernmost corner of Turkey, Camili (Macahel) region, indicating clearly a centre of endemism.

The zoogeographical outlines of the Trichoptera fauna

The caddisfly fauna of Turkey is represented by 402 taxa (389 species and 13 subspecies), belonging to 80 genera in 22 families. The family Molannidae is not represented in Turkey. The richness of the species is seen especially in southern Turkey (168 species) and northeastern Turkey (140 species). Southeastern Turkey has only 14 species, corresponding to the arid climate of the region (Table 1)

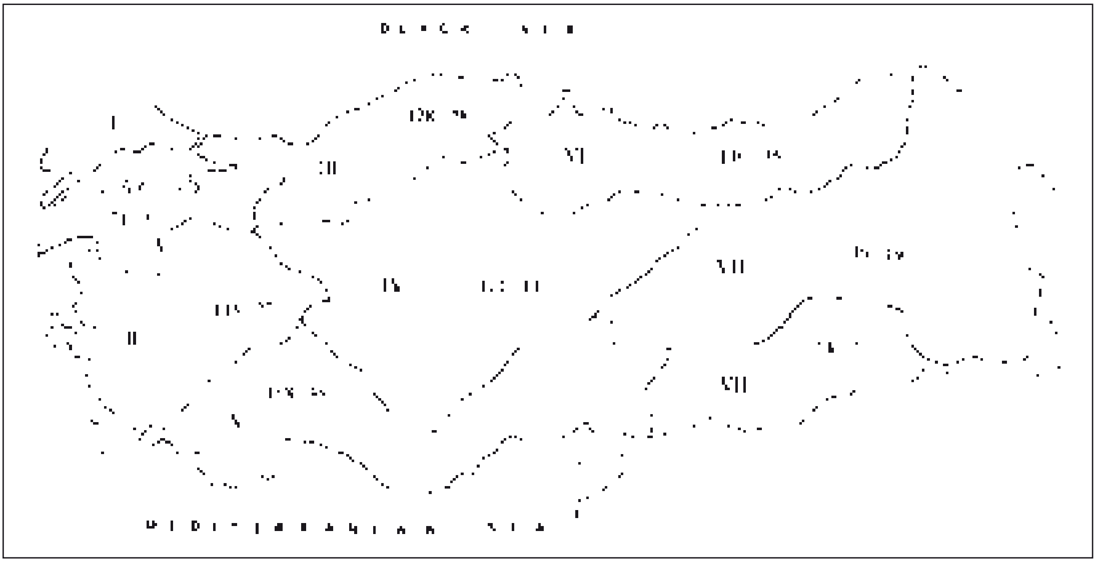

Fig. 1: Geogrophical regions of Turkey. I, Marmara Region; II, West Anatolia Region; III, North west Anatolia Region; IV, Central Anatolia Region; V, Mediterranean Region; VI, North east Anatolia Region; VII, East Anatolia Region; VIII, South east Anatolia Region. Arabic numbers indicate the known species/endemics from each region.

Table 1: The list of the families and the number of the known genera/species of Trichoptera in Turkey. E: Endemics, I-VIII: The geographical regions in Turkey, I: Marmara region, II West Anatolia region, III, North western Anatolia region, IV, Central Anatolia region, VI, North eastern Anatolia region, VII, East Anatolia region, VIII, South Anatolia region.

Family/ species & subspecies (total)	**E**	**Genus**	**Regions/species**							
			I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
Rhyacophilidae/21	7	2	2	4	8	2	5	15	5	-
Glossosomatidae/19	12	3	4	6	4	4	7	4	8	-
Ptilocolepidae/2	-	1	1	1	2	-	2	2	-	-
Hydroptilidae/57	18	8	4	27	14	19	27	5	10	2
Philopotamidae/12	4	2	4	3	4	1	3	8	-	-
Polycentropodidae/21	7	5	10	17	8	8	20	12	7	1
Ecnomidae/3	1	1	-	1	-	2	2	-	1	2
Psychomyiidae/31	12	3	6	11	8	4	15	7	2	-
Hydropsychidae/57	22	3	11	16	16	15	29	22	26	4
Phryaneidae/6	1	2	-	1	3	1	3	2	2	-
Brachycentridae/4	2	2	1	1	2	1	2	2	-	-
Uenoidae/2	-	1	-	-	1	-	-	2	-	-
Goeridae/5	-	3	1	-	2	-	1	1	2	-
Lepidostomatidae/10	5	4	2	3	3	2	2	5	2	-
Apataniidae/3	2	2	-	1	-	-	1	2	1	-
Limnephilidae/76	22	16	18	18	32	19	29	29	31	2
Sericostomatidae/14	9	5	-	6	3	2	2	6	2	-
Odontoceridae/1	-	1	-	1	-	-	-	1	-	-
Helicopsychidae/1	-	1	1	-	1	-	-	-	-	-
Calamoceratidae/1	-	1	1	1	1	1	1	-	-	1
Beraeidae/14	9	4	-	5	5	3	4	4	1	-
Leptoceridae/44	9	9	5	21	13	17	14	11	19	2
Total 22/402		**80**	**71**	**145**	**128**	**101**	**168**	**140**	**119**	**14**
Endemic species/genera	141	2	5	27	28	14	49	35	19	2
Endemics %	**35**		**07**	**18.5**	**21.8**	**13.8**	**29**	**25**	**16**	**14**

The significant characteristic of the Turkish Trichoptera fauna is the high percentage of the endemism. Two limnephilid genera, (*Rizeiella* and *Hadimina*) and 141 of the known species are endemic to Turkey (35 %). Compared to different countries of Europe, e.g. in the peninsular Italy the percentage of endemics is 29 %, which is the highest rate in the southern regions; in Basilicata 31 %, in Calabria 32 %, even Sicily shows 32 % of endemism. Similarly, the rate in the Balkans is 22 %, in the Iberian Peninsula 13 % (Cianficconi at al, 1997). Excluding the Mediterranean islands and southern Italy, the Caucasus is the only region with 31 % of endemics that close to the rate of the Turkish fauna. Within the families Apatanidae (66%), Sericostomatidae and Beraeidae show the highest rate of endemism (64%).

The endemics, occurring in the Marmara region, including the European part of Turkey are only five species, which are found in the Asian part of Turkey. The southern Anatolia is the richest region, having 168 species; which of these 49 species are endemics.

The Trichoptera fauna of Turkey is strongly related to the European fauna (Fig. 2). 168 of the known 402 species (42 %) are found in Europe, of which 91 species (22.6 %) have European distribution, 62 species (15.5) % distributed in the southeast Mediterranean region and 15 species show holartic or palearctic distribution. The Trichoptera fauna of northeastern Turkey is related to Caucasian/ Transcaucasian fauna; 60 species (15 %) distribute in the Caucasus or through Iran. 44 species (10.9 %) of which are found only In Turkey and the Caucasus;

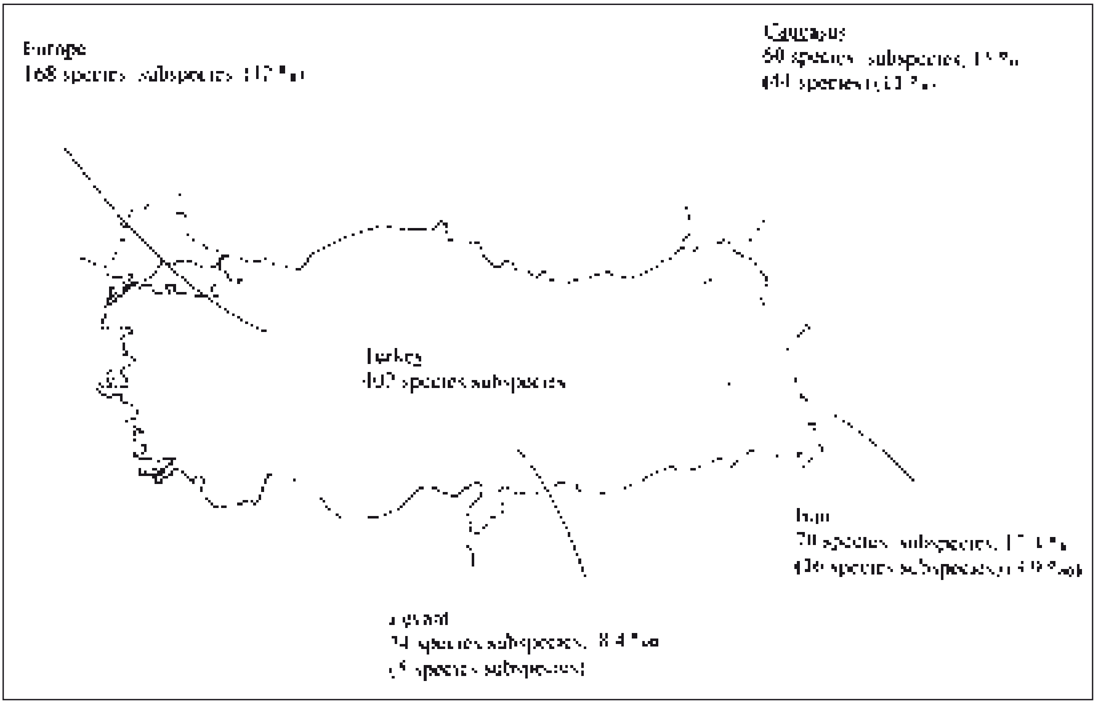

Fig. 2: Similarities of the Trichoptera fauna of Turkey to the adjacent regions. The numbers in the brackets indicate the species that occur only in both regions.

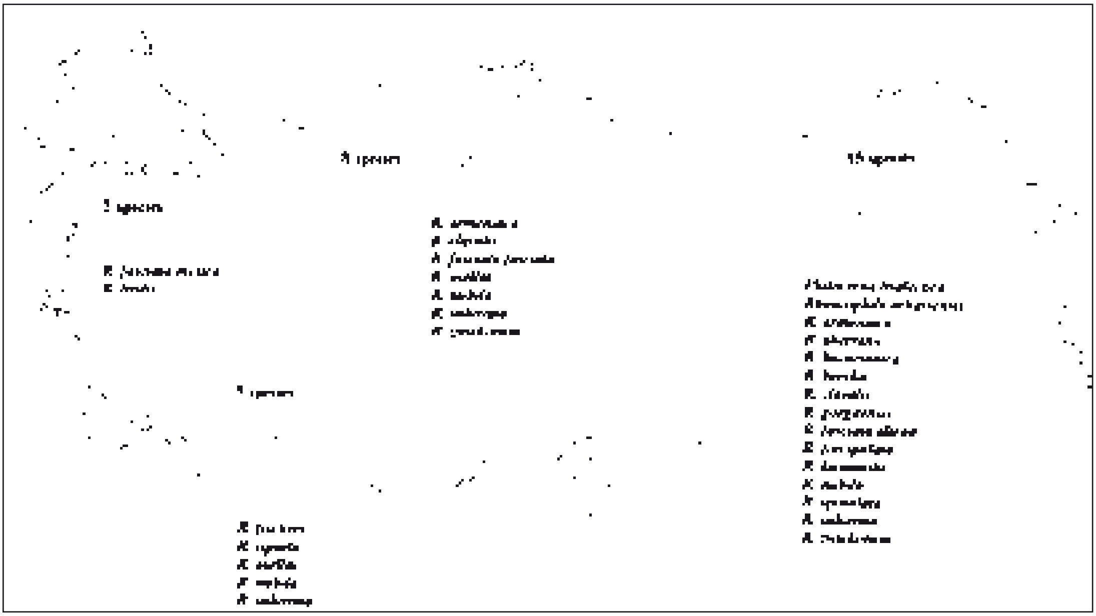

Fig. 3: Distribution of the species of the family Rhyacophilidae in Turkey. Spotted areas indicate the areas of the listed species.

Table 2: The families and the number of the species in different countries (**TR:** (Sipahiler, 2004, 2005, 2005a and unpublished data), **GR: Greece, GB: Grand** Britania (Barnard, 1985), **A:** Austria (Malicky, 1999), **I:** Italy (Cianficconi, 2002; Malicky, 2002), **BG:** Bulgaria (Kumanski, 1985, 1988), **RL:** Libanon, **IL:** Israël (Botosaneanu 1992), **SY:** Syria (Sipahiler & Malicky, 1987; Malicky, 1997), **IR:** Iran (Mirmoayedi &Malicky, 2002; Mey, 2004).

Families	TR	GR	GB	A		I	BG	RL	IL	SY	IR
Hydrobiosidae	-	-	-	-		-	-	-	-	-	1
Rhyacophilidae	21	21	4	24		37	18	2	1	-	4
Glossosomatidae	19	16	6	13		12	14	3	2	1	3
Ptilocolepidae	2	-	-	1		1	-	-	-	-	1
Hydroptilidae	57	42	31	27		50	28	14	15	4	25
Philopotamidae	12	12	5	9		22	11	1	1	-	4
Polycentropodidae	21	16	13	17		30	10	1	2	-	7
Ecnomidae	3	1	1	1		1	1	-	2	-	3
Psychomyiidae	3	34	12	27		27	12	7	6	1	8
Hydropsychidae	57	29	11	17		24	19	4	4	6	27
Phryganeidae	6	2	10	9		8	4	1	-	-	1
Brachycentridae	4	3	1	7		6	4	-	-	1	2
Uenoidae	2	1	-	-		1	1	-	-	-	-
Goeridae	5	5	3	6		9	6	-	-	-	1
Lepidostomatidae	10	4	3	4		4	3	-	-	-	4
Apataniidae	3	3	1	2		2	-	-	1	-	-
Limnephilidae	76	57	58	105		112	73	12	7	6	16
Sercostomatidae	14	9	2	4		10	2	1	-	-	1
Odontoceridae	1	2	1	1		1	1	-	-	-	-
Molannidae	-	-	2	3		-	-	-	-	-	-
Helicopsychidae	1	2	-	-		2	1	-	-	-	-
Calamoceratidae	1	1	-	-		-	1	-	-	-	-
Beraeidae	14	11	-	7		20	5	1	1	-	1
Leptoceridae	44	34	31	33		33	31	4	7	1	13
Total	**402**	**305**	**199**	**317**		**412**	**245**	**51**	**49**	**20**	**120**

among them, 2 species, *Glossosoma capitatum* and *Hydropsyche cornuta* are also found in Lebanon and Syria respectively.

Excluding the endemics, which are found in northeastern Turkey, almost all the relatives of the endemic species are also European. Even in northeastern Anatolia 20 % of the endemics have their close relatives in Europe.

Turkey has a rich fauna, compared to some countries in Europe and in the Middle East (Table 2). The families Hydroptilidae and Hydropsychidae (both with 57 taxa), Leptoceridae (with 44 taxa) and Sericostomatidae with (14 taxa) are best represented in Turkey in having highest number of the species when compared to the European and Middle East Countries. The family Rhyacophilidae is well represented in Turkey most of the species are found in northern Anatolia (Fig.3).

Limnephilidae is the largest family, represented in Turkey by 76 species belonging to 22 genera.

The genus *Limnephilus* is well represented with 26 species, compared to several parts of Europe, e.g. in the Balkans 20 species, in Italy, 25 species and in the Caucasus 21 species are known (Cianficconi, 2002; Malicky, 1983).

The similarities with the Iranian fauna are less prominent; 70 species (17%) that occur in Turkey are also found in Iran; 16 species are distributed only in both Countries, which belong to the families Hydroptilidae, Hydropsychidae, Polycentropodidae, Lepidostomatidae and Leptoceridae.

The similarities with the Levantine fauna are limited with 34 species; the species distributed only in Turkey and Levant are 5, namely, *Hydroptila* *atargatis* Malicky, *H. mendli levanti* Botosaneanu, *Orthotrichia ammanensis* Malicky, *Hydropsyche jordanensis* Tjeder and *Ernodes saltans* Martynov.

Trichoptera fauna of northeastern Turkey

In this region 140 species/subspecies belonging to the 47 genera in 19 families occur, excluding the families Ecnomidae, Helicopsychidae and Calamoceratidae. Most of the species of the family Rhyacophilidae in Turkey, namely 15 of 21 known taxa are found in this region.

Four small genera that have one or a few species, namely, *Philocrena* (Rhyacophilidae), *Kelgena* (Limnephilidae, Chaetopterygini), *Martynomyia* (Lepidostomatidae) and *Cerasma* (Sericostomatidae) are endemic for northeastern Anatolia and the Caucasus. Among them *Martynomyia* has two of the known three species and *Cerasma* the known two species in northeastern Turkey. *Philocrena trialetica*, the only species of the genus *Philocrena*, represented in the Caucasus and northeastern Turkey. In addition, the genera *Apataniana* (Apatanidae) and *Metaneoa* (Limnephilidae, Drusinae) are represented in this region by one species each. *Apataniana borcka* Sipahiler is the Pleistocene relict, discovered in Karchal Mountains at 2200 m altitude in late autumn. The relative species is *Apataniana bulbosa* Martynov, found in central Asia. On the contrary, the genus *Metanoea* represented in northeastern Turkey by one species, by *M. anatolica* Sipahiler, the relatives are found in the Alps and Western Europe (Sipahiler, 1999). *Rizeiella* Sipahiler (Chaetopterygini) is the endemic genus, described from this region, represented by two species. The family Ptilocolepidae, which was discovered recently in Thailand and shows a relict distribution with a few species found in the Mediterranean region (Malicky & Chantaramaongkol, 1996), represented in Turkey by 2 species, *Ptilocolepus colchicus* Martynov and *P. dilatatus* Martynov. Both species are found sympatrically in several places in northeastern Anatolia (Fig.4).

The analysis of the endemic species and their close relatives (Tab. 3) indicates that the fauna of the region is not the extending part of the Caucasian fauna, but shows its own characteristics. In the region, 1 endemic genus and 35 endemic species occur; only 6 species have their close relatives in the Caucasus. The relationships of 11 endemics

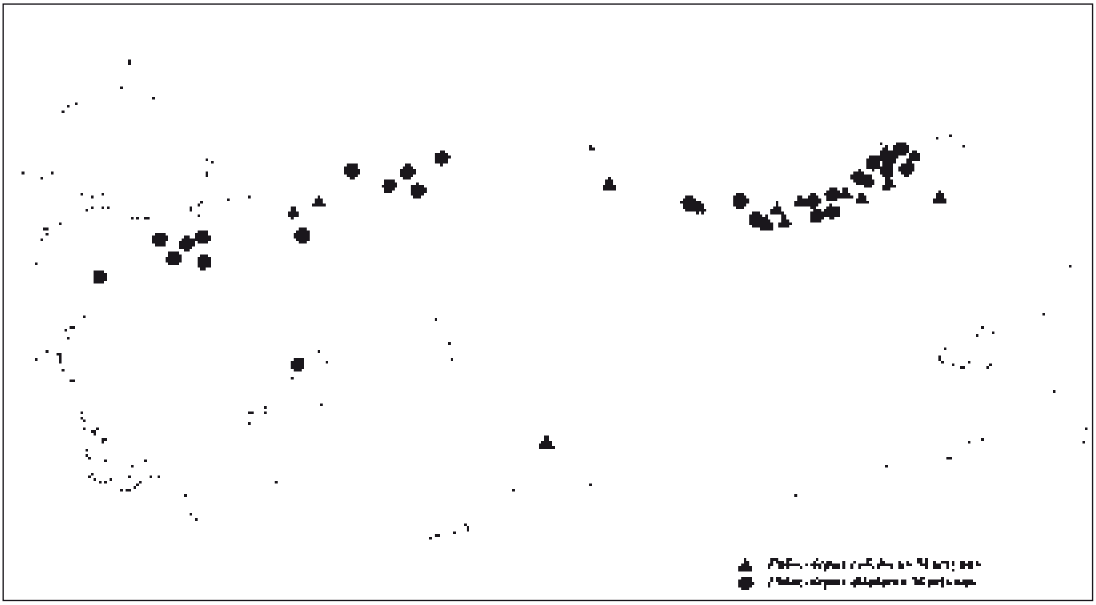

Fig. 4: Distributions of the genus *Ptilocolepus* species in Turkey.

Table 3: Endemic species and their close relatives in northeastern Turkey.

Family/Species	**Distribution in Turkey**	**Close relatives and their Distributions**
Rhyacophilidae		
Rhyacophila arhaviensis Sipahiler, 1986	Rize	Unknown
R. borcka Sipahiler,1996	Artvin (Camili)	*R. pubescens* Pictet, 1834, Europe
R. gorgitensis Sipahiler, 1997	Artvin (Camili)	Unknown
R. zwickorum Malicky, 1972	Trabzon, Rize,Artvin, Bolu	*stigmatica*-group, Europe
Glossosomatidae		
Synagapetus gorgitensis Sipahiler, 1996	Artvin(Camili)	unknown
Hydroptilidae		
Stactobia cermikensis Sipahiler, 1998	Artvin (Camili)	*S. olgae* Martynov, 1927, Turkestan *S. klapaleki* Schmid, 1959, Pakistan
S. lekoban Sipahiler, 1998	Artvin (Camili)	*S. wimmeri* Malicky, 1988, Trabzon
S. wimmeri Malicky, 1988	Trabzon	*S. lekoban* Sipahiler, 1998, Artvin
Philopotamidae		
Wormaldia dizkiran Sipahiler, 2001	Artvin (Camili)	*W. hemsinensis* Sipahiler, 1987, Rize
W. hemsinensis Sipahiler, 1987	Rize	*W. dizkiran* Sipahiler, 2001, Artvin
W. ikizdere Sipahiler, 2000	Rize, Gümüşhane	*W.triangulifera* McLachlan,1878 Europe
Polycentropodidae		
Plectrocnemia rizeiensis Sipahiler, 1987	Rize	*P. brevis* McLachlan, Europe *P. kydon* Malicky, 1975 south Balkans
Polycentropus yuecelcaglari Sipahiler, 1999	Artvin (Camili)	*P. segregatus* Mey, 1982, Caucasus
Hydropsychidae		
Hydropsyche gemecika Malicky, 1981	Giresun	unknown
H. kebab Malicky, 1974	Regions I-VI	*instabilis*-group
H. orduensis Sipahiler, 1987	Ordu, Artvin	*instabilis*-group
H. yukaritepe Sipahiler, 2004	Ordu	*instabilis*-group
Lepidostomatidae		
Martynomyia ayderensis Sipahiler, 1989	Rize, Artvin	*M. tripartita* Martynov, 1913, Caucasus
M. martynovi Sipahiler, 1995	Rize	unknown
Apataniidae		
Apataniana borcka Sipahiler, 1996	Artvin (Camili)	*A. bulbosa* Martynov, 1918 Siberia
Limnephilidae		
Drusus bayburti Cakin, 1983	Regions III, V,VI, VII	*D. caucasicus* Ulmer, 1907 Caucasus, Region VII
D. fuesunae Malicky, 1986	Trabzon	*D. bayburti* Cakin, 1983
D. rizeiensis Sipahiler, 1986	Rize	*D. biguttatus* Pictet, 1834 Europe
Limnephilus ponticus McLachlan, 1898	Regions II-VI, Rize	*lunatus*-group, Europe, Iran
Metanoea anatolica Sipahiler, 1986	Rize	unknown
Micropterna sipahilerae Kumanski & Malicky, 1997	Giresun	unknown
Kelgena macahelensis Sipahiler, 1999	Artvin (Camili)	*K. kelensis* Martynov, 1926 Caucasus
Rizeiella anatolica Sipahiler, 1986	Rize	*R. camiliensis* Sipahiler, 1999 Artvin
R. camiliensis Sipahiler, 1999	Artvin (Camili)	*R. anatolica* Sipahiler, 1986 Rize

Family/Species	Distribution in Turkey	Close relatives and their Distributions
Sericostomatidae		
Cerasma chairon Malicky, 1986	Rize	C. cornuta McLachlan, 1876 Caucasus
Notidobia demelti, Malicky, 1974	Rize, Gümüshane	*N. forsteri* Malicky, 1974, Caucasus
Beraeidae		
Ernodes macahelensis Sipahiler, 1997	Artvin (Camili)	*E. saltans* Martynov, 1913 Caucasus, Iran, Levant
E. rizeiensis Sipahiler, 1987	Rize	unknown
Leptoceridae		
Adicella thalia Malicky, 1976	Trabzon	*A. balcanica* Botosaneanu & Novak, 1965, Balkans
Setodes dehensuerae Cakin & Malicky, 1983	Antalya, Artvin, Erzurum	*S. kuehbandneri* Malicky, 1987 East Anatolia

(31 %) are unknown; 8 of the endemics have their close relatives elsewhere in Turkey, but mostly in the region and 7 of the species in Europe, even 1 species has a close relative in Siberia.

The centres of endemics of the region

Although in northeastern Anatolia every province has its own endemics, two regions, namely Kackar Mountains in the Rize province with 40 % of endemics and Karchal Mountains in the Artvin province (Camili region) are important centres of endemism (see Tab. 3).

Camili (Macahel) Region in the Karchal Mountains

The northernmost corner of the region shows interesting features of the composition of the fauna, indicating that this small area remained isolated longer than the other part of northeastern Anatolia Region. So, the distribution of the endemics in the north eastern Turkey point a centre of endemics, Karchal Mountains (village Camili) in the Artvin province, separated by Çoruh valley from the Rize province, and by Rion-Kura depression from the Caucasus, located near the state border to Georgia. The region is covered with dense subtropical rainy forest; most of the places are without human effect, which provides to the animal species rich and different biotopes. This small region is an important refuge area in the Artvin province, has a rich fauna with own endemics, of which the closest relatives are found in the neighbouring Rize province, Trabzon, in the Caucasus, even in Europe, Turkestan, Pakistan or in Siberia (Tab. 3). For example, *Ernodes macahelensis* Sipahiler (Beraeidae) is found only in Karchal Mountains, the close relative species *E. saltans* Martynov is found in the Caucasus and distributes in Rize through southern Turkey and Levant (Fig.5); similarly, *Wormaldia dizkiran* Sipahiler is an endemic species occurring in Camili region, while the sister species *W. hemsinensis* Sipahiler is found in the Rize province, the distributions of the latter and some more species found in this region were given in the (Fig.6). Although the area is only 1/6 of the area of the Rize province, the family Rhyacophilidae represents here by 13 species belonging to two genera, while in the neighbouring Rize province has 8 species and one genus. In the Artvin province, 18 of the known 35 endemics of the north eastern Turkey (51 %) are found; the species, which are the Caucasian endemics, distributing only in the Caucasus and only in northeastern Anatolia, represent here by 18 species. The number of the endemics decreases in the neighbouring Rize province, there are found 14 endemics (41 %) and 13 Caucasian endemics. In addition, some species, like *Micrasema bifoliatum* Martynov (Fig.7), *Ernodes saltans* Martynov, *Agapetus caucasicus* Martynov and *Limnephilus ponticus* McLachlan, which are widely distributed in Turkey or in the surrounding area, but not found in Camili region. These features of the fauna indicate isolation, for continued long periods in the past geological times. Indeed, the Rioni-Kura depression between the Black Sea and Caspian Sea

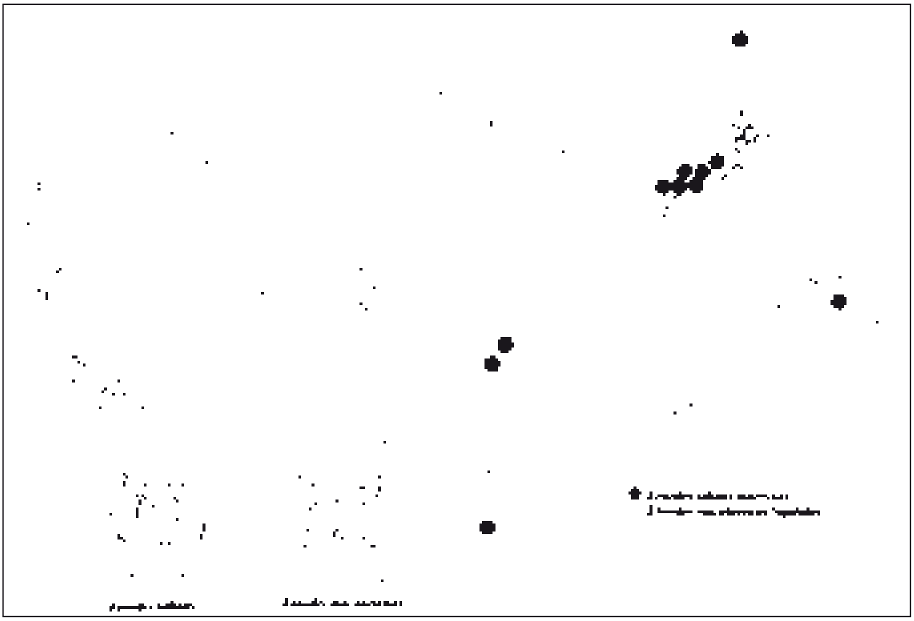

Fig. 5: Distributions of *Ernodes saltans* Martynov and *Ernodes macahelensis* Sipahiler (Map references for the Caucasus Kornouhova, 1986; Levant, Botosaneanu, 1992).

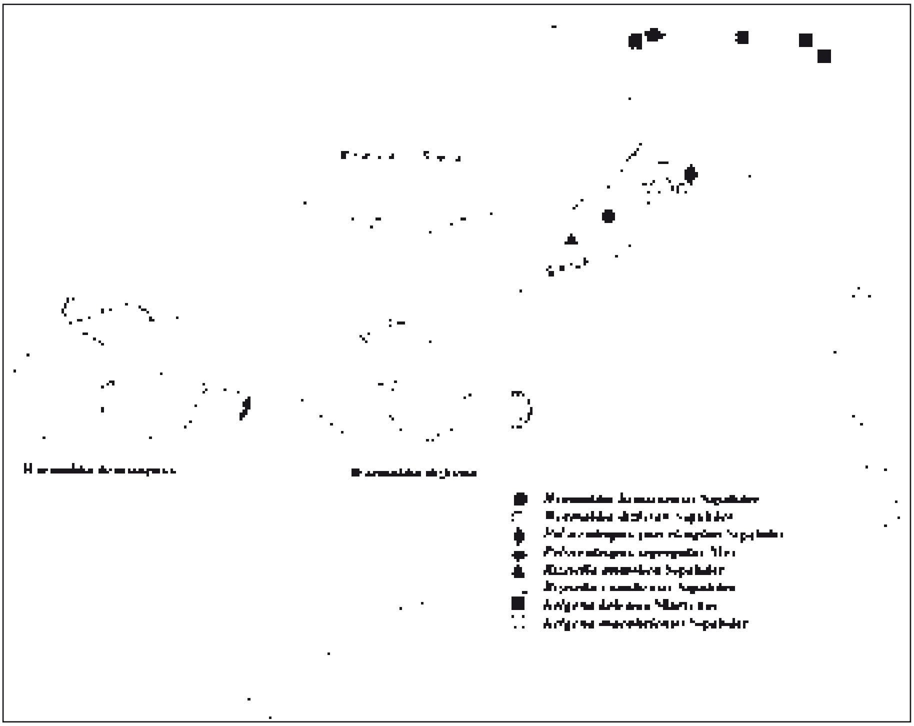

Fig. 6: Distribution of the close related species of Trichoptera in northeastern Anatolia and in the Caucasus (Map reference for the Caucasus Kumanski, 1980).

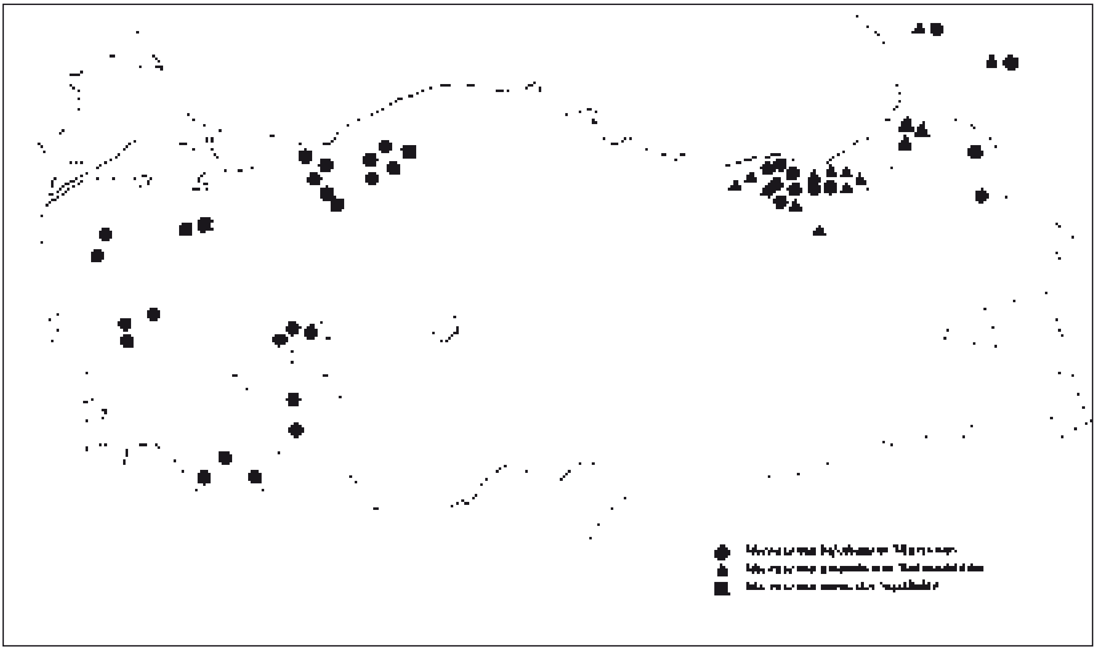

Fig. 7: Distributions of the genus *Micrasema* species in Turkey and in the Caucasus (Map reference for the Caucasus Kornouhova, 1986)

in the north of the Camili Region was flooded by the sea at the beginning of Oligocene, remaining in the middle Miocene. In Pliocene, the Rioni-Kura depression was under the influence of the Caspian basin; the transgression of the sea with brackish water covered the area from the southeast (Lüttig & Steffens, 1976). In Pleistocene and even in Holocene the evolution of the Ponto-Caspian basin continued; the transgressions of the Black Sea was in the maximum level in the interglacial periods, while the pluvial transgressions of the Caspian Sea took place at the end of interglacial period and beginning of glaciations (Alizade & Alieva, 1995).

One of the interesting features of the Camili region is to find some rheophile species that enter in the alpine lakes found on high mountains. For example, in Nachadrev Lake located at 2950 m altitude in the region two *Drusus* species, *D. amanus* Mey & Müller and *D. rizeiensis* Sipahiler are found; both species are also found in Yildiz Lake located before the summit of the Karchal Mountains at 2800 m altitude.

Northwestern Turkey

In northwestern Turkey 128 species are known, belonging to 51 genera in 19 families. Twenty-eight species are the endemics (21.8 %). The families Ecnomidae, Apatanidae and Odontoceridae are not represented in the region. The family Helicopsychidae occurs in northwestern part of Turkey (Marmara and northwestern Anatolia), this region could be the eastern limit of its distribution. In this region, three main elements can be recognized in the fauna:

- European elements.

The fauna of the region is strongly related to the European fauna, 81 species (63 %) are found in Europe, of which 23 species (28 %) have southeastern Mediterranean type of the distribution and 9 species have palearctic or holarctic distribution.

- Caucasian elements.

Fourteen species (10 %) distribute also in the Caucasus and/or in northeastern Turkey, expanding their area through the west (Tab.4).

Table 4: List of the species found in northwestern and northeastern Turkey and/or Caucasicus

	Families	Distribution
	Rhyacophilidae	
1	*Rhyacophila clavalis* Martynov	North eastern Turkey, Caucasus
2	*R. subovata* Martynov	North eastern, southern Turkey, Caucasus
3	*R. zwickorum* Malicky	North eastern Turkey, endemic
	Ptilocolepidae	
4	*Ptilocolepus colchicus* Martynov	Northeastern Turkey, southern Turkey, Caucasus, Iran
5	*P.dilatatus* Martynov	Northeastern, southern Turkey, Caucasus
	Polycentropodidae	
6	*Plectrocnemia latissima* Martynov	Northeastern Turkey, northern part of central Anatolia, Caucasus, Iran
	Psychomyiidae	
7	*Tinodes unidentatus* Klapalek	Caucasus
	Hydropsychidae	
8	*Hydropsyche acuta* Martynov	Western, eastern, central Turkey, Caucasus
9	*H. lepneva* Botosaneanu	Northwestern, eastern and southern Turkey, Caucasus
10	*H. mahrkusha* Schmid	Northeastern Turkey, Iran
11	*H. martynovi* Botosaneanu	Northeastern Turkey, Caucasus
	Brachycentridae	
12	*Micresema bifoliatum* Martynov	Northeastern, western and southern Turkey, Caucasus (Fig. 7)
	Limnephilidae	
13	*Limnephilus microdentatus* Martynov	North eastern Turkey, Caucasus
	Sericostomatidae	
14	*Schzopelex grusiense* Martynov	Western, northeastern Turkey, Caucasus

- Iranian elements.

Only five species, *Hydroptila armathai* Schmid, *Hydropsyche ressli* Malichy, *Hydropsyche mahrkusha* Schmid, *Dinarthrum iranicum* Schmid and *Polycentropus* cf. *mazdacus* Schmid are found in Turkey and Iran.

The species of the family Ptilocolepidae are found in the region; the area of *P. dilatatus* Martynov expands through the west Anatolia; both species occur rarely in the south (Fig. 4).

The family Limnephilidae represented in the region by 32 species, which are 42 % of the known Limnephilids, belonging to 10 genera. *Limnephilus* is the largest genus with 14 species, which is represented in northeastern Turkey by 10 species. The small genus *Psilopteryx* (Chaetopterygini), occurring with 5 species (and 5 subspecies of *P. psorosa* Kolenati) in central Europe, the Carpathians and the Balkans, represented in this region by one species and one subspecies, which is the southern limit of the distribution area of the genus (Fig. 8). Similarly, *Limnephilus extricatus* McLachlan, *Goera pilosa* Fabricius (Goeridae), *Oecetis notata* Rambur (Leptoceridae), occurring in large area in Europe, each found only in one place in the region, indicating southern and eastern limits of the distributions in this area. *Rhyacophila tristis* Pictet has also a large area in Europe, found in this region in several places and does not expand through the east In this region 28 endemic species occur (Tab. 5), 10 of these have close relatives in Europe (36%). Seven endemic species have their close relatives in Turkey (25 %) and 5 species in the Caucasus (18 %).

Distribution Patterns

In the glacial periods of the Pleistocene, Anatolia was in the pluvial periods that caused more precipitations, resulting in the enlargement of the areas of the lakes and the rivers in Turkey and formation of new lakes in the suitable areas. Indeed, especially in central Anatolia that has an arid climate today, there was a large lake in the Konya plain, of which the depth was 25 m. It is

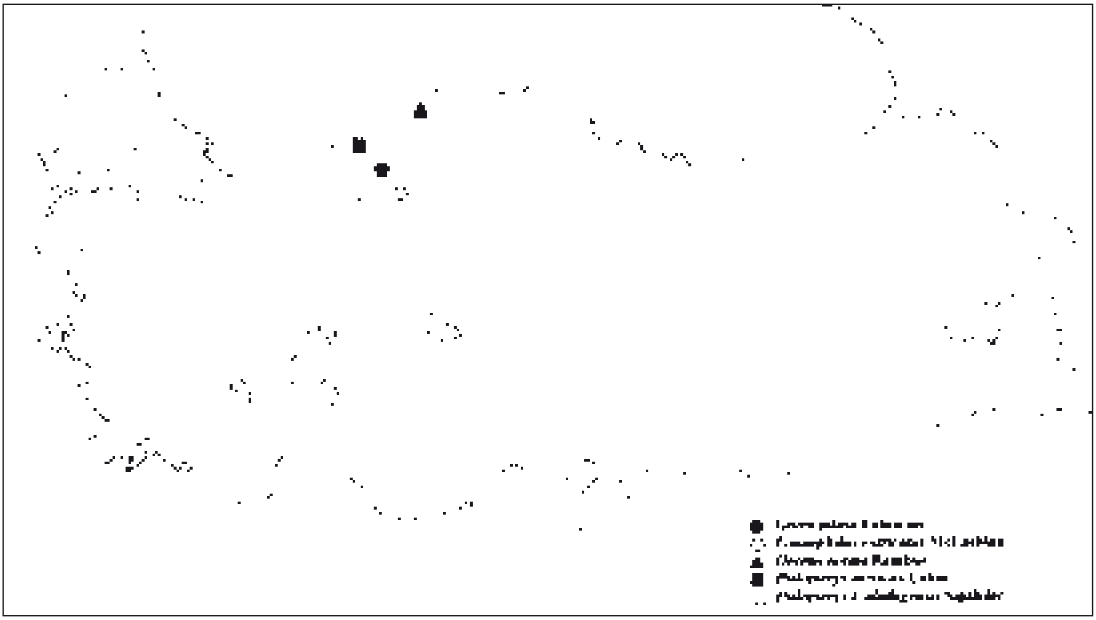

Fig. 8: Distributions of some species of Trichoptera, which are widely distributed in Europe and the distribution of the genus *Psilopteryx* in Turkey.

Table 5: Endemic species and their close relatives in northwestern Turkey.

No	North western Turkey endemics	Distribution in Turkey	Close relatives and their distribution
	Rhyacophilidae		
1	*Rhyacophila osellai* Malicky	Southern Turkey	*R. polonica* McLachlan, Europe
2	*R. zwickorum* Malicky	Northeastern Turkey	*R. stigmatica* Kolenati, Europe
	Glossosomatidae		
3	*Agapetus karabagi* Çakin	-	*A. laniger* Pictet, Europe
4	*Synagapetus anatolicus* Çakin	West and south Turkey	*S. birgi* Sipahiler, western Turkey
5	*Glossosoma yigilca* Sipahiler	-	*G. capitatum* Martynov, north east, east, west Turkey, Caucasus, Levant
	Hydroptilidae		
6	*Hydroptila abantica* Sipahiler	-	*H. ovacikensis* Sipahiler, east Turkey
7	*H. oemerueneli* Sipahiler	-	*H. brissaga* malicky, Europe
8	*H. varla* Sipahiler	-	*occulta*-group, Europe, Levant
	Hydropsychidae		
9	*Hydropsyche kebab* Malicky	South, east, northeast Turkey	*instabilis*-group, Europe
10	*H. sinopensis* Sipahiler	-	*Instabilis*-group, Europe
	Psychomyiidae		
11	*Psychomyia mengensis* Sipahiler	West, south Turkey	*P. pusilla* Fabricius, Europe
12	*P. dadayensis* Sipahiler	West, south Turkey	*P. pusilla* Fabricius, Europe
13	*Tinodes yuecelaskini* Sipahiler	-	*T. valvatus* Martynov, Caucasus, Turkey, Levant

No	North western Turkey endemics	Distribution in Turkey	Close relatives and their distribution
	Brachycentridae		
14	*Micrasema mencilis* Sipahiler	-	*M. bifoliatum* Martynov, Caucasus
	Limnephilidae		
15	*Drusus bayburti* Çakin	Northeast, east, southern Turkey	*D. caucasicus* Ulmer, Caucasus, north east Turkey
16	*Drusus demirsoyi* Çakin	-	*D. hackeri* Malicky, north west Turkey
17	*D. hackeri* Malicky	-	*D demirsoyi* Sipahiler, north west Turkey
18	*D. muchei ilgazensis* Sipahiler	-	*D. muchei kazdagensis* Sipahiler, west Turkey
19	*Limnephilus ponticus* McLachlan	Regions II-VII	-
20	*Chaetopteryx nalanae* Sipahiler	-	-
21	*Psilopteryx turcicus* Çakin	-	-
22	*P. t. aladagensis* Sipahiler	-	-
	Sericostomatidae		
23	*Oecismus monedula* pinkeri Malicky	Marmara Region	*O. monedula* Hagen, Europe
24	*Schzopelex rhamnes* Malicky	-	*S. cachetica* Martynov, Caucasus
	Beraeidae		
25	*Beraeamyia devrekensis* Sipahiler	-	*B. kamberlera* Malicky & Sipahiler, west Turkey
26	*Ernodes abanticus* Çakin	-	*E. anatolicus*, central Anatolia
27	*E. dirginensis* Sipahiler	-	*E.digitatus* Martynov, Caucasus
	Leptoceridae		
28	*Oecetis brignolii* Malicky	-	Not evident

also evident that some lakes in the Lake District were 90-110 m higher than the present-day levels. Similarly, several lakes in the north and east Anatolia and the adjacent regions were higher, e.g. Van Lake was 80 m, and Urmiye Lake in Iran was 110 m higher than the present-day level (Erol, 1979). In this way, many lakes and the river systems were connected to each other, so that the northern fauna have found a route to distribute through the south. After the end of the pluvial periods, at the beginning of the Holocene, the lakes retreated from these areas, which caused the destruction of the faunas in these areas, some of them found smaller areas in the Taurus Mountains in the south. Several examples for these species are given below.

1 - Species, which are widely distributed in the Palaearctic, are also found dominantly in the standing waters of Turkey; these are *Ecnomus tenellus* Rambur, *Oecetis ochracea* Curtis, *Athripsodes longispinosus* and *Ceraclea senilis*. *E. tenellus* Rambur is found in the lakes of Lake District in southern Anatolia (Karamik, Egirdir and Beysehir lakes), and in the lakes of the northern part of Turkey (Abant, Iznik, Manyas and Borabay lakes), found in Hirfanli Dam near Ankara, similar to *Oecetis ochracea* Curtis, which is found in the lakes of northern Turkey, including Hirfanli Dam and in the lakes of Lake District. It is found enormously in Egirdir Lake. This species occupies a large area in Europe through the central Asia, but is not found in the Mediterranean peninsulas (Malicky, 1983). Lake District in southern Turkey is the southern limit of its distribution. Also *Holocentropus picicornis* Stephens, which shows holarctic distribution and found in many countries in Europe including Scandinavia, is found in two lakes in western part of Anatolia (Abant Lake and Karamik Lake), reaching to the northern part of Taurus Mountains (Sipahiler, 2003). In the Taurus Mountains, it was found in only one place in Dedegöl Mountain, in a small alpine lake at 2350 m altitude.

2 - Species, which have a large area in northern Europe or distribute through the north, have small area in southern Turkey or at least the close relatives live there. Some of such species are found in cold streams and have a small area in the northern slopes of the Taurus Mountains. For example, *Anabolia anatolica* Sipahiler, which is the unique species of the genus *Anabolia* in Turkey, lives in one source spring, of which the water temperature was measured 9.9 ºC in August. The species was not found in the other springs in the surrounding areas that also have cold water. The close relative species is *Anabolia laevis* Zetterstedt found in northern Europe. *Ecclisopteryx dalecarlica* Kolenati (Drusinae) distributes in Europe from Scandinavia through the Balkans and recorded from Turkey in Marmara region (Sipahiler, 1999), is found also in the northern slopes of Taurus Mountains in southern Turkey.

Phryganea grandis L has a large area in Europe, the vicarious subspecies *P. grandis serti* Sipahiler is found in the Lake District in southern Turkey; or the species, which is largely distributed in Europe, has close relatives in Turkey e.g. *Rhyacophila polonica* McLachlan, occupies a large area in Europe, close relative species *Rhyacophila osellai* Malicky is found in northern and southern Turkey Some species, which have smaller area in Europe, found also in a smaller area in the western or southern Turkey; e.g. *Drusus botosaneanui* Kumanski found in the Balkans; has a small area in the Sultan Mountains in southern Turkey (Sipahiler, 1999). The other example for such species is *Rhyacophila fischeri* Botosaneanu, which has a relative smaller area in the Balkans (Roumania, Bulgaria, Greece and Yugoslavia), found in southwestern Turkey.

3 - Distributions of some of the species of Glossosomatidae in Turkey are probably an example for Paleo- Mediterranean type of distribution (Malicky, 1988:2). The family is represented in Turkey by 19 species, 9 of which are found in the Mediterranean Region with 6 endemics. *Agapetus hadimensis* Sipahiler, *Agapetus selgensis* Sipahiler in the southern Anatolia and *Agapetus altineri* Sipahiler in central Anatolia have relatives in the Mediterranean countries. In northwestern Anatolia 6 species occur, both southern and northwestern fauna has high percentage of endemics (66 %). Northeastern Anatolia region has 5 species (two of which are endemics), of which two species, *Glossosoma capitatum* Martynov and *Agapetus caucasicus*

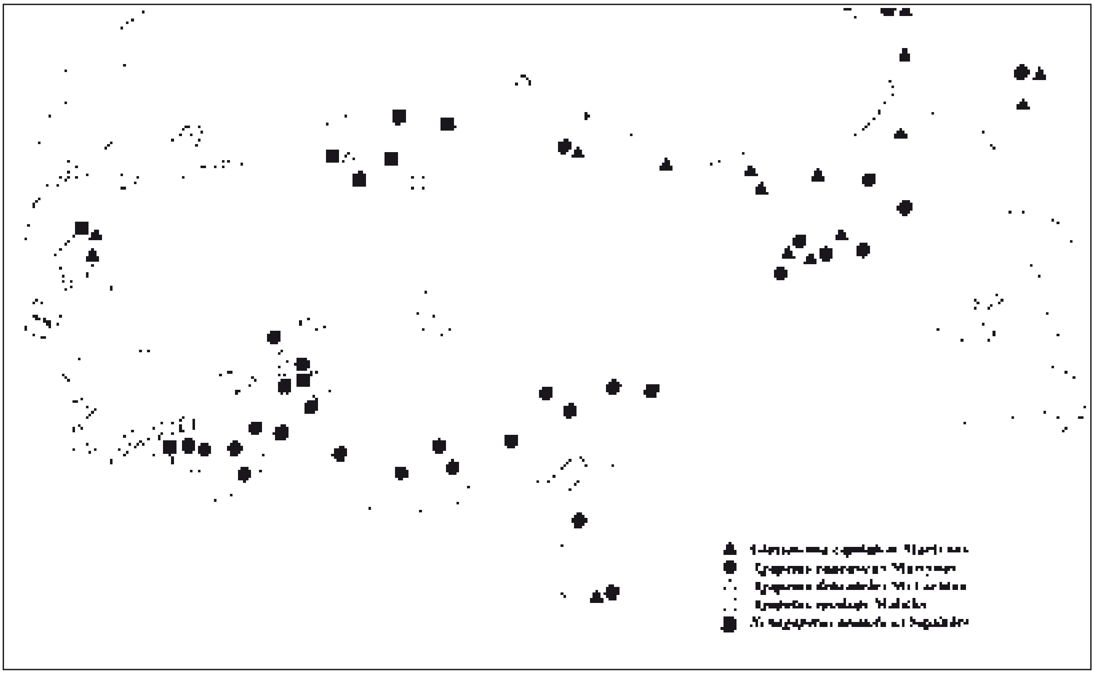

Fig. 9: Distributions of some species of the family Glossosomatidae in Turkey and the Caucasus.

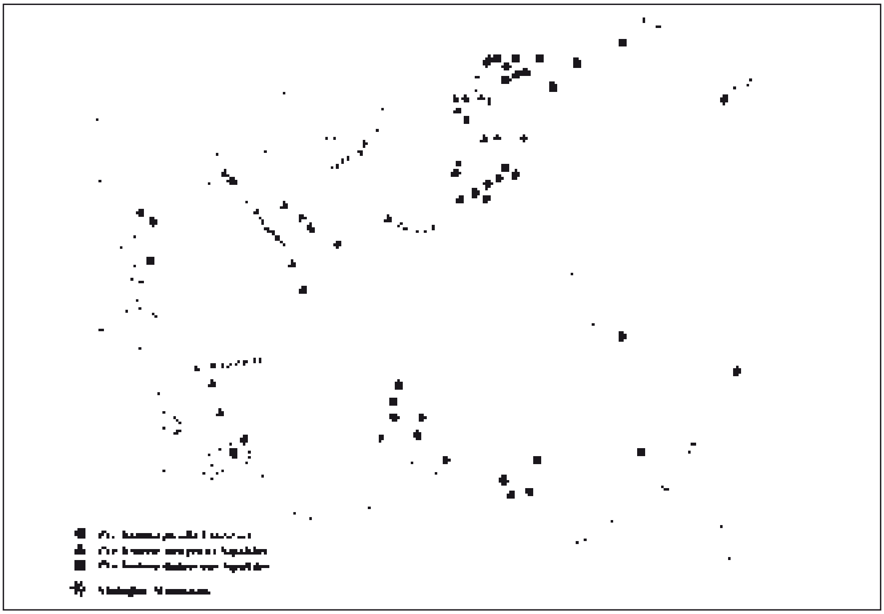

Fig. 10: Distributions of the species of the genus *Psychomyia* in the western part of Anatolia.

Martynov distribute through the western and southern Anatolia and Levant, found also in Cyprus and Rhodes (Fig.9). Other species of the family have a limited distribution. The largely distributed species *Agapetus caucasicus* is not found in the isolated Camili Region mentioned above, the distributions of the species could be the result of the post glacial expansion from the refuge area in the Caucasus.

In the west, 6 species are found. Among them *Agapetus delicatulus* McL. is found in the Balkans, Iberian Peninsula and Britain and *Agapetus episkopi* Malicky, in Greece (Botosaneanu & Malicky, 1978). Both species are not found in the east and northeastern Turkey. The endemic species *Synagapetus anatolicus* Çakin has also a similar type of distribution, found in the western part of Turkey and not found in central and east Anatolia.

4 - The species of the genus *Psychomyia* (Psychomyiidae), which are widely distributed in the rivers and streams of Turkey show an interesting distribution. *Psychomyia mengensis* Sipahiler, characterized by the long spine on the top of the phallus, found in the western part of Turkey, following certain river systems and streams, while the neighbouring river system is occupied by the other species (Sipahiler, 2005). Sympatry occurs only in two places in northwestern part of Turkey.

P. mengensis Sipahiler is found only in two streams namely, in the south in Düden Stream near Antalya and in southwestern Turkey and in the tributary of Menderes River.

In northwestern Turkey this species also occurs in certain streams and rivers, e.g. Orhaneli River in the west and Porsuk Stream, which is the tributary of adjacent river basin Sakarya (Fig. 10). In the other tributaries of Sakarya River inhabits *Psychomyia pusilla* Fabricius. In Aladağlar-Köroğlu Mountains the sources of two streams are found, one of which, namely Aladağ Stream, is found on the southern slopes of Aladağlar Mountains, is the tributary of Sakarya River, the other, Gerede Stream, is found on the northern slopes of Köroğlu mountains and flows down to Filyos River. *P. pusilla* occur in Aladağ Stream, the tributary of Sakarya River, while in Gerede Stream, the tributary of Filyos River, inhabits *P. mengensis*, like the other tributaries of the river basin. In this case, species distributed in several river basins is not a consequence of the crossing of the watersheds but the result of the dispersal and the modifications of the riverine nets (Banarescu, 1990, 1991). The appearance of the barriers during the past geological times caused the modifications

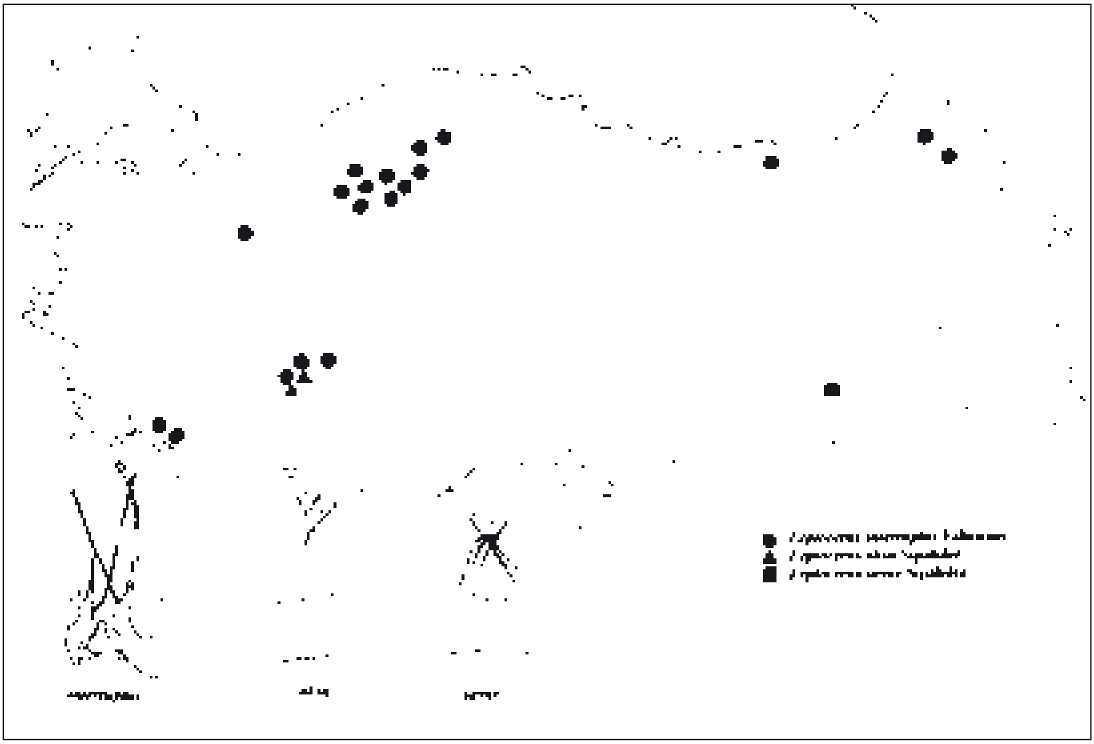

Fig. 11: Distribution of the species of the genus *Leptocerus* in Turkey.

of the river systems, resulting in the change of the basin of the river. When the barriers disappear the species are found sympatrically.

5 - In Turkey, the species of the *Leptocerus interruptus* group is represented by three species. *Leptocerus interruptus* Fabricius, characterized by asymmetrical prolongations of segment 10, of which the right one is small and pointed at the apex, is distributed in Europe and Turkey but most of the related species are found in southeastern Asia. It is found in Turkey many places in the southern and northern Turkey. The closely related species *L. aksu* Sipahiler and *L. savur* Sipahiler, both have primitive features in the male genitalia in having longer prolongations of segment 10, are found in southern Anatolia, *L. aksu* is found sympatrically with *L. interruptus* in the Taurus Mountains. The third species *L. savur* is found almost 1000 km east of this area (Fig. 11). Taurus Mountains in southern Turkey is the centre of origin of this species group, in having two primitive species.

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First revision of the Romanian caddisflies (Insecta: Trichoptera)

Part 1: Systematic checklist (updated 12/2005)

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Abstract

The first faunistical, nomenclatorial and systematical revised checklist of the caddisflies (Trichoptera) from Romania since Ciubuc (1993) is presented here. The systematic checklist now contains 266 species (14 are endemic for Romania corresponding to 5,3 % of the total fauna) from 85 genera and 19 families (tab.1). Of these 24 taxa are named for the first time. These are: *Rhyacophila armeniaca* Guerin-Meneville, 1843 *R.. obtusa* Klapalek, 1894, *Synagapetus slavorum* Botosaneanu, 1960, *Hydroptila aegyptia* Ulmer, 1963, *H. angustata* Mosely, 1939, *H. martini* Marshall, 1977, *Orthotrichia tragetti* Mosely, 1930, *Hydropsyche incognita* Pitsch, 1993, *H. peristerica* Botosaneanu & Marinkovic, 1968, *Polycentropus ierapetra* Malicky, 1972, *Lepidostoma basale* (Kolenati, 1848), *Anabolia concentrica* (Zetterstedt, 1840), *Anisogamus difformis* (McLachlan, 1876), *Chaetopteryx bosniaca* Marinkovic, 1955, *C. rugulosa* Kolenati, 1848, *Drusus monticola* McLachlan, 1878, *Hydatophylax infumatus* McLachlan 1865, *Isogamus czarnohorensis* (Dziedzielewicz, 1912), *Limnephilus sericeus* (Say, 1824), *Melampophylax polonicus* Malicky, 1990, *Potamophylax carpathicus* (Dziedzielewicz, 1912), *Stenophylax meridiorientalis* Malicky, 1990, *Ceraclea albimacula* (Rambur, 1842), *Oecetis notata* (Rambur, 1842).

On the other hand 31 taxa mentioned by Ciubuc (1993) and others have been omitted from the list.

These are: *Rhyacophila valkanovi* Botosaneanu, 1957, *Agapetus fuscipes* Curtis, 1834, *Orthotrichia melitta* Malicky, 1976, *Wormaldia triangulifera* McLachlan, 1878, *Hydropsyche siltalai* Doehler, 1963, *Tinodes waeneri* (Linnaeus, 1758), *Lasiocephala basalis* (Kolenati, 1848), *Anabolia nervosa* (Curtis, 1834), *Annitella transilvanica* Murgoci, 1957, *Asynarchus lapponicus* (Zetterstedt, 1840), *Chaetopteryx cissylvanica* Botosaneanu, 1959, *C. fontisdraconis* Botosaneanu, 1993, *C. schmidi* Botosaneanu, 1957, *Drusus annulatus* (Stephens, 1837), *Ecclisopteryx guttulata* (Pictet, 1834), *Halesus rubricollis* (Pictet, 1834), *Limnephilus centralis* Curtis, 1834, *L. microdentatus* Martynov, 1913, *L. politus* McLachlan, 1865, *Melampophylax mucoreus* (Hagen, 1861), *Mesophylax impunctatus* McLachlan, 1884, *Nemotaulius punctatolineatus* (Retzius, 1783), *Stenophylax vibex* (Curtis, 1834), *Silo nigricornis* (Pictet, 1834), *Athripsodes aterrimus* (Stephens, 1836), *A. leucophaeus* (Rambur, 1842), *Ceraclea alboguttata* (Hagen, 1860), *C. nigronervosa* (Retzius, 1783), *Erotesis baltica* McLachlan, 1877, *Oecetis intima* McLachlan, 1877, *Ylodes conspersus* (Rambur, 1842).

In the checklist species are only included, if reliable records of adults exist. All taxa, for which only larval data are known, have been excluded from the list. All changes are briefly explained. The revision is on the one hand based on a large quantity of adult material mainly collected by the authors in the last thirteen years comprising 182 species. Beside our recent data, all relevant and reliable literature references and data from the Fauna Europaea project were included.

Introduction

In the last decades since the crisis of biodiversity has been globally recognized researches, which focused on high quality faunistical data, have increased. The recently finalized "Fauna Europaea Project" gave a major contribution to evaluate the biodiversity of Europe, based mainly on reliable records from different countries. In such projects updated information dealing with a local or regional fauna is always well appreciated as well as a critical revision of the published information from each country based on recently collected material.

Investigation of the caddisfly (Trichoptera) fauna has a long tradition in Romania; even this research was made with changing intensity in different periods. The first faunistical data from Romania were published just before the turn of the 19th century by Klapalek (1898, 1899). The papers on "Fauna Regni Hungariae" also gave further information about the diversity of caddisfly species mostly from the Carpathians (Mocsáry 1900; Pongrácz 1914).

The major contribution to the knowledge of the Romanian Trichoptera was delivered by Botosaneanu, who published especially between 1952 and 1978 a large number of important taxonomical, faunistical and ecological data about the majority of the Trichoptera species occurring in Romania (see literature list in Ciubuc 1993). The first checklist of the entire fauna of the country was published by Ciubuc in 1993, based largely on the analysis of the published literature, but as well on unpublished material collected by Botosaneanu, Malicky and himself. This list contained 267 Trichoptera species and other 10 were mentioned, but considered as doubtful for Romania.

Since this first summary of Romanian Trichoptera several taxonomic problems have found a better solution and a lot of new records were published. The literature data published since Ciubuc (1993) are critically revised and enriched with our recent new records.

In the first part of the revision of the Romanian Trichoptera we present a faunistical, nomenclatorial and systematical revised checklist of the caddisfly species occurring in Romania. The second part, which will be published later, will present a regionalized and updated distribution of the species in Romania.

Material and methods

The checklist is based on a critical revision of the first summary of Romanian Trichoptera published by Ciubuc (1993) and the faunistical data published by Botosaneanu (1993, 1995), Ciubuc (2004), Pauls (2004), Ujvárosi (1994, 1995, 1997a,b,c, 1998a,b, 1999, 2000, 2002, 2003), Ujvarosi & Chisu (1999), Ujvarosi & Negru (1996), Ujvarosi & Nogradi (1999) and Ujvarosi et al. (1995). We have also taken into consideration the important recent revisions, recommendations published by Botosaneanu (1995) and Malicky (2005) as well as unpublished samplings done from different regions in Romania not only by the authors, but also by Nográdi (Pécs), Pauls (Frankfurt) and Uherkovich (Pécs).

In the present list we use only doubtless data of adults. Therefore all species of which only larval data are known have been omitted from the checklist. As for the majority of Romanian Trichoptera species the geographical variability of morphological parameters was less studied at population level (except some work of Botosaneanu 1973, 1975, 1995; Mey and Botosaneanu 1985) we avoid using subspecies taxa in our list for the moment.

The nomenclature and systematic arrangement of the checklist follows Malicky (2005) as was generally agreed at the first conference on faunistics and zoogeography of European Trichoptera in Luxembourg, but it should be noted that the senior author in some cases is of different opinion (Robert 2001, 2004) .

Results

The present checklist of Romanian caddisflies (Trichoptera) contains 266 species from 85 genera and 19 families.

The presence of 182 species has been confirmed in the last thirteen years based on adults collected mainly by the authors (marked with * in the list).

Systematic checklist of Romanian Trichoptera

Rhyacophilidae Stephens, 1836

Rhyacophila Pictet, 1834

Rhyacophila aquitanica McLachlan, 1879
Rhyacophila armeniaca Guerin-Meneville, 1843
Rhyacophila cibinensis Botosaneanu & Marinkovic, 1967
Rhyacophila confinium Botosaneanu, 1957
Rhyacophila doehleri Botosaneanu, 1957
Rhyacophila fagarashiensis Botosaneanu, 1964
Rhyacophila fasciata Hagen, 1859
Rhyacophila fischeri Botosaneanu, 1957
Rhyacophila flava Klapalek, 1898
Rhyacophila furcifera Klapalek, 1904
Rhyacophila glareosa McLachlan, 1867
Rhyacophila kimminsiana Botosaneanu, 1958
Rhyacophila laevis Pictet, 1834
Rhyacophila mocsaryi Klapalek, 1898
Rhyacophila motasi Botosaneanu, 1957
Rhyacophila nubila (Zetterstedt, 1840)
Rhyacophila obliterata McLachlan, 1863
Rhyacophila obtusa Klapalek, 1894
Rhyacophila orghidani Botosaneanu, 1952
Rhyacophila philopotamoides McLachlan, 1879
Rhyacophila polonica McLachlan, 1879
Rhyacophila torrentium Pictet, 1834
Rhyacophila tristis Pictet, 1834

Glossosomatidae Wallengren, 1891

Glossosoma Curtis, 1834

Glossosoma boltoni Curtis, 1834
Glossosoma conformis Neboiss, 1963
Glossosoma discophorum Klapalek, 1902
Glossosoma intermedium (Klapalek, 1892)

Agapetus Curtis, 1834

Agapetus belareca Botosaneanu, 1957
Agapetus delicatulus McLachlan, 1884
Agapetus laniger (Pictet, 1834)
Agapetus ochripes Curtis, 1834
Agapetus rectigonopoda Botosaneanu, 1957

Synagapetus McLachlan, 1879

Synagapetus armatus (McLachlan, 1879)
Synagapetus iridipennis McLachlan, 1879
Synagapetus moselyi (Ulmer, 1938)
Synagapetus slavorum Botosaneanu, 1960

Hydroptilidae Stephens, 1836

Hydroptila Dalman, 1819

Hydroptila aegyptia Ulmer, 1963
Hydroptila angustata Mosely, 1939
Hydroptila forcipata (Eaton, 1873)
Hydroptila lotensis Mosely, 1930
Hydroptila martini Marshall, 1977
Hydroptila occulta (Eaton, 1873)
Hydroptila pulchricornis Pictet, 1834
Hydroptila simulans Mosely, 1920
Hydroptila sparsa Curtis, 1834
Hydroptila tineoides Dalman, 1819
Hydroptila vectis Curtis, 1834

Ithytrichia Eaton, 1873

Ithytrichia lamellaris Eaton, 1873

Orthotrichia Eaton, 1873

Orthotrichia angustella (McLachlan, 1865)
Orthotrichia costalis (Curtis, 1834)
Orthotrichia tragetti Mosely, 1930

Allotrichia McLachlan, 1880

**Allotrichia pallicornis* (Eaton, 1873)

Agraylea Curtis, 1834

Agraylea multipunctata Curtis, 1834
**Agraylea sexmaculata* Curtis, 1834

Tricholeiochiton Kloet & Hincks, 1944

Tricholeiochiton fagesi (Guinard, 1879)

Oxyethira Eaton, 1873

**Oxyethira falcata* Morton, 1893
**Oxyethira flavicornis* (Pictet, 1834)

Stactobiella Martynov, 1924

Stactobiella risi (Felber, 1908)

Stactobia McLachlan, 1880

Stactobia caspersi Ulmer, 1950
Stactobia maclachlani Kimmins, 1949

Philopotamidae Stephens, 1829

Wormaldia McLachlan, 1865

**Wormaldia occipitalis* (Pictet, 1834)
**Wormaldia pulla* (McLachlan, 1878)
Wormaldia subnigra McLachlan, 1865

Philopotamus Stephens, 1829

**Philopotamus montanus* (Donovan, 1813)
**Philopotamus variegatus* (Scopoli, 1763)

Ecnomidae Uulmer, 1903

Ecnomus McLachlan, 1864

**Ecnomus tenellus* (Rambur, 1842)

Polycentropodidae Uulmer, 1903

Holocentropus McLachlan, 1878

Holocentropus dubius (Rambur, 1842)
**Holocentropus picicornis* (Stephens, 1836)
Holocentropus stagnalis (Albarda, 1874)

Cyrnus Stephens, 1836

**Cyrnus crenaticornis* (Kolenati, 1859)
**Cyrnus trimaculatus* (Curtis, 1834)

Polycentropus Curtis, 1835

**Polycentropus excisus* Klapalek, 1894
**Polycentropus flavomaculatus* (Pictet, 1834)
**Polycentropus ierapetra* Malicky, 1972
**Polycentropus irroratus* Curtis, 1835
Polycentropus schmidi Novak & Botosaneanu, 1965

Neureclipsis McLachlan, 1864

**Neureclipsis bimaculata* (Linnaeus, 1758)

Plectrocnemia Stephens, 1836

**Plectrocnemia brevis* McLachlan, 1871
**Plectrocnemia conspersa* (Curtis, 1834)
**Plectrocnemia kisbelai* Botosaneanu, 1967
**Plectrocnemia minima* Klapalek, 1899

Psychomyiidae Curtis, 1835

Lype McLachlan, 1878

**Lype phaeopa* (Stephens, 1836)
**Lype reducta* (Hagen, 1868)

Psychomyia Latreille, 1829

**Psychomyia pusilla* (Fabricius, 1781)

Tinodes Curtis, 1834

Tinodes kimminsi Sykora, 1962
Tinodes pallidulus McLachlan, 1878
**Tinodes polifurculatus* Botosaneanu, 1956
Tinodes raina Botosaneanu, 1960
**Tinodes rostocki* McLachlan, 1878
Tinodes unicolor (Pictet, 1834)

Hydropsychidae Curtis, 1835

Diplectrona Westwood, 1840

Diplectrona atra McLachlan, 1878

Cheumatopsyche Wallengren, 1891

**Cheumatopsyche lepida* (Pictet, 1834)

Hydropsyche Pictet, 1834

**Hydropsyche angustipennis* (Curtis, 1834)
Hydropsyche botosaneanui Marinkovic, 1966
**Hydropsyche bulbifera* McLachlan, 1878
**Hydropsyche bulgaromanorum* Malicky, 1977
**Hydropsyche contubernalis* McLachlan, 1865
Hydropsyche emarginata Navas, 1923
**Hydropsyche fulvipes* (Curtis, 1834)

Hydropsyche incognita Pitsch, 1993
**Hydropsyche instabilis* (Curtis, 1834)
**Hydropsyche modesta* Navas, 1925
Hydropsyche ornatula McLachlan, 1878
**Hydropsyche pellucidula* (Curtis, 1834)
**Hydropsyche peristerica* Botosaneanu & Marinkovic, 1968
**Hydropsyche saxonica* McLachlan, 1884
Hydropsyche sinuata Botosaneanu & Marinkovic, 1966
**Hydropsyche tabacarui* Botosaneanu, 1960

Phryganeidae Leach, 1815

***Agrypnia* Curtis, 1835**

**Agrypnia pagetana* Curtis, 1835
Agrypnia picta Kolenati, 1848
**Agrypnia varia* (Fabricius, 1793)

***Hagenella* Martynov, 1924**

**Hagenella clathrata* (Kolenati, 1848)

***Oligostomis* Kolenati, 1848**

Oligostomis reticulata (Linnaeus, 1761)

***Oligotricha* Rambur, 1842**

**Oligotricha striata* (Linnaeus, 1758)

Trichostegia **Kolenati, 1848**

Trichostegia minor (Curtis, 1834)

***Phryganea* Linnaeus, 1758**

Phryganea bipunctata Retzius, 1783
**Phryganea grandis* Linnaeus, 1758

Brachycentridae Ulmer, 1903

***Brachycentrus* Curtis, 1834**

Brachycentrus maculatus (Fourcroy, 1785)
Brachycentrus montanus Klapalek, 1892
**Brachycentrus subnubilus* Curtis, 1834

***Micrasema* McLachlan, 1876**

**Micrasema minimum* McLachlan, 1876

Uenoidae Iwata, 1927

***Thremma* McLachlan, 1876**

Thremma anomalum McLachlan, 1876

Goeridae Ulmer, 1903

***Goera* Stephens, 1829**

**Goera pilosa* (Fabricius, 1775)

***Lithax* McLachlan, 1876**

**Lithax niger* (Hagen, 1859)
**Lithax obscurus* (Hagen, 1859)

***Silo* CURTIS, 1830**

**Silo graellsi* Pictet, 1865
**Silo pallipes* (Fabricius, 1781)
**Silo piceus* (Brauer, 1857)

Lepidostomatidae Ulmer, 1903

***Lepidostoma* Rambur, 1842**

**Lepidostoma basale* (Kolenati, 1848)
**Lepidostoma hirtum* (Fabricius, 1775)

***Crunoecia* McLachlan, 1876**

Crunoecia irrorata (Curtis, 1834)
Crunoecia monospina Botosaneanu, 1960

Limnephilidae Kolenati, 1848

Dicosmoecinae Schmid, 1955

***Ironoquia* Banks, 1916**

**Ironoquia dubia* (Stephens, 1837)

Apataniinae Wallengren, 1886

***Apatania* Kolenati, 1848**

**Apatania carpathica* Schmid, 1954

Drusinae Banks, 1916

***Ecclisopteryx* Kolenati, 1848**

**Ecclisopteryx dalecarlica* Kolenati, 1848
**Ecclisopteryx madida* (McLachlan, 1867)

***Drusus* Stephens, 1837**

**Drusus biguttatus* (Pictet, 1834)
**Drusus brunneus* Klapalek, 1898
Drusus buscatensis Botosaneanu, 1960
Drusus carpathicus Dziedzielewicz, 1911
**Drusus discolor* (Rambur, 1842)
Drusus monticola McLachlan, 1876

Drusus romanicus Murgoci & Botosaneanu, 1953
Drusus tenellus (Klapalek, 1898)
Drusus trifidus McLachlan, 1868

Limnephilinae Kolenati, 1848

Limnephilini Kolenati, 1848

Anabolia Stephens, 1837

Anabolia brevipennis (Curtis, 1834)
Anabolia concentrica (Zetterstedt, 1840)
Anabolia furcata Brauer, 1857
Anabolia laevis (Zetterstedt, 1840)

Glyphotaelius Stephens, 1837

Glyphotaelius pellucidus (Retzius, 1783)

Grammotaulius Kolenati, 1848

Grammotaulius nigropunctatus (Retzius, 1783)
Grammotaulius nitidus (Müller, 1764)

Limnephilus Leach, 1815

Limnephilus affinis Curtis, 1834
Limnephilus auricula Curtis, 1834
Limnephilus binotatus Curtis, 1834
Limnephilus bipunctatus Curtis, 1834
Limnephilus coenosus Curtis, 1834
Limnephilus decipiens (Kolenati, 1848)
Limnephilus extricatus McLachlan, 1865
Limnephilus flavicornis (Fabricius, 1787)
Limnephilus flavospinosus (Stein, 1874)
Limnephilus fuscicornis Rambur, 1842
Limnephilus griseus (Linnaeus, 1758)
Limnephilus hirsutus (Pictet, 1834)
Limnephilus ignavus McLachlan, 1865
Limnephilus incisus Curtis, 1834
Limnephilus lunatus Curtis, 1834
Limnephilus nigriceps (Zetterstedt, 1840)
Limnephilus rhombicus (Linnaeus, 1758)
Limnephilus sericeus (Say, 1824)
Limnephilus sparsus Curtis, 1834
Limnephilus stigma Curtis, 1834
Limnephilus vittatus (Fabricius, 1798)

Chaetopterygini Hagen, 1858

Annitella Klapalek, 1907

Annitella lateroproducta (Botosaneanu, 1952)
Annitella obscurata (McLachlan, 1876)

Chaetopterygopsis Stein, 1874

Chaetopterygopsis maclachlani Stein, 1874
Chaetopterygopsis sisestii Botosaneanu, 1961

Chaetopteryx Stephens, 1837

Chaetopteryx biloba Botosaneanu, 1960
Chaetopteryx bosniaca Marinkovic, 1955
Chaetopteryx major McLachlan, 1876
Chaetopteryx polonica Dziedzielewicz, 1889
Chaetopteryx sahlbergi McLachlan, 1876
Chaetopteryx rugulosa Kolenati, 1848
Chaetopteryx subradiata Klapalek, 1907

Psilopteryx Stein, 1874

Psilopteryx curviclavatus Botosaneanu, 1957
Psilopteryx psorosa (Kolenati, 1860)

Stenophylacini Schmid, 1955

Acrophylax Brauer, 1867

Acrophylax vernalis Dziedzielewicz, 1912

Allogamus Schmid, 1955

Allogamus auricollis (Pictet, 1834)
Allogamus dacicus (Schmid, 1951)
Allogamus uncatus (Brauer, 1857)

Anisogamus McLachlan, 1875

Anisogamus difformis (McLachlan, 1876)

Chionophylax Schmid, 1951

Chionophylax czarnohoricus (Dziedzielewicz, 1911)
Chionophylax mindszentyi Schmid, 1951

Halesus Stephens, 1836

Halesus digitatus (Schrank, 1781)
Halesus tessellatus (Rambur, 1842)

Hydatophylax Wallengren, 1891

Hydatophylax infumatus (McLachlan, 1865)

Isogamus Schmid, 1955

Isogamus aequalis (Klapalek, 1907)
Isogamus czarnohorensis (Dziedzielewicz, 1912)
Isogamus lineatus Klapalek, 1903

Melampophylax Schmid, 1955

Melampophylax nepos (McLachlan, 1880)
Melampophylax polonicus Malicky, 1990

***Micropterna* Stein, 1874**

**Micropterna lateralis* (Stephens, 1837)
**Micropterna nycterobia* McLachlan, 1875
**Micropterna sequax* McLachlan, 1875
Micropterna testacea (Gmelin, 1789)

***Parachiona* Thomson, 1891**

**Parachiona picicornis* (Pictet, 1834)

***Potamophylax* Wallengren, 1891**

**Potamophylax carpathicus* (Dziedzielewicz, 1912)
**Potamophylax cingulatus* (Stephens, 1837)
**Potamophylax jungi* Mey, 1976
**Potamophylax latipennis* (Curtis, 1834)
**Potamophylax luctuosus* (Piller & Mitterpacher, 1783)
**Potamophylax millenii* (Klapalek, 1898)
**Potamophylax nigricornis* (Pictet, 1834)
**Potamophylax pallidus* (Klapalek, 1899)
**Potamophylax rotundipennis* (Brauer, 1857)

***Rhadicoleptus* Wallengren, 1891**

**Rhadicoleptus alpestris* (Kolenati, 1848)

***Stenophylax* Kolenati, 1848**

**Stenophylax meridiorientalis* Malicky, 1980
Stenophylax mitis McLachlan, 1875
**Stenophylax permistus* McLachlan, 1895

Sericostomatidae Stephens, 1836

***Oecismus* McLachlan, 1876**

**Oecismus monedula* (Hagen, 1859)

***Sericostoma* Latreille, 1825**

**Sericostoma personatum* (Kirby & Spence, 1826)
**Sericostoma flavicorne* Schneider, 1845

***Notidobia* Stephens, 1829**

Notidobia ciliaris (Linnaeus, 1761)

Odontoceridae Wallengren, 1891

***Odontocerum* Leach, 1815**

**Odontocerum albicorne* (Scopoli, 1763)
**Odontocerum hellenicum* Malicky, 1972

Helicopsychidae Ulmer, 1906

***Helicopsyche* Siebold, 1856**

Helicopsyche bacescui Orghidan & Botosaneanu, 1953

Beraeidae Wallengren, 1891

***Beraea* Stephens, 1833**

Beraea maurus (Curtis, 1834)
**Beraea pullata* (Curtis, 1834)

***Beraeamyia* Mosely, 1930**

Beraeamyia hrabei Mayer, 1937
Beraeamyia schmidi Botosaneanu, 1960

***Beraeodes* Eaton, 1867**

Beraeodes minutus (Linnaeus, 1761)

***Ernodes* Wallengren, 1891**

**Ernodes articularis* (Pictet, 1834)
**Ernodes vicinus* (McLachlan, 1879)

Leptoceridae Leach, 1815

***Adicella* McLachlan, 1877**

Adicella altandroconia Botosaneanu & Novak, 1965
**Adicella filicornis* (Pictet, 1834)
Adicella reducta (McLachlan, 1865)
Adicella syriaca Ulmer, 1907

***Triaenodes* McLachlan, 1865**

Triaenodes bicolor (Curtis, 1834)

***Ylodes* Milne, 1934**

**Ylodes kawraiskii* (Martynov, 1909)
**Ylodes simulans* (Tjeder, 1929)

***Parasetodes* McLachlan, 1880**

Parasetodes respersella (Rambur, 1842)

***Mystacides* Berthold, 1827**

**Mystacides azurea* (Linnaeus, 1761)
**Mystacides longicornis* (Linnaeus, 1758)
**Mystacides nigra* (Linnaeus, 1758)

***Athripsodes* Billberg, 1820**

Athripsodes albifrons (Linnaeus, 1758)
**Athripsodes bilineatus* (Linnaeus, 1758)

Athripsodes cinereus (Curtis, 1834)
**Athripsodes commutatus* (Rostock, 1874)

Ceraclea Stephens, 1829

**Ceraclea albimacula* (Rambur, 1842)
Ceraclea annulicornis (Stephens, 1836)
Ceraclea aurea (Pictet, 1834)
**Ceraclea dissimilis* (Stephens, 1836)
Ceraclea fulva (Rambur, 1842)
Ceraclea riparia (Albarda, 1874)
**Ceraclea senilis* (Burmeister, 1839)

Setodes Rambur, 1842

Setodes hungaricus Ulmer, 1908
**Setodes punctatus* (Fabricius, 1793)
Setodes viridis (Fourcroy, 1785)

Leptocerus Leach, 1815

**Leptocerus interruptus* (Fabricius, 1775)
**Leptocerus tineiformis* Curtis, 1834

Oecetis McLachlan, 1877

**Oecetis furva* (Rambur, 1842)
**Oecetis lacustris* (Pictet, 1834)
**Oecetis notata* (Rambur, 1842)
**Oecetis ochracea* (Curtis, 1825)
**Oecetis testacea* (Curtis, 1834)
Oecetis tripunctata (Fabricius, 1793)

The proportion of the families for the Trichoptera fauna is shown in table 1. The composition is very similar to that described by Ciubuc (1993), although 55 taxa (about 20 %) of the fauna have changed compared with Ciubuc (1993). This is a high rate of change in the species composition between the first and this second checklist. For Germany in comparison, one of the most well investigated countries of Europe, the rate of change in the species composition in the same time is clearly below 10 % of the fauna (Robert unpublished data). So the high rate of change is

Table 1: Proportion of families for the Trichoptera fauna of Romania.

Families	Number of species 2005	Number of species Ciubuc (1993)	Percentage 2005	Percentage Ciubuc (1993)
	n	n	%	%
Rhyacophilidae	23	21	8,6	7,9
Glossosomatidae	13	13	4,9	4,9
Hydroptilidae	24	21	9,0	7,9
Philopotamidae	5	5	1,9	1,9
Ecnomidae	1	1	0,4	0,4
Polycentropodidae	15	14	5,6	5,2
Psychomyidae	9	10	3,4	3,7
Hydropsychidae	18	16	6,8	6,0
Phryganeidae	9	9	3,4	3,4
Brachycentridae	4	4	1,5	1,5
Uenoidae	1	1	0,4	0,4
Goeridae	6	7	2,3	2,6
Lepidostomatidae	4	4	1,5	1,5
Limnephilidae	87	89	32,7	33,3
Sericostomatidae	4	4	1,5	1,5
Odontoceridae	2	2	0,8	0,8
Helicopsychidae	1	1	0,4	0,4
Beraeidae	7	7	2,6	2,6
Leptoceridae	33	38	12,4	14,2
Summe:	266	267	100	100

a strong hint upon that the fauna of the country is not so intensively investigated until now and a lot of new discoveries could be made in the future. We estimate that minimally a number of 10-20 species will be detected for the country especially in the family Hydroptilidae.

Comments on the revised checklist of the Romanian Trichoptera

In the following the changing's that happened since the publishing of the first checklist by Ciubuc (1993) are briefly explained.

a) Caddisfly taxa that have been added to the Romanian fauna since Ciubuc (1993)

From the actual checklist a number of 246 taxa were already listed in Ciubuc (1993). Seventeen additional species are mentioned in reliable papers that were published since Ciubuc (1993). Two species are listed only in the Fauna Europaea database. One species is mentioned for Romania in this publication for the first time. Five taxa are new because of nomenclatorial/systematical changes. Altogether 24 taxa are recorded here for the first time compared to Ciubuc (1993). These taxa are:

1. *Rhyacophila armeniaca*: in the Fauna Europaea database (Barnard 2005) the species is listed for Romania. Ciubuc (1993) stated that the presence of the species for Romania is doubtful. Concerning Malicky (2005) the taxon is not conspecific with *R.. torrentium* as stated by Botosaneanu (1995). A first brief revision of some material deposited under *R.. torrentium* in the collection of the first author revealed the presence of *R.. armeniaca* in the Eastern Carpathians.
2. *Rhyacophila obtusa*: cited from Botosaneanu (1993).
3. *Synagapetus slavorum*: cited from Botosaneanu (1993, 1995).
4. *Hydroptila aegyptia*: cited from Botosaneanu (1995).
5. *Hydroptila angustata*: cited from Ujvárosi (1994), Botosaneanu (1995).
6. *Hydroptila martini*: cited from Botosaneanu (1993).
7. *Orthotrichia tragetti*: cited from Ciubuc (2004). In 2002 and 2003 the species was caught in the Danube Delta (Caraorman, Chituc, Enisala, Gorgova, Maliuc, Mila 23, Murighiol) at light in high numbers.
8. *Hydropsyche incognita*: cited from Malicky (1999) and in 2004 also collected by M. Balint (Cluj) and P. Neu from the Eastern Carpathians and Transylvanian Depression (see also publication of Balint in this volume).
9. *Hydropsyche peristerica*: New for the Romanian fauna!

   Sampling data are listed here for the first time:

   1 male, 35 females, 21.VII. 2004, leg. et det. Neu, Sacele, district Brasov, Eastern Carpathians, stream near road 1A at Babarunca, 960 m a.s.l., light trap, col. Neu, GPS coordinates: 9410021 5042190.

   10 males, 7 females, 23.VII .2004, leg. et det. Neu, Baia Sprie, district Maramures, Eastern Carpathians, peatbog, 950 m a.s.l., light trap, col. Neu, GPS coordinates: 8475293 5298451
   7 females, 25.VII. 2004, leg. et det. Neu, Valea Vinului, district Bistrita-Nasaud, Eastern Carpathians, stream, 630 m a.s.l., light trap, col. Neu, GPS coordinates: 8562509 5260471
10. *Polycentropus ierapetra*: this species was mentioned for the first time by Ujvárosi (1994), but the single female collected in the Eastern Carpathians turned out to be *P. irroratus* (Ujvárosi 1995). The species was again briefly noted in Ujvárosi (2003), but without complete sampling data. These are published here for the first time: 1 male, 4 females, 15.VII.1992, leg. Uherkovics, from Homorod stream, Baile Homorod, district Harghita, Eastern Carpathians, identified by Nogradi & Uherkovich confirmed the presence for the country now.
11. *Lepidostoma basale*: in Ciubuc (1993) the species is mentioned under *Lasiocephala basalis* (Kolenati, 1848). Concerning Malicky (2005) the genus *Lasiocephala* Costa, 1857 has recently been synonymized with *Lepidostoma*.
12. *Anabolia concentrica*: cited from Ujvárosi (1995) and Ujvárosi et al. (1995).
13. *Anisogamus difformis*: cited from Botosaneanu (1993).

14. *Chaetopteryx bosniaca*: cited from Botosaneanu (1995), where it is mentioned as *Chaetopteryx bosniaca cissylvanica* Botosaneanu, 1959, but for acceptance of subspecies status see also Malicky (2005).

15. *Chaetopteryx rugulosa*: Ciubuc (1993) mentioned it under *Chaetopteryx schmidi* Botosaneanu, 1957. Malicky (2005) has reduced *C. schmidi* to a subspecies of *C. rugulosa*.

16. *Drusus monticola*: cited from Botosaneanu (1993)

17. *Hydatophylax infumatus*: cited from Ujvárosi (2003). The following complete sampling data are given here for the first time:

    10 males, 5 females, 11. VII. 2002, leg. et det. Ujvárosi, Voşlobeni, Senetea stream, "Mlaştina După Luncă" nature reserve, district Harghita, Eastern Carpathians, 740 m, light trap, col. Ujvárosi.

    3 males, 13. VII. 2002, leg. et det. Ujvárosi, Voşlobeni, Senetea stream, district Harghita, Eastern Carpathians, 740 m, at light, col. Ujvárosi.

18. *Isogamus czarnohorensis*: species listed in Fauna Europaea database (Barnard 2005) for Romania.

    According to Fischer (1969) the taxon was originally described as *Anisogamus aequalis* var. *czarnohorensis* Dziedzielewicz, 1912, from the Czarnohora Mountains, Eastern Carpathians, which are today devided by the border between Romania and Ukraina. Any other information about the occurrence and distribution of the species in Romania is unknown to the authors at the moment and would be highly appreciated therefore.

19. *Limnephilus sericeus*: cited from Botosaneanu (1993).

20. *Melampophylax polonicus*: cited from Botosaneanu (1995).

21. *Potamophylax carpathicus*: cited from Ujvárosi (1998b).

22. *Stenophylax meridiorientalis*: Botosaneanu (1995) stated that only *S. vibex meridiorientalis* Malicky, 1980 occurs in Romania. Here we follow the recommendation from Malicky (1980, 2005) who treated *S. meridiorientalis* as bona species.

23. *Ceraclea albimacula*: in Ciubuc (1993) the species is mentioned under *Ceraclea alboguttata* (Hagen, 1860). Concerning Malicky (2005) *C. alboguttata* is a synonym of *C. albimacula*.

24. *Oecetis notata*: cited from Ujvárosi (1995)

b) Caddisfly taxa formerly mentioned for the Romanian fauna, but are now omitted

A number of 31 taxa, which were listed in the checklist of Ciubuc (1993) or in other publications, are now omitted from the Romanian fauna, because no reliable records are known or because of misidentifications, nomenclatorial changes and taxonomical revisions published in the last decade (Botosaneanu 1995; Malicky 2005). These taxa are:

1. *Rhyacophila valkanovi* Botosaneanu, 1957: it is stated by Botosaneanu (1995) that it is a synonym of *R. torrentium*.

2. *Agapetus fuscipes* Curtis, 1834: listed in Ciubuc (1993), but we consider it as extremely doubtful, because the only known records published by Botosaneanu (1952) are based only on larval identification. Concerning the Fauna Europaea database (Barnard 2005) the species is also unknown from all neighboring countries of Romania except Hungary. There it occurs only in the most northern and western parts of the country (Nogradi & Uherkovich 2002), which minimally are 100 km far from the Romanian border with the Great Hungarian Plain in between.

3. *Orthotrichia melitta* Malicky, 1976: record considered as doubtful by Botosaneanu (1995). The species is also no longer listed for the Danube Delta by Ciubuc (2004).

4. *Wormaldia triangulifera* McLachlan, 1878: the species was mentioned in Ujvárosi (1997a) based on old literature data, but Ciubuc (1993) already stated that all former citations were not correct.

5. *Hydropsyche siltalai* Doehler, 1963: Ujvárosi (1995) stated that the determination published by Ujvárosi (1994) was not correct. The single male collected in the Eastern Carpathians turned out to be *H. instabilis*. The record of the species in Ujvarosi & Chisu (1999) is based only on the determination of larvae and therefore classified as doubtful. The species is mentioned in the Fauna Europaea database (Barnard 2005)

probably based on the records in Ujvarosi (1994) and/or Ujvarosi & Chisu (1999), but we believe this erroneous, because any other reliable source of data for the occurrence in Romania is totally unknown to us. Also from the known distribution of *H. siltalai* in Europe it is unlikely that it occurs in Romania. Concerning the Fauna Europaea database (Barnard 2005) it is unknown from all neighboring countries of Romania except Hungary. There it occurs only in the most northern and western parts of the country (Nogradi & Uherkovich 2002), which minimally are 150 km far from the Romanian border with the Great Hungarian Plain in between.

6. *Tinodes waeneri* (Linnaeus, 1758): record considered as doubtful by Botosaneanu (1995).

7. *Lasiocephala basalis* (Kolenati, 1848): concerning Malicky (2005) all species of genus *Lasiocephala* have been transferred to the genus *Lepidostoma*.

8. *Anabolia nervosa* (Curtis, 1834): record considered as doubtful by Botosaneanu (1995). As can be seen in Ciubuc (1993) all known records are based only on larvae.

9. *Annitella transilvanica* Murgoci, 1957: taxonomical and nomenclatorial status of the taxon is still unclear (Botosaneanu 1995). Malicky (2005) treated the taxon as an intermediate form between *A. lateroproducta* and *Annitella chomiacensis* (Dziedzielewicz, 1908).

10. *Asynarchus lapponicus* (Zetterstedt, 1840): cited in Ujvárosi (1998b, 2002b), but a revison showed, that all specimens collected from the Eastern Carpathians belonged to *A. brevipennis*.

11. *Chaetopteryx cissylvanica* Botosaneanu, 1959: Malicky (1994) synonymized the taxon with *C. bosniaca*; later Botosaneanu (1995) mentioned it as *C. bosniaca cissylvanica*; but for acceptance of subspecies status see also Malicky (2005).

12. *Chaetopteryx fontisdraconis* Botosaneanu, 1993: Malicky (2005) stated that the taxon is a variety of *C. bosniaca*.

13. *Chaetopteryx schmidi* Botosaneanu, 1957: Malicky (2005) has reduced it to a subspecies, *Chaetopteryx rugulosa schmidi* Botosaneanu, 1957, in the *C. rugulosa*-complex.

14. *Drusus annulatus* (Stephens, 1837): record considered as doubtful by Botosaneanu (1995). All known records are based only on larvae.

15. *Ecclisopteryx guttulata* (Pictet, 1834): record considered as doubtful by Botosaneanu (1995). Former records are based only on larvae (see Ciubuc 1993).

16. *Halesus rubricollis* (Pictet, 1834): record considered as doubtful by Botosaneanu (1995). Former records are based only on larvae (see Ciubuc 1993).

17. *Limnephilus centralis* Curtis, 1834: record considered as doubtful by Botosaneanu (1995). As can be seen in Ciubuc (1993) all former records are based only on larvae.

18. *Limnephilus microdentatus* Martynov, 1913: cited in Ujvárosi (1998b), but the single female collected from the Western Plain belonged to *L. flavicornis*.

19. *Limnephilus politus* McLachlan, 1865: record considered as doubtful by Botosaneanu (1995). Former records are based only on larvae (see Ciubuc 1993).

20. *Melampophylax mucoreus* (Hagen, 1861): Botosaneanu (1995) stated that all specimens determinated in Romania as *M. mucoreus* belong to *M. polonicus*.

21. *Mesophylax impunctatus* McLachlan, 1884: record considered as doubtful by Botosaneanu (1995). As can be seen in Ciubuc (1993) all former records are based only on larvae.

22. *Nemotaulius punctatolineatus* (Retzius, 1783): record considered as doubtful by Botosaneanu (1995). Former records are based only on larvae (see Ciubuc 1993).

23. *Stenophylax vibex* (Curtis, 1834): Botosaneanu (1995) stated that only *S. vibex meridiorientalis* Malicky, 1980 occurs in Romania, but Malicky (2005) treated the taxon as a species, *S. meridiorientalis*. So all records from Ciubuc (1993) concerning *S. vibex vibex* and *S. vibex meridiorientalis* should refer to *S. meridiorientalis*.

24. *Silo nigricornis* (Pictet, 1834): listed in Ciubuc (1993), but we consider it as extremely doubtful, because the only known records published by Boga (1943-45) and Murgoci & Stonescu

(1955) are based only on larval identification. Concerning the Fauna Europaea database (Barnard 2005) the species is also unknown from all neighboring countries of Romania except Hungary. There it occurs only in the most northern and western parts of the country (Nogradi & Uherkovich 2002), which minimally are 100 km far from the Romanian border with the Great Hungarian Plain in between.

25. *Athripsodes aterrimus* (Stephens, 1836): record considered as doubtful by Botosaneanu (1995). Former records are based only on larvae (see Ciubuc 1993). For this species there is a high chance that it also occurs in Romania, because in Hungary it is known from the Szamos/Somes river-region at the direct border to Romania (see Nogradi & Uherkovich 2002).
26. *Athripsodes leucophaeus* (Rambur, 1842): record considered as doubtful by Botosaneanu (1995).
27. *Ceraclea alboguttata* (Hagen, 1860): Malicky (2005) stated that the taxon is a synonym of *C. albimacula*.
28. *Ceraclea nigronervosa* (Retzius, 1783): record considered as doubtful by Botosaneanu (1995).
29. *Erotesis baltica* McLachlan, 1877: record considered as doubtful by Botosaneanu (1995).
30. *Oecetis intima* McLachlan, 1877: record considered as doubtful by Botosaneanu (1995).
31. *Ylodes conspersus* (Rambur, 1842): record considered as doubtful by Botosaneanu (1995).

The taxon *Phryganea ochrida* Malicky, 1975 was mentioned as a new species for Romania by Ciubuc (2004) in his publication about the Trichoptera of the Danube Delta Reserve, but Wiggins (1998) has synonymized *P. ochrida* with *Phryganea grandis* before. Malicky (2005) doesn't agree with Wiggins (1998) and reestablishes the taxon as *Phryganea grandis ochrida* (Malicky, 1975). Until a revision of the *P. grandis*-complex is conducted, we follow Malicky (2005) and therefore the subspecies is not listed in the checklist.

The listing of the species *Rhyacophila hirticornis* McLachlan, 1879, *Halesus radiatus* (Curtis, 1834) in Ujvárosi & Chisu (1999), *Silo nigricornis* in Chisu (2002) and *Rhyacophila aurata* Brauer, 1857 in Robert & Curtean-Banaduc (2005) is based only on larval determination and therefore they are not included in the checklist of the Trichoptera of Romania.

Comparison with the data of the Fauna Europaea project

A comparison of the revised Trichoptera checklist presented here with the data for Romania in the data base of the Fauna Europaea project shows the following results. Thirteen species are missing in the data base for Romania and should be added:

Anisogamus difformis, Chaetopteryx bosniaca, Drusus monticola, Hydatophylax infumatus, Hydropsyche peristerica, Hydroptila martini, *Orthotrichia tragetti*, *Limnephilus sericeus, Melampophylax polonicus, Polycentropus ierapetra, Rhyacophila obtusa, Sericostoma flavicorne, Stenophylax meridiorientalis*.

As well as thirteen species should be added in the database so also six species should be omitted from the list of Romania in the Fauna Europaea data base. These are:

Agapetus fuscipes, Chaetopteryx fontisdraconis, Hydropsyche siltalai, Melampophylax mucoreus, Silo nigricornis, Stenophylax vibex.

Endemic species

Regarding biodiversity one important factor is to know, which species are endemic for the territory of a state. For such species even on a worldwide level the state is totally responsible concerning their protection and conservation.

Taking into account the known European distribution of the Trichoptera occurring in Romania as documented in Barnard (2005), Botosaneanu (1975) and Wiberg-Larsen (2004) the following fourteen species are endemic for the territory of Romania:

Allogamus dacicus, Chaetopteryx biloba, *Drusus brunneus, D. buscatensis, Hydropsyche sinuata, Isogamus lineatus, Potamophylax jungi, P. millenii, Rhyacophila cibinensis, R. confinium, R. doehleri, R. fagarashiensis, R. kimminsiana, R. motasi*.

On the species level these are 5,3 % of the total Trichoptera fauna of Romania. According to Wiberg-Larsen (2004) this is of medium magnitude in Europe, where the highest rates of endemism are found in the Iberian Peninsula (34 %), Greece (25 %) and the Italian fauna (20 %).

Comparison of the Romanian Trichoptera fauna with other European states

The Romanian Trichoptera fauna is compared with other selected European states by the use of the Bray-Curtis index of similarity based on presence/ absence data. The number of species is corrected after Malicky (2005). The results are shown in table 3. It is very interesting, that the highest degree of similarity exists with Slovakia (77,2 %), Poland (72,6 %) and Hungary (72,0 %), states which also share great parts of the Carpathian Mountain Range, although Slovakia and Poland are not direct neighbors of Romania. For Bulgaria, which is a direct neighbor, with 69,9 % the degree of similarity is a little bit smaller. It is also notable, that the faunistic similarity with Central Europe (Germany 66,1 %) is as high as that of the direct neighbor Serbia & Montenegro (64,2%). The lowest similarities have been found with the central and western Mediterranean region represented by Italy (47,9 %) and the Iberian Peninsula (36,9 %).

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Table 3: Comparison of the Romanian Trichoptera fauna with other selected European states by the use of Bray-Curtis index of similarity based on presence/absence data. The number of species is corrected after Malicky (2005).

State	Bray-Curtis index in %	Number of species	Number of species in common	Reference
Slovakia	77,2	216	186	Barnard (2005)
Poland	72,6	288	201	Czachorowski (2005)
Hungary	72,0	209	171	Nogradi & Uherkovich (2002)
Bulgaria	69,9	246	179	Barnard (2005)
Germany	66,1	315	192	Robert (2004) & additons
Serbia & Montenegro	64,2	201	150	Barnard (2005)
Greece	54,3	246	139	Barnard (2005)
Norway	51,0	193	117	Johannson (2003)
Italy	47,9	389	157	Cianficconi (2002) & additons
Iberian Peninsula	36,9	352	114	Wiberg-Larsen (2004)
Romania		266		

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Zoogeographic division of Slovenia based on caddisfly distribution

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Abstract

Distribution of caddisflies, collected at more than 800 sites, was used to make a zoogeographic division of Slovenia. Four natural geographic units - Alps, Dinarids, Pannonian lowland and Po lowland - were selected a priori as zoogeographic regions. The method of zoogeographic indicative species (species occurring in only one region according to the literature data and distribution in Slovenia) was used for allocation of sampling sites to one of the regions. This method was followed by nonmeric multidimensional scaling (NMS) of sampling sites containing at least five species. NMS method confirmed that sites of each of the selected four regions are grouped together. This method was also used for allocating the sampling sites where no indicative species were found. In addition to four regions, two subregions in the Alpine region and Dinaric region, respectively, were determined.

Introduction

Several zoogeographic divisions of Slovenia were made in the past (Carnelutti 1992; Hadži 1931; Illies 1978; Mršić1997; Sket 2003). They were made either for the area of Slovenia only or Slovenia was included as a part of a larger geographic area (e.g. former Yugoslavia (Hadži 1931), Europe (Illies 1978)), which impacted also the precision of delineation of the regions. Furthermore, these divisions were made using data on distribution of i) terrestrial animals (e.g. Carnelutti 1992; Mršić 1997; Sket 2003), ii) terrestrial and freshwater animals (Hadži 1931; Sket 2003) or iii) only freshwater animals (Illies 1978; Sket 2003). Results of these divisions proved that different groups of organisms have different distribution patterns. Banarescu (1972) stated that only among freshwater animals four main types of distribution can be accepted considering distributions of single species and not lineages. These are distribution of i) epigaean primary aquatic animals ii) hypogean freshwater animals iii) primary aquatic animals and iv) aquatic insects. In Slovenia, divisions based on freshwater animals were performed on hypogean freshwater animals (Sket 2003), epigaean primary aquatic animals (Sket 2003), primary aquatic animals (Sket 2003) and also aquatic insects (Illies 1978). However, the latter one was performed as a part of a zoogeographic division of Europe on the scale 1:24 million and in the case of Slovenia also political borders were used for delineation of regions. Moreover, none of these divisions were supported by statistical analyses.

The aim of this work was to make a zoogeographic division of Slovenia based on the caddisfly distribution and support this division by statistical analysis.

Material and methods

Our zoogeographic analysis was based on caddisflies - adults and larvae collected at 804 running water sampling sites all over Slovenia (Fig. 1). Most of the material was collected by researchers of the Slovenian Museum of Natural History, Biotechnical Faculty Department of Biology and Environmental Agency of the Republic of Slovenia between 1985 and 2003, although some older samples were also considered. In statistical analyses only species data were used. All species collected at one sampling site possibly at different dates represented an operational unit (OU), which was used in the analyses as a statistical

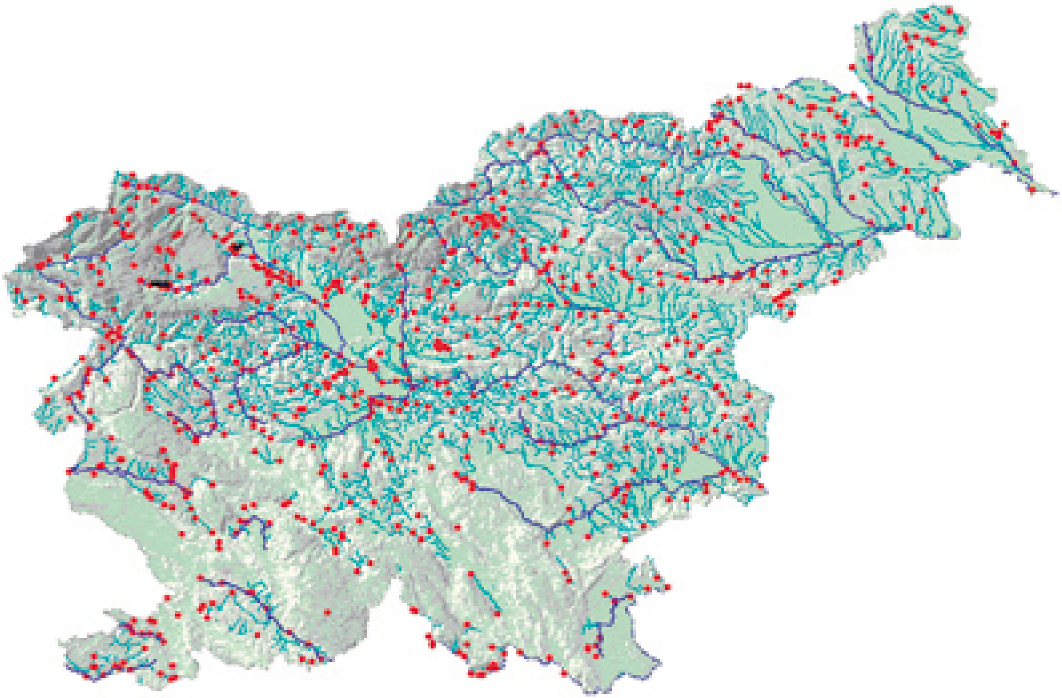

Fig. 1: Map of the sampling sites and the river network of Slovenia.

sample. Species collected using light traps were not considered because of the possible attraction of caddisflies from long distances (Malicky 1987, Urbanič 2003).

Steps in the zoogeographic analyses

1. In a first step four main regions were a priori determined according to the tectonic map of Slovenia and neighbouring regions (Fig.2). These regions are Alps on the north, Dinarids on the south, Pannonian lowland on the east and Po lowland on the west of Slovenia.

2. Determination of the indicator species.

a) First, the first class indicator species were determined. Such were considered all species which were found only in one of the a priori determined regions according to literature. Sites containing first class indicator species were allocated to the region that the first class indicator species represented. Appropriateness of such a priori classification was tested using a nonmetric multidimensional scaling (NMS) analyses. Sites containing at least five species were included in the analyses.

b) In the next step second class indicator species - species that occur in two of the four a priori determined regions were determined (e.g. in the Alps and Dinarids). For site allocation exclusion principle was used; if at the same sampling site a species occurred, that is found in Alps and Dinarids and another species, found in Dinarids and Pannonian lowland, the site was allocated to the Dinaric region. Appropriateness of such a priori classification was tested again using a nonmetric multidimensional scaling (NMS) analyses. Only sites containing at least five species were included in the analyses.

c) The procedure of the allocation of sites containing first and second class indicator species was used also for those sites which were not included in the NMS analyses because the number of species was too low.

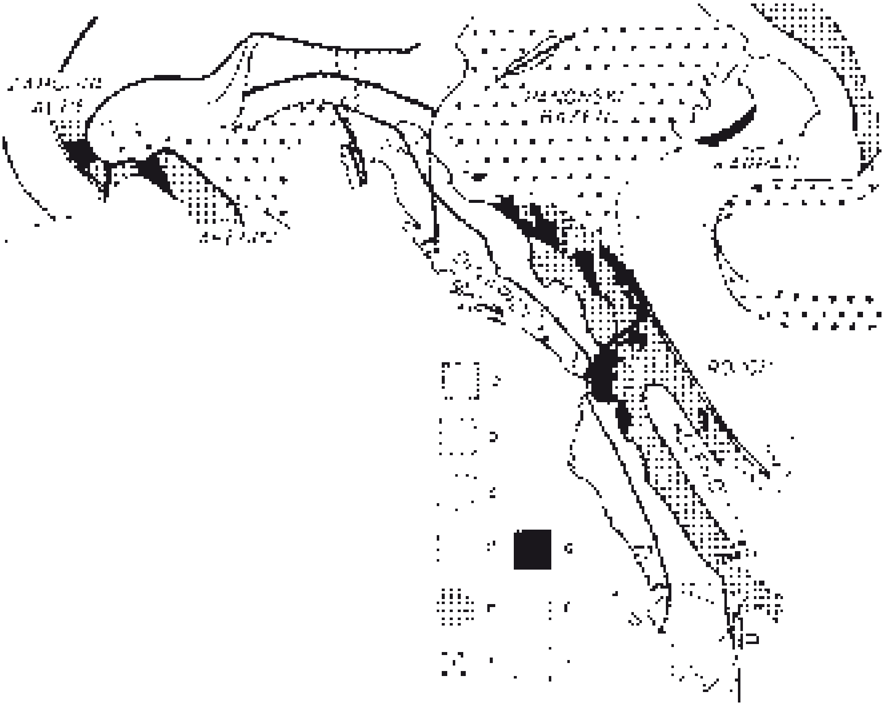

Fig. 2: Very simplified synthetical structure tectonic map of central and western Balkan and adjacent regions (a – Outer Dinarids and Helenids, b – Inner Dinarids and Helenids, c – Southern Alps, d – Eastern Alps, e – deep sea sediments, f – young tectonic hollows filled with Molasse, g – remains of the oceanic lithosphere (ophiolits), h – a tectonically affected edge of the Eurasian plate, i – a stable Eurasian plate) (Mršić, 1997: 38).

3. Sites that contained second class indicator species but where exclusion principle could not be used, because only species characteristic for two regions were present, were analysed together with all sites allocated to one of this two regions using a NMS analysis. These sites were allocated in one of the two regions according to the assemblage similarity.

4. Sampling sites where no indicator species were collected (less than 5 % of all sites) were allocated to one region according to their geographic position.

5. For final delineation of regions all sampling sites of two neighbouring regions were analysed again using NMS analyses (e.g. Alpine region and Dinaric region, but not Pannonian region and Po region).

Beside the procedure for delineation of regions also a procedure for delineation of two subregions in Alps and Dinarids was performed. In both cases the same procedure was used.

Results

Delineation of regions

On the basis of the indicator caddisfly species distribution and the similarity analyses of species assemblages, a delineation of four hydrozoogeographic regions was made in Slovenia (Fig. 3):

- Alpine region
- Dinaric region
- Pannonian region and
- Po region.

The Alpine region includes watercourses of north-eastern and eastern Slovenia. In the Dinaric region

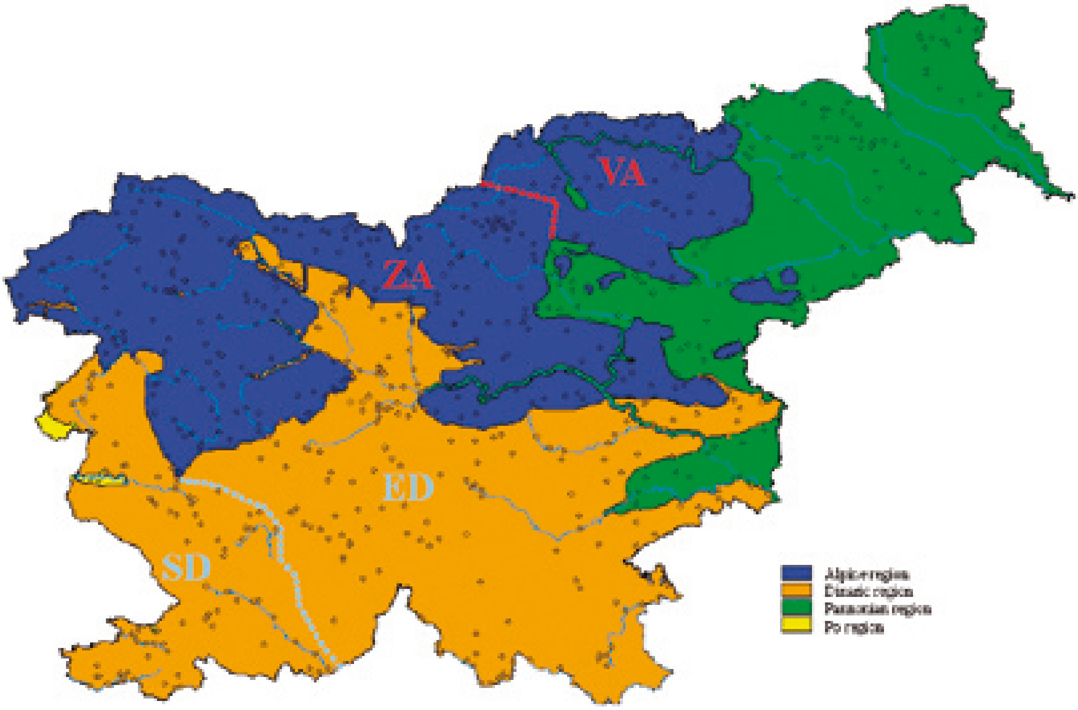

Fig. 3: Hydrozoogeographic regions and subregions (ZA - West alpine, VA - East alpine, ED - Eudinaric, SD - Submediterranean-dinaric) of Slovenia according to distribution of caddisflies; points represent sampling sites.

most watercourses of the southern Slovenia and plains of the central Slovenia were included. Watercourses of lowlands and hilly region of south-eastern and eastern Slovenia compose the Pannonian region, whereas the Po region includes watercourses of the smaller part of the lowland and hilly region of western Slovenia. Alpine and Dinaric regions were each divided into two subregions. The Alpine region was divided into:

- West alpine subregion; this subregion includes watercourses of the west and central Alpine region, with mostly carbonate geology.
- East alpine subregion; this subregion includes watercourses of the east Alpine region, with mostly silicate geology.

Dinaric region was divided into:

- Submediterranean-dinaric subregion; this subregion includes watercourses of the southwest dinaric region with mostly flysch geology. All these watercourses, apart of the Pivka river basin, are part of the Adriatic river basin.
- Eudinaric subregion; this subregion includes watercourses of the central and east Dinaric region, with mostly carbonate geology. All these watercourses are part of the Danube river basin.

Statistical analyses

A total of 237 species were determined and used in the similarity analyses of the caddisfly species assemblages. Of the determined species, 89 were found only in one region. The most species were found in the Alpine region. Many species of the subfamily Drusinae (e.g. *Drusus destitutus*, *D. monticola*, *D. slovenicus*, *Ecclisopteryx asterix*, *E. guttulata*…), some *Rhyacophila* species (e.g. *R. stigmatica*, *R. bonaparti*, *R. glareosa*…), *Tinodes* species (e.g. *T. zelleri*, *T. sylvia*) and some other species occur only in the Alps. All together, 53 species were found only in the Alpine region. In the Dinaric region, 27 species were found. Some Drusinae species (e.g. *Ecclisopteryx dalecarlica*, *Drusus croaticus*), *Rhyacophila* species (e.g. *R. palmeni*) and *Chaetopteryx* species (*C. irenae*, *C. marinkovicae*) are the most characteristic. 18 species were found only in the Pannonian region, and species of the family Leptoceridae (e.g. *Triaenodes bicolor*, *Ceraclea riparia*) were the most characteristic. In the Po region only *Tinodes antonioi* was a characteristic species.

Results of the NMS analyses confirmed the correct a priori allocation of the sampling sites to four regions (Alpine, Dinaric, Pannonian, Po) according to the occurrence of the indicator species (Figs. 4-5). Similarity analyses showed that caddisfly assemblages in the Alpine region and Pannonian region are the most diverse. Points that mark these sampling sites are on the opposite sites of the ordination diagram. Between these two regions are points that mark sampling sites of the Dinaric region. Points that mark sampling sites of the Po region are located together with points of the Pannonian region, which means that in both these two regions similar caddisfly species assemblages were found.

Discussion

Zoogeographic regions

Geographic position of Slovenia, where mountainous Alps and Dinarids meet and where there are continental and mediterranean lowlands resulted not only in the high biodiversity of the area, but also in the overlapping of distribution areas of species characteristic of different zoogeographic units. As a consequence, this mix of fauna constrained many different approaches and results of the zoogeographic divisions. Sket (2003) also named some regions as a combination of two geographic regions (e.g. Subpannonian-predinaric region).

Four approaches of zoogeographic division of Slovenia were based on freshwater animals (Illies 1978, Sket 2003), but only division of Illies (1978) included rheophilic aquatic insects. However, latter division was performed on a large scale and Slovenia contributed to two zoogeographic (eco)regions only, Alps (ecoregion 4) and Western Dinaric Balkan (ecoregion 5), although Slovenia bordered also to two more neighbouring regions,

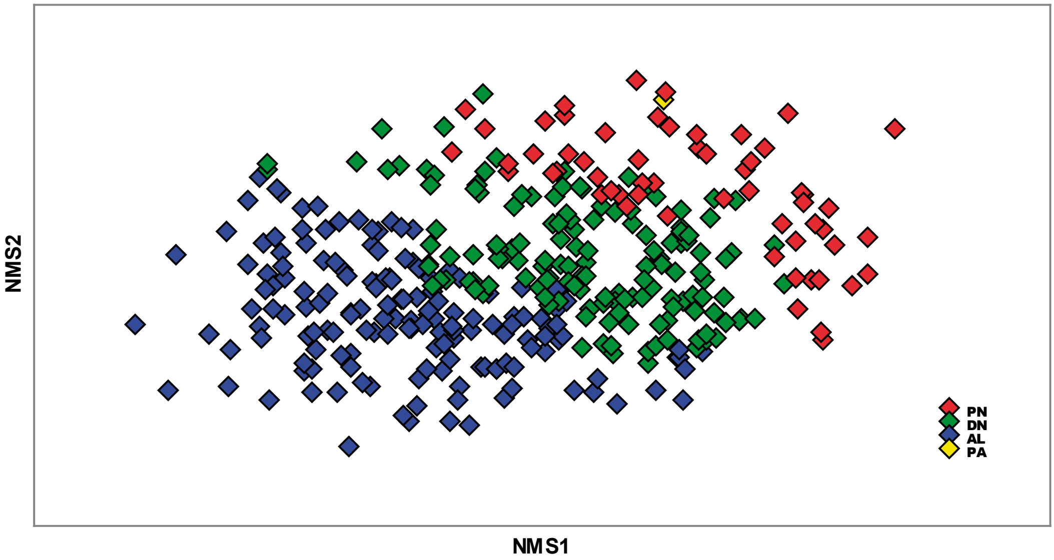

Fig. 4: Nonmetric multidimensional scaling ordination diagram of sampling sites containing at least one indicator species, the overlay indicates the hydrozoogeographic region: AL - Alpine region, DN - Dinaric region, PN - Pannonian region, PA - Po region. Stress = 0,15.

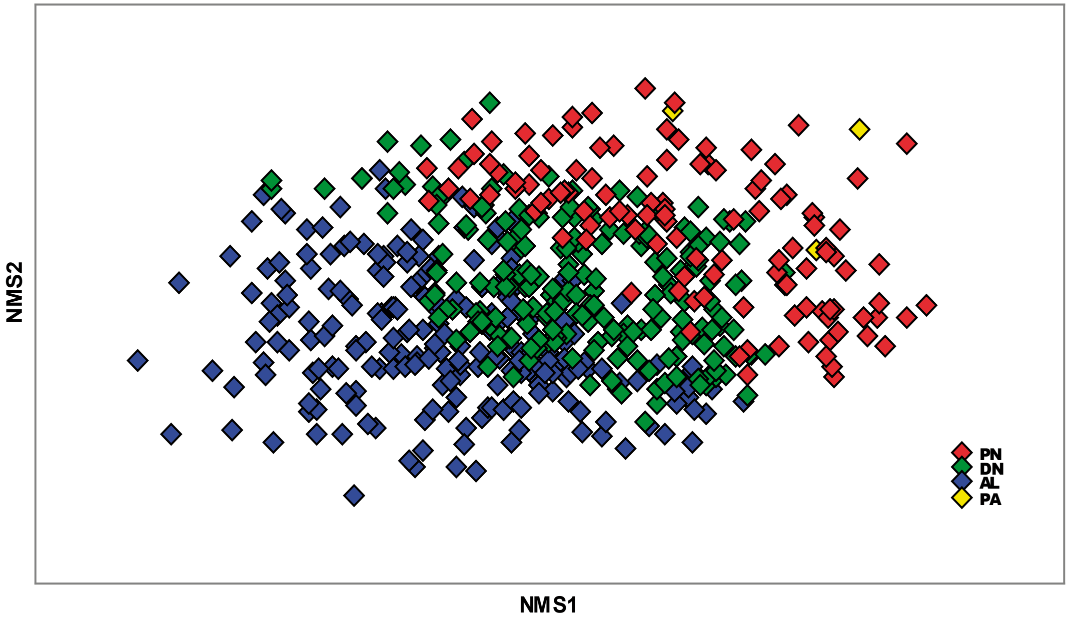

Fig. 5: Nonmetric multidimensional scaling ordination diagram of all sampling sites, the overlay indicates the hydrozoogeographic region: AL – Alpine region, DN – Dinaric region, PN – Pannonian region, PA – Po region. Stress = 0,15.

Hungarian lowland (ecoregion 11) and Italy (ecoregion 3). In our study we allocate large eastern part of Slovenian area to Pannonian lowland, what might correspond to Illies' ecoregion Hungarian lowland. However, on the west Illies (1978) determined Ecoregion Italy, which includes also Alps to the elevation of 1000 m. In the west of Slovenia our approach does not fit the Illies' one. Only small hilly and lowland area up to 200 m was recognised as the Po region. Also in central Slovenia different approaches were used. It is obvious that here we can find Alpine and Dinaric species and that delineation of the area is not simple (Sket 2003, Urbanič 2004). This might be also the reason why Illies (1978) defined the border between the ecoregion 4 (Alps) and ecoregion 5 (Dinaric Western Balkan) very simply. Dispersal ability of caddisflies is the reason why geographic division (Perko & Orožem Adamič 1998) of the Dinarids and Alps based mainly on historical events does not correspond well to our division. In the so called "Alpine plains" of the central Slovenia dinaric species can be found (e.g. *Rhyacophila schmidinarica*, *R. palmeni*). Moreover, in the nortwestern part of the Dinaric Mountains (Idrijsko hribovje) typical alpine species can be found (e.g. *Ecclisopteryx asterix*, *Metanoea rhaetica*).

On the other hand, at the prealpine lake outflows no typical alpine caddisfly species were found. Moreover, at the Bohinj lake outflow *Micrasema setiferum* was found, a species which occurs in Slovenia only in the Dinaric region with a probably disjunctive area at the Bohinj lake outlet (Urbanič 2004). Also the whole caddisfly assemblage found at this lake outlet was more similar to assemblages from the Dinaric region than to Alpine region. The reason is probably in the high summer temperatures which impact the caddisfly distribution most (Urbanič 2004). The importance of the summer maximum temperature on caddisfly distribution was obvious also at karst springs where at low elevation typical mountainous species were found, which resulted in some islands and gaps of one region inside another. The other reason for such gaps is also a flow of a large plain river with caddisflies characteristic for lowland rivers through the isolated alpine mountain range. Such cases are

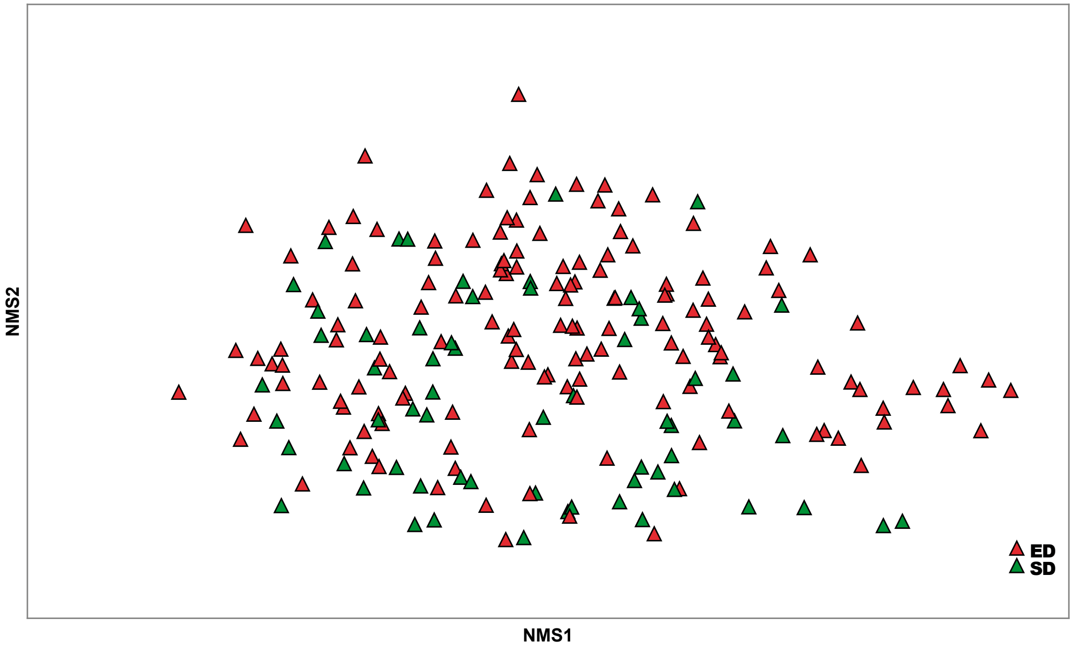

Fig. 6: Nonmetric multidimensional scaling ordination diagram of sampling sites of the Alpine region, the overlay indicates the hydrozoogeographic subregion: VA – Eastalpine subregion, ZA – Westalpine subregion. Stress = 0,17.

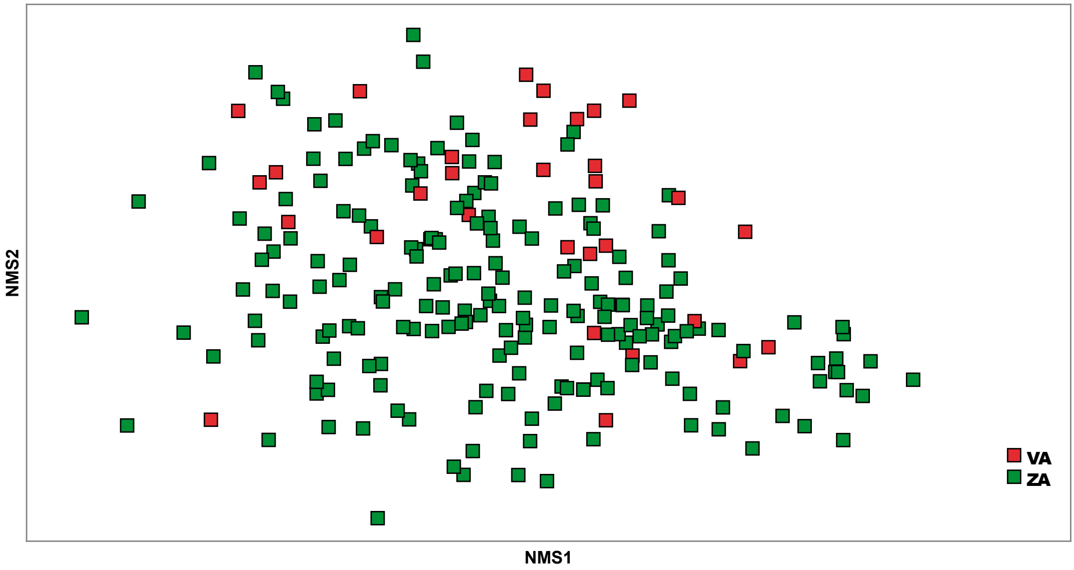

Fig. 7: Nonmetric multidimensional scaling ordination diagram of sampling sites of the Dinaric region, the overlay indicates the hydrozoogeographic subregion: ED – Eudinaric subregion, SD – Submediterranean-dinaric subregion. Stress = 0,18.

Sava River and Savinja River through Posavsko hribovje and Drava River which flows between Pohorje and Kozjak. Gaps of the Alpine region inside the Dinaric regions can be found also at the plains where large river leave the mountains and enter the plane. In both cases of gaps, the presence of alpine elements in the first case and Pannonian in the latter also confirms the theory that the water temperature maximum is an important ecological factor affecting the caddisfly distribution in the Alps and Dinarids (Urbanič 2004).

Statistical analyses

Using an indicator species approach and NMS analyses, we confirmed the a priori determination of four main zoogeographic regions in Slovenia, Alpine, Dinaric, Pannonian and Po region. However, division of the Dinaric and Alpine regions into two subregions according to species assemblages similarity was not as obvious as division into main four regions, despite the first class indicator species in each of subregions (Figs. 6-7). Nevertheless, zoogeographic dissimilarity of the subregions was confirmed by different numbers of species found at each subregion:

a) Alpine region; In the West alpine subregions 128 species were recorded whereas in the East alpine only 81 species.

b) Dinaric region; In the Eudinaric subregion 141 species were determined, whereas in the Submediterranean-dinaric subregion 107 species.

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The author would like to thank all colleagues from the Slovenian Museum of Natural History, Biotechnical Faculty University of Ljubljana, Environmental Agency of the Republic of Slovenia and all other colleagues who collected the caddisflies. The author also acknowledges the Natural History Museum of Luxembourg for enabling him the participation at the conference.

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The larva of *Micrasema cenerentola* Schmid, 1952 (Insecta: Trichoptera: Brachycentridae)

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Keywords: Trichoptera, Brachycentridae, Micrasema cenerentola, larval description, endemic, Iberian Peninsula.

Abstract

The larva of *Micrasema cenerentola S*chmid, 1952, an endemic of the Iberian Peninsula, is described for the first time. Among the European species of this genus, the larva of *M. cenerentola* is the only with two mesonotal sclerites and a strongly flattened head in combination. Typical larval and pupal cases are made of sand; pupal cases show a characteristic lateral opening for water flow improvement. The habitat of this species seems to be restricted to small mountain brooks.

Résumé

La larve de *Micrasema cenerentola* Schmid, 1952, un endémique de la Péninsule Ibérique, est décrite pour la première fois. Parmi les espèces européennes de ce genre, la larve de *M. cenerentola* c´est la seule qui possède deux sclérites mésonotales et une tête fortement aplatie en association. Les fourreaux larvaires et pupales typiques sont faits de sable; ceux-ci montrent une ouverture latérale caractéristique pour l'amélioration de l´écoulement de l'eau. L'habitat de cette espèce semble être limité à des petits ruisseaux de montagne.

Zusammenfassung

Die Larve von Micrasema cenerentola Schmid, 1952, ein Endemit der Iberischen Halbinsel, wird zum ersten Mal beschrieben. Im Vergleich der europäischen Arten dieser Gattung ist die Larve von M. cenerentola die Einzige, die die Kombination von mesonotale Skleriten und einem stark abgeflachten Kopf aufweist Die typischen Larval- und Puppenköcher bestehen aus Sand; sie besitzen eine charakteristische laterale Öffnung, die der Verbesserung des Wasserabflusses dient. Das Habitat dieser Art scheint auf kleine Bergbäche beschränkt zu sein.

Introduction

One of the most ticklish problems related to the taxonomy of European Trichoptera is that most of the Iberian and Pyrenean species of the genus *Micrasema*, significant inhabitants of rhitral habitats, are poorly known to this day and not clearly distinguished, both larvae and adults.

According to González et al. (1992) and Vieira-Lanero (2000), the genus *Micrasema* is represented in the Iberian Peninsula by *M. cenerentola* Schmid, 1952, *M. longulum* McLachlan, 1876, *M. minimum* McLachlan, 1876, *M. morosum* (McLachlan, 1868) and *M. servatum* (Navás, 1918). A special problem is that of *Micrasema moestum* (Hagen, 1868): under this name two cryptic species might be concealed. Moreover, in a recent review of the *Micrasema* species living in the Iberian Peninsula and Pyrenees, Botosaneanu & González (2006) concluded that both *Micrasema salardum* Schmid, 1952 and *Micrasema vestitum* Navás, 1918, are "good species" and must be added to the previous list.

The larvae of some of these Iberian species have been described by different authors (see Vieira-Lanero et al., 1998) but at the moment the larvae of *M. cenerentola*, *M. salardum* and *M. vestitum*, remain still undescribed. In this paper the larva of *Micrasema cenerentola* is described for the first time.

Material and methods

Some years ago, we collected 100 last instar larvae and 201 pupae of *Micrasema sp*. from two small mountain brooks –Cabanas Vellas and Río de la Vara– located in Sierra de Ancares (Lugo, Galicia, NW Spain). We have confirmed that our unidentified pupae (and, therefore, also the larvae) belong to the species *M. cenerentola.* In this paper we describe the final instar larva of this species. Setal nomenclature and terminology follows Wallace *et al.* (1990) and Williams & Wiggins (1981).

Description of the final instar larva

Body length 5.3 - 5.8 mm (N = 20). General appearance typical of the genus (Figs. 1-3).

Head capsule: Mean head length 0.66 mm (N = 20). Head reddish-chestnut in colour, rounded in dorsal view (Fig.4) but slightly longer than wide. Dorsum flattened (Figs. 1-3, 6-9), even slightly concave at eye level, and with a fine, granular ornamentation covering the surface (Fig. 4), excepting on the muscle attachment spots. A conspicuous dorsolateral, supraocular ridge arise along each side, and also a -shorter and less conspicuous-lateral infraocular ridge is present (Fig. 7 a and b, respectively). Posterior part of the head capsule angled when viewed in profile (Fig. 8).

Ventral side of the head capsule slightly paler than dorsum. Anterior ventral apotome quadrangular, extending from the oral margin to the aboral foramen (Fig. 5). Submental sclerites quadrangular, paired, each with a single seta. Antennae short, inconspicuous in dorsal view.

Seta 18 small and inserted close to the posterior margin; setae 17 and 3-6 hyaline; setae 2 and 3 bifurcated at apex.

Thorax: Pronotum trapezoidal in dorsal view (Figs. 8, 9), the anterior margin wider. A distinct, curved, transverse ridge is present running from one anterolateral margin to the opposite across the central point of the dorsum. Four strong and several small setae are inserted on the edge of the this carina. Anterior margin of pronotum slightly curved downwards and covered with small setae, some of them pointing upwards, but most of them thinner and bent downwards. Hemisclerites chestnut coloured, darker ahead the ridge.

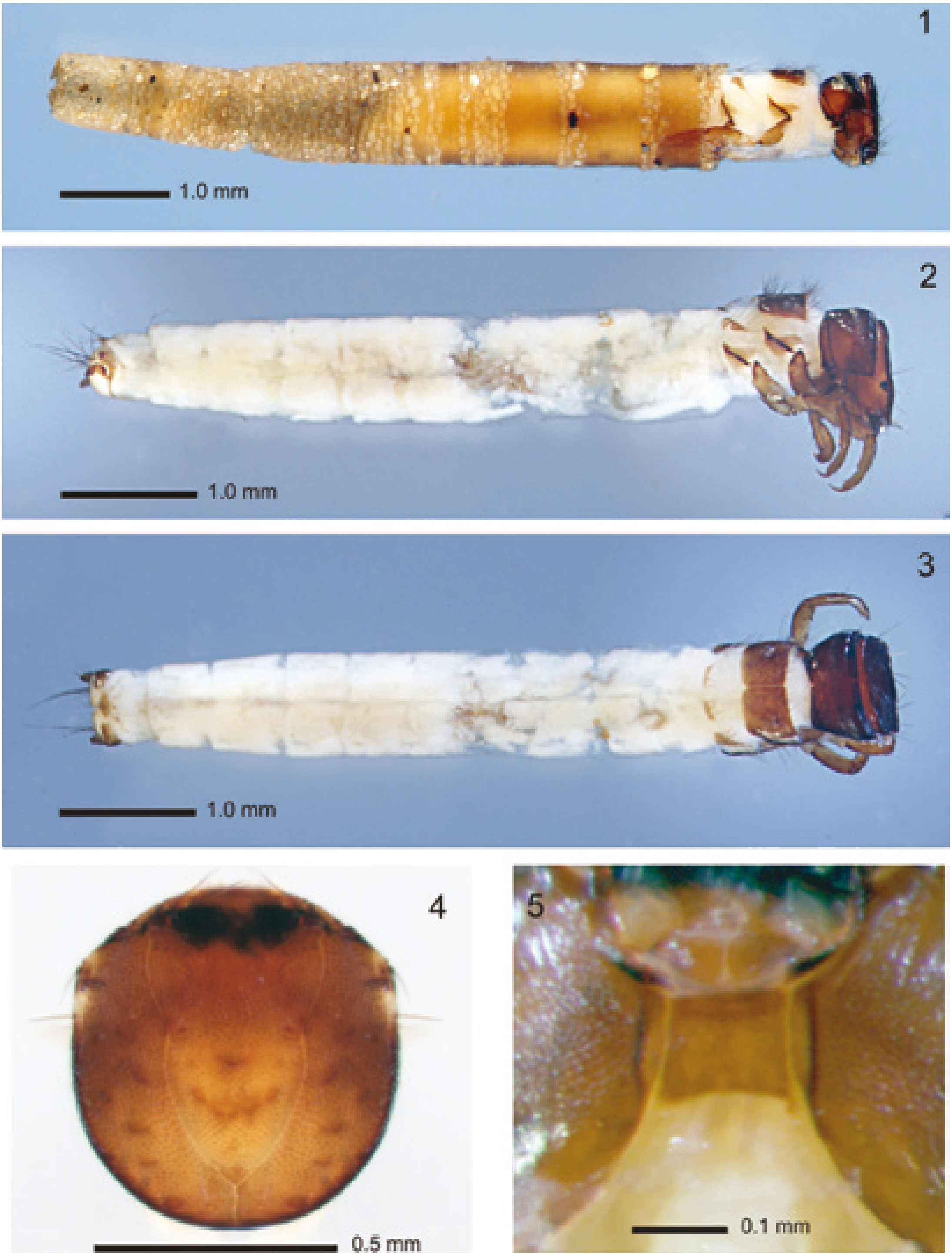
Mesonotum chestnut brown (Figs. 8-10), paler than pronotum and covered with two sclerites, each with a dark oblique line laterally. Excepting the area placed behind this line, each hemisclerite is covered with 58 - 68 setae; some of them are inserted on the anterior margin and hyaline, but most of them are dark coloured.

Metadorsum (Figs. 8, 9) membranous with 2 pairs of small, chestnut coloured, sclerites; median sclerites with 5 - 6 setae; lateral sclerites triangulate, with a dark, oblique line medially and 18 - 20 setae placed on the anterior margin.

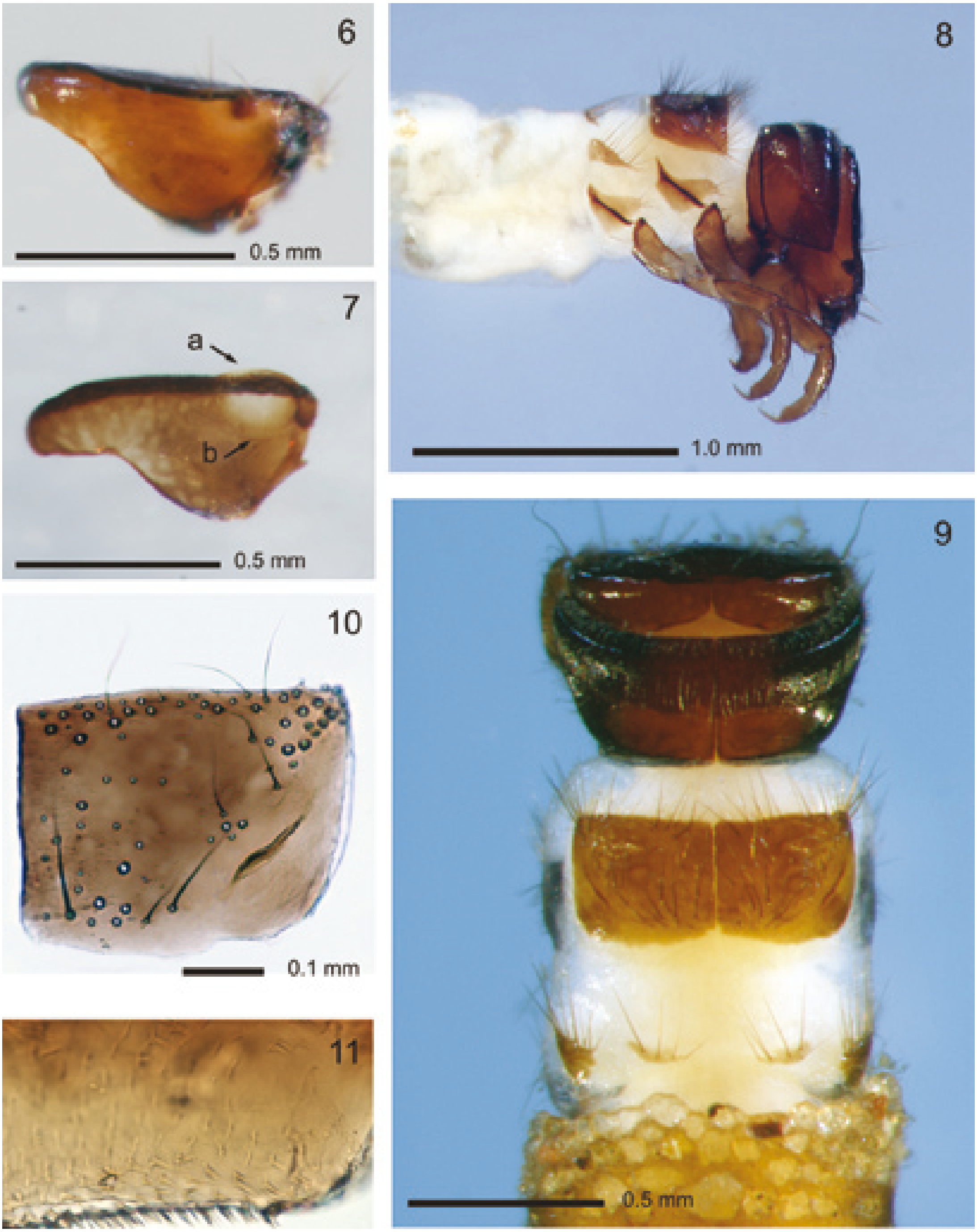
Prothoracic legs (Fig. 12): shorter than meso- and metathoracic legs. A polyfurcate seta is inserted on both anterior and posterior faces of the coxa. Ventral margin of proximal segment of trochanter with several microspines (as in Fig. 11) and a distal seta; distal segment with a polyfurcate seta on the posterior face, two ventrodistal spurs and several serrated setae along the ventral margin. Prothoracic femur wide and scout when compared with the tibia. The small ventral margin bears 4 - 5 stout spurs, 4 - 5 strong setae (light coloured and very similar to spurs) and several serrated setae. Posterior face with a polyfurcate seta. Dorsal margin covered of microspines and bears 10 long setae (1 proximal and 9 distal setae).

Both ventral and dorsal margins of the tibiae are fully covered by microspines. The dorsal margin bears 4 distal setae and the ventrodistal margin only one spur and one seta. Tarsi with a dorsodistal seta and, ventrodistally, 5 strong spurs and a distal seta. Tarsal claw and tibia similar in length, basal seta roughly exceeding half claw length.

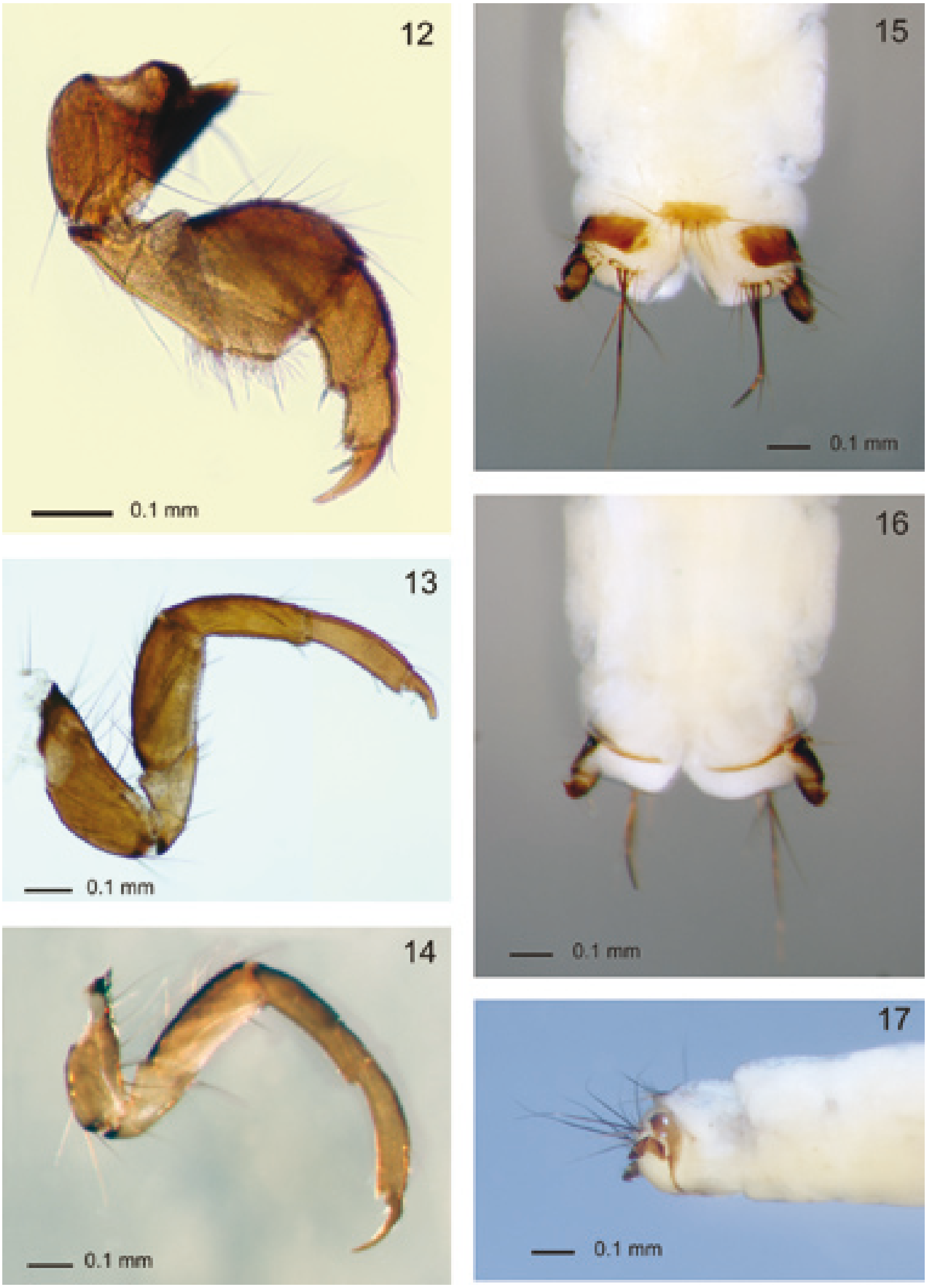
Mesothoracic legs (Fig. 13): ventral margin of coxae, trochanter and tarsi covered of microsetae. A group of three polyfurcate setae are inserted on the anterior side of the coxa. Ventrodistal margin of trochanter with a group of serrated setae. Both



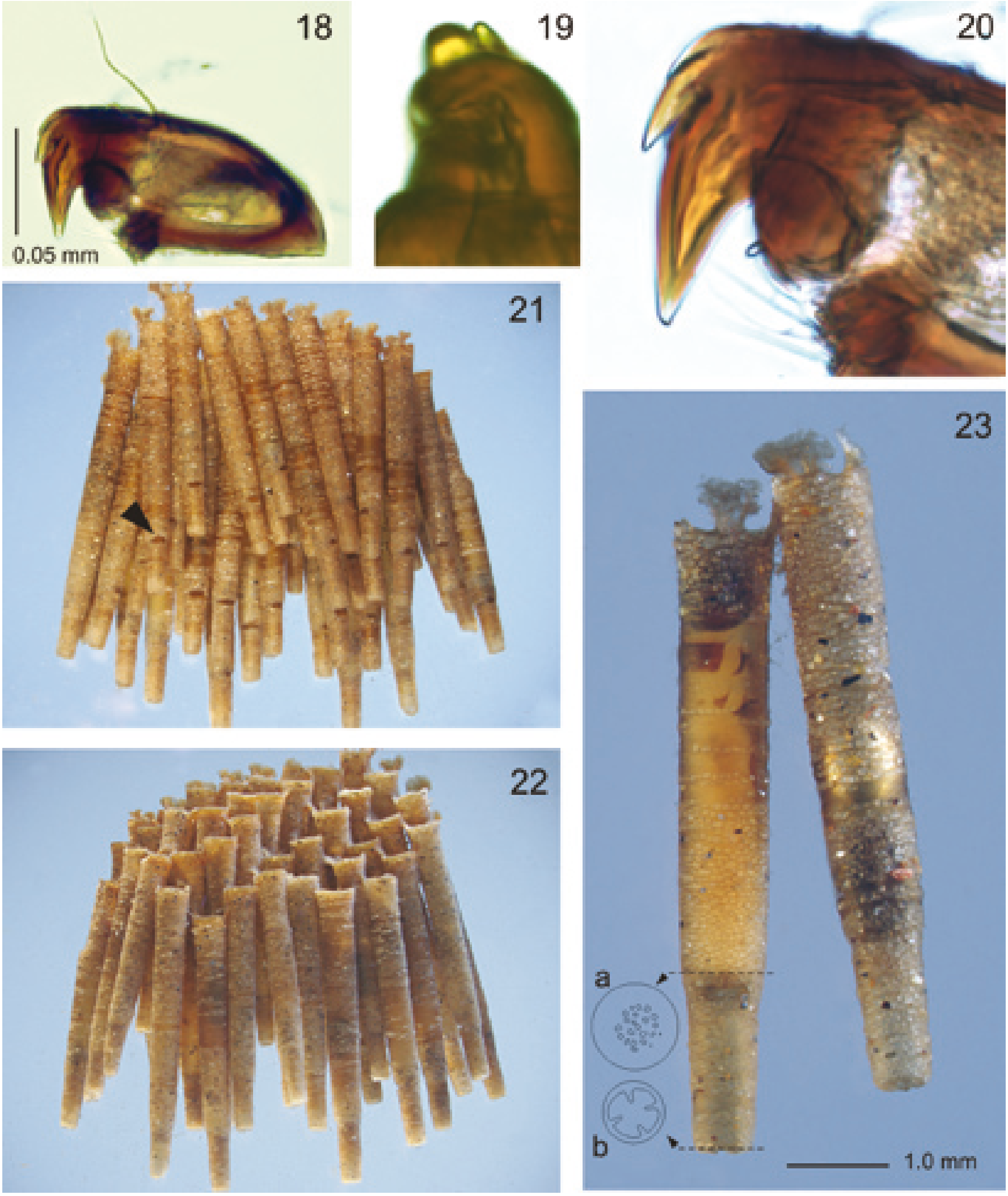
Figs. 1 - 5: *M. cenerentola,* final instar larva. 1 Larval case and larva in lateral view. 2 Habitus, lateral view . 3 Habitus, dorsal view. 4 Head capsule, dorsal view . 5 Head, a detailed view of the anterior ventral apotome.



Figs. 6 – 11: *M. cenerentola,* final instar larva. 6 Head, lateral view. 7 Right lateral sclerite of head showing the dorsolateral, supraocular ridge (a) and the lateral infraocular ridge (b). 8 Anterior half of larva in lateral view. 9 Anterior half of larva in dorsal view. 10 Right mesothoracic hemisclerite. 11 Microsetae and microspines on the metathoracic femur.



Figs. 12 – 17: *M. cenerentola,* final instar larva. 12 Prothoracic leg, lateral view. 13 Mesothoracic leg, lateral view. 14 Metathoracic leg, lateral view. 15 Abdominal segments VIII and IX in dorsal view. 16 Idem in ventral view. 17 Idem in lateral view.



Figs. 18 – 23: *M. cenerentola,* final instar larva. 18 Right anal claw in lateral view. 19 Detail of the anal claw in ventral view showing the stout main claw and two dorsal accessory hooks. 20 Detail of the anal claw in lateral view. 21 Mass of pupal cases; note the lateral openings (arrow). 22 The opposite side of the same mass of pupal cases. 23 Pupal cases, and line drawings of the multiperforated membrane (a) and the posterior opening (b).

ventral and dorsal margins of the femora and tibiae covered by microspines. Anterior face of femur with one polyfurcate seta, dorsal margin with a group of 7 setae (2 proximal and 5 distal setae); ventrodistally there is a strong, hyaline seta. Tibia with 4 setae on the dorsal margin and one strong, hyaline seta on the ventrodistal margin. Anterior side of the tarsi covered of microspines; dorsal margin with 2 setae, ventrally with 3 spurs (one median and 2 distal). Basal seta small.

Metathoracic legs (Fig. 14): ventral margin covered of microspines in all the leg segments, and also on the dorsal margin of femur, tibia and tarsus, and on the anterior face of tibia and tarsus. Two polyfurcate setae are inserted on the anterior face of the coax. Trochanter with a ventrodistal brush of 10-12 serrated setae. Anterior side of the femur with one polyfurcate seta; posterior face with a dark, distal seta. Ventral margin with 2 strong, hyaline setae; dorsal margin with a group of 8-9 setae (1 proximal and 7-8 distal setae). Dorsal margin of tibiae with 4 setae (2 median and 2 distal seate), and ventral margin with one distal spur. The dorsal margin of the tarsus bears 2 distal setae; the ventral margin one median spur and a distal group of 3 small spurs. Tarsal claw similar to mesothoracic claw.

Abdomen nearly cylindrical and posterior half gradually tapered, ninth segment clearly thinner (Figs. 2, 3). Abdominal gills absent. Dorsal hump absent and lateral humps indistinct in segment I. Segments II-VIII with a lateral line composed of a group of 14 - 23 lateral tubercles and a small seta on each side.

Mid dorsal sclerite of segment IX (Fig. 15) weakly sclerotized, elliptical, with 16 setae different in size along posterior margin. One lateral seta is placed on the soft cuticle, outside this sclerite.

Dorsal side of anal prolegs (Figs. 15-17) almost completely membranous; posterior dorsal margin with 17 setae: 12 small and thin and 5 long, stout, dark setae. Ventral side membranous, covered with micro-spines. A pair of bar-like sclerites can be distinguished on each side of the anal opening. Lateral sclerite weakly sclerotized. Anal claw (Figs. 18-20) with two small accessory hooks, the inner smaller than the outer.

Larval and pupal cases (Figs. 1, 21-23): The larvae build a cylindrical, straight, slightly conical case, with a characteristic narrow posterior third. Typical cases are made of silk and a variable percentage of sand; as a result, some cases present large silky areas and some other are mostly made of sand. The posterior third is usually made of fine sand grains and the posterior opening is only partially closed by four thin, silk extensions (Fig. 23b).

Pupal cases are modified larval cases, improved for a better water flow through the pupal case (see ecological notes). Distinctively, the last instar larvae build an internal, multiperforated membrane (Fig. 23a) just above the case narrowing, and open a small hole in the wall behind it (see the arrow in Fig. 21), keeping the posterior opening unmodified.

Discussion

According to the number of mesonotal sclerites of the last instar larva, two groups can be distinguished among the Iberian species of the genus: a group of larvae with two mesonotal sclerites (comprising *M. cenerentola*, *M. morosum* and *M. longulum*) and a group with four (the remainder known species).

The larva of *M. cenerentola* can be easily distinguished from that of *M. morosum* and *M. longulum* by its strongly flattened head (see Table I for additional characters).

An interesting finding from this research is that the larvae of some species of this genus are more easily distinguishable among themselves than adults are. For instance, the adults of *M. servatum* and *M. cenerentola* are very much alike, while the larvae are clearly different and, seemingly, belong to different groups.

Notes on distribution and ecological preferences

The larvae of *M. cenerentola* were collected only in small mountain brooks located at 1150-1380 m. a.s.l. They were found in large numbers on the underside of big stones placed just before small waterfalls. The larvae usually attach the anterior border of the case to the substrate with a secretion disc, avoiding to be washed downstream.

Table I: Some other characters that can be useful when separating the larvae of the known Iberian species of the genus *Micrasema* with two mesonotal sclerites (see Waringer & Graf, 1997; pg. 133, fig. 2; and pg. 135, fig.7).

	M. cenerentola	*M. morosum*	*M. longulum*
Anterolateral margin of mesonotal sclerites	rounded, slightly angled	rounded	extended anteriorly
Head, occipital area in profile	angled	rounded	rounded
Ventrodistal edge of meso- and metathoracic tarsi	without conical projection	without conical projection	with a conical projection
Case	sand grains and silk	vegetal fragments arranged in spiral	only silk

They often aggregate for pupation, selecting areas with heavy current and attaching the anterior opening of the case to the substrate with one or more stalked discs. Large numbers of pupal cases have been found together, arranged in one or two levels and resulting in a compact structure (Figs. 21, 22). This peculiar arrangement can be favoured if water flow to he case is made through the small hole opened by the last instar larva in the case wall.

M. cenerentola is an endemic of the Iberian Peninsula (Botosaneanu and González, 2006). The species was previously cited only by Schmid (1952) from the type locality (Avila, Central Spain). Afterwards we have been the only to find it in a few sampling sites, all located in Sierra de Ancares and Sierra do Caurel (Lugo, NW Spain).

Acknowledgements

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Light-trapping of Trichoptera at the March, an eighth-orderAustrian lowland river

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Poster Abstract

Adult Trichoptera were caught from 26 September, 2001 to 7 November, 2002 at the banks of the March River at Angern, Lower Austria (16° 50' 05''E; 48° 22' 44'' N; 144 m above sea level), using a Jermy-type light trap. From a total of 36,780 specimens caught, the most abundant species were *Hydropsyche bulgaromanorum* Malicky, *Hydropsyche contubernalis* McLachlan, *Setodes punctatus* (Fabricius), *Ceraclea dissimilis* (Stephens), *Ceraclea albimacula* (Rambur) and *Hydropsyche modesta* Navas (Tab. 1). Nearly all species collected at the March show large distributional ranges, many of them covering whole Europe.

In five out of the thirteen most abundant species the sex ratios significantly differed from 1:1, with an excess of males in *H. modesta* and *S. punctatus* and an excess of females in *Agapetus laniger*, *Orthotrichia costalis* and *Ecnomus tenellus*.

Of the meteorological parameters tested, only sunset and midnight air temperatures as well as precipitation had significant ($P< 0.05$) effects on total catch. The longitudinal classification of the sampling station based on species-specific zonal distribution patterns of caddisflies yielded highest scores in the epi- and metapotamal region.

With respect to functional feeding groups, passive filtering collectors made up to 48.5 % of the total catch, reflecting the high proportion of Hydropsyche species. The second and third most abundant feeding groups were predators (29.5%) and grazers (19.7%). Combined with the low percentage of shredders (1.1% of the total), the species inventory reflects the shift from coarse to fine particulate organic matter downstream, as suggested by the River Continuum Concept.

Table 1: Trichoptera species caught by a light trap on the banks of the March River at Angern, Lower Austria, from 26 September, 2001 to 7 November, 2002; showing the species, probable breeding habitat (M= March River, S= standing waters of the floodplain), total number of individuals caught (n; males and females), percentage of total catch (%) and times when species were present in the trap. Species are arranged in taxonomic order. Another four species (*Agraylea multipunctata* Curtis, 1834, *Hydroptila simulans* Mosely, 1920, ***Hydropsyche bulbifera* McLachlan, 1878**, *Trichostegia minor* (Curtis, 1834)) were collected by W. Graf at a March station ten kilometres to the south in August, 2004. **Bold characters:** Larvae collected in the March.

Species	Habitat	Males/females	%	Flight period
Glossosoma boltoni Curtis, 1834	M	1 / 0		25 Jul
Agapetus laniger (Pictet,1834)	M	16 / 37	0.14	20 Jun – 25 Jul
Agraylea sexmaculata Curtis, 1834	S	1 / 2	0.01	20 Jun – 28 Aug
***Hydroptila sparsa* Curtis, 1834**	M	23 / 28	0.17	15 May – 11 Sep
Oxyethira flavicornis (Pictet, 1834)	S	0 / 3	0.01	20 Jun
Orthotrichia costalis (Curtis, 1834)	S	0 / 21	0.06	20 Jun – 27 Jun
Orthotrichia tragetti Mosely, 1930	S	0 / 1		21 Aug
***Psychomyia pusilla* (Fabricius, 1781)**	M	26 / 26	0.14	22 May – 11 Sep
Ecnomus tenellus (Rambur, 1842)	S, M	6 / 31	0.10	29 May – 30 Oct
Cyrnus crenaticornis (Kolenatı, 1859)	S	1 / 0		29 May – 30 Oct
Holocentropus stagnalis (Albarda, 1874)	S	0 / 1		22 May
***Neureclipsis bimaculata* (Linnaeus, 1758)**	M	28 / 25	0.14	1 May
***Hydropsyche bulgaromanorum* Malicky, 1977**	M	4256 / 3003	19.74	8 May – 24 Oct
***Hydropsyche contubernalis* McLachlan, 1865**	M	11922 / 15733	75.19	1 May – 7 Nov
Hydropsyche incognita Pitsch, 1993	M	1 / 0		25 Jul
***Hydropsyche modesta* Navas, 1925**	M	134 / 33	0.45	8 May – 2 Oct
Hydropsyche pellucidula (Curtis, 1834)	M	1 / 0		22 May
Phryganea grandis Linnaeus, 1758	S	1 / 0		18 Jul
***Brachycentrus subnubilus* Curtis, 1834**	M	2 / 2	0.01	1 May – 8 May
Glyphotaelius pellucidus (Retzius, 1783)	S	1 / 0		17 Oct
Grammotaulius nigropunctatus (Retzius, 1783)	S	2 / 2	0.01	26 Sep – 17 Oct
Limnephilus affinis Curtis, 1834	S	2 / 13	0.04	26 Sep – 24 Oct
Limnephilus auricula Curtis, 1834	S	1 / 2	0.01	8 May – 30 Oct
Limnephilus decipiens (Kolenati, 1848)	S	1 / 0		23 Oct
Limnephilus flavicornis (Fabricius, 1787)	S	2 / 1	0.01	27 Jun – 24 Oct
Limnephilus lunatus Curtis, 1834	S	1 / 1	0.01	10 Oct – 7 Nov
Limnephilus vittatus (Fabricius, 1798)	S	1 / 0		16 Oct
Halesus tesselatus (Rambur, 1842)	M	1 / 0		17 Oct
Stenophylax permistus McLachlan, 1895	M	8 / 4	0.03	8 May – 24 Oct
Goera pilosa (Fabricius, 1775)	M	0 / 4	0.01	15 May – 20 Jun
***Athripsodes cinereus* (Curtis, 1834)**	M	6 / 7	0.04	20 Jun – 11 Sep
Ceraclea albimacula (Rambur, 1842)	M	88 / 105	0.52	6 Jun – 21 Aug
Ceraclea annulicornis (Stephens, 1836)	M	1 / 5	0.02	22 May – 27 Jun
***Ceraclea dissimilis* (Stephens, 1836)**	M	160 / 218	1.03	22 May – 3 Oct
Leptocerus tineiformis Curtis, 1834	S	0 / 9	0.02	20 Jun – 25 Jul
Oecetis furva (Rambur, 1842)	S	2 / 1	0.01	20 Jun – 25 Jul
Oecetis lacustris (Curtis, 1834)	S	0 / 1		20 Jun
***Oecetis notata* (Rambur, 1842)**	M	9 / 10	0.05	20 Jun – 14 Aug
***Oecetis ochracea* (Curtis, 1825)**	M	3 / 2	0.01	22 May – 27 Jun
***Oecetis tripunctata* (Fabricius, 1793)**	M	2 / 0	0.01	27 Jun – 25 Jul
***Setodes punctatus* (Fabricius, 1793)**	M	539 / 172	1.93	6 Jun – 11 Sep
Mystacides azurea (Linnaeus, 1761)	S	0 / 1		20 Jun
Mystacides longicornis (Linnaeus, 1758)	S	0 / 16	0.05	15 May – 11 Sep
Number of specimens		17260 / 19520		
Number of species	43			

Overall distributional patterns of European Trichoptera

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Abstract

The European Trichoptera fauna was analysed for overall patterns related to area, latitude and occurrence of mountainous areas, respectively, using checklists from 26 countries. There was a significant correlation between latitude and species richness: An increasing richness going south for lotic species, but an increasing richness going north for lentic species. Further, the number of lotic species was significantly correlated with the occurrencesdel of mountainous areas. Overall patterns could also be demonstrated using multidimensional scaling of similarity indices between the checklists, showing that the faunas of the southern countries (e.g. Greece, Portugal + Spain, and Italy) are much more different from each other than are the faunas of northern Europe. The relationships and patterns are discussed.

Introduction

Nearly thirty years ago, Botosaneanu & Malicky (1978) compiled the most recent comprehensive checklist of European Trichoptera including 895 species distributed among 27 geographic regions (see Illies 1978). Most of these geographic regions, or 'ecoregions', have recently been used as the template for the Water Framework Directive (European Union 2000). Unfortunately, the distribution of European Trichoptera has not been updated on an ecoregional scale. This does not mean that faunistics of European Trichoptera has been neglected in recent years. On the contrary, a relatively great number of new species have been detected and described from the area, and national checklists have been provided or revised for most countries. In addition, some taxonomic revisions have taken place, although some species groups may still need a careful examination.

Zoogeographically, Europe sensu Illies (1978) may hold almost 1100 species. This is quite a large number compared with the 1653 species recorded from North America including Greenland and Mexico (Morse 1993) that represents a much larger area and a somewhat wider climatic range. A comparison between Europe and North America are relevant, as they share almost the same families of Trichoptera and largely the same relative species richness of these families (although only 33 species occur in both "regions"). This similarity may, however, not be surprising as Europe and North America were connected until about 120 million years ago (i.e. during the Cretaceous period).

The relatively high species richness of Europe makes zoogeographical analyses interesting. There have been several studies of that kind, dealing with more or less restricted geographical areas (e.g. Malicky 1985; Pitsch 1993; Cianficconi, Moretti & Tucciarelli 1997; Laasonen, Laasonen & Nybom 1998; Uherkovich & Nogradi 1999; Robert 2001). No studies, however, seem to have focussed on the overall patterns of the distribution of European Trichoptera using statistical methods and other analytical tools. This is the purpose of the present study that primarily focuses on the distribution on the European continent.

Material and methods

In the absence of suitable faunistic data from the European ecoregions a dataset using the most recent checklist from 26 countries was compiled, supplemented by additional published or even unpublished records (Tab. 1). Among these countries Spain and Portugal were represented by a common checklist for the Iberian Peninsula. Sufficiently comprehensive data were not available for Lithuania, Belarus, Ukraine, and the former Yugoslavia (except Slovenia). The country datasets were adjusted only to include species occurring on the continent (except in case of the United Kingdom and Ireland). Thus, for example species occurring on the Iberian, French and Italian checklists, but only found on the islands of Mallorca, Corsica and Sardinia/Elba, respectively, were omitted. Accordingly, Greek species occurring only on the island of the Aegean region or on Crete were omitted from the Greek dataset. Being located close to the Italian Mainland the Sicilian Island was, however, regarded a part of the continent.

I only included species, although a lot of subspecies could have been taken into consideration.

Species were divided into lotic species (i.e. species primarily occurring in running waters) and lentic species (species primarily occurring in lakes and ponds). Species found in hygrophilous habitats (e.g. springs) was designated as lotic. The families Arctopsychidae, Beraeidae, Brachycentridae, Calamoceratidae, Dipseudopsidae, Glossosomatidae, Hydropsychidae, Goeridae, Lepidostomatidae, Odontoceridae, Philopotamidae, Rhyacophilidae, Sericostomatidae, Uenoidae, and most species of Psychomyiidae were regarded as lotic, whereas Ecnomidae, Phryganeidae and Molannidae were regarded as lentic. Several genera of Hydroptilidae, Limnephilidae and Polycentropodidae were considered lotic, whereas several other species belonging to these families were considered lentic.

A significant number of species was designated as endemic. There is no precise definition of endemic species regarding the size of the restricted area in which the species are found. Thus generally, I have regarded species found in only one country or on the Iberian Peninsula as endemic. Exceptions are of course cases, where a species also occurs outside the 26 countries in consideration. This is of course a rather rigid approach as some species may be endemic to restricted mountain areas crossing country borders.

Geographical data including the total area, mean latitude, and area of "high" mountains of the respective countries were obtained from official maps and databases. The total area of France, Italy and Greece was reduced by the area of Corsica, Sardinia, Crete and the Aegean Islands, respectively (according to the correction of the species lists, see above). Mean latitude for a given country was estimated as the simple average of the most northern and southern readings. For practical reasons "high" mountains were defined as areas with heights of more than 1000 m a.s.l., although the definition according to the Water Framework Directive are areas above 800 m. Further, the total area of lakes was roughly estimated for each country by multiplying the so-called "Limnicity Index" (UNEP/DEWA 2005), defined as the percentage of total freshwater surface area, with the total land area of the respective country.

Statistical analyses of the relationships between species richness and geographical parameters were carried out using the programme ASTUTE (DDU Software 1993). The correlation between species richness and area (for each country the total geographical area and total lake area), the so-called species – area relationship (SAR) was analysed according to the form $S = c\ A^z$, where S is species richness, A is the area, and c and z are constants (e.g. Rosenzweig 1995). The formula may be written as $\log S = \log c + z \log A$, i.e. a linear function on a log-log scale. This is a general relationship found repeatedly among different groups of plants and animals, and at different scales (e.g. Rosenzweig 1995, Sand-Jensen 2000). Other correlations were tested non-parametrically (Spearman rank correlation) as the respective relationships were not expected to follow a certain mathematical formula.

PRIMER version 5 (PRIMER-E Ltd. 2000, see also Clarke & Warwick 1994) was used to analyse similarities between the faunas using Bray-Curtis similarity index on presence/absence data.

Table 1: Species richness of Trichoptera and geographic characteristics of 26 European countries. Species that are only recorded from Mallorca, Corsica, Sardinia, Elba, Crete, and the Aegean Islands are excluded. Values for latitude are means (northern latitude + southern latitude/2).

Country	Area (km^2)	Latitude	Species richness	References
Austria (A)	83 850	47.2	302	Malicky 1999
Belgium (BE)	30 513	50.5	200	Stroot 1987
Bulgaria (BU)	110 912	42.5	239	Kumanski 1981, 1985, 1988
Czech Republic (CZ)	78 664	50.0	247	Chvojka & Novak 2001
Denmark (DK)	43 080	56.0	169	Wiberg-Larsen 2005[1]
Estonia (EE)	45 100	58.7	179	Viidalepp & Timm, unpubl.[1]
Finland (FI)	337 032	64.6	212	Laasonen et al. 1998[2]
France (FR)	538 300	46.3	393	Tachet 2005[2,3]
Germany (DE)	356 829	51.0	312	Robert 2001
Greece (GR)	118 300	37.0	231	Malicky 1993, 2004[3]
Hungary (HU)	93 036	47.0	210	Uherkovich & Nógrádi 1999[2]
Iberian Peninsula (IB)	588 700	40.0	361	Gonzalez et al. 1992[1,2,3], Malicky 2004
Ireland (IR)	70 283		143	Wallace et al. 1990; Edington & Hildrew 1995
Italy (ITA)	276 900	42.0	360	Cianficconi 2002[2,3]
Latvia (LA)	63 700	57	189	Spuris 1989
Luxembourg (LU)	2586	49.8	183	Musée national d'histoire naturelle, Luxembourg 2005
Netherlands (NL)	41 160	52.2	175	Higler 1995[2]
Norway (N)	386 317	64.5	195	Solem & Gullefors 1996[2]
Poland (PL)	312 683	52.0	276	Czachorowski 2002[2]
Romania (RO)	237 500	46.0	265	Ujvarosi 1998[2,3]
Slovakia (SLK)	49 035	49.0	219	Chvojka & Novak 2001
Slovenia (SLN)	20 255	46.0	224	Krusnik & Urbanic 2002[2]
Sweden (SE)	450 089	62.3	220	Gullefors 2002[2]
Switzerland (SCH)	41 293		314	Lubina-Ferlin & Vicentini 2005[3]
United Kingdom (UK)	244 102		197	Wallace 1991

Remarks:

[1] Supplemented by unpublished records

[2] Supplemented by recent published records

[3] Corrections according to Malicky 2005

Results

The original dataset included 976 species occurring in at least one of the 26 countries in consideration. After exclusion of island species from the lists of the Iberian Peninsula, France, Italy and Greece (see methods and materials) the dataset was reduced to 891 species. Of these 83.5% was designated lotic, 16.2% lentic and only 0.3% terrestrial.

The SAR for lotic and lentic species, respectively, was very weak (r^2=0.04/0.08) and not significant (P=0.10/0.19) for the 24 countries considered on the European continent (Fig. 1). However, a significant positive relationship was found between the number of lentic species and lake area (r^2=0.34, P<0.001), see Fig. 2.

There was a highly significant negative correlation between species richness and latitude for lotic species (r_s=-0.79, P<0.0001), whereas the richness of lentic species showed a strong positive correlation with latitude (r_s=0.83, P<0.0001), see Fig. 3. According to Fig. 4 endemic species richness, that

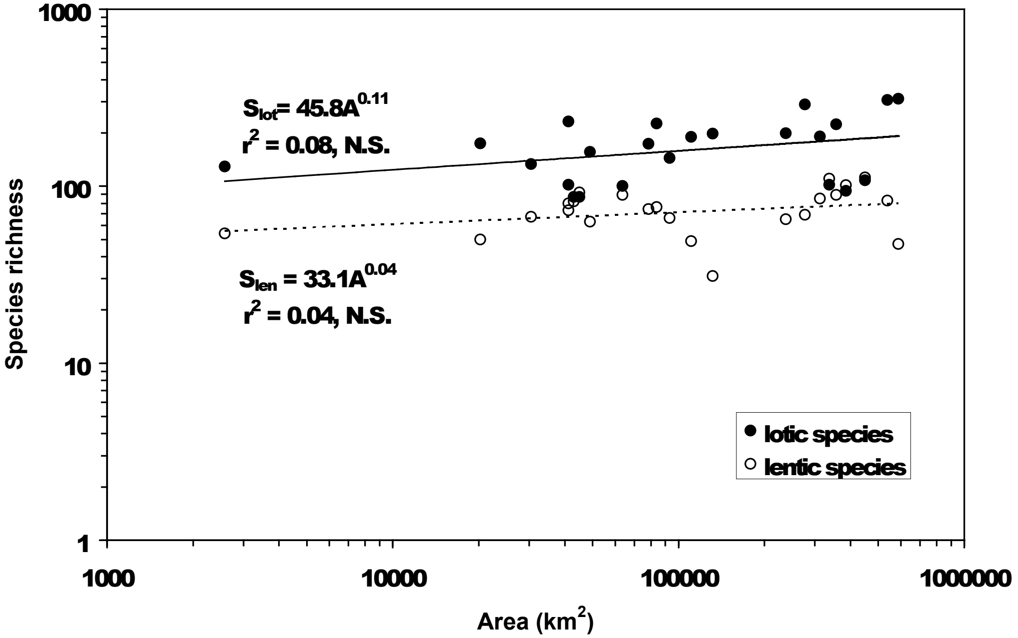

Fig. 1: The relationship between species richness of Trichoptera and geographic area for 24 countries on the European continent. Analyses are carried for lotic and lentic species, respectively.

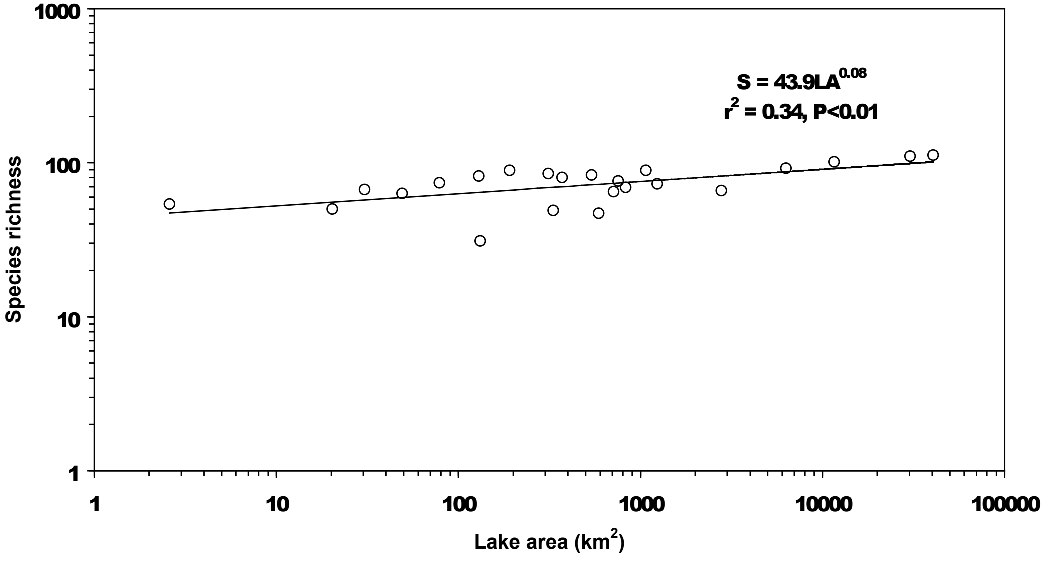

Fig. 2: The relationship between species richness of lentic Trichoptera and total lake area for 24 countries on the European continent.

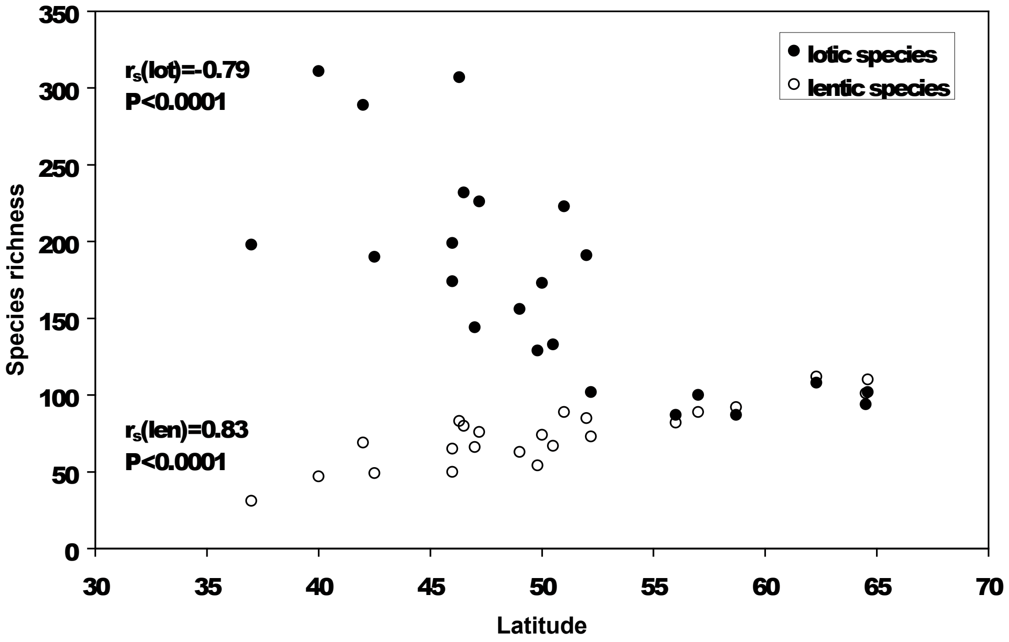

Fig. 3: The relationship between species richness of lentic Trichoptera and latitude for 24 countries on the European continent. The analyses are carried out for lotic and lentic species, respectively.

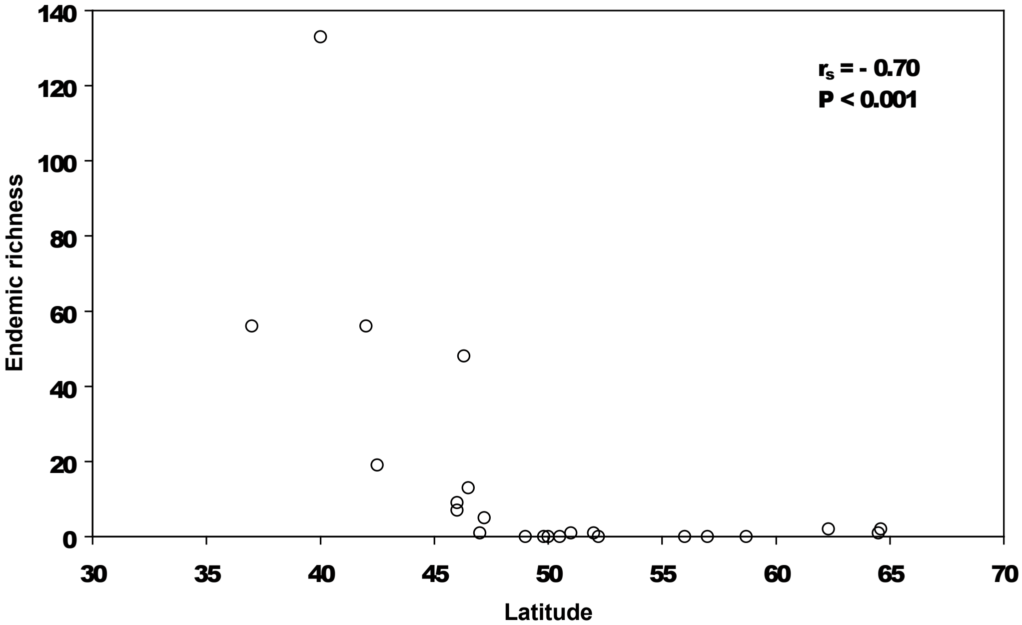

Fig. 4: The relationship between the number of endemic Trichoptera species and latitude for 24 countries on the European continent.

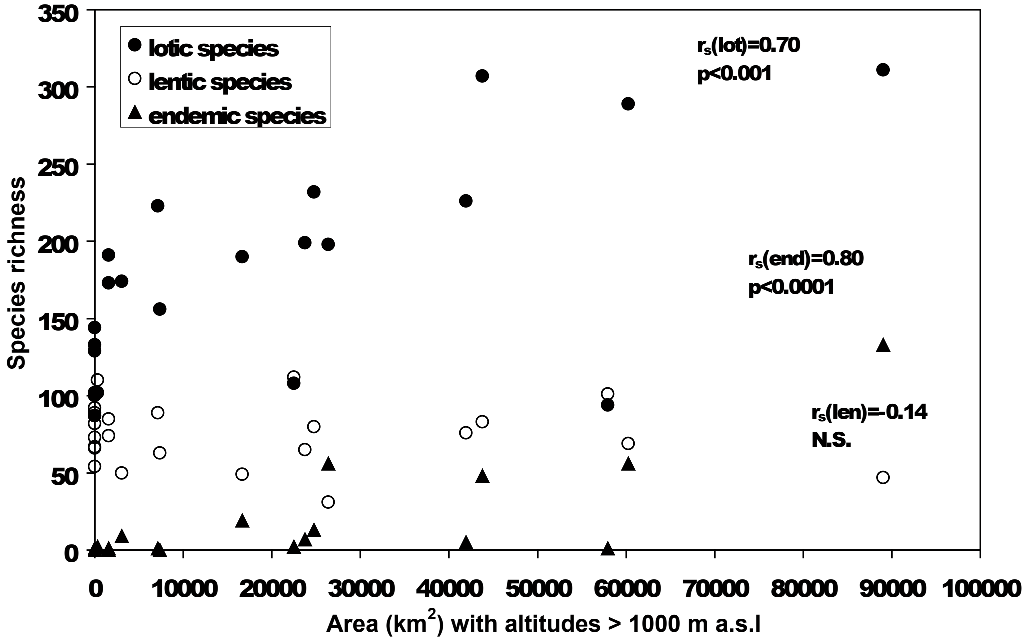

Fig. 5: The relationship between species richness of Trichoptera and area with altitudes above 1000 m a.s.l for 24 countries on the European continent. The analyses are carried out for lotic, lentic, and endemic species, respectively.

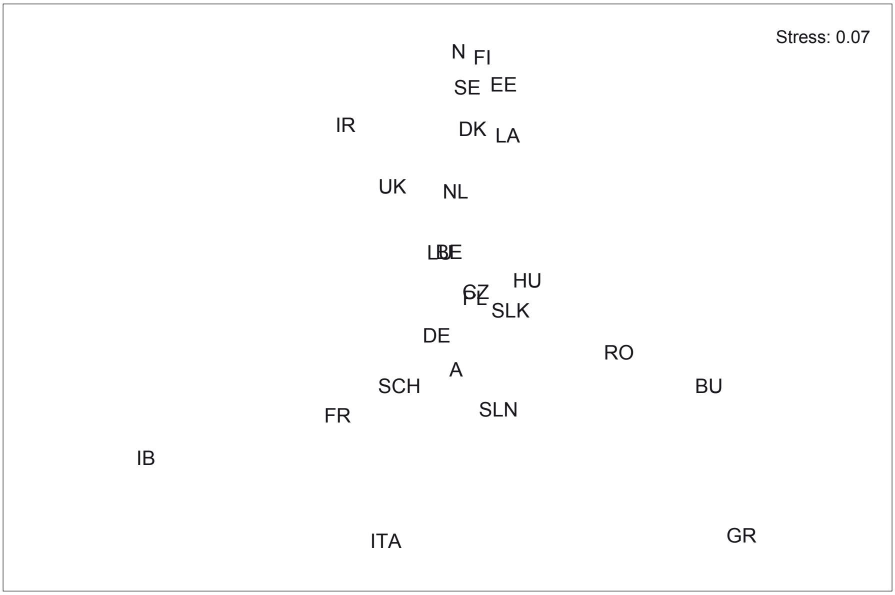

Fig. 6: Multidimensional scaling of Bray-Curtis similarities between lotic Trichoptera faunas of 26 European countries (see Table 1 for explanation of the abbreviations) using presence/absence data. The stress value is <0.1 indicating a good 2-dimensional ordination with no real prospect of a misleading interpretation.

was positively correlated with the richness of lotic species (r_s=0.75, P<0.0001), increased from north to south (r_s=-0.70, P<0.001). Endemic species richness, however, was not correlated with the richness of lentic species (r_s=-0.32, P>0.10).

In addition, there was a highly significant positive correlation between the area with altitudes above 1000 m a.s.l. and the number of lotic species and the number of endemic species, respectively (lotic species: r_s=0.70, P<0.001; endemic species: r_s=0.80, P<0.0001), see Fig. 5. A similar relationship was, however, not found for lentic species (r_s=-0.14, P=0.51).

Among the 24 countries considered the area with altitudes above 1000 m a.s.l. was negatively correlated with latitude (r_s=-0.52, P<0.05), whereas lake area was not at all correlated with latitude (r_s=0.34, P>0.05).

Multidimensional Scaling (MDS) of the similarities between the lotic fauna of all the 26 different European countries considered in this study showed an overall pattern relative closely reflecting the geographical position of the respective countries (Fig. 6). However, the faunas of Norway, Sweden, Finland, and Estonia were rather much alike, as was the faunas of Denmark and Latvia. Also the faunas of Luxembourg and Belgium were almost similar, as were those of The Czech Republic, Slovakia and Poland. There were much greater differences between the lotic faunas of the more southerly and easterly located countries. Thus, there were great differences between the faunas of the Iberian Peninsula, France, Italy, Bulgaria, and Greece, respectively. Finally, the lotic fauna of Ireland are rather different from that of the United Kingdom and closest countries on the continent.

Discussion

The number of Trichoptera species was not correlated with the size of the countries that were included in the analyses, neither for lotic nor for lentic species, although there was some indication of the general species-area relationship found repeatedly among different groups of plants and animals, and at different scales (e.g. Rosenzweig 1995, Sand-Jensen 2000). Thus, the estimated z-values were almost within the range of 0.1-0.3 that has been reported for areas on the same continent and within the same geographical province (Rosenzweig 1995). One obvious reason why Trichoptera species richness may not depend on the simple geographic area is that these aquatic organisms by nature are expected rather to relate to the size of freshwater habitats within a given geographical area. Actually, a significant relationship between richness of lentic species and total lake area was documented by the present study.

No attempts were made to test a similar relationship with watercourse area due to difficulties in obtaining suitable estimates of these. Nevertheless, species richness of lotic Trichoptera on a large scale is apparently related to other geographical variables than watercourse area. Thus, species richness generally increased going from the north to the south. The dependence of species richness on latitude may not be a surprise, as this pattern is repeatedly found among groups of both animals and plants in both the terrestrial and aquatic environment (e.g. Rosenzweig 1995). In a global perspective and going from the polar areas to the tropics, there are several explanations related to area, time and energetics (Rosenzweig 1995). Although it is easy to see differences between the tropics and the arctic/temperate zones, it is more difficult to explain mechanisms behind the north-south gradient of lotic Trichoptera species richness in Europe that only extend through the arctic, boreal and temperate zone. Moreover, species richness of lentic Trichoptera does not increase – but decrease - along the north-south gradient.

One possible explanation regarding the lotic Trichoptera relates to temperature. On a global scale, Jacobsen, Schultz & Encalada (1997) found a positive linear relationship between invertebrate family richness (including families of Trichoptera) and maximum stream temperature in streams. This implies that taxon richness should decrease with latitude as well as with altitude. The effect of temperature may be direct on speciation, as high temperature leads to higher mutation rates and shorter generation times, speeding up evolution and speciation (Rohde 1992). This might be supported by the fact that the richness of endemic European Trichoptera species, being primarily lotic, decrease with latitude. However, the richness of these endemic species as well as the richness of lotic species is highly correlated with the area of 'high mountains' (in case defined as altitudes above 1000 m a.s.l.) and therefore may not depend on "high" temperatures, even though several species may be confined to valleys rather than to habitats at higher altitudes. Moreover, the lotic faunas of mountain-rich countries in central and southern Europe are very different, especially in the most southern part. This indicate an explanation related to the long periods without glaciations that this part of Europe has experienced compared to northern Europe, to the possibility of a more pronounced local isolation in mountainous areas that also supports a large variety of stream habitats, and to the relative isolation of the Iberian, Italian, and Greek peninsula. Malicky (1983, 1988, 2000) defined a zoogeographic biome type for lotic Trichoptera, the "DINODAL" (i.e. "aqua turbulenta") and suggested that species richness of these was highest in mountains of Central Europe and Balkan. Malicky (1988, 2000) further argued that the majority of DINODAL Trichoptera has relatively small distributional areas and that these presentday areas relate to refugia where montane species survived unfavourable glaciation periods (e.g. in peripheral highlands). This hypothesis has recently received solid support by Pauls (2004) who studied the genetic structure of European populations of *Drusus discolor* (Rambur 1842). Thus, the differentiation between presentday populations of *D. discolor* may have been a result of retreat into multiple independent Pleistocene refugia and lineage divergence during periods of isolation. Further, Pauls (2004) suggests that these processes are analogous to those that have led to high species diversity and large number of local endemics, thereby supporting the idea that retreat into glacial refugia can promote speciation. However, the study by Pauls (2004) also points at a more recent speciation among lotic European Trichoptera.

My study indeed indicates that distributional areas of lotic Trichoptera are in general relatively small as 65 % of these species were found in just 1-3 countries/regions, whereas this is only the case for 25 % of the lentic species of which more than half are widely distributed (i.e. found in more than 15 countries/regions). Moreover according to the present study, 42 % of the continental Iberian fauna, 28 % of the continental Greek fauna, and 19 % of the continental Italian fauna may be regarded as endemics. Actually the degree of endemism is even higher if the numerous subspecies that occur in e.g. the Iberian Peninsula and especially Italy are taken into consideration (see Cianficconi, Moretti & Tucciarelli 1997). This would also have resulted in even greater differences between the faunas in Fig. 6, primarily in the southern part of Europe.

Botosaneanu (1975) convincingly described the isolation influence of mountains on endemism. Thus, at least 42 species or subspecies are endemic to the Carpathian range, representing about 15 % of the whole Carpathian Trichoptera fauna. The considerable length of the Carpathian range, its subdivision by transverse valleys and intramontane depressions, and its function as a biogeographical crossway may have promoted this high degree of endemism. This is supported by studies of a Rocky Mountain stonefly, showing that steep mountain walls may act as effective barriers of dispersal increasing the genetic differentiation in adjacent but yet isolated populations (Hughes, Mather, Sheldon & Allendrof 1999). In addition, it is demonstrated that organisms with limited dispersal capacity are relatively rich in endemics (e.g. Sand-Jensen 2000). Endemic species are especially abundant among the families Beraeidae, Glossosomatidae, Hydroptilidae, Philopotamidae, Psychomyiidae, Rhyacophilidae, and the subfamily Drusinae (Limnephilidae), all being obligate or predominantly confined to different types of running waters. There are indications that members of at least some of these groups may have a rather limited dispersal capacity (e.g. Sode & Wiberg-Larsen 1993; Collier & Smith 1998; Pauls 2004) compared with lentic species of e.g. Phryganeidae and certain limnephilid genera (e.g. Svensson 1972, 1974; Wiberg-Larsen & Karsholt 1999). Limited dispersal capacities combined with a large area without mountains may also explain why many lotic Trichoptera inhabiting the Central European Mountains have been unable to colonize suitable habitats in the Scandinavian mountains following the latest deglaciation.

The difference in distributional patterns between lotic and lentic Trichoptera may to some extent be explained by a generally higher tolerance towards wide temperature amplitudes among species occupying lakes and ponds. Thus, the temperature range of ponds and lakes may be considerable compared with that of groundwater fed streams and mountainous streams. In addition, opportunistic and very mobile species that may have coped well with the glacial periods are more abundant in lentic than in lotic environments (Sand-Jensen 2000). Generally, this may imply a relatively wider geographic distribution among lentic species than among lotic species and therefore a greater similarity over larger geographical areas. Thus, the high richness of lentic species in northern Europe could be explained by migration from Pleistocene refuges somewhere in the East through the plains of Russia (Malicky, in litt.). And some of these species may not have arrived to southern Europe yet. However, a straight forward explanation is related to the presentday high abundance and area of lakes and ponds in northern Europe (due to the glaciations that created many lakes, see Sand-Jensen 2000) as shown by my analyses, to the high diversity of the lakes and ponds in northern Europe, and to the predominance of lentic limnephilid and phryganeid species that exploit these habitats. Thus, these two families constitute up to 60 % of the total lentic Trichoptera fauna, and many of their representatives occur only in specific lentic habitats. The hypothesis may be partly supported by a study of high altitude North-American wetlands that may be comparable to the north European wetlands, showing that the distribution of limnephilid and phryganeid species depends on a prevailing large permanence gradient and, thus, on many different habitats (Wissinger, Brown & Jannot 2003).

The fauna of the UK and The Netherlands are rather similar. This may not be a surprise as England was connected with the European Continent until about 7000 – 8000 calender years BP. Palaeolimnological studies of sediments in the River Trent floodplain have shown that this river had almost the same Trichoptera fauna approx. 13 000 cal. years BP as it has nowadays (Greenwood, Agnew & Wood (2003). Moreover, *Micrasema setiferum* (McLachlan 1876) and *Brachycentrus maculatum* (Fourcroy 1785), that do not occur on the British Isles nowadays but are widely distributed on the continent, were found as subfossils in the River Trent floodplain sediments (Greenwood, Agnew & Wood 2003; Greenwood, Wood & Monk, in press). This implies that colonisation by lowland species from the south must have been relatively fast following the latest deglaciation; see also Wiberg-Larsen, Bennike, Jensen & Lemke (2001) who found an almost presentday Trichoptera assemblage in 10,300 cal. years old river sediments in the Great Belt (Denmark). Ireland was linked to England until about 12 000 – 8000 cal. years ago and, thus, it was before that time also a part of the continent. However, being separated from the continent for a longer time than England, Ireland generally has a somewhat poorer flora and fauna – including Trichoptera - than England.

The use of Illies's 'ecoregions' instead of country borders would have been the natural template analysing the overall distributional pattern of European Trichoptera in the present study. However, an up to date revision of the checklist by Botosaneanu & Malicky (1978) was not available. Nevertheless, the use of country checklists may in some parts of Europe be preferable compared with ecoregional lists. Thus, the similarity analysis showed remarkably large differences between the faunas of Denmark and the Netherlands that both belong to ecoregion 14. This is also the case for the fauna of the rest of this ecoregion that includes the northern lowland of Germany and Poland (analyses not shown here).

The present study has clearly focussed on the distribution of European Trichoptera on an absolutely large scale, and the conclusions drawn must therefore be preliminary. However, the analyses used in the study have certainly shown their potential and may be applied to dataset describing the distribution of caddisflies in much more detail, e.g. the very diverse and regionally varied Italian Fauna (see Cianfficoni, Moretti & Tucciarelli 1997). Such analyses using data from 80 provinces in Fennoscandia and Denmark may show interesting results (Gullefors, Salokannel & Wiberg-Larsen, in prep.).

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