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Trichoptera in assessment and classification of streams in the lowlands of north-eastern Germany

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Abstract

1. This paper presents the various communities of Trichoptera of five stream types in the lowlands of north-eastern Germany and their role as bioindicators for the assessment of river quality. By using caddisflies in a bioindicative working procedure, called Standorttypieindex, it could be shown, that the integrative ecological classification of watercourses is possible in this way. This assessment system works in all stream types of the north-eastern-lowlands, also in the streams, which are otherwise difficult to assess, like the slow-running and natural back-dammed streams. The aim of the assessment is to determine the degree of man-made-stress, which influences relatively homogeneous river sites.
2. The Standorttypieindex uses the total amount of bioindicative species-groups of a habitat for the assessment. The index represents mainly the ratio of the differently adapted species-groups due to the total amount of evident species. Its values are dependent on the degrees of man-mades-stress in the different river sites and the river-types.
3. The type-specific calibration of the assessment method was done, by using unstressed and stressed river sites. Five ecological quality classes (see European Water Framework Directive 2000) were defined for each of the types. The classification scale of five different river types should be demonstrated in this paper.
4. About 80 species of Trichoptera were recorded during the investigation, among them about a third of endangered and rare species.

Key words: Trichoptera, stream assessment, new method, lowlands of north-eastern Germany

Introduction

The lowlands of north-east-Germany are geological relatively young and therefore mostly morphological different. The landscape was predominately formed by the postglacial processes of the Weichselian Ice Age. A result of the landscape formation is a wide variety of different stream types, which are often heavily disturbed by human activities. Therefore it is necessary to evaluate the extent of environmental impacts and the degree of man-made-stress. The EU Water Framework Directive (2000) demands a scientific basis for the development of integrated water management approaches and criteria for bioindicative assessments (for example composition and abundance of aquatic flora and benthic invertebrate fauna). An increasing number of countries use benthic macroinvertebrates in surveillance and monitoring programmes to produce biological classifications of streams that evaluate different kind of man-made stress (e.g. NEWMAN 1988, AFNOR 1992, ARMITAGE & PETTS 1992, METCALFE-SMITH 1994, WRIGHT et al. 1989, 1993, 1997, VERDONSCHOT 2000). The taxa of benthic macroinvertebrate found during a survey is normally used to calculate a biological index or score which is related to a particular stress (ROSENBERG & RESH 1993, METCALFE 1989). A classification can be realized by comparison between a reference community, which represents unstressed conditions, and the observed community (GQA 1997, ISO/FDIS 8689-1 1999, ISO/FDIS 8689-2 1999). This type of classification takes into account the natural variability of biological communities. Many countries developed their own assessment method of rivers so up to now there is no single classification or index scheme that covers all geographical regions. In Germany two main methods for assessing running water exist: 1) saprobic index and 2) classification using physico-chemical parameters. The saprobien system (DIN 38410, part 2) uses invertebrates as bioindicators for saprobic pollution. This method has been introduced in Germany to standardise the evaluation of water pollution (FRIEDRICH 1990, 1998). It is possible to determine cumulative and very complex effects, but there are two difficulties when applying the method to slow-running waters (BÖRNER et al. 1994):

- the naturally high autosaprobic production of the streams overlaps with the allo-saprobic phenomena, which should be detected. Therefore, the differences in the classification values are not a true reflection of the degradation.

- the procedure only allows the assessment of the watercourse and valuation of only one man-made-stress component.

There are also many problems in applying the classification using physico-chemical parameters, especially the limiting values of the parameters depending on the different river types. Using this method, it is only possible to classify the actual state of the watercourse. The procedure frequently yields very similar classification results for partly very different hemerobic sites because of the one-sided evaluation of the physico-chemical characteristics of the rivers. A new bioindicative method, called Standorttypieindex (THIELE et al. 1994, BERLIN 1995, THIELE et al. 1996, THIELE 1999), was developed over a period of five years, based on the knowledge and the difficulties of the former assessment systems. This method is applicable on the watercourse and on the river banks as well as on the floodplains. Bioindicators are the aquatic macrophytes, the Trichoptera and the Lepidoptera. Therefore a very complex indication is possible, so that the demands of the European Water Framework Directive (2000) (esp. Appendix V) are considered. The Standorttypieindex uses the total number of bioindicative species in a river/floodplain area for assessment. It represents the ratio between stenotopic and eurytopic species that is dependent on river types and expresses this value in an index. Differences in the index in more or less degraded areas are indications of man-made-stress on these sites. This paper presents the developing state of the assessment method Standorttypieindex due to the evaluation of different stream types using Trichoptera. As a by-product of this work, the composition of Trichoptera communities of various types of running water was investigated and described.

Investigation areas and sampling

The investigations were undertaken on several unstressed and stressed rivers sites in the federal state of Mecklenburg-Western Pomerania. In the end of the year 2000 more than 140 river sites were analysed. The sites covers the most of the important river types, which were described for the young glacial landscape of north-eastern Germany by MEHL & THIELE (1998). Samples were taken in representative river sites using standard methods. Larvae of Trichoptera were collected by nets and surber samplers. The adults were trapped with automatically working light traps. This method was recommended by BOURNAUD et al. 1983, FONTAINE (1982) and CRICHTON (1960, 1976) because widespread rivers are often poor to investigate. The combination of different collecting methods is a good opportunity to improve the holistic assessment of river sites. The analyses were carried out from March to October and repeated for several years.

Methods for determining caddis flies were described by: EDINGTON & HILDREW (1981), MALICKY (1983), SCHMEDTJE & KOHMANN (1992), TOBIAS & TOBIAS (1981), WALLACE et al. (1990) and WARINGER & GRAF (1997). The nomenclature follows ILLIES (1978).

Principle

One part of the new developed assessment system "Standorttypieindex" uses the merolimnic group of Trichoptera as bioindicators, because caddis flies are very sensitive for different disturbances in stream and riparian ecosystems. The basis of the Standorttypieindex Trichoptera (STI-T) is the type-specific spectra of caddis flies existing under natural conditions and is, therefore, a qualitative working system. The species are divided into ecological categories, which express the species-specific degree of adaptation on river sites (Fig. 1). Reference data are obtained in similar unstressed sites. To evaluate man-made-stress, the data from the observed site were compared with a set of reference data. The index shows evident differences in various levels of stress. Due to the different stream types there are several classification schemes.

- Category 1: (ec=1.0) Species living in many types of river sites (eurytopic species)
- Category 2: (ec=2.0) Species living in lakes and slow running waters
- Category 3: (ec=3.0) Species having a slightly preference for running waters
- Category 4: (ec=4.0) Species having a specific preference for running waters

Fig. 1: Definition of ecological categories.

Calculation

The Standorttypieindex is calculated using the formulae in Fig. 2. By analysing the natural sites of a type the 100% value could be defined on a classification scale. It is postulated that a stable biocoenosis exists under such natural conditions. When defined different stressed sites are investigated, it is possible to find the values of the other ecological quality classes.

$$STI_T = \frac{\sum_{i=1}^{n} ec_i}{n}$$

STI_T = Standorttypieindex Trichoptera
ec = ecological categories
n = number of taxa
i = i-taxon

Fig. 2: Formula for calculating the STI in watercourse using Trichoptera as bioindicators.

Type specific spectra of Trichoptera and calibration of the method

Table 2 shows examples of type specific Trichoptera spectra and the value of the Standorttypieindex for five different type specific reference sites. These are:

- streams in beech forests (bf),
- streams in v-shaped valleys (vs),
- streams in sandy soil (sa),
- streams with broad peat floodplains and organic river beds (bp)
- streams with small peat floodplains and organic river beds (sp).

About 80 species of Trichoptera were recorded during the investigations. Among them is about a third of endangered and rare species. For *Setodes punctatus* and *Brachycentropus subnubilus* the v-shaped valleys of the Nebel (vs) are until now the only known localities in Mecklenburg-Western Pomerania. *Limnephilus tauricus* is recorded in Germany for the first time. Therefore, especially undisturbed river sites are very important for the occurrence of species with specific adaptations.The spectra of the caddis species varied widely for the different river reference types (Tab. 1). Therefore the values of the type-specific indices ranged from 4,8 (stream with broad peat floodplains and organic river bed) to 13,3 (stream in beech forests). In streams with organic substrate the indices (reference data) were relatively low, compared with the Standorttypieindices of watercourses with mineralic beds. The cause for this phenomenon is that the most of Trichoptera, living in such streams, are predominantly lentic species and prefer slow-running waters. They are classified in the ecological categories 2 and 3.

Classification

By comparing the degrees of disturbance in defined river sites and the Standorttypieindex values for more than three years, it was possible to create a classification system with five quality classes. In contrast to the saprobien system, which uses seven classes, this method follows the recommendations of the European Commission. The definitions of the classes of water quality correspond with the Harmonised Monitoring and Classification of Ecological Quality of Surface Waters in the European Union. They are presented below (Tab. 2).

Tab. 3 represents the range of quality classes for the different river types. Special attention must be paid to the assessment of streams with peat floodplains: there is a difference between mineral (sand, clay, silt etc.) and organic (peat) river beds in the structure of underwater habitats and biocoenoses. Therefore two classification scales are needed for one river type.

An example of use can be presented for 19 sites for streams in sandy soils in Mecklenburg-Western Pomerania (Fig. 3). The results of the assessment indicate that there is a strong relationship between the visual degree of man-made-stress and the value of Standorttypieindex. Five quality classes could be calibrated for watercourses in dependence on river sites representing different degrees of stress.

Tab 1. Spectra of type specific species of caddis flies and the value of index for reference sites (abbr.: EC – Ecological Class, bf - stream in beech forests, Reppeliner Bach; vs - stream in v-shaped valleys, Nebel near Koppelow; sa - stream in sandy soil, Gehlsbach; bp - stream with broad peat floodplains and organic river bed, Warnow near Hohen Schwarfs; sp - stream with small peat floodplains and organic river bed, Nebel near Dobbin).

Species	**ec**	**bf**	**vs**	**sa**	**bp**	**sp**
Agapetus ochripes CURTIS, 1834	4		x	x		
Agraylea multipunctata CURTIS, 1834	2				x	
Agraylea sexmaculata CURTIS, 1834	2				x	x
Agrypnia pagetana (CURTIS, 1835)	2				x	
Anabolia nervosa (CURTIS, 1834)	2	x		x	x	x
Athripsodes albifrons (LINNAEUS, 1758)	4		x			
Athripsodes cinereus (CURTIS, 1834)	2		x	x		x
Beraeodes minutus (LINNAEUS, 1761)	2					x
Brachycentrus subnubilus CURTIS, 1834	4		x			
Ceraclea alboguttata (HAGEN, 1860)	3		x			
Ceraclea dissimilis (STEPHENS, 1836)	3		x			
Ceraclea nigronervosa (RETZIUS, 1783)	3		x			
Ceraclea senilis (BURMEISTER, 1839)	2				x	
Chaetopteryx villosa (FABRICIUS, 1798)	4		x	x		
Cheumatopsysche lepida (PICTET, 1834)	4		x			
Cyrnus crenaticornis (KOLENATI, 1859)	2				x	
Cyrnus flavidus McLACHLAN, 1864	2				x	
Ecnomus tenellus (RAMBUR, 1842)	2				x	
Glyphotaelius pellucidus (RETZIUS, 1783)	2	x		x	x	x
Grammotaulius nigropunctatus (RETZIUS, 1783)	1				x	
Halesus digitatus (SCHRANK, 1781)	3			x	x	
Halesus radiatus (CURTIS, 1834)	3	x	x	x	x	x
Halesus tesselatus (RAMBUR, 1842)	1			x		
Hydropsyche pellucidula (CURTIS, 1834)	3	x	x	x		
Hydropsyche saxonica McLACHLAN, 1884	4	x	x			
Hydropsyche siltalai DÖHLER, 1963	4	x	x			
Hydroptila sparsa CURTIS, 1834	2		x			
Ironoquia dubia (STEPHENS, 1837)	3				x	
Ithytrichia lamellaris EATON, 1873	3		x			
Lepidostoma hirtum (FABRICIUS, 1775)	3		x			
Leptocereus tineiformis CURTIS, 1834	2				x	
Limnephilus affinis CURTIS, 1834	1				x	
Limnephilus auricula CURTIS, 1834	2				x	x
Limnephilus decipiens (KOLENATI, 1848)	3				x	
Limnephilus extricatus McLACHLAN, 1865	1			x		x
Limnephilus flavicornis (FABRICIUS, 1787)	1				x	x
Limnephilus griseus (LINNAEUS, 1758)	1					x
Limnephilus hirsutus (PICTET, 1834)	3					x
Limnephilus ignavus McLACHLAN, 1865	3				x	x

Tab. 1. (cont.)

Limnephilus lunatus CURTIS, 1834	1					x
Limnephilus marmoratus CURTIS, 1834	2					x
Limnephilus nigriceps (ZETTERSTEDT, 1840)	2				x	
Limnephilus politus McLACHLAN, 1865	2				x	
Limnephilus rhombicus (LINNAEUS, 1758)	2				x	
Limnephilus sparsus CURTIS, 1834	1				x	x
Limnephilus stigma CURTIS, 1834	1				x	x
Limnephilus tauricus SCHMID, 1964	3					x
Limnephilus vittatus (FABRICIUS, 1798)	2					x
Lype phaeopa (STEPHENS, 1836)	3					x
Lype reducta (HAGEN, 1868)	4	x	x	x		
Micropterna lateralis (STEPHENS, 1837)	4	x				
Micropterna sequax McLACHLAN, 1875	4					x
Molanna angustata CURTIS, 1834	2				x	x
Mystacides azurea (LINNAEUS, 1761)	2				x	
Mystacides longicornis (LINNAEUS, 1758)	2				x	x
Odontocerum albicorne (SCOPOLI, 1763)	4	x				
Oecetis furva (RAMBUR, 1842)	2				x	
Oecetis lacustris (PICTET, 1834)	2			x		
Oecetis ochracea (CURTIS, 1825)	1					x
Orthotrichia angustella McLACHLAN, 1865	3				x	
Orthotrichia costalis (CURTIS, 1834)	2				x	
Oxyethira flavicornis (PICTET, 1834)	3			x	x	x
Phacopteryx brevipennis (CURTIS, 1834)	2		x			x
Phryganea bipunctata RETZIUS, 1783	2					x
Phryganea grandis LINNAEUS, 1758	2				x	x
Plectrocnemia conspersa (CURTIS, 1834)	4	x	x	x		x
Polycentropus flavomaculatus (PICTET, 1834)	1		x	x		
Polycentropus irroratus (CURTIS, 1835)	3		x	x		
Potamophylax latipennis (CURTIS, 1834)	4	x	x	x		
Potamophylax nigricornis (PICTET, 1834)	4	x				
Potamophylax rotundipennis (BRAUER, 1857)	3			x		
Rhyacophila fasciata HAGEN, 1859	4	x	x			
Rhyacophila nubila (ZETTERSTEDT, 1840)	3		x			
Sericostoma personatum (KIRBY & SPENCE, 1826)	4	x	x	x		
Setodes punctatus (FABRICIUS, 1793)	4		x			
Silo nigricornis (PICTET, 1834)	4		x	x		
Silo pallipes (FABRICIUS, 1781)	4		x	x		
Stenophylax permistus McLACHLAN, 1895	4				x	
Tinodes waeneri (LINNAEUS, 1758)	1				x	

Tab. 1. (cont.)

Trichostegia minor (CURTIS, 1834)	2				x	
Wormaldia subnigra (McLACHLAN, 1865)	4		x			
Value of Standorttypieindex Trichoptera (Reference data):		13,3	12,1	9,6	4,8	5,2

Tab. 2. Generalised definitions of ecological quality for use as a harmonised classification.

Quality class 1 (high ecological quality)	Little or no evidence of anthropogenic impacts on biological communities and their habitats. The nature (composition and diversity) and status (productivity) of the biota reflect that they are normally associated with undisturbed habitats.
Quality class 2 (good ecological quality)	Detectable but low-level impacts on biological communities and their habitats. The biota shows signs of disturbance but are fully self-sustaining and deviate only slightly from that normally associated with the habitat under undisturbed conditions.
Quality class 3 (fair ecological quality)	Significant impacts on biological communities and their habitats. The biota exhibits moderate deviations from that normally associated with the habitat under undisturbed conditions.
Quality class 4 (poor ecological quality)	Severe impacts on biological communities and their habitats. The biota exhibits large deviations from those normally associated with the habitat under undisturbed conditions.
Quality class 5 (bad ecological quality)	Only a few stress-tolerant species present or completely dead.

Tab. 3. Classification scales for five river types.

River types	**EQC 1**	**EQC 2**	**EQC 3**	**EQC 4**	**EQC 5**
Streams in beech forests	≥13,0	≥11,0<13,0	≥9,0<11,0	≥7,0<9,0	<7,0
Streams in v-shaped valleys	≥12,0	≥10,0<12,0	≥8,0<10,0	≥6,0<8,0	<6,0
Streams in sandy soils	≥9,0	≥7,0<9,0	≥5,0<7,0	≥3,0<5,0	<3,0
Streams with broad peat floodplains and organic river bed	≥4,5	≥3,5<4,5	≥2,5<3,5	<2,5	n.d.
Streams with small peat floodplains and organic river bed	≥4,5	≥3,5<4,5	≥2,5<3,5	<2,5	n.d.

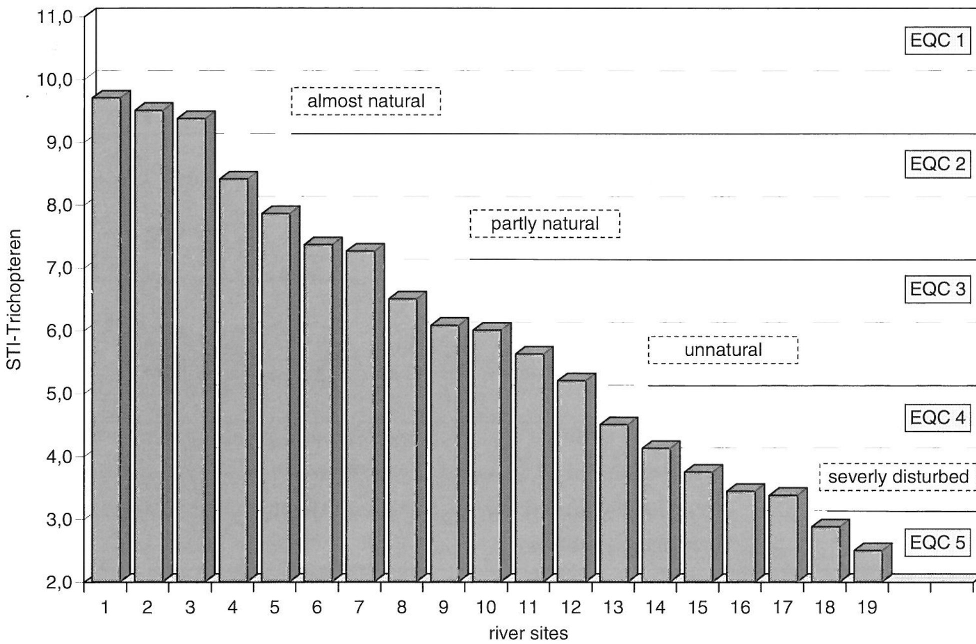

Fig. 3. Example for the calibration method in streams with sandy soils via Standorttypieindex STI-T.

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