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Chironomids as Bioindicators in Acidified Streams: a Contribution to the Acidity Tolerance of Chironomid Species with a Classification in Sensitivity Classes

key words: autecology, macroinvertebrates, indicator-organisms, pH

Abstract

In 12 forest brooks differing in acidity (pH-values from 2.79 to 6.89) chironomids were sampled to establish their acid-tolerance based on their occurrence in a certain pH range. Some taxa were found only at pH values higher than pH 6.0, others not below pH 5.5. A relatively high number of species could tolerate periodical pH values below 4. Only a few species were limited to high pH. Using these results, 25 species were classified according to their acid-sensitivity. The suitability of these species for the assessment of the acidity-state of running waters was tested. The study demonstrates that chironomids are qualified bioindicators for assessment of the acidity-state within technical water quality monitoring. It is recommended that the classified chironomid species be added to the list of macroinvertebrate acidity indicators.

1. Introduction

Macroinvertebrates which have a specific sensitivity to acidity have recently been used as bioindicators in the technical monitoring of acidity-assessment of running waters. However, the sensitivities of macroinvertebrates listed by SCHNELBÖGL (1996) and BRAUKMANN (1992) exclude chironomids. Nevertheless, the family Chironomidae is one of the most species-rich aquatic macroinvertebrate groups and these organisms are typically found in large numbers in flowing waters. Although the species are strongly ecologically differentiated (PINDER, 1986) and the running water communities are well known in Central Europe, their usefullness as acidity indicators in streams has not been implicated except for a single study by ROMMELMANN and HEITKAMP (1989). The affinity of other flowing water species to pH (e.g. fish, *Gammarus fossarum, Gammarus pulex, Asellus aquaticus*) is relatively well studied (ALENÄS, 1995; HARGEBY, 1990; HEITKAMP and LESSMANN, 1990; WEATHERLY *et al.*, 1989; HERRMANN *et al.*, 1993; WASSMANN, 1987; FOECKLER, 1992). Chironomids, however, have been neglected or at best treated on family level. This situation is explained on the one hand by the fact that little is known about the specific acidity tolerance, and, on the other hand, chironomids have not been determinated to species level (e.g. SIMPSON, 1983; GRIFFITHS, 1992).

It is well known that chironomid communities react to changes in the acidity of a water body through shifts in their species composition. Some knowledge has been gained in standing waters impacted by acidity (BRODIN and GRANSBERG, 1993; LEUVEN *et al.*, 1987; RADDUM and SÆTHER, 1981; EMEIS-SCHWARZ, 1985). However, in those habitats, species composition is very different from that of running waters and therefore not comparable. In the studies mentioned above, chironomids were often determined to species group-, genus-, or even family- or tribes-level. Regarding the species level some information on acidity-tole-

Table 1. pH values, conductivity and temperature of the brooks studied (* data from ORENDT, 1998).

	pH			conductivity (μS/cm)			temperature	
	median	min-max	N	median	min-max	N	min-max	N
brook								
Mark Schmelz	6.97	5.69–6.35	4	174	168–179	3	9.9–11.2	5
Breitewitzer Bach	6.58	6.24–6.77	3	.	226–260	2	9.8–11.0	4
Ochsenkopf 1*	6.44	5.51–6.67	41	270	160–293	41	3.5–15.4	41
Parnitz*	6.44	5.95–6.89	41	478	369–534	41	1.9–18.7	41
Ochsenkopf 2	5.76	5.64–6.52	3	268	267–268	3	9.7–14.2	4
Lutherstein	5.46	5.45–5.87	5	81	54–87	5	10.3–12.2	5
Heidemühle*	5.35	3.87–6.41	41	273	145–346	41	3.2–19.2	41
Ausreisser*	4.94	3.80–6.89	41	431	206–477	41	6.3–18.7	41
Taura*	3.83	3.25–4.20	41	389	276–458	41	0.2–16.2	41
Lausa*	3.71	3.36–5.58	39	500	172–695	40	0.2–17.8	38
Deubitzwiesen	3.65	3.44–4.18	5	303	299–310	3	6.1–16.1	5
Grenzbach	3.27	2.79–4.62	5	400	378–403	3	7.1–13.8	5

rance is given only by ROMMELMANN and HEITKAMP (1989). This situation demands knowledge on the acid sensitivity of chironomids at the species level. Usually, it is not possible to determine whether a species or a community only reacts essentially to acid itself or to the processes combined to a certain acidity level (e.g. high aluminium concentration in the water). Nevertheless, TOWNSEND *et al.* (1983) found that acidity is the dominant factor determining the composition of a stream community. The pH value can be regarded as its indicator. The role of other factors is adressed in the discussion.

This study is a contribution to the autecology of chironomids. The aims are (1) to publish the pH amplitudes in which the chironomid species of the study area collected were found, (2) to classifiy the species according to their occurrence within a pH range and (3) to demonstrate how the species can serve as indicators for the assessment of the acidity-state of a brook. For the last, only taxa on the species level were included, as this is considered as essential for an ecological characterization.

2. Study Area

The brooks in which the chironomids were collected, are located in the "Dübener and Dahlener Heide Heathland". This area is situated between the southern part of the Torgau-Magdeburg Elbe Valley and the Vereinigte Mulde River, about 30 km east and northeast of Leipzig. It is characterized by moraines covered by loess and sand with soils of mainly nutrient-poor and dry sands, wherein scattered wet areas with moors are found. The present forest vegetation is dominated by *Pinus sylvestris*.

The region has been heavily affected by industrial emissions for more than 100 years (NEUMEISTER *et al.*, 1991). In the northwestern part of the region, mainly sulphuric acid and high amounts of limy fly ashes have been deposited. The latter has caused the alkalinization of the formerly acidic streams. In the southeastern part, only sulphuric acid has been deposited and has led to an increase in acidification. The depositions have affected the soil, vegetation and water bodies. NEUMEISTER *et al.* (1991) give an extensive overview of these impacts. Moreover, the region is characterized by a rich pedological and geological mosaic, which, in addition to the depositions of acid and limy ashes, was responsible for different acidification levels of a number of waters, even within small areas (ORENDT and REINHART, 1997). The distribution of the communities in these streams is described in ORENDT (1998) and REINHART and ORENDT (1997). Table 1 shows the pH, specific conductivity and of other important parameters of the waters from which the chironomids were collected. The average hardness of these brooks is from 5.6 to 12.2 mg CaO/l. REINHART and ORENDT (1997) give an extensive overview of the chemical and physicochemical parameters of some acidic and non-acidic spring streams (among others pH, Ca, ANC, Al, sulfate). From the latter, the data are integrated in this study in part.

3. Methods

In the presented study, data were used both from surface drift capture as well as from kick sampling of benthos. The samples and measurements at the springs and spring brooks Lutherstein, Ochsenkopf 2, Mark Schmelz, Breitewitzer Bach, Grenzbach and Deubitzwiesen were taken and performed, respectively, on 14 April, 6 May, 4 July, 30 August and 5 November 1996. At the latter two sites, the separation of spring and spring brook was not possible, so samples were taken only in the ditches which are described here as "brooks". The abiotic parameters were measured in the field on the chironomid sampling days and with electronic instruments: conductivity with Lf96B, temperature and oxygen (saturation and mg/l) with Oxi 320, pH with pH95 of WTW Ltd. From the values of conductivity and pH the medians were calculated.

For sampling the surface chironomid fauna, a hand net ("Thienemann-Kescher") was used (mesh size 250 μm). The net was pulled for ten minutes along a stretch of about 30 m through the water surface (upstream) in order to obtain surface drift, mainly pupal exuviae, some adults and larvae. In the spring itself, the net was pulled with great care through all compartments of the aquatic area in order not to destroy the habitat. The chironomids were sorted in the field from other material caught in the net and preserved in 70% isopropanole. After preparation in Euparal, the taxa were mainly determinated according to the works of LANGTON (1991) and WIEDERHOLM (1983, 1986, 1989) and special papers on chironomid taxonomy. Abundance was estimated in 7 classes (1 = 1 specimen per sample; 2 = 2–4; 3 = 5–15; 4 = 16–32; 5 = 33- 74; 6 = 75–150; 7 = >150). This estimation earlier proved to be suitable for both surface sampling and kick sampling (ORENDT, 1998).

Data from other spring brooks of the region (Ochsenkopf 1, Parnitz, Heidemühle, Ausreisser, Taura, Lausa) were included in the evaluation (data from ORENDT, 1998). There, chironomid larvae, pupal exuviae and adults were sampled by kick sampling (500 μm mesh size of the net), picking up the organisms from solid substrata (coarse detritus, stones, macrophytes) and catching the surface drift with a hand net (mesh size 250 μm). The abundances were estimated in the same way (7 classes) as specified in the preceeding paragraph (see ORENDT, 1998).

From the data, a list was made up displaying the pH range in which the taxa had been found in order to elucidate the pH-tolerance of each taxon. Then, the occurrence of the taxa were correlated with the pH values and conductivtiy values (Kendall's Tau, $p < 0.05$) in order to determine whether the taxa have a preferred pH- or conductivity range. For the same reason and in order to find similar spring brooks based on the chironomid communities, a principal component analysis (PCA) was performed. This analysis excludes the findings of a singular specimen record for clearer results.

Finally, the taxa were classified according to the occurrence of the species within the pH ranges. Taxa were only considered, if they could be identified at species level or species group level. As indicators, the latter are not as valuable as defined species, but hold possibly important information for further studies. The classification method follows BRAUKMANN (1992). It is based on the occurrences of the species considered in four types of streams:

(I) Non-acidic streams: pH generally >6.5, minimum never <6 in the course of the year.

(II) episodically slightly acidic: pH similar type (I), but with rare depressions which do not lie <5.5 in the course of the year.

(III) periodically acidic: pH normally <6.5, but generally not <4.3 in the course of the year; at low discharge (basic discharge) the values may lie in a circumneutral range.

(IV) permanently acidic: pH <5.5 during all the year, minima often <5, sometimes <4.3 and lower in the course of the year.

If a taxon occurred only in type I (non-acidic streams), it was classified as "extremely sensitive to acidity". If another occurred in type II and I, it was classified as "moderately sensitive to acidity or moderately tolerant to acidity". Taxa found only in type III and lower were described as "tolerant to acidity". Those occurring in type IV were classed as "extremely tolerant to acidity".

The determination of the acidity class of the waters follows RADDUM *et al.* (1988) based on the occurrence of indicator species. According to these authors, a certain acidity class was ascribed when only one specimen from the corresponding sensitivity class was found in the sample (presence/absence data). In this study, acidity assessment was based not only on the presence, but also on the abundances of species recorded. In order to determine the acidity class, abundance 3 as a threshold-value was used, which means that the sum of the abundances of all taxa of a certain sensitivity class must result in at least 3, in order to reach the according acidity class. A more detailed description of the evaluation procedure is given in ORENDT (1998) and SCHNELBÖGL (1996).

4. Results

4.1. Occurrence of the Taxa in the pH-Ranges

Figure 1 shows the pH-ranges in which the chironomid taxa were found. For reason of completeness, those taxa which were not determined at the species level, were also included in the analysis. Table 2 gives the number of specimens of the different species found in the various streams. It can be seen from the figure that some taxa were found only at pH-values higher than 6 (*Apsectrotanypus trifascipennis, Rheocricotopus fuscipes, Eukiefferiella claripennis*-group), others only at a pH higher than 5.5 (*Prodiamesa olivacea, Eukiefferiella brevicalcar, Polypedilum pullum, Trissopelopia longimana, Pseudorthocladius virgatus*-group). A relatively high number of other taxa could tolerate pH-values below 4. Some taxa were found exclusively under strongly acidic conditions (*Limnophyes minimus, Limnophyes* sp., *Corynoneura fittkaui*).

4.2. Species Occurrences and pH, PCA

No significant correlations were found between the occurrences of the species and pH values and conductivity. However, PCA helps to recognize some tendencies in the distribution of the taxa.

First, the streams were used as variables and ordinated according to their chironomid communities (Table 3) excluding taxa recorded with only one individual found. Factor 1 is highly loaded by the neutral streams (Mark Schmelz, Lutherstein, Ochsenkopf 2, Parnitz, Breitewitzer Bach), whereas factor 2 is highly loaded by the acidic streams (Taura, Lausa, Deubitzwiesen, Grenzbach). Heidemühle, Ausreißer and Ochsenkopf 1 present themselves more or less indifferently.

Second, the chironomid species were arranged as variables according to their distribution in the streams (excluding species recorded with only one individual found, but including those taxa, which could be determined at species-group or nearly species-level, i.e. "*cf.*" or "Pe"). According to the factor loads (Table 4), some distribution tendencies of the species tolerances shown in Fig. 1, are recognized and confirmed: factors 1 and 3 are highly loaded by mainly tolerant species (*Heterotanytarsus apicalis, Heterotrissocladius marcidus* resp. *Macropelopia notata, Corynoneura fittkaui*), whereas factors 2 are highly loaded by mainly sensitive species (*Prodiamesa olivacea, Rheocricotopus fuscipes, Eukiefferiella brevicalcar*). These three factors explain 61.2% of the variance.

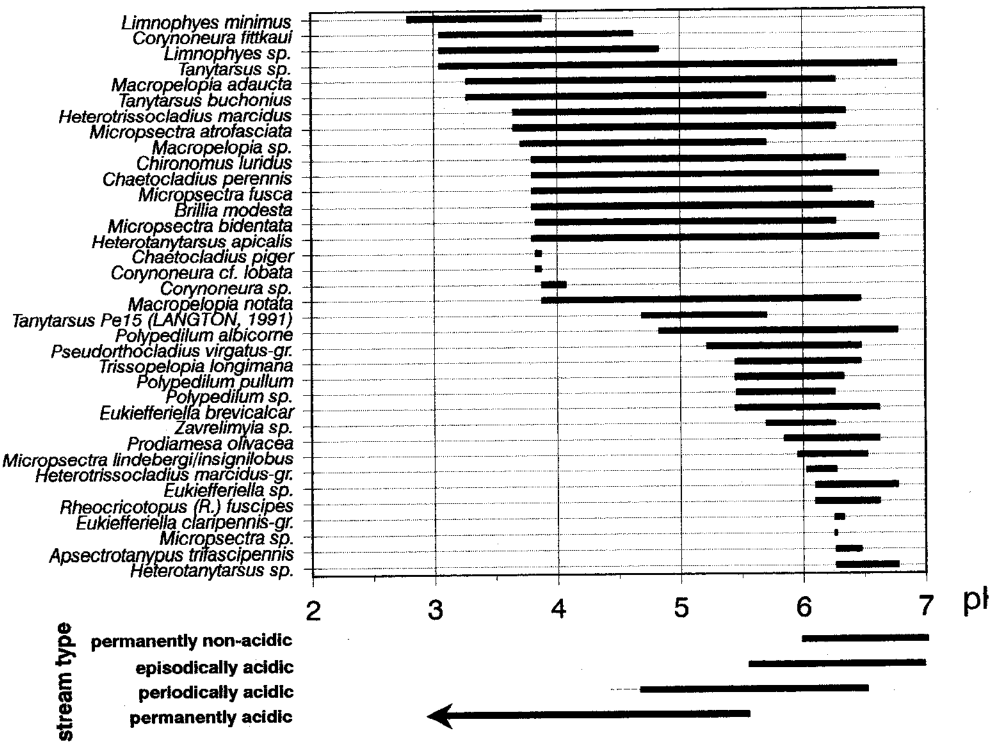

Figure 1. The ranges of pH values measured in the brooks (maximum/minimum from the forest brooks of the Dübener and Dahlener Heide Heathland) in which the chironomids were recorded and the stream types depending on the pH regime (lower part of the chart).
1 = permanently non-acidic streams: pH generally >6.5, minimum never <6 in the course of the year;
2 = episodically slightly acidic: pH similar type (I), but with rare depressions which do not lie <5.5 in the course of the year;
3 = periodically acidic: pH normally <6.5, but generally not <4.3 in the course of the year, at low discharge (basic discharge) the values may lie in a circumneutral range;
4 = permanently acidic: pH <5.5 during all the year, minima often <5, sometimes <4.3 and lower in the course of the year.

4.3. Classification of the Species According to their pH-Sensitivity and a Test Assessment Using the Chironomids Classified

25 taxa could be classified to species level (Table 5) in four sensitivity classes. According to this classification, only two species (*Apsectrotanypus trifascipennis, Rheocricotopus fuscipes*) were "extremely sensitive to acid" (sensitivity class 1) in this study. Most are "tolerant to acid" (sensitivity class 3) or "extremely tolerant to acid" (sensitivity class 4).

A test assessment of the acidity state of the streams based exclusively on the chironomid communities resulted in a high accordance with the pH-medians of the streams considered (Table 6), regardless of whether the analysis was performed with presence/absence data or with abundances and threshold value 3. Using the data published by ORENDT (1998) for six streams, the chironomid-assessment could be compared with that using macroinvertebrates and pH regime (Table 6). Only in one case (Ausreisser) and here only from the analysis using presence/absence data, was a difference of more than one acidity class found.

Table 2. Number of individuals of the taxa found within a certain pH range (see Fig. 1).

taxon	N	taxon	N
Apsectrotanypus trifascipennis (ZETT.)	2	*Macropelopia notata* (MG.)	2
Brillia modesta (MG.)	23	*Macropelopia* sp.	10
Chaetocladius perennis (MG.)	2	*Micropsectra atrofasciata* K.	8
Chaetocladius piger (G.)	2	*Micropsectra bidentata* G.	3
Chironomus cf. *luridus* STR.	2	*Micropsectra fusca* (MG.)	11
Corynoneura cf. *lobata* EDW.	2	*Micropsectra lindebergi/insignilobus*	2
Corynoneura fittkaui SCHLEE	6	*Micropsectra* sp.	3
Corynoneura sp.	4	*Polypedilum albicorne* (MG.)	16
Eukiefferiella brevicalcar (K.)	6	*Polypedilum pullum* (ZETT.)	2
Eukiefferiella claripennis group	2	*Polypedilum* sp.	2
Eukiefferiella sp.	4	*Prodiamesa olivacea* (MG.)	9
Heterotanytarsus apicalis (K.)	7	*Pseudorthocladius virgatus* group	2
Heterotanytarsus sp.	2	*Rheocricotopus (Rh.) fuscipes* (K.)	3
Heterotrissocladius marcidus (WALK.)	22	*Tanytarsus* Pe15 (LANGTON, 1991)	2
Heterotrissocladius marcidus group	3	*Tanytarsus buchonius* REISS & FITT.	8
Limnophyes minimus (MG.)	6	*Tanytarsus* sp.	6
Limnophyes sp.	3	*Trissopelopia longimana* (STAEG.)	3
Macropelopia adaucta K.	17	*Zavrelimyia* sp.	2

Table 3. Factor loadings of the brooks (no rotation, total variance of the first four factors: 70.2%). Bold figures: loadings >0.5.

	pH median*	factor 1	factor 2	factor 3	factor 4
brook					
Lutherstein	5.87	**0.83690**	–0.10248	0.13219	0.03582
Mark Schmelz	6.35	**0.83524**	0.08703	–0.04950	–0.11702
Breitewitzer Bach	6.58	**0.80124**	–0.22683	–0.01341	0.09107
Ochsenkopf 2	5.76	**0.71062**	–0.16584	0.37101	–0.03387
Parnitz	6.44	**0.64793**	–0.01632	0.11973	–0.49061
Deubitzwiesen	4.18	0.16568	**0.86827**	0.09961	0.17250
Taura	4.20	0.07185	**0.83216**	–0.04793	0.18719
Lausa	3.71	0.10455	**0.80033**	0.25538	0.11416
Grenzbach	3.27	0.05486	**0.62327**	0.24360	–0.16856
Heidemühle	5.35	**0.54362**	0.17593	**–0.59228**	0.00658
Ochsenkopf 1	6.44	0.12203	–0.44536	**0.58464**	**0.51049**
Ausreisser	4.94	0.44706	–0.08852	–0.45241	**0.50586**

5. Discussion

As communities in mineral-acidic waters as well as humin-acidic waters were considered, the question may arise as to whether these water types do have different effects on the communities. HARGEBY (1990) found in a field experiment that humic particles had only a neglectable effect on the physiological condition of species sensitive to acidity (*Gammarus*

Table 4. Factor loadings of the chironomid taxa (after varimax rotation, total variance of the first four factor loadings: 71.0%). Bold figures: loadings > ±0.5.

taxon	factor 1	factor 2	factor 3	factor 4
Tanytarsus buchonius	**0.93885**	−0.04087	−0.07649	0.27099
Corynoneura fittkaui	**0.89502**	−0.03742	−0.08091	0.39198
Heterotrissocladius marcidus	**0.77016**	0.27342	0.18365	0.09216
Heterotanytarsus apicalis	**0.74056**	−0.04353	−0.27907	0.46184
Chaetocladius perennis	**0.6894**	−0.13764	**0.59088**	−0.09861
Corynoneura Pe2a	**0.6894**	−0.13764	**0.59088**	−0.09861
Pseudorthocladius virgatus-GR.	**0.62193**	−0.10211	−0.13692	−0.1873
Micropsectra fusca	−0.10354	**0.85219**	0.10928	−0.19684
Micropsectra bidentata	−0.07034	**0.81222**	0.09406	0.36484
Eukiefferiella brevicalcar	−0.17573	**0.80063**	−0.19264	0.07434
Rheocricotopus (R.) fuscipes	−0.22636	**0.76187**	−0.17498	−0.0443
Brillia modesta	0.14193	**0.76128**	−0.39357	0.29853
Polypedilum tritum	0.29043	**0.75158**	−0.21912	−0.01876
Prodiamesa olivacea	0.17336	**0.67978**	−0.21616	−0.37107
Polypedilum albicorne	**0.6099**	**0.61159**	0.06171	−0.2005
Trissopelopia longimana	−0.19355	**0.60692**	−0.0988	−0.18265
Chironomus cf. *luridus*	−0.01086	−0.10546	**0.81608**	−0.03133
Macropelopia adaucta	−0.07688	−0.171	**0.72425**	0.01793
Corynoneura cf. *lobata*	−0.22495	−0.47186	**0.71931**	−0.10757
Limnophyes minimus	−0.17696	−0.28813	**0.66047**	−0.04469
Macropelopia notata	0.11381	−0.08834	**0.65793**	−0.1298
Tanytarsus Pe15 (LANGTON, 1991)	0.32334	−0.44677	**0.60998**	0.12741
Polypedilum pedestre	−0.14545	−0.04167	**−0.54575**	−0.06963
Zavrelimyia sp.	0.32351	−0.14245	−0.49765	−0.09334
Micropsectra atrofasciata	0.35875	−0.08861	0.41881	**0.80381**
Micropsectra lindebergi/insignilobus	**0.57782**	−0.07339	0.11384	**0.71206**
Apsectrotanypus trifascipennis	−0.00234	−0.06305	−0.14737	**0.65859**
Polypedilum pullum	−0.06611	**0.50758**	**0.53903**	**0.61656**
Micropsectra contracta/apposita	0.39341	0.4812	0.26225	**0.57369**

pulex, Asellus aquaticus). Therefore, one can assume that the species were mainly sensitive to the concentration of H^+-ions (no matter of their origin). Generally, it is presumed that the pH-value is the dominant factor controlling the distribution of the taxa (TOWNSEND *et al.*, 1983; MATTHIAS, 1983; HARGEBY, 1990). The availability of food may be another parameter affecting the distribution of the invertebrates. As MACKAY and KERSEY (1985) reported from a field experiment, leaves decomposed more slowly in acidic than in non-acidic streams probably giving an advantage to shredders in comparison to other feeding types in acidic waters. HARGEBY (1990), however, could not prove a change of the competition situation for macroinvertebrates during the acidification of streams. Moreover, MATTHIAS (1983) found in experiments in acidic mountain brooks, that pH had a greater effect on the number of macroinvertebrate species than the availability and quality of food. In this study, however, it was not possible to separate the influence of each parameter measured on the community structure. Generally, with a change of the hydrogen ion concentration, a cascade of consequences for the chemistry of the water can be expected. Nevertheless, most studies on acid stressed waters have found acid to be one of the most important factors affecting the lotic community structure, often linked to others factors which are also correlated to acidity (e.g.

Table 5. Classification of the chironomids according to their sensitivity to acidity.

taxon	sensitivity classification	
Apsectrotanypus trifascipennis (ZETT.)	1	*extremely sensible to acid*
Rheocricotopus (R.) fuscipes K.	1	
Eukiefferiella brevicalcar (K.)	2	*moderately sensible to acid or moderately tolerant to acid*
Micropsectra lindebergi/insignilobus	2	
Polypedilum pullum (ZETT.)	2	
Prodiamesa olivacea (MG.)	2	
Trissopelopia longimana (STAEG.)	2	
Polypedilum albicorne (MG.)	3	*tolerant to acid*
Pseudorthocladius virgatus group	3	
Tanytarsus Pe15 (LANGTON 1991)	3	
Brillia modesta (MG.)	4	*extremely tolerant to acid*
Chaetocladius perennis (MG.)	4	
Chaetocladius piger (G.)	4	
Chironomus cf. *luridus* STR.	4	
Corynoneura cf. *lobata* EDW.	4	
Corynoneura fittkaui SCHLEE	4	
Heterotanytarsus apicalis (K.)	4	
Heterotrissocladius marcidus (WALK.)	4	
Limnophyes minimus (MG.)	4	
Macropelopia adaucta K.	4	
Macropelopia notata (MG.)	4	
Micropsectra atrofasciata (K.)	4	
Micropsectra bidentata G.	4	
Micropsectra fusca (MG.)	4	
Tanytarsus buchonius REISS & FITT.	4	

TOWNSEND *et al.*, 1983; DILLS and ROGERS, 1974; HARGEBY, 1990). This should also be valid for chironomid communities.

In this study, no significant correlations were found between the presence and abundance of the species and pH values resp. conductivity. However, other studies have shown a decline in species number with increasing acidity (SIMPSON, 1983; LEUVEN *et al.*, 1987). This is apparently true only at moderate latitudes, since CRANSTON *et al.* (1997) found an increasing species richness in tropic streams with declining pH. One reason for the result presented is perhaps due to the small number of samples which will reduce the level of significance. Fig. 1 and Table 4 show, however, that a gradient is found in the distribution of the species. PCA demonstrates a gradient between the acidic and neutral streams within the study area explained by the chironomid communities (Table 3). I conclude from the analysis that a pattern of species occurrence and abundance in waters differing in acidity exists. However, in order to elevate the statistical significance of the results, a higher number of samples or individuals, which is quite low in some taxa (Table 2), should have been available for the analysis.

Nevertheless, the results so far allow for a preliminary classification of the species according to their sensitivity to pH. However, the classification of the following taxa based on their occurrences within a certain pH range (Fig. 1) must be discussed. A clear ecological classification of taxa only determined to genus level should be avoided unless the genera are

Table 6. Comparison of the assessments of the acidity states (acidity classes) based on pH measurements (annual pH regime), macroinvertebrates and chironomids.

Acidity classes:

1 = non-acidic streams: pH generally >6.5, minimum never <6 in the course of the year;
2 = episodically slightly acidic: pH similar type (I), but with rare depressions which do not lie <5.5 in the course of the year;
3 = periodically acidic: pH normally <6.5, but generally not <4.3 in the course of the year, at low discharge (basic discharge) the values may lie in a circumneutral range;
4 = permanently acidic: pH < 5.5 during all the year, minima often < 5, sometimes <4.3 and lower in the course of the year.
± = presence/absence data, thr = threshold value of abundance class 3; * = from ORENDT (1998, assessments without chironomids); . = no assessment because lack of data.

brook	pH median	pH regime*	macroinvertebrates*	chironomids ±	chironomids thr = 3
Mark Schmelz	6.97	.	.	2	2
Breitewitzer Bach	6.58	.	.	1	2
Ochsenkopf 1	6.44*	2	2	2	2
Parnitz	6.44*	1	3	1	2
Ochsenkopf 2	6.23	.	.	1	2
Lutherstein	5.46	.	.	2	2
Heidemühle	5.35*	4	3	2	2
Ausreisser	4.94*	4	4	1	3
Taura	3.83*	4	4	4	4
Lausa	3.71*	4	4	4	4
Deubitzwiesen	3.65	.	.	4	4
Grenzbach	3.27	.	.	4	4

monospecific. It is quite striking that the taxon *Heterotanytarsus* sp. determined by larval material, seems to be relatively sensitive, whereas the species *Heterotanytarsus apicalis* determined by a pupal exuvia is widely tolerant. It can not be assumed that *Heterotanytarsus* sp. represents another species from the genus, but it was not possible to determinate the taxon to species level, as only larval material was available. Therefore, the collected specimen of *Heterotanytarsus* sp. can be considered as a larva of *H. apicalis*. A similar situation is found for the *Heterotrissocladius marcidus*-group and *H. marcidus*. *Limnophyes minimus* seems to be bond to low pH, as all specimens collected as pupal exuviae were recorded at pH not higher than 3.8. The larvae of the species live in seeps and margins of streams and are regarded as typical for the surrounding moorland rather than for the stream itself. However, acidity is high in moorland and therefore, the classification as "extremely sensitive to acid" holds.

The classification of the taxa is preliminary and can hopefully extended based on further research and the experience of collegues.

The assessment of the six streams (see ORENDT, 1998) carried out with chironomids, macroinvertebrates and pH regime (Table 6) shows, that within the brooks extremely differing in acidity classification (acidity class 1: "permanently not acidic" resp. class 4: "permanently acidic", i.e. Ochsenkopf 1 or Taura, Lausa) a nearly complete congruence of the assessments in found. In the acidity classes 2 and 3, there was a difference of one class. Only in one brook (Ausreisser; Table 6) a higher difference of two classes appeared from the assessments. This is due to the fact that by using presence/absence data in the assessment (according to RADDUM *et al.*, 1988) the record of *Apsectrotanypus trifascipennis* (sensitivity class 1, i.e. "extremely sensitive to acidic conditions") leads to a low acidity class (acidity class 1, "permanently non-acidic"), although only a single individual of the species was recorded (ORENDT, 1998). In contrast, using abundances in the assessment method of BRAUKMANN (1992) the assessment leads to acidity class 3 ("periodically acidic") which is only one class away from the other classifications basing on pH median, pH regime and macroinvertebrates. This is because the threshold value 3, indicating the according acidity class, is reached only due to presence of the "acid-tolerant" species *Polypedium albicorne* (sensitivity class 3). This example shows that it is very important to include the abundances for a correct assessment.

6. Concluding Remarks

The results of this study show that chironomids may be used as indicators for the acidification-assessment of running waters. Therefore, it is recommended that acid-sensitive and tolerant chironomids are added to the current list of acidification indicators (SCHNELBÖGL, 1996). The results of acidity assessments of the brooks using only chironomids corresponded closely with those from other methods. However, the question whether chironomids can be applied exclusively for the assessment is still to be answered. At least, chironomids can be profitably used to verify assessments by other macroinvertebrates. Moreover, they are very helpful acidification indicators if too few indicator species from other groups (macroinvertebrates) can be found for a reliable analysis.

The classification should be tested for application in other regions threatened by acidification. Further studies can contribute to more precise definitions of the tolerance of chironomids towards acidification. In any case, the group should be involved in the sampling programs in order to provide more evaluation material.

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