Zeitschrift: Contributions to Natural History : Scientific Papers from the Natural History Museum Bern

Herausgeber: Naturhistorisches Museum Bern

Band: - (2009)

Heft: 12/2

Artikel: Spatial distribution of chironomids (Diptera: Chironomidae) in an alpine catchment

Autor: Füreder, Leopold

DOI: https://doi.org/10.5169/seals-786981

Nutzungsbedingungen

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Mehr erfahren

Conditions d'utilisation

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. En savoir plus

Terms of use

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. Find out more

Download PDF: 04.08.2025

ETH-Bibliothek Zürich, E-Periodica, https://www.e-periodica.ch

Spatial distribution of chironomids (Diptera: Chironomidae) in an alpine catchment

Leopold Füreder

ABSTRACT Contrib. Nat. Hist. 12: 525–543.
Among freshwater insects, chironomids are perhaps the most successful group of insects inhabiting the most extreme aquatic habitats. At higher altitudes and latitudes, the proportion of chironomids in the aquatic fauna is relatively high compared to freshwater at lower elevations. In alpine areas, stream character is mostly influenced by local water sources and the origin of major tributaries. Usually, a complex mosaic of different habitats and specific environmental conditions in alpine catchments is found. Here, the chironomid assemblages of four biotopes with various microhabitats were compared.

Introduction

The dipteran family Chironomidae or non-biting midges is distributed worldwide, where they have successfully colonized a variety of freshwater and terrestrial habitats (Cranston 1995). The family's realized ecological niches cover a wide spectrum of environmental conditions, they may occur in fresh and saline waters, in the hypolimnion and littoral of lakes, in glacial lakes and thermal water, in springs, in all kinds of riverine habitats and even in small water bodies like phytothelmic water (Pinder 1995).

Among freshwater insects, chironomids are perhaps the most successful group inhabiting the most extreme aquatic habitats. They regularly occur in ice-cold glacial trickles, turbulent glacial streams and temporary waters as well as in a considerable variety of semi-aquatic habitats. They may be the dominant component of the madicolous fauna that lives in hygropetric biotopes (Pinder 1995).

At higher altitudes and latitudes, the proportion of chironomids in the aquatic fauna is relatively high compared to freshwater at lower elevations

(Füreder 1999; Lods-Crozet & al. 2001a, 2001b; Boggero & al. 2006; Füreder & al. 2006; Füreder 2007). In extreme aquatic biotopes they usually contribute more than 80% of taxa numbers and abundances, and this value may even increase with increasing degree of harshness (Füreder 2007).

Ecosystems at high elevations and high latitudes are characterised by extremely harsh conditions, among them daily and annual extremes in wind and low temperature, extended periods of snow cover, low humidity, and precipitation. The snow-free season can be relatively short where the incident solar radiation may be intense in high alpine areas of the temperate and tropical zone, but low in the polar region. The combination of physiologically demanding conditions, a short growing season, and limited energy and nutrient resources make survival, development, and reproduction difficult. Year-round low temperature appears to be the single most important factor limiting biotic communities; it requires special adaptations for survival in winter and limits development and reproduction in summer. This has been the subject of numerous studies of terrestrial organisms and has just begun in aquatic systems.

Climate, (i.e., regional climate and also local weather conditions), magnitude and seasonality of rain fall, watershed geology, and riparian vegetation influence hydrology; temperature gradients, substrate composition, channel geomorphology, and chemistry define the local character of running waters (Brown & al. 2006). In alpine areas, however, stream character is mostly influenced by local water sources and the origin of major tributaries. This has led to the designation of three stream types that can be generally distinguished based on their origin and/or glacial influence: glacier-fed, spring-fed, and rainfall-/snow-melt dominated streams have been recorded from various cold regions (e.g. An der Lan, 1936; Steffan, 1973; Kownacka & Kownacki, 1972; Ward, 1992, 1994; Gislason & Adalsteinsson, 1996; Oswood & al. 1995; Petersen & al., 1995).

Nevertheless, a complex mosaic of environmental conditions in alpine catchments was asserted (e.g. Ward & al. 2002) which furthers the development of quite a variety of aquatic habitats in an alpine catchment (Malard & al. 1999). Therefore, apart from four general stream types defined by Ward (1994) and Füreder (1999), alpine catchments may contain a great diversity of aquatic and semi-aquatic habitats and microhabitats.

Typical macrozoobenthic assemblages of alpine running waters consist of Ephemeroptera, Plecoptera and Trichoptera and numerous Diptera, but also non-insects like oligochaete and nematode worms and crustaceans. The benthic community of alpine aquatic systems has been identified from species-poor to species-rich and from low to high abundance, depending on season and freshwater type (Brittain & Milner 2001, Füreder & al. 2001, Schütz & al. 2001). Chironomids, a very successful group of aquatic insects, which have developed special adaptations to a variety of harsh environments, including extreme temperatures and even freezing (e.g. Irons & al. 1993), often dominate the alpine stream fauna (Füreder & al. 2001).

The dipteran family Chironomidae belongs to the species-richest and often individual-richest insect family of alpine and arctic running waters. Especially at higher altitudes in the Alps they are the dominant group of aquatic invertebrates. Because of their consistent occurrence, their diversity and their ecological and biological traits, they may be used as indicator organisms for the demonstration of effects from environmental change. They also are favourable as keystone species for the reference conditions of freshwater habitats. Despite these values, a detailed knowledge about autecological and synecological ramifications is nearly lacking. A species- or species-group level consideration of chironomids has often been ignored or given little more than a brief mention in many ecological studies. Only recently, some investigations analysed alpine chironomids in more detail (Füreder & al. 1998, 2000; Lencioni 2000; Füreder & al. 2001; Lods-Crozet & al. 2001a, b; Lencioni & al. 2007; Boggero & al. 2006; Füreder & al. 2006; Füreder 2007).

Former investigations in alpine areas showed a stronger seasonal and longitudinal gradient in a glacier-fed stream when compared to a spring-fed stream (Füreder & al. 2001, Schütz & al. 2001). A lower taxa richness but also lower insect abundances were observed for most periods of the year. Although alpine springs can show considerable variations in the invertebrate fauna (Crema & al. 1996), spring-fed streams sometimes have higher zoobenthic densities and more taxa than kryal and rhithral habitats due to relatively benign and stable environmental conditions (Ward 1994).

Based on the results of former investigations the objectives of the present research were to investigate taxa richness, abundance and diversity patterns of chironomids in a variety of aquatic and semi-aquatic habitats in an alpine catchment.

This contribution is dedicated to Konrad Thaler who was an excellent scientist, accurate teacher, cooperative colleague and good friend, who intensively carried out his investigations in the Alps above the tree line with a particular interest in the mountainous area around Obergurgl.

Material and Methods

Study area

The study area was situated within the UNESCO Biosphere Reserve "Gurgler Kamm". The area is easily accessible as the University of Innsbruck operates an alpine research station in Obergurgl. The Rotmoosache is a tributary of the Gurgler Ache which drains the Inner Oetz Valley near Obergurgl (1900 m a.s.l., 46°52' N, 11°02' E), in the Austrian Central Alps, Tyrol. The Rotmoosache subcatchment (Rotmoostal), where the study was conducted, is 10.3 km^2 large, there the Rotmoosache is 4.5 km long and is glacier-fed (4.1 km^2 are glaciated). The highest peaks in the catchment are around 3000 m a.s.l. (Tab. 1). After a steeper reach below the glacial snout (Rotmoosferner, the main glacier of ~3 km^2 in area) a long lower gradient sector follows where distinct deglaciation zones are visible: firstly, the outer Rotmoostal, ice free for several centuries, then terminal and lateral moraines of 1850, terminal and lateral moraines of 1920, and the recent ice free area (up to the glacial snout). Below the glacial floodplain, the stream enters a canyon before it flows into the Gurgler Ache, the main river of the Gurgl Valley. The mean gradient from the glacial snout to the lowest sampling station was 7.2%.

Benthic samples were collected randomly from four principal biotopes: the glacial stream itself, the Rotmoosache (RM), a spring-fed stream with mixed

	Rotmoosache
Latitude, Longitude	46° 49' N, 11° 03' E
Highest point in the catchment [m a.s.l.]	3472
Catchment area at lowest sampling point	10.4 km^2
Glacier area	4.1 km^2
Glacier state	retreating
Treeline [m a.s.l.]	~2000
Altitudinal range of river studied [m a.s.l.]	2250–2450
Mean gradient [%]	7.2
Degree of glaciation [%] at lowest point	40
Number of study sites / samples / specimens	4 / 60 / 18649
Taxa richness / mean chironomid abundance [Ind. m^{-2}]	43 / 7065
Chironomids within all aquatic invertebrates [%]	58.1
Chironomids within all aquatic insects [%]	81.0

Tab. 1. General characteristics of sampling area and sites in the Rotmoosache catchment (Tyrol, Austria).

Glacier-fed Rotmoosache

Microhabitat:	Rocks	Lithal	Lithal (near bank)	Psammal
Rel. densities [%]: (min-max):	95.7 (86.2–100)	79.9 (39.9–93.0)	73.4 (21.7–98.1)	63.2 (0–100)
Chironomid taxa:	*Brillia modesta*	*Brillia modesta*	*Corynoneura* sp.	*Corynoneura* sp.
	Corynoneura sp.	*Chaetocladius* sp.	*Diamesa bertrami*	*Diamesa cinerella/zernyi*-Gr.
	Diamesa cinerella/zernyi-Gr.	*Corynoneura* sp.	*Diamesa cinerella/zernyi*-Gr.	*Diamesa* juv.
	Diamesa juv.	*Diamesa bertrami*	*Diamesa* juv.	*Diamesa latitarsis*-Gr.
	Diamesa latitarsis-Gr.	*Diamesa cinerella/zernyi*-Gr.	*Diamesa latitarsis*-Gr.	
	Diamesa steinboecki	*Diamesa* juv.	*Diamesa steinboecki*	*Eukiefferiella tirolensis/ brevicalcar*-Gr.
	Eukiefferiella fuldensis	*Diamesa latitarsis*-Gr.	*Eukiefferiella fuldensis*	*Micropsectra* sp.
	Orthocladiinae juv.	*Diamesa steinboecki*	*Heleniella* sp.	Orthocladiinae juv.
	Orthocladius rivicola-Gr.	*Eukiefferiella fuldensis*	*Krenosmittia* sp.	*Pseudodiamesa branickii*
	Parametriocnemus stylatus	*Eukiefferiella minor/fittkaui*	Orthocladiinae juv.	*Pseudokiefferiella parva*
	Tanytarsini juv.	*Eukiefferiella tirolensis/ brevicalcar*-Gr.	*Orthocladius rivicola*-Gr.	*Thienemanniella* sp.
		Micropsectra sp.	*Parorthocladius nudipennis*	
		Orthocladiinae juv.	*Pseudodiamesa branickii*	
		Orthocladius frigidus	*Thienemanniella* sp.	
		Orthocladius rivicola-Gr.	*Tvetenia bavarica*	
		Orthocladius sp.	*Tvetenia calvescens*	
		Parametriocnemus stylatus		
		Parorthocladius nudipennis		
		Pseudodiamesa nivosa		
		Pseudokiefferiella parva		
		Stilocladius montanus		
		Thienemanniella sp.		
		Tvetenia bavarica		

Tab. 2. Chironomidae of an alpine catchment - glacier-fed Rotmoosache: Microhabitats, relative abundance of Chironomidae and typical chironomid taxa occurring in the microhabitats.

calcareous geology (SBS), a sping-fed stream with crystalline geology (SWS) and the very slow-flowing to stagnant water in the floodplain (FEN) within the alpine catchment of the Rotmoosache. The variable nature of sites necessitated different sampling methods and efforts. Details on types of sites and habitats as well as number of replicates are provided in Tab. 1.

Chironomid larvae and pupae were sorted from the zoobenthos samples and kept in separate vials in 70% alcohol for further taxonomic processing. Species identification was conducted with dissecting and transmitted-light microscopes at highest magnification by considering widely accepted identification keys. Apart from several specific publications basically the following keys were used: Janecek (1998); Ferrarese & Rossaro (1981); Rossaro (1982); Wiederholm (1983, 1986); Ferrarese (1983); Nocentini (1985); Langton (1991); Schmid (1993).

Biodiversity patterns of benthic assemblages are herein presented with a special focus on the chironomids. Taxa richness, abundance, Shannon's diversity index and evenness are compared between biotopes, habitats and micro-habitats, in order to provide some estimate of the diversity patterns of typical alpine aquatic systems.

Results

A total of 60 benthic samples yielded 18 649 chironomid specimens from the four biotopes sampled in the alpine catchment (Tab. 1). Within a variable number of aquatic invertebrate taxa, 43 chironomid taxa were identified, accounting for a mean abundance of 7065 m^{-2} and a relative share of 58.1% in all aquatic groups and 81.0% in the aquatic insects.

Despite seasonal and habitat-specific variations, the dipteran family Chironomidae exhibited the highest relative abundance in most biotopes. This was especially true for the glacier-fed RM where all habitats/micro-habitats were dominated by chironomids (Tab. 2). In the spring-fed SBS and SWS, the mean relative abundance of chironomids was in most habitats above 50% (Tab. 3). A lower relative share was observed in the ecotone area, where less than 50% of the fauna were chironomids (Tab. 4).

Of the 43 chironomid taxa occurring in all sampled biotopes, about half were found in the lithal habitat of RM (23 taxa). Numerically important taxa were of the sub-family Diamesinae, dominated by several species of *Diamesa latitarsis*-Gr. and *D. cinerella/zernyi*-Gr. The other subfamily typical for alpine streams, the Orthocladiinae, was represented with more but numerically less important taxa. Regular recurrent taxa were within the genera *Corynoneura*, *Eukiefferiella*, *Orthocladius*, *Parametriocnemus*, *Parorthocladius*, *Thienemanni-*

Spring-fed streams			
Microhabitat:	Spring area	Riffle	Pool
Rel. densities [%]: (min-max):	72.6	51.4 (31.4–71.3)	65.4
Chironomid taxa:	*Corynoneura* sp.	*Brillia modesta*	*Diamesa cinerella/zernyi*-Gr.
	Diamesa cinerella/zernyi-Gr.	*Corynoneura* sp.	*Heterotrissocladius marcidus*
	Diamesa juv.	*Diamesa cinerella/zernyi*-Gr.	*Micropsectra atrofasciata*-Gr.
	Orthocladiinae juv.	*Diamesa* juv.	*Orthocladiinae* juv.
	Orthocladiinae "COP"	*Diamesa latitarsis*-Gr.	*Orthocladius frigidus*
	Paratrichocladius nivalis	*Krenosmittia* sp.	*Orthocladius* sp.
	Parorthocladius nudipennis	*Micropsectra atrofasciata*-Gr.	*Parakiefferiella* sp.
	Pseudokiefferiella parva	*Orthocladiinae* juv.	*Paratanytarsus* sp.
	Thienemanniella sp.	*Orthocladius frigidus*	*Paratrichocladius nivalis*
		Orthocladius sp.	*Pseudodiamesa branickii*
		Parakiefferiella sp.	*Pseudokiefferiella parva*
		Paratrichocladius nivalis	*Thienemanniella* sp.
		Parorthocladius nudipennis	
		Pseudokiefferiella parva	
		Rheocricotopus effusus	
		Smittia sp.	
		Thienemanniella sp.	
		Tvetenia bavarica	

Tab. 3. Chironomidae of an alpine catchment – Spring-fed streams: Microhabitats, relative abundance of Chironomidae and typical chironomid taxa occurring in the microhabitats.

ella and *Tvetenia*. Only one genus per subfamily or tribe was found in the Prodiamesinae and Tanytarsini, respectively.

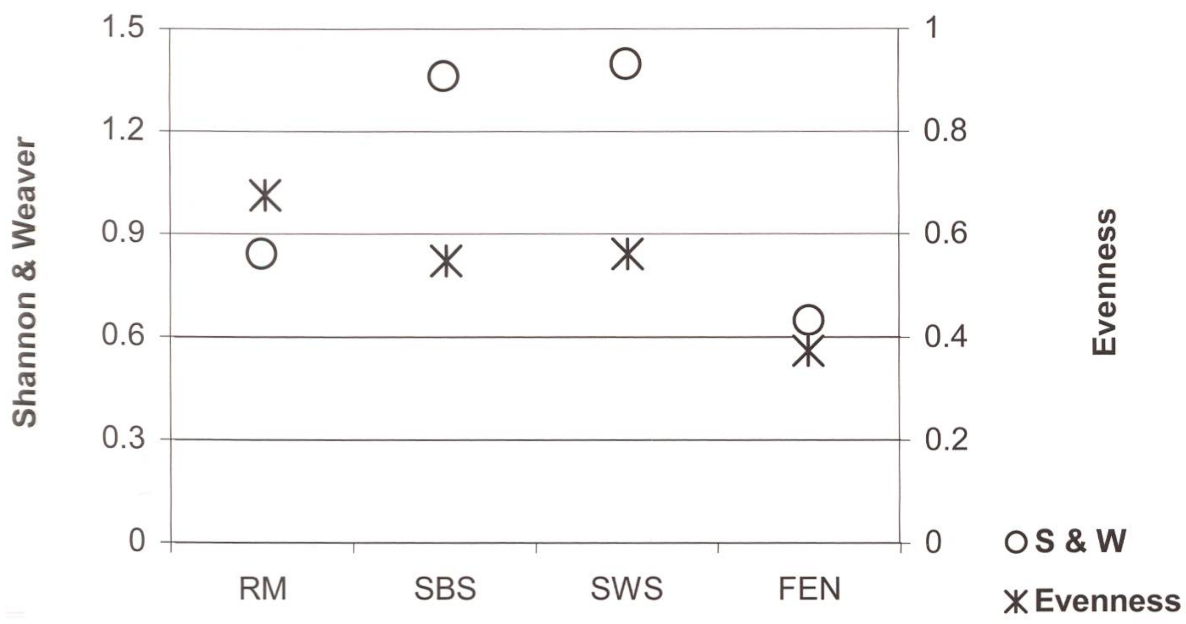
The chironomid association of the spring-fed streams compared well with the assemblage of the glacier-fed stream, however, it was dominated by taxa of the subfamily Orthocladiinae. Only one to three *Diamesa* taxa and single taxa within the Tanytarsini were found in the spring-fed habitats (Tab. 3).

As expected, the species assemblage of the ecotone was considerably different (Tab. 4). The obvious distinctions from the glacier-fed Rotmoosache (substrate, temperature, current) accounted for the occurrence of taxa known to be typical for less harsh conditions. Besides some abundant Orthocladiinae, representatives of the tribes Tanytarsini and Pentaneurini (*Micropsectra atrofasciata*-Gr., *Neozavrelia* sp., *Paratanytarsus* sp., *Tanytarsus lugens*-Gr., *Krenopelopia binotata*) were typical. Most of these taxa are known to occur in aquatic moss and spring habitats; some of them are considered hygropetric species (e.g. species of *M. hygropetricus*-Gr.).

Spring-fed aquatic, semi-aquatic and fen biotope					
Microhabitat:	Spring, cobble	Moss	Algae	Detritus	Pool
Rel. densities [%]: (min-max):	19.1 (18.1–20.2)	15.1 (9.1–23.4)	4.3 (3.6–5.0)	41.1 (27.2–54.9)	10.8 (7.3–20.9)
Chironomid taxa:	*Chaetocladius* sp.	*Chaetocladius* sp.	*Chaetocladius* sp.	*Corynoneura* sp.	*Corynoneura* sp.
	Corynoneura sp.	*Corynoneura* sp.	*Corynoneura* sp.	*Diamesa* juv.	*Diamesa* juv.
	Krenopelopia sp.	*Krenopelopia binotata*	*Krenopelopia binotata*	*Diamesa cinerella/zernyi*-Gr.	*Micropsectra* sp.
	Krenosmittia sp.	*Krenopelopia* sp.	*Krenopelopia* sp.	*Heterotrissocladius marcidus*	*Neozavrelia* sp.
	Micropsectra atrofasciata-Gr.	*Metriocnemus hygropetricus*-Gr.	*Metriocnemus hygropetricus*-Gr.	*Krenopelopia* sp.	Orthocladiinae juv.
	Orthocladiinae juv.	*Micropsectra* sp.	*Neozavrelia* sp.	*Micropsectra* sp.	Tanytarsini juv.
	Parametriocnemus stylatus	Orthocladiinae juv.	Orthocladiinae juv.	Orthocladiinae juv.	*Tanytarsus lugens*-Gr.
	Parorthocladius nudipennis	*Orthocladius* sp.	*Parametriocnemus stylatus*	*Orthocladius* sp.	
	Rheocricotopus effusus	*Parametriocnemus stylatus*	*Rheocricotopus effusus*	*Paratanytarsus* sp.	
	Tanypodinae juv.	*Pentaneurini* juv.	*Tanytarsini* juv.	*Pseudodiamesa nivosa*	
	Tanytarsini juv.	*Rheocricotopus effusus*		*Rheocricotopus effusus*	
	Thienemanniella sp.	Tanytarsini juv.		Tanytarsini juv.	
	Tvetenia bavarica	*Tvetenia bavarica*		*Tvetenia bavarica*	

Tab. 4. Chironomidae of an alpine catchment - Spring-fed aquatic, semi-aquatic and fen biotope: Microhabitats, relative abundance of Chironomidae and typical chironomid taxa occurring in the microhabitats.

A)



B)

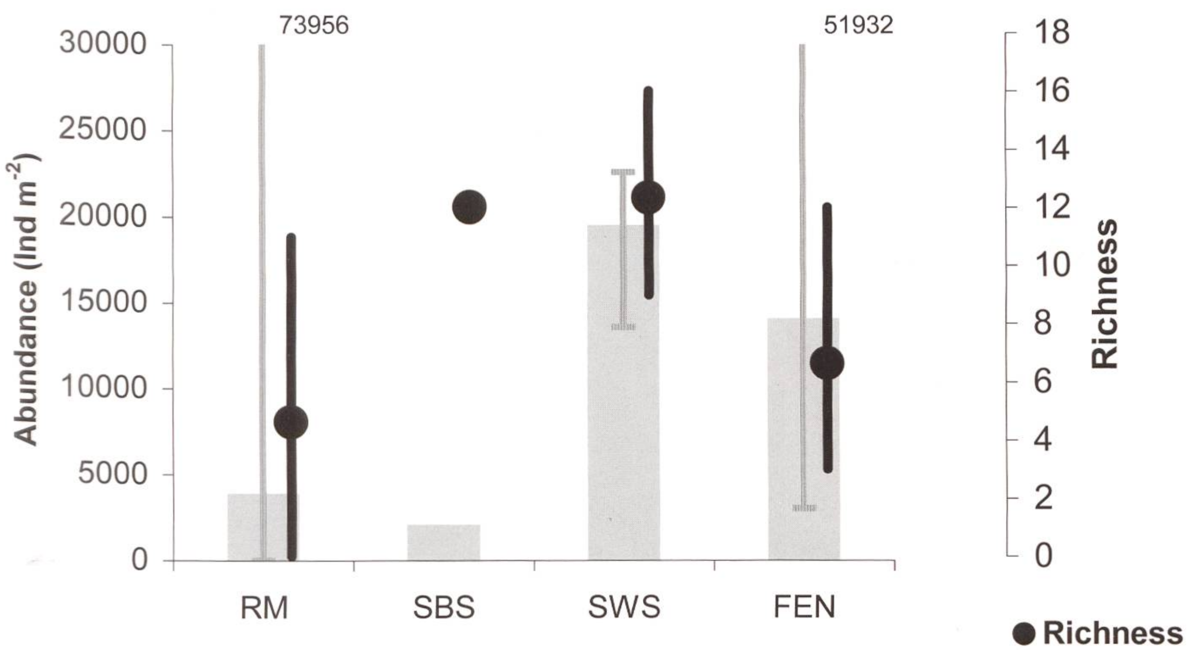


Fig. 1. Chironomids in an alpine catchment - Comparison of biotopes. – A: diversity and evenness (symbols are means of available replicates); – B: abundance (grey columns are means of sampled microhabitats, vertical bars indicate maximum and minimal abundances), and taxa richness (black dots indicate the mean and bars maximum and minimum taxa numbers). RM glacial Rotmoosache, SBS and SWS spring-fed Schneebergzugbach and Schönwiesbach, FEN variable spring-fed aquatic and semi-aquatic habitats.

Total densities of chironomids ranged from 0 to almost 74 000 m^{-2}, varying across temporal and spatial dimensions. Mean chironomid abundance was lowest in the spring-fed SBS and the glacier-fed RM (Fig. 1). Highest mean abundance was observed in spring-fed SWS and the aquatic/semi-aquatic

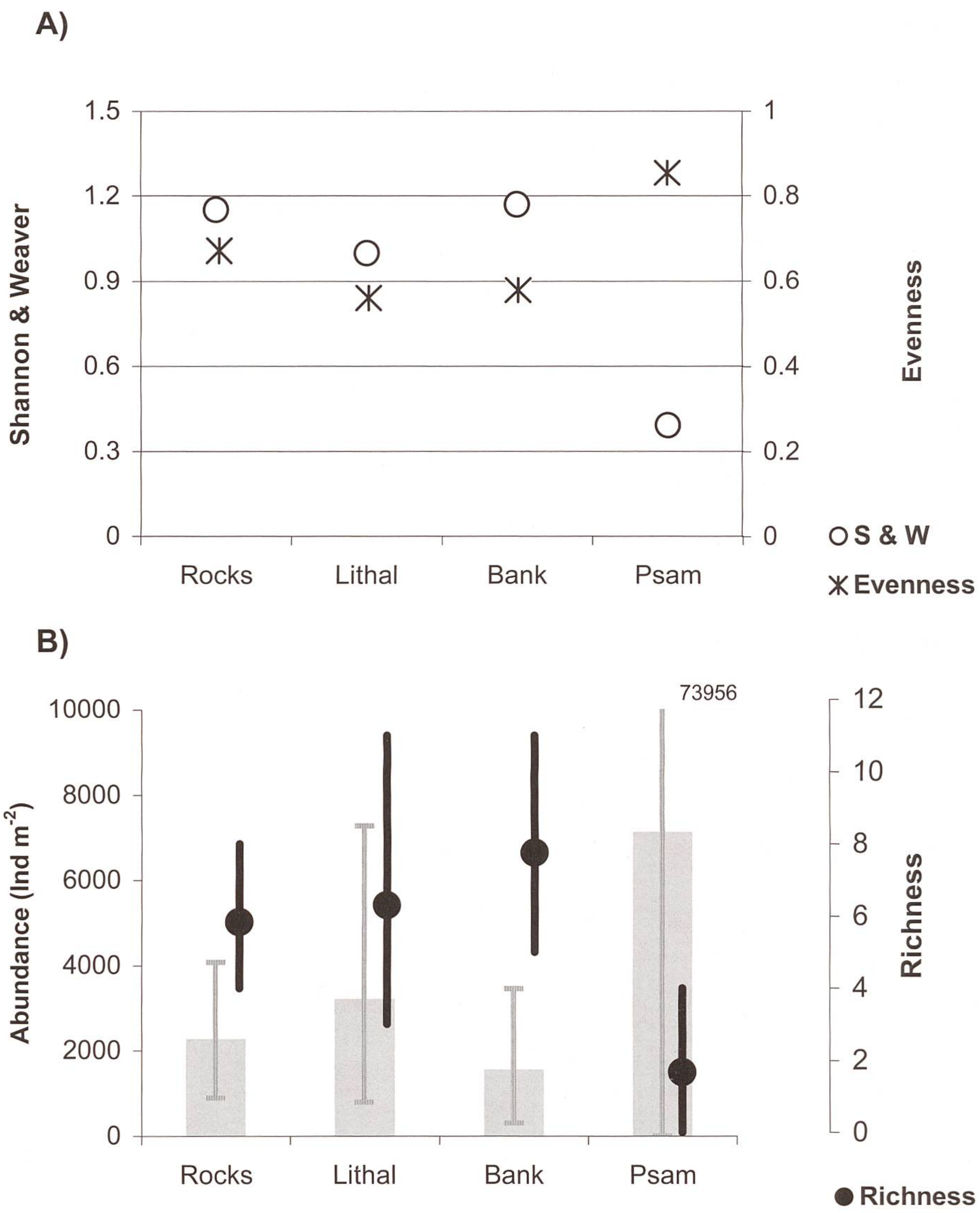


Fig. 2. Chironomids in an alpine catchment – Comparison of microhabitats in the glacial Rotmoosache. – A: Diversity and evenness (symbols are means of all available replicates); – B: Abundance (grey columns are means of all sampled microhabitats, vertical bars indicate maximum and minimum abundances), and taxa richness (black dots are means and bars maximum and minimum taxa numbers). Samples were from different microhabitats: Rocks - rocks > 40 cm; Lithal – cobble of varying size; Bank – cobble near the bank with low current, Psam – Psammal, sand and silt with very low current.

habitats (FEN), whereas a maximimum abundance of 73 956 m^{-2} was sampled in the glacier-fed RM. Except for the spring-fed SBS, taxa richness followed a comparable pattern, being low in glacier-fed RM (4.6 taxa) and highest in the spring-fed streams (12 taxa). In the aquatic and semi-aquatic habitats (FEN), A)

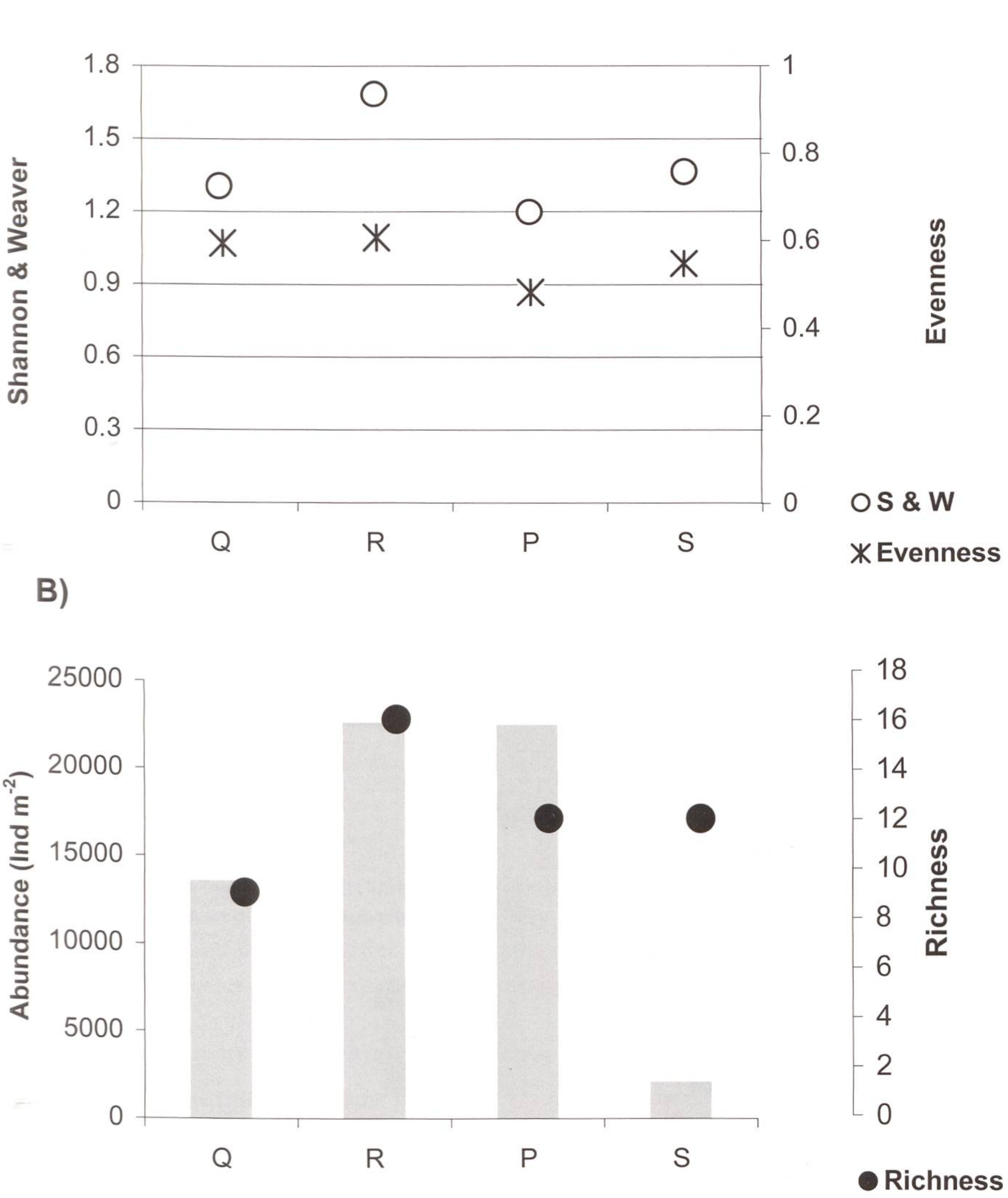


Fig. 3: Chironomids in an alpine catchment – Comparison of habitats/sites in the spring-fed streams Schönwiesbach and Schneebergzugbach. – A: Diversity and evenness; – B: Abundance and taxa richness. All symbols and columns are single sample values. Letters indicate different habitats: Q – spring area, R – riffle, P – pool, S – riffle in Schneebergzugbach.

mean chironomid taxa number (6.6) lay in-between the glacier-fed and spring-fed biotopes. Correspondingly, Shannon's diversity was highest in the spring-fed streams (1.4), followed by the glacier-fed RM (0.8) and was lowest in the ecotone (0.7). Evenness was generally low, mean values were highest in RM

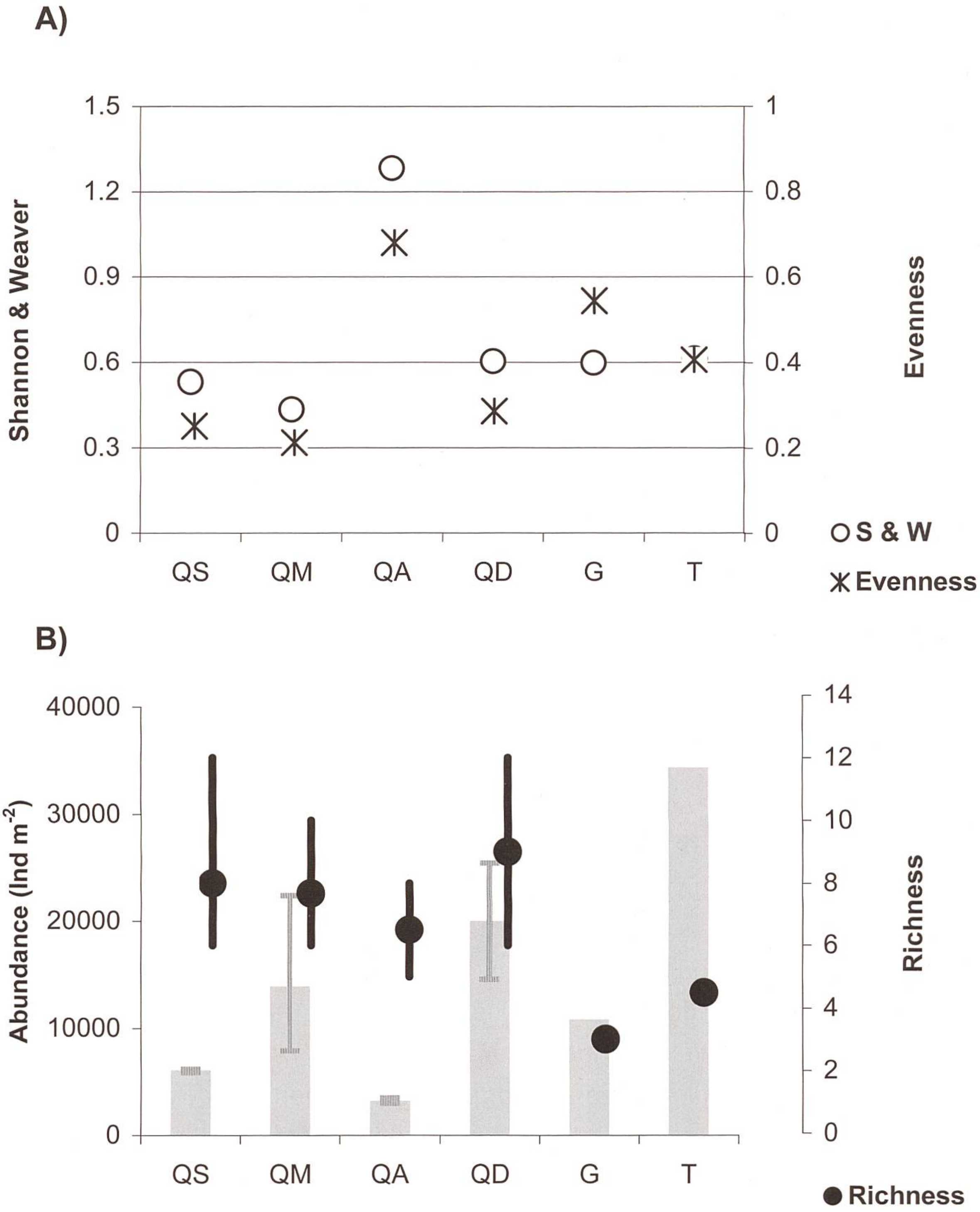


Fig. 4: Chironomids in an alpine catchment – Comparison of habitats in various aquatic and semi-aquatic habitats and FEN area. – A: Diversity and evenness (symbols are means of all available replicates); – B: Abundance (grey columns are means of all sampled microhabitats, vertical bars indicate maximum and minimum abundances), and taxa richness (black dots are means and bars maximum and minimum taxa numbers). Samples were from different microhabitats: QS – cobble substrate in spring-fed system, QM – moss in spring-fed system, QA – algae in spring-fed system, QD – detritus in spring-fed system, G - lotic system with grass (presumable temporary system) and T – pool. At G and T only two replicates were available.

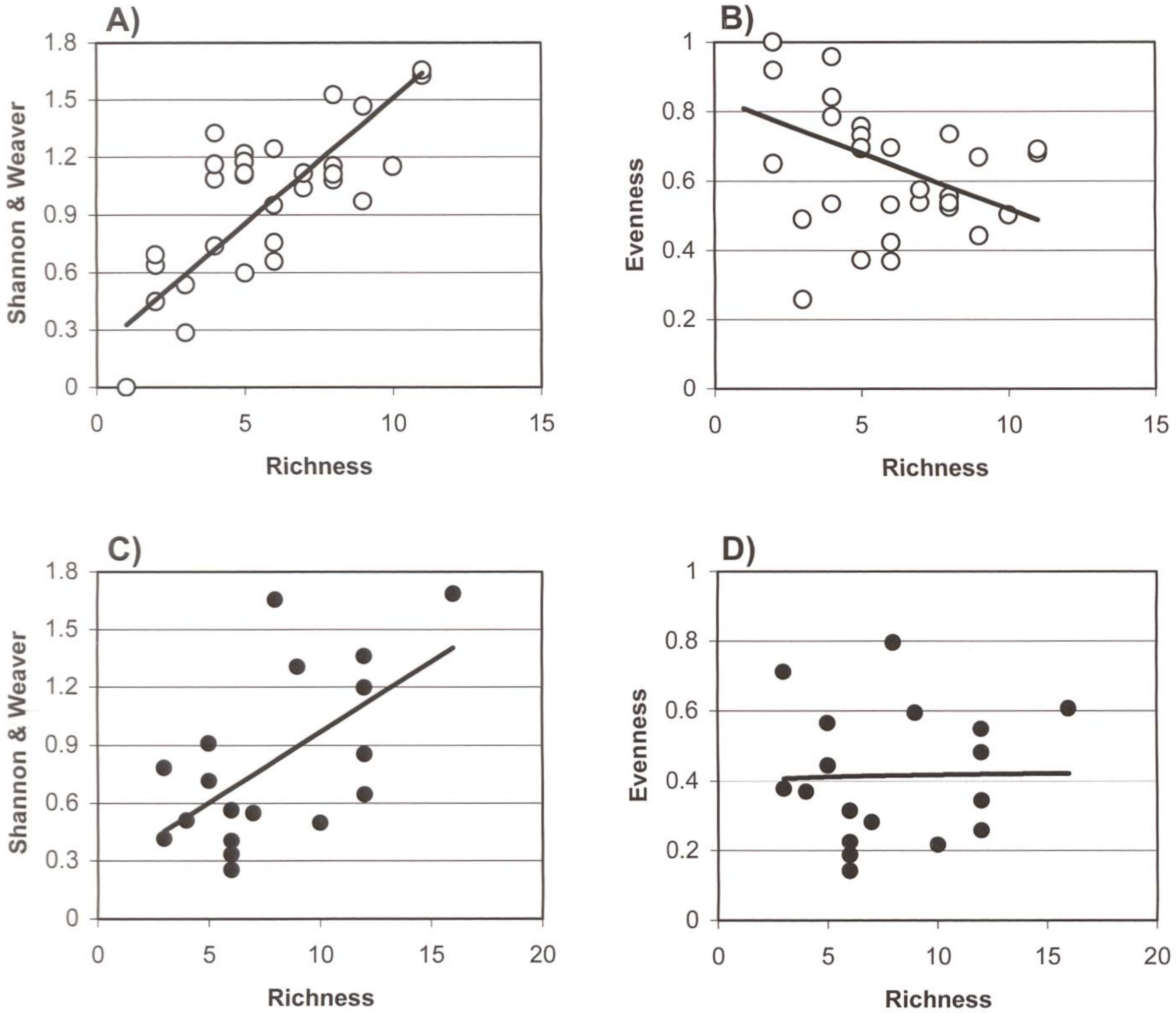


Fig. 5: Chironomids in an alpine catchment – Chironomid diversity in glacier-fed (A, B) and spring-fed (C, D) systems. – A and C: Shannon-Weaver Diversity and taxa richness; – B and D: Evenness and taxa richness.

(0.7), moderate in the spring-fed streams (0.5; 0.6) and lowest again in the aquatic/semi-aquatic biotope (0.4).

When the habitats and microhabitats in the sampled biotopes were compared, observed differences became even more distinct. Apart from a single maximum in the sand microhabitat of the glacier-fed Rotmoosache (Fig. 2), highest chironomid densities were found in the spring-fed Schönwiesbach (Fig. 3). Corresponding high taxa numbers and highest Shannon-diversity demonstrate the distinctiveness of this result. Abundances and richness across habitats were generally lower in the glacier-fed stream, and were moderate in the ecotone habitats (Fig. 4). Evidently, here the relatively high abundances were accompanied by the lowest diversity and evenness values.

In both systems, the glacier-fed and the spring-fed, respectively, there was an increase in diversity with higher taxa richness (Fig. 5). In terms of a balanced distribution of the chironomids, the two kinds of systems responded differently. While in the glacier-fed Rotmoosache evenness values decreased with increasing richness, evenness in the spring-fed systems was generally low and did not follow a specific trend.

Discussion

Ecosystem structure, dynamics and function in Alpine streams at higher elevations are dependent on regional climate and local weather conditions, geomorphology of the catchment but primarily on their prevailing water source, such as groundwater and glacial meltwater (Ward 1994, Tockner & al. 1997, Füreder 1999, Ward & al. 1999). The alpine catchment chosen for this investigation comprises different aquatic biotopes, from the glacier-fed Rotmoosache, spring habitats and adjacent spring-fed streams (SWB, Schönwiesbach, SBS Schneebergzugbach) and other aquatic and semi-aquatic habitats (ecotone, FEN). These different types of aquatic habitats comprised a spectrum of habitat conditions typical for an alpine catchment.

In a literature review, Füreder (1999) concluded that the presence of relatively few species and the absence of many common "temperate" taxa suggested the extreme conditions in alpine areas to exclude many species. This is true for terrestrial ecosystems as well as for streams. While this has been generally accepted, contradicting evidence also exists from some investigations. Although a common alpine assemblage has been repeatedly observed, the harshest alpine conditions (e.g., in glacier-fed streams) are known to eliminate all but a few species. Less extreme locations (i.e., downstream and/or near a spring source) support a more diverse community, facts that were also demonstrated in our findings.

The present results suggest that the chironomid assemblages in alpine aquatic systems is characterised by specialists, which dominate in the various habitats and microhabitats. This is true for the glacier-fed stream, where harsh environmental conditions favour well adapted species (e.g. *Diamesa* spp.), or the various spring-fed systems, where specialists for less dynamic environmental conditions dominate. Local richness in the individual habitats appears to be to a high degree dependent on the surrounding taxa pool (of the whole catchment) and secondarily to the rigors of environmental conditions. The mosaic pattern of aquatic (micro-) habitats favours the heterogeneous situation of species diversity and equability.

The consistence and diversity of chironomids when compared between habitat and microhabitat types, demonstrates that a taxonomic consideration of this family is necessary when specific questions in alpine areas are

Plate I. Typical chironomid taxa of a glacial catchment. a) and b) taxa with a preference for higher current velocities, c) – d) taxa with a preference for slower current and/or stagnant water. – a: *Diamesa cinerella/zernyi*-Gr. (70x); – b: anal setae of *D. latitarsis*-Gr. (very short and short) and *D. cinerella/zernyi*-Gr. (longer setae) (50x); – c: *Corynoneura* sp. (70x) in the psammal habitat of the glacial stream; – d: *Corynoneura* sp. (70x); – e: *Micropsectra* sp. (70X); – f: *Rheocricotopus effuses* (30x) in the aquatic and semi-aquatic ecotone in the FEN-area.

addressed. Most of the aquatic species are chironomids and they are highly adapted to a specific habitat type (or environmental condition). Although this investigation has to be considered preliminary, the regional chironomid diversity pattern supports well the general conclusion that chironomids are key elements in alpine aquatic habitats. In investigations and methods designed to elucidate effects from climate or environmental change, the qualitative and quantitative structure of the chironomid fauna has to be considered.

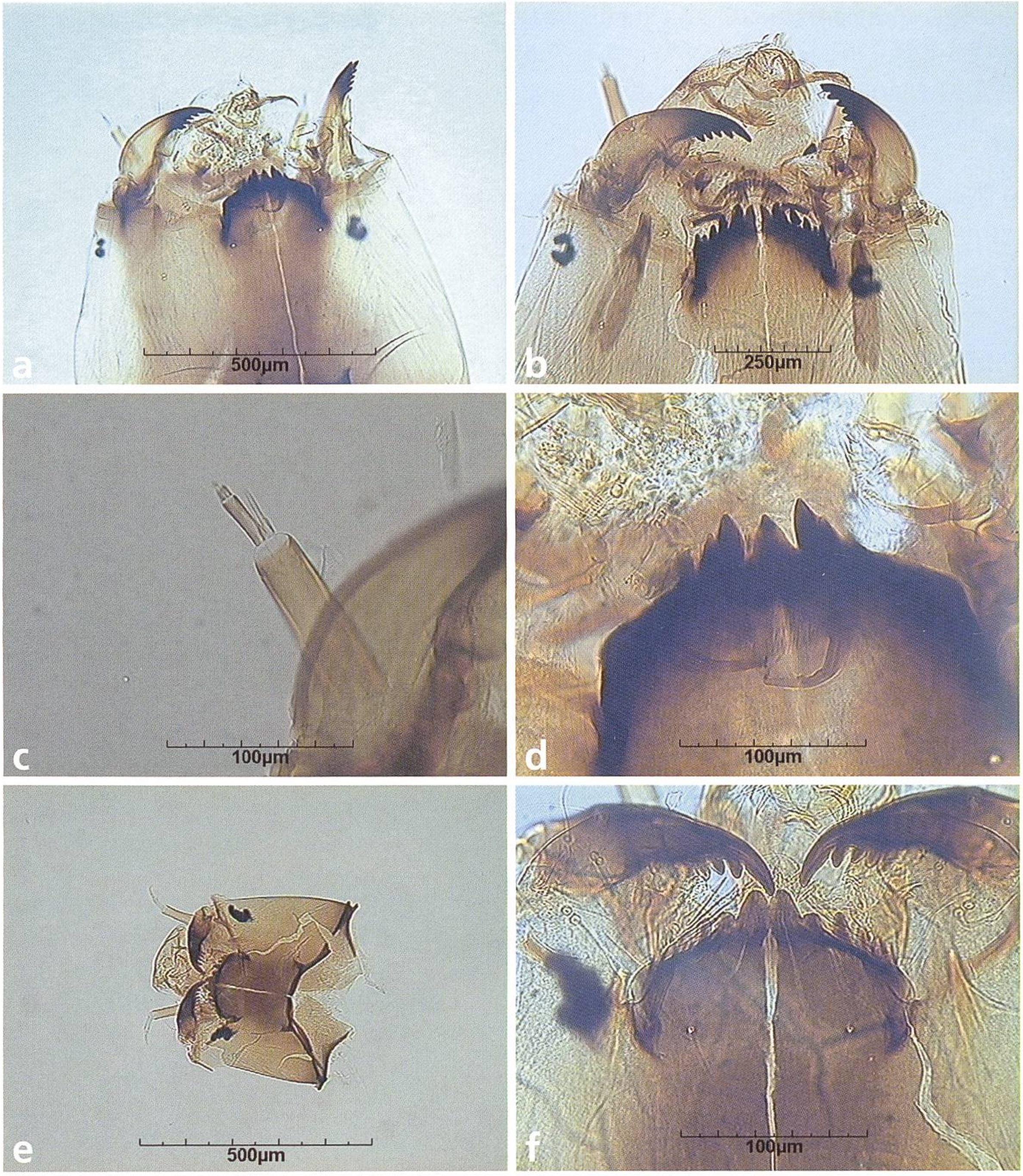


Plate II. Typical chironomid taxa of a glacial catchment: Examples of head capsules and mentum. – a) *Pseudodiamesa branickii* (100 x); – b: *Pseudodiamesa nivosa* (100 x); – c: *Pseudodiamesa branickii* Antenna (400 x); – d: *Pseudodiamesa branickii* Mentum (400 x); – e: *Heterotrissocladius marcidus* (100 x); – f: *Heterotrissocladius marcidus* Mentum, Mandibel (400 x).

Identification at species, species-group or at least generic level (which is in many cases the only option with chironomid larvae) has to be considered essential. Combined efforts should be directed towards a better understanding of aquatic insect taxonomy together with explorative and experimental studies to understand the role of environmental factors for species occurrence. Both features are necessary for describing and understanding biodiversity patterns in alpine landscapes.

Acknowledgements

The help in field and lab work of various people is highly appreciated: Cornelia Schütz, Bettina Sonntag, Anton Wille contributed to the chironomid database used herein for the analysis. Roland Psenner is acknowledged for taking the initiative for the coordiation of the Rotmoosproject.

References

An der Lan, H. (1936): Hydrographische und hydrologische Beobachtungen im Liesenser Gletscherbachgebiet. — Veröffentlichungen des Museum Ferdinandeum Innsbruck 15: 29–51.

Boggero, A., Füreder, L., Lencioni, V., Simcic, T., Thaler, B., Ferrarese, U., Lotter, A.F. & Ettinger, R. (2006): Littoral chironomid communities of Alpine lakes in relation to environmental factors. — Hydrobiologia 562: 145–165.

Brittain, J.E. & Milner, A.E. (2001): Glacier-fed rivers – unique lotic ecosystems. — Freshwater Biology 46. Special Issue.

Brown, L.E., Milner, A.M. & Hannah, D.M. (2006): Stability and persistence of alpine stream macroinvertebrate communities and the role of physicochemical habitat variables. — Hydrobiologia 560: 159–173.

Cranston P.S. (1995): Introduction. — In: Armitage, P.D., Cranston, P.S. & Pinder L.C.V. (eds.), The Chironomidae: Biology and ecology of non-biting midges, pp. 1–7, ref. 448–537, Chapman & Hall, London.

Crema, S., Ferrarese, U., Golo, D., Modena, P., Sambugar, B. & Gerecke, R. (1996): Ricerche sulla fauna betonica e interstiziale di ambienti sorgentizi in area alpina e prealpina. A research on benthic and interstitial fauna in alpine and pre-alpine springs. — Centro di Ecologia Alpina, Trento, Report N. 8: 1–104.

Ferrarese, U. & Rossaro, B. (1981): Guide per il riconoscimento delle specie animali delle acque interne italiane. 12. Chironomidi, 1 (Diptera, Chironomidae: Generalità, Diamesinae, Prodiamesinae). — Consiglio nazionale delle ricerche AQ/1/129: 1–97.

Ferrarese, U. (1983): Guide per il riconoscimento delle specie animali delle acque interne italiane. 26. Chironomidi, 3 (Diptera, Chironomidae: Tanypodinae). — Consiglio nazionale delle ricerche AQ/1/204: 1–67.

Füreder, L. (1999): High Alpine Streams: Cold Habitat for Insect Larvae. — In: Margesin, R. & Schinner, F. (Eds.), Cold Adapted Organisms. Ecology, Physiology, Enzymology and Molecular Biology, pp. 181–196, Springer Verlag, Berlin.

Füreder, L. (2007): Life at the edge: Habitat condition and bottom fauna of Alpine running waters. — Internationale Review der gesamten Hydrobiologie 92: 491–513.

Füreder, L., Schütz, C., Burger, R. & Wallinger, M. (1998): High Alpine streams as models for ecological gradients. — IAHS Publication 248: 387–394.

Füreder, L., Schütz, C., Burger, R. & Wallinger, M. (2000): Seasonal abundance and community structure of Chironomidae in two contrasting high alpine streams. — Verhandlungen der Internationalen Vereinigung für Limnologie 27: 1596–1601.

Füreder, L., Schütz, C., Wallinger, M. & Burger, R. (2001): Physico-chemistry and aquatic insects of a glacier-fed and a spring-fed alpine stream. — Freshwater Biology 46: 1673–1690

Füreder, L., Ettinger, R., Boggero, A., Thaler, B. & Thies, H. (2006): Macroinvertebrate diversity in Alpine lakes: effects of altitude and catchment properties. — Hydrobiologia 562: 123–144.

Gislason, G.M. & Adalsteinsson, H. (1996): Animal communities in Icelandic rivers in relation to catchment basins. Preliminary results from a study in Iceland. — Nordic Association for Hydrology, Nordic Hydrological Conference, Akureyri, Iceland: 1–15.

Irons, J.G.III, Miller, L.K. & Oswood, M. (1993): Ecological adaptations of aquatic macroinvertebrates to overwintering in interior Alaska (U.S.A.) subarctic streams. — Canadian Journal of Zoology 71: 98–108.

Janecek, B.F.R. (1998): Fauna aquatica austriaca: Taxonomie und Ökologie aquatischer wirbelloser Organismen. Diptera: Chironomidae (Zuckmücken). — Bestimmungsunterlagen, Universität für Bodenkultur, Abt. Hydrobiologie: 1–117.

Kownacka, M. & Kownacki, A. (1972): Vertical distribution of zoocenosis in the streams of the Tatra, Caucasus and Balkan Mts. — Verhandlungen der Internationalen Vereinigung für Limnologie 18: 742–750.

Langton, P.H. (1991): A key to pupal exuviae of West Palaearctic Chironomidae. — 386 pp., Huntingdon, Cambridgeshire, England.

Lencioni, V. (2000): Chironomid (Diptera: Chironomidae) assemblages in three Alpine glacial systems. — Ph. D. Thesis, University of Innsbruck (Austria): 1–202.

Lencioni, V., Rossaro, B. and Maiolini, B. (2007): Alpine chironomid distribution: a mere question of altitude? — In: Andersen, T. (ed.): Contributions to the systematics and ecology of aquatic Diptera - a tribute to Ole A. Sæther, pp. 165–180. Caddis Pr., Columbus.

Lods-Crozet, B., Castella, E., Cambin, D., Ilg, C. , Knispel, S. & Mayor-Siméant, H. (2001a): Macroinvertebrate community structure in relation to environmental variables in a Swiss glacial stream. — Freshwater Biology 46: 1641–1661.

Lods-Crozet, B., Lencioni, V., Olafsson, J.S., Snook, D.L., Velle, G., Brittain, J.E., Castella , E. & Rossaro, B. (2001b): Chironomid (Diptera: Chironomidae) communities in six European glacier-fed streams. — Freshwater Biology 46: 1791–1809.

Malard, F., Tockner, K. & Ward, J.V. (1999): Shifting dominance of subcatchment water sources and flow paths in a glacial floodplain, Val Roseg, Switzerland. — Arctic, Antarctic, and Alpine Research 31: 135–150.

Nocentini, A. (1985): Guide per il riconoscimento delle specie animali delle acque interne italiane. 29. Chironomidi, 4 (Diptera, Chironomidae: Chironominae). — Consiglio nazionale delle ricerche AQ/1/171: 1–80.

Oswood, M.W., Irons, J.G. & Milner, A.M. (1995): River and stream ecosystems of Alaska. — In: Cushing, C.E., Cummins, K.W. & Minshall, G.W. (Eds.), River and stream ecosystems, pp. 9–32, Elsevier, Amsterdam.

Petersen, R.C., Gislason, G.M. & Vought, L.B-M. (1995): Rivers of the Nordic countries. — In: Cushing, C.E., Cummins, K.W. & Minshall, G.W. (Eds.), River and stream ecosystems, pp. 295–341, Elsevier, Amsterdam.

Pinder, L.C.V. (1995): The habitats of chironomid larvae. — In: Armitage, P.D., Cranston, P.S. & Pinder L.C.V. (eds.), The Chironomidae: Biology and ecology of non-biting midges, pp. 107–135, ref.448–537, Chapman & Hall, London.

Rossaro, B., Lencioni, V., Boggero, A. & Marziali, L. (2006): Chironomids from Southern Alpine running waters: ecology, biogeography. — Hydrobiologia 562: 231–246.

Rossaro, B. (1982): Guide per il riconoscimento delle specie animali delle acque interne italiane. 16. Chironomidi, 2 (Diptera, Chironomidae: Orthocladiinae). — Consiglio nazionale delle ricerche AQ/1/171: 1–80.

Schmid, P.E. (1993): A key to the larval chironomidae and their instars from Austrian Danube region streams and rivers. Part I. Diamesinae, Prodiamesinae and Orthocladiinae. — Wasser und Abwasser, Supplement 3/93: 1–514.

Schütz, C., Wallinger, M., Burger, R. & Füreder, L. (2001): Effects of snow cover on the benthic fauna in high alpine streams. — Freshwater Biology 46: 1691–1704.

Steffan, A.W. (1973): Qualitative Unterschiede in Energiefluss, Nahrungskreislauf und Produktivität von Fliessgewässer-Ökosystemen. — Verhandlungen der Gesellschaft für Ökologie, Saarbrücken, 1973: 181–191.

Tockner, K., Malard, F., Burgherr, P., Robinson, C.T., Uehlinger, U. & Ward, J.V. (1997): Physicochemical characterization of channel types in a glacial floodplain ecosystem (Val Roseg, Switzerland). — Archiv für Hydrobiologie 140: 433–463.

Ward, J.V. (1992): Aquatic Insect Ecology, Vol. 1: Biology and Habitat. — 438 pp., Wiley, New York.

Ward, J.V. (1994): Ecology of alpine streams. — Freshwater Biology 32: 277–294.

Ward, J.V., Tockner, K., Arscott, B. & Claret, C. (2002): Riverine landscape diversity. — Freshwater Biology 47: 517–539.

Ward, J.V., Malard, F., Tockner, K. & Uehlinger, U. (1999): Influence of ground water on surface water conditions in a glacial flood plain of the Swiss Alps. — Hydrological Processes 13: 277–293.

Wiederholm, T. (1983): Chironomidae of the Holarctic region. Keys and diagnosis. Part 1. Larvae. — Entomologica Scandinavica, Supplement 19: 1–457.

Wiederholm, T. (1983): Chironomidae of the Holarctic region. Keys and diagnosis. Part 2. Pupae. — Entomologica Scandinavica, Supplement 28: 1–482.

Address of the author:

Leopold Füreder
River Ecology and Benthic Invertebrates
Institute of Ecology
University of Innsbruck
Technikerstr. 25
A–6020 Innsbruck, Austria

E-mail: leopold.fuereder@uibk.ac.at