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## Faunistics and altitudinal distribution of net-winged midges (Diptera: Blephariceridae) in Switzerland and Liechtenstein

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Five species of net-winged midges (Diptera: Blephariceridae) are found in Switzerland. They are quite common and occur in all mountainous regions, i.e. the Alps, the prealpine region and the Jura hills. *Liponeura cinerascens minor* is the most abundant species, followed by *L. cordata*, *L. decipiens*, *Hapalothrix lugubris* and *Blepharicera fasciata fasciata*. Only *Liponeura* species are found in the Jura hills. *H. lugubris* is restricted to the central parts of Switzerland (mostly the Alps), and *B. fasciata fasciata*, a thermophilic species, occurs only in the most southern parts of Switzerland. *L. cinerascens minor* was found at elevations between 300 and 2270 m. Its median elevation was 1120 m. The corresponding values for the other species were: *L. cordata*: 198–1652 m (700 m); *L. decipiens*: 236–1780 m (730 m); *H. lugubris*: 424–1960 m (995 m); *B. fasciata fasciata*: 198–450 m (271 m). At 61.8% of the sites only one blepharicerid species was found. 22.0% of the sites were colonized by two, 11.0% by three, and 5.2% by four species. *H. lugubris* and *B. fasciata fasciata* were never found at the same site.

Keywords: Distribution, faunistics, altitude, co-occurrence, Switzerland, Liechtenstein, Blephariceridae, net-winged midges

### INTRODUCTION

Mountain streams are usually characterized by fast flowing water and heterogeneous substrata. The larvae of the net-winged midges (Diptera: Blephariceridae) are highly specialized to inhabit torrential streams and hygropetric zones (spray zones) and thus represent a typical faunal element of such running waters. Commonly, they are thought to be quite rare, and only a few investigations have focused on their geographical distribution in Switzerland (ZSCHOKKE, 1900; LAUTERBORN, 1939; ZWICK, 1998). But since they regularly appear in taxa lists of environmental impact statements and scientific publications concerning alpine streams (e.g. MARRER, 1987; FRIEDLI, 1991; AMMANN, 1993; KRAFTWERK TASCHINAS, 1996), they are presumably widely distributed throughout the Swiss alpine and prealpine region (i.e. the northern foothills of the Alps).

According to ZWICK (1998), five blepharicerid species occur in Switzerland: *Liponeura cinerascens minor* BISCHOFF, 1922; *L. cordata* VIMMER, 1916; *L. decipiens* BEZZI, 1913; *Hapalothrix lugubris* LOEW, 1876; and *Blepharicera fasciata fasciata* (WESTWOOD, 1842). The genus *Liponeura* (42 species; ZWICK, 1992) is endemic to Europe, North-west Africa and Asia Minor. *H. lugubris* is found only in the Alps, Kosovo, and Montenegro (ZWICK, 1982). The thermophilic species *B. fasciata fasciata* is widely distributed throughout southern and eastern parts of Europe, but in Switzerland it is restricted to southern regions (ZWICK, 1980, 1998). The goal of the present study was to describe and analyze the geographical and

altitudinal distribution of the net-winged midges on a fairly fine geographical and altitudinal scale in Switzerland and Liechtenstein.

#### METHODS

Available records from previous studies and environmental impact statements that contained blepharicerid data were collated and analyzed. Additionally, several sampling campaigns were undertaken between June 1996 and September 1997 to improve information on regions where data were sparse. Only larvae and pupae were collected. Specimens were identified using keys of ZWICK (1980) and NICOLAI (1983).

Data from the following sources are also included in this study: BANGERTER (1932), NADIG (1942), PERRET (1977), KLÖTZLI & MARRER (1987), BÜSSER (1989, and in prep.), JANN (1990), LIMNEX (1992), MARRER (1992), AQUAPLUS (1995), DIMMLER (1996), and NIEDERHAUSER (1997).

Coordinates and altitudes of sampling sites were based on the Swiss national topographical map 1:25000 at  $\pm 25$  m (Swiss national coordinate system) and  $\pm 5$  m (altitudes), respectively. The maps given in this paper (Figs 1–6) were generated using the computer software MapInfo.

#### RESULTS

In total, 1369 records from 1026 sites, that ranged from 198 to 2500 m in elevation, are included in this report. Blepharicerids were found at 393 sites between 198 and 2270 m (Tab. 1). They are distributed throughout most of the mountainous regions of Switzerland, i.e. the Alps, the prealpine area and Jura hills. Most sites without blepharicerids, on the other hand, are located in the (low gradient) Swiss plateau (Fig. 1).

*Liponeura cinerascens minor* is the most frequently collected blepharicerid species. It was found at 188 sites. It occurs in all regions and almost the entire altitudinal range where blepharicerids are found (Tab. 1, Fig. 2). Its altitudinal distri-

Tab. 1. Numbers and altitudinal distribution of the sites included in this study.

	sites [n]	altitude [m a. s. l.]							
		lowest	5%-value	25%-value	Median	Mean	75%-value	95%-value	highest
Total of sites included	1026	198	303	441	635	830	1060	1930	2500
Sites with blepharicerids	393	198	300	600	879	989	1343	1845	2270
Sites with <i>L. cinerascens minor</i>	188	300	435	760	1120	1165	1560	1790	2270
Sites with <i>L. cordata</i>	132	198	273	488	700	729	950	1216	1652
Sites with <i>L. decipiens</i>	106	236	298	509	730	778	985	1390	1780
Sites with <i>H. lugubris</i>	84	424	460	780	995	1051	1373	1705	1960
Sites with <i>B. fasciata fasciata</i>	12	198	-	210	243	271	323	-	450

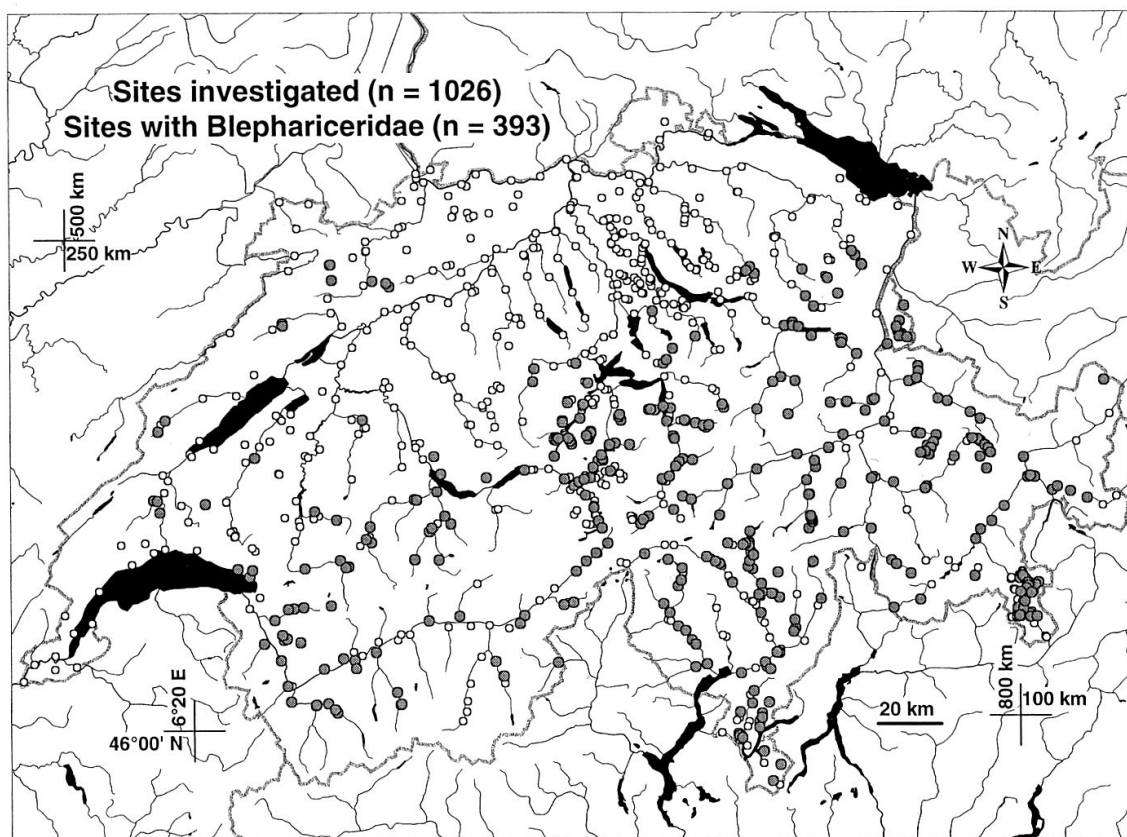


Fig. 1. Geographical distribution of all sites included in this study. The dark dots represent sites where blepharicerids were found, whereas the smaller, open dots show sites without blepharicerids. Global coordinates (bottom left) and coordinates from the Swiss national system are shown (reproduced with the permission of the Federal Office of Topography from Aug. 13, 1997).

bution, however, is clearly biased towards higher altitudes ( $p < 0.001$ , t-test). The median elevation of sites with *L. cinerascens minor* was 1120 m. This is 241 m higher than the median elevation of all sites with blepharicerids. *L. cinerascens minor* was the only species above 1960 m.

*L. cordata*, the second most frequently observed species, was found at 132 sites. Similar to *L. cinerascens minor*, it occurs in the Alps and the prealpine region. In the Jura hills it was found too, but only sparsely (Fig. 3). In contrast to *L. cinerascens minor*, it prefers lower altitudes ( $p < 0.001$ , t-test). The median altitude of sites with *L. cordata* is only 700 m (420 m lower than for *L. cinerascens minor*), and its highest elevation is at 1652 m (Tab. 1).

The third most often found species was *L. decipiens*. It occurred at 106 sites, which, like in the other two *Liponeura* species, are distributed throughout all regions with blepharicerids (Fig. 4). In the Jura hills and the western part of Switzerland it is somewhat more abundant than *L. cordata*, which, on the other hand, is more abundant in the central and southern slope of the Alps. *L. decipiens*, like *L. cordata*, prefers lower sites. The altitudinal distributions of these two species is not different ( $p = 0.22$ , t-test). *L. decipiens*, however, occasionally occurs at higher elevations than *L. cordata*. This can be seen from its 95 %-value which exceeds the corresponding value of *L. cordata* by 174 m. Also, its peak elevation is 1780 m, 128 m higher than that of *L. cordata* (Tab. 1).

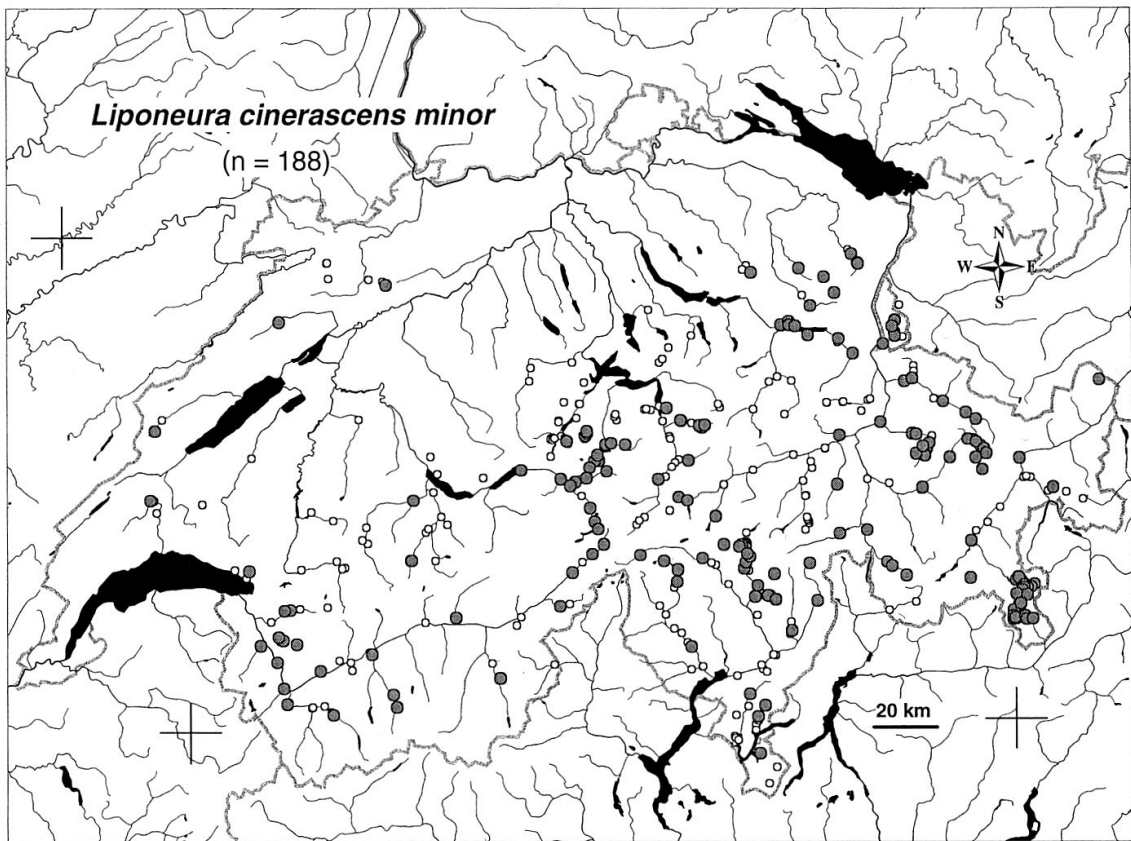


Fig. 2. Geographical distribution of *Liponeura cinerascens minor* (dark dots). The smaller, open dots show sites where other blepharicerid species were found. For coordinates see Fig. 1 (reproduced with the permission of the Federal Office of Topography from Aug. 13, 1997).

*H. lugubris* was found at 84 sites (Fig. 5). Its geographical distribution is restricted to the central areas of Switzerland. It is absent from the Jura hills and the Swiss northern prealpine regions. On the southern slope of the Alps it was found only at few sites close to the continental divide. Its altitudinal distribution also is more restricted than that of the three *Liponeura* species ( $p < 0.05$ , t-test, in all three cases). It only occurred between 424 and 1960 m (Tab. 1). Its median elevation is 995 m a. s. l., which is 125 m less than *L. cinerascens minor*, but exceeds *L. cordata* and *L. decipiens* by 295 and 265 m, respectively.

The fifth blepharicerid species, *Blepharicera fasciata fasciata*, was found only at 12 sites situated in the southernmost part of Switzerland (Canton Ticino, Fig. 6) and below 451 m in elevation (Tab. 1).

The present study confirms that net-winged midges are common in Liechtenstein and all alpine and prealpine regions of Switzerland. Absence of blepharicerids from particular rivers or valleys in these regions is most often due to severe organic pollution or hydroelectric power production (e.g. total or almost complete water abstractions; own unpublished observations). In the Jura hills, only *Liponeura* species occur, and here they are less common than in the alpine and prealpine regions.

*H. lugubris*, and especially, *B. fasciata fasciata*, are geographically more restricted than the three *Liponeura* species. *H. lugubris* is limited to the central parts

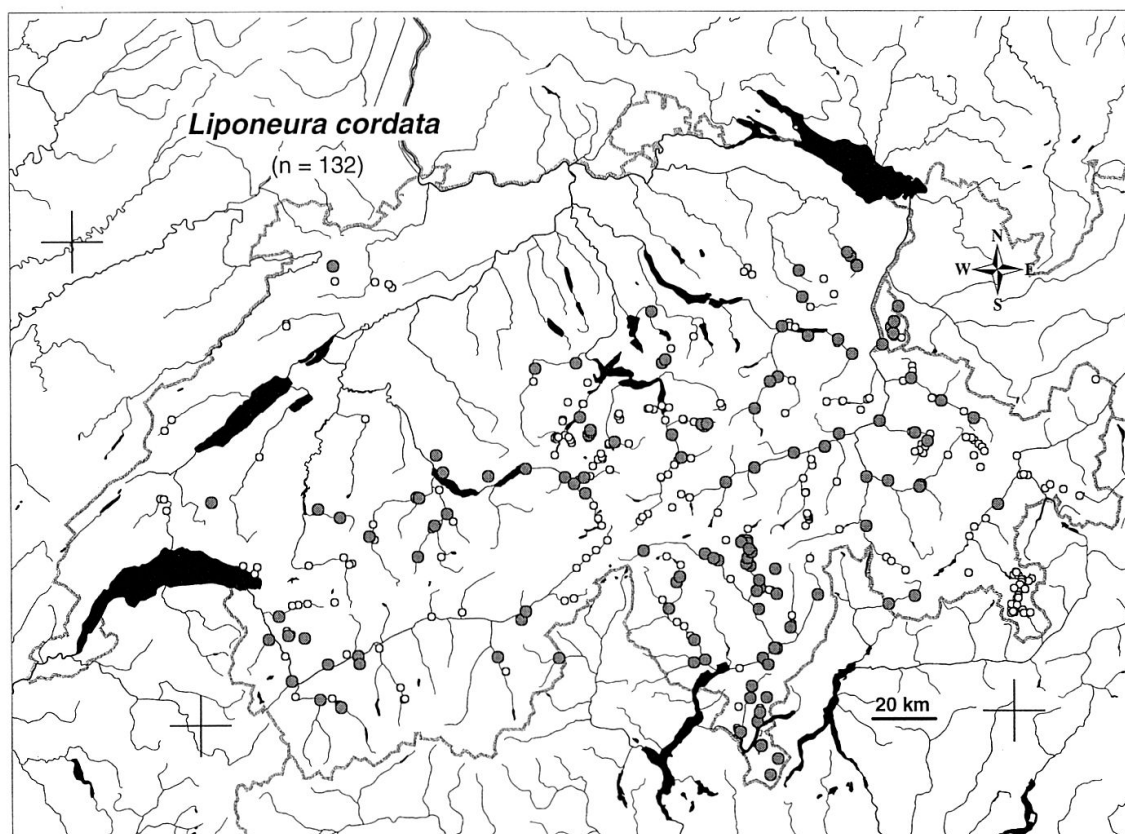


Fig. 3. Geographical distribution of *Liponeura cordata*. For explanations see Fig. 2 (reproduced with the permission of the Federal Office of Topography from Aug. 13, 1997).

of Switzerland (mostly the Alps) and almost absent from the southern slope of the Swiss Alps, whereas *B. fasciata fasciata* was found only in the most southern parts of Switzerland.

#### DISCUSSION

The altitudinal distribution of the five blepharicerid species in this study supports most of the observations of HETSCHKO (1919), MANNHEIMS (1935), LAUTERBORN (1939), GULICKA (1966), VAILLANT (1968), and GIUDICELLI & LAVANDIER (1974). All members of the *L. cinerascens* group are psychrophilic (VAILLANT, 1968). *L. cinerascens minor*, the only *L. cinerascens* subspecies in Switzerland, prefers cold streams of higher altitudes and attains the highest sites of all blepharicerids. However, it is also found at low altitudes. Similar elevational patterns have been observed for other *L. cinerascens* subspecies in the French Pyrenees and the Central Massif (VAILLANT, 1968, GIUDICELLI & LAVANDIER, 1974). *L. cordata* and *L. decipiens* occur at lower sites than *L. cinerascens minor*. Their altitudinal ranges are very similar. In Switzerland *L. decipiens* attains somewhat higher elevations than *L. cordata*. This agrees with the observations from Eastern Europe (GULICKA, 1966). In the French Pyrenees, however, *L. cordata* was found at slightly higher sites than *L. decipiens* (GIUDICELLI & LAVANDIER, 1974).

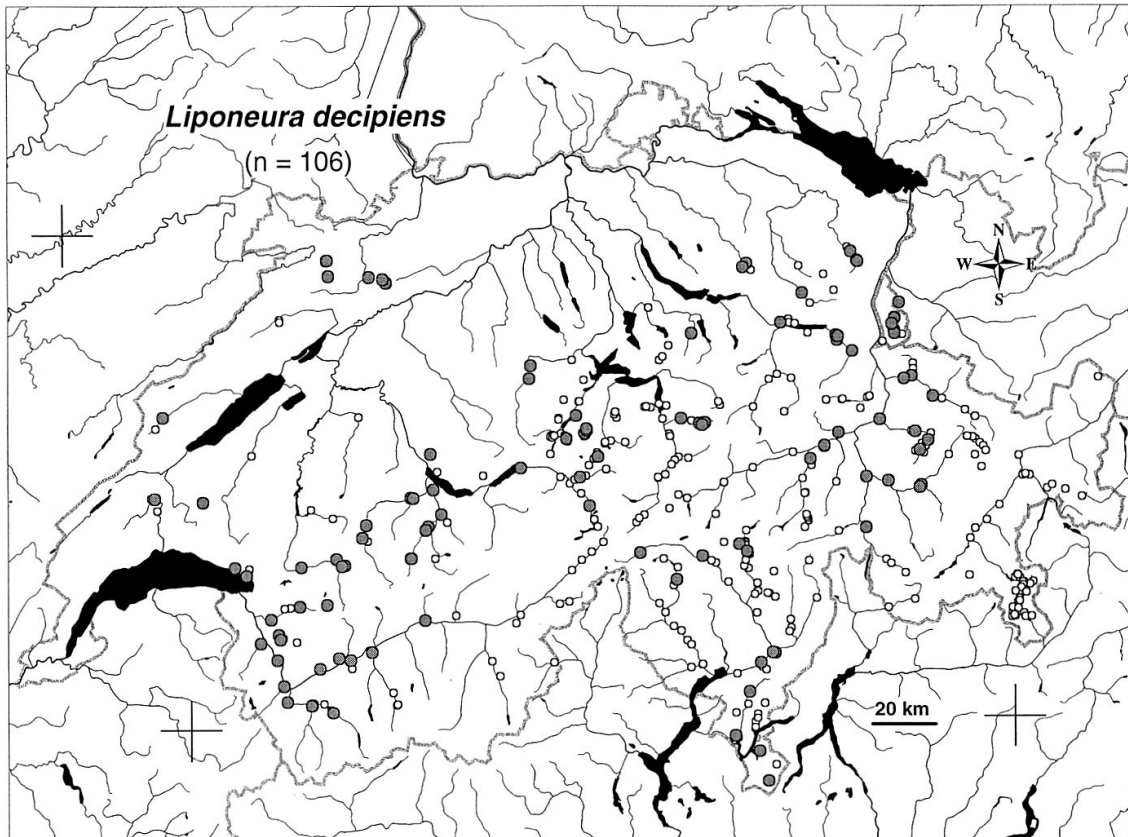


Fig. 4. Geographical distribution of *Liponeura decipiens*. For explanations see Fig. 2 (reproduced with the permission of the Federal Office of Topography from Aug. 13, 1997).

In the present study, *H. lugubris* was restricted to intermediate altitudes. It was not found below 424 or above 1960 m. In the French Alps it occurred only between 590 and 1800 m (VAILLANT, 1968). An elevation of ca. 1960 m probably represents the upper limit of this species, since this value corresponds well with the highest altitude of *H. lugubris* recorded (LOEW, 1876). The lowest elevation, however, where *H. lugubris* occurred in this study (424 m), is unlikely to be the absolute lower limit of its distribution since it was found at 310 m by HETSCHKO (1919) and even at 220 m by MANNHEIMS (1935). In Switzerland, such low sites are either too far (north) from the central Alps to be colonized by *H. lugubris*, or they are too warm and, in most cases, severely used for hydroelectric power production (e.g. rivers Ticino, Brenno, Maggia) and thus unsuitable for this species.

Due to its zoogeographical constraints and its thermophily (GULICKA, 1966; VAILLANT, 1968, ZWICK, 1980), *B. fasciata fasciata* is limited to regions south of the Alps where it occurs in the lower reaches of larger rivers (e.g. Melezza, Maggia, Ticino). In Switzerland it is not found above 450 m. In more southern (i.e. warmer) regions of Europe, however, it attains altitudes up to 1000 m (VAILLANT, 1968, GIUDICELLI & LAVANDIER, 1974).

Tab. 2 provides an analysis of the co-occurrence of the different blepharicerid species. It shows the number and percentage of sites with certain species combinations. The table is sorted according to the number of sites. A total of 20 differ-

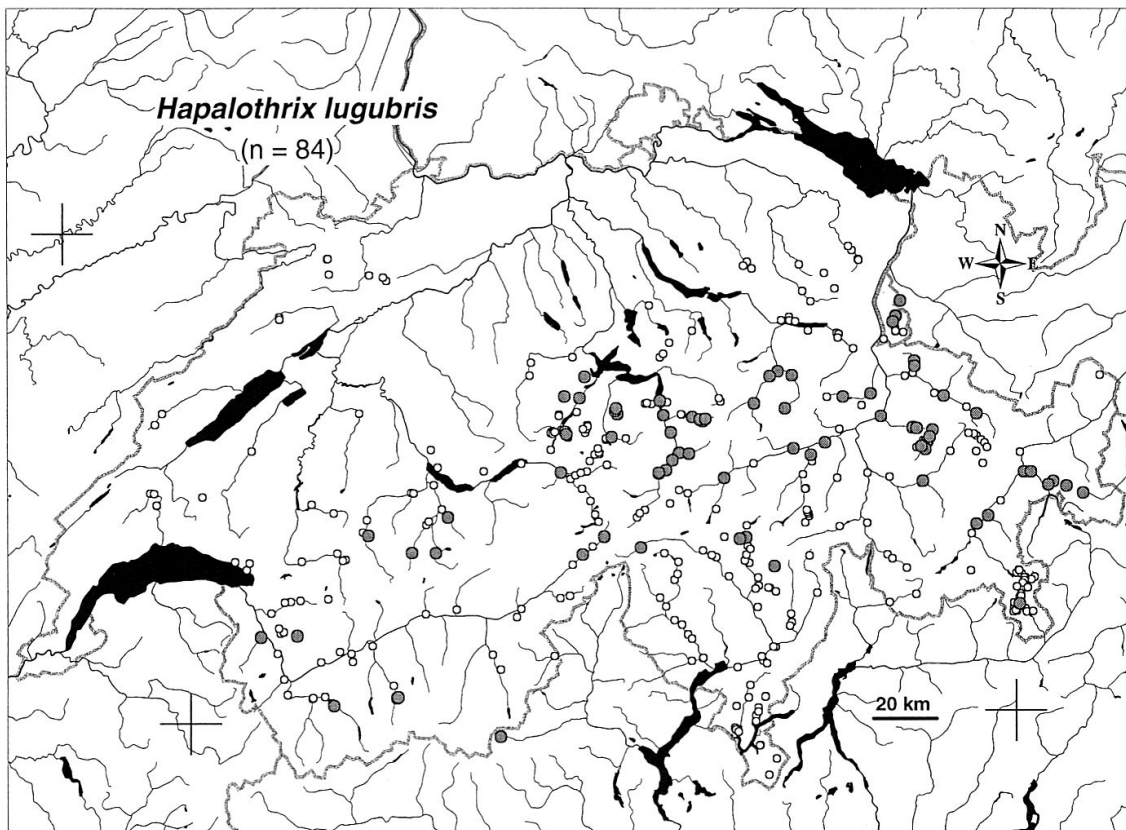


Fig. 5. Geographical distribution of *Haplothrix lugubris*. The site east of Monte Rosa (bottom, just outside of the Swiss border), where this species was found the first time on July 11, 1876 (LOEW, 1876) is also shown, although it is otherwise not included in this study. For explanations see Fig. 2 (reproduced with the permission of the Federal Office of Topography from Aug. 13, 1997).

ent species combinations were found. The table reveals that at 202 sites (61.8% of all sites with blepharicerids) only one species was present. 72 sites (22.0%) were colonized by two species. Three species occurred at 36 sites (11.0%) and 4 species where found at 17 sites (5.2%).

*L. cinerascens minor* occurred most often alone (at 30.3% of all sites), followed by *H. lugubris* (11.0%), *L. cordata* (10.4%) and *L. decipiens* (8.9%). Also, *L. cinerascens minor* was the only species that occurred more often alone than together with other species; 52.7% of all sites with *L. cinerascens minor* were colonized only by this species. This can be explained, at least partly, by its sole occurrence at altitudes above ca. 2000 m. *L. cordata* and *L. decipiens*, on the other hand, showed an almost complete overlap in their altitudinal distribution, and consequently represent the most frequently found “two-species community”.

According to our field experience, it is unlikely that a site is inhabited exclusively by *H. lugubris*. In the present study, however, this situation was found at 36 sites. We think that this is mainly an artifact due to the following two reasons: 1) about half of these 36 sites were sampled only once during winter (September to February) when *Liponeura* larvae are rarely present; and 2) *H. lugubris* was reported from ca. 20 sites together with other blepharicerids that were not determined to a

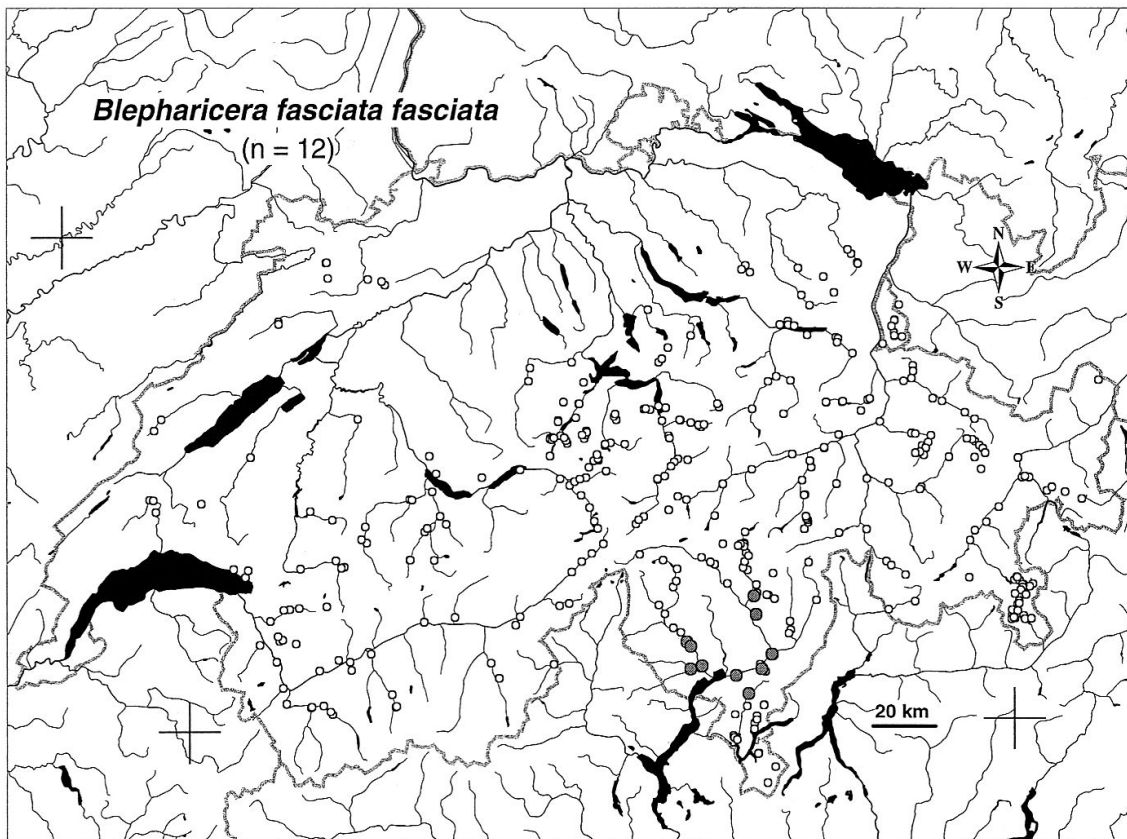


Fig. 6. Geographical distribution of *Blepharicera fasciata fasciata*. For explanations see Fig. 2 (reproduced with the permission of the Federal Office of Topography from Aug. 13, 1997).

lower taxonomic level. These reports (“Blephariceridae undetermined”) were not used in this study to calculate co-occurrence. It is quite likely that in some of these cases *Liponeura* species were a component of these undetermined blepharicerids.

In summary, this study confirms that net-winged midges are quite widespread in Switzerland and Liechtenstein. They occur in all mountainous regions below ca. 2300 m, but are absent from the Swiss Plateau due to their rheosteny (sensu AMBÜHL, 1959). Temperature is the main factor controlling their altitudinal distribution (VAILLANT, 1968). The geographical as well as the altitudinal distribution of four species (all three *Liponeura* species and *H. lugubris*) overlap to a large degree. Except for *H. lugubris* and *B. fasciata fasciata*, which were never found together at the same site, coexistence may occur between all species.

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Tab. 2. Co-occurrence of the five blepharicerid species that are found in Switzerland.

<i>L. cinerascens minor</i>	+					+	+	+	+	+	+						+	+				+	
<i>L. cordata</i>			+			+	+	+	+					+	+				+			+	+
<i>L. decipiens</i>					+	+	+	+			+								+	+	+	+	+
<i>H. lugubris</i>		+						+			+	+	+						+	+	+		
<i>B. fasciata fasciata</i>														+	+	+						+	+
n species	1	1	1	1	2	3	4	2	2	2	3	2	1	2	3	3	3	3	2	3	4		
sites [n]	99	36	34	29	22	20	16	15	12	12	9	6	4	4	2	2	2	1	1	1			
% of sites	30.3	11.0	10.4	8.9	6.7	6.1	4.9	4.6	3.7	3.7	2.8	1.8	1.2	1.2	0.6	0.6	0.6	0.3	0.3	0.3			

## ZUSAMMENFASSUNG

*Faunistik und Höhenverteilung der Netzflügel­mücken (Diptera: Blephariceridae) in der Schweiz und in Liechtenstein.* – In der Schweiz gibt es fünf Arten Netzflügel­mücken (Diptera: Blephariceridae). Sie sind recht häufig und kommen in allen gebirgigen Gegenden vor (d.h. in den Alpen, den Voralpen und im Jura). *Liponeura cinerascens minor* ist die häufigste Art, gefolgt von *L. cordata*, *L. decipiens*, *Hapalothrix lugubris* und *Blepharicera fasciata fasciata*. Im Jura findet man nur *Liponeura*-Arten. *H. lugubris* ist auf die Alpen beschränkt, und die thermophile Art *B. fasciata fasciata* kommt nur in den Unterläufen grösserer Bäche des Kantons Tessin vor. *L. cinerascens minor* wurde in Höhen zwischen 300 und 2270 m (Median: 1120 m) gefunden. Die entsprechenden Werte für die anderen vier Arten sind: *L. cordata*: 198–1652 m (700 m); *L. decipiens*: 236–1780 m (730 m); *H. lugubris*: 424–1960 m (995 m); *B. fasciata fasciata*: 198–450 m (271 m). 61.8 % aller untersuchten Stellen waren nur mit einer Blephariceridenart besiedelt. Zwei Arten zusammen wurden bei 22.0 % der Stellen gefunden, drei Arten zusammen bei 11.0 %, und vier Arten zusammen bei 5.2 % der Stellen. *H. lugubris* und *B. fasciata fasciata* kamen an keiner Stelle gemeinsam vor.

## RÉSUMÉ

*Faunistique et zonation verticale des blépharicérides (Diptera: Blephariceridae) en Suisse et au Liechtenstein.* – La Suisse compte 5 espèces de Blephariceridae. Elles occupent toutes les régions de montagne: les Alpes, les Préalpes et le massif du Jura. *Liponeura cinerascens minor* est l'espèce la plus fréquente, suivie de *L. cordata*, *L. decipiens*, *Hapalothrix lugubris* et *Blepharicera fasciata fasciata*. Les cours d'eau Jurassiens n'abritent que des espèces de *Liponeura*. L'espèce *H. lugubris* occupe uniquement la Suisse centrale (les Alpes, essentiellement) alors que *B. fasciata fasciata*, espèce thermophile, ne se rencontre que dans les régions les plus méridionales de Suisse. *L. cinerascens* se rencontre à des altitudes variant de 300 à 2270 m, l'altitude médiane étant de 1120 m. Pour les autres espèces, les valeurs sont les suivantes: *H. lugubris*: 424–1960 m (995 m); *L. decipiens*: 236–1780 m (730 m); *L. cordata*: 198–1652 m (700 m); *B. fasciata fasciata*: 198–450 m (271 m). Le nombre d'espèces recensées atteint un pour 61.8 % des stations, deux pour 22.0 % des stations, trois pour 11.0 % des stations et quatre pour seulement 5.2 % des stations. Les espèces *H. lugubris* et *B. fasciata fasciata* ne cohabitent dans aucune des stations visitées.

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