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Faunistic Characterisation of Alpine Springs in the Swiss National Park

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Abstract

Springs are unique ecosystems for highly adapted organisms that are endangered by anthropogenic impacts. Alpine springs are even more special as species have to adapt to lower temperatures and a short growth season during summer. The springs in the Swiss National Park have not been influenced by anthropogenic impacts since 1914, when the park was founded. In 1942 the only complete faunistic study of springs in the Swiss National Park was realised. A new monitoring of these unaffected alpine springs is of special interest today. In this Master's project 20 springs of the Swiss National Park were characterised. In early summer and autumn 2012 the springs were mapped and physiochemical parameters were measured. The macroinvertebrates were sampled quantitatively with a surber-sampler and qualitatively by hand-picking. Results show that Diptera, Trichoptera and Plecoptera are the most diverse orders. Within these orders cold-stenothermal species with alpine altitudinal preferences and endemic species were found. They are partly endangered or at least vulnerable in Switzerland. This underlines the importance of protected areas as refuges for endangered species living in endangered habitats such as springs. Moreover, a protection of the springs outside of the park would be desirable.

Keywords

Alpine springs, Swiss National Park, macroinvertebrates, endangered species

Introduction

Springs are ecotones between the groundwater and the surface water and provide a habitat for specialised organisms due to constant environmental conditions (VAN DER KAMP 1995; GERECKE & FRANZ 2006). Due to environmental changes and anthropogenic impacts springs are highly endangered. In Switzerland only few springs still remain in a natural condition (ZOLLHÖFER 1997). Alpine springs are sensitive habitats as they often exhibit a high degree of individuality (BONETTINI & CANTONATI 1996) and usually have a small spatial extent (CANTONATI & ORTLER 1998). A comprehensive review of alpine springs is given by CANTONATI et al. (2006), recent studies on alpine springs in Switzerland are rare (but see e.g. WEBER 2004; ROBINSON et al 2008).

The Swiss National Park (SNP) was founded in 1914 and has been subject to total nature protection since then. As research is one of the main aims of the Park, the fauna and flora is well investigated. However, scientific research on springs in the SNP was mostly limited to chemical and physical parameters until now (NOLD & SCHMASSMANN 1955; DÖRING 2002). There is only one study from NADIG (1942), who intensively investigated five springs around Il Fuorn.

In this study 20 springs were investigated whereof 15 are situated within the borders of the Swiss National Park and five in the area of Buffalora. The spring fauna was quantitatively sampled and physico-chemical as well as structural parameters were monitored. An explicit aim was to provide an inventory of macroinvertebrates living in the studied springs. The main questions were (a) to determine the main abiotic factors influencing the macroinvertebrate assemblages of the springs within and outside of the SNP and (b) to assess the function of the SNP as a refuge for endangered species. This study gives a first comprehensive insight into the fauna of the springs around Il Fuorn in the Swiss National Park and the Alp Buffalora in the Biosfera Val Müstair.

Methods

The Swiss National Park is located in the southeast of Switzerland in the canton Grisons. The area of the park measures 172 square kilometres with an elevation of 1400 to 3174 m a.s.l.. Fifteen of the investigated springs are situated within the park borders around the hotel Il Fuorn (Val Ftur, God dal Fuorn, Val Chavagl, Val Brüna), five springs are located in the region Buffalora in the biosphere reserve Val Müstair. The geology in the study area consists of limestone (TRÜMPY et al. 1997). The altitudinal range varies from 1770 m to 2255 m a.s.l.. This alpine to subalpine area is covered by snow up to 9 months a year. The mean precipitation at Buffalora is 793 mm/a (1968 m; MeteoSchweiz). The average annual air temperature reaches 0.7° C, whereupon temperatures vary between -9.2 °C during winter and 10.3° C during summer. Since 1990 increasing temperatures have been measured (KETTERER & HALLER 2009). The studied springs all flow into the Ova dal Fuorn that feeds the river Spöl.

All springs were sampled twice, in early June and late September 2012. Of each spring four quantitative samples were taken with a small surber-sampler (10 x 10 cm; 500 µm mesh) and preserved in 70% ethanol. Additionally the springs were sampled by hand-picking. The samples were sorted in the laboratory and the specimens were determined to species level whenever possible. Water temperature, pH, oxygen (mg/l, %), and electrical conductivity were measured using portable meters (WTW, Weilheim, Germany). The springs were mapped and evaluated based on the manual of Lubini et al. (2009).

All statistical analyses were calculated using PRIMER 6.0 (Clarke & Gorley 2006). The statistical analysis of the faunistic data was performed with the data of the quantitative sampling. For the faunistic data the Bray-Curtis similarity and a log (x+1) – transformation were used. Abiotic data was normalized and the Euclidian distance was used as similarity measure. Ordination of the springs was conducted using non-metric multidimensional scaling (nMDS). The analysis of similarities-procedure (ANOSIM), which is analogous to an ANOVA, but relies on a similarity matrix and makes few assumptions on the data was used for testing the grouping of the springs. Additionally a principal components analysis was performed with the abiotic data in order to extract the most important substrate types characterizing the springs.

Results

The water temperature in the springs varied from 3.0 °C (BUF3) to 7.0 °C (LIM) during the summer sampling (mean: 5.1 °C). The temperature amplitude was between 0.1 (GF3, LIM) and 4.7 (BUF4). The pH ranged from 7.2 (Q2) to 8.9 (VCh2) and the electrical conductivity from 107 µS/cm (BUF3) to 575 µS/cm (GF1). The only limnocrene spring had a very high electrical conductivity (1511 µS/cm). The oxygen concentration varied from 4.6 mg/l (GF2) to 10.0 mg/l (OFb2) and the saturation from 47% to 98%. The limnocrene had very low values with an oxygen concentration of 0.3 mg/l (3%). Discharge varied from 2 L/min (Buf2) to 144 L/min in VCh3 (Tab. 1). Several springs had a much lower discharge in autumn (VCH2, GF1-GF3, BUF1), and spring BUF5 did not show any surface flow in autumn. Most springs were rheocrenes. The springs Q4, GF1 and BUF5 were grouped as helocrenes and BUF1 and LIM are typical limnocrenes.

Table 1: Abiotic characteristics of the investigated springs. Electrical conductivity and oxygen content and saturation are given as means of two measurements. *: the physico-chemistry of Buf5 was monitored once, the pH is therefore a single measurement

Site	Area	Altitude [m]	pH [median]	conductivity [µS/cm; 25°C]	O_2 [mg/l]	O_2 [%]	discharge [l/min]	temperature [°C; summer]	temperature [°C; autumn]	no of substrates
Q1	Val Ftur	1832	7,9	273	8,1	96	9,6	5,0	5,3	5
Q2	Val Ftur	1920	7,4	328	7,5	93	3,6	5,7	6,7	7
Q3	Val Ftur	1960	7,8	286	8,1	96	6,0	4,5	4,8	6
Q4	Val Ftur	1900	8,2	275	7,7	93	9,6	5,2	5,4	4
Q5	Val Ftur	1780	8,0	275	9,6	95	36,0	5,2	5,7	6
FiW	Val Ftur	1770	7,6	319	6,9	84	3,6	4,4	6,7	4
Q6	Val Chavagl	1975	8,3	240	9,5	93	24,0	3,0	4,8	7
Q7	Val Chavagl	1965	8,5	266	8,9	87	9,6	4,0	4,7	6
Q8	Val Chavagl	1845	8,1	276	9,6	94	144,0	3,0	5,2	5
GF1	God dal Fuorn	1800	8,3	575	6,6	68	3,6	5,2	7,0	8
GF2	God dal Fuorn	1802	8,2	324	4,6	47	4,2	3,8	6,5	8
GF3	God dal Fuorn	1805	8,0	226	8,0	79	4,2	5,9	6,0	5
Lim	God dal Fuorn	1822	7,5	1511	0,3	3	16,8	7,0	6,9	4
Buf1	Buffalora	2177	7,6	161	7,7	79	14,4	4,9	5,2	5
Buf2	Buffalora	2176	7,7	213	8,4	91	1,8	4,4	7,4	6
Buf3	Buffalora	2255	8,3	107	9,5	93	16,8	2,8	3,0	4
Buf4	Buffalora	2163	7,9	259	6,8	73	5,4	2,7	7,4	7
Buf5	Buffalora	1980	7.9*	-	-	-	6,0	4,4	-	7
OFb2	Buffalora	1960	8,1	185	10,0	98	78,0	4,4	4,6	7

In the 20 springs 70 taxa were identified altogether, of which 46 taxa were determined to species level (Tab. 2, see appendix, p. 189-190). The most diverse order were Diptera (20 taxa), Trichoptera (17 taxa), and Plecoptera (12 taxa). Less diverse were Gastropoda (11), Coleoptera (4), and Ephemeroptera (2). Only one taxon appeared in the orders of Turbellaria, Oligochaeta, Bivalvia, Acari and Ostracoda. A rather high diversity is, however, expected within the Acari, of which the results are not yet available. Among the EPT-taxa (Ephemeroptera, Plecoptera, Trichoptera) 15 of 26 species are listed on the Red List (Lubini et al. 2012). *Nemoura undulata*, a species highly isolated and threatened with extinction, was found in the highest situated spring of the study on the Alp Buffalora. *Acrophylax zerberus*, a near endemic species (Oertli et al. 2008), *Drusus melanchaetes*, *Drusus nigrescens* and *Rhyacophila bonaparti* are vulnerable species of the Trichoptera. Also the molluscs *Quickella arenaria*, *Vertigo genesii* and *Truncatellina monodon* show a restricted distribution.

The principal components analysis (PCA) conducted with the abiotic data showed that the PC axes one and two explained 32 and 21% of the variance, respectively. The first three PC axes together explained 71% of the variance. Component one is dominated by the oxygen concentration on the positive axis and by the electrical conductivity on the negative axis. Component two is dominated by the number of substrates and the temperature amplitude on the positive axis. The limnocrene shows a very high loading on the negative axis of PC1 as it had a very high electrical conductivity.

The nMDS-diagram shows a rather homogeneous composition of the macroinvertebrate fauna in the springs with the limnocrene and the highest spring BUF3 being the most different. The analysis of similarities (ANOSIM) provided overall significant differences between the sampling sites (R: 0.293, p: 0.007). The differences between the springs in the Val Chavagl and around God dal Fuorn were highest (R: 0.778) (Fig. 1).

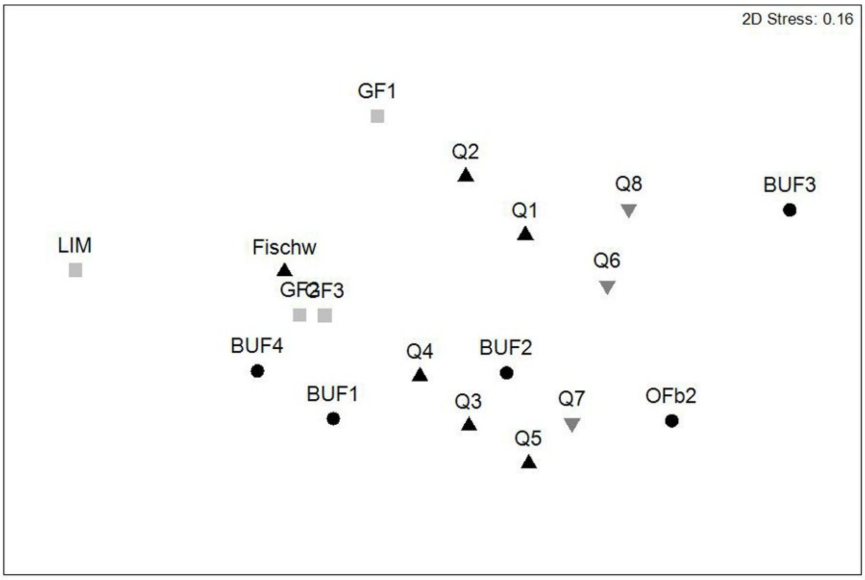

Figure 1: Non-metric multidimensional scaling (nMDS) of the investigated springs based on the average of the faunistic data; similarity index: Bray-Curtis, transformation: log (x+1); factor: area; ▼ = Val Chavagl; ■ = God dal Fuorn; ▲= Val Ftur; ● = Buffalora; Analysis of Similarities (ANOSIM) with area as discriminating factor: R = 0.293, p = 0.007.

Discussion

Electrical conductivity was determined as the main environmental factor differentiating the springs. This is mostly due to the high electrical conductivity of the limnocrene, which was also reported by DÖRING (2002) and NADIG (1942). It also had extremely low oxygen concentrations emphasizing the special character of this spring. It differs morphologically from the other springs due to its large size (62 m^2) and the depth of the pond (2.1 m) (NADIG 1942). Extreme conditions are also indicated by high sulphate concentrations measured by NADIG (1942) and also by DÖRING (2002). Apart from this limnocrene spring the abiotic parameters showed moderate differences between the sampled springs. The studied area provides similar environmental conditions for the macroinvertebrates as all springs are situated on the same geological layer. The altitudinal difference between the lowest and highest spring is less than 500 m. However, all springs in the area of the Alp Buffalora outside of the SNP are above the tree line minimizing the input of leaf-litter as an important food-source.

Comparisons with the red list of molluscs (RÜETSCHI et al. 2012) and of the Ephemeroptera, Plecoptera and Trichoptera (LUBINI et al. 2012) showed that the SNP is an important nature protection zone. Most of the identified gastropods are not vulnerable terrestrial species. The two endangered species which were found are both associated with wet conditions occurring on meadows, bogs and also next to springs (BOSCHI 2011). *Quickella arenaria* is vulnerable due to its fragmented habitat in the Alps. Concerning climate change this species might be replaced by more common species such as *Succinella oblonga* (TURNER et al. 1998). *Vertigo genesii* shows its main distribution in the canton Grisons. *V. genesii* is an endemic species for Switzerland (TURNER et al. 1998) and highly endangered (BOSCHI 2011). According to WARINGER & GRAF (2011) *Drusus melanchaetes* and *Drusus nigrescens* are endemic Trichoptera for the western Alps, with *D. melanchaetes* being restricted to an altitudinal distribution between 1960 m and 2560 m (MALICKY 2004). In the Swiss National Park they probably reach the eastern border of their distribution area. The species of the Drusinae are generally often restricted to small distribution areas and are typical cold-stenothermic species, which only occur in water bodies with a high water quality and constant low water temperatures. They are therefore valuable bioindicators (GRAF et al. 2002; WARINGER & GRAF 2011). Overall, six different species of the genus Drusus were found in this study, most of them in the small Val Ftur. Among the Trichoptera listed as vulnerable many spring specialists are found (LUBINI et al. 2012). The highly endangered Plecoptera *Nemoura undulata* is an endemic species of the central Alps above 1800 meters and only appears in isolated patches in Switzerland (LUBINI et al. 2012). Two specimens of *Nemoura undulata* were also detected in the Berchtesgaden National Park in Germany (GERECKE & FRANZ 2006) but not in the Gesäuse National Park in the eastern part of Austria (GERECKE et al. 2012).

On the one hand similar species assemblages were detected in the investigated springs. On the other hand many of the endangered or vulnerable species only occurred in one single spring. This underlines the high individuality of the fauna of the sampled springs. It is therefore likely for species to go extinct if springs get damaged or polluted. This is especially true for the springs at Alp Buffalora outside of the SNP, which are at least potentially threatened by anthropogenic impacts. Moreover, the study revealed a grouping of the springs according to the valley or area they are situated. This higher similarity of the macroinvertebrate assemblages of neighboured springs hints at the restricted dispersal abilities of spring species. The study stresses the importance of protected areas as refuges for endangered species living in unique habitats such as springs.

Conclusion

In the high altitudinal springs within the Swiss National Park rare species occurring in low abundances were found that are endangered of extinction if springs get disturbed. Compared to other alpine regions, the springs in the SNP are totally protected and suffer only minor anthropogenic impact. Considering Global Change and anthropogenic impacts the SNP provides a valuable refuge for the crenobiontic and cold-stenotherm fauna in an alpine area. Moreover, a protection of the springs outside of the park, especially in the Biosfera Val Müstair, would be desirable as they are also inhabited by endangered species.

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Tab. 2: List of presence (+) and absence (-) of the 70 taxa at each investigated site.

	Q1	Q2	Q3	Q4	Q5	FiW	Q6	Q7	Q8	GF1	GF2	GF3	LIM	BUF1	BUF2	BUF3	BUF4	BUF5	OFb2
Turbellaria																			
Crenobia alpina (Dana, 1766)	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+
Oligochaeta	-	+	+	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+
Gastropoda																		-	
Galba truncatula (Müller, 1774)	-	+	-	-	-	+	-	-	-	+	+	-	+	-	+	-	+	+	-
Cochlicopa cf. lubrica (Müller, 1774)	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
Euconulus fulvus (Gray, 1840)	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Trochulus cf. sericeus (Draparnaud, 1801)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Punctum pygmaeum (Draparnaud, 1801)	-	+	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-
Pyramidula pusilla (Vallot, 1801)	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Quickella cf. arenaria (Bouchard-Chanteraux. 1837)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Columella cf. edentula (Draparnaud, 1805)	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Truncatellina monodon (Held, 1837)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vertigo genesii (Gredler, 1856)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nesovitrea petronella (Pfeiffer, 1853)	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+
Bivalvia																		-	
Pisidum cf. personatum (Malm, 1855)	-	-	-	-	-	+	-	-	-	-	+	+	+	+	-	-	+	+	-
Acari	-	-	+	+	-	+	+	-	-	-	+	-	-	+	+	-	+	+	+
Ostracoda	-	-	-	+	-	+	-	-	-	+	+	+	-	+	+	-	+	-	-
Ephemeroptera																		-	
Baetis alpinus (Pictet, 1843)	+	-	-	-	-	-	-	-	+	-	-	+	-	+		-	-	-	+
Rhithrogena loyolaea (Navas, 1922)	-	+	-	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-
Plecoptera																		-	
Leuctra armata (Kempny, 1899)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Leuctra gr. braueri-muranyii	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-
Leuctra cf. rosinae (Kempny, 1900)	-	-	-	-	+	-	-	+	+	-	-	-	-	-	-	+	-	-	-
Amphinemura sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Nemoura cinerea (Retzius, 1783)	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Nemoura mortoni (Ris, 1902)	-	-	-	+	-	-	-	-	-	-	-	-	-	+	+	-	+	+	+
Nemoura cf. sinuata (Ris, 1902)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Nemoura undulata (Ris, 1902)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Nemurella pictetii (Klapalek, 1900)	+	-	-	-	-	+	-	-	-	+	+	+	-	+	+	-	+	+	-
Protonemura cf. lateralis (Ris, 1902)	+	-	-	+	+	+	-	+	+	-	-	-	-	+	+	-	-	-	+
Dictyogenus alpinum (Pictet, 1841)	-	+	+	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Isoperla rivulorum (Pictet, 1841)	-	-	-	-	+	+	-	-	+	-	-	-	-	-	+	-	-	-	+
Coleoptera																		-	
Agabus bipustulatus (Linnaeus, 1767)	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroporus sp	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haliplus lineatocollis (Marsham, 1802)	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnebius sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-

	Q1	Q2	Q3	Q4	Q5	FiW	Q6	Q7	Q8	GF1	GF2	GF3	LIM	BUF1	BUF2	BUF3	BUF4	BUF5	OFb2
Trichoptera																			
Beraea pullata (Curtis, 1834)	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
Lithax niger (Hage, 1859)	-	+	+	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	+
Acrophylax zerberus (Brauer, 1867)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Chaetopterygini/Stenophylacini	-	-	+	+	-	-	-	+	-	-	-	+	-	-	+	-	-	-	+
Consorophylax consors (McLachlan 1880)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drusus biguttatus (Stephens, 1837)	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drusus chrysotus (Rambur, 1842)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drusus discolor (Rambur, 1842)	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drusus melanchaetes (McLachlan, 1876)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Drusus monticola (McLachlan, 1876)	+	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Drusus nigrescens (Meyer-Dür, 1875)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnephilus coenosus (Curtis, 1834)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Parachiana picicornis (Pictet, 1834)	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-
Plectrocnemia conspersa (McLachlan, 1871)	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Rhyacophila bonaparti (Schmid, 1947)	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhyacophila glareosa (McLachlan, 1867)	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhyacophila sensu stricto	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diptera																			
Ceratopogoninae	-	+	-	+	-	+	-	-	-	+	+	-	+	+	+	-	+	-	+
Chironomidae	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Prodiamesa olivaceae (Meigen, 1818)	-	-	-	-	-	+	-	-	-	-	+	-	+	+	-	-	+	-	-
Tanypodinae	-	-	+	+	+	+	-	-	-	-	+	+	-	-	+	-	+	-	-
Chironomini	-	-	-	+	-	-	-	-	-	+	+	+	+	+	-	-	+	-	-
Tanytarsini	+	+	+	+	-	+	+	+	-	+	+	+	+	+	+	-	+	-	+
Culcididae	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Dixa sp.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dolichopodidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Clinocerinae	-	-	+	-	+	-	-	-	+	-	-	-	-	-	+	-	-	-	-
Limoniinae	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dicranota sp.	-	-	+	+	-	-	-	+	+	-	+	-	-	+	+	-	-	-	-
Eleophila sp.	+	-	-	-	-	+	-	-	-	+	-	+	-	+	+	-	-	-	-
Psychodidae	-	-	+	+	-	-	-	-	-	-	+	-	-	-	+	-	+	-	-
Oxycera cf. pardalina (Meigen, 1822)	+	-	+	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-
Oxycera cf pseudoamoena (Dusek & Rozkosny, 1974)	+	+	+	+	+	-	-	-	-	-	-	-	+	-	+	-	-	-	-
Oxycera rara (Scopoli, 1783)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Thaumalea sp.	-	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Tipula sp.	+	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Number of Species	14	22	21	18	14	20	7	9	12	16	18	15	11	20	24	4	17	10	15