Freshwater macroinvertebrates of the Piora Valley (Canton Ticino, Switzerland)

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Abstract. The Piora Valley is particularly rich in water. The presence of 21 lakes, 28 ponds, 14 bogs, and 58 streams has been recorded. This work presents the results of a field survey that took place in July 2010, during the "48h of biodiversity" event. Samples were taken with a kicknet in seven streams and one spring to survey their macroinvertebrate fauna and add new species to the already existing faunistic lists. This campaign took also in consideration, for the first time, Chironomids and Oligochaetes. The eight sampling locations included a wide spectrum of aquatic environments: a spring, first and second degree brooks, the main river of the valley, as well as the in- and outlet of Lake of Cadagno. These samples resulted in 23 different EPT taxa (4 Ephemeroptera, 6 Plecoptera, and 12 Trichoptera), as well as 12 taxa of Chironomids - with the subfamily Orthocladiinae being the best represented- and 5 taxa of Oligochaetes. EPT were well represented, with 9 new taxa added to the previous lists (2 Ephemeroptera, 2 Plecoptera, 5 Trichoptera). The Chironomidae wera also well represented, while Oligochaeta were scarce.

Macroinvertebrati di ambienti d'acqua dolce della Val Piora (Cantone Ticino, Svizzera)

Riassunto. La regione della Val Piora è particolarmente ricca di acque: risultano infatti censiti 21 laghi, 58 corsi d'acqua, 28 stagni e 14 bolle. Questo lavoro presenta i risultati di un campionamento condotto nel mese di luglio 2010, durante le "48 ore della biodiversità", tramite retino immanicato (kicknet), in sette corsi d'acqua e una sorgente della Val Piora, per analizzare la composizione della fauna di macroinvertebrati e ampliare il precedente elenco faunistico. Questo campionamento costituisce il primo risultato su due gruppi non ancora considerati nell'area di studio: i Ditteri Chironomidi e gli Oligocheti. Gli otto siti scelti per il campionamento comprendono una serie di ambienti acquatici: una sorgente, corsi d'aqua di primo e secondo grado, il corso d'acqua principale della valle, come pure l'immissario e l'emissario del Lago Cadagno. Tali campioni hanno permesso di approfondire le conoscenze sulla fauna macroinvertebrata, contribuendo alla raccolta di 23 differenti taxa di EPT (4 Ephemeroptera, 6 Plecoptera e 12 Trichoptera), nonché 12 taxa di Ditteri Chironomidi con la sottofamiglia delle Orthocladiinae come entità più rappresentata e 5 taxa di Oligocheti. Il gruppo degli EPT era ben rappresentato, con 9 nuovi taxa aggiunti alle liste faunistiche precedenti (2 Ephemeroptera, 2 Plecoptera, 5 Trichoptera). I Chironomidi, erano pure ben rappresentati, mentre gli Oligocheti erano scarsi.

Keywords: southern Swiss Alps, high altitude insects, Ephemeroptera, Plecoptera, Trichoptera, Chironomidae, Oligochaeta.

INTRODUCTION

Biodiversity is the result of the historical (evolutionary) and dynamical (ecological) processes of each biome and is one of the major concerns of present time conservation efforts. The study of all aspects of simplified but not simple biomes, such as remote ones, represents an important tool for assessing the reliability, resilience and the conservation of freshwater ecosystems, and a valuable support in order to maintain their integrity.
Streams fed by snowmelt waters represent our last resource of freshwater for the future, and for this reason more attention should be paid by the scientific community, but also by public administration, to the conservation of such ecosystems. Freshwater fauna is typically represented by zooplankton and benthic fauna (macroinvertebrates) adapted to extreme physical and chemical environments such as those found at high altitude. Alpine aquatic ecosystems, hosting zoobenthic communities, simplified in structure and function, exhibit high resilience and may thus be used as early warning systems. Invertebrates of harsh mountain freshwater environments such as aquatic ecosystems of high altitude and latitude, are of extreme importance as source of biodiversity at lower altitude, and are a key factor in revealing environmental changes of natural or anthropic origin. In this context, researches on such ecosystems are nowadays frequent in mountain regions of Europe, Africa, Asia and North America.
The National Research Council - Institute for Ecosystem Study (CNR-ISE) of Pallanza has been involved in the "Days of Biodiversity" that took place in Val Piora, considered one of the Swiss "Landscapes of national importance" (DIPARTIMENTO FEDERALE DELL'INTERNO

Tab. 1 – Types of freshwater habitats considered in this study and their morphometric and environmental characteristics (s. fig. 1). N. of replicates = 8 for each site. * distance between the 2 sampling sites lower than GPS error.

Code	Zone	Swiss coordinates CH1903+		Geographic coordinates		Altitude
		N	E	N	E	m a.s.l.
1	Passo dell'Uomo	701'427	156'444	46° 33' 05"	08° 45' 40"	2010
2	Passo dell'Uomo	701.48	156'417	46° 33' 04"	08° 45' 42"	2008
3	Pian Murinascia	698.87	155.66	46° 32' 41"	08° 43' 39"	1980
4	Motti (Pizzo dell'Uomo)	701'916	155'275	46° 32' 27"	08° 46' 02"	2320
5A	Motti (Pizzo dell'Uomo)	*701.823	*155.271	46° 32' 27"	08° 45' 58"	2305
5B	Motti (Pizzo dell'Uomo)	*701.823	*155.271	46° 32' 27"	08° 45' 58"	2305
6	Inlet L. Cadagno	697'817	156'666	46° 33' 14"	08° 42' 51"	1945
7	Outlet L. Cadagno	697'159	155.99	46° 43' 53"	08° 42' 19"	1915

1977) due to floristic and zoological findings. Seven streams and one spring, undisturbed by human activity, located above the local timberline, were selected and sampled with a common protocol (Stucki 2010) in July 2010, in order to create a first list of macroinvertebrate species characteristic for stream ecosystems in the Piora Valley.
More knowledge of the response of species to different abiotic factors is required in order to distinguish the effects of chemical and climate conditions, from the natural variability affecting community structures. Therefore our main goal is to extend our studies to cover a wider spectrum of high altitude mountain environments in the same area.

STUDY AREA, MATERIALS AND METHODS

Freshwater fauna samples taken at 8 sampling locations were analyzed for species composition and zoogeographical distribution. The locations included a spring, springbrooks, first, second and higher order stretches (krenal and rhithral). Except for the spring region - where samples were picked by hand and by turning rocks - the benthic fauna was collected by means of kicknet sampling (net mesh size 250 µm). Eight replicates were taken for each location, on a stretch equivalent to 10 times its width. As there were no toponyms to identify the sampling sites, the authors assigned them a code, from 1 to 7.
The sampling stations differed by origin, granulometry, water flow and width (tab. 1, fig. 1). Granulometry was detected by direct observation of the river bed, flow speed by a float and stopwatch, and width and length were tape measured. Biological samples were fixed with 80% alcohol to preserve them for sorting and identification.
Ephemeropterans, Plecopterans and Trichopterans (afterwards referred to as EPT) were identified to species level, while Oligochaetes and Chironomids were identified to family/genus/groups of species. In some cases, Chironomids were not identified to species level, being the larval stage the only observed, while most taxonomic literature referred to pupae and adults.

RESULTS

In the eight sampling stations were found a total of 41 taxa, of which 7 were non-insects (15%) (appendix 1). Stations 5A and 7 were the most biologically diversified, while station 4 (spring) was scarcely inhabited, and stations 3 and 4 lacked Chironomids, Oligochaetes, Triclads and Molluscs.
In total, 4 taxa of Ephemeropterans, 6 of Plecopterans, 12 of Trichopterans, 12 of Chironomids, and 5 of Oligochaetes were identified from the sampled environments.

Ephemeroptera

Baetis alpinus is very widely distributed geographically - being present in the whole European continent (Belfiore 1983) - as well as altitudinally: in Switzerland it has been found at altitudes ranging from 200 to 2500 m a.s.l. (Studemann *et al.* 1992). It represents, together with *Rhithrogena loyolaea*, the colonisation species par excellence of extreme, high altitude environments. *R. loyolaea* has a smaller altitudinal range, being found in Switzerland between 1200 and 2900 m a.s.l. (Studemann *et al.* 1992). Two Heptagenidae species were recorded for the first time in Piora. *Ecdyonurus alpinus* is a strict alpine species, being found only above 1500 m a.s.l. in epi- and meta-rhithral streams and brooks, in crystalline rock environments (Sartori & Landolt 1999); it has been classified as near threatened (NT) by the Swiss Red List of EPT (Lubini *et al.* 2012). *Rhithrogena puthzi* is in general a still poorly known species of Switzerland: the altitudinal range given by the Atlas of the Fauna Helvetica (Sartori & Landolt 1999) is 600-1300 m a.s.l. well under 1980 m, where it was found during this study.

Plecoptera

The 3 Plecopteran taxa identified to species level (*Protonemura nimborum, Dictyogenus fontium, Isoperla rivulorum*) were already mentioned by Aubert (1959) among those living South of the Alps. *D. fontium*, new for the Piora region, is described for small and narrow brooks surrounded by pastures, with slow current and fine sediments, or for swampy mountain meadows. We recorded 1

Habitat	Substrate	Width	Estimated speed	Substrate cover
		m	m sec^{-1}	
2nd degree stream	cobbles+sand	1.5	0.5 - 0.25	epilitic diatoms, scarce vegetation
main stream	pebbles+cobbles	3.0	1.0 - 0.5	epilitic diatoms, scarce vegetation
main stream	pebbles+cobbles	3.5	1.0 - 0.5	epilitic diatoms, scarce vegetation
spring	pebbles+cobbles	0.5	< 0.25	absent
spring outlet, 1st degree stream	pebbles+cobbles+sand	0.5	0.25 - 0.05	absent
spring outlet, 1st degree stream	pebbles+cobbles+sand	0.5	0.25 - 0.05	absent
main stream	cobbles+gravel	0.4	0.25 - 0.05	epilitic diatoms, bryophytes
main stream+sand	cobbles+gravel	1.0	1.0 - 0.5	epilitic diatoms, vegetation absent

specimen in a larger river, but surrounded by an area like the one described by Aubert, so we presume that it is a drifted individual. This species has been classified as near threatened (NT) by the Swiss Red List of EPT (Lubini *et al.* 2012). *I. rivulorum* is a very common species for mountain areas above 1000 m (Aubert 1959): together with *P. nimborum* - also a new record for Piora - it inhabits main rivers and streams in the Alpine and Prealpine region. The width and flow rate of them may vary greatly, but usually they present a very fast flow, sometimes turbulent, and rocky shores that separate the river from the pasture.

Trichoptera

Of the Trichoptera, *Silo nigricornis* is a widely distributed species, being present in Central and Southern Europe, with an altitudinal range of 200-1300 m a.s.l. (Moretti 1983).
The genus *Rhyacophila* represents mainly rheophilic species, living in cold streams and brooks (Waringer & Graf 1997). Both species found in this survey, *R. intermedia* and *R. vulgaris*, have been already recorded in Piora in previous years. The same is true for *Philopotamus ludificatus*, a species characteristic of the epirhithral zone of stony brooks (Waringer & Graf, 1997).
Five of the 12 taxa identified in this study belonged to the family Limnephilidae. The subfamily Drusinae was represented by 3 species of the genus *Drusus*. *D. discolor*, already recorded in previous years, and 2 new species, both found in the spring (St. 4): *D. muelleri* recorded for the Swiss Alps between 1900 and 2450 m a.s.l. (Graf *et al.* 2005) and *D. nigrescens*, described as a western alpine species, present also in spring fed brooks (Waringer *et al.* 2007). As both species are endemic to the Alps, and live in natural springs which are a menaced environment, they have been classified as vulnerable (VU) by the Swiss Red List of EPT (Lubini *et al.* 2012).
Two species of the subfamily Limnephilinae are also new for the Piora region: *Consorophylax consor* was found also in the spring region (St. 4). While it is already known for Switzerland, this species was first recorded in Italy in the previously mentioned springs' survey (Maiolini *et al*, 2011), confirming its preference for this type of habitat. It has been classified as near threatened (NT) by the Swiss Red List of EPT (Lubini *et al.* 2012) On the other side *Pseudopsilopteryx zimmeri*, as well mentioned in the study by Maiolini *et al.* (2011), with an altitudinal range of 800-2800 m a.s.l., was recorded in the inlet of Lake Cadagno (St. 6).

Diptera Chironomidae

The subfamily Orthocladiinae was the most widely distributed among Chironomids, followed by Tanypodinae, Diamesinae and Chironominae. *Parametriocnemus stylatus* was in absolute the most abundant species, dominating St. 5 (A and B), while *Cricotopus annulator* and *Diamesa steinboecki* prevailed at St. 7. Rare species were: the Orthoclads *Corynoneura lobata, Heterotrissocladius marcidus, Parorthocladius nudipennis, Psectrocladius sordidellus* and *Tvetenia discoloripes/verralli*; the Chironominae *Micropsectra* sp. and *Microtendipes* pedellus and the Tanypodinae serie *Thienemannimyia*.
Parametriocnemus stylatus is typical of Alpine, Prealpine, and Appennine springs, brooks, streams (Rossaro 1982, Boggero & Lencioni 2006). In freshwater springs is also possible to find *Cricotopus annulator* and *Diamesa steinboecki*, known from the Alps, as recently found in pristine alpine and prealpine springs (Northern Italy) (Lencioni *et al.* 2011), the Pyrenees and the Swedish Lapland, at altitude above 1600 m a.s.l. (Casas & Vilchez-Quero 1993). The last one is a cold-stenothermic species characteristic of glacial streams and springs usually found at temperatures below 4 °C, feeding on periphyton. *Heterotrissocladius marcidus* and *Parorthocladius nudipennis* are as well characteristic of high altitude cold environments (Maiolini *et al.* 2006).

Annelida Oligochaeta

Four families were recorded: Lumbriculidae, found in high numbers, Naididae, Lumbricidae and Enchytraeidae. Lumbriculidae, with the genus *Stylodrilus*, were the commonest family, present in 4 out of 5 stations; Lumbricidae were represented in 2 out of 5 stations

Fig. 1 – Sampling stations for aquatic macroinvertebrates (s. tab. 1).

with *Eiseniella tetraedra*. Naididae with *Nais bretscheri* and *N. simplex* were found only at St. 7.
Stylodrilus (probably *heringianus*, the commonest species) is a cold water species generally found in oligotrophic environments (springs and lakes) of relatively small size with high oxygen content (Piguet & Bretscher 1913, Giani 1976), while generally, scraper-feeding organisms like Naididae preferred stony and sandy substrate, where the water speed provided sufficient oxygen supply. In particular, *Nais bretscheri* is typical of high-altitude waters, mostly of cool streams (Dumnicka & Boggero 2007). Enchytraeidae were mentioned, but not identified in the present paper, because of the still persistent taxonomic problems.

Fig. 2 – *Baetis sp.*, imago ♀ (© Catalogue photographique de Sandro Marcacci et Nadia Vuilleumier)

DISCUSSION AND CONCLUSIONS

Generally, high altitude streams are mainly represented by larval stage of insects and dominated by EPT and Dipterans. Spring and first order streams, above the timber line, are usually devoid of life, or poorly settled due to the scarce vegetation present along their banks, steep slopes, with river bed scarce in organic matter and specialised microhabitats. Among the identified species, *Stylodrilus* sp. (Lumbriculida), *Baetis alpinus* (Ephemeroptera) and *Protonemura nimborum* (Plecoptera) were the most widespread (4 out of 8 stations each), with *B. alpinus* being the most abundant. Moreover, *Stylodrilus* is certainly the most widespread oligochaetes as regard zoogeographic distribution, being present from lowland to high altitude lakes and streams all over the Holarctic region (Balian *et al.* 2008), while *B. alpinus* belongs to the most vertically distributed species of EPT (Studemann *et al.* 1992). *Rhithrogena loyolaea* is a very typical species for mountain streams, but the taxonomy of this genus has been defined as still "cryptic" by Vuataz *et al.* (2011). Although just 4 species were identified at the spring station, 3 of them are recorded in the Swiss Red List of EPT (Lubini *et al*, 2012), showing the critical situation of this kind of environment and the need for further study and effective protection.
Our results confirm that Trichoptera are the most species-rich EPT order in springs, although they were generally less abundant than Plecoptera in this study, while Chironomids prevail in quality and in quantity in streams, either inlets-outlets of lakes or spring-outlets. Oligochaetes, on the contrary, tend to be found in lateral ponds where lower flow, higher organic matter and finer substrata were found. Their scarcity in fact should be the signal of unfavourable environmental conditions or can be regarded as natural in springs, due to low organic content usually not present or poor in these environments where watershed weathering do not yet have any influence. In two days of sampling, it was possible to add 9 new taxa of EPT to the 26 previously known (CSCF faunistic lists).
Due to serious risks of loss of habitats undergone by cold water environments in relation with global climatic change, the authors foster as future needs to pair biological to chemical-physical sampling to relate presence and abundance of species to environmental factors, actually unknown, for a correct management of surface Alpine inland waters to preserve their integrity.

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Fig. 3 – *Isoperla rivulorum*, imago ♂ (© Catalogue photographique de Sandro Marcacci et Nadia Vuilleumier)

Fig. 4 – *Philopotamus ludificatus*, imago ♂ (© Catalogue photographique de Sandro Marcacci et Nadia Vuilleumier)

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Appendix 1 – List of taxa found in the present study divided per freshwater habitats represented by codes (codes as in table 1). **LR:** Red List. **CSCF:** Swiss Centre for Faunal Cartography. **N. of individuals found:** + (1-10); ++ (11-100).

Groups	Author	1	2	3	4	5A	5B	6	7	LR	CSCF
INSECTA											
Ephemeroptera											
Baetidae											
Baetis alpinus	Pictet, 1843		++	++		+		++			•
Baetis rhodani	(Pictet 1843)										•
Heptageniidae											
Edyonurus alpinus	Hefti, Tomka & Zurwerra 1987		+	++						NT	
Rhithrogena loyolaea	Navás 1922		+			+					•
Rhithrogena puthzi	Sowa 1984			+							
Leptophlebiidae											
Leptophlebia marginata	(Linnaeus 1767)										•
Plecoptera											
Chloroperlidae											
Siphonoperla montana	(Pictet 1841)										•
Leuctridae											
Leuctra sp.		+	+			++					
Nemouridae											
Nemoura sp.							+				
Nemoura sinuata	Ris 1902										•
Nemourella pictetii	(Klapàlek 1900)										•
Protonemura sp.								+			
Protonemura lateralis	(Pictet 1836)										•
Protonemura nimborum	(Ris 1902)	+		++		+		+			
Perlodidae											
Dictyogenus alpinus	(Pictet 1842)										•
Dictyogenus fontium	(Ris 1896)		+							NT	
Isoperla rivulorum	(Pictet 1841)				+						•
Perlodes intricatus	(Pictet 1841)										•
Trichoptera											
Beraeidae											
Beraea pullata	(Curtis, 1834)										•
Goeridae											
Lithax niger	(Hagen, 1859)										•
Silo nigricornis	(Pictet 1834)								+		
Limnephilidae											
indet.		+									
Allogamus uncatus	(Brauer 1857)										•
Anisogamus difformis	(McLachlan 1867)										•
Consorophylax consor	(McLachlan 1880)				++	+				NT	
Drusus chrysotus	(Rambur 1842)										•
Drusus discolor	(Rambur 1842)			+				+			•
Drusus monticola	McLachlan 1876										•
Drusus muelleri	McLachlan 1868				+					VU	
Drusus nigrescens	Meyer-Dür 1875				+	+				VU	
Limnephilus rhombicus	(Linnaeus 1758)										•
Prachiona picicornis	(Pictet 1834)										•
Potamophylax cingulatus	(Stephens 1837)										•
Pseudopsilopteryx zimmeri	(McLachlan 1876)							+			
Philopotamidae											
Philopotamus ludificatus	McLachlan 1878					+	+				•
Polycentropodidae											
Plectrocnemia conspersa	(Curtis 1834)								+		•
Rhyacophilidae											
Rhyacophila sp.		+							+		
Rhyacophila intermedia	McLachlan 1868							+			•
Rhyacophila tristis	Pictet 1834										•

Groups	Author	1	2	3	4	5A	5B	6	7	LR	CSCF
Rhyacophila vulgaris	Pictet 1834								+		•
Sericostomatidae											
Sericostoma personatum/flavicorne									+	(NT)	
Coleoptera				+							
indet.							+				
Dytiscidae											
Elmidae									++		
Diptera											
Blephariceridae								+			
Simuliidae				+		+		+			
Thaumaleidae								+			
Chironomidae											
Diamesa prob. steinboecki									+		
Zavrelimyia sp.		+				+					
Corynoneura lobata	Edwards 1924					+					
Cricotopus annulator	Goetghebuer 1927	+							++		
Heterotrissocladius marcidus	(Walker 1856)						+				
Parametriocnemus stylatus	(Kieffer 1924)					++	+				
Parorthocladius nudipennis	Kieffer & Thienemann 1908					+					
Psectrocladius sordidellus gr.									+		
Thienemannimyia sp.									+		
Tvetenia discoloripes/verralli						+					
Micropsectra sp.						+					
Microtendipes pedellus	(De Geer 1776)								+		
ENCHYTRAEIDA											
Enchytraeidae								+			
CRASSICLITELLATA											
Eiseniella tetraedra	(Savigny 1826)						+		+		
LUMBRICULIDA											
Stylodrilus sp.			+			+	+		+		
TUBIFICIDA											
Nais bretscheri	Michaelsen 1899								+		
Nais prob. *simplex*									+		
TRICLADIDA											
Crenobia alpina	(Dana 1766)					+	+				
CNIDARIA											
Hydridae									+		
Totali		**6**	**5**	**4**	**3**	**14**	**8**	**9**	**14**		
		0	**1**	**3**	**1**	**2**	**0**	**1**	**2**		
		6	**6**	**7**	**4**	**16**	**8**	**10**	**16**	**5 (6)**	**26**