

Macroinvertebrate Spatial Diversity Patterns of Shore Habitats in Italian High-Altitude Natural and Permanent Lakes and Ponds

Supplementary Information

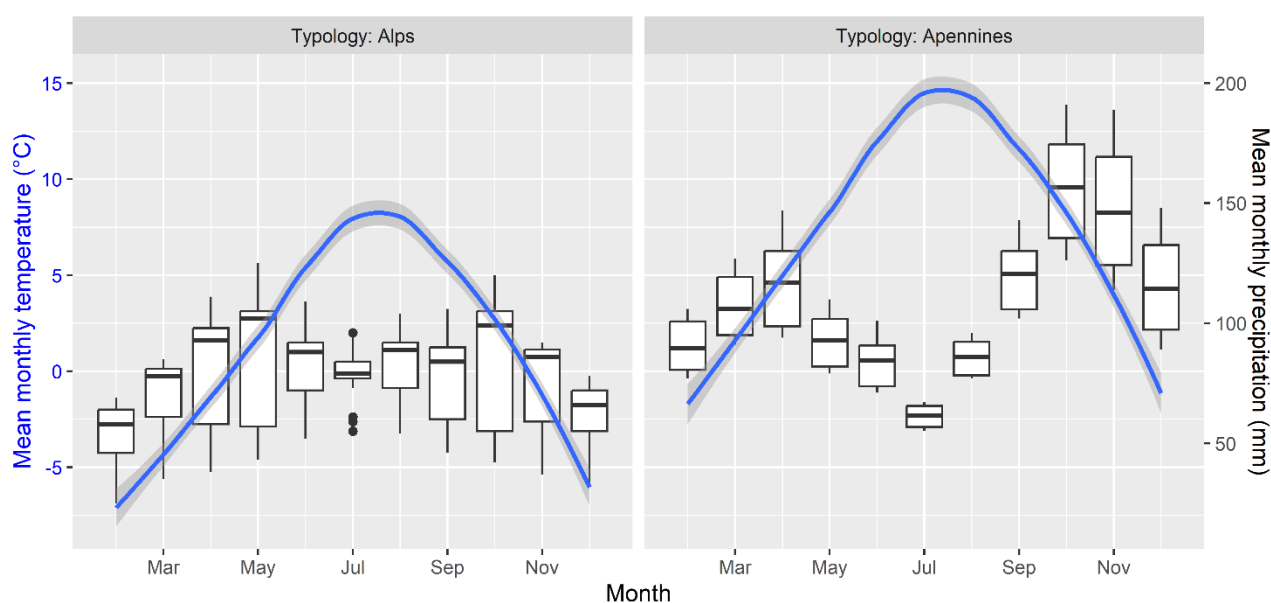


Figure S1. Mean monthly temperatures (blue lines) and mean monthly precipitations (boxplots) for the CW Alps (left) and for the MA (right).

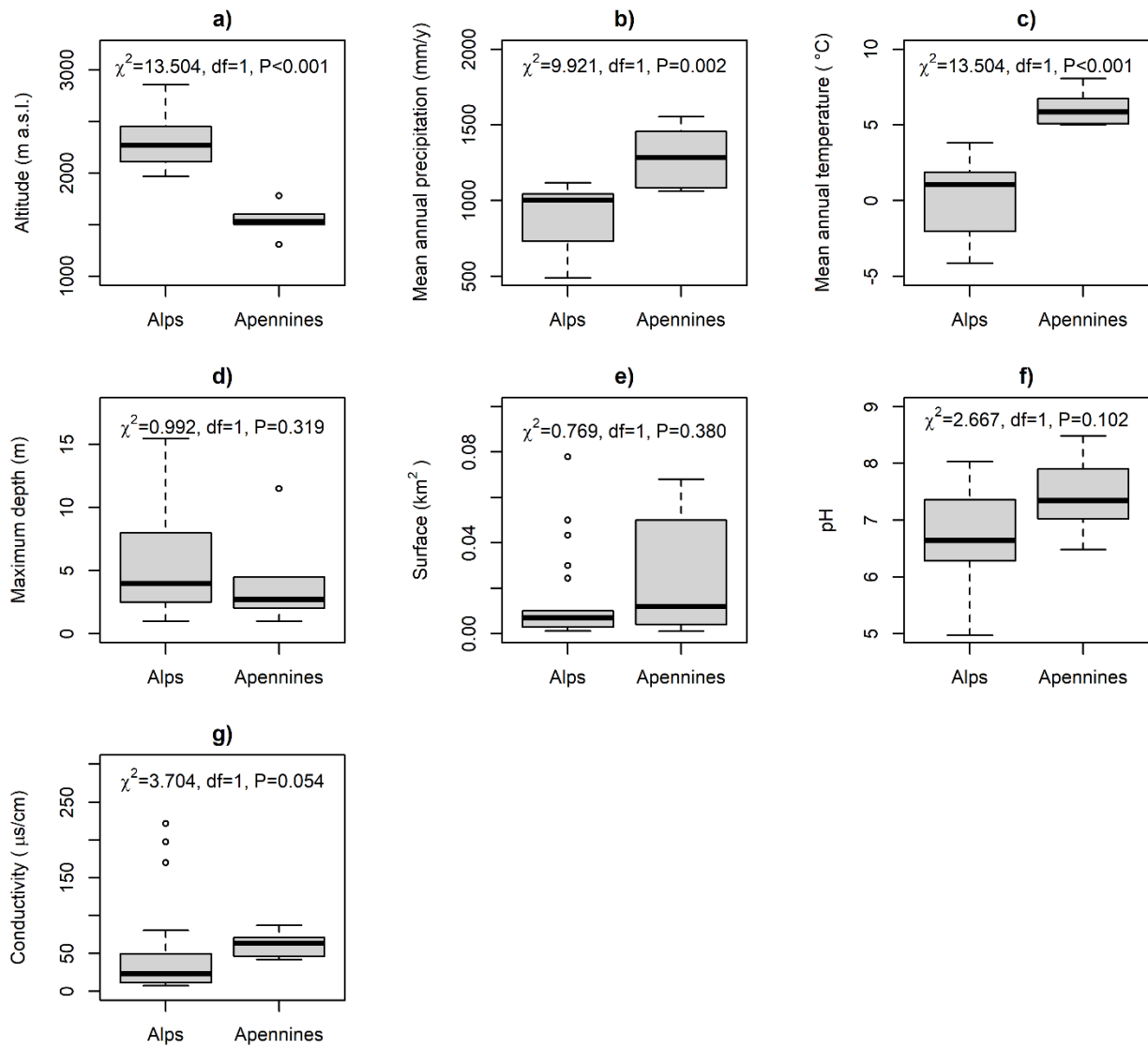


Figure S2. Box plots of selected geographic and morphometric characteristic for the studied Italian mountain ranges (CW Alps and MA Apennines). Statistical significance through Kruskal-Wallis test between categories are reported.

Table S1. List of lakes studied distributed on the two Italian mountain chains. Columns represents Region where the lakes are, River basin, lake name, main geology, year of sampling, Latitude and Longitude (WGS 84), Altitude (m a.s.l.), maximum depth (m), lake area (km²), water temperature (°C), conductivity (μS cm⁻¹), and pH.

	Mountain range	Region	Basin	Lake name	Geology	Sampling year	Latitude N	Longitude E	Altitude	Depth max	Area	Temp	Cond	pH
1	Alps	Lombardy	Adda	Bianco	micaschists/gneiss	2011	45.34467500	10.49230833	2608	8	0.043	4.0	73	7.57
2	Alps	Piedmont	Toce	Campo IV	orthogneiss	2000	46.12944444	8.130555556	2279	7	0.007	5.2	49	7.47
3	Alps	Piedmont	Toce	Capezzone	kinzigites	2000	45.94055556	8.210000000	2100	6	0.009	8.5	23	6.77
4	Alps	Piedmont	Maggia	Geccio	paragneiss	2000	46.09585556	8.417688889	2109	2	0.010	8.5	19	6.62
5	Alps	Piedmont	Toce	Grande	gneiss	2000	46.00277778	8.078333333	2269	5	0.007	6.4	7	5.76
6	Alps	Lombardy	Adda	L1 Pisella	micaschists/gneiss	2011	46.43935833	10.53855278	2857	3	0.003	9.3	222	8.00
7	Alps	Lombardy	Adda	L1 Rosole	micaschists/gneiss	2011	46.42538889	10.59011667	2834	3	0.001	11.0	197	6.84
8	Alps	Lombardy	Adda	L2 Pisella	micaschists/gneiss	2011	46.44128333	10.54330556	2842	3	0.002	8.0	27	7.36
9	Alps	Lombardy	Adda	Manzina	micaschists/gneiss	2011	46.43737500	10.53218333	2785	3	0.024	5.5	170	7.78
10	Alps	Piedmont	Maggia	Marmo	amphibolites	2000	46.06333333	8.480083330	1988	2	0.002	10.0	30	6.60
11	Alps	Piedmont	Toce	Matogno	orthogneiss	2000	46.25083333	8.401388889	2087	14	0.030	11.7	80	8.03
12	Alps	Lombardy	Oglio	Nero	micaschists/gneiss	2011	46.33587222	10.48132222	2386	13	0.078	10.5	29	7.19
13	Alps	Piedmont	Toce	Paione_inf	orthogneiss	2000	46.16888889	8.190833333	2002	14	0.007	16.0	13	6.64
14	Alps	Piedmont	Toce	Paione_med	orthogneiss	2000	46.17222222	8.191944444	2147	5	0.007	13.0	13	6.53
15	Alps	Piedmont	Toce	Paione_sup	orthogneiss	2000	46.17583333	8.190833333	2269	12	0.009	13.3	9	6.06
16	Alps	Piedmont	Toce	Pojala	marbles/schists	2000	46.32944444	8.334722222	2305	16	0.050	7.9	33	7.17
17	Alps	Piedmont	S. Bernardino	Pozza_Scaredi	amphibolites	2000	46.06126670	8.473600000	1970	1	0.002	11.1	13	4.97
18	Alps	Lombardy	Adda	Rosole	gneiss	2011	46.41313889	10.58502222	2452	3	0.003	16.5	11	6.38
19	Alps	Piedmont	Toce	Sfondato	gneiss	2000	46.00694444	8.087777778	2422	2	0.005	4.2	9	5.58
20	Alps	Piedmont	Toce	Variola_inf	ortogneiss	2000	46.17638889	8.215277778	2117	2	0.003	10.0	10	6.19
21	Alps	Piedmont	Toce	Variola_sup	ortogneiss	2000	46.18000000	8.211666667	2190	4	0.009	9.1	10	6.28
22	Apennines	Emilia-Romagna	Panaro	Baccio	quartz	2006	44.12972222	10.58861111	1554	3	0.014	19.8	42	6.48
23	Apennines	Emilia-Romagna	Panaro	Ninfa	quartz	2011	44.21083333	10.72500000	1503	2	0.004	16.9	87	7.90
24	Apennines	Emilia-Romagna	Panaro	Pratignano	quartz	2006	44.17361111	10.81833333	1307	5	0.050	16.0	71	7.02
25	Apennines	Emilia-Romagna	Panaro	Santo	quartz	2001	44.13694444	10.58472222	1501	12	0.068	17.4	57	7.23
26	Apennines	Emilia-Romagna	Panaro	Scaffaiolo	quartz	2008	44.11861111	10.80777778	1780	2	0.010	17.9	46	8.49
27	Apennines	Emilia-Romagna	Panaro	Turchino	quartz	2010	44.12027778	10.59916667	1600	1	0.001	12.5	70	7.46

Table S2. Presence/absence matrix of lakes macroinvertebrates in the two Italian mountain chains (from Bianco Gavia to Variola Sup are lakes of Alps Region; from Baccio to Turchino are lakes of Apennines Region). Columns represents lake name, and presence (1) or absence (0) for all the targeted taxa.

	Bianco_Gavia	Campo_IV	Capezzone	Geccio	Grande	Val_Pisella_L1	Val_Rosole_L1	Val_Pisella_L2	Manzina	Marmo	Matogno	Nero_Valle_Messi	Paione_Inf	Paione_Med	Paione_Sup	Pojala	Pozza_Scaredi	Rosole	Sfondato	Variola_Inf	Variola_Sup	Baccio	Ninfa	Pratignano	Santo	Scaffaiolo	Turchino
<i>Agrypnia varia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
<i>Lispe</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
<i>Paratendipes</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Microtendipes</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Hydaticus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
<i>Micronecta scholtzi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
<i>Habrophlebia fusca</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Siphonurus lacustris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Baetis niger</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Baetis digitatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
<i>Gammarus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Chirocephalus diaphanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Procladius</i>	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	1	1	0	1	0	0	1
<i>Macropelopia</i>	0	1	1	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	1
<i>Ablabesmyia longistyla</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Zavrelimyia</i>	0	1	1	1	1	0	0	0	0	1	1	0	1	1	1	1	0	0	1	1	1	0	0	0	0	0	0
<i>Apsectrotanypus trifascipennis</i>	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Psectrotanypus varius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Tanypus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Polypedilum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
<i>Chironomus</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	1	1	0	0	0
<i>Einfeldia pagana</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Phaenopsectra</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Dicrotendipes</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Endochironomus</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0

<i>Glyptotendipes</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
<i>Paracladopelma</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	
<i>Cladopelma</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	
<i>Tanytarsus</i>	1	1	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	
<i>Cladotanytarsus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	
<i>Paratanytarsus</i>	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	1	1	
<i>Micropsectra</i>	1	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0	0	1	0	1	1	0	0	1	0	0	1	0	0	1	0	
<i>Chaetocladius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Corynoneura</i>	0	1	0	1	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	0	0	0	
<i>Cardiocladius</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Heterotrissocladius marcidus</i>	0	1	1	1	1	0	0	0	0	0	1	0	1	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Cricotopus</i>	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	
<i>Paracladius alpicola</i>	1	1	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Eukiefferiella</i>	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Psectrocladius</i>	0	1	0	0	0	0	0	0	0	1	1	0	1	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
<i>Acamptocladius reissi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Camptocladius</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bryophaenocladius subvernalis</i>	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Heleniella</i>	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Limnophyes</i>	0	1	0	0	1	0	0	0	1	0	0	0	1	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
<i>Paracricotopus</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Parasmittia</i>	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Paratrichocladius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Parorthocladius nudipennis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Rheocricotopus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Smittia</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Thienemanniella</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Tvetenia calvescens</i>	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0
<i>Natarsia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Prodiamesa olivacea</i>	0	1	1	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
<i>Diamesa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Protanypus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pseudodiamesa</i>	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[illegible]

Polycentropodidae	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Melampophylax mucoreus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sericostoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Odontocerum albicorne	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaetopteryx gessneri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Plectrocnemia	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Rhyacophilidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhyacophila italica	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Caenis horaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0
Cloeon cognatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Proclleon pennulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Leuctra	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nemouridae	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Nemoura	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0
Nemurella pictetii	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Elophila nymphaeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Sialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0
Orthetrum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Sympetrum sanguineum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Anax imperator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1
Sympecma fusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Coenagrion puella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Libellula depressa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ischnura elegans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
Aeshna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Sigara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Notonecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Aquarius najas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Velia muelleri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gerris asper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Limnodrilus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Tubificidae	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	1
Tubifex tubifex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

[illegible]

<i>Lebertia dubia</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sperchon squamosus</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceratopogonidae</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table S3. IndVal analysis for Alpine and Apennines sites. A: probability that the surveyed site belongs to the target site group given the fact that the taxon has been found; B: probability of finding the taxon in sites belonging to the site group. All the reported associations were not significant after 999 permutations at $\alpha = 0.05$ and the Holm correction for multiple comparisons.

Alps				
Taxonomic rank	Taxa	A	B	IndVal
Chironomidae	<i>Zavreliomyia</i>	1.00	0.62	0.79
Chironomidae	<i>Heterotrissocladius marcidus</i>	1.00	0.52	0.72
Apennines				
Hirudinea	<i>Helobdella stagnalis</i>	1.00	0.67	0.82
Oligochaeta	<i>Homochaeta</i> spp.	1.00	0.67	0.82
Chironomidae	<i>Cladotanytarsus</i> spp.	0.93	0.67	0.79
Trichoptera	<i>Limnephilus</i> spp.	0.93	0.67	0.79
Hirudinea	<i>Herpobdella testacea</i>	0.93	0.67	0.79
Chironomidae	<i>Tanytarsus</i> spp.	0.71	0.83	0.77
Odonata	<i>Anax imperator</i>	1.00	0.50	0.71
Ephemeroptera	<i>Caenis horaria</i>	1.00	0.50	0.71
Chironomidae	<i>Cladopelma</i> spp.	1.00	0.50	0.71
Coleoptera	<i>Haliphus</i> spp.	1.00	0.50	0.71
Oligochaeta	<i>Pristina bilobata</i>	1.00	0.50	0.71
Gastropoda	<i>Radix labiata</i>	1.00	0.50	0.71
Bivalvia	<i>Sphaerium corneum</i>	1.00	0.50	0.71