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Vegetation shapes alpine ground-dwelling macro-invertebrate communities: A case study from the Stilfserjoch/ Stelvio National Park (Martell/Martello, South Tyrol, Italy)

Abstract

There are few studies on ground-dwelling invertebrates from alpine ecosystems, often with only one or a few samplings per growing season. However, to get a most comprehensive picture of the faunal community present, samplings throughout an entire season are needed. Here we present data on ground-dwelling macro-invertebrate communities from four characteristic alpine habitats (i.e., pasture, dwarf shrub heath, grassland, and fragmented grassland) along a short elevation gradient. They were monitored continuously over almost an entire growing season (June to October) using pitfall traps.

We found considerable differences between the four habitat types, with the pasture having the lowest abundances (i.e., activity densities as individuals per sampling day). At the other three sites, biodiversity indices (i.e., Shannon and Evenness) increased with elevation, while the activity densities of the main taxa Araneae, Myriapoda and Coleoptera decreased; they showed a peak activity in mid-July to mid-August. The faunal communities, despite sharing many families among habitat types, showed a clear separation of three groups in the ordination plot (CCA), with the pasture and grassland harbouring similar communities and being well separated from the ones of the dwarf shrub heath and the fragmented grassland.

In this study we found distinct ground-dwelling macro-invertebrate communities in four characteristic alpine habitats, despite their spatial proximity. We found the vegetation (i.e., here plant life-forms as proxy) being a strong driver shaping faunal communities. Additionally, the quite intensive grazing activities on the pasture might have negative impact on the invertebrates, while low/no grazing at the more natural higher plots (i.e., grassland and fragments) and a high habitat heterogeneity (at the fragmented grasslands) might be reflected in high numbers of abundances and biodiversity indices. Our study underlines the importance of assessing alpine soil fauna by performing many samplings throughout a growing season to depict most complete faunal communities.

Keywords: pitfall traps, protected area, alpine plant communities, Diplopoda, Coleoptera, Araneae

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Introduction

Invertebrates living in the soil or on the soil surface are important for ecosystem functioning, as they provide or at least contribute to numerous ecosystem services such as nutrient cycling, water filtration, and pest control (Wagg et al. 2014). Living in (high) mountains soil ecosystems is a challenge for these animals, since temperatures are low, growing seasons short, and soils shallow, which calls for adaptations such as cold hardiness, prolonged life cycles, and omnivory (Sømme 1989, Steinwandter et al. 2018). Although we know in principle about the living conditions in high mountains and the adaptations necessary for survival, we still know little about which invertebrates are found in high mountain soils (but see Winkler et al. 2018, Gobbi et al. 2020, Seeber et al. 2021).
Mountain ecosystems around the world are experiencing an above-average increase in mean annual temperatures compared to lowlands (Kohler et al. 2014). In the European Alps the current warming increase is 2 °C, twice the increase of the entire northern hemisphere (Rebetez & Reinhard 2008; Vitasse et al. 2021). This makes it all the more necessary to learn more about the biodiversity and community composition of invertebrates in mountain soils. Further, many mountain areas – including the European Alps – were found to be blind spots of soil biodiversity (Guerra et al. 2020), but at the same time of high priority regarding the conservation value of soil biota (Guerra et al. 2022).
In this study we investigated invertebrate communities living on the surface of soils associated with plant communities characteristic of mountain areas. Plant communities influence the microclimate through the vegetation structure (Bauer & Kenyeres 2007) and soil properties such as pH and organic matter through litter inputs (as summarized in Steinauer et al. 2020); thus, they can have a strong, indirect effect on the ground-dwelling macro-invertebrate community. With this study we aimed to find out (i) if faunal community composition differs between vegetation types and (ii) if seasonal patterns can be described for the main ground-dwelling macro-invertebrate groups Araneae, Coleoptera and Myriapoda.
Both the general description of mountain invertebrate communities and their relationship with plant communities can serve as a basis for much needed research regarding impacts of climate change and important drivers that shape these communities in mountain ecosystems.

Material and methods

Sampling site

The Stilfserjoch/Stelvio National Park is the northernmost of the 24 National Parks in Italy and is located in the provinces of Bolzano (South Tyrol), Trento and Sondrio. The South Tyrolean Martell Valley (municipality of Martell/Martello) and its side valley Madritsch lie entirely within the National Park. This side valley spans from about 2200 m up to 3300 m, peaking in the Mt. Südliche Schöntaufspitze/Punta Beltovo di Dentro (3325 m). The area is part of the Ortler Alps, the second-highest massif of the Eastern Alps after the Bernina group. The geology consists of a crystalline bedrock covered with a 1,000 m thick layer of dolomite and limestone (prominent in the Ortler main crest, Dal Piaz et al. 1988).
Northwest of the hut Zufallhütte/Rifugio Nino Corsi (2265 m) at the beginning of the Madritsch valley, we selected four characteristic alpine habitats for sampling along a south-facing slope and within a short elevational gradient (GPS coordinates 46.48654° N, 10.66785° E): (1) a grazed alpine pasture (abbreviated as PST), (2) a dwarf shrub heath (SHR), (3) an alpine grassland (GRA) and (4) a fragmented alpine grassland (FRA); see Table 1 for site characteristics. The plots had a straight-line distance of at least 300 m from each other. The pasture was used by cows for only a short but intensive period of two weeks during summer and sporadically by sheep and has a relatively wet soil due to water coming from the surrounding slopes. The alpine grassland was grazed sporadically by sheep that roamed the entire Madritsch valley, while no indication of sheep present was found at the fragmented grassland.

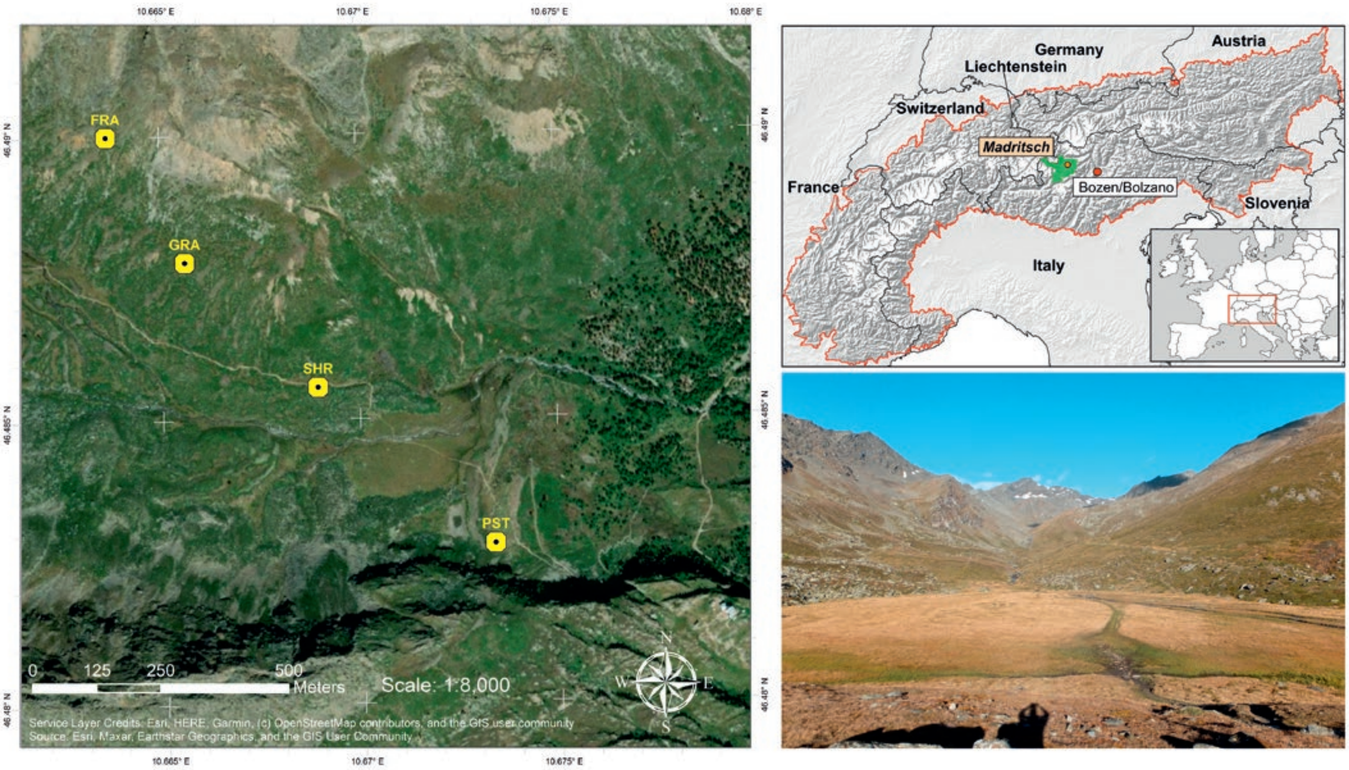

Fig. 1: Overview map and photo of the study site in the Madritsch valley, a side valley of Martell/Martello (South Tyrol, Italy). The study site is located in the National Park Stilfserjoch/Stelvio (green area in the mini map) and represents a short elevational gradient with a cattle pasture (PST), a dwarf shrub heath (SHR), an alpine grassland (GRA), and a fragmented grassland (FRA). The hut Zufallhütte/Rifugio Nino Corsi (2265 m) can be seen in the right lower corner of the satellite photo (Photo: Michael Steinwandter).

Table 1: Plot characteristics of the four investigated alpine habitats at the Madritsch valley in the Stilfserjoch/Stelvio National Park. The results of ANOVAs with Tukey's HSD test for soil pH and SOM were $p < 0.001$ ($F_{3,35} = 28.88$) and $p = 0.366$ ($F_{3,35} = 1.09$), respectively.

	Pasture PST	**Dwarf shrubs SHR**	**Grassland GRA**	**Fragments FRA**
Elevation [m]	2322	2370	2489	2605
Exposition	E	S	SE	SE
Inclination [°]	3	20	0	5
Soil pH	4.43 (±0.35)^{a}	3.60 (±0.17)^{b}	3.57 (±0.18)^{b}	3.84 (±0.17)^{b}
SOM [%]	26.65 (±12.35)	20.51 (±3.53)	26.42 (±9.42)	25.15 (±4.17)
Vegetation community	Poion alpinae	Juniperion nanae	Nardion strictae	Caricion curvulae
Vegetation cover [%]	90	90	90	75
Stones cover [%]	10	10	2	10
Moss cover [%]	–	–	< 1	< 2
Lichen cover [%]	–	–	–	< 5

Field work

With a special permit by the South Tyrolean National Park management, we installed ten pitfall traps during the growing season of 2014 with a distance of 3 m from each other at each of the four sampling plots. Traps consisted of yoghurt cups (500 ml) with an opening of 8 cm and a depth of 9 cm and were filled with 200 ml of 75 % ethylene glycol solution as collection fluid, mixed with a few drops of detergent to decrease surface tension. A transparent polycarbonate roof (20 × 20 cm, 5 mm thick, 10 cm above the traps) on two metal poles protected the traps from rain.

All pitfall traps were activated from 15th June 2014 and were left in the field until 20th October 2014; the traps were emptied approximately every two weeks (i.e., 10–23 days), resulting in eight sampling dates and 320 samples in total. Due to damage by cows, 16 of these samples were lost at PST during end of July to mid-August. After returning to the laboratory, the collected animals were rinsed with tap water and transferred to 75 % ethanol until identification.

Identification of invertebrates

Animals were identified using dissection stereo microscopes (SMG-TLED 171, MoticEurope S.L.U., Barcelona, Spain). The collected ground-dwelling macro-invertebrates (i.e., body size > 2 mm) were counted and identified – where possible – at least to family level (e.g. Araneae, Coleoptera, Myriapoda) following the identification keys of Hauser & Voigtländer (2019), Klausnitzer (2011) and Nentwig et al. (2022). Pterygote taxa such as adult Diptera, Hymenoptera and Lepidoptera (mostly moths) were documented but declared as bycatch and therefore excluded from analyses.

Plant communities

On each plot we conducted a vegetation survey at the end of July following the sampling protocol of Braun-Blanquet (1964, with the extension after Wilmanns 1989). Within a 4 × 4 m square, a plant species list with the relative cover per species was assessed and evaluated in the six categories "+" (< 1 % cover), "1" (1–5 %), "2m" (< 5 % with 50+ specimens), "2a" (5–15 %), "2b" (15–25 %), and "4" (51–75 %). Each plant species' life-form was assessed according to the internet database 'Flora Italiana Altervista' (2018, URL: http://luirig.altervista.org/flora/taxa/floraindice.php) following the classification after Raunkiær (1934). The categories present were: Chamaephytes, geophytes, hemicryptophytes, nanophanerophytes, therophytes, and lichens.

Site parameters

In September 2014 we took a small soil sample (approx. 100 g) next to each pitfall trap (i.e., ten per plot). The material was air-dried in the laboratory for 48 h and sieved to 2 mm. We measured soil pH (with a pH Meter, Metrohm, Herisau, Switzerland) and soil organic matter (SOM, using the dry combustion method by incinerating the material at 500 °C for 4 h in a muffle furnace, Nabertherm, Lilienthal, Germany), following standard protocols (Table 1).

Statistical analysis

Abundance data (i.e., activity densities as individuals per pitfall trap) were standardized by dividing the numbers of individuals per taxon by the number of active days. Activity densities from single pitfall traps per plot and sampling date were summed up to gather a picture of the ground-dwelling fauna present at each time point (i.e., data on season level). These data were used to depict seasonal variations of single taxa and to create ordination plots. For biodiversity measures, yearly means were calculated from the standardized data to gather the most complete community found over the course of the entire sampling period (i.e., data on plot level).

All calculations of biodiversity indices were conducted in the open-source statistical programming environment R (version 4.2.0; R Core Team 2022) in RStudio (version 2022.02.02+485; RStudio Team 2022) and the package vegan (version 2.6–2; Oksanen et al. 2022). The ordination was calculated in the multivariate data exploration software CANOCO 5 (version 5.15; Šmilauer & Lepš 2014) excluding four very rare taxa which were present in only one out of the 320 pitfall traps (i.e., Araneidae, Theridiidae, Cybaeidae, and Isopoda).

Results

Community structure

In total we captured 14162 ground-dwelling macro-invertebrates with the majority of them being Formicidae (30.1 %) followed by Araneae (24.4 %) and Coleoptera (16.6 %) (Table 2). Except for PST, the number of total individuals decreased with elevation (i.e., PST with 2813, SHR with 4311, GRA with 3751, and FRA with 3287). The most abundant taxa at PST were Hemiptera (37.1 %) and Formicidae (27.6 %); those at SHR Formicidae (51.9 %) and Araneae (10.9 %). In the upper sites GRA and FRA, Araneae (36.0 % and 30.4 %, respectively) and Coleoptera (19.6 % and 29.4 %) dominated, with a decreasing proportion of Formicidae (21.1 % and 13.9 %).

In more detail, within the Araneae, Lycosidae was the most abundant family accounting for always more than 55 % of all spider specimens found. Further abundant families were Linyphiidae and Gnaphosidae, and Thomisidae especially at the highest plot FRA. Within the Coleoptera, abundant families were Carabidae (especially in SHR accounting for 46.8 %), Staphylinidae (notably at PST with 33.6 %), and Melyridae, which increased with elevation and accounted for up to 55.3 % at FRA.

Looking at the faunal community structure in association with environmental and vegetation factors (i.e., plant life-forms) in a constraint Canonical Correspondence Analysis (CCA) plot, we found the four habitats clearly separated, thereby forming three groups (Fig. 2). Important factors influencing the plots SHR and FRA were different plant life-forms such as chamaephytes and therophytes, while the soil parameters pH and SOM mostly affected community composition at PST and GRA.

Table 2: Yearly mean activity densities of ground-dwelling macro-invertebrate communities of four alpine habitats at the Madritsch valley in the Stilfserjoch/Stelvio National Park. Data were standardized to individuals per sampling day. The values represent means (± standard deviations) calculated from the sums of captured invertebrates per sampling date and sampling plot. n = 80

Taxa [ind. / day]	Pasture PST		Dwarf shrubs SHR		Grassland GRA		Fragments FRA	
GASTROPODA	**0.044**	**(0.116)**	**1.141**	**(1.184)**	**0.507**	**(0.408)**	**0.017**	**(0.032)**
('slugs')	0.044	(0.116)	1.068	(1.154)	0.197	(0.253)	–	
('snails')	–		0.073	(0.137)	0.309	(0.208)	0.017	(0.032)
LUMBRICIDAE	**0.032**	**(0.042)**	**–**		**0.044**	**(0.100)**	**–**	
ARANEAE	**6.597**	**(6.778)**	**4.056**	**(3.518)**	**11.967**	**(9.770)**	**8.878**	**(6.914)**
Araneidae	–		0.013	(0.035)	–		–	
Theridiidae	–		0.010	(0.027)	–		–	
Linyphiidae	0.968	(1.142)	0.342	(0.261)	1.372	(1.211)	0.400	(0.321)
Lycosidae	4.548	(4.937)	2.264	(2.264)	8.841	(7.618)	6.076	(5.912)
Agelenidae	–		0.007	(0.020)	–		0.016	(0.044)
Cybaeidae	–		–		–		0.011	(0.031)
Hahniidae	–		0.047	(0.087)	0.039	(0.064)	0.015	(0.042)
Cheiracanthiidae	–		0.157	(0.278)	0.125	(0.155)	–	
Clubionidae	0.011	(0.029)	0.017	(0.032)	–		–	
Gnaphosidae	0.935	(1.016)	0.875	(0.799)	1.068	(0.952)	0.949	(0.893)
Philodromidae	0.118	(0.149)	0.100	(0.138)	0.207	(0.224)	0.290	(0.320)
Thomisidae	0.017	(0.030)	0.130	(0.098)	0.315	(0.168)	1.111	(0.575)
Salticidae	–		0.096	(0.114)	–		0.010	(0.027)

Taxa [ind. / day]	Pasture PST		Dwarf shrubs SHR		Grassland GRA		Fragments FRA	
OPILIONES	**0.390**	**(0.490)**	**0.418**	**(0.191)**	**1.059**	**(0.701)**	**2.328**	**(1.117)**
Trogulidae	0.010	(0.027)	0.053	(0.065)	0.149	(0.374)	0.179	(0.367)
Nemastomatidae	–		0.088	(0.100)	0.018	(0.034)	0.590	(0.310)
Phalangiidae	0.379	(0.495)	0.277	(0.135)	0.893	(0.438)	1.559	(0.961)
ISOPODA	**–**		**–**		**0.016**	**(0.044)**	**–**	
CHILOPODA: Lithobiomorpha	**–**		**0.088**	**(0.078)**	**0.077**	**(0.104)**	**0.150**	**(0.099)**
DIPLOPODA	**0.082**	**(0.170)**	**2.725**	**(1.997))**	**0.604**	**(0.302)**	**1.477**	**(0.566)**
Glomeridae	–		2.239	(1.907)	0.093	(0.118)	0.492	(0.329)
Julidae	0.065	(0.143)	0.431	(0.386)	0.375	(0.286)	0.701	(0.287)
Polydesmidae	–		–		0.007	(0.020)	0.208	(0.119)
Craspedosomatidae	0.017	(0.031)	0.055	(0.103)	0.129	(0.208)	0.076	(0.143)
HEMIPTERA	**11.421**	**(14.366)**	**1.541**	**(0.655)**	**2.999**	**(1.964)**	**2.573**	**(1.905)**
Auchenorrhyncha	9.857	(12.435)	0.863	(0.420)	2.125	(1.568)	2.219	(1.650)
Sternorrhyncha	0.359	(0.518)	0.125	(0.127)	0.271	(0.162)	0.121	(0.098)
Heteroptera	1.204	(1.551)	0.553	(0.436)	0.603	(0.546)	0.233	(0.246)
COLEOPTERA	**2.243**	**(1.833)**	**3.376**	**(2.341)**	**6.035**	**(3.733)**	**8.079**	**(5.877)**
Carabidae	0.234	(0.195)	1.542	(1.392)	1.199	(0.620)	1.550	(1.320)
Hydrophilidae	0.037	(0.049)	0.010	(0.027)	0.014	(0.026)	–	
Leiodidae	0.133	(0.168)	0.108	(0.179)	0.137	(0.153)	0.109	(0.155)
Staphylinidae	0.708	(0.563)	0.350	(0.229)	1.105	(1.137)	0.558	(0.467)
Cantharidae	0.011	(0.029)	0.008	(0.022)	–		–	
Melyridae	0.247	(0.320)	0.518	(0.648)	2.343	(2.201)	4.531	(3.899)
Elateridae	0.011	(0.029)	–		0.030	(0.043)	–	
Cryptophaghidae	0.047	(0.089)	0.098	(0.159)	0.110	(0.153)	0.079	(0.114)
Coccinellidae	0.056	(0.087)	–		–		–	
Ptinidae	0.031	(0.043)	–		0.015	(0.028)	0.063	(0.077)
Tenebrionidae	0.011	(0.029)	0.135	(0.155)	0.068	(0.114)	0.222	(0.252)
Geotrupidae	–		0.081	(0.163)	0.101	(0.074)	0.050	(0.062)
Aphodiidae	0.229	(0.272)	0.117	(0.174)	0.735	(0.967)	0.821	(1.528)
Chrysomelidae	0.064	(0.069)	0.024	(0.046)	0.020	(0.037)	0.012	(0.023)
Brentidae	0.040	(0.076)	–		0.013	(0.035)	–	
Curculionidae	0.385	(0.518)	0.386	(0.354)	0.144	(0.140)	0.083	(0.082)
COLEOPTERA Larvae	**0.104**	**(0.216)**	**0.014**	**(0.026)**	**0.070**	**(0.090)**	**0.059**	**(0.081)**
FORMICIDAE	**7.957**	**(5.648)**	**18.190**	**(11.439)**	**6.521**	**(4.046)**	**3.733**	**(1.304)**
DIPTERA Larvae	**0.168**	**(0.171)**	**0.079**	**(0.102)**	**0.228**	**(0.356)**	**0.071**	**(0.065)**
Nematocera Larvae	0.168	(0.171)	0.048	(0.054)	0.196	(0.285)	0.071	(0.065)
Brachycera Larvae	–		0.031	(0.048)	0.032	(0.071)	–	
CAELIFERA	**0.211**	**(0.246)**	**2.850**	**(1.362)**	**0.957**	**(0.549)**	**0.200**	**(0.117)**
LEPIDOPTERA Larvae	**0.327**	**(0.389)**	**0.941**	**(0.658)**	**0.543**	**(0.327)**	**0.372**	**(0.298)**

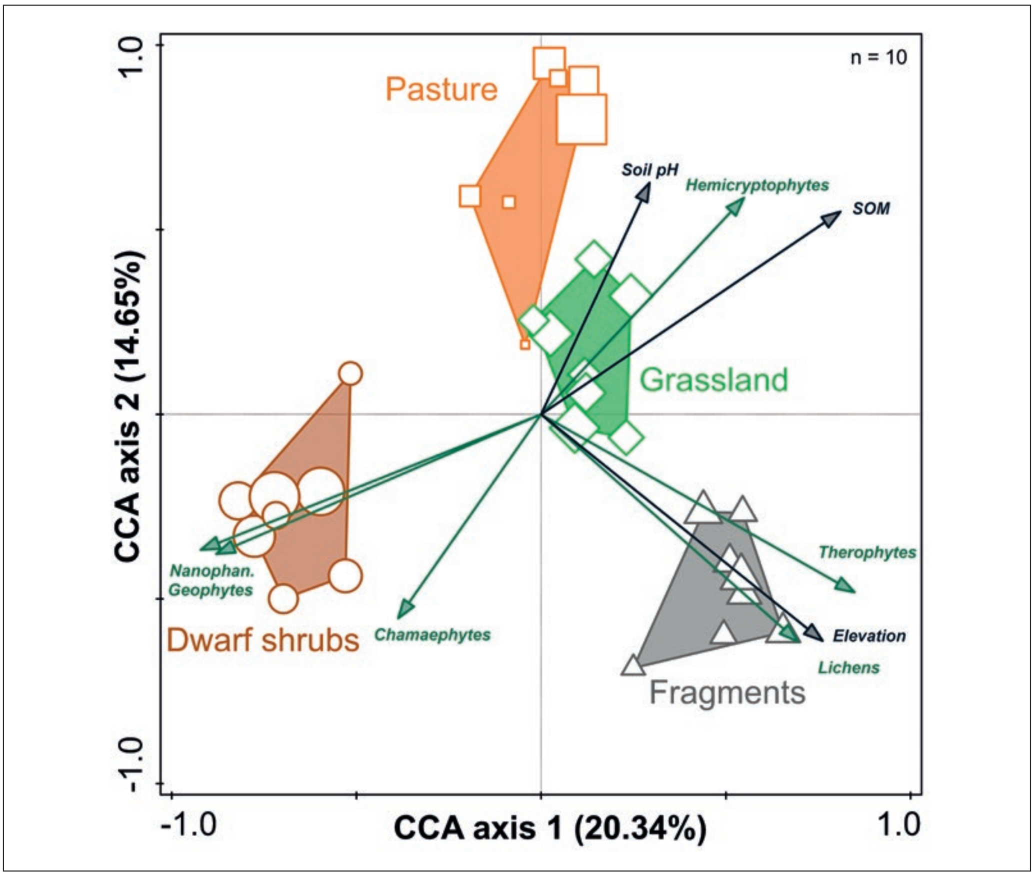

Fig. 2: Constrained Canonical Correspondence Analysis (CCA) plot of ground-dwelling macro-invertebrate communities of four alpine habitats in the Madritsch valley in the Stilfserjoch/Stelvio National Park. Each data point represents one of eight sampling dates (June to October 2014, n = 10), their sizes the number of found taxa (from 12 to 32). Arrows correspond to cumulative percentage of plant life-forms (dark green) and soil parameters (black). Nanophan. = Nanophanerophytes.

Seasonal dynamics

The mean seasonal activity patterns differed between the main taxa Araneae, Myriapoda and Coleoptera and between the four habitat types (Fig. 3). All three taxa were highly active already during the first sampling period, with the Coleoptera showing particularly high and consistent densities until the end of August. Araneae and Myriapoda showed a peak in activity in mid-July, with a permanent decline in activity thereafter, while Coleoptera showed only a short-lived decline at sampling time 3 (end of July); all activity curves level off by mid-September at the latest on all four habitats. Figure 3 depicts again the low presence of these main taxa on PST, while they were abundant on SHR (especially Myriapoda), GRA (Araneae) and FRA (Coleoptera).

Faunal diversity

In total we were able to identify 50 different taxa of ground-dwelling macro-invertebrates, most of them at family level (Table 2). Overall, SHR and GRA showed the highest number of taxa (both 42), PST the lowest (Table 3). The Shannon index increased gradually along the short elevation gradient; also, the Evenness index was higher in the higher plots GRA and FRA.

In more detail, we identified 13 Araneae families, almost all of which inhabit SHR (i.e., 12). All five identified Myriapoda families were present in the higher plots GRA and FRA, but only two were found on PST (i.e., Julidae and Craspedosomatidae). Coleoptera were present in high family numbers (i.e., 16 in total) in all four investigated habitats, with the highest diversity found in the grassland habitats PST and GRA (15 and 14 families, respectively).

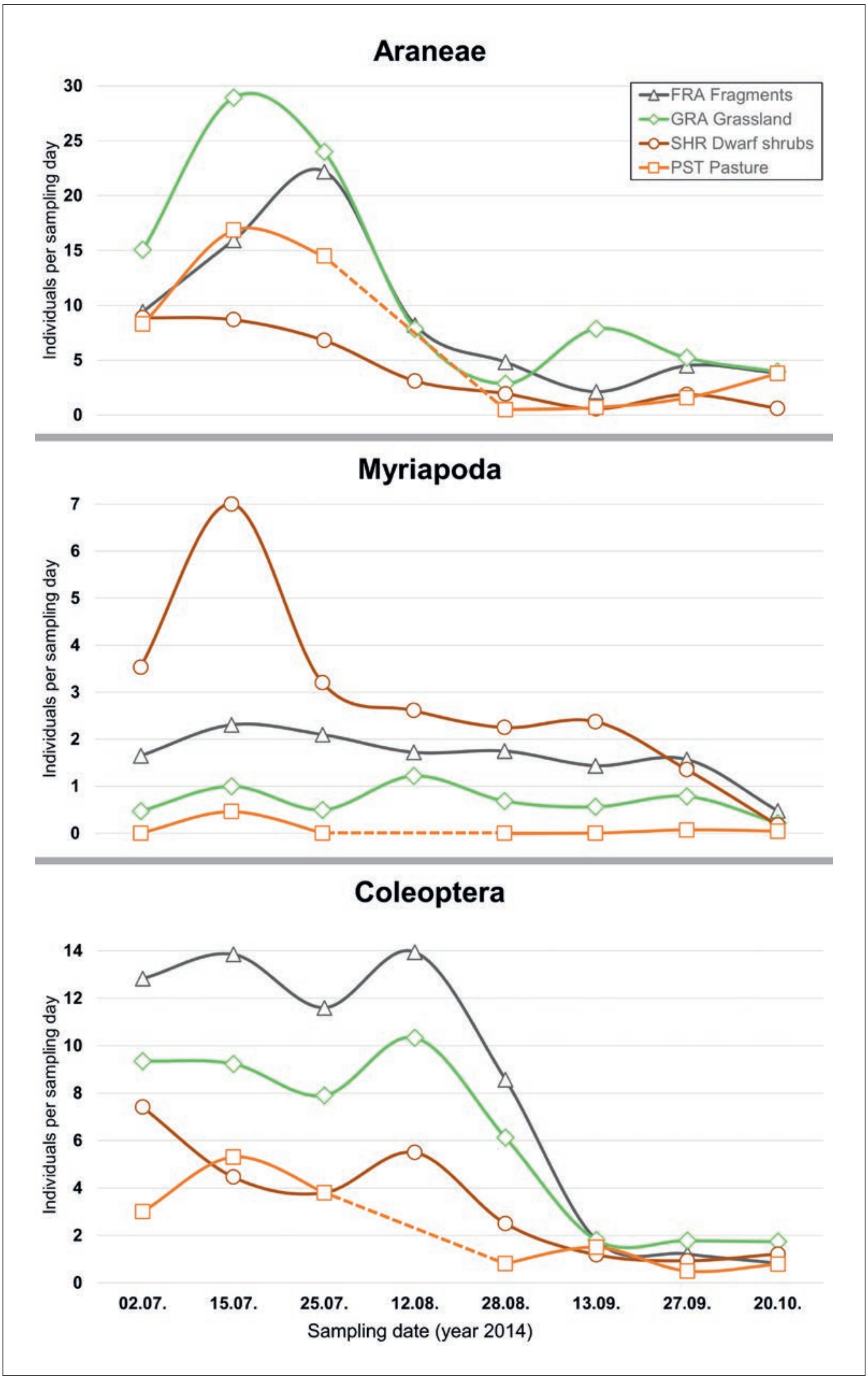

Fig. 3: Seasonal dynamics (i.e., activity densities) of ground-dwelling Araneae, Myriapoda and Coleoptera communities of four alpine habitats at the Madritsch valley in the Stilfserjoch/Stelvio National Park. Each data point per habitat represents the mean activities of the eight sampling dates (June to October 2014, n = 10). As samples on PST were destroyed on sampling date 4 (12.08.2014), a dashed line was added to connect the data points of sampling date 3 and 5.

Table 3: Biodiversity indices of ground-dwelling macro-invertebrate communities of four alpine habitats at the Madritsch valley in the Stilfserjoch/Stelvio National Park. The indices were calculated using yearly taxa means from all eight sampling dates per habitat type (see statistical analyses). Numbers in parentheses represent the total number of taxa found.

	Pasture PST	Dwarf shrubs SHR	Grassland GRA	Fragments FRA
Taxa Richness (50)	35	42	42	37
Shannon index (H')	2.599	2.633	3.186	3.280
Pielou's Evenness (J')	0.384	0.336	0.576	0.718
Araneae families (13)	6	12	7	9
Myriapoda families (5)	2	4	5	5
Coleoptera families (16)	15	12	14	11
Unique Taxa	Coccinellidae	Araneidae, Theridiidae	Isopoda	–

Discussion

Here, we present one of few studies dealing on ground-dwelling macro-invertebrates caught with pitfall traps in four different alpine vegetation types, characteristic for mountains in the European Alps. With 50 taxa mostly on family level, we found a wide range of taxonomic diversity across our short elevation gradient. Also, even if being only a snapshot sampling, we found differences in measures of taxa diversity and community composition between vegetation types, despite their spatial proximity. Seasonal dynamics of all taxa studied showed that, if time and financial resources allow, sampling during an (almost) entire growing season is of advantage and results in depicting most comprehensive invertebrate communities.

Our results suggest that the ground-dwelling macro-invertebrate community is active right after snow melt. The first samples were activated in mid-June, when snow was still present in the Madritsch valley (pers. obs.), and we were able to document already high activity densities for the main groups. Therefore, it seems that the ground-dwelling macro-invertebrates make use of the full available growing season, even if it is relatively short in alpine ecosystems (i.e., late May to end of October with reoccurring snow in cold summer periods). The main groups of Araneae, Myriapoda and Coleoptera reach their activity peak at the end of July and beginning of August, which is in line with other studies from the alpine zone (e.g., Steinwandter et al. 2018, Pilar et al. 2020).

The four habitats differed considerably in their faunal community composition (Fig. 2), with the more natural habitats SHR, GRA, and FRA showing a mostly higher biodiversity and higher abundances compared to the more disturbed PST (Table 2). The four sampled plots also differed considerably in their vegetation and habitat structure, despite their spatial proximity. At the lowest plot PST, the dominating plant life-forms were hemicryptophytes (i.e., herbs and grasses), kept very short (i.e., on average 2 cm) due to short-term but intensive grazing of cattle and further roaming sheep; the GRA had a similar vegetation structure with almost exclusively hemicryptophytes of an average height of 15 cm. Both plots were found to be similar but still separated regarding their faunal communities (Fig. 2), suggesting that the less intensive and sporadic grazing by sheep at GRA allows the development of a more diverse and abundant faunal community, which is reflected by the higher biodiversity indices and numbers (Tables 2 and 3).

This may apply also for the highest plot FRA at 2600 m – characterized by a high portion of therophytes (i.e., ephemeral and annual herbs), chamaephytes (“dwarf shrubs”) and scattered stones – where no grazing animals were observed. Even if lower temperatures and a harsher environment may restrict the development of invertebrates in alpine ecosystems in general and increasingly with higher elevation (i.e., taxa richness decreases with increasing elevation; Gilgado et al. 2022), it seems that a higher spatial and vertical habitat heterogeneity (Stein et al. 2014) and low/no disturbance by grazing mammals (here sheep; Steinwandter et al. 2017) promotes the diversity of ground-dwelling macro-invertebrates which can be seen in high values of the biodiversity indices (Table 3).

Conclusion

Our study demonstrates, despite being a snapshot sampling of few but representative alpine habitat types, that the composition of the vegetation (i.e., plant cover and life-forms) is a strong driver of ground-dwelling macro-invertebrate communities. Even if many taxa (i.e., mostly families) are shared between the four habitats, we were able to find distinct invertebrate communities between grasslands (pasture and grassland), dwarf shrub heath and fragmented grassland. Sampling an (almost) entire growing season without interruption allowed us to get a most comprehensive picture of the present taxa and their seasonal activity dynamics. This approach underlines the importance of having multiple sampling dates, also to increase the chances to document rare and cryptic-living taxa. Our study further confirms that alpine ecosystems, despite having a reputation of being poor in soil fauna biodiversity due to its harsh environmental conditions, harbour a rich ground-dwelling macro-invertebrate community that still needs to be investigated more deeply.

Zusammenfassung

Die Vegetation prägt die Gemeinschaft alpiner bodenbewohnender Makroinvertebraten: Eine Fallstudie aus dem Nationalpark Stilfserjoch (Martell, Südtirol, Italien)

Es gibt nur wenige Studien über bodenbewohnende Wirbellose in alpinen Ökosystemen; oft werden diese mit nur einer oder wenigen Probenahmen pro Vegetationsperiode durchgeführt. Um jedoch ein möglichst umfassendes Bild der vorhandenen Tiergemeinschaft zu erhalten, sind Probenahmen während einer ganzen Saison erforderlich. Hier präsentieren wir Daten über bodenbewohnende Makroinvertebraten-Gemeinschaften aus vier charakteristischen alpinen Lebensräumen (d. h. Weide, Zwergstrauchheide, alpiner Rasen und fragmentierter Rasen) entlang eines kurzen Höhengradienten. Sie wurden über fast eine gesamte Vegetationsperiode (Juni bis Oktober) kontinuierlich mithilfe von Barberfallen erhoben.

Wir stellten erhebliche Unterschiede zwischen den vier Lebensräumen fest, wobei die Weide die geringsten Abundanzen (d.h. Aktivitätsdichten als Individuen pro Probentag) aufwies. An den anderen drei Standorten nahmen die Biodiversitätsindizes (d. h. Shannon und Evenness) mit der Höhe zu, während die Aktivitätsdichten der Haupttaxa Araneae, Myriapoda und Coleoptera abnahmen; sie wiesen einen Aktivitätshöhepunkt von Mitte Juli bis Mitte August auf. Obwohl die Tiergemeinschaften in den verschiedenen Lebensräumen viele Familien teilen, zeigte sich in der Ordinationsgrafik (CCA) eine klare Trennung in drei Gruppen, wobei die Weide und der alpine Rasen ähnliche Gemeinschaften beherbergten und von denen der Zwergstrauchheide und des fragmentierten Rasens deutlich getrennt waren.

In dieser Studie fanden wir in vier charakteristischen alpinen Lebensräumen trotz ihrer räumlichen Nähe unterschiedliche bodenbewohnende Makroinvertebraten-Gemeinschaften. Vor allem die Vegetation (hier dargestellt durch die pflanzlichen Lebensformen) übt einen starken Einfluss auf die Tiergemeinschaften aus. Darüber hinaus könnte sich die recht intensive Beweidung auf der Weide negativ auf die Wirbellosen ausgewirkt haben, während sich die geringe/fehlende Beweidung auf den natürlicheren, höher gelegenen Flächen (d.h. alpiner Rasen und fragmentierter Rasen) und die hohe Habitatheterogenität (auf dem fragmentierten Rasen) in hohen Zahlen von Abundanzen und der Biodiversitätsindizes niederschlug. Unsere Studie unterstreicht die Wichtigkeit, die alpine bodenbewohnende Fauna durch mehrfache Probenahmen während einer Vegetationsperiode zu untersuchen, um möglichst vollständige Tiergemeinschaften abzubilden.

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