Biological characterisation of humus profiles along a climatic gradient in subalpine forest soils

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Introduction

Humus forms are indicators of organic matter turnover and carbon storage in soils. Developing as a function of vegetation, geology and climate, they are highly sensitive to climate change. Differentiation of humus forms is primarily driven by the interaction of soil animals and microorganisms. We studied the effect of climate on the biological and morphological development of humus profiles by comparing sites similar in vegetation and geology (subalpine spruce forest), but differing in exposure (south-facing, north-facing) and altitude (1600 m, 1900 m), thus representing distinct gradients of temperature.

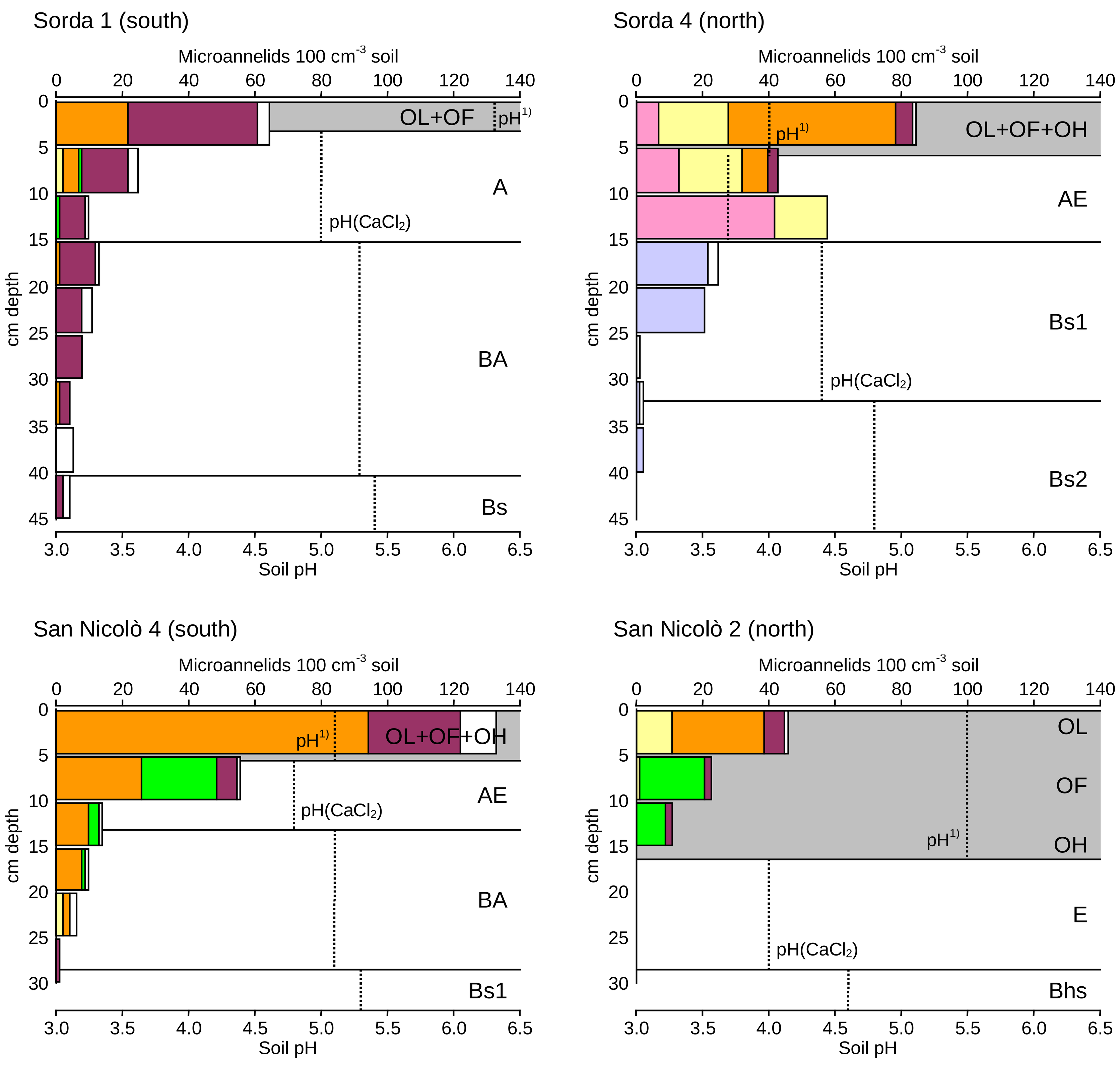

Fig. 2 Microannelid species composition and abundance as a function of soil depth in 4 topsoil profiles (Val di Fassa, Italy). Colours indicate the individual species reported in Table 2. 1)The pH of the organic layer was measured in the field colorimetrically.

Table 2 Microannelid species extracted from 4 topsoil profiles and their ecological classification with respect to soil acidity

	Sorda 1 south	Sorda 4 north	Nicolò 4 south	Nicolò 2 north	Acidity indicator group
Enchytraeidae					
Bryodrilus ehlersi	-	1	-	1	strong
Buchholzia appendiculata	29	59	142	28	slight
Cognettia sphagnetorum	2	56	2	12	strong
Enchytraeus buchholzi	11	1	-	-	slight
Enchytraeus christenseni	2	-	12	-	slight
Enchytraeus norvegicus	-	-	1	-	moderate
Enchytronia oligosetosa	-	1	-	-	slight
Enchytronia parva	-	3	4	-	moderate
Fridericia bisetosa	7	-	3	-	slight
Fridericia bulboides	5	-	10	-	slight
Fridericia christeri	-	-	1	-	slight
Fridericia paroniana	-	-	6	-	slight
Fridericia cf. *stephensoni*	-	2	-	9	moderate
Fridericia waldenstroemi	24	-	1	-	slight
Fridericia sp. juv.	57	6	18	1	slight
Hemifridericia parva	1	-	4	-	slight
Henlea perpusilla	2	-	28	29	slight
Henlea ventriculosa	1	-	-	-	slight
Marionina argentea	2	-	-	-	slight
Marionina brendae	2	-	-	-	slight
Marionina clavata	-	62	-	-	strong
Polychaeta					
Hrabeiella periglandulata	-	48	-	-	moderate
Total of extracted microannelids	145	239	232	80	
Abundance (individuals m^{-2})	73 848	121 722	118 157	40 744	
Number of species	13	10	13	6	
Shannon diversity index	1.81	1.61	1.44	1.38	
Evenness	0.71	0.70	0.56	0.77	
Indicators of strong acidity	1%	50%	1%	16%	
Indicators of moderate acidity	0%	22%	2%	11%	
Indicators of slight acidity	99%	28%	97%	73%	

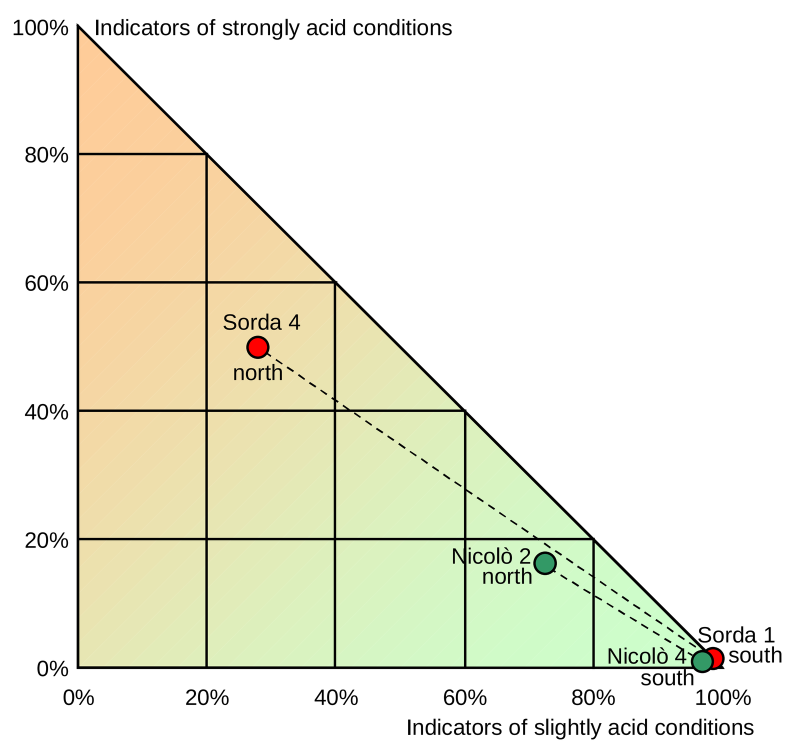

Fig. 4 Acidity indicator diagram of microannelid species assemblages. The position on the triangle shows the relative abundance of three ecological species groups present in the soils. The distances visualize the extent to which exposure has changed the community structure.

Material and methods

- Soil sampling at 4 spruce forest sites that differed in exposure and altitude allowing paired comparisons (Fig. 1, Table 1).
- Morphological and chemical description of the humus profiles.
- Measuring abundance, species composition and vertical distribution of microannelids as proxy for the mesofauna.
- Polyphasic biochemical fingerprinting of soil microbial communities by denaturing gradient gel electrophoresis (DGGE) and phospholipid fatty analysis (PLFA).

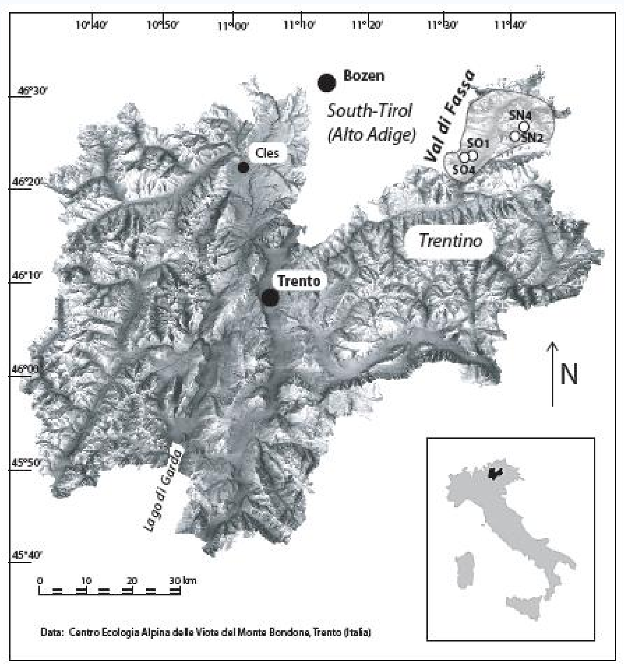

Fig. 1 Study area, Val di Fassa (Trentino), Sorda (SO1, SO4) and San Nicolò (SN2, SN4).

Table 1 Characteristics of the study sites in Val di Fassa - Southern Alps (Italy)

Locality	Elevation (m asl)	Aspect (°N)	Slope (°)	Parent material	Vegetation	Land use	Soil type (WRB 2006)	Humus form (ERB 2011)	Humus form (biologically)
Sorda 1 (south)	1620	165	35	Basaltic latite	Piceetum	Natural forest	Umbric Podzol (Episkeletic)	Hemimoder	Mull
Nicolò 4 (south)	1915	195	33	Basaltic latite debris	Piceetum	Natural forest	Umbric Podzol (Endoskeletic)	Dysmoder	Amphi
Sorda 4 (north)	1640	350	36	Basaltic latite debris	Piceetum	Natural forest	Umbric Podzol (Endoskeletic)	Eumoder	Moder
Nicolò 2 (north)	1920	300	29	Basaltic latite debris	Piceetum	Natural forest	Entic Podzol (Endoskeletic)	Humimor	Mor

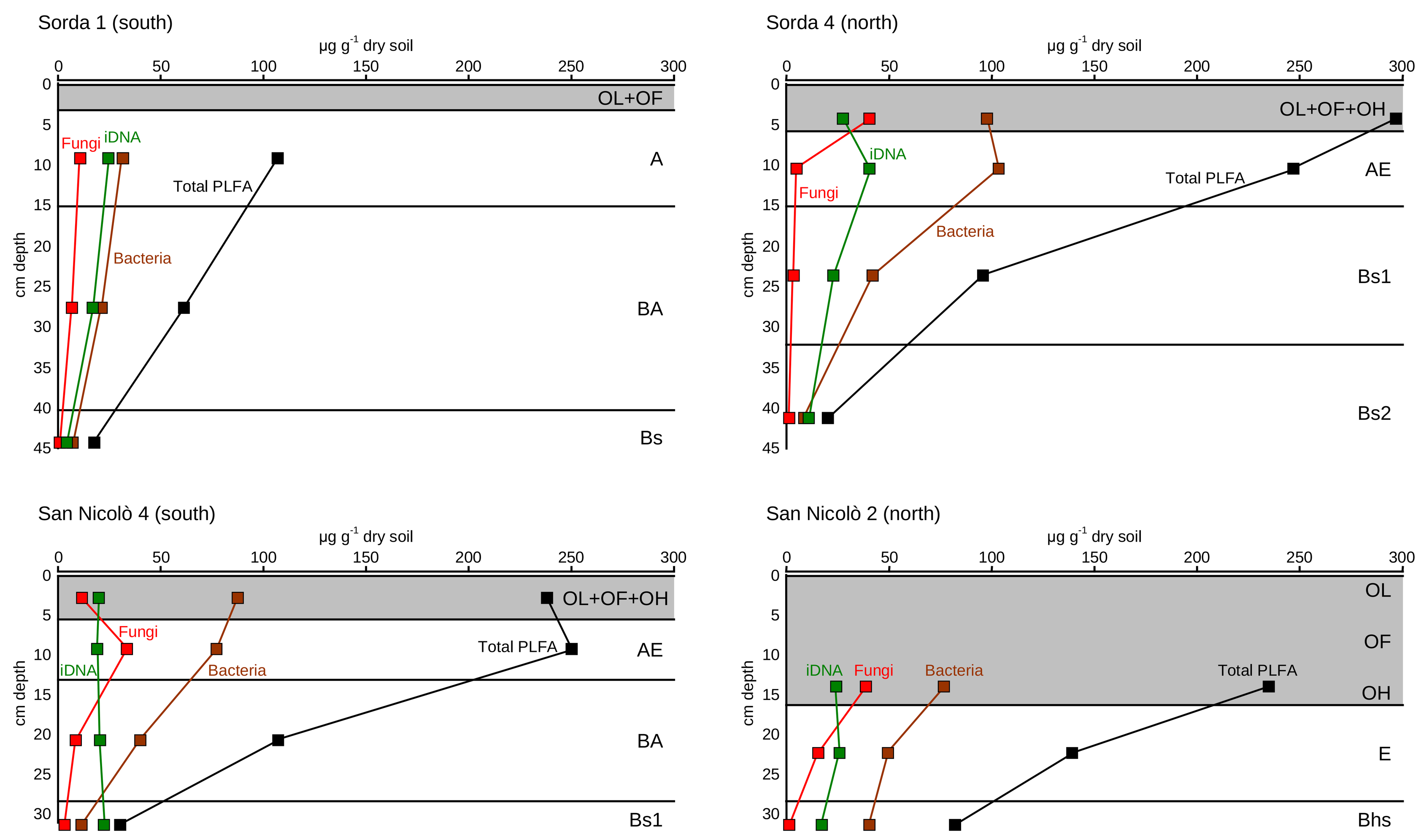

Fig. 3 PLFA concentration (μg g^{-1} dry soil) indicating fungal and bacterial biomass (sum of Gram-negative bacteria, Gram-positive bacteria and actinomycete) and intracellular DNA (μg g^{-1} dry soil) as a function of soil depth in 4 topsoil profiles.

Results

- The vertical distribution of microannelid abundance and microbial biomass showed similar patterns and provided evidence that the organic layer is the hotspot of biological activity in all 4 studied humus profiles (Fig. 2, Fig. 3).
- The thickness of the organic layer increased both at north-facing sites and at higher altitudes inversely to the thickness of the A horizon. The relation of endohumic (A) to ectohumic (O) horizons decreased along the sequence Sorda-south > Nicolò-south > Sorda-north > Nicolò-north following the gradient of decreasing mean annual temperature.
- The same gradient is shown by the activity of microannelids which was predominantly located in mineral horizons at Sorda-south and exclusively in the organic layer at Nicolò-north. In terms of humus forms the climatic gradient coincides with the sequence Mull, Amphi, Moder, Mor from the biological point of view.
- Analysis of microannelid species composition (Table 2) revealed highest similarities between sites with same exposure. Both south-facing sites were dominated by indicators of slight acidity being also indicators of Mull humus forms. This points to similar conditions of Mull and Amphi especially in the A horizon. Indicators of strong acidity were found in higher proportions only at the north-facing sites (Fig. 4).

Conclusions

The biological characterisation of humus profiles provides useful information for questions of organic matter stabilisation in soils (Andreetta et al. 2011; Ascher et al. 2011; Bonifacio et al. 2011) as well as for the classification of humus forms (Zanella et al. 2011).

References

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