

The orophilous relict High Campoese finely-toothed willow communities

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Received: 13 February 2018 / Accepted: 5 December 2019 / Published online: 6 March 2020

Abstract. This paper examines High Campoese orophilous snowbed dwarf communities of finely-toothed willow *Salix breviserrata* Flod. The acidophilous, rupicolous, and temporarily hygrophilous character of this species results in a singular floristic composition that is very different from the *Salix breviserrata* s.l. Picoeuropean communities. Based on the relevés sampled, the authors describe the endemic High Campoese dwarf scrub association *Alchemillo alpinae-Salicetum breviserratae*, which we ascribe to the *Salicetea herbaceae* class, where the mildest ecological conditions are represented, accounting for its relict character. These are Sites of Community Importance as stipulated by the European Commission Habitats Directive, which, together with their sensitivity to global climate change stemming from their limited synchronology, underlines their threatened status and the need for conservation policy.

Keywords: Community Importance Habitat; chionophilous; relict; *Salix breviserrata*; alpine vegetation.

Las comunidades orófilas relictas Altocampurrianas de sauce breviserrado

Resumen. Se estudian las saucedas arbustivas orófilas Altocampurrianas del sauce breviserrado *Salix breviserrata* Flod. El carácter acidófilo, rupícola y temporihiográfico redundan en un cortejo florístico propio, muy distinto a las comunidades Picoeuropeas donde participa *Salix breviserrata* s.l. En base a los inventarios levantados se describen las nanofruticedas endémicas Altocampurrianas *Alchemillo alpinae-Salicetum breviserratae* que adscribimos a la clase *Salicetea herbaceae*, en donde representa las condiciones ecológicas más suaves y explica su carácter relicto. Se trata de Hábitats Naturales de Interés Comunitario por la Directiva Europea, lo que junto a la sensibilidad al Cambio Global de sus escasas representaciones enfatiza el grado de amenaza y la necesidad de protección.

Palabras clave: Hábitat de Interés Comunitario; quionófilo; relicto; *Salix breviserrata*; vegetación orófila.

Introduction

The study and understanding of plant communities is an essential tool in conservation sciences. Classic or Braun-Blanquet phytosociology, as a science of syntaxa, allows a suitable approach to the study of biodiversity at an intermediate scale between species and landscape. Moreover, species conservation strategies cannot be separated from preserving the ecosystems in which the species live. In the European context, the CORINE biotope classification program (Devillers *et al.*, 1991) and the Habitats Directive (Anon., 1992), which are mainly based on phytosociological units, are good indicators of the impact of this science on the preservation of biodiversity (Izco, 2017).

High mountain ecosystems, characterized by harsh climatic conditions, restrict vital possibilities and require a high degree of adaptation from orophilous taxa. The complex of plant communities that shape the summit landscape is particularly sensitive to any alteration, whether local or related to global climate change (Thuiller *et al.*, 2005), especially when its survival is directly related to the persistence of snow cover and the hydromorphia associated with summer snowmelt.

In this study, the authors investigated the floristic composition, bioclimatic parameters, water regime and geomorphology of the orophilous *Salix breviserrata* s.l. communities in the eastern Orocantabrian Mountains (Spain). This dwarf willow, classified as vulnerable in the Spanish Red List of threatened flora (Bañares *et al.*, 2010), appears in the Iberian Peninsula only in the Orocantabrian subprovince (Figure 1), traditionally associated with Picoeuropean and Somiedese basophilous communities. Here, the authors document for the first time a phytosociological approach to the finely-toothed willow community on the High Campoese acidophilous soils.

The goals of this study were to: 1) review the role of *Salix breviserrata* s.l. in the Iberian orophilous communities; 2) develop a phytosociological analysis of the orophilous High Campoese finely-toothed willow communities by prospecting favourable habitats and recording relevés; 3) characterize the chorological and physiognomic profile of the High Campoese finely-toothed willow communities, as well as the bioclimatic, geomorphological and moisture factors that define them; 4) discuss the syntaxonomical ascription of the association studied; 5) emphasize the threats to the community in the context of global climate change and the need for conservation policy.

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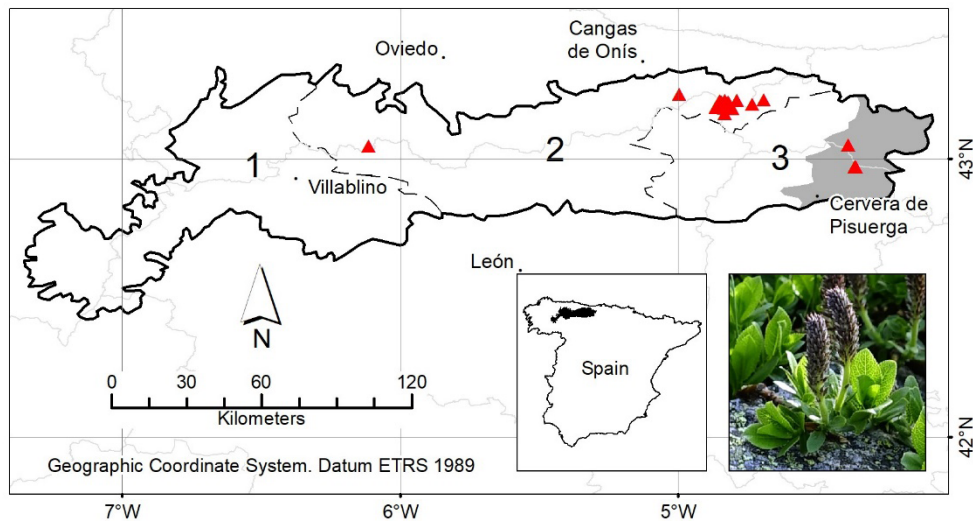


Figure 1. Orocantabrian biogeographical Subprovince and *Salix breviserrata* s.l. occurrences in the Iberian Peninsula (red triangles). 1: Laciana and Ancares Sector, 2: Picos de Europa and Ubiña Sector, 3: High Campoo and Carrión Sector. Shaded in grey: High Campoo District.

Study area and Methods

The Cantabrian range is a mountainous area located in the northwest of the Iberian Peninsula. It coincides basically with the Orocantabrian biogeographical subprovince. The Iberian representation of finely-toothed willow is limited to the eastern Orocantabrian sectors: Picos de Europa-Ubiña and High Campoo-Carrión sectors (Figure 1).

The High Campoo district, included in the High Campoo and Carrión sector, is located on the eastern edge of the Cantabrian range. It is essentially formed by the Peña Labra range, which serves as a boundary between the basins of the Cantabrian Sea (fed by the Nansa River), the Mediterranean Sea (Ebro River) and the Atlantic Ocean (Pisuerga-Duero River); as well as being the frontier between the administrative provinces of Cantabria and Palencia. Materials of Triassic origin dominate the Peña Labra massif summits: conglomerates, sandstones and shales. There are many peaks with an altitude of over 2000 m asl (Tres Mares 2171 m asl, Valdecebollas 2143 m asl, Peña Labra 2028 m asl). This territory has a temperate climate, marked by an absence of summer aridity, although its proximity to the Mediterranean region is reflected in its floristic background. In this zone, on acidophilous substrates in the Orotemperate belt, generally with a hyperhumid ombrotype, the dominant vegetation comprises Orocantabrian subalpine silicicolous juniper woods with black-blueberry *Vaccinio microphylli-Juniperetum alpinae*, where *Calluna vulgaris* is the dominant heath. In areas with a developed humiferous horizon, generally covered by snow most of the year, there is a presence of an *Erico tetralicis-Vaccinietum microphylli* association (Díaz & Penas, 2017). In addition to finely toothed willow, the Peña Labra massif holds many orophilous species with considerable conservation interest such as *Adonis pyrenaica*, *Androsace cantabrica*, *Lychnis alpina*, *Pulsatilla vernalis* and *Sedum alpestre*, included

in the list of threatened flora in the Castilla and León region (Anon., 2007).

The nomenclature used corresponds to the proposal in Flora Iberica (Castroviejo, 1986-2017), and for the *Asteroidae* and *Gramineae* taxa, not addressed by the former, we applied Flora Europaea (Tutin *et al.*, 1964-1980) except *Festuca*, which follows the checklist proposed by Devesa *et al.* (2013). Some taxa (*Avenella iberica*, *Juniperus alpina*) correspond to the Rivas-Martínez *et al.* (2011a) nomenclature.

The differentiation of the Picoeuropean finely-toothed willows, characterized by smaller size and length of catkins, motivated the cleavage of the subspecies *fontqueri* (Díaz *et al.*, 1988). The present authors have recently encountered a taxonomic proposal for peninsular finely-toothed willow species (Fernández-Prieto *et al.*, 2017). The authors of the proposal raise the Picoeuropean specimens to the specific range *Salix fontqueri*. The rest of the populations of finely-toothed willow (Somiedese and High Campoese) are named by the authors of the proposal as *Salix montifringillarum*. In this paper we maintained the criterion of conservative nomenclature of *Salix breviserrata* s.l. Blanco (1993) for all Orocantabrian (Picoeuropean, Somiedese and High Campoese) representations of finely-toothed willow.

The phytosociological nomenclature accords with that followed by Rivas-Martínez *et al.* (2011b). The authors prospected the scarce High Campoese populations of *Salix breviserrata*, sampling one phytosociological relevé in the Cantabrian population, and five in Palencia. For this, we followed the Braun-Blanquet (1979) methodology. For each relevé we considered the following factors: floristic composition, relative abundance, altitude, area, coverage, slope inclination and exposition. The combination of the new association complies with the rules of the International Code of Phytosociological Nomenclature (Weber *et al.*, 2000). The biogeographic units and bounds correspond to those set out in Rivas-Martínez *et al.* (2017a).

To study the habitat preferences of the Iberian finely-toothed willow, the authors focused on the relevés where

Salix breviserrata appears with an abundance-dominance index value of ≥ 2 . The ecological characterization of the communities, selected following the criterion mentioned above, was based on the phytosociological affinities of the species that make up each relevé. For this, we followed the relationship of characteristic species and bioindicators of syntaxa (Rivas-Martínez *et al.*, 2011a) and the ecological indications from the floristic catalogue of Alonso-Redondo (2003) for species not treated in the relationship as mentioned above. The biological forms and chorological groups of each taxon were essentially taken from Aizpuru *et al.* (2000).

Results and Discussion

Picoeuropean finely-toothed willow communities

In the Picos de Europa District (Picos de Europa and Ubiña Sector, Orocantabrian Subprovince) *Salix breviserrata* is distributed in the alpine and subalpine belts, from the vicinity of the Ordiales refuge (western massif) to the vicinity of the Samelar peak (eastern massif), about 25 km distant each other. Almost all the citations come from the Asturian part of the central massif (Alonso-Felpete *et al.*, 2011).

Of the 48 Picoeuropean relevés in which *Salix breviserrata* participates (Rivas-Martínez *et al.*, 1984; Nava, 1988; Jiménez-Alfaro *et al.*, 2014), in 20 of them, it does so with an abundance index of ≥ 2 (Appendix 1). In this paper, the term “finely-toothed willow communities” will be used to refer to these vegetal communities in which the finely-toothed willow dominates, in spite of its varied physical and chemical environment. They are found on rocky limestone substrates, at an altitude of 2254 ± 100 m asl ($n = 20$), preferring shady enclaves ($N = 38.89\%$, $NE = 27.78\%$, $NW = 16.67\%$, $W = 11.11\%$, $E = 5.55\%$; $n = 18$) where there is the possibility of long-term snow cover in appropriate geomorphologies. They are more or less open communities, with coverage values of $56.94 \pm 17.24\%$ ($n = 18$). 84 taxa participate, amounting to a total of 379 records. They exhibit a high proportion of endemism (27.38%): 23 species or subspecies of chorology restricted to the Iberian Peninsula or lower biogeographical units (two Picoeuropean, 11 Orocantabrian, eight Pyrenean-Cantabrian, and two Iberian endemism).

Within the conditions described above (low cover, basophilous alpine belt, in shady snow-covered places) the finely-toothed willow has some ecological plasticity. Traditionally, it has been viewed as an indicator of the *Linarion filicaulis* alliance (Rivas-Martínez *et al.*, 2011a), which is represented through the *Galiopyrenaici-Salicetum fontqueri* association. In most of the Picoeuropean finely-toothed willow communities; however, *S. breviserrata* receives the treatment of accompanying taxa of different and varied associations (Appendix 1).

The habitat preferences of these willow communities can be sketched through the phytosociological affinities (*sensu* Rivas-Martínez *et al.*, 2011a) of the taxa that make up the records (Table 1). 30.36% of the re-

ords correspond to species and subspecies related to the *Kobresio myosuroidis-Seslerietea caeruleae* class; 17.83% to *Thlaspietalia rotundifolii* and 13.65% to *Festuco hystricis-Ononidetia striatae*. This profile reflects, respectively, the participation of the willow in orophilous grassland communities with persistent snow coverage of the *Armerion cantabricae* alliance, basophilous-chionophilous glericolous associations of *Linarion filicaulis* and grasslands-dwarf scrublands on calcareous and shallow soils exposed to intense geliturbation of *Festucion burnatii*.

Table 1. Percentage participation in the main syntaxonomical groups obtained from Picoeuropean and High Campoese records of finely-toothed willow communities (f.t.w.comm.)relevés. The affinities of the records come from the bioindicator characterization of each taxon (Rivas-Martínez *et al.*, 2011a). S.S. = superior syntaxa; f.t.w.comm. = finely-toothed willow communities.

Syntaxon	Picoeuropean f.t.w.comm.	High Campoese f.t.w.comm.
<i>Armerion cantabricae</i> and S.S.	30.36	14.47
<i>Linarion filicaulis</i> and S.S.	17.83	1.97
<i>Festucion burnatii</i> and S.S.	13.65	1.97
<i>Caricetea curvulae</i>	8.36	25
<i>Molinietalia caeruleae</i>	0	9.21
<i>Festucetalia curvifoliae</i>	0	9.21
<i>Carici rupestris-Kobresietea myosuroidis</i>	8.91	1.97
Other syntaxa (altogether)	20.89	36.2

High Campoese finely-toothed willow communities

The discovery of *Salix breviserrata* in the Valdecebol-las massif (Cantoral *et al.*, 2016) prompted the study of the autoecology of this species in the High Campoo District (High Campoo and Carrion Sector, Orocantabrian Subprovince). In addition to the population in Palencia that has been discovered, the present authors had the opportunity to prospect the finely-toothed willow communities cited by Aedo *et al.* (1984: 127), which we found near Cornón and Tres Mares peaks (Uznayo, Cantabria). Despite its limited presence, the ecological, geomorphological, synchorological, and floristic consistency allowed us to sample six phytosociological relevés, which formed the basis for a proposed new association, *Alchemilla alpinae-Salicetum breviserratae* ass. nova *hoc loco* (Table 2, *holotypus* rel. 3).

1. Differential species

Finely-toothed willow is a procumbent woody chamaephyte of dwarf size that covers most of the terrain prospected (average coverage of relevés = 87.5%). Circumboreal calcifugous *Alchemilla alpina*, present in all our relevés, defines the synecology of the community: herbaceous chamaephyte of the moderately humid subal-

pine belt, acidophilous, poor in nutrients, of open spaces, subatlantic to subcontinental (Lauber *et al.*, 2012 *sensu* Landolt, 2010).

Together with the eponyms *Salix breviserrata* and *Alchemilla alpina*, the chionophilous species are to varying degrees characteristic of this association: *Sedum candollei*, *Sedum alpestre*, *Anthemis carpatica*, *Poa alpina*, *Polygonum viviparum* and *Plantago alpina*.

2. Floristic composition

The rupicolous herbaceous species *Anthemis carpatica*, *Helictotrichon sedense*, *Festuca indigesta* s.l. and *Festuca heteromalla* are conspicuous against a woody carpet. The community is significantly diversified around the willow. Despite the considerable degree of stoniness and relatively little edaphic development, the glades that accompany and precede the willow scrub exhibit a high number of species in the orophile context that concerns us here. 68 taxa participate, with an average richness of 27 species or subspecies per relevé, with a cumulative total of 158 records.

Table 2. *Alchemilla alpinae*-*Salicetum breviserratae* ass. nova (*Salicion herbaceae*, *Salicetalia herbaceae*, *Salicetea herbaceae*)

	207	208	208	206	198	210
Altitude (1=10 m asl)	207	208	208	206	198	210
Area (m ²)	5	5	35	10	10	30
Cover (%)	80	80	80	100	100	85
Slope (°)	25	25	25	40	15	30
Exposition	N	N	N	N	N	N
N. species	20	27	40	20	15	39
Relevé N.	1	2	3	4	5	6
Characteristics						
<i>Salix breviserrata</i>	3	3	3	4	2	3
<i>Alchemilla alpina</i>	+	+	+	+	+	+
<i>Anthemis carpatica</i>	1	+	1	.	.	+
<i>Polygonum viviparum</i>	.	+	+	.	.	+
<i>Poa alpina</i>	+	+	+	.	.	.
<i>Sedum candollei</i>	.	.	+	.	.	+
<i>Plantago alpina</i>	.	+	+	.	.	.
<i>Sedum alpestre</i>	.	.	+	.	.	.
Edaphohydrophilous differentials from <i>Adenostylin alliariae</i>						
<i>Aconitum vulparia</i> subsp. <i>neapolitanum</i>	.	.	.	.	1	.
<i>Alchemilla straminea</i>	.	.	.	.	1	.
<i>Polygonum bistorta</i> subsp. <i>bistorta</i>	.	.	.	.	1	.
<i>Caltha palustris</i>	.	.	.	.	+	.
<i>Geum rivale</i>	.	.	.	.	+	.
<i>Veratrum album</i>	.	.	.	.	+	.
<i>Viola bubanii</i>	.	.	.	.	+	.
<i>Rumex acetosa</i> subsp. <i>acetosa</i>	.	.	.	.	+	.
Transition differentials to <i>Juniperion alpinae</i> scrublands						
<i>Vaccinium uliginosum</i>	.	.	+	.	+	1
<i>Juniperus alpina</i>	.	.	+	+	.	+
<i>Vaccinium myrtillus</i>	.	.	.	.	+	2
<i>Calluna vulgaris</i>	.	.	+	.	.	1
<i>Huperzia selago</i> subsp. <i>selago</i>	.	.	.	.	.	+
Companions of <i>Caricetea curvulae</i>						
<i>Thymus praecox</i> subsp. <i>britannicus</i>	1	1	1	+	.	+
<i>Minuartia recurva</i>	+	+	1	+	.	+
<i>Pedicularis pyrenaica</i> subsp. <i>pyrenaica</i>	.	+	+	+	.	+
<i>Helictotrichon sedense</i>	1	.	+	1	.	+
<i>Silene ciliata</i>	+	+	.	+	.	+
<i>Jasione crispa</i> subsp. <i>crispa</i>	+	1	+	.	.	+
<i>Gentiana verna</i>	+	+	+	.	.	+
<i>Agrostis rupestris</i>	+	1	.	.	.	+
<i>Jasione laevis</i>	.	+	+	.	.	+
<i>Phyteuma hemisphaericum</i>	+	.	+	.	.	+
<i>Galium marchandii</i>	+	.	+	+	.	.
Other species:						
<i>Festuca heteromalla</i>	.	+	+	+	.	+

Table 2. *Alchemillo alpinae-Salicetum breviserratae* ass. nova (*Salicion herbaceae*, *Salicetalia herbaceae*, *Salicetea herbaceae*)

<i>Saxifraga granulata</i>	.	+	+	+	.	+
<i>Scorzoneroides pyrenaica</i> subsp. <i>cantabrica</i>	.	+	+	+	.	+
<i>Festuca indigesta</i> s.l.	+	+	1	.	.	+
<i>Euphrasia salisburgensis</i>	+	+	+	.	.	+
<i>Luzula spicata</i>	+	+	+	.	.	+
<i>Cerastium arvense</i>	.	+	+	+	+	.
<i>Sedum album</i>	+	+	+	+	.	.
<i>Linaria supina</i> subsp. <i>supina</i>	.	+	+	.	.	+
<i>Lotus corniculatus</i> subsp. <i>carpetanus</i>	1	1	+	.	.	.
<i>Cruciata glabra</i>	.	.	.	.	1	+
<i>Saxifraga moschata</i>	.	.	.	.	+	+
<i>Rhinanthus minor</i>	.	.	+	.	.	+
<i>Vicia pyrenaica</i>	.	.	+	1	.	.
<i>Saxifraga fragosoi</i>	+	.	+	.	.	.
<i>Trifolium repens</i>	.	+	+	.	.	.

Companions of *Caricetea curvulae*: *Euphrasia minima*, *Festuca eskia* and *Juncus trifidus* + in 6. Other species: *Botrychium lunaria* + in 2; *Armeria castellana*, *Carex leporina*, *Erica tetralix*, *Euphrasia hirtella*, *Ranunculus bulbosus* subsp. *castellanus* and *Sedum villosum* + in 3; *Anthoxanthum odoratum*, *Myosotis alpestris* subsp. *alpestris*, *Pyrola minor*, *Sedum forsterianum* and *Hieracium cezycola* + in 4; *Pulsatilla alpina* subsp. *cantabrica* 1, *Antennaria dioica*, *Anthyllis vulneraria* subsp. *vulnerarioides*, *Avenella iberica*, *Euprasia minima*, *Festuca eskia*, *Juncus trifidus*, *Melampyrum pratense* s.l. and *Solidago virgaurea* + in 6.

Localities: 1,2: Valdecebollas Cirque, Brañosera, Palencia, 30TUN887582, 14.07.2016; 3: Valdecebollas Cirque, Brañosera, Palencia, 30TUN887582, 14.07.2016, *holotypus* ass.; 4,5: Valdecebollas Cirque, Brañosera, Palencia, 30TUN886583, 14.07.2016; 6: Near the Cornón peak, Uznayo, Cantabria, 30TUN869671, 15.07.2016.

3. Life forms and chorotypes

The chorotype spectrum of the participating taxa (Table 3) shows a dominance of European-Orophile (25%) and Alpine-Boreal elements (16.18%), with a high proportion of endemisms (16.17%), although notably smaller than that observed in the Picoeuropean finely-toothed willow communities (two Orocantabrian, five Pyrenean-Cantabrian and four Iberian endemisms).

Thymus praecox subsp. *britannicus*, *Minuartia recurva*, *Jasione crispa* subsp. *crispa* and *Cerastium arvense* occur frequently. These taxa, of higher fidelity and coverage, are chamaephytic ones; however, analysis of the life form spectrum of the total taxa reveals that 57.35% are hemicryptophytes, 29.41% chamaephytes, 4.41% geophytes, and 8.82% therophytes. This proportion of hemicryptophytes/chamaephytes is similar to those studied in pre-Alpine communities with persistent snow coverage (Giovagnoli & Tasinazzo, 2014).

Table 3. Chorotype of taxa participating in High Camposee finely-toothed willow association.

Floristic Element	N° of taxa	%
Subcosmopolitan	2	2.94
Pluriregional	2	2.94
Circumboreal	8	11.76
European s.l.	10	14.70
European Orophile	17	25
Atlantic	4	5.88
Mediterranean	1	1.47
Mediterranean Orophile	2	2.94
Alpine-Boreal	11	16.18
Orocantabrian Endemic	2	2.94
Pyrenean-Cantabrian Endemic	5	7.35
Iberian Endemic s.l.	4	5.88

4. Synecology

The average altitude of the populations is 2062 m asl (n = 6), always in shaded orientations. The bioclimatic parameters (Table 4) corroborate the strong Euroceanic Temperate

character and the Hyperhumid Orotemperate bioclimatic belt; it should, however, be remembered that the climatic data do not take the local factors into account (terrain morphology, wind exposure, and snow cover) (Ferrari, 2018), determinant factors of the supra-treeline vegetation type.

Table 4. Mean values (n = 6) of the bioclimatic indexes and parameters and the corresponding classification, *sensu* Rivas-Martínez *et al.* (2017b) calculated from the thermo-pluviometric data of Hijmans *et al.* (2005) for the locations of finely-toothed willow relevés.

Index	Parameter definition	Value	Bioclimatic classification
Ic	Annual thermic interval. Simple continentality index.	14.77	Strong Euroceanic
Io	Annual ombrothermic index	13.74	Hyperhumid Ombroclimatic type
Ios ₂	Ombrothermic index of the hottest two months of the summer quarter	5.04	Temperate Macrobioclimate
It	Thermicity index (T+M+m) × 10	2.81	-
m	Average temperature of the minimums of the coldest month (°C)	-5.52	-
M	Average temperature of the maximums of the coldest month (°C)	1.28	-
P	Average annual precipitation (mm)	1113.33	-
Pp	Positive annual precipitation (mm) of the months with mean monthly temperature > 0°C	803.33	-
T	Mean annual temperature (°C)	4.47	-
Tmax	Average temperature of the hottest month of the year (°C)	12.65	-
Tmin	Average temperature of the coldest month of the year (°C)	-2.12	-
Tp	Positive annual temperature (Σ mean monthly temperature ₁₋₁₂ > 0°C)	584.5	Orotemperate Thermoclimatic type

Moderately chionophilous, calcifuge, rupicolous, temporarily hygrophilous of the High Orotemperate Hyperhumid belt, the relict High Camposee finely-toothed willow permanent community inhabits the ramps that follow depressions with snowpacks, located in the headers of glacial cirques, lying on north-facing slopes. The gentle slope that precedes the escarpments

allows the snow to accumulate and endure for about eight months. The summer melting of the snowpack, which drains immediately into the willow carpets (Figure 2), provides a temporarily hygrophilous character; although the soils dry up at the end of summer, coinciding with the bloom of most taxa in the snowbed community.

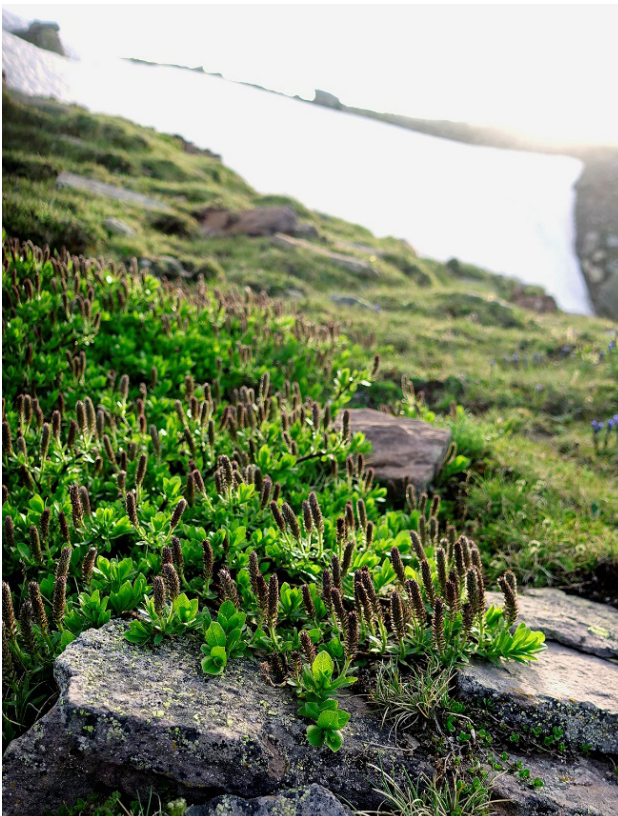


Figure 2. *Alchemillo alpinae-Salicetum breviserratae* of the Orotemperate acidophilous belt in High Camposee District (summit area of Valdecebollas, Celada de Robledo, Palencia). 22.06.2018.

Unlike Picoeuropean finely-toothed willow communities, eminently basophilous, the High Campoese dwarf scrubs colonize acidic soils, so their ecological preferences and floristic composition differ markedly from the former. Thus the comparative analysis of the profile of phytosociological affinities (Table 1) reveals the virtual disappearance of *Linarion filicaulis* and S.S. elements, *Festucion burnatii* and S.S. and *Carici rupestris-Kobresietea myosuroidis*; in favour of a clear dominance of taxa related to *Caricetea curvulae*, rare in the Picoeuropean relevés.

The siliceous High Campoese summit landscape is characterized by a polytessellar vegetation complex that features fine-scale variations of land inclination and exposure, associated with different degrees of snow persistence-geliturbation, erosion-sedimentation, drainage-hygomorphy, etc.

The enclaves on flat deep soils that remain covered in snow for a considerable time maintain a certain hygromorphy during the summer and buffer the drying effect of solar radiation. The humidity and the edaphic development allow the enrichment of *Mulgedio aconitetea* taxa, such as *Aconitum vulparia* subsp. *neapolitana* and *Veratrum album*, together with others of *Calthion palustris* alliance such as *Geum rivale* and *Polygonum bistorta*; at the same time, the species of *Caricetea curvulae* disappear. This situation applies to the finely-toothed willow community recorded in relevé 5, which we have denominated as a variant with *Aconitum vulparia* and *Veratrum album*.

On the steeper slopes the snow persistence is less prolonged and dense lower tickets of creeping juniper with blueberries of the association *Vaccinio microphylli-Juniperetum alpinae* appear. This is the climax stage of the upper Supratemperate and Orotemperate Hyperhumid belt in acidophilous Orocantabrian territory. We have characterized the contact of finely-toothed willow communities with the creeping juniper as a variant with *Vaccinium uliginosum* and *Vaccinium myrtillus* (relevé 6).

5. Syntaxonomy

The syntaxonomical framework of this association is not easy to define. Some authors have focused on the rupicolous and sometimes glericolous character of the finely-toothed willow, linking it to the *Thlaspietea rotundifolii* class. Along the same lines, the present authors note the bioindicator value attributed by Rivas-Martínez *et al.* (2011a) to the Picoeuropean finely-toothed willow, and the ascription of the Prealpine association *Salicetum reticulato-breviserratae* (Giovagnoli & Tasinazzo, 2014).

However, the participation of typical species of *Thlaspietea rotundifolii* is reduced to the presence of *Linarion supina* s.str. in three of our relevés. Besides, the dominant dwarf scrub physiognomy provided by the *Salix breviserrata* chamaephyte gives this association great singularity, clearly adapted to the weight of snow cover of considerable duration. Furthermore, the widespread subhorizontal root system of finely-toothed

willow (Pohl *et al.*, 2011) promotes stabilization and soil development, encouraged by the sedimentation of silt deposited on the snow cover and the soil litter from fallen willow leaves, and enables laminar water flow from the melting snowpacks to be utilized.

These habitat preferences are closely related to those of Pyrenean snowbed communities formed by *Salix herbacea* (*Salicetea herbaceae*) corresponding to the association *Anthelio juratzkanae-Salicetum herbaceae*; however, the characteristic species recorded in our relevés are very scarce, restricted to the succulents *Sedum alpestre* and *Sedum candollei*. Other characteristic taxa of *Salicetea herbaceae*, such as *Cerastium cerastoides*, *Omalotheca supina* and *Epilobium anagallidifolium* are present in the territory, although they do not appear in our relevés. A large body of literature (Braun-Blanquet, 1948; Petraglia & Tomaselli, 2007; Ferrari, 2018) has supported this gradual impoverishment in characteristic species of snowbed communities in the North-South European gradient. They are still represented in the Pyrenean massif and do not reach as far as the Orocantabrian territory: *Arenaria biflora*, *Cardamine alpina* and *Salix herbacea*.

The summer snow-free months allow for enrichment in orophilous, chionophilous and acidophilous grassland companion taxa, of ecological optimum in the *Caricetea curvulae* class, such as *Alchemilla alpina*, *Jasione laevis* and *Galium marchandii*. In addition, *Agrostis rupestris*, *Pedicularis pyrenaica* subsp. *pyrenaica*, *Phyteuma hemisphaericum*, *Plantago alpina* and *Luzula spicata*, present in our relevés, take part in the floristic composition of *Salicion herbaceae* communities (Petraglia & Tomaselli, 2007: 74). The contact and ecological affinities between the chionophilous grasslands of *Caricetea curvulae* and the long-lasting snow scrublands of *Salicetea herbaceae* have been referenced by other authors (Ferrari, 2018) and ratifies the syntaxonomical framework of the High Campoese willow community. The dominant pulviniform chamaephytic physiognomy, life form spectrum and the acidophilous character of the community leads us to the inclusion of this association in the *Salicion herbaceae* alliance.

However, the low latitude and altitude of our relevés suggest a shortening of the snow cover persistence and higher climatic fluctuations than the conditions applying to the Pyrenean or Alpine massif snowbed communities. In addition, the Mediterranean influence of the southern slope of the Cantabrian range produces certain drought stress in late summer (the period between the cessation of water contributions by melting of the adjacent snowpacks and the first snowfall). All such considerations lead us to interpret the presence of this community as a relict, a remnant of colder interglacial periods that finds a residual arrangement in these High Campoese plots.

6. Synchorology

The distance between the Valdecebollas and the Cornón summits is approximately 9 Km. The easternmost

Picoeuropean finely-toothed willow communities are about 30 km from the High Campoese ones. The area in which these populations have an accredited presence is limited to 0.7 ha in Valdecebollas and only 70 m² in the Cornón. Therefore, with the current knowledge, the proposed association is endemic to the High Campoo District (High Campoo and Carrión Sector, Orocantabrian Subprovince, European Atlantic Province, Atlantic-Central European Subregion, Eurosiberian Region).

7. Conservation

Salix breviserrata s.l. is listed as vulnerable in the Red List of the Spanish Vascular Flora (Moreno, 2011). Besides, finely-toothed willow communities should be interpreted as a Natural Habitat of Community Interest of type 4080, subtype 31.6214 (Anon., 2013): Pyrenean-Cantabrian subalpine and alpine willow brush.

The increase in regional mean annual temperatures since the last quarter of the 20th century, together with the 20% reduction in snowfalls in the Cantabrian range in recent decades (Ortega & Morales, 2015) exacerbates the risk of these relict communities disappearing, aggravated by their very reduced and localized synchrology.

Conclusions

The High Campoese finely-toothed willow community inhabits a singular physical and chemical environment, distinct from that observed in the Picoeuropean

territory, enabling the identification of a new association: *Alchemillo alpinae-Salicetum breviserratae*. This orophilous acidophilous relict community, endemic to the High Campoo District, is characterized by enduring snow cover and a temporarily hygrophilous character produced by the melting of the snowpack located in the vicinity of the association.

The more southerly location compared to the main European mountain ranges, together with the relatively low altitude, produce an impoverishment in the characteristic chionophilous taxa of the *Salicetea herbaceae* class.

Nonetheless, the present authors include the association in this class because of its habitat preferences and physiognomy, although we believe it to be a relict association, a remnant of colder periods that is on the ecological edge of the group. The persistence of a snow cover and the temporarily hygrophilous character of acidophilous High Campoese finely-toothed willow community determine an edaphic profile, synecology, woody reptant chamaephytic physiognomy, life form spectrum and floristic composition that leads us to the inclusion in the *Salicion herbaceae* alliance; very different from the basophilous Picoeuropean communities in which *Salix breviserrata* participates, predominantly caespitose and directed by their rupicolous character. This new community contributes to complete the knowledge of the Orocantabrian orophilous landscape.

The rarity of the taxa in the national context, as well as the reduced synchrology of this type of community in the European continent, are an indication of its potential threats exacerbated by new scenarios of climate change.

Appendix 1. Picoeuropean relevés with dominance-abundance index values for *Salix breviserrata* of ≥ 2 , grouped by the plant association to which they belong.

Galio pyrenaici-Salicetum fontqueri sub *Galio pyrenaici-Salicetum breviserratae* (*Linarion filicaulis*, *Thlaspietalia rotundifolii*, *Thlaspietalia rotundifolii*)

Rivas-Martínez *et al.* (1984; Table 45).

Oxytropido neglectae-Kobresietum myosuroidis (*Oxytropido-Kobresion myosuroidis*, *Carici rupestris-Kobresietea myosuroidis*)

Rivas-Martínez *et al.* (1984; Table 1, rel. 7: subass. *salicetosum breviserratae*).

Jiménez-Alfaro *et al.* (2014; Table 6, rels. 1 and 2).

Nava (1988, Table 14, rel. 6 sub “communities with *Elyna myosuroides*”).

Pediculari fallacis-Armerietum cantabricae (*Armerion cantabricae*, *Seslerietalia caeruleae*, *Kobresio myosuroidis-Seslerietea caeruleae*)

Jiménez-Alfaro *et al.* (2014; Table 4, rel. 25).

Saxifrago coniferae-Helianthemum urrielense (*Armerion cantabricae*, *Seslerietalia caeruleae*, *Kobresio myosuroidis-Seslerietea caeruleae*)

Jiménez-Alfaro *et al.* (2014; Table 5, rels. 22-29).

Nava (1988; Table 11, rel. 11 sub “geliturbated communities”).

Jasiono cavanillesii-Helictotrichetum sedenensis (*Festucion burnatii*, *Festuco hystrixis-Poetalia ligalatae*, *Festuco hystrixis-Ononidetea striatae*)

Jiménez-Alfaro *et al.* (2014; Table 2, rels. 19, 20, 23 and 24).

Nava (1988; Table 12, rel. 13 sub “geliturbated communities”).

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