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Grazing history influences biodiversity: a case study on ground-dwelling arachnids (Arachnida: Araneae, Opiliones) in Maritime Alps (NW Italy)

Running title: Grazing history and Arachnids assemblages

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## **ABSTRACT**

Alpine pastures represent typical examples of “high nature value farmlands”, representing important habitats harbouring unique biocoenosis. Disturbance induced by overgrazing influences significantly ecosystem processes, in which invertebrates play a major role. To develop new models of sustainable management of pastures, more knowledge on animal communities that are essential to the ecological functioning of pasture ecosystems is needed. The outward critic situation of several pastures in the Natural Park of Alpi Marittime (NW-Italy) lead us to set an ecological study aiming to evaluate the influence of grazing history on biodiversity, using spider and harvestmen assemblages as key groups. Four different pasture types characterized by four different grazing histories were identified using Daget-Poissonet method. Spiders and harvestmen were collected by means of pitfall traps. Generalized Linear Models were used to characterize the different assemblages occurring in each pasture type in terms of diversity, abundance, richness of endemic species and taxonomical relatedness. Specificity and fidelity of every spider and harvestmen species within pasture types were explored by the IndVal (Indicator Value) procedure. Fifty-eight species of spiders and seven species of harvestmen were collected (2304 individuals). Pasture types related to overgrazing were characterized by the dominance of diurnal spiders while, conversely, nocturnal wanderers were more abundant in extensive pasture types. GLM showed that both species richness and spider abundance were lower in actively heavily grazed type. Endemic assemblages were richer and more abundant in lightly grazed type, which also hosted the most taxonomically diverse assemblages. Most of the indicator species of lightly grazed types were endemic ones, characterized by more demanding ecological requirements.

Keywords: alpine pastures; disturbance; spiders; harvestmen; taxonomical relatedness; endemic species

## **INTRODUCTION**

The conservation value of the so called ‘high nature value farmlands’ is acknowledged in several EU policy documents, such as the EU Regulations on rural development (EC 1257/1999 and Council Reg 1698/2005). Such areas, usually characterised by extensive farming practices, are defined as “those areas in Europe where agriculture is a major land use and where agriculture sustains or is associated with either a high species and habitat diversity, or the presence of species of European conservation concern, or both” (Andersen et al. 2003). Typical high nature value farmlands are Alpine meadows and pasture, extensively

grazed uplands and steppic areas in eastern and southern Europe. High nature value farmlands have been subjected to dramatic losses in the past decades, with consequent decline of biodiversity, due to intensification trends in agriculture but also to abandonment, since these habitats cannot survive without a moderate human intervention (Paracchini et al. 2008). Alpine pastures are typical examples in this sense, representing important grassland habitats harbouring unique biocoenosis and also facing dramatic decline over the past few decades. Despite in the Italian Alps pastures are still managed in traditional ways, increasing pressure for higher yields, rising price of labour and abandonment is leading to significant habitat alterations. As consequence of economic and social changes, the traditional pasture management, which have been in use for hundreds of years and which resulted in a high diversity of plants and invertebrates, is now rapidly shifting towards intensification with increased stocking rates or abandonment (Groombridge 1992).

In a pasture ecosystem, the plant and animal biodiversity depends critically upon the level of grazing and overgrazing may lead to land degradation and loss of biodiversity (Noellemeyer et al. 2006). Disturbance induced by overgrazing influences significantly animal and vegetal diversity (Pucheta et al. 1998; McIntyre et al. 2003), vegetation structure (Fleischner 1994; Pucheta et al. 1998), and, consequently, ecosystem processes (Fleischner 1994; Chapin III et al. 1996). A major role in ecosystem processes is played by invertebrates, whose importance in terms of ecosystem functionality is increasingly recognized (McGeoch 1998; Coleman and Hendrix 2000).

Overgrazing is regarded a major cause of decrease of richness and abundance of ground dwelling arthropods (Gibson et al. 1992; McCracken and Tallowin 2004). Intensively managed pastures in fact usually harbour a depleted arthropod fauna (Manhart et al. 2004). On the other hand, extensive uses are frequently associated to high levels of biodiversity (Wettstein and Schmid 1999) and to a general improvement of the nutrient cycle promoting the floral and faunal diversity (Bilotta et al. 2007).

In the Alps, especially in the southern Italian and French Alps, overgrazing has caused damage to vegetation, the deterioration of soil already under threat of erosion, the prevention of forest renewal and a noticeable increase in the risk of avalanches and landslides. To develop a new model of sustainable pasture management more knowledge is needed about the effect of grazing on animal communities, especially those that are essential to the ecological functioning of pasture ecosystems, like ground-dwelling arthropods. Spiders (Araneae), in particular, have been widely recommended as bioindicators (Finch and Löffel 2010) and usually they are the most diverse and abundant predatory animal group of open habitats.

Spider assemblages are influenced by many aspects of land use and management (Dennis et al. 2001; Cattin et al. 2003; Warui et al. 2005). Being arthropod predators they are important components of natural and agricultural ecosystems; they play vital role in structuring arthropod communities and also in natural pest control (Marc et al. 1999; Sunderland and Samu 2000). Therefore, the study of spiders which are vital components of agricultural ecosystems is essential to understand the effect of land use processes on biodiversity.

The present work is set within the ATBI+M (All Taxa Biodiversity Inventory + Monitoring) project ruled by the European Distributed Institute of Taxonomy (EDIT), founded in 2006 in the frame of the Sixth Framework Programme of the European Commission (Work Package 7). All Taxa Biodiversity Inventories (ATBI) are intensive community efforts to identify and record all living species that exist within a given area. An ATBI+M not only compiles lists of species, collects information on habitat, distribution, time and date of occurrences of the observed species, but also promotes the monitoring and the study of the factors affecting biodiversity conservation. The European Distributed Institute of Taxonomy (EDIT) stimulated the first European ATBI+M in the Alpi Marittime and Mercantour Natural Parks in order to apply the science of taxonomy to the conservation of biodiversity.

The outward critic situation of several pastures within the Park of Alpi Marittime lead us to set an ecological study aiming to evaluate the influence of grazing history on biodiversity, using spider and harvestmen assemblages as key groups. Given the particular biogeographical frame in which the Park is located, a special reference to endemic species is also emphasized.

## **MATERIAL AND METHODS**

### **Study area**

The study was carried out in the Alpi Marittime Natural Park in the SW Italian Alps. Given its peculiar faunistic diversity, such Alpine district has been defined as a key area to understand the dynamics that shaped the fauna of the Italian peninsula as well as the Western European one (Minelli et al. 2006).

The work was conducted in 2008 in two pastoral areas located in two adjacent valleys: Pian della Casa (Valletta Valley, 1743 m a.s.l., 44°10'15'', 7°16'12''E) and Lagarot (Lourousa Valley, 1959 m a.s.l., 44°12'14'', 7°17'52''E). At Pian della Casa, grazing is active since 1950's, with cows grazing from mid June to mid September (approximately 140 hectares used by 200 cows from June to October). The entire

pastoral area of Pian della Casa is interested by the presence of cows but grazing pressure is not uniform across the area, resulting in a shifting mosaic of grassland types according to grazing history. In some portions, heavy trampling and traditional sedentary herding caused high deprivation of grass. On the other hand, different grassland types occur at the base of the steeper slopes of the valley, with higher abundance of rocks on the ground grass and a minor frequentation by livestock.

Being the closest area without active grazing, we included in the work the pastoral area at Lagarot (approximately 80 hectares), located about 4 Km in straight line from Pian della Casa. Extensive grazing at Lagarot was abandoned in 1988 and since that time no grazing has been practiced.

Wild ungulates (ibex and chamois) are also present in both valleys.

### **Vegetation sampling**

We choose 12 linear transects characterized by homogeneous ecological conditions and uniform vegetation at Pian della Casa and 6 at Lagarot (18 linear transects in total). The number of transects (12+6) was chosen according to the extension of the pastoral areas (140 hectares at Pian della Casa and 80 hectares at Lagarot). Cavallero et al.'s work (2007) was used to define pasture types occurring along each transect. As suggested by the authors, the vegetation composition was determined by means of Daget-Poissonet method.

According to such methods, the definition of the pasture type is achieved compiling the inventory of the species along homogeneous linear transects. The list of the species recorded for each pasture type is reported in Appendix 1.

Four major pasture types were identified:

- i) *Festuca rubra* and *Agrostis tenuis* type (FR) is characterized by a mosaic of several Gramineae species like *Festuca* gr. *rubra*, *Agrostis tenuis*, *Poa supina* and *Poa annua* and by a high level of grazing pressure. This vegetation assemblage has a wide ecological demand and can be found in a wide altitudinal interval. It is indifferent to the substrate and can be found on mature soils with poor skeleton, rich in organic matter and acidified in the superficial horizons. This type, representing the dominant pasture type at Pian della Casa, is determined by the abundance of zoogenic species related to grazing. Eight linear transects at Pian della Casa were assigned to this type. Vegetation was dominated by *Festuca rubra*, *Nardus stricta*, *Ranunculus montanus* and species richness of plants in this type was high, with 68 species identified.

- ii) *Rumicetum alpini* (RA) type is dominated by the alpine dock *Rumex alpinus*, an erect nitrophilous plant with large leaves, unpalatable to cows. RA types (so called “gias” by the locals) are the typical outcome of heavy manuring and are generally avoided by cattle. According to Cavallero et al. (2007), this type represents a typical association of the montane and subalpine belt, nitrophil, indifferent about the substrate. The presence of such type indicates irrational management, with heavy concentration of nutrients in restricted areas and nutritional impoverishment of the nearby areas. Three linear transects at Pian della Casa were found to belong to this type. Vegetation was dominated by *Rumex alpinus* and a poor vegetal diversity was recorded (22 species of plants).
- iii) *Festuca ovina* type (FO), represents a lightly grazed typology and is generally found at the base of the slopes. These types are partially avoided by the cows, mainly because of the roughness of the soil surface and because of the presence of more superficial rocks. The type is primarily determined by extensive grazing and by the scattered presence of zoogenic species. Only a small part of the study area at Pian della Casa was found to belong to this type and only one linear transect was assigned to this type. Plant diversity was high, with 43 species identified along the transect.
- iv) *Festuca scabriculumis* type (FS) is characterized by semirupicolous termophil vegetal formations of the subalpine and alpine belt and is generally found on slopes with moderate steepness, rich in skeleton on moderately evolved soils. According to climatic (high insolation) and edaphic (lack of articulated horizons, poor supply of organic matter, high drainage) factors, it is particularly stable. According to Cavallero et al. (2007), extensive grazing represents the main determinant of this pasture type. All transects (6) placed at Lagarot were found to belong to this type. This type was found to be the most diverse in terms of species plants, with 51 species identified.

### **Sampling design**

Along each linear transect used for the vegetation surveys, we placed seven pitfall traps at a distance of 5 m one from the other. As a result  $8 \times 7 = 56$  traps were placed in FR type,  $3 \times 7 = 21$  traps in RA type,  $1 \times 7 = 7$  traps in FO type and  $7 \times 6 = 42$  traps in FS type. Traps were placed at the beginning of June 2008 and emptied every three weeks until the end of September (4 replicates), for a total of  $126 \times 4 = 504$  observations. In all analyses comparing arachnids assemblages in the different pasture types (GLM and



ISA, see later paragraphs), we used as basic sample unit the mean value of the 4 replicates per trap for each community parameter. Consequently, 126 basic sample units were used.

We used pitfall traps of 10 cm in mouth diameter and 12 cm deep filled with 50 ml of a mixture of water and glicole 50%. Because of the high level of disturbance, large stones were placed around the traps to protect them from the livestock at Pian della Casa and from wild ungulates at Lagarot.

Spiders and harvestmen caught were sorted and identified to species level using updated standard keys or specialist works. Spider nomenclature follows Platnick (2012). For harvestmen we refer to Fauna Europea (Martens 2011).

Environmental characteristics of each observation were also recorded. In circular areas of 5 m radius (centered on the pitfall trap) we measured 1) percentages of grass cover, 2) bare soil cover, 3) rock cover, 4) dung cover (estimated by eye) and 5) mean grass height (ten measurements, in centimeters). The final habitat structure matrix was then composed by 504 observations and 5 environmental variables.

## **Data analysis**

### *Pasture types characterization and sampling accuracy*

Pasture types were characterized by means of Principal Component Analysis (PCA). Axes with broken-stick eigenvalues less than the actual eigenvalues for that axis were considered for interpretation (Jackson 1993). PCA was run with PC-ord (McCune and Mefford 1999).

An abundance-based richness estimator (ACE) was used to predict the expected species richness at each pasture type. The inventory completeness for each site was measured as the percentage of the total number of species predicted by the estimator that we actually observed. The richness estimator was computed using EstimateS 8.0.0 (Colwell 2006).

### *Differences among spider assemblages*

Spider diversity in the four pasture types was compared by using *Compare diversity module* in PAST V. 2.06 (Hammer et al. 2001). We computed evenness for each pasture type and then compared them using two different randomization procedures, bootstrapping and permutation (1000 runs). The same analysis was performed for functional groups of spiders, which were derived from the Regional check-list of Isaia et al. (2007).

For each basic sample unit, we computed abundance (N) both for spiders and harvestmen. Given the low number of harvestmen, species richness (R) and richness of endemic species (Rend) were computed for

spiders only. We refer to endemic species as species with Western Alpine-North Appenninic, Western Alpine and SW-Alpine distributions (AWNA, ALPW and ALSW corotypes after Stoch and Vigna-Taglianti 2005).

Given that number of species was too low in harvestmen, we computed taxonomic diversity ( $\Delta$ ), average taxonomic distinctness ( $\Delta^+$ ) and taxonomic distinctness ( $\Delta^\circ$ ) for spider assemblages only, using PRIMER-E software version 6.0 (Clarke and Gorley 2006). Such indices quantify diversity as the taxonomic relatedness of the species within a sample, attempting to capture phylogenetic diversity rather than simple richness of species.

Given that parametric tests could not be properly employed because several assumptions were not met, generalized linear models (GLM) were used. For each analysis, one categorical factor (pasture type) was considered. The best distribution to describe abundance of spiders and harvestmen, spider species richness and richness of endemic species of spiders was found to be Poisson, while for taxonomic relatedness indexes ( $\Delta$ ,  $\Delta^\circ$  and  $\Delta^+$ ) for spiders, the best distribution found was Gamma; therefore these distributions of errors were assumed and the spider community parameters were related to explanatory variables via a logarithmic link function for Poisson distributed data (N, R, Rend) and via an inverse link function for the gamma distributed ones ( $\Delta$ ,  $\Delta^\circ$  and  $\Delta^+$ ) (McIntyre and Lavorel 1994). Tests for the significance of the effects in the models were performed by means of the Wald statistic (Dobson 1990). GLM and Wald statistics were calculated using the STATISTICA 6.0 package (StatSoft 2001). According to this package, if one selects the sigma-restricted parameterization, the last category that is specified for a categorical variable is the reference category and hence only pairwise comparisons between the effects of the remaining categories of the predictor variable on the response (dependent variable) are allowable. Given the current absence of disturbance and given its grazing history (the association is close to native vegetation), we used FS type as the reference category in the parameter estimation analysis.

#### *IndVal procedure*

Specificity and fidelity of every spider and harvestmen species within pasture types were explored by the IndVal (Indicator Value) procedure (Dufrêne and Legendre 1997). The statistical significance of the maximum indicator value was evaluated by a Monte Carlo randomization test (1000 runs). IndVal analyses were run using PC-Ord software (McCune and Mefford 1999).

## **RESULTS**

### *Habitat characterization*

The first three principal components (PC1, PC2 and PC3) accounted for 83.02% of the total variation in the habitat structure matrix, with eigenvalues >1 (Table 1). The percentage of grass cover provided the major positive loading, suggesting a gradient from grasslands with heterogeneous cover to homogeneous grazed grassy areas. The height of grass and the percentage of bare soil cover showed the highest negative loading on PC2 scores together with a positive loading of rock cover, suggesting a gradient from the RA type to un type. The relative position of pitfall traps in the PC1 and PC2 biplot roughly outlined three distinct clusters, separating RA type (bare soil with sparse erect nitrophilous plants), from FO type (non-homogeneous natural grassland with reduced presence of dungs), from FS type (ungrazed grassland without dungs). FR type clustered more indistinctly in the central part of the plot, with most plots being characterized by reduced grass cover, higher presence of dungs and bare soil cover (Fig. 1).

### *Spider assemblages*

A total of 58 species of spiders (1972 individuals) belonging to 13 families (Agelenidae, Amaurobiidae, Dysderidae, Gnaphosidae, Linyphiidae, Liocranidae, Lycosidae, Pimoidae, Pisauridae, Salticidae, Segestriidae, Theridiidae, Thomisidae) were collected (Appendix 2). 279 individuals could not be identified at species level, so they were excluded from the analysis. The final dataset was composed for spiders by 1693 individuals. Spider sampling in each of the four pasture types was adequate given that most of the expected species were effectively caught (richness estimator for spiders: FR 65.38%, RA 69.11%, FO 77.80%, FS 77.12%; harvestmen: FR 99.99%, RA 85.71%, FO 100%, FS 75.00%).

When considering the two valleys, rare species of spiders (less than 9 individuals per species) accounted for 10% of the total sample. The majority of the most representative species (90% of the sample) was shared by the two valleys with the exception of *Malthonica silvestris*, *Xerolycosa nemoralis*, *Araeoncus vaporariorum* and *Haplodrassus signifer* that were only represented in Pian della Casa pasture types (FR, FO and RA).

Distribution of spider abundances was different in the four pasture types: the assemblage of FO type was dominated by three species endemic to SW Alps (*Coelotes poweri*, 19.09%, *Harpactocrates drassoides*, 16.36% and *Amaurobius scopolii*, 14.55%), whereas FS was dominated by one species (*Zelotes aeneus*,

41.35%) followed by *Drassyllus pusillus* (10.54%). FR and RA types were characterized by the dominance of *Pardosa mixta*, representing 46.50% and 50.73% of the sample, respectively.

Differences between the four assemblages were clearly highlighted, especially when considering their composition in terms of evenness of species and functional groups (Fig. 2). Evenness of species distribution was significantly higher in FO type (0.67) than the other pasture types (FR: 0.22, FS: 0.28, RU: 0.27, bootstrapping  $<0.001$ ; permutation  $P < 0.001$  for all comparisons). Abundance of functional groups was also significantly different according pasture type, with the exception of FR vs. RU types, for which no significant differences was found (bootstrapping  $p = 0.292$ ; permutation  $p = 0.239$ ). The highest evenness of functional groups was found in FO type (bootstrapping  $P < 0.001$ ; permutation  $p < 0.001$  for all comparisons). The assemblages of FR and RA types were dominated by diurnal wanderers (62.37% and 63.12% respectively) while nocturnal wanderers dominated the sample in FS (71.31%) and FO types (32.18%). Abundance of functional groups was more evenly distributed in FO type, with 32.18% of nocturnal wanderers, 24.14% of diurnal wanderers, and 17.24% of tubular web spiders (Fig. 2).

#### *Harvestmen assemblages*

An amount of 332 harvestmen belonging to seven species and two families (Phalangiidae, 6 species and Nemastomatiidae, 1 species) was collected (Appendix 3). The majority of the sample (81.62%) was represented by *Mitopus morio*, a widespread species abundant in Alpine environment, followed by *Dasylobus ligusticus* (10.24%). The final dataset included 305 individuals and 2 species. The sampling of harvestmen in each of the four pasture types was adequate given that most of the expected species were effectively caught (Table 1). The two most representative species (90% of the sample) were shared by the two valleys, despite only one individual of *Dasylobus ligusticus* was found at Lagarot (33 at Pian della Casa). All pasture types were dominated by *Mitopus morio*, representing more than 80% of the sample in FR, FS and RA types and approximately 50% in FO type. No differences were found among pasture types in terms of evenness (FO: 0.81, FR: 0.41, FS: 0.52, RU: 0.32, permutation  $p$ : NS for all comparisons).

#### *Differences among pasture types*

Mean abundance (N) and species richness (R) of spiders significantly differed between pasture types ( $P < 0.001$ ). GLM estimates, in particular, showed that abundance of spiders in the traps set in the FS types were higher than those of FR (N: Estimates = -0.187, Wald stat = 19.118,  $P < 0.001$ ; R: Est = -0.33, Wald stat. = 21.701,  $p < 0.001$ ). No significant differences were found in respect to the other pasture types (RU,

N: Estimates = -0.091, Wald stat. = 2.933, ns; R: Estimates = +0.070, Wald stat. = 0.765, ns; FO, N: Estimates = +0.102, Wald stat. = 1.855, ns; R: Estimates = +0.141, Wald stat = 1.444, ns) (Fig. 3).

Richness in endemic species of spiders significantly differed between pasture types ( $P < 0.001$ ). Traps set in the FO type showed higher richness of endemic species (FO, Rend: Estimates: +1.166, Wald stat. 59.039,  $p < 0.001$ ), while in respect to other pasture types, no differences were found (RU, Rend: Estimates = +0.108, Wald stat. = 0.884, ns; FR, Rend: Estimates = -0.123, Wald stat. = 0.933, ns) (Fig. 4).

Taxonomic relatedness indexes ( $\Delta$ ,  $\Delta^\circ$ ,  $\Delta^+$ ) significantly differed between pasture types. When considering FS as reference type, traps set in the FO type showed higher taxonomic diversity (FO,  $\Delta$ : Estimates: -0.0041, Wald stat. 3.768,  $p < 0.05$ ) while FR showed significant lower values (FR,  $\Delta$ : Estimates: +0.002, Wald stat. 4.474,  $p < 0.05$ ). RA showed no significant differences (RA,  $\Delta$ : Estimates: -0.001, Wald stat. 1.023, ns). FO also showed higher level of taxonomic distinctness (FO,  $\Delta^\circ$ : Estimates: -0.0041, Wald stat. 3.281,  $p < 0.05$ ) while for FR and RA no significant differences were observed (FR,  $\Delta^\circ$ : Estimates: +0.0001, Wald stat. 0.001, ns; RA,  $\Delta^\circ$ : Estimates: -0.0003, Wald stat. 0.321, ns). No significant in differences among types were found when considering average taxonomic distinctness (FO,  $\Delta^+$ : Estimates: -0.0001, Wald stat. 1.740, ns; FR,  $\Delta^+$ : Estimates: +0.0001, Wald stat. 0.073, ns; RA,  $\Delta^+$ : Estimates: -0.0003, Wald stat. 0.463, ns) (Fig. 5).

Concerning harvestmen, RA showed higher abundance (RA, N: Estimates = 1.453, Wald stat. = 198.635,  $p < 0.001$ ), while no differences were found in the other pasture types in respect to the reference category (FR, N: Estimates = -0.130, Wald stat. = 1.327, ns; FO, N: Estimates = -0.056, Wald stat. = 0.072, ns) (Fig. 6).

#### *IndVal Procedure*

Preferences of each spider and harvestmen species for pasture type were detected through Indicator Value Procedure (Table 2). Sixteen species of spiders and two species of harvestmen showed significant preferences. Concerning spiders, one species showed a significant preference for FR (*Pardosa amentata* (Clerck 1757),  $p < 0.05$ ), five for RA (*Alopecosa aculeata*,  $p < 0.05$ ; *Erigone dentipalpis*,  $p < 0.01$ ; *Micaria pulicaria*,  $p < 0.05$ , *Pardosa mixta*,  $p < 0.01$ ; *Zelotes talpinus*,  $p < 0.05$ ), five for FO (*Amaurobius scopolii*,  $p < 0.001$ ; *Coelotes poweri*,  $p < 0.01$ ; *Harpactocrates drassoides*,  $p < 0.001$ ; *Malthonica silvestris*,  $p < 0.01$ ; *Xerolycosa nemoralis*,  $p < 0.01$ ) and five for FS (*Alopecosa cuneata*,  $p < 0.01$ ; *Gnaphosa lugubris*,  $p < 0.001$ ; *Xysticus desidiosus*,  $p < 0.01$ ; *Zelotes aeneus*,  $p < 0.001$ ; *Zelotes petrensis*,  $p < 0.01$ ). Two species of harvestmen (*Mitopus morio*,  $p < 0.01$  and *Dasylobus ligustigus*,  $p < 0.05$ ) showed significant preference for RA type.

## DISCUSSION

Grazing history influences different ecosystem components (Chapin III et al. 1996; Bilotta et al. 2007). Short and long term effects may be distinguished, the first involving the simplification of vegetal architecture due to trampling and/or removal of the vegetal cover, leading up to the formation of areas of bare soils. Long term effects are mainly caused by changes of the vegetal associations with the establishment of zoogenic species and the alteration of the chemical and physical condition of the soil (Kruess and Tschardt 2002).

In our study area, short term effects induced by grazing are firstly highlighted in the PCA analysis (Fig. 1), in which observations cluster according to the degree of vegetal coverage, to the presence of bare soil and to the presence of dungs, attesting the presence of active grazing. Concerning long term effects, floristic surveys highlight the remarkable presence of zoogenic species (i.e. RA and FR types) and the establishment of peculiar vegetal associations, primarily determined by different grazing history. According to PCA results and their combination with the information derived from vegetal surveys, pasture types reflect different grazing histories: FS type is found in areas where extensive grazing was abandoned more than 20 years ago and is characterized by higher grass coverage, higher presence of rocks and absence of dungs and absence of active disturbance induced by the presence of cows. In addition, according to Cavallero et al. (2007), FS type is highly stable and can be considered very close to the native vegetation of Alpine prairies. On the other hand, RA type is characterized, among the others, by the stronger perturbation in terms of long term effects induced by grazing. At the same time, RA shows a very low level of direct disturbance due to the scarce association with cows. In the case of RA type, the native vegetation is totally altered (Cavallero et al. 2007), both in terms of composition and structure (erect nitrophilous plants with large leaves). FO type represents a low level of disturbance, as attested by the position of FO type plots in the PCA biplot (lower presence of dungs and higher vegetal cover in respect to FR, higher presence of rocks) and by the presence of some zoogenic vegetal species related to light extensive grazing. Finally, FR type is characterized by a high level of active disturbance (higher presence of dungs and lower vegetal cover in respect to FO type, lower presence of rocks) and an abundance of zoogenic species, attesting a moderate degree of transformation of the native vegetation.

Changes in vegetal communities may lead, in turn, to remarkable changes in the composition and diversity of arthropod assemblages (Gibson et al. 1992). Several studies enhance how the alteration of vegetation due to the presence of cattle, is the main factor influencing spider assemblages living in pastures (Gibson et

al. 1992; Dennis et al. 2001), acting directly on the availability of preys and indirectly modifying the microclimatic conditions at ground level (Bell et al. 2001). As far as we are concerned, the influence of grazing on harvestmen has never been taken into consideration.

Given that most of the species were shared by the two valleys, we suggest therefore that the remarkable impoverishment of the spider assemblages found in FR and RA types at Pian della Case are due to intensive grazing, both in terms of long term- (RA type) and short term- (FR type) effects. Direct impacts are clearly seen when observing the composition of the spider coenosis in terms of functional groups (Fig. 2), with a remarkable dominance of diurnal dwelling spiders (i.e. wolf spiders of the genus *Pardosa*) in the actively grazed type (FR). On the other hand, in FO and FS types (lightly grazed and ungrazed close to the native vegetation, respectively), most spiders are nocturnal wanderers, which are generally associated to the presence of hiding places, like rocks and litter (De Keer et al 1989; Bell et al. 2001). In accordance with literature (Bell et al. 2001; Kruess and Tschardtke 2002; Batary et al. 2008) the most evenly distributed spider assemblages are found in lightly grazed type.

Invertebrate communities at the first step of the ecological succession are dominated by generalist species with good dispersal ability and with unstable population dynamics, like, in our case, diurnal wandering spiders (Gibson et al. 1992). Species, like those belonging to nocturnal wanderers that require a more complex vegetation structure, a more heterogeneous habitat and that are more demanding in terms of microclimatic requirements (Southwood et al. 1979) are more abundant where active disturbance is lower (namely FO and FS types). In accordance with Dennis et al. (2001), in our study diurnal wanderers and ballooning spiders were found to prefer low vegetation cover or bare soils (RA and FR types). Such spiders have been proved to be very competitive in disturbed habitats (De Keer and Maelfait 1988; Bell et al. 2001) attesting their role as indicators of disturbance. Similar results were also obtained by De Keer et al. (1989). IndVal procedure proved similar trends, showing a higher preference for FR type (actively grazed) for diurnal wanderers like *Pardosa amentata*, *Micaria pulicaria*, and *Pardosa mixta* and for ballooning spiders like *Erigone dentipalpis*. Conversely, higher preference for FO type (lightly grazed) or FS type (ungrazed close to native vegetation) are found for several nocturnal species, like *Amaurobius scopolii*, *Coelotes poweri*, *Harpactocrates drassoides* *Malthonica silvestris*, *Alopecosa cuneata*, *Gnaphosa lugubris*, *Xysticus desidiosus*, *Zelotes aeneus* and *Z. petrensis*. It is worth to notice that most of the indicators of lightly grazed areas (FO type) are endemic species, characterized by more demanding ecological requirements.

Furthermore, such trend is highlighted by GLM results on species richness and spider abundance, showing significant differences among spider assemblages according to pasture types. Both species richness and spider abundance are lower in actively grazed areas (FR type), that are characterized by higher levels of physical disturbance. Intense trampling is proved to reduce spider abundance and their locomotory activity (Delchev and Kajak 1974). In addition, it has been demonstrated (De Keer et al., 1989; Bell et al. 2001) that lightly grazed areas like FO type may host the highest abundance of individuals. Such areas are in fact chosen by spiders for ovodeposition and overwintering (De Keer and Maelfait 1988) in order to avoid unfavourable climatic conditions (i.e. high temperature and excessive dryness) (De Keer et al. 1989). Such trend is particularly evident where the vegetal association is closer to the native one and the effect of grazing is light (FO and FS types): dense vegetation cover with sparse rocks of different dimensions, providing heterogeneous microclimatic conditions and different hiding places. According to GLM results, the lowest species richness and the lowest abundance of spiders (Fig. 3) are found where grazing is active and intense (FR type), while the highest richness of endemic species, with higher ecological requirements is found in lightly grazed type (FO) (Fig. 4). Accordingly, for Hungarian pastures, Batary et al., (2008) report similar effects on rare species (rare in Hungary according to the national spider database), that resulted more abundant in extensively grazed areas.

Harvestmen seem to be particularly sensible to the architecture of vegetation, but also to disturbance. According to GLM analysis, they are dominant where the native vegetation is totally altered (RA type) and virtually absent in the other grassland types, including in the closer one to the native vegetation (FS type) (Fig. 6). The possible reason for the lower abundance of the dominant opilionid *Mitopus morio* on dense grass pasture-like habitats (FO and FS types) could be due to the fact that these animals may be prevented from falling into pitfall traps when three dimensional pathways are found among vegetation, like in the case of dense and short grass pasture type. The same trend was observed in Negro et al. (2010). Conversely, the lower abundance in actively grazed pastures (FR type) may be due to the presence of cattle and the consequent higher disturbance related to trampling.

Several works focusing on the conservation of alpine prairies highlight the importance of grazing management on the survival of spider assemblages (Batary et al. 2008). Grazing is the result of the interaction between man and alpine environment and its equilibrium depends strongly on this kind of interaction. In the last decades the abandonment, the overexploitation and the irrational management of



alpine prairies resulted in a progressive decline of the biodiversity of alpine pastures (Batary et al. 2008) and spiders proved to be good indicators in this sense.

In our study, where the effect of grazing is light (FO type), the more taxonomical diverse assemblage is found (Fig. 5), attesting the importance of such habitat in terms of conservation issues. As suggested by Warwick and Clarke (1998) and Gallardo et al. (2011), high values of taxonomic relatedness indices reflect the functionality and the heterogeneity of the ecosystem. In this sense FO type, surviving with moderate human intervention provides a functional and heterogeneous ecosystem associated with highly diversified coenosis, attesting its importance in terms of High Nature Value Farmlands. On the other hand, in accordance with other studies (Heino 2008) irrational management of actively grazed areas determines poor animal (and vegetal) communities characterized by lower values of taxonomical relatedness (FR type).

From our study, we may assert that lightly grazed, heterogeneous pastures with dense vegetation coverage and sparse rocks may favour the species richness and the abundance of spider assemblages, with special regards to the presence of rare and endemic species. These conditions may be maintained with a favorable, sustainable management, providing the right grazing pressure and the preservation of natural patches within the pasture. Unfortunately, like we have observed in the Alpi Marittime and according to Cernusca et al. (1999), the abandonment of the pastures at the highest elevations (less accessible and thus less remunerative), lead to the concentration of the cattle in low elevation valley floors, with the consequent overexploitation of these habitats and the relative decrease of the arthropod diversity (FR and RA types). As confirmed by our results, spider assemblages, and especially endemic spider species, resulted negatively affected by intense grazing history. Major negative effects are provided by active intense grazing (FR type) and by the alteration of the vegetation architecture and composition and by the alteration of the structure of the soil (RA type), leading directly and indirectly to the alteration of the arthropod coenosis. In particular, overgrazing seems the major responsible of the impoverishment of the arthropod coenosis, while, on the other hand extensive management (FO type) seems to provide higher species richness and a more balanced structure of the spider assemblage.

In accordance with previous studies (Kruess and Tschardtke 2002; Dennis et al. 1997; Gardner et al. 1996), also for the preservation of spider coenosis and related biodiversity, we recommend the maintenance of patches of undisturbed areas (source areas) within the pasture in order to preserve the natural habitat of rare and endemic species, the rotation of the grazed areas in order to avoid overexploitation of certain portion of the pasture and the avoidance of excessive loads of cattle.

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## REFERENCE

- Andersen E, Baldock D, Bennet H, Beaufoy G, Bignal E, Brower F, Elbersen B, Eiden G, Godeschalk F, Jones G, McCracken DI, Nieuwenhuizen W, van Eupen M, Hennekes S, Zervas G (2003) Developing a high nature value indicator. Report for the European Environment Agency, Copenhagen
- Batary P, Baldi A, Samu F, Szuts T and Erdos S (2008) Are spiders reacting to local or landscape scale effects in Hungarian pastures? *Biol Cons* 141:2062–2070
- Bell JR, Wheeler CP, Cullen WR (2001) The implication of grassland and heathland management for the conservation of spider communities: a review. *J Zool* 255:377–387
- Bilotta GS, Brazier RE and Haygarth PM (2007) The impacts of grazing animals on the quality of soils, vegetation, and surface waters in intensively managed grasslands. *Adv Agron* 94:237–280
- Cattin MF, Blandenier G, Banašek-Richter C, Bersier LF (2003) The impact of mowing as a management strategy for wet meadows on spider (Araneae) communities. *Biol Cons* 113:179–188
- Cavallero A, Aceto P, Gorlier A, Lonati M, Lombardi G, Martinasso B and Tagliatori C (2007) I tipi pastorali delle alpi piemontesi. Alberto Perdisa Editore
- Cernusca A, Tappeiner U, Bayfield N (1999) Land-use Changes in European Mountain Ecosystems. Blackwell, Berlin
- Chapin FS III, Torn MS, and Tateno M (1996) Principles of ecosystem sustainability. *Am Nat* 148:1016–1037
- Clarke KR, Warwick RM (1998) A taxonomic distinctness index and its statistical properties. *J Appl Ecol* 35:523–531
- Coleman DC and Hendrix PF (2000) Invertebrates as Webmasters in Ecosystems. CAB International Wallingford, UK

- Colwell RK (2006) EstimateS: statistical estimation of species richness and shared species from samples. Version 8.0
- Delchev K, Kajak A (1974) Analysis of a sheep pasture ecosystem Pieniny Mountains (The Carpathians) XVI. Effect of pasture management on the number and biomass of spiders (Araneae) in two climatic regions (the Pieniny and the Sredna Gora Mountains). *Ekologia Polska*, 22: 693–710
- De Keer R, Alderweireldt M, Declerck K, Segers H, Desender K, Maelfait JP (1989) Horizontal distribution of the spider fauna of intensively grazed pastures under the influence of diurnal activity and grass height. *J Appl Entomol* 107:455–473
- De Keer R, Maelfait J-P (1988) Laboratory observations on the development and reproduction of *Erigone atra*, Blackwall, 1833 (Araneae, Linyphiidae). *Bull Br Arachnol Soc* 7:237-242
- Dennis P, Young MR, Bentley C (2001) The effects of varied grazing management on epigeal spiders, harvestmen and pseudoscorpions of *Nardus stricta* grassland in upland Scotland. *Agr Ecosyst Environ* 86:39–57
- Dobson AJ (1990) An introduction to generalized linear models. Chapman and Hall, New York
- Dufrêne M, Legendre P (1997) Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecol Monogr* 67:345–366
- Finch OD, Löffler J (2010) Indicators of species richness at the local scale in an alpine region: a comparative approach between plant and invertebrate taxa. *Biodivers Conserv* 19:1341–1352
- Fleischner T L (1994) Ecological costs of livestock grazing in western North America. *Cons Biol* 8:629–644
- Gallardo B, Gascón S, Quintana X, Comín FA (2011) How to choose a biodiversity indicator – Redundancy and complementarity of biodiversity metrics in a freshwater ecosystem. *Ecol Ind* 11:1177–1184
- Gardener SM, Hartley SE, Davies A, Palmer SCF (1997) Carabid communities on heather moorlands in northeast Scotland: the consequences of grazing pressure for community diversity. *Biol Cons* 81:275–286
- Gibson CWD, Hambler C, Bown VK (1992) Changes in spider (Araneae) assemblages in relation to succession and grazing management. *J Appl Ecol* 29:132–142
- Groombridge B (1992) Global Biodiversity Status of the Earth's Living Resources. World Conservation Monitoring Centre. Chapman and Hall, London
- Hammer Ø, Harper DAT, Ryan PD (2001) PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontol electron* 4:1–9

- Heino J (2008) Patterns of functional biodiversity and function-environment relationships in lake littoral macroinvertebrates. *Limn Ocean* 53:1446–1455
- Isaia M, Pantini P, Beikes S, Badino G (2007) Catalogo ragionato dei ragni (Arachnida, Araneae) del Piemonte e della Lombardia. *Memorie dell'Associazione Naturalistica Piemontese* 9:1-161
- Jackson DA (1993) Stopping rules in principal component analysis. *Ecology* 74: 2204–2214
- Kruess A and Tschamtker T (2002) Contrasting responses of plant and insect diversity to variation in grazing intensity. *Biol Cons* 106:293–302
- Manhart C, Marschalek H and Karg J (2004) Renaturierung feucht-nassen Grünlands im Voralpenraum. Untersuchungen zur Vegetationsentwicklung sowie zur Biomasse und Diversität bei Insekten Natur und Landschaft 79:257-263
- Marc P, Canard A and Ysnel F (1999) Spiders (Araneae) useful for pest limitation and bioindication *Agr Ecosyst Environ* 74:229–273
- Martens J (2011) Fauna Europaea: Opiliones Fauna Europaea version 24, <http://www.faunaeur.org>
- McCracken DI and Tallowin JR (2004) Swards and structure: the interactions between farming practices and bird food resources in lowland grasslands. *Ibis* 146:108–114
- McCune B, Mefford MJ (1999) *Multivariate Analysis of Ecological Data*, version 4.25. MjM Software Design, Gleneden Beach, Oregon, USA
- McGeoch (1998) The selection, testing and application of terrestrial insects as bioindicators. *Biol Rev* 73:181-201
- McIntyre S, Heard KM and Martin TG (2003) The relative importance of cattle grazing in sub-tropical grasslands – does it reduce or enhance plant biodiversity? *J Appl Ecol* 40:445–457
- McIntyre, S and Lavorel, S (1994) Predicting richness of native, rare and exotic plants in response to habitat and disturbance variables across a variegated landscape. *Cons Biol* 8:521–531
- Minelli A, Ruffo S, Vigna Taglianti A (2006) The Italian faunal provinces In: Ruffo, Sand Stoch, F (Eds), Checklist and distribution of the Italian fauna. *Memorie del Museo Civico di Storia Naturale di Verona*, 17: 37-39
- Negro M, Isaia M, Palestini C, Rolando A (2010) The impact of forest ski-pistes on diversity of ground-dwelling arthropods and small mammals in the Alps. *Biodiv Conserv* 19:1853–1870
- Noeltemeyer E, Quiroga AR, Esterlich D (2006) Soil quality in three range soils of the semi-arid Pampa of Argentina. *J Arid Environ* 65:142–155

- Paracchini ML, Petersen JE, Hoogeveen Y, Bamps C., Burfield I., van Swaay C. (2008): High Nature Value Farmland in Europe - An estimate of the distribution patterns on the basis of land cover and biodiversity data. Report EUR 23480
- Platnick NI (2012) The world spider catalog, version 125 American Museum of Natural History. Online at <http://researchamnh.org/iz/spiders/catalog> DOI: 105531/dbiz0001. Accessed 20 December 2011.
- Pucheta E, Cabido M, Díaz S, Funes G (1998) Floristic composition, biomass, and aboveground net plant production in grazed and protected sites in a mountain grassland of Central Argentina. *Acta Oecol* 19:97–105
- Stoch F, Vigna Taglianti A (2005) I corotipi della fauna italiana In: Ruffo, S, Stoch, F (Eds), Checklist e distribuzione della fauna italiana. *Memorie del Museo Civico di Storia Naturale di Verona*, 16: 25-28
- Sunderland KD, Samu F (2000) Effects of agricultural diversification on the abundance, distribution, and pest control potential of spiders: a review. *Entomol Exp Appl* 95:1–13
- Warui CM, Villet MH, Young TP, Jacque R (2005) Influence of grazing by large mammals on the spider community of a Kenyan savanna biome. *J Arachnol* 33:269–279
- Wettstein W, Schmid B (1999) Conservation of arthropod diversity in montane wetlands: effect of altitude, habitat quality and habitat fragmentation on butterflies and grasshoppers. *J Appl Ecol* 36:363–373

TABLES

Table 1. Results of a Principal Component Analysis carried out on five habitat variables measured for each trap in a circular area of 5 m radius.

Variables	Factor Loadings		
	PC1	PC2	PC3
Bare soil	-0.2587	-0.5626	0.4155
Grass cover	0.7781	0.0443	0.0167
Dung cover	-0.3195	-0.3726	-0.6979
Rocks cover	-0.4725	0.5881	0.3212
Grass height	0.0478	-0.4437	0.4866
Eigenvalue	1.616	1.359	1.176
Cum. % of variance	32.323	59.906	83.023

Table 2. IndVal calculated for each pasture typology. The symbol ° indicates endemic species.

Species	Indicator Value	Mean S.Dev	p
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Festuca rubra and Agrostis tenuis type (FR)					
Spiders					
	<i>Pardosa amentata</i>	19.7	8.7	4.59	0.041*
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Rumicetum alpini type (RA)					
Spiders					
	<i>Alopecosa aculeata</i>	23.7	7.7	4.74	0.016*
	<i>Erigone dentipalpis</i>	43.4	9.5	5.14	0.003**
	<i>Micaria pulicaria</i>	14.3	4.8	3.78	0.015*
	<i>Pardosa mixta</i>	51.7	23.1	5.95	0.004**
	<i>Zelotes talpinus</i>	19.0	5.3	3.81	0.018*
Harvestmen					
	<i>Mitopus morio</i>	29.7	7.8	2.21	0.010*
	<i>Dasylobus ligustigus</i>	7.9	2.2	1.29	0.011*
-----					
Festuca ovina type (FO)					
Spiders					
	<i>Amaurobius scopolii</i> <sup>o</sup>	82.5	8.0	5.06	0.001***
	<i>Coelotes poweri</i> <sup>o</sup>	47.0	17.7	5.64	0.004**
	<i>Harpactocrates drassoides</i> <sup>o</sup>	58.5	11.5	5.46	0.001***
	<i>Malthonica silvestris</i>	32.8	6.3	3.98	0.003**
	<i>Xerolycosa nemoralis</i>	14.1	4.1	3.58	0.045*
-----					
Festuca scabriculmis type (RA)					
Spiders					
	<i>Alopecosa cuneata</i>	28.6	8.4	4.62	0.008**
	<i>Gnaphosa lugubris</i>	51.2	11.3	4.87	0.001***
	<i>Xysticus desidiosus</i>	16.7	6.7	4.12	0.048*
	<i>Zelotes aeneus</i>	95.0	16.0	5.55	0.001***
	<i>Zelotes petrensis</i>	39.0	10.1	5.20	0.004**
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FIGURE LEGENDS

Fig. 1. Biplot of a Principal Component Analysis (PC1 vs. PC2). Distribution of observations is shown. Different symbols indicates different pasture types. FR: Festuca rubra and Agrostis tenuis type; RA: Rumicetum alpini; FO: Festuca ovina type; FS: Festuca scabriculmis type.

Fig. 2. Distribution of abundances of spider functional groups expressed as percentages of individuals sampled in each pasture type. FR: Festuca rubra and Agrostis tenuis type; RA: Rumicetum alpini; FO: Festuca ovina type; FS: Festuca scabriculmis type.

Fig. 3. Mean abundance (N) and species richness (R) of spiders at each pasture type. Bars are standard errors. The symbol \* indicates significant difference in respect to reference category (FS) according to GLM analysis. FR: Festuca rubra and Agrostis tenuis type; RA: Rumicetum alpini; FO: Festuca ovina type; FS: Festuca scabriculmis type.

Fig. 4. Mean richness of endemic species (R<sub>end</sub>) of spiders at each pasture type. Bars are standard errors. FR: Festuca rubra and Agrostis tenuis type; RA: Rumicetum alpini; FO: Festuca ovina type; FS: Festuca scabriculmis type.

Fig. 5. Taxonomic relatedness of spiders at each pasture type.  $\Delta$ = Taxonomic diversity;  $\Delta^\circ$ = Taxonomic distinctness;  $\Delta^{+}$ = Average taxonomic distinctness. Bars are standard errors. FR: Festuca rubra and Agrostis tenuis type; RA: Rumicetum alpini; FO: Festuca ovina type; FS: Festuca scabriculmis type.

Fig. 6. Mean abundance (N) of harvestmen at each pasture type. Bars are standard errors. The symbol \* indicates significant difference in respect to reference category (FS) according to GLM analysis. FR: Festuca rubra and Agrostis tenuis type; RA: Rumicetum alpini; FO: Festuca ovina type; FS: Festuca scabriculmis type.



Appendix 1 – List of the plant species according to pasture types. Number indicates categories of % coverage per pasture type: 3: >50%, 2: 15-50%, 1: <15%.

Festuca scabriculum type (FS)	
<i>Nardus stricta</i> L.	3
<i>Alchemilla</i> gr. <i>alpina</i> L.	2
<i>Poa nemoralis</i> L.	2
<i>Achillea erba-rotta</i> All.	1
<i>Achillea</i> gr. <i>millefolium</i>	1
<i>Agrostis canina</i> L.	1
<i>Agrostis rupestris</i> All.	1
<i>Alchemilla</i> gr. <i>Vulgaris</i>	1
<i>Anthoxanthum alpinum</i> Love et Love	1
<i>Campanula scheuchzeri</i> Vill.	1
<i>Carduus defloratus</i> L.	1
<i>Carex caryophyllea</i> La Tourr.	1
<i>Carex leporina</i> L.	1
<i>Carex sempervirens</i> Vill.	1
<i>Carex</i> sp.	1
<i>Carlina acaulis</i> L.	1
<i>Cerastium arvense</i> L.	1
<i>Chenopodium bonus-henricus</i>	1
<i>Cryptogramma crispa</i> (L.) R. Br.	1
<i>Dactylis glomerata</i> L.	1
<i>Daphne mezereum</i> L.	1
<i>Dianthus neglectus</i> Loisel.	1
<i>Euphrasia alpina</i> Lam.	1
<i>Festuca</i> gr. <i>ovina</i>	1
<i>Festuca</i> gr. <i>rubra</i>	1
<i>Festuca paniculata</i> (L.) Sch. Et Th.	1
<i>Festuca violacea</i> Gaudin	1
<i>Galium</i> gr. <i>pusillum</i>	1
<i>Gnaphalium sylvaticum</i> L.	1
<i>Hieracium pilosella</i> L.	1
<i>Hypericum richeri</i> Vill.	1
<i>Juncus trifidus</i> L.	1
<i>Juniperus nana</i> Willd.	1
<i>Lotus alpinus</i> (DC.) Schleicher	1
<i>Luzula lutea</i> (All.) Lam. et DC.	1
<i>Luzula nivea</i> (L.) Lam. Et DC.	1
<i>Phleum alpinum</i> L.	1
<i>Plantago alpina</i> L.	1
<i>Poa alpina</i> L.	1
<i>Poa violacea</i> Bellardi	1
<i>Potentilla grandiflora</i> L.	1
<i>Ranunculus</i> gr. <i>montanus</i>	1
<i>Ranunculus pyrenaicus</i> L.	1
<i>Rubus</i> sp.	1
<i>Sempervivum arachnoideum</i> L.	1
<i>Thymus</i> gr. <i>serpyllum</i>	1
<i>Trifolium alpinum</i> L.	1
<i>Trifolium</i> sp.	1
<i>Urtica dioica</i> L.	1
<i>Veronica fruticans</i> Jacq.	1
<i>Viola</i> sp.	1

Festuca ovina type (FO)	
<i>Festuca</i> gr. <i>rubra</i>	2
<i>Nardus stricta</i> L.	2
<i>Ranunculus pyrenaicus</i> L.	2
<i>Achillea</i> gr. <i>millefolium</i>	1
<i>Alchemilla</i> gr. <i>alpina</i> L.	1
<i>Alchemilla</i> gr. <i>vulgaris</i>	1
<i>Antennaria dioica</i> (L.) Gaertner	1
<i>Anthoxanthum alpinum</i> Love et Love	1
<i>Biscutella laevigata</i> L.	1
<i>Botrychium lunaria</i> (L.) Swartz	1
<i>Cardamine</i> sp.	1
<i>Carex sempervirens</i> Vill.	1
<i>Carlina acaulis</i> L.	1
<i>Centaurea uniflora</i> Turra	1
<i>Cerastium arvense</i> L.	1
<i>Crocus albiflorus</i> Kit.	1
<i>Daphne mezereum</i> L.	1
<i>Festuca</i> gr. <i>ovina</i>	1
<i>Galium</i> gr. <i>rubrum</i>	1
<i>Hieracium pilosella</i> L.	1
<i>Hypericum richeri</i> Vill.	1
<i>Jovibarba allionii</i> L.	1
<i>Juniperus nana</i> Wild.	1
<i>Lotus alpinus</i> (DC.) Schleicher	1
<i>Luzula lutea</i> (All.) Lam. et DC.	1
<i>Luzula multiflora</i> (Ehrh.) Lej.	1
<i>Myosotis alpestris</i> Schmidt	1
<i>Phyteuma betonicifolium</i> Vill.	1
<i>Plantago alpina</i> L.	1
<i>Poa alpina</i> L.	1
<i>Potentilla grandiflora</i> L.	1
<i>Ranunculus</i> gr. <i>montanus</i>	1
<i>Rumex acetosa</i> L.	1
<i>Rumex acetosella</i> L.	1
<i>Rumex scutatus</i> L.	1
<i>Sedum alpestre</i> Vill.	1
<i>Sempervivum arachnoideum</i> L.	1
<i>Taraxacum laevigatum</i> L.	1
<i>Thymus</i> gr. <i>serpyllum</i>	1
<i>Trifolium ochroleucum</i> Hudson	1
<i>Vaccinium myrtillus</i> L.	1
<i>Viola biflora</i> L.	1
<i>Viola calcarata</i> L.	1
Festuca rubra and Agrostis tenuis type (FR)	
<i>Poa supina</i> L.	3
<i>Nardus stricta</i> L.	2
<i>Festuca</i> gr. <i>rubra</i>	2
<i>Polygonum bistorta</i> L.	2
<i>Poa alpina</i> L.	2
<i>Ranunculus</i> gr. <i>montanus</i>	2
<i>Anthoxanthum alpinum</i> Love et Love	2
<i>Vaccinium myrtillus</i> L.	1

<i>Rumex alpinus</i> L.	1
<i>Chenopodium bonus-henricus</i>	1
<i>Hieracium pilosella</i> L.	1
<i>Festuca</i> gr. <i>ovina</i>	1
<i>Crocus albiflorus</i> Kit.	1
<i>Biscutella laevigata</i> L.	1
<i>Ranunculus pyrenaicus</i> L.	1
<i>Plantago alpina</i> L.	1
<i>Capsella bursa-pastoris</i> (L.) Medicus	1
<i>Rumex acetosa</i> L.	1
<i>Ornithogalum kochii</i> Parl.	1
<i>Rumex acetosella</i> L.	1
<i>Potentilla</i> sp.	1
<i>Achillea</i> gr. <i>millefolium</i>	1
<i>Thymus</i> gr. <i>serpyllum</i>	1
<i>Barbarea bracteosa</i>	1
<i>Meum athamanticum</i> Jacq.	1
<i>Taraxacum alpinum</i> (Hoppe) Hegetschw.	1
<i>Trifolium repens</i> L.	1
<i>Ajuga pyramidalis</i> L.	1
<i>Armeria alpina</i> Willd.	1
<i>Artemisia</i> gr. <i>vulgaris</i>	1
<i>Cirsium spinosissimum</i> (L.) Scop.	1
<i>Gagea</i> sp.	1
<i>Homogyne alpina</i> (L.) Cass.	1
<i>Larix decidua</i> Miller	1
<i>Leontodon helveticus</i> Merat	1
<i>Luzula alpino-pilosa</i> Breistr.	1
<i>Oxyria digina</i> (L.) Hill	1
<i>Pinguicula leptoceras</i>	1
<i>Potentilla erecta</i> (L.) Rauschel	1
<i>Ranunculus acris</i>	1
<i>Soldanella alpina</i> L.	1
<i>Trifolium pratense</i>	1
<i>Veratrum album</i> L.	1
<i>Viola palustris</i> L.	1
<i>Geranium pyrenaicum</i> Burm.	1
<i>Veronica serpyllifolia</i> L.	1
<i>Phleum alpinum</i> L.	1
<i>Cryptogramma crispa</i> (L.) R. Br.	1
<i>Dactylis glomerata</i> L.	1
<i>Juniperus nana</i> Willd.	1
<i>Poa violacea</i> Bellardi	1
<i>Rubus</i> sp.	1
<i>Veronica fruticans</i> Jacq.	1
<i>Viola</i> sp.	1
<i>Carex sempervirens</i> Vill.	1
<i>Potentilla grandiflora</i> L.	1
<i>Alchemilla</i> gr. <i>alpina</i>	1
<i>Carlina acaulis</i> L.	1
<i>Lotus alpinus</i> (DC.) Schleicher	1
<i>Botrychium lunaria</i> (L.) Swartz	1
<i>Jovibarba allionii</i>	1

<i>Luzula multiflora</i> (Ehrh.) Lej.	1
<i>Myosotis alpestris</i> Schmidt	1
<i>Phyteuma betonicifolium</i> Vill.	1
<i>Luzula lutea</i> (All.) Lam. et DC.	1
<i>Cerastium arvense</i> L.	1
<i>Daphne mezereum</i> L.	1
<i>Alchemilla</i> gr. <i>vulgaris</i>	1
Rumicetum alpini type (RA)	
<i>Rumex alpinus</i> L.	3
<i>Poa supina</i>	2
<i>Achillea</i> gr. <i>millefolium</i>	1
<i>Alchemilla</i> gr. <i>vulgaris</i>	1
<i>Barbarea bracteosa</i>	1
<i>Chenopodium bonus-henricus</i>	1
<i>Crocus albiflorus</i> Kit.	1
<i>Fallopia dumetorum</i> (L.) Holub	1
<i>Festuca</i> gr. <i>rubra</i>	1
<i>Geranium pyrenaicum</i> Burm.	1
<i>Myosotis sylvatica</i> Hoffm.	1
<i>Phleum alpinum</i> L.	1
<i>Poa chaixi</i>	1
<i>Poa nemoralis</i> L.	1
<i>Ranunculus</i> gr. <i>montanus</i>	1
<i>Ranunculus</i> gr. <i>nemorosus</i>	1
<i>Ranunculus pyrenaeus</i> L.	1
<i>Taraxacum officinalis</i>	1
<i>Trifolium repens</i> L.	1
<i>Trisetum flavescens</i> (L.) Beauv.	1
<i>Urtica dioica</i> L.	1
<i>Veronica chamaedrys</i> L.	1
<i>Veronica serpyllifolia</i> L.	1

Appendix 2 - List of the spider species (adult) collected and abundance according to pasture types. The symbol \* indicates endemic species.

Festuca rubra and Agrostis tenuis type (FR)	
<i>Pardosa mixta</i> (Kulczynski, 1887)	253
<i>Coelotes poweri</i> Simon, 1875*	81
<i>Drassyllus pusillus</i> (C. L. Koch, 1833)	49
<i>Pardosa blanda</i> (C. L. Koch, 1833)	46
<i>Haplodrassus signifer</i> (C. L. Koch, 1839)	27
<i>Pardosa amentata</i> (Clerck, 1757)	24
<i>Micaria rossica</i> Thorell, 1875	14
<i>Steatoda phalerata</i> (Panzer, 1801)	12
<i>Araeoncus vaporariorum</i> (O. P. Cambridge, 1875)*	9
<i>Erigone dentipalpis</i> (Wider, 1834)	7
<i>Pardosa</i> cf. <i>albatula</i> (L. Koch, 1870)	6
<i>Tenuiphantes tenuis</i> (Blackwall, 1852)	4
<i>Meioneta rurestris</i> (C. L. Koch, 1836)	4
<i>Alopecosa aculeata</i> (Clerck, 1757)	3
<i>Pardosa cribrata</i> Simon, 1876	3
<i>Xysticus gallicus</i> Simon, 1875	2
<i>Malthonica silvestris</i> (L. Koch, 1872)	2
<i>Zelotes similis</i> (Kulczynski, 1887)	2
<i>Zelotes petrensis</i> (C. L. Koch, 1839)	2
<i>Pseudoeuophrys erratica</i> (Walckenaer, 1862)	2
<i>Harpactocrates drassoides</i> (Simon, 1882)*	1
<i>Drassodes cupreus</i> (Blackwall, 1834)	1
<i>Histoipona italica</i> Brignoli, 1977	1
<i>Segestria senoculata</i> (Linnaeus, 1758)	1
<i>Ceratinella brevis</i> (Wider, 1834)	1
<i>Evansia merens</i> O. P. Cambridge, 1900	1
<i>Poecilometes variegata</i> (Blackwall, 1841)	1
<i>Tiso vagans</i> (Blackwall, 1834)	1
<i>Xerolycosa nemoralis</i> (Westring, 1861)	1
<i>Amaurobius scopoli</i> Thorell, 1871*	1
<i>Agroeca proxima</i> (O. P. Cambridge, 1870)	1
<i>Callilepis nocturna</i> (Linnaeus, 1758)	1
<i>Gnaphosa lugubris</i> (C. L. Koch, 1839)	1
<i>Zelotes aeneus</i> Simon, 1878	1
<i>Ozyptila atomaria</i> (Panzer, 1801)	1
<i>Heliophanus aeneus</i> (Hahn, 1832)	1
Rumicetum alpini type (RA)	
<i>Pardosa mixta</i> (Kulczynski, 1887)	138
<i>Pardosa blanda</i> (C. L. Koch, 1833)	21
<i>Coelotes poweri</i> Simon, 1875*	21
<i>Drassyllus pusillus</i> (C. L. Koch, 1833)	14

<i>Erigone dentipalpis</i> (Wider, 1834)	13
<i>Araeoncus vaporariorum</i> (O. P. Cambridge, 1875)*	8
<i>Alopecosa aculeata</i> (Clerck, 1757)	8
<i>Haplodrassus signifer</i> (C. L. Koch, 1839)	6
<i>Harpactocrates drassoides</i> (Simon, 1882)*	4
<i>Tenuiphantes tenuis</i> (Blackwall, 1852)	4
<i>Micaria pulicaria</i> (Sundevall, 1831)	4
<i>Zelotes talpinus</i> (L. Koch, 1872)	4
<i>Xysticus gallicus</i> Simon, 1875	4
<i>Steatoda phalerata</i> (Panzer, 1801)	3
<i>Drassodes cupreus</i> (Blackwall, 1834)	3
<i>Micaria rossica</i> Thorell, 1875	3
<i>Malthonica silvestris</i> (L. Koch, 1872)	2
<i>Bolyphantes luteolus</i> (Blackwall, 1833)	1
<i>Collinsia inerrans</i> (O.P. Cambridge, 1855)	1
<i>Meioneta rurestris</i> (C. L. Koch, 1836)	1
<i>Pardosa</i> cf. <i>albatula</i> (L. Koch, 1870)	1
<i>Pardosa amentata</i> (Clerck, 1757)	1
<i>Pisaura mirabilis</i> (Clerck, 1757)	1
<i>Histoipona italica</i> Brignoli, 1977	1
<i>Amaurobius fenestralis</i> (Strom, 1768)	1
<i>Drassodes pubescens</i> (Thorell, 1856)	1
<i>Micaria fulgens</i> (Walckenaer, 1802)	1
<i>Zelotes apricorum</i> (L. Koch, 1876)	1
<i>Zelotes similis</i> (Kulczynski, 1887)	1
Festuca ovina type (FO)	
<i>Pardosa mixta</i> (Kulczynski, 1887)	27
<i>Coelotes poweri</i> Simon, 1875*	21
<i>Harpactocrates drassoides</i> (Simon, 1882)*	18
<i>Amaurobius scopolii</i> Thorell, 1871*	16
<i>Pardosa blanda</i> (C. L. Koch, 1833)	14
<i>Drassyllus pusillus</i> (C. L. Koch, 1833)	9
<i>Steatoda phalerata</i> (Panzer, 1801)	8
<i>Xerolycosa nemoralis</i> (Westring, 1861)	8
<i>Haplodrassus signifer</i> (C. L. Koch, 1839)	6
<i>Malthonica silvestris</i> (L. Koch, 1872)	3
<i>Zelotes similis</i> (Kulczynski, 1887)	3
<i>Alopecosa alpicola</i> (Simon, 1876)	2
<i>Saitis barbipes</i> (Simon, 1868)	2
<i>Pardosa amentata</i> (Clerck, 1757)	1
<i>Pardosa</i> cf. <i>albatula</i> (L. Koch, 1870)	1
<i>Histoipona italica</i> Brignoli, 1977	1
<i>Evansia merens</i> O. P. Cambridge, 1900	1
<i>Pimoa rupicola</i> (Simon, 1884)*	1

Festuca scabriculum type (FS)	
<i>Zelotes aeneus</i> Simon, 1878	294
<i>Drassyllus pusillus</i> (C. L. Koch, 1833)	75
<i>Pardosa blanda</i> (C. L. Koch, 1833)	62
<i>Haplodrassus signifer</i> (C. L. Koch, 1839)	44
<i>Zelotes petrensis</i> (C. L. Koch, 1839)	41
<i>Gnaphosa lugubris</i> (C. L. Koch, 1839)	32
<i>Alopecosa cuneata</i> (Clerck, 1757)	27
<i>Steatoda phalerata</i> (Panzer, 1801)	24
<i>Pardosa</i> cf. <i>albatula</i> (L. Koch, 1870)	16
<i>Harpactocrates drassoides</i> (Simon, 1882)*	15
<i>Pardosa mixta</i> (Kulczynski, 1887)	13
<i>Xysticus desidiosus</i> Simon, 1875	11
<i>Zelotes similis</i> (Kulczynski, 1887)	9
<i>Tiso vagans</i> (Blackwall, 1834)	9
<i>Callilepis nocturna</i> (Linnaeus, 1758)	6
<i>Drassodes cupreus</i> (Blackwall, 1834)	5
<i>Amaurobius scopoli</i> Thorell, 1871*	3
<i>Meioneta orites</i> (Thorell, 1875)	3
<i>Histoipona italica</i> Brignoli, 1977	2
<i>Meioneta rurestris</i> (C. L. Koch, 1836)	2
<i>Xysticus gallicus</i> Simon, 1875	2
<i>Crustulina guttata</i> (Wider, 1834)	2
<i>Tapinocyba praecox</i> (O. P. Cambridge, 1873)	2
<i>Drassodex hypocrita</i> (Simon, 1878)	2
<i>Euophrys frontalis</i> (Walckenaer, 1802)	2
<i>Micaria rossica</i> Thorell, 1875	1
<i>Tenuiphantes tenuis</i> (Blackwall, 1852)	1
<i>Alopecosa aculeata</i> (Clerck, 1757)	1
<i>Heliophanus aeneus</i> (Hahn, 1832)	1
<i>Bolyphantes luteolus</i> (Blackwall, 1833)	1
<i>Piniphantes pinicola</i> (Simon, 1884)	1
<i>Aelurillus</i> v- <i>insignitus</i> (Clerck, 1758)	1
<i>Heliophanus lineiventris</i> Simon, 1868	1

Appendix 3 - List of the harvestmen species collected and abundance according to pasture types. The symbol \* indicates endemic species.

Festuca rubra and Agrostis tenuis type (FR)	
<i>Mitopus morio</i> (Fabricius, 1779)	89
<i>Dasylobus ligusticus</i> (Roewer, 1923)	11
<i>Eudasylobus nicaeensis</i> (Thorell, 1876)	3
<i>Odiellus coronatus</i> Chemini, 1986	1
Rumicetum alpini type (RA)	
<i>Mitopus morio</i> (Fabricius, 1779)	155

<i>Dasylobus ligusticus</i> (Roewer, 1923)	22
<i>Odiellus coronatus</i> Chemini, 1986	8
<i>Eudasylobus nicaeensis</i> (Thorell, 1876)	3
<i>Centetostoma centetes</i> (Simon, 1881)*	1
<i>Amilenus aurantiacus</i> (Simon, 1881)	1
Festuca ovina type (FO)	
<i>Mitopus morio</i> (Fabricius, 1779)	7
<i>Leiobunum religiosum</i> (Simon, 1879)*	7
<i>Centetostoma centetes</i> (Simon, 1881)*	1
Festuca scabriculmis type (FS)	
<i>Mitopus morio</i> (Fabricius, 1779)	20
<i>Leiobunum religiosum</i> (Simon, 1879)*	2
<i>Dasylobus ligusticus</i> (Roewer, 1923)	1