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Spiders as potential bioindicators of mountain grasslands health: the Argentine tarantula *Grammostola vachoni* (Araneae, Theraphosidae)

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Abstract

Context. Bioindicators are used for conservation prioritisation by means of spatial comparisons of a site value, or monitoring of ecosystem recovery or response to management. Spiders are characterised by their selection of quality habitats and guild responses to environmental change. However, they have only occasionally been used as bioindicators. *Grammostola vachoni* is an endemic tarantula that only occurs in the grasslands of the mountainous system in central Argentina and it is included in the Red List of the IUCN as Vulnerable.

Aims. In this study, we performed a characterisation of the microhabitat of *G. vachoni* at sites with different disturbance regimes and we analysed the potential use of this species as a bioindicator of mountain grassland health.

Methods. We determined the microhabitat characteristics around their refuges by mean of the soil parameters, as well as the composition and structure of vegetation and amount of refuge available.

Key results. We found significant differences in the number of individuals and the percentage of occupation between sites. No significant differences were recorded in the soil characteristics and occupation of *G. vachoni* but we found that the composition of vegetation, and the heterogeneity and diversity of plants are influenced by different disturbance regimes, altering the distribution of spiders.

Conclusions. Our results are consistent with those of other studies where the spiders have proved to be good bioindicators of different disturbances and we propose for the first time a Theraphosidae species for evaluating the state or health of a natural grassland.

Implications. The information reported in this study is very important to provide data for a future re-categorisation of *G. vachoni* for the Red List of IUCN. Also, we add new component of ecosystems for to use as indicator, open up the possibility for new research for the same and other species of a grasslands of the mountainous system.

Additional keywords: Ecological indicator, microhabitat, endangered species, endemic spider, Ventania System.

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Introduction

Bioindicators are taxa or functional groups that can reflect the state of the environment, by acting as early warning indicators, monitoring a specific stress in an ecosystem or indicating levels of taxonomic diversity (Lencinas *et al*. 2015). Bioindicators may also be used for conservation prioritisation by means of spatial comparisons of the value of a site, for monitoring the recovery of ecosystem or the response to management decisions (Peri *et al*. 2016). Terrestrial arthropods share several qualities that make them highly appropriate as biological indicators, which includes their sensitivity to habitat change, rapid response to disturbance, and the easy and cost-effective sampling (Bouyer *et al*. 2007; Gardner *et al*. 2008; Lencinas *et al*. 2015; Ossamy *et al*. 2016). Therefore, the incorporation of arthropods in monitoring programs and conservation strategies is important due to their high diversity in terrestrial ecosystems, as well as their potential in revealing habitat and environmental disturbances (Kremen *et al*. 1993).

Among the invertebrates, spiders have only occasionally been used as bioindicators and the results suggest that they are good bioindicators (Maelfait and Hendrickx 1998; Marc *et al*. 1999; Scott *et al*. 2006; Dias *et al*. 2011; Ghione *et al*. 2013; Kaltsas *et al*. 2014; Ossamy *et al*. 2016; Torres *et al*. 2016; Landsman and Bowman 2017). They are characterised by great taxonomic diversity, their high selection of quality habitats and guild responses to environmental change and intense sensitivity to small changes in habitat structure, including vegetation complexity, litter depth and microclimate characteristics (Uetz 1991; Wise 1993; Pearce and Venier 2006; Morais-Filho and Quevedo Romero 2008). Therefore, their potential use as potential indicators of environmental change constitute an important tool for management conservation plans.

Grammostola vachoni Schiapelli and Gerschman, 1961 is an endemic tarantula that occurs in the grasslands of the mountainous system in central Argentina. This species is characterised by a poor dispersal mechanism with an aggregated distribution and with late sexual maturity. Consequently, due to its biological characteristics and environmental threats, it was included in the Red List of Threatened Species of the IUCN (International Union for Conservation of Nature and Natural Resources) under the 'vulnerable' category (Ferretti and Pompozzi 2012).

The original habitat that has been lost in the mountain grasslands of central Argentina has a long history (over 300 years). The principal threats are cattle grazing, habitat fragmentation, invasion of exotic plants and urbanisation. According to Pucheta *et al*. (1998), cattle grazing has altered plant communities by increasing their diversity. Also, this area is suffering from overgrazing mainly by feral horses that results in changes in the vegetation structure and species composition, reflecting those changes on the richness and diversity of several animal taxa (Zalba and Cozzani 2004; de Villalobos and Zalba 2010).

The aims of this investigation are: i) the characterisation of the microhabitat of *G. vachoni* at sites with different disturbance regimes, and ii) to analyse the potential use of *G.vachoni* as a bioindicator of mountain grassland health. We studied the abundance of this species in different natural disturbed and non-disturbed mountain grasslands. We also tested how different types of habitat modification influence the occurrence of *G. vachoni*. For the purpose of analysis, we determined microhabitat characteristics around their refuges by mean of the soil parameters, as well as the composition and structure of vegetation and amount of refuge available. The hypotheses tested here are: (1) *G. vachoni* is sensitive to environmental and ecosystem stress produced by the disturbances in mountain grasslands resulting in different distributional patterns, and so greater abundance is expected in non-disturbed grasslands; (2) Soil and vegetation parameters can influence the abundance of *G. vachoni*. Using this information, we discussed the potential utility of *G. vachoni* as a bioindicator of the conservation status of mountain grasslands.

Materials and methods

Study sample area

This study was conducted in the Ventania orographical system in Buenos Aires province, Argentina (Fig. 1). Two important

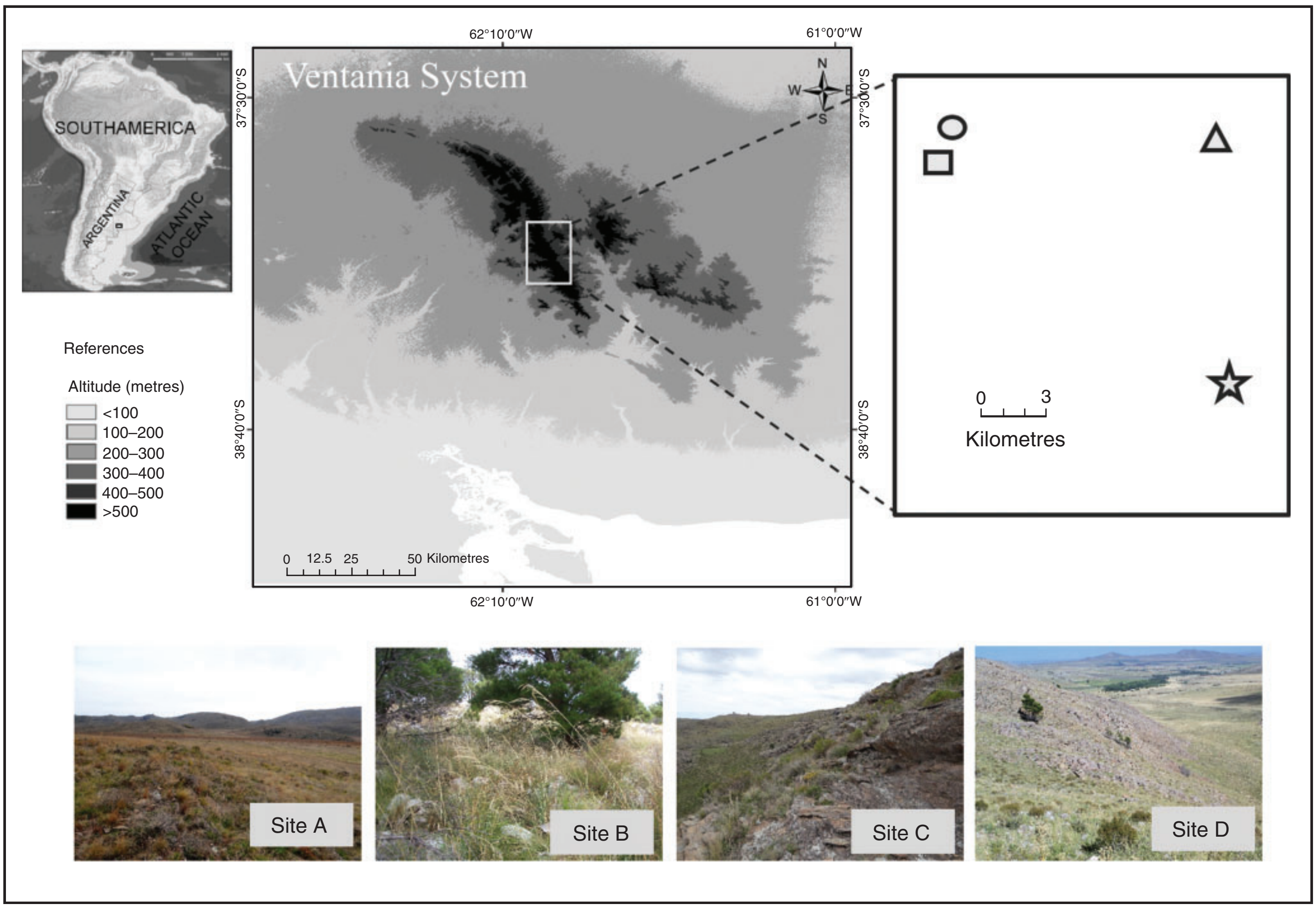

Fig. 1. Map showing the location of the four samples sites within Vantania System. Samples sites are identified as triangle = site A, square = site B, star *t* = site C, circle = site D.

protected areas with relicts of natural grassland are localised in the Ventania System: the 'Ernesto Tornquist' Provincial Park (ETPP) and 'Sierras Grandes' Natural Reserve (SGNR). ETPP is located between 38° 00' - 38° 07' S and 61°52′ - 62° 03' W and has 67 km^2 of valleys and hills with heights of 450–1000 m. SGNR (38°10′23.0''S; 61°54′06.0''W) has similar characteristics to ETPP and has 27.4 km^2.

The climate is humid and temperate with an average annual rainfall of 850 mm and the mean annual temperature is 14.5°C (Pérez and Frangi 2000). The natural vegetation comprises more than 400 native species with high endemism. On grassland slopes, species of Poaceae such as *Briza subaristata* Lam., *Stipa ambigua* Speg., *Stipa caudata* Phil., and *Nassella. neesiana* (Trin. and Rupr.) Barkworth are common. *Paspalum quadrifarium* Lam. covers the humid slopes, and endemic grass species, such as *Festuca ventanicola* Speg., *F. pampeana* Speg., and *N. pampeana* (Speg.) Barkworth, are present above 500 m. (Frangi and Bottino 1995).

Field methods

We took samples monthly between August 2015 and July 2016 from four sites of mountain grasslands, each separated by 8 km on average: three localised in the ETPP: sites A, B and D; and one in SGNR: site C (Fig. 1). Site A (18 Ha, 579 masl) was characterised by the presence of cattle and horses; site B (10 Ha, 507 masl), characterised by an invasion of exotic woody species (*Pinus haleapensis* and *P. radiata*); site D (11 Ha, 611 masl), characterised by the presence of tourist activities, and the site C (21 Ha, 478 masl) without any alterations, undisturbed.

Spider sampling and burrow description

Successive and adjacent transects 100 m long and 10 m wide were arranged each month. Spiders were searched for by hand under all the rocks; the rocks were counted and considered as potentially available refuges. When an individual of *G. vachoni* was found the rock was considered as effective refuge. We measured the length and width of the carapace and the body length of each individual. The body size (BS) was estimated as described by Johnson (2005). Individuals were classified into size 1 ($BS \leq 0.5$), size 2 ($0.5 < BS > 1.3$) and size 3 ($BS \geq 1.3$). For characterising each burrow, we took the following measurements using the TpsDIG program (Rohlf 2005): diameter of the entrance; length of the tunnel (from the burrow entrance to the entrance of the last chamber); depth of the burrow (from the surface to the deepest point); height, length and width of the chambers.

Vegetation and soil analysis

At each site, we evaluated four experimental plots (1 m2) with spiders and another four plots (1 m2) without any spiders. In each plot, we recorded the number of plant species and the cover of each one as the percentage of soil covered for each species (Daubenmire 1959). We categorised the plant species recorded in functional groups according to the life cycles and growth type. We calculated the Jaccard index (CJ, similitude), Shannon index (diversity), Buzas and Gibson's evenness and equitability indexes for each site. To determine the characteristics of the soil, we collected soil samples in the centre of each experimental plot and we determined the pH (KCl) and apparent density (compaction relative, gr/cm3) using standard methods.

Statistical analyses

The abundances of the spiders between sites were analysed by means of an analysis of variance (ANOVA) and the means were compared using Tukey test. The normality and homogeneity of all data were evaluated with Levene and Shapiro-Wilk tests. Pearson correlation test was used to explore possible linear relationships between the abundance of the spiders and refuge availability. We also calculated the percentage of occupation of a spider: number of effective refuges and number of potential refuges available. For the calculation of the indexes and all statistical analyses, we used Past Paleontological Statistics Software 3.02a (Hammer *et al*. 2001) and InfoStat (Di Rienzo *et al*. 2013).

Results

Abundance

We found significant differences in the number of individuals between sites ($F = 6.43$, $P < 0.01$). At sites A and C, spiders were more abundant than at B and D (Table 1). We recorded more potential refuges at sites D and C than at sites A and B ($F = 3.42$, $P < 0.05$) (Table 1). However, we did not find any significant correlations between the abundances of individuals and the number of the potential refuges (Pearson; $r = 0.62$, $P > 0.05$). In addition, we found significant differences between sites in the percentage of occupation: (ANOVA: $F = 4.89$, $P < 0.01$; Tukey, $P < 0.05$) (Table 1).

Burrow description

Grammostola vachoni excavate horizontal and simple burrows. These were tubular, with slight variations in the basic profile. The most common burrow consisted in an entrance (usually without or with scarce silk) with a curved profile followed by a horizontal tunnel that may continue, or not, with a vertical tunnel with or without a chamber at the end. All the entrances were found covered with the rock or adjacent vegetation. We found that the burrows of females had a chamber, whereas the refuges of juvenile individuals in general, only presented horizontal or vertical tubes without a chamber. Table 2 shows the results obtained from the analysis of refuges measured considering the size of the individuals. We found a significant positive correlation between the length of the refuges and the size of the individuals (Pearson; $r = 0.56$, $P < 0.05$), of average,

Table 1. Abundance, number of potential refuges available and percentage of occupation of *Grammostola vachoni* in the four sites sampled

Values followed by the same letter are not significantly different ($P > 0.05$, Tukey test) for each site

	Site A	Site B	Site C	Site D
Individuals	86	25	58	30
Potential refuges available	2106	1858	2201	2789
Occupation (%)	4.08(b)	1.34(a)	2.63(ab)	1.07(a)

the largest individuals were seen to have the largest refuges ($F = 4.01$, $P < 0.05$).

Soil characteristics

The highest value of the relative compaction of the soil was recorded at site A (0.77 ± 0.08) and the lowest was at site B (0.66 ± 0.04) (Table 3). No significant differences were found in the relative soil compaction between sites, with or without *G. vachoni* (Table 3). The pH of site C was significantly lower (pH = 4.52 ± 0.22; $F = 16.78$, $P < 0.01$) than those recorded at the other sites. In addition, the minimum values recorded at each site were associated with the plots without *G. vachoni* (Table 3).

Vegetation characteristics and composition

Forty-four species and 11 morphospecies were recorded, belonging to 16 families (Table 4). *Poaceae* and *Asteraceae* were the best represented plant families. The mean species richness ($n = 8$ for each site) was 7.13 ± 2.42 in A; 5.38 ± 1.41 in C and 4.38 ± 1.6 in B. We found significant differences between sites A and B ($F = 6.418$, $P < 0.05$ and $F = 6.231$, $P < 0.05$ respectively). In addition, we found differences in the species composition between three sites, the CJ was A = 0.39, in B = 0.25 and C = 0.28. *Acanthostyles buniifolius* (a native Asteraceae) was the only species shared in the plots with *G. vachoni* in all sample areas. *Glandularia platensis* (Verbenaceae) was only recorded at site A. *Nasella melanosperma* (Poaceae) and *Pinus radiata* (Pinaceae) were only reported at B, whereas *Facelis retusa* (Asteraceae) and *Schizachyrium spicatum* (Poaceae) were recorded exclusively at site C. *Krapovickasia flavescens* (Malvaceae) and *Piptochaetium lejopodum* (Poaceae) were found at all the sites in plots with and without *G. vachoni*. The site C showed higher quantity of endemic species than the other sites ($F = 2.87$, $P < 0.05$; $n = 8$ in each site) (Table 3). We did not record any differences between the number of endemic, native and exotic plants between the plots with or without spiders. The functional group with the highest level of significance of cover was that of the perennial tussock grasses in both plots, with and without spiders.

Table 2. Characteristics of *Grammostola vachoni* burrows according to their body size

(*) indicate positive correlation between characteristics of burrow and size of individuals ($P < 0.05$, Pearson)

Characteristics	Size 1 (≤ 0.5)	Size 2 (0.5–1.3)	Size 3 (1.3 ≥)
Number of entrances	1	1 or 2	1
Refuges width (mm)	42.07 ± 3.05	33.27 ± 4.10	55.28 ± 11.21
Refuges length (mm)*	100.58 ± 48.28	128.62 ± 28.28	189.84 ± 59.99
Depth (cm)	12.48 ± 9.79	5.02 ± 4.07	12.08 ± 11.33
Number of chambers	0	0 or 1	1

Heterogeneity and diversity

We evaluated different indices for determining the heterogeneity and diversity of the microhabitat at each site. Although the Simpson index (evenness of the community) and Equitability index were lower in plots with *G. vachoni* than without spiders, these results were not statistically different (Table 3). In addition, the Shannon index (diversity) was lower in the absence than in the presence of *G. vachoni* (Table 3).

Discussion

Abundance

The number of potential refuges counted at site D was larger than at the other sites, but we recorded fewer individuals, thus the percentage of occupations also was less than at other sites. The disturbance due to tourism at site D, probably negatively affected the abundance of *G. vachoni*. M'rabet *et al*. (2007) also showed a negative relationship between the density and intensity of human activity for the tarantula *Brachypelma vagans* Ausserer 1875. Further, we also found few individuals at site B but we also recorded less potential refuges. Alteration of natural habitats and the introduction of alien tree species may be detrimental to the distribution of *G. vachoni*, restricting the number of available refuges. On the other hand, at site A, the presence of cattle and horses did not seem to affect the abundance of individuals because it was the site with the highest abundance and percentage of occupation. It is likely that the plant heterogeneity caused by cattle breeding (Loydi and Distel 2010) might be more appropriate for the development of populations of *G. vachoni*, promoting higher complexity around the refuges. This affirmation is also in agreement with earlier observations, which showed that the presence of cattle increases the abundance of arthropods, a potential prey of spiders (Oliveira Leal *et al*. 2016).

Burrow description and soil characteristics

In contrast with other studies where more complex constructions were reported, the burrow of *G. vachoni* is simple (Yáñez and Floater 2000; Canning *et al*. 2014); such simplicity can be explained by the presence of the rocks as part of the natural

Table 3. Summary of microhabitat variables across sites types for Presence (P) and Absence (A) of *Grammostola vachoni* on study sample area

(*) indicate significant differences between sites ($P < 0.05$)

	Variable	Site A	Site B	Site C
Status of vegetation (% cover)	Endemic P-A	14.29–14.29	22.22–10.00	33.33*–20.00
	Natives P-A	61.90–64.29	61.11–50.00	66.67–40.00
	Exotics P-A	23.81–14.29	16.67–40.00	0–6.67
Index heterogeneity and diversity	Equitability P-A	0.71–0.73	0.64–0.73	0.75–0.69
	Shannon P-A	1.24–1.05	1.01–0.67	0.94–1.0
	Simpson P-A	0.61–0.69	0.58–0.80	0.72–0.61
Soil characteristics	pH P-A	5.47 (0.09)–5.20 (0.39)	5.69 (0.68)–5.67 (0.6)	4.61 (0.24)–4.44 (0.21)
	Compaction Relative P-A	0.72–0.77	0.72–0.66	0.67–0.70

Table 4. Species and morphospecies of vegetation registered at samples areas (*P* = presence and A = absence of *G. vachoni*) during the period of study

	Site C		Site B		Site A	
	P	A	P	A	P	A
Acanthostyles buniifolius	X	–	X	–	X	–
Achyrocline satureioides	–	–	–	–	X	–
Aristida spegazzinii	–	X	X	–	–	X
Baccharis crispa	–	–	–	–	X	–
Briza minor	–	–	X	–	–	–
Briza subaristata	–	X	–	X	X	X
Cheilanthes buchtienii	X	–	–	–	–	–
Cheilanthes squamosa	–	X	–	–	–	–
Conium maculatum	–	–	–	X	–	–
Danthonia cirrata	–	X	X	X	X	X
Dichondra sericea	X	–	–	X	X	X
Echium plantagineum	–	–	X	–	–	–
Echuim vulgare	–	–	–	X	–	X
Eragrostis lugens	–	X	X	–	X	X
Evolvulus sericeus	–	–	–	–	–	X
Facelis retusa	X	X	–	–	–	–
Galium richardianum	–	–	X	–	–	–
Gamochaeta spicata	X	X	–	–	–	–
Gamochaeta stachydifolia	–	X	–	–	–	–
Glandularia platensis	–	–	–	–	X	X
Glandularia sp.	–	–	–	–	–	–
Gomphrena pulchella	X	X	X	–	X	X
Gomphrena sp.	–	–	–	–	–	–
Hybanthus parviflorus	–	–	–	–	–	X
Krapovickasia flavescens	X	X	X	X	X	X
Lolium multiflorum	–	–	–	–	X	–
Lucilia acutifolia	–	–	X	–	X	–
Margyricarpus pinnatus	–	–	X	–	X	X
Melica eremophila	–	–	–	–	X	–
Mimosa rocae	X	X	X	–	–	–
Nassella melanosperma	–	–	X	X	–	–
Nassella tenuis	X	–	–	–	–	–
Oenothera sp.	–	–	–	–	X	–
Panicum vermun	–	–	–	–	X	–
Paronychia sp.	–	X	–	–	–	–
Paspalum plicatulum	–	X	–	–	–	–
Paspalum sp.	X	–	–	–	–	–
Pavonia cymbalaria	–	X	X	X	–	–
Petrorhagia nanteuilii	–	–	–	–	X	–
Pfaffia sp.	–	–	X	–	–	–
Pinus radiata	–	–	–	X	–	–
Piptochaetium lejopodum	X	X	X	X	X	X
Plantago ventanensis	–	–	–	–	X	–
Rhynchosia senna	–	–	X	–	–	–
Schizachyrium spicatum	X	X	–	–	–	–
Senecio pampeanus	–	–	X	–	–	–
Senecio sp.	–	–	–	–	X	X
Sommerfeltia spinulosa	X	X	–	–	–	–
Stipa sp.	–	–	–	–	–	–
Stipoides sp.	–	–	–	–	–	–
Tradescantia sp.	–	–	–	X	–	–
Vulpia myurus	–	–	–	–	X	–
Wahlenbergia linarioides	–	–	–	–	X	–
Wahlenbergia sp.	–	–	–	–	–	–
Wedelia buphtalmiflora	X	–	–	–	X	X

protection of individuals. In addition, we recorded smaller sizes of refuges for the medium size of individuals (Size 2). It could suggest that these individuals use the refuges temporarily and not necessarily larger refuges, whereas juveniles and adults have permanent refuges and would require larger dimensions that allow a place for prey capture, alimentation, molt and nesting site.

Gotelli (1993) showed that in a sit-and-wait predator the microhabitat selection is strongly influenced by soil characteristics. Furthermore, M'rabet *et al*. (2007) found that densities of the tarantula *B. vagans* were dependent on the soil type. Conversely, in our study we did not find any relationship between the occurrence of *G. vachoni* and the soil characteristics. The type of soil apparently seems to be important for burrow construction in other species, because of the possibility of collapse when these spiders only partially line their burrows with silk (Canning *et al*. 2014). However, *G. vachoni* makes shallow refuges, reducing the probability of soil collapse.

The invasion of *Pinus* at site B has an influence on humidity and causes low levels of direct sunlight (Cuevas and Zalba 2010). Therefore this factor could be another reason why there were less individuals of *G. vachoni* reported at site B than at the other sites. Numerous studies have reported that environmental factors, such as temperature, humidity and light intensity, are known to affect the distribution of other spider species and can affect development rates, survival, reproduction, adult size and longevity between both individuals of the same species and between different species of spider (Evans and Hambler 1995; Yáñez and Floater 2000).

Characterisation of the vegetation

We found that the composition of species, and the heterogeneity and diversity of plants are influenced by different disturbance regimes, altering the distribution of spiders. In general, in plots with spiders the microhabitats were more heterogeneous and diverse than in the plots without spiders, although we did not find any significant differences in the diversity index. Habitat heterogeneity provides alternative prey for the generalist predators to set up their populations and get benefit from a variety of natural prey accessible in more structurally diverse habitats (Siira- Pietikäinen *et al*. 2003; Cai *et al*. 2010). In addition, some authors proposed that in the mountain grasslands of the Ventania System, moderate grazing intensity appears to favour plant diversity (Nai-Bregaglio *et al*. 2002; Loydi and Distel 2010), which could explain the higher abundance of *G. vachoni* at site A, that is subjected to grazing. *Acanthostyles buniifolius* was the only species shared at all sites for plots with spiders. This could show a preference in the distribution of *G. vachoni* because *A. buniifolius* has a characteristic distribution in piedmont mountain grassland, growing in areas that are dry and warm, with high solar radiation and greater thermal seasonal amplitude (Frangi and Bottino 1995). These factors might influence the distribution of refuges indirectly through their effect on the microclimate.

While many studies showed the importance of habitat structure on the distribution and abundance of web-spinning and cursorial spiders (Hurd and Fagan 1992; Bradley 1993; Simmonds *et al*. 1994; Podgaiski and Rodriguez 2016; Barton *et al*. 2017; Spear *et al*. 2017), no evidence was found to show that surrounding vegetation had any direct influence on the burrows of tarantulas. However, high resource heterogeneity (e.g. plant richness) and availability (e.g. plant density or a different type of prey) can increase the niche space available for spiders in mountain grassland and thereby provide resources to expand species' niches and, consequently, allow the establishment of new species and survival of others.

Conclusions

We found that *G. vachoni* is sensitive to environmental and ecosystem stress produced in the disturbed mountain grasslands resulting in different occurrence patterns, and greater abundance was found in the grazed and non-disturbed grasslands. Whereas factors such as grazing did not affect the presence of individuals, the presence of *G. vachoni* might be associated with grassland without any human activities and without exotic tree invasion that indirectly alters the availability of refuges.

However, more research on this topic needs to be undertaken to understand the definitive association between *G. vachoni* and mountain grassland health. According to Langellotto and Denno (2004), the abundance of palatable insect prey and habitat structural complexity are two of the most significant predictors of spider abundance, density, and habitat selection. Wise (1979) and Leborgne and Pasquet (2005) highlighted the importance of prey availability on the fecundity, body condition, and the spider web residence. Nevertheless, the theraphosids can survive without food for long periods and their relatively low metabolic rate reduces the need for high feeding rates, leading to life history traits of slow development and high longevity (Cloudsley-Thompson 1983; Provencher and Riechert 1991). However, the majority of studies have been on web-building spiders, and only a few were based on spiders as 'sit and wait predators', such as the tarantulas. The availability of trophic resources, as well as competition for them, could be highlighted as one of the main factors conditioning the presence and the abundance of *G. vachoni* in the grassland.

Large-scale changes in the native grassland vegetation limit the opportunity of dispersing towards new habitats and it is a cause for concern for a species with a limited distribution. This study has shown that the occurrence of *G. vachoni* in degraded habitats is not totally limited. However, there is concern for the long-term welfare of the species, because natural temperate grasslands are habitats in regression (Bilenca and Miñaro 2004). In addition, theraphosids present poor dispersion ability and do not balloon as a means of dispersal (Cutler and Guarisco 1995; Jankowski-Bell and Horner 1999). This incapacity of dispersing through the matrix of altered habitats, usually a fragmented environment, would decrease the chance of recolonisation and the abundance of individuals in the fragments.

The overwhelming pressure imposed by human activities on natural systems puts not only the species and their interactions at risk but also limits conservation and management options, reducing the number of ways in which human populations can interact with natural remnants (Brown 1996; Kim and Byrne 2006). Identification of the effects that such disturbances have on the local or regional biota is only the first step in a long journey towards the conservation of natural grassland.

This study should help to localise the areas where reproductive populations of *G. vachoni* may be maintained by revealing soil and vegetation preferences for burrowing, as well as the abundance of individuals under different disturbance regimes. Moreover, the information reported in this study is very important to provide data for a future re-categorisation for the Red List of IUCN. Our results are consistent with those of other studies where the spiders have proved to be good bioindicators of different disturbances (Dias *et al*. 2011; Ghione *et al*. 2013; Samu *et al*. 2014; Ossamy *et al*. 2016; Torres *et al*. 2016; Spear *et al*. 2017) and we propose a species of Theraphosidae as representative to evaluate the state or health of a natural grassland for the first time.

Conflicts of interest

The authors declare no conflicts of interest.

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