Short Communication

Do disturbed environments affect density of the tunnel-web spider *Acanthogonatus centralis* (Mygalomorphae: Nemesiidae) from native grasslands in Argentina?

Gabriel POMPOZZI[1],[*] ⓘ, **Leonela SCHWERDT**[2] ⓘ, **Sofía COPPERI**[3] ⓘ, **Nelson FERRETTI**[1] ⓘ

[1]Institute of Biological and Biomedical Sciences of South (INBIOSUR, UNS-CONICET), Bahía Blanca, Argentina
[2]Renewable Natural Resources Centre of Semi-arid Zone (CERZOS-CONICET), Bahía Blanca, Argentina
[3]Entomology Laboratory, IADIZA (CCT CONICET-Mendoza), Mendoza, Argentina

Abstract: Disturbance is an important factor affecting community composition and biodiversity in natural ecosystems. The Ventania hill system in central Argentina presents several ecosystem disturbances. Spiders are good candidates for studies related to human impact and conservation, as they can be good biological indicators of certain ecosystems. Therefore, we tried to elucidate if the abundance and spatial distribution of the mygalomorph spider *Acanthogonatus centralis* (Nemesiidae) are affected by different degrees of disturbance in these hilly grasslands. We studied 3 sites with different levels of disturbance located in the Ventania system in southwestern Buenos Aires Province, Argentina. We did not find differences in the mean density of *A. centralis* among sites. The highest density of this spider species was found in the site with the highest level of disturbance. In addition, the spatial arrangement indicated an aggregate distribution. In conclusion, we found that *A. centralis* populations are not affected by different levels of disturbances.

Key words: Spatial distribution, urbanization, livestock, Araneae

It has been recognized that disturbance is an important factor affecting community composition and biodiversity in natural ecosystems (Brunbjerg et al., 2015). Agriculture, urbanization, and tourism are disturbances that considerably alter local landscapes and climates and are increasing in intensity, constituting some of the greatest threats to ecosystems (Brooks et al., 2006). These threats often lead to a reduction in vegetation cover, modifications in habitat complexity, heat retention, and landscape connectivity (Bierwagen, 2007; Cadenasso et al., 2007; Yuan and Bauer, 2007). Moreover, they have an important effect on biodiversity, driving major changes in species abundances and distributions (McKinney, 2008).

The Ventania hill system is a unique upland ecosystem in central Argentina. In addition, it is one of the last relicts of relatively well-conserved areas of Pampean grassland where several endemic taxa and unique habitat types can be found (Zalba and Cozzani, 2004; Delucchi, 2006). Unfortunately, this hill system shows many ecosystem disturbances: overgrazing by large and exotic herbivores including feral horses and livestock (Loydi and Distel, 2010; Scorolli and López-Cazorla, 2010); invasion of pine and other exotic plants (Zalba and Villamil, 2002; de Villalobos et al., 2011); tourism and urbanization (Gil et al., 2014). It has been demonstrated that spiders are good candidates for studies related to human impact and conservation, and may be useful as biological indicators for particular ecosystems (Scott et al., 2006; Ghione et al., 2013; Schwerdt et al., 2017). Arguably, knowing the density and distributional patterns of a common spider species could be very important in elucidating the potential of the species as a biological indicator for assessing the conservation degree of native grassland.

Nemesiidae spiders are widely distributed across the tropical and subtropical regions of South America, but data about their biology and ecology is scarce, with only notes and some particular ecological studies available from a few species from Argentina, Brazil, Chile, and Uruguay (Capocasale and Pérez-Miles, 1990; Pinto and Sáiz, 1997; Indicatti et al., 2008; Ferretti et al., 2012, 2014a; Souza-Silva et al., 2014).

The genus *Acanthogonatus* Karsch 1880 comprises 29 species distributed in southern South America, mainly in Argentina and Chile (Goloboff, 1995). Some species of this genus live in long, dense tunnel-webs or under rocks or logs, and others live in burrows in open spaces. These spiders close their burrows, at most, with an accumulation of silk and debris without trapdoors (Capocasale and Pérez-Miles, 1990; Goloboff, 1995; Pinto and Sáiz, 1997; Ferretti et al., 2011). *Acanthogonatus centralis* Goloboff

* Correspondence: gabrielpompozzi@gmail.com

1995 is a medium-sized spider found in the hilly areas of central Argentina, and is particularly common in the Ventania system (Goloboff, 1995; Ferretti et al., 2012). These spiders build horizontal tunnel-webs that are often connected to a short burrow (Ferretti et al., 2011). *Acanthogonatus centralis* can be easily found living under rocks in the mountain system of Ventania in central Argentina (Ferretti et al., 2011, 2012). Ferretti et al. (2012) recorded the highest activity periods for males of *A. centralis* as at the end of autumn and spring, having 2 clear activity peaks. Moreover, despite being a mygalomorph spider, *A. centralis* shows high individual motility, as was reported by Ferretti et al. (2012), rendering it more interesting to study their ecology and how different levels of disturbance impact their populations. This spider species has been well studied in recent years, but only their sexual and agonistic behavior has been documented (Ferretti et al., 2011, 2014a). Although some ecological aspects such as the phenology of this species in a nature reserve have been reported (Ferretti et al., 2012), specific demographic data at the population level or habitat preferences are still unknown.

Despite its relatively high abundance in some areas, *A. centralis* has never been considered an ecological indicator. It may be of great importance to study *A. centralis* in order to implement suitable management and conservation actions for Pampean grasslands. For these reasons, our goal was to elucidate if the abundance and spatial distribution of *A. centralis* are affected by different degrees of disturbance. In order to elucidate this, we evaluated the abundance and spatial distribution of *A. centralis* in different disturbed areas. Then we predicted that if the species could be a good bioindicator for the Pampean grasslands, a gradient from high density of *A. centralis* in areas of low disturbance to lower density in areas with moderate and high disturbance should be obtained.

The study was conducted in the Ventania hill system in southwestern Buenos Aires Province, Argentina. The topography ranges from steep slopes at high elevations of the mountain system to gentler slopes at lower levels (piedmont). The climate is humid and temperate, with an average annual rainfall of 850 mm that decreases from NE to SW during fall and spring (Pérez and Frangi, 2000). The mean annual temperature is about 14.5 °C (Kristensen and Frangi, 1995). The natural vegetation consists of more than 400 native species with high endemism (Zalba and Villamil, 2002). We studied 3 areas with different degrees of disturbance (Figure 1): i) the Ernesto Tornquist Provincial Park (ET) (38°00′–38° 07′S, 61°52′–62°03′W); ii) the Funke Ranch (FR) (38°04′19.2″S, 62°02′55.1″W); iii) the Cerro Ceferino area (CC) (38°07′69″S, 61°47′33″W). The ET comprises a natural reserve with a restricted area without evidence of disturbance, representing a low disturbance level (LD). The FR shows a certain degree

of disturbance involving grazing by domestic livestock (cows) and cultivars (sunflower and corn) at the base of the hills; thus, we considered it to be at medium disturbance level (MD). Finally, the CC is located near the locality of Sierra de la Ventana, which has grazing by domestic livestock (cows), exotic vegetation, regular tourism, and urbanization; thus, we considered it to be at a high disturbance level (HD).

We carried out the research over a 1-year period (2013–2014) with sampling during each season. The seasonal sampling involved 4 collections in each of the 3 different areas. To describe the spatial patterns and to measure the density of *A. centralis*, four 10×10 m quadrants were established in each area. Since we were interested in discovering how *A. centralis* position themselves in relation to nearby conspecifics, the selection of the quadrants' positions was not random. We established each quadrant at a location where we had identified high rock densities or suitable places to find *A. centralis*. Inside each quadrant, we meticulously looked under all rocks for any *A. centralis* tunnel-webs. Each spider was identified as adult male, female, or juvenile according to the size of the spider and the shape of the tunnel-web (Ferretti et al., 2011). We also recorded the total number of examined rocks per quadrant. We considered each examined rock to be a potential shelter for these spiders. We calculated the percentage of occupation as the number of effective shelters and the number of potential shelters available.

We used an ANOVA test to compare the density of the spiders among areas and dates. We tested the normality of the data using the Shapiro–Wilk test. When data did not fit a normal distribution, we transformed them using the logarithm function. We used the Pearson correlation to explore the possible linear relationship between the densities of *A. centralis* and the mean density of potential shelters per quadrant. We inferred the spatial distribution of *A. centralis* using Morisita's method (1959). For the initial plot, we reiterated the calculation of Morisita's index (Iδ) for 6.25 m^2 (64 quadrants), 25 m^2 (16 quadrants), and 100 m^2 (4 quadrants), looking for changes in the distribution pattern. Measuring spatial patterns at multiple scales is essential because aggregations are a function of the scale at which they are viewed. For each quadrant size, index values ≤1 occur when distribution is nonaggregated, and >1 when aggregated (Vandermeer, 1990). Abrupt changes in the index value between 2 quadrant sizes denote the approximate area encompassed by the aggregations (Vandermeer, 1990). We only analyzed the quadrants and dates where the observed abundance of the spiders was greater than 20 individuals. All statistical analyses were performed using INFOSTAT (Di Rienzo et al., 2016).

Although we did not find significant differences in the mean density of *A. centralis* among sites (F: 0.72, P = 0.51; Figure 2), spiders tended to be denser at HD and LD
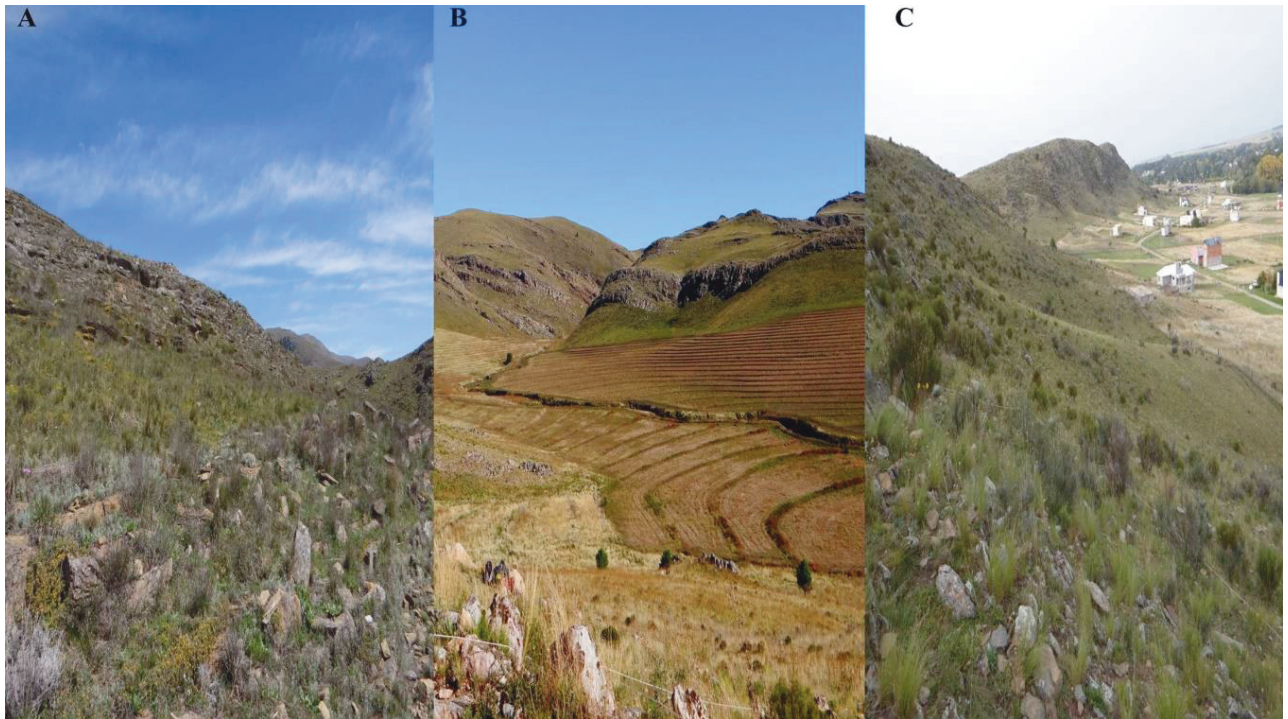
Figure 1. Details of the 3 sampling sites in Sierra de la Ventana, Buenos Aires, Argentina. **A**: Ernesto Tornquist Provincial Park, considered to be at low disturbance level (LD); **B**: Funke Ranch, considered to be at medium disturbance level (MD); **C**: Cerro Ceferino, considered to be at high disturbance level (HD).
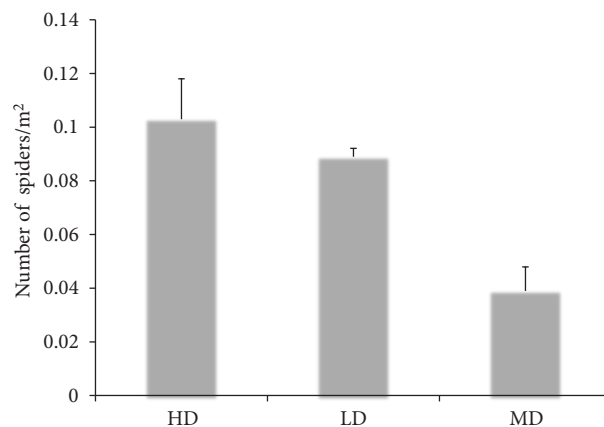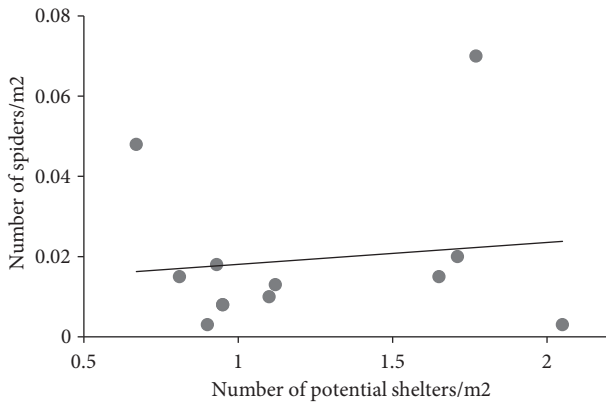

Figure 2. Density of *A. centralis* (spiders/m²) at sites with different disturbance levels. HD: High disturbance; MD: Intermediate disturbance; LD: Low disturbance. Nonsignificant differences were found among the sites (F: 0.72; P = 0.51).

sites. No significant correlation between density of spiders and number of potential shelters (Pearson, r = –0.05, P = 0.88; Figure 3) was found. However, we found significant differences in the density of potential shelters among sites, the density being significantly higher in HD (F: 6.94, P = 0.0024). The percentage of occupation was highest in MD (2.59%), followed by HD (1.7%) and LD (0.97%).

The densest populations were registered in autumn and winter, but we did not find significant differences in the mean density among the sampling seasons (F: 1.03, P = 0.43; Figure 4).

We performed the Morisita index and analyzed the spatial distribution only in autumn at CC due to the number of individuals recorded (Figure 5) (26 spiders in

Figure 3. Relationship between the density of potential shelters and the density of spiders.
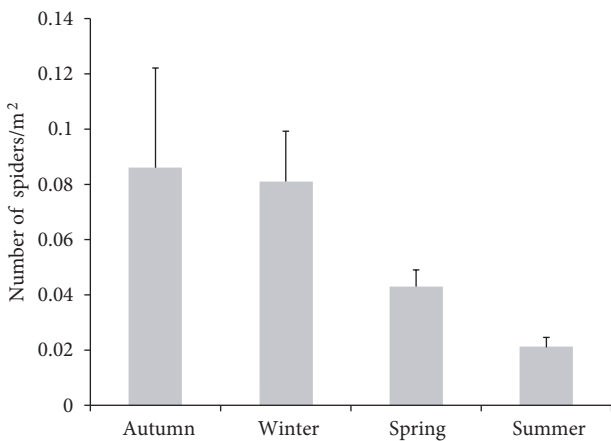
Figure 4. Seasonal density of *A. centralis* (spiders/m²). Nonsignificant differences were found among seasons (F: 1.03; P = 0.43).
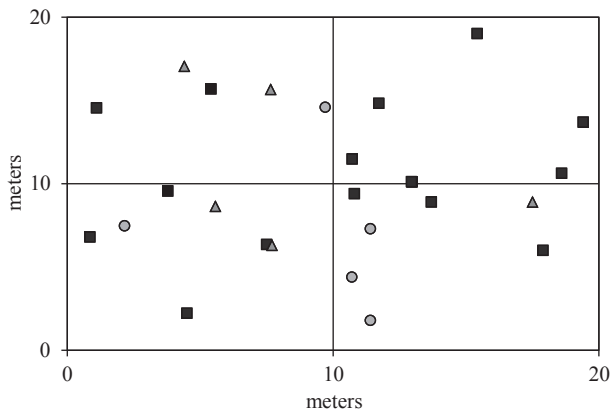
Figure 5. Spatial distribution of *A. centralis* plotted from the four 10 × 10 quadrants during autumn at Cerro Ceferino, Sierra de la Ventana, Argentina. Circles: males; triangles: females; squares: juveniles.

plots). The juveniles were more abundant (61.54% of total individuals) than adult individuals (38.46%). Five males and 5 females were registered on these plots. The Morisita dispersion index within the 100-m² quadrants was 0.89; in the 25-m² quadrants, the Iδ was 0.85; for the 6.25-m² quadrants, the Iδ was 4.16.

It is probable that disturbance does not affect the density of this spider species in the Ventania mountain system. Arguably, the highest density was observed in the site with the highest disturbance. Moreover, we registered more potential shelters in this area, and the second highest percentage of occupation. This site is disturbed by cattle grazing, tourism, and urbanization at the base of the hills. It has been documented in some studies that terrestrial arthropod abundances declined as disturbance increased (Kimberling et al., 2001; M'Rabet et al., 2007). However, other studies have found that disturbance may lead to an increase in species richness and abundances of arthropods (Brunbjerg et al., 2015; Oliveira Leal et al., 2016). These studies in general were focused at the family or order taxonomic level; thus, comparisons with the results obtained in our study need to be made with caution. In addition, Lowe et al. (2017) found that the web spider, *Nephila plumipes*, was not affected negatively by urbanization. In fact, the lifestyle of the spiders, being nocturnal and living under stones, suggests that they are able to avoid human contact. Cattle grazing may have a negative effect on spider diversity (Warui et al., 2005). Certainly, overgrazing by livestock may diminish the abundance of insects (Debano, 2006), reducing the availability and variety of prey for spiders. However, this does not seem to negatively affect the density of *A. centralis*, which was higher at sites with greater grazing pressure from cattle. Schwerdt et al. (2017) found similar tendencies in a theraphosid species in this hill system. An explanation might be that disturbance could generate synergetic effects and increase prey availability, leading to a more suitable area for this spider species (Cai et al., 2010). Although we did not find a relationship between the density of spiders and the density of shelters, the high density of spiders at the HD site could be explained by the highest availability of shelters at this site. The availability of shelters should not be discarded as an important factor in the distribution of this spider species, but clearly more studies are needed to corroborate this observation. The percentage of occupation of *A. centralis* was similar to that found by Schwerdt et al. (2017) for the theraphosid spider *Grammostola vachoni* in the same hill system.

The highest abundance of *A. centralis* during the coldest seasons (autumn and winter) was in agreement with the results of Ferretti et al. (2012). The reason for this activity during the coldest months could be the search for a more suitable habitat, the search for food to reduce competition,

to avoid predators, or the search for a mate during their reproductive period (Aitchinson, 1987).

We did not find a relationship between the spiders' density and the number of potential shelters. Therefore, *A. centralis* were not aggregated as a consequence of the shelters' availability, similar to what was reported by Reichling et al. (2011) for *Sphodros rufipes*. An explanation of this type of distribution could be the poor dispersal capabilities of the spiderlings of mygalomorphs, leading to them being restricted to living in high-density groups (Reichling et al., 2011). In addition, many spider species' preferred particular microhabitats are restricted to small areas, and this preference may influence different biological traits of this species such as their longevity, sedentary lifestyle, and low dispersion ability (Ferretti et al., 2014b; Souza-Silva et al., 2014).

The spatial arrangement of *A. centralis* in the 6.25-m^2 quadrants clearly indicated an aggregate distribution, while in the 100-m^2 and 25-m^2 quadrants the spatial arrangement indicated a random distribution. Unfortunately, we were not able to carry out a more extensive analysis due to the low numbers of spiders found for the other sampling dates and sites. Aggregation is usually found in mygalomorph spiders, as has been reported for 2 different populations of the atypid *Sphodros rufipes* (Latreille, 1829) (Mackena-Foster et al., 2011; Reichling et al., 2011), and for the nemesiid spider *Prorachias bristowei* Mello-Leitão 1924 (Souza-Silva et al., 2014). Moreover, the trapdoor species

Calathotarsus simoni Schiapelli & Gerschman 1975 (Migidae), from the same area as *A. centralis*, also showed a clumped distribution (Ferretti et al., 2014b).

Despite our findings suggesting that this particular spider species is not directly influenced by different types of disturbances, we are very cautious with our assumptions due to the relatively low number of spiders that we found. Moreover, in the same study area, Schwerdt et al. (2017) recently found that the theraphosid spider *Grammostola vachoni* showed different occurrence patterns and greater abundance in grazed and undisturbed grasslands, being sensitive to environmental and ecosystem stress. Although many disturbances such as agriculture or urbanization may not directly affect the *A. centralis* populations' persistence in the Ventania mountain system, more studies are needed to understand if such disturbances could have a future impact on those populations. In this way, monitoring and studying the populations of mygalomorph spiders in natural protected areas and disturbed areas is important from a conservation standpoint.

References

Aitchison CW (1987). Feeding ecology of winter-active spiders. In: Nentwig W, editor. Ecophysiology of Spiders. Berlin, Germany: Springer-Verlag, pp. 264-273.

Bierwagen BG (2007). Connectivity in urbanizing landscapes: the importance of habitat configuration, urban area size, and dispersal. Urban Ecosyst 10: 29-42.

Brooks TM, Mittermeier RA, Da Fonseca GBA, Gerlach, J, Hoffman M, Lamoreux JF, Mittermeier CG, Pilgrim JD, Rodrigues ASL (2006). Global biodiversity conservation priorities. Science 313: 58-61.

Brunjberg AK, Jørgensen GP, Nielsen KM, Pedersen ML, Svenning JC, Ejrnæs R (2015). Disturbance in dry coastal dunes in Denmark promotes diversity of plants and arthropods. Biol Conserv 182: 243-253.

Cadenasso ML, Pickett ST, Schwarz K (2007). Spatial heterogeneity in urban ecosystems: reconceptualizing land cover and a framework for classification. Front Ecol Environ 5: 80-88.

Cai HJ, You MS, Lin C (2010). Effects of intercropping systems on community composition and diversity of predatory arthropods in vegetable fields. Acta Ecol Sin 30: 190-95.

Capocasale MR, Pérez-Miles F (1990). Behavioural ecology of *Acanthogonatus tacuariensis* (Pérez & Capocasale) (Araneae, Nemesiidae). Stud Neotrop Fauna Environ 25: 41-47.

de Villalobos AE, Zalba SM, Peláez DV (2011). *Pinus halepensis* invasion in mountain pampean grassland: effects of feral horses grazing on seedling establishment. Environ Research 111: 953-959.

Di Rienzo JA, Casanoves F, Balzarini MG, Gonzalez L, Tablada M, Robledo CW (2016). InfoStat, version 2016. Córdoba, Argentina: Grupo InfoStat, FCA, Universidad Nacional de Córdoba.

Debano SL (2006). Effects of livestock grazing on aboveground insect communities in semi-arid grasslands of southeastern Arizona. Biodivers Conserv 15: 2547-2564.

Delucchi G (2006). Las especies vegetales amenazadas de la Provincia de Buenos Aires: una actualización. Bol Cientif Aprona 39: 19-31.

Ferretti N, Pompozzi G, Pérez-Miles F (2011). Sexual behavior of *Acanthogonatus centralis* (Araneae: Mygalomorphae: Nemesiidae) from Argentina, with some notes on their burrows. J Arachnol 39: 533-536.

Ferretti N, Copperi S, Pompozzi G (2014a). Fight or flight: agonistic interactions between females of *Acanthogonatus centralis* Goloboff 1995 (Araneae, Mygalomorphae). Turk J Zool 38: 354-360.

Ferretti N, Copperi S, Schwerdt L, Pompozzi G (2014b). Another migid in the wall: natural history of the endemic and rare spider *Calathotarsus simoni* (Mygalomorphae: Migidae) from a hill slope in Central Argentina. J Nat Hist 48: 1907-1921.

Ferretti N, Pompozzi G, Copperi S, Pérez-Miles F, González A (2012). Mygalomorph spider community of a natural reserve in a hilly system in central Argentina. J Insect Sci 12: 1-16.

Ghione S, Simó M, Aisenberg A., Costa FG (2013). *Allocosa brasiliensis* (Araneae, Lycosidae) as a bio-indicator of coastal sand dunes in Uruguay. Arachnology 16: 94-98.

Gil VN, Gil V, Campo AM (2014). Capacidad de carga turística en el sendero del cerro ventana: Parque Provincial Ernesto Tornquist, Argentina. Estudios y perspectivas en turismo 23: 362-375.

Goloboff PA (1995). A revision of the South American spiders of the family Nemesiidae (Araneae, Mygalomorphae). Part I: species from Peru, Chile, Argentina, and Uruguay. B Am Mus Nat Hist 224: 1-189.

Indicatti RP, Lucas SM, Ott R, Brescovit AD (2008). Litter dwelling mygalomorph spiders (Araneae: Microstigmatidae, Nemesiidae) from Araucaria forests in Southern Brazil, with the descriptions of five new species. Rev Bras Zool 25: 529-546.

Kimberling DN, Karr JR, Fore LS (2001). Measuring human disturbance using terrestrial invertebrates in the shrub-steppe of eastern Washington (USA). Ecol Indic 1: 63-81.

Kristensen MJ, Frangi JL (1995). Mesoclimas de pastizales de la Sierra de la Ventana. Ecol Austral 5: 55-64.

Lowe EC, Wilder SM, Hochuli DF (2017). Life history of an urban-tolerant spider shows resilience to anthropogenic habitat disturbance. J Urban Ecol 2017: 1-10.

Loydi A, Distel RA (2010). Diversidad florística bajo diferentes intensidades de pastoreo por grandes herbívoros en pastizales serranos del sistema de Ventania, Buenos Aires. Ecol Austral 20: 281-291.

M'Rabet SM, Hénaut Y, Sepúlveda A, Rojo R, Calmé S, Geissen V (2007). Soil preference and burrow structure of an endangered tarantula, *Brachypelma vagans* (Mygalomorphae: Theraphosidae). J Nat Hist 41: 1025-1033.

Mackena-Foster A, Draney ML, Beaton C (2011). An unusually dense population of *Sphodros rufipes* (Mygalomorphae: Atypidae) at the edge of its range on Tuckernuck Island, Massachusetts. J Arachnol 39: 171-173.

Mckinney ML (2008). Effects of urbanization on species richness: a review of plants and animals. Urban Ecosyst 11: 161-176.

Morisita M (1959). Measuring the dispersion of individuals and analysis of the distributional patterns. Memoirs Faculty Science, Kyushu Univers S Biol 2: 215-235.

Oliveira Leal CR, Oliveira Silva J, Sousa-Souto L, de Siqueira Neves F (2016). Vegetation structure determines insect herbivore diversity in seasonally dry tropical forest. J Insect Conserv 20: 979-988.

Pérez CA, Frangi JL (2000). Grassland biomass dynamics an altitudinal gradient in the Pampa. J Range Manag 53: 518-528.

Pinto C, Sáiz F (1997). Uso del recurso trófico por parte de *Acanthogonatus franckii* Karsch, 1880 (Araneae: Nemesiidae) en el bosque esclerófilo del Parque Nacional "La Campana", Chile central. Rev Chilena Entomol 24: 45-59.

Reichling SB, Baker C, Swatzell C (2011). Aggregations of *Sphodros rufipes* (Araneae: Atypidae) in an urban forest. J Arachnol 39: 503-505.

Schwerdt L, de Villalobos A, Pérez-Miles F (2018). Spiders as potential bioindicators of mountain grasslands health: the Argentine tarantula *Grammostola vachoni* (Araneae, Theraphosidae). Wildlife Research 45: 64-71.

Scorolli A, López Cazorla A (2010). Demography of feral horses (*Equus caballus*): a long-term study in Tornquist Park, Argentina. Wildlife Research 37: 207-214.

Scott AG, Oxford GS, Selden PA (2006). Epigeic spiders as ecological indicators of conservation values for peat bogs. Biol Conserv I27: 420-428.

Souza-Silva M, Silva IG, Brescovit AD (2014). Bionomic aspects of *Prorachias bristowei* (Araneae: Mygalomorphae: Nemesiidae): burrow density and shape, food items, body size and reproduction. Stud Neotrop Fauna Environ 49: 106-113.

Vandermeer J (1990). Elementary Mathematical Ecology. Malabar, Florida: Krieger Publishing Co.

Warui CM, Villet MH, Young TP, Jocqué R (2005). Influence of grazing by large mammals on the spider community of a Kenyan savanna biome. J Arachnol 33: 269-279.

Yuan F, Bauer ME (2007). Comparison of impervious surface area and normalized difference vegetation index as indicators of surface urban heat island effects in Landsat imagery. Remote Sens Environ 106: 375-386.

Zalba SM, Cozzani NC (2004). The impact of feral horses on grassland bird communities in Argentina. Anim Conserv 7: 35-44.

Zalba SM, Villamil CB (2002). Woody plant invasion in relictual grasslands. Biol Invasions 4: 55-72.