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Original Paper

Analysis of spontaneous vegetation in semi-arid cattle fields of the middle valley of Río Negro

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Abstract

The advance of the agricultural frontier in the north of Río Negro led to the land on the plateau being used for dryland livestock production. Livestock practices such as these result in an ecological imbalance that involves the spontaneous plant species in the scrublands. In this study, the species that grow spontaneously in this area were identified, as well as their specific richness and distribution. The native species were related to cattle consumption and the exotic species to toxic potential. The Sörensen similarity index was calculated to express the degree of similarity between the sites. The study area included 59 families, 197 genera and 300 species of vascular plants. The most representative families being the Asteraceae, Poaceae, Fabaceae, Solanaceae, Verbenaceae and Chenopodiaceae. The highest percentage of species consumed were native and 66% of the exotic species are potentially toxic to cattle. The Riparian Zone presented a greater number of exotic species. The highest similarity was between the Plateau Plain and the Foot of Escarpment. The information provided is a basis for evaluative studies between dryland cattle production and plant conservation in the Middle Valley of Río Negro.

Key words: livestock production, monte, plant species.

Resumen

El avance de la frontera agropecuaria en el norte de Río Negro impulsó a que los campos de meseta se destinaran a la producción ganadera de secano. Dichas prácticas ganaderas generan un desequilibrio ecológico que involucra a las especies vegetales espontáneas del monte. En este trabajo se identificó las especies que crecen en forma espontánea en estos campos, su distribución y su riqueza específica; se relacionó las especies nativas con el consumo por parte del ganado y las especies exóticas con el potencial tóxico y se calculó el índice de similitud de Sörensen para expresar el grado de semejanza entre los sitios. El área estudiada cuenta con 59 familias, 197 géneros y 300 especies de plantas vasculares. Las familias más representativas son Asteraceae, Poaceae, Fabaceae, Solanaceae, Verbenaceae y Chenopodiaceae. El mayor porcentaje de especies consumidas son nativas y el 66% de las especies exóticas son potencialmente tóxicas para el ganado. La Zona Riparia presenta mayor número de especies exóticas. La similitud más elevada se da entre la Planicie de Meseta y el Pie de Barda. Los aportes brindados son la base para estudios evaluativos entre la ganadería de secano y la conservación vegetal en el Valle Medio de Río Negro.

Palabras clave: producción ganadera, monte, especies vegetales.

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Introduction

The province of Río Negro is part of the two thirds of arid and semi-arid territory present in Argentina. The hydrology, topography, geomorphology and other factors, such as low rainfall and markedly seasonal and fluctuating temperatures, determine the type and spatial distribution of the vegetation (Bisigato *et al.* 2009; Fernández *et al.* 2017). From the phytogeographic point of view, the north of Río Negro is part of the southern sector of the Phytogeographic Province of Monte (Cabrera 1976; Morrone 2014; Fernández *et al.* 2017; Oyarzabal *et al.* 2018). The plant communities that characterize the plateau sector of this region are xerophytic shrub species, aphyllous, with photosynthesizing stems, spiny, or with small deciduous or perennial leaves, and sometimes with waxes or resins on the leaves and stems. Species of the genus *Larrea* Cav. ("jarilla" - *L. divaricata* Cav., *L. cuneifolia* Cav. and *L. nitida* Cav.), of the Zygophyllaceae family, are dominant. The extensive "jarillales" (low scrubland) are associated with plants from different families, such as the Anacardiaceae, Asteraceae, Fabaceae, Solanaceae, Verbenaceae, or halophyte species, such as *Atriplex* L. and *Suaeda* Forssk. *ex* J.F.Gmel. (Chenopodiaceae), among others. Also, smaller clumps of "chilladora" (*Chuquiraga erinacea* D.Don, Asteraceae), "mata cebo" (*Monttea aphylla* (Miers) Benth. & Hook., Scrophulariaceae) and "chañar" (*Geoffroea decorticans* (Gillies *ex* Hook. & Arn.) Burkart, Fabaceae) are frequent, as well as cacti and various species of annual and perennial herbs, that are protected by their association with patches of shrubs. Some species of grass and / or dicotyledonous herbs become established in the interpatches. The grass species that dominate the herbaceous stratum belong to the genera of *Jarava* Ruíz & Pav., *Nassella* Desv. and *Poa* L. (Cabrera 1976; Walter 1977; Soriano & Sala 1983; León *et al.* 1998; Oyarzabal *et al.* 2018). *Salix humboltiana* Willd. is characteristic on the banks of the river Rio Negro and also several exotic species of Asteraceae, Brassicaceae, Chenopodiaceae, Fabaceae, Salicaceae, etc. are common, as well as introduced shrubs, such as *Elaeagnus angustifolia* L. (Elaeagnaceae), *Tamarix ramosissima* Ledeb. (Tamaricaceae), *Rosa rubiginosa* L. (Rosaceae) (Klich 2016).

With the shift of the agricultural frontier to the north of Patagonia at the end of the 20th century, the valley areas were transformed into important agricultural production systems, mainly with orchards and pastures. The construction of complex irrigation systems facilitated the advancement of these enterprises. Likewise, the non-irrigated dryland areas were used for extensive grazing of domestic herbivores. The food source for these herbivores is the spontaneous vegetation that grows on the plateau, especially in the case of cattle rearing (Zeberio 2012).

These livestock practices and all the related tasks (clearing of the land, construction of roads, demarcation of pastures, installation of water supplies and fences, among others), contribute to an ecological imbalance. These disturbances facilitate degradation processes and result in the introduction and invasion of exotic species that lead to a decrease and fragmentation in the populations of native species (Derner *et al.* 2009; Milchunas & Lauenroth 1993). At the same time, several of these species contain various chemical components potentially toxic to cattle, which cause a deterioration in the natural pastures (Bisigato *et al.* 2005; Krikor & Hierro 2011; Marino 2008; Peralta & Klich 2021).

Moreover, Cingolani (2008) and Zeberio *et al.* (2008) suggested that an understanding of the system and its characteristics would enable the conservation of the biodiversity in the scrublands and a good development of extensive cattle production.

It is in this regard that there is a need for accurate data from the land destined for livestock production in order to make good use of the resources of natural vegetation. For this reason, the present contribution aims to analyze the spontaneous plant species that grow on the land used for extensive cattle production in the Middle Valley of Río Negro. Knowledge of the vegetation will facilitate the design of conservation strategies on a local scale.

Materials and Methods

Study area

The study was carried out in the drylands in the Middle Valley of Rio Negro and surrounding areas (38º50–39º55'S, 65º15–66º35'W), (Fig. 1). In general, the surveyed area is used for extensive cattle production, mainly for breeding. Establishments with feedlots are scarce in this rainfed area (Klich *et al.* 2020).

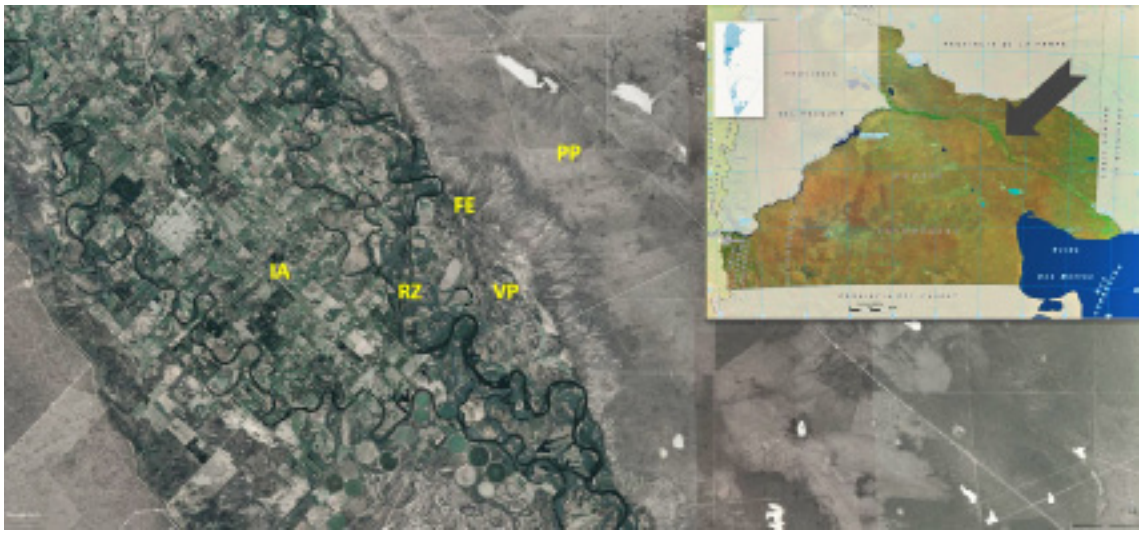

Figure 1 – Satellite image showing the location of the study area, indicating the different sites surveyed. PP: Plateau plain; FE: Foot of escarpment; VP: Valley plain; RZ: Riparian zone; IA: Irrigation area (excluded in this study).

The average annual temperature is 15.4 °C and the average precipitation is 268 mm. In addition, fires, both natural and intentional, are frequent and they modify the structure and composition of the vegetation.

Four sites were delimited according to the characteristics of the relief, such as areas with plateaus, alluvial plains and flood plains: Riparian Zone (RZ), Valley Plain (VP), Foot of Escarpment (FE) and Plateau Plain (PP). The surveyed area totalizes 135,000 ha, 60 % is PP, 20 % is VP and the remained 20 % is occupied by FE, the ecotone area between PP and VP, and RZ or river coast fields.

Floristic survey

The floristic survey was carried out at different times of the year in the natural areas with anthropogenic use. Standard species recognition techniques were used to identify the taxonomic groups. Collection trips to the study area were undertaken periodically, taking account of the climatic conditions and the rotation of cattle in the different pastures. Fifty recognition plots, 2 km long and 2 m width, were surveyed every season in each collection site in three successive years. Phenological observations were made and photographs of the plants and the habitats where they grow were taken at the same time. The specimens were herbalized and the environmental data were recorded. Specific bibliography was used (Correa 1999; Kröpfl *et al.* 2012; Velasco & Siffredi 2009; Zuloaga *et al.* 2008) for identifying the species and establishing their biogeographic origin (native / exotic), as well as electronic databases of the regional flora, such as SIB (<https://sib.gob.ar>) and the Catalogue of Flora Argentina, published by Darwinion Botanical Institute (<www2.darwin.edu.ar/Proyectos/FloraArgentina/FA.asp>).

Data analysis

The proportion of herbs, shrubs and trees was determined. The richness and representativeness of the families in relation to the total number of species recorded was calculated for each sampling site. The identification of species with toxic potential (Odriozola 2015; Peralta & Klich 2021) was related to their biogeographic origin. The Sörensen Similarity Index (IS) was used to express the degree to which two of the sites were similar due to the species present / absent in them (Sörensen 1948).

In addition, the field work was complemented with observations and guided walks together with the producers, which resulted in information about the spontaneous forage resources[1]. Bibliographic information and preliminary data from microhistological analysis of feces were used to complete this information.

[1] The spontaneous forage resources are those plant species or some of them, native or exotic, that grow spontaneously and are consumed by cattle.

Results and Discussion

Analysis of the study area

The natural distribution of the vegetation is extremely heterogeneous. A total of 59 families, 197 genera and 300 species were identified. The list with the families, genera and species of each site surveyed is shown in Table S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.16877134.v1>. The list of reference specimens examined is given in Appendix S2, available on supplementary material <https://doi.org/10.6084/m9.figshare.16877134.v1>.

Table 1 lists the 59 families of plants present in the study area, showing the number of species for each one and their percentage of representativeness. The most represented family is the Asteraceae with 20% of the total species. It is followed by, in descending order, the Poaceae representing 15.66% of the species, Fabaceae (8.66%), Solanaceae (6%), Verbenaceae (4%) and Chenopodiaceae (3.33%). There are also 47 families that have less than 2% representation, including, for example, the Zygophyllaceae (4 sp., 1.33%), Anacardiaceae (2 sp., 0.66%), and Elaeagnaceae (1 sp., 0.33%) that have a high abundance of individuals.

Of the species identified, 70.67% were native and 29.33% were exotic (Fig. 2a). The exotic species are found in areas of greater disturbance, such as tracks, roadsides, fencelines and power lines. These are sectors in the natural areas where vehicular traffic is very frequent, such as trucks and agricultural machinery that come from areas outside the Middle Valley, which are a means of transporting seeds and other propagules of these foreign species. The disturbance caused by clearing also modifies the structure and composition of the plant communities, for example, the cleaning of fences and clearing of the surrounding area, studied by Peralta *et al.* (unpublished) in two agricultural establishments in the Middle Valley, which is a pattern repeated throughout the area.

In relation to the habit, the largest part corresponded to herbaceous dicotyledons, followed by the shrubs and sub-shrubs, monocotyledons herbs, of which 84% were

[2] Here reference is made to the habit of the identified species, not to the abundance of different types of habits that are present in the study area. As it is an area typical of the Monte ecoregion, it is clear that shrubs and subshrubs dominate the region.

Table 1 – List of the families present on cattle properties in the middle valley of Río Negro, with the number (N) of species recorded and the percent (%) of representativeness for each on.

Family	N	Representativeness (%)
Amaranthaceae	2	0.66
Amarylidaceae	1	0.33
Anacardiaceae	2	0.66
Apiaceae	4	1.33
Apocynaceae	1	0.33
Arecaceae	3	1
Asclepiadaceae	1	0.33
Asparagaceae	1	0.33
Asteraceae	60	20
Boraginaceae	5	1.66
Brassicaceae	8	2.66
Cactaceae	7	2.33
Calyceraceae	3	1
Campanulaceae	1	0.33
Capparidaceae	1	0.33
Caryophyllaceae	3	1
Ceratophyllaceae	1	0.33
Chenopodiaceae	10	3.33
Convolvulaceae	3	1
Cyperaceae	2	0.66
Elaeagnaceae	1	0.33
Ephedraceae	2	0.66
Equisetaceae	1	0.33
Euphorbiaceae	4	1.33
Fabaceae	26	8.66
Geraniaceae	3	1
Hydrocharitaceae	1	0.33
Hydrophyllaceae	3	1
Juncaceae	1	0.33
Malvaceae	7	2.33
Nyctaginaceae	1	0.33
Oleaceae	2	0.66
Onagraceae	2	0.66
Orobanchaceae	1	0.33
Oxalidaceae	1	0.33
Passifloraceae	1	0.33
Plantaginaceae	8	2.66
Poaceae	47	15.66
Polygalaceae	3	1

Family	N	Representativeness (%)
Polygonaceae	4	1.33
Portulacaceae	2	0.66
Ranunculaceae	1	0.33
Rhamnaceae	1	0.33
Rosaceae	5	1.66
Rubiaceae	2	0.66
Salicaceae	3	1
Salviniaceae	1	0.33
Schoepfiaceae	1	0.33
Scrophulariaceae	2	0.66
Solanaceae	18	6
Tamaricaceae	1	0.33
Typhaceae	1	0.33
Ulmaceae	1	0.33
Urticaceae	2	0.66
Verbenaceae	12	4
Vitaceae	1	0.33
Zygophyllaceae	4	1.33

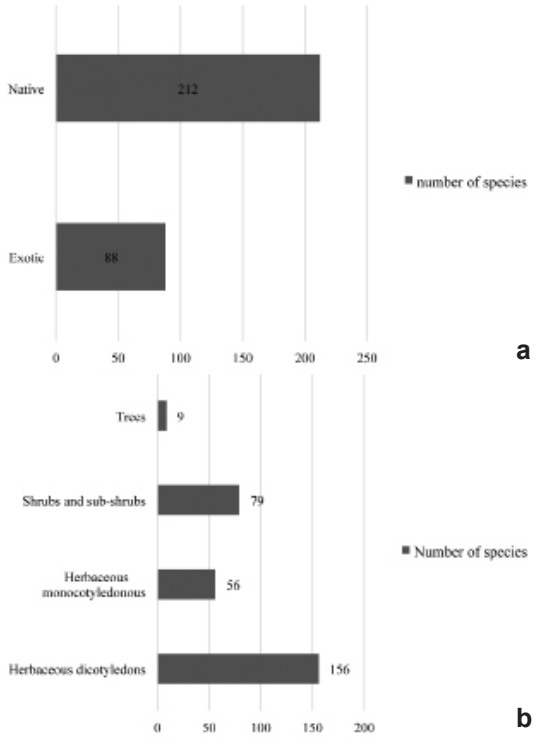

Figure 2 – a. The total number of native and exotic species identified in the whole study area. b. the total number of species according to habit.

Poaceae, and the least represented was the arboreal habit[2]. (Fig. 2b).

Regarding the analysis of the relationship between these plant species and the cattle, it is seen that 30% (93 sp) of the total taxa identified is consumed. The most consumed, according to the habit, were the herbaceous species (55 sp.; 59%), of which 31 sp. were grasses, whereas the shrub or sub-shrub group reached 33% (31 sp.) and the rest corresponded to the arboreal habit (Fig. 3a).

Although the richness of forage grasses is high, the role of shrub species in consumption is very notable. Preliminary data from microhistological samples of the cattle feces (Klich & Peralta 2019; Klich *et al. unpublished*) revealed that some taxa, such as *Lycium* L., *Larrea*, *Schinus* L., *Prosopis* L., *Elaeagnus angustifolia*, *Atriplex lampa* (Moq.) D.Dietr. and *Ephedra ochreata* Miers, are consumed with the same or similar frequency as many species of grasses. This is interesting because they are species with a high abundance in the community of the Monte ecoregion. Another characteristic to highlight is that more than 70% of the species consumed are native (Fig. 3b).

As mentioned by Klich (2018), the herbaceous compositions underneath the *E. angustifolia* stands vary with climate and with accompanying trees. As this invader improves organic matter and disponible nitrogen of the soils, the best conditions to use its properties and raise forage input are to avoid the formation of dense stands and to procure the establishment of small stand with proportional bigger edges surfaces. Cattle can browse *E. angustifolia* (Klich *et al.* 2018) and may grass the borders of all invaded zones. These boundary zones show higher diversity than the understories, and include many edible herbaceous, mostly belonging to two of the important spontaneous forage families identified in this zone, Poaceae and Fabaceae.

As mentioned in previous paragraphs, the percentage of exotic species increases in places where some type of cultivation has been carried out, where the transit of machinery is frequent or in pastures with excessive stocking rates. This brings with it the problem that 66% of these species (51 sp.) are toxic or potentially toxic to cattle. Several authors (Krikor & Hierro 2011; Peralta & Klich 2021) are in agreement with this and they expressed a warning about the introduction of adventitious species in the disturbed areas, many of which present

these unfavourable and harmful characteristics for cattle production, (Fig. 3c). Examples of these adventitious species are *Conium maculatum* L. (Apiaceae), *Diplotaxis tenuifolia* (L.) DC., *Hirschfeldia incana* (L.) Lagr.-Foss. and *Sisymbrium irio* L. (Brassicaceae), *Vicia villosa* Roth. and *Trifolium repens* L. (Fabaceae) and *Cynodon dactylon* (L.) Pers. (Poaceae).

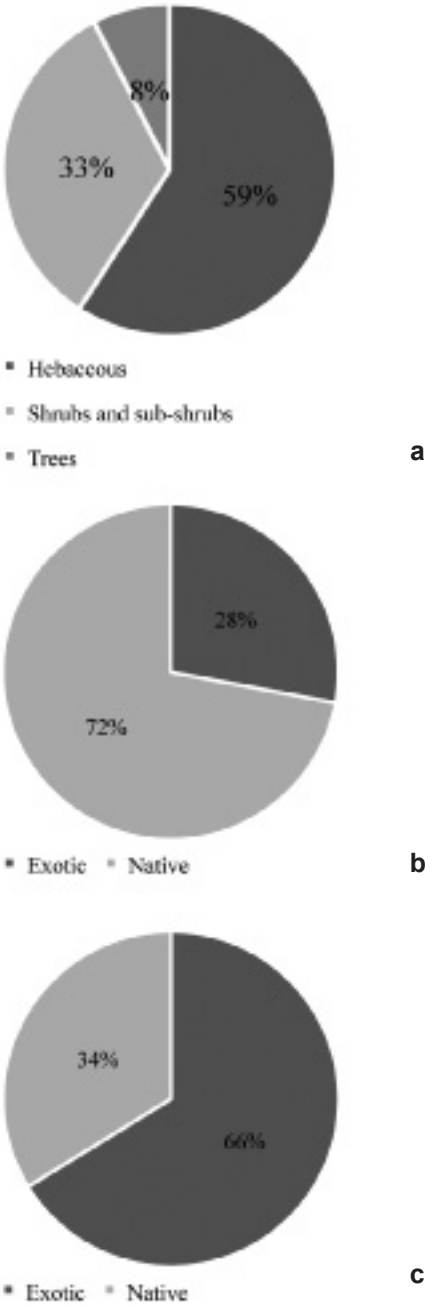

Figure 3 – a. The percentage of total species consumed by cattle. b. the percentage of native and exotic species consumed by cattle. c. the percentage of toxic or potentially toxic species according to their origin.

Data analysis for the four sites identified: Plateau Plain (PP), Foot of Escarpment (FE), Valley Plain (VP) and Riparian Zone (RZ)

The distribution and number of taxa in the Plateau Plain (PP), Foot of Escarpment (FE), Valley Plain (VP) and in the Riparian Zone (RZ) are shown in Table 2. The data show that the richest sites in the number of families, genera and species were the RZ (72.88%, 59.39% and 47%, respectively) and the VP (54.23%, 55.84% and 54.33%).

Only 13 families of the 59 present in the area were shared by all four sites (Apiaceae, Asteraceae, Boraginaceae, Brassicaceae, Calyceraceae, Caryophyllaceae, Chenopodiaceae, Euphorbiaceae, Fabaceae, Plantaginaceae, Poaceae, Solanaceae, Verbenaceae and Zygophyllaceae). Other families were found in three of the four sites. The three sites PP-FE-VP, but excluding RZ, shared 13 families, and the FE-VP-RZ sites, excluding PP, had 7 shared families.

At the specific level, four species of Asteraceae are distributed in all the sites (*Centaurea calcitrapa* L., *C. soltistialis* L., *Gaillardia megapotamica* (Spreng.) Baker and *Gamochaeta filaginea* (DC.) Cabrera) which are all frequent in highly disturbed areas; and following, in descending order, the Poaceae family with three species (*Bromus catharticus* Vahl. var. *catharticus*, *Hordeum murinum* L. and *Nassella tenuis* (Phil.) Barkworth) which are the main forage plants in the area; two species of Brassicaceae, *Eruca vesicaria* Mill. and *Sysimbrium irio*, both exotic species commonly found on road verges and tracks along power lines; and four families have only one species in the four sites: *Amsinckia calycina* (Moris) Chater (Boraginaceae), *Stellaria media* (L.) Cirillo (Caryophyllaceae) (in PP and FE it is found under shrubs), *Euphorbia collina* Phil. (Euphorbiaceae) and *Plantago patagonica* Jacq. (Plantaginaceae).

P. patagonica and *G. filaginea* are native species and it is common to see them covering large areas, especially in places that are exposed to intensive grazing for long periods or without sufficient recovery time.

On the other hand, there were families exclusive to each site (Tab. 3), with the exception of FE. In the RZ there were 14 families, four of which are representatives of the aquatic habitat

Table 2 – Distribution of families, genera and species for each of the sites analyzed.

	Plateau plain	Foot of escarpment	Valley plain	Riparian zone
Number of families	32	27	32	43
Number of genera	108	80	92	117
Number of species	163	108	121	141

(Arecaceae with 3 sp, and Ceratophyllaceae, Hydrocharitaceae, Salviniaceae with 1 sp. each), and the rest are families that are common in humid and somewhat shady habitats, such as the Asparagaceae (1 sp.), Campanulaceae (1 sp.), Cyperaceae (2 sp.), Oxalidaceae (1 sp.), Typhaceae (1 sp.) and Vitaceae (1 sp.); and the Portulacaceae (2 sp.) and Tamaricacae (1 sp.) in open, sandy places. The Salicaceae (3 sp.) and Ulmaceae (1 sp.), of arboreal habit, form dense groves on the banks of the river that are often impenetrable; in the autumn they form beds of leaves that the cattle consume. In the PP the exclusive families were the Shoepfiaceae with 1 sp. (*Arjona tuberosa* Cav.) Orobanchaceae (*Agalinis communis* (Cham. & Schltdl.) D'Arcy) and Hydrophyllaceae (*Phacelia* Juss. 3 sp.). No exclusive families were found in the FE and only one (Apocynaceae, *Tweedia brunonis* Hook. & Arn.) in the VP.

Regarding the distribution of the species according to their origin, we can see that the highest percentage of species are native in all the sites. The PP and FE sites (Fig. 4) presented the highest percentages (87% and 82%, respectively), whereas the RZ had 51% of native species. The highest percentage of exotic species was in the RZ and VP, which might be because they are areas with more frequent traffic, and because, in general, that is where the landowners and employees live, and/or because they are areas that are close to the river which is an important vector in the transport of propagules and plants in general.

Figure 5 shows the relationship between the species consumed and their origin; PP and FE showed the highest percentage of native species consumed. A higher number of species of a shrub or sub-shrub habit was consumed than for the grasses (PP: 33 sp. shrubs or sub-shrubs and 25 sp. of grasses; FE: 20 sp. and 15 sp. respectively). The RZ (Fig. 5), on the other hand, had a low percentage of native species that were consumed, which were mostly herbaceous (25 sp. herbaceous dicots, 8 sp. grasses), contrasting with that obtained for the total area (Fig. 3b).

The toxic or potentially toxic species for cattle at each of the sites are shown in Figure 6.

As mentioned at a general level, the highest percentage of toxic or potentially toxic species is of exotic origin. The analysis for each of the sites shows that in the RZ and VP there was a higher percentage of exotic toxic species than native, but in the PP and FE the native toxic species (*Asclepias mellodora* A.St.-Hil., *Baccharis ulicina* Hook. & Arn., *Euphorbia collina*, *E. serpens* Kunth, *E. hieronymi* Subils, *Clematis montevidensis* Spreng., *Nierembergia linariaefolia* Graham, *Nicotiana noctiflora* Hook., *Solanum triflorum* Nutt.) presented a higher percentage than the exotic ones (Fig. 7).

Finally, the Sörensen similarity index (SI) was calculated for the four sampled sites (Tab. 4).

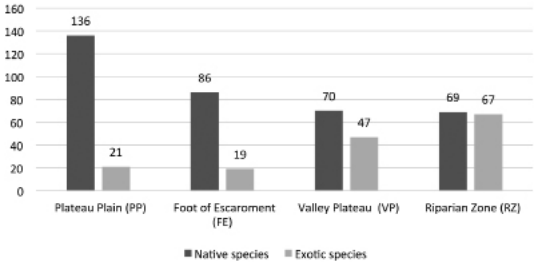

Figure 4 – Number of native and exotic species for each of the sites sampled.

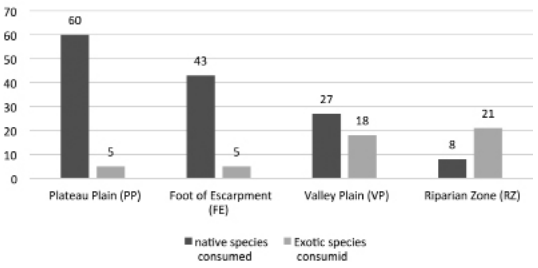

Figure 5 – Number of species consumed according to their origin at each sampled site.

Table 3 – List of exclusive families in each of the analyzed sites.

	Exclusive taxa	
Riparian Zone (RZ)	Arecaceae	3sp.
	Ceratophyllaceae	1 sp.
	Hydrocharitaceae	1 sp.
	Salviniaceae	1 sp.
	Asparagaceae	1 sp.
	Campanulaceae	1 sp.
	Cyperaceae	2 sp
	Oxalidaceae	1 sp
	Portulacaceae	2 sp
	Tamaricaceae	1 sp
	Typhaceae	1 sp
	Vitaceae	1 sp
	Salicaceae	3 sp
	Ulmaceae	1 sp
Valley Plain (VP)	Apocynaceae	1 sp
Plateau Plain (PP)	Shoepfiaceae	1 sp
	Orobanchaceae	1 sp
	Hydrophyllaceae	3sp.

Table 4 – Results of the Sörensen Similarity Index in the four sampled sites.

Eco-sites	**Plateau Plain**	**Foot of Escarpment**	**Valley Plain**	**Riparian Zone**
Plateau Plain	1	0.61	0.37	0.15
Foot of Escarpment		1	0.50	0.24
Valley Plain			1	0.536
Riparian Zone				1

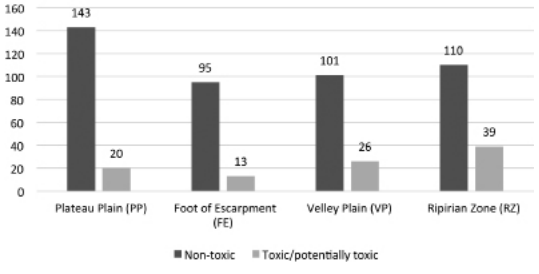

Figure 6 – Number of toxic or potentially toxic species for each of the sampled sites.

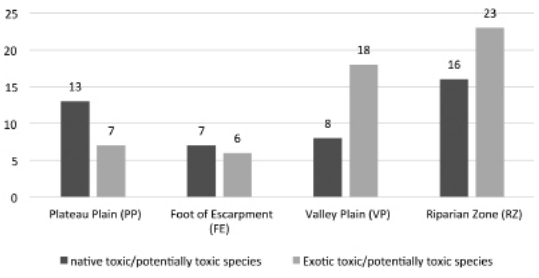

Figure 7 – Number of toxic or potentially toxic species according to origin for each sampled site.

In general terms, the SI indicates that the four sites shared at least one species. The highest similarity was observed between the PP and FE, which is logical because those areas are in contact, whereas the PP and the ZR shared a smaller number of species. In relation to this last comparison, low similarity values were also expected, mainly due to the environmental differences between the two sites. Moreover, the shared taxa (24 sp.) correspond to species that were also found in other sites and, in general, they are species that grow in disturbed environments and whose main characteristics are their great plasticity for occupying those environments.

The information presented in this study shows that the semiarid livestock fields of the Middle Valley of the Río Negro maintain the native vegetation representative of the Monte ecoregion. The Asteraceae family contributes the largest number of species (60 sp.), followed by Poaceae (47 sp.), Fabaceae (26 sp.), Solanaceae (18 sp.), Verbenaceae (12 sp.) and Chenopodiaceae (10 sp.). A total of 72% of the native species are consumed by cattle, and 66% of exotic species are toxic or potentially toxic. The introduction of exotic species has been limited to sectors that with more disturbance, either from maintenance work or by different vehicles used on the field. This characteristic is more marked in the Riparian Zone.

The Plateau Plain is the site with the greatest specific richness, followed by the Riparian Zone, the Valley Plain and the Foot of Escarpment.

In regard to the Similarity Index calculation, the sites that share the greatest number of species were the Plateau Plain and the Foot of Escarpment. On the contrary, the lowest Similarity Index was between the Plateau Plain and the Riparian Zone, which only shared species of wide distribution.

In conclusion, the data obtained in the present analysis can serve as the basis for subsequent studies that would result in a comprehensive evaluation of the relationship between livestock production and the conservation of plant diversity in the fields used for extensive livestock production in the Middle Valley. from Río Negro.

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