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Exclusion of grazing on dry Puna grassland: Floristic composition and animal carrying capacity

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Abstract
The degradation of Andean dry puna grasslands is part of the deterioration of terrestrial ecosystems. As a response, exclusionary grazing practices have been applied. However, knowledge of the dynamics of ecological restoration in grasslands is in full development, which is why the evaluation of the changes that occur in floristic wealth and abundance, ecological condition and animal carrying capacity in two areas excluded from grazing in August 2015 in the Nor-Yauyos Cochas Landscape Reserve, Peru, was proposed. The agrostological evaluation used the method of linear transection of interception points in 32 transects of 10 meters. The evaluation began in the year of the grazing exclusion and at the end of the 2016 low season and continued until the 2017 low season. Wealth and abundance showed significant increases only in the rainy season ($p = 0.0125$), no significant difference in ecological condition or animal carrying capacity was observed between seasonal periods, but between plots for $p=0.001$. In conclusion, the practice of exclusion of grazing did not show a rapid response in the change of biological indicators, which suggests that the evaluation should be carried out in a longer time.

Keywords: Andean grassland, floristic composition, animal carrying capacity, grazing exclusion

1. Introduction

Natural grasslands cover a quarter of the Earth's surface, producing a diversity of ecosystem services that benefit rural and urban populations (Divinsky *et al*. 2017) [6]; and constitute the primary source of the economy and self-development of populations that base their main activity on extensive livestock [Fillet, Aguirre, Pauné & Fondevilla, 2012] [29] cited by Gartzia *et al*. (2016) [14]. These grasslands are plant communities that form an important part of mountain ecosystems, composed of perennial and temporal species, which develop in the highest parts of hydrographic basins, of great economic, environmental and social importance for the inhabitants (Caro *et al*. 2014; Krause *et al*. 2017: Yaranga, Custodio, Chanamé, & Pantoja, 2018) [4, 18, 34]. However, anthropogenic pressures are rapidly degrading these ecosystems (McGinlay *et al*. 2017) [22], altering their composition and wealth, level of primary productivity and environmental services (Divinsky *et al*., 2017; Wang, Deng, Song, Li, & Chen, 2017) [6, 31], which are exacerbated by climate change (Zhao *et al*. 2016) [36]. The deterioration of grassland ecosystems not only affects the environment but also the economy of livestock families (Divinsky *et al*. 2017) [6]. One of the greatest threats to the sustainability of Andean grassland ecosystems is overgrazing, which compromises the stability of floristic richness and diversity (McGinlay *et al*., 2017; Hu & Nacun, 2018) [22, 17]. Overgrazing is caused by the animal load to grazing well above the forage response capacity of the pasture permanently without rest (Estelrich, Martin, & Ernst, 2016) [7], which affects the sustainability of the resource (Lok, 2010) [20] with loss of desirable livestock species and reduced land cover (Adema, Butti, Babinec, & Distel, 2016) [1], facilitating the entry or multiplication of invasive species of little or no forage value (Hinojosa, Napoléone, Moulery, & Lambin, 2016) [16] These facts put at risk the sustainability of livestock activity, and therefore the standard of living of the rural population (Ribeiro *et al*. 2014; Krause *et al*. 2017; McGinlay *et al*. 2017) [25, 18, 22]. In this regard, many researchers are concerned about the need to monitor the dynamics of degradation processes in order to establish sustainable management strategies (Fabio *et al*. 2013; Pan *et al*. 2017) [8, 23]. Along with these problems, the ecological condition of grassland decreases, directly affecting its animal carrying capacity (McGinlay *et al*., 2017) [22]. Grassland ecological condition is measured through the composition, structure, and function of the plant.

Community (Lawley, Lewis, Clarke, & Ostendorf, 2016) [19] and its typification is based on the assessment of the health status of grassland, which depends on vegetation and desirable species for livestock (Wiesmair, Otte, & Waldhardt, 2017) [32]. The ecological condition of site establishes five categories: excellent, good, regular, poor and very poor, according to ranges of score reached (Florez, 2005) [12]. (Farfan, San Martin, & Duran, 2010) [9] Animal carrying capacity is directly related to the ecological condition of pasture ecosystems, and degradation of these by overuse seriously affects the ecological sustainability of this resource (Zhang *et al*. 2014) [35]. In the case of the Peruvian Andes, the carrying capacity varies from 0.5 to 2 sheep units per hectare (UO ha/year) (Caro *et al*. 2014) [4]. Some work in relation to the effects of grazing exclusion has been carried out mostly in arid and semi-arid areas, and there is very little knowledge about the dynamics of recovery of degraded grasslands through exclusion of grazing along temporal and spatial gradients (Zhao, Li, Li, Tian, & Zhang, 2016) [36], as well as the dynamics of diversity useful for livestock feeding and its relationship with animal carrying capacity (Ren, Lü, & Fu, 2016) [24]. In Peru, Farfan *et al*. (2010) [9] carried out ecological restoration in Cuzco, by fertilizing pasture with manure and urine directly left by sheep as a temporary roost for 14 days; in the evaluation during 2 years of grazing exclusion, found the reduction of the presence of Alchemilla pinnata from 13% to 12%, the appearance of 13 new desirable species, the increase of Calamagrostis vicunarum from 7% to 12% and Aciachane pulvinata decenció from 8% to 4%, the animal carrying capacity increased from 1.9 to 7.6 alpaca units (LAU) per ha/year and plant cover increased from28% to 69%. Degraded grassland restoration practices help significant recovery of plant vigour and seedling (Ribeiro *et al*. 2014) [25], increase soil cover and consequently increase phytomass production (Zhao *et al*. 2016; Fedrigo *et al*. 2017) [36, 10]. The level of restoration depends on the type of practice, in the case of exclusion from grazing, diversity improves by 32.44% (Ren *et al*. 2016) [24] and could improve significantly in degraded areas excluded from grazing, rather than areas of moderate and severe grazing (Fedrigo *et al*. 2017) [10]. There are also other appropriate practices that can help restoration such as soil amendments, rotational grazing, implementation of irrigation systems, climate change mitigation schemes, among others (Rolando *et al*., 2017) [26], which were not considered because of the limited budget of the protected area administration. For this reason, the question arose as to what are the differences between floristic richness and abundance, ecological condition, and animal carrying capacity in two sites evaluated and between seasonal periods? It was expected to observe a decrease in the value of the variables in the seasonal low water period due to the scarce availability of rainwater, but an increase in these values due to the influence of the exclusion time of grazing. The objective was to evaluate the differences that exist between sites and between seasonal periods in the value of the variables under study, in conditions of exclusion of grazing in natural pastures of the Nor-Yauyos Cochas Landscape Reserve, Peru.

2. Material and Methods

2.1 Area of study

The research was conducted in two fenced areas for exclusion from grazing during five seasonal periods (dry 2015, rainy and dry 2016 and rainy and dry 2017), in the Nor-Yauyos Cochas Landscape Reserve, Junín, Peru. Each fenced area had an extension of one hectare of grassland covered by grassland vegetation and grass with dominance of poaceas and asteraceae. The areas are geographically located in zone 18S with UTM: Jutopuquio (E1) 422523 E and 8684096 W at 4374 meters' altitude, Condornioc (E2) 423281 E and 8683772 W at 4280 meters' altitude (Figure 1). The landscape is characterized by its moderately gentle slope, whose slope varies from 3 to 5%. The soil in Jutopuquio is made up of alluvial-coluvial material made up of sandstone rocks and tufor, with a sandy clay loam texture, crumbly structure, pH 5.8 (acid), its effective depth is 15 cm. superficial, brownish brown, stony 20%, gravosity 1%; and, in Condornioc it is also made up of the same material as the previous one, pH 6.0 (acid), its depth is 10 cm

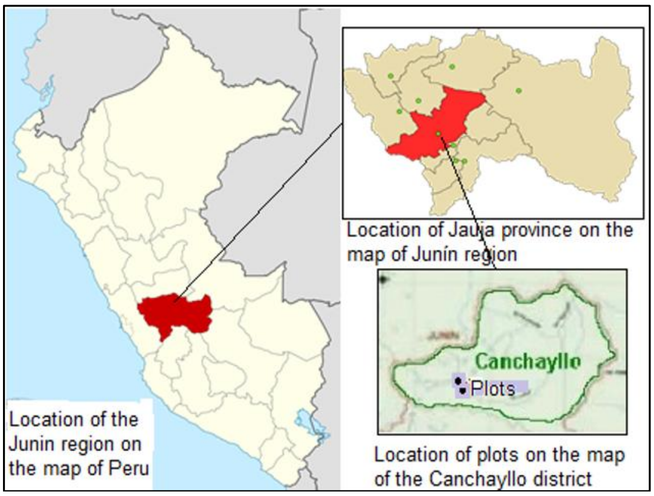

Fig 1: Location of the study area in the Nor-Yauyos Cochas Landscape Reserve, Junín, Peru

2.2 Design and sampling

The sampling was carried out in parallel lines according to Canfield's procedure (1941), applying the method of linear transection of interception points in 32 control transects, of 10 meters in length distributed in a systematic way, 10 meters from the sides of the edge of the plot (Figure 2). A field transection card of 100 cells was used to record the species intercepted at each point of the transect, spaced 10 centimeters between points, as well as bare soil, rock, mulch and moss. 3200 points were recorded per fenced area and per seasonal period. The transect was read using a 50-meter tape graduated in centimeters and meters. A three-meter flex meter was also used to measure the height of the key plants. The agrostological evaluation was carried out at the end of the 2016 dry season, at the end of the 2017 rainy season and at the end of the 2017 dry season. The natural grass species were transferred to the botanical laboratory - HBFIF, of the Faculty of Forestry and Environmental Engineering of the National University of Central Peru, for identification and storage

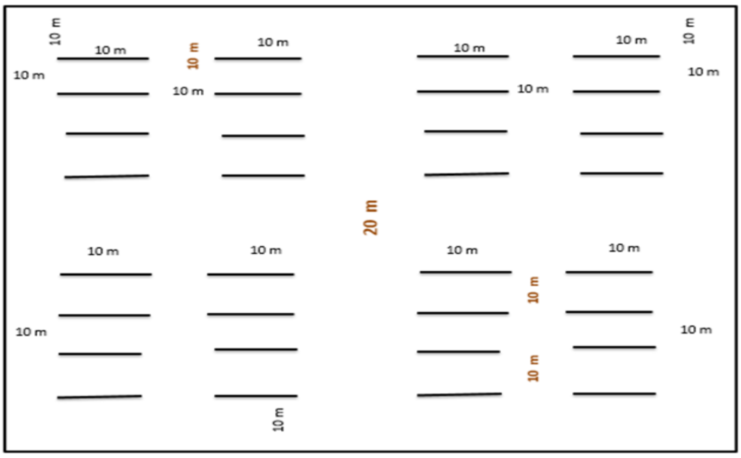

Fig 2: Distribution of linear transects for agrostological evaluation

2.3 Data analysis

The agrostological data were arranged in double-entry matrices in Microsoft Excel spreadsheets, the species and other row annotations and column transects, with which the tables required by the statistical analysis software were prepared. The difference of the upper limit of means between seasonal periods and fenced plots was analyzed using the generalized mixed linear model (GLMM) for the repeated measurements in the transects, using the free software R Studio version 5.3.1 by means of its packages VEGAN, Car Data, Lsmeans, ggplot and others, with which the richness (Number of species) and abundance of species (number of individuals registered by species), the ecological condition and the animal load capacity for sheep were analyzed (according to the formula established by Florez, 2005) [12]: IC*0.5+IF*0.2+Icob*0.2+IV*0.1, where: IC=quality index, IF=forage index, Icob=coverage index, IV= vigor index*0.1, where: IC=quality index, IF=forage index, Icob=cob=coverage index, IV=forage index, IV= vigour index (number of individuals registered by species), the ecological condition and the animal load capacity for sheep (according to the formula established by Florez, 2005) [12]: IC*0.5+IF*0.2+Icob*0.2+IV*0.1. The final score was compared with the table of animal load capacity for sheep units (UO) ha/year according to the table of the same author.

1. Results

3.1 Floristic composition and abundance

The floristic composition of the pasture in Jutopuquio, showed the presence of 13 families, 29 genera and 45 species, of which the family Poaceae occupied 43.16% of the total composition, followed by the Asteraceae with 16.64% and the Cyperaceae with 9.47%, the remaining families formed groups containing between 3.16% and 4.21%. While in Condornioc there were 12 families with 24 genera and 26 species, of which the family Poaceae occupied 44.44% of the total composition, followed by Asteraceae with 16.05% and Cyperaceae with 11.11%, the remaining families formed groups that occupy between 2.47% and 3.70%; in both cases the distribution varied between seasonal periods and time (Figure 3)

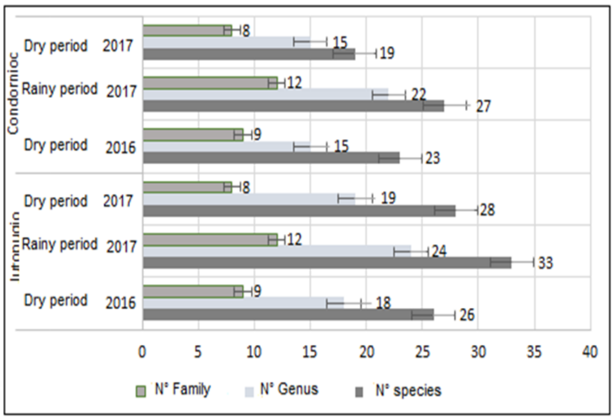

Fig 3: Distribution of families, genera and species of natural grass in two control areas and three seasonal periods

Species richness varied according to seasonal periods and time of exclusion from grazing. In the rainy season, Jutopuquio was richer in 2017 ($p = 0.0001$), while in the Condornioc plot no difference was found (Figure 4). The most important species in Jutopuquio were: *Festuca rígida*, *Aciachne pulvinata*, *Calamagrostis vicunarum*, while in Condornioc they were: *Aciachne pulvinata*, *Piptochaetium fimbriatum*, *Stipa hans-meyeri*

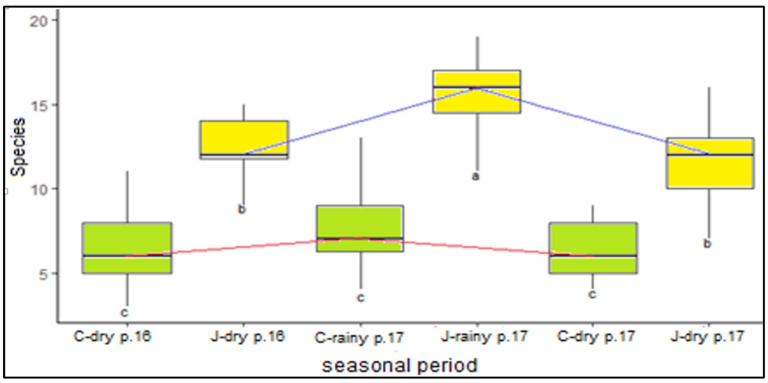

Fig 4: Upper limit of mean species richness, according to seasonal period, time of exclusion from grazing and fenced plots (C= Condornioc, J= Jutopuquio).

Letters below each box of whiskers indicate significant difference in GLMM

In the abundance analysis (Figure 5), a difference was found between seasonal periods, with the 2017 rainy season in Jutopuquio being longer for p= 0.0001, due to the increase in abundance in the rigid fescue species from 187 in the low season of 2016 to 281 in the dry season of 2017. In Condornioc, there was no evidence of differentiation between seasonal periods, because the main species *Aciachne pulvinata* decreased from 672 to 553 individuals, due to the increase of *Stipa hans-meyeri*, *Calamagrostis vicunarum* and *Calamagrostis intermedia* species.

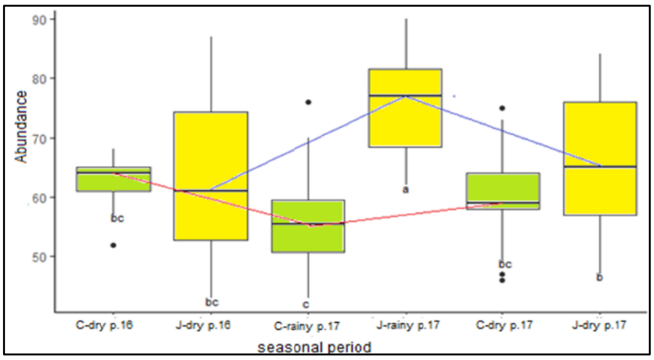

Fig 5: Upper limit of mean abundance, according to seasonal period, time of exclusion from grazing and fenced plots (C= Condornioc, J= Jutopuquio).

Letters below each box of whiskers indicate significant difference in MLGMU.

3.2 Ecological condition and animal carrying capacity

The ecological condition of the grassland (Table 1) expressed in score varied between 43.73±11.99 and 46.64±10.55 in Jutopuquio and between 28.62±8.96 and 30.39±7.85 in Condornioc, with statistical difference between seasonal periods only in Jutopuquio and in the rainy season; and difference between plots fenced in favor of Jutoquio with p = 0.001. The scores obtained in the three periods in Jutopuquio, typify the pasture as a regular condition (for the range of values between 41 and 60) whose carrying capacity is 1.5 UO per hectare year, while in Condornioc typifies the pasture as a poor condition (value range 21 to 40). The animal load capacity for sheep in Jutoqupuio varied between 0.75±0.37 and 0.86±0.37 UO ha/year and in Condornioc between 0.36±0.18 and 0.38±0.10 UO. The upper limit of averages found no difference between seasonal periods, but between p = 0.001 fenced plots. The analysis of the ecological condition was not carried out because the behaviour of the load capacity is derived directly from it.

Table 1: Total of species, genera and families; ecological condition and animal carrying capacity, according to seasonal period and plot excluding grazing.

Description	Jutopuqio			Condornioc		
	Dry period 2016	Rainy period 2017	Dry period 2017	Dry period 2016	Rainy period 2017	Dry period 2017
Ecological condition **	43.73±11.99(R)b	46.64±10.55(R)a	44.82± 9.54(R)b	28.68± 7.69(P)c	30.39± 7.85(P)c	28.62± 8.96(P)c
Animal carrying capacity	0.78±0.49b	0.86±0.37a	0.75±0.37b	0.37±0.13c	0.38±0.10c	0.36±0.18c

* Lowercase letters accompanying the figures indicate statistical difference for $p < 0.05$ in GLMM.
** R regular condition, P poor condition in sheep units (UO) per hectare/year.

4. Discussion

The floristic composition found in the two evaluation areas (Jutopuquio and Condornioc) differ in the number of families, genera and species, by their location in different altitudinal gradients of 4374 and 4280 meters respectively, in addition to the depth of the soil that differs by 15 and 10 centimeters, the climatic variation, among other factors (Suarez Duque, Acurio, Chimbolema, & Aguirre, 2016; Gallego *et al*. 2017) [29]. In both cases, the dominance of the Poaceae family puts it in similarity with other Andean grasslands and paramunos (Squeo *et al*. 2006; Salvador *et al*. 2016) [28].

The greater abundance of the rigid fescue in Jutopuquio is due to the preference of this species to moderately deep soils (15 cm) that is associated with some species of greater cattle interest such as *Alchemilla pinnata*, *Carex ecuadorica* and protects the poaceas of smaller size mainly of temporary growth, which improves the availability of phytomass that sustains the economic activity of the cattle families (Reiné *et al*. 2009; Salvador *et al*. 2016) [27]; while in Condornioc the most abundant *Aciachne pulvinata* behaves as an invasive species and an indicator of degraded grassland with lower quality ecosystem services (Villa-Herrera *et al*, 2014; Martínez-Hernández *et al*. 2014) [30], due to the shallow soil depth (10 cm), which slowed the rate of recovery. This low rate of recovery shown in the three seasonal periods indicates that the effects of overgrazing negatively impacts net primary production and ecosystem services for a long time (Divinsky *et al*., 2017; Wang *et al*., 2017; Hu & Nacun, 2018) [6, 31, 17]; which suggests that longer time evaluations of grazing exclusion are required to generate more knowledge on the dynamics of recovery (Ferrer *et al*. 2011; Guillen *et al*. 2015) [11, 15].

Ecological condition and animal carrying capacity did not increase significantly despite the increase in the number of species and abundance in the rainy season, since desirable species for sheep did not increase in abundance (Villa-Herrera *et al*, 2014; Gallego *et al*. 2017) [30, 13], due to the fact that these species were extremely defoliated before the exclusion of grazing, which takes time to enhance their photosynthesis capacity (Fedrigo *et al*., 2017) [10], the scarcity of seedlings and the low viability of the soil seed bank (Andrade *et al*., 2015) [2]. This dynamic of slow recovery of the grassland ecosystem does not favor the interest of rural families in seeking rapid recovery of the profitability of their land (Divinsky *et al*. 2017) [6]. The practice of natural restoration of degraded pastures with positive results in wealth and ecological condition (Ribeiro *et al*., 2014) [25] is very important in the process of recovery of degraded pastures; however, the little progress observed in two and a half years suggests that it is necessary to make long-term monitoring to appreciate the effectiveness of the different times of exclusion, up to 15 years as advanced by Martínez-Hernández *et al*. (2014).

Annex

Table A1: Family structure and species of Jutopuquio plot

Family	Species dry period 2016	Species – rainy period 2017	Species – dry period 2017
Gramineae	*Aciachne pulvinata*	*Aciachne pulvinata*	*Aciachne pulvinata*
	Calamagrostis curvula	*Bromus lanatus*	*Calamagrostis tarmensis*
	Calamagrostis tarmensis	*Calamagrostis curvula*	*Calamagrostis vicuna rum*
	Calamagrostis vicuna rum	*Calamagrostis tarmensis*	*Calamagrsotis intermedia*
	Calamagrostis intermedia	*Calamagrostis vicuna rum*	*Disanthelium calicynum*
	Disanthelium calicynum	*Calamagrostis intermedia*	*Festuca homelier*
			Festuca rigida
			Muhlenbergia ligularis
	Festuca rigida	*Festuca rigida*	*Muhlenbergia peruviana*
	Muhlenbergia ligularis	*Pitptochaetum fimbriatum*	*Pitptochaetum fimbriatum*
	Muhlenbergia peruviana	*Poa aequigluma*	*Poa gimnantha*
	Pitptochaetum fimbriatum	*Poa gimnantha*	*Stipa depauperata*
	Poa aequigluma	*Stipa depauperata*	*Stipa hans-meyeri*
	Poa gimnantha	*Stipa hans-meyeri*	*Stipa mucronata*
	Stipa depauperata		
	Stipa hans-meyeri		
	Stipa mucronata		
Asteraceae	*Werneria caespitosa*	*Gnaphalium sandwicensium*	*Misbrookea strigosissima*
	Werneria lamprophylla	*Hypochaeris taraxacoides*	*Novenia acaulis*
		Liabum ovatum	*Werneria candamoana*
		Novenia acaulis	*Werneria lamprophylla*
		Werneria candamoana	*Werneria pygmaea*
		Werneria pygmaea	*Werneri villosa*
		Werneria nubigena	
		Werneria sp	
Plantaginaceae	*Plantago rigida*	*Plantago australis*	*Plantago rigida*
		Plantago tubulosa	
Cyperaceous	*Carex ecuadorica*	*Carex ecuadorica*	*Carex cuadorica*
	Cyperus sp	*Cyperus sp*	*Cyperus sp*
	Scirpus rigidus	*Scirpus rigidus*	*Scirpus rigidus*
Meliaceae	*Nototriche acaulis*	*Acaulimalva krapov*	*Nototriche acaulis*
Rubiaceae		*Galium sp*	*Galium sp*
Fabaceae		*Vicia andicola*	
Juncaceae	*Luzula racemosa*	*Luzula racemosa*	*Luzula racemosa*
Rosaceae	*Alchemilla pinnata*	*Alchemilla pinnata*	*Alchemilla pinnata*
Hypericaceae	*Hipericum sp*		
Geraniaceae	*Geranium sessiliflorum*	*Geranium sessiliflorum*	
Portulacaceae		*Calandrinia acaulis*	
Iridaceous		*Sizirinchium junceum*	

Table A2: Family structure and species of Condornioc plot

Family	Species dry period 2016	Species – rainy period 2017	Species – dry period 2017
Gramineae	*Aciachne pulvinata*	*Aciachne pulvinata*	*Aciachne pulvinata*
	Calamagrostis intermedia	*Calamagrostis intermedia*	*Calamagrostis intermedia*
	Calamagrostis vicuna rum	*Calamagrostis vicunarum*	*Calamagrostis vicunarum*
	Disanthelium calicynum	*Disanthelium calicynum*	*Disanthelium calicynum*
	Disanthelium macusaniense	*Disanthelium macusaniense*	*Disanthelium macusaniense*
	Disanthelium matewsi	*Festuca rígida*	*Festuca rígida*
	Festuca rígida	*Piptochaetum fimbriatum*	*Piptochaetum fimbriatum*
	Piptochaetum fimbriatum	*Poa gimnantha*	*Poa gimnantha*
	Poa aequigluma	*Stipa depauperata*	*Stipa depauperata*
	Poa gimnantha	*Stipa hans-meyeri*	*Stipa hans-meyeri*
	Stipa brachyphylla	*Stipa mucronata*	*Stipa mucronata*
	Stipa depauperata		
	Stipa hans-meyeri		
	Stipa ichu		
Asteraceae	*Baccharis tricuneata*	*Baccharis tricuneata*	*Baccharis tricuneata*
	Werneria caespitosa	*Hypochaeris taraxacoides*	*Misbrookea strigosissima*
	Werneria villosa	*Liabum ovatum*	*Novenia acaulis*
		Novenia acaulis	*Plantago rigida*
		Werneria caespitosa	
		Werneria candamoana	

		Werneria nubigena	
Plantaginaceae	*Plantago rigida*	*Plantago tubulosa*	
Cyperaceae	*Scirpus rigidus*	*Scirpus rigidus*	*Scirpus rigidus*
	Carex ecuadorica	*Carex ecuadorica*	*Carex ecuadorica*
	Cyperus sp	*Cyperus sp*	*Cyperus sp*
Rubiaceae		*Galium sp*	
Rosaceae	*Alchemilla pinnata*	*Alchemilla pinnata*	*Alchemilla pinnata*
Geraniaceae		*Geranium sessiliflorum*	
Portulacaceae		*Calandrinia acaulis*	
Caryophyllaceae	*Paronychia andina*		
Apiaceae		*Azorella crenata*	
Ranumculaceae		*Oreithales integrifolia*	

5. Conclusion

The seasonal difference in floristic wealth and abundance was due to the magnitude of rainfall.

Ecological condition and animal carrying capacity did not show differences in the two and a half years of grazing exclusion, which indicate that more monitoring time is needed to verify the impact of grazing exclusion as an ecological restoration tool.

6. Acknowledgement

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7. References

1. Adema E, Butti L, Babinec F, Distel R. Comparación entre pastoreo continuo y pastoreo rotativo en un pastizal rolado del Centro Oeste de la Provincia de la Pampa. Revista Argentina de Producción Animal. 2016; *36*(1): 9-17.
2. Andrade BO, Koch C, Boldrini II, Vélez-Martin E, Hasenack H, Hermann JM. Grassland degradation and restoration: A conceptual framework of stages and thresholds illustrated by southern Brazilian grasslands. Natureza e Conservacao. 2015; 13(2):95-104. https://doi.org/10.1016/j.ncon.2015.08.002
3. Beguet H. Manejo de pastizales naturales serranos. In Producción bovina de carne (p5). Argentina: Pasturas naturales 2002, 1(5).
4. Caro C, Sánchez E, Quinteros Z, Castañeda L. Respuesta de los pastizales alto andinos a la perturbación generada por extracción mediante la actividad de "champeo" en los terrenos de la comunidad campesina Villa de Junín, Perú. Ecología Aplicada. 2014; 13(2):85-95.
5. Condori G. Influencia de la fragmentación en la diversidad de la flora silvestre y en los cambios de uso de suelo y cobertura vegetal en Huertas Huayrara, Puno. Ecosistemas. 2012; 21(1-2):230-234. https://doi.org/http://www.revistaecosistemas.net/articulo.asp?Id=730
6. Divinsky I, Becker N, Bar (Kutiel) P. Ecosystem service tradeoff between grazing intensity and other services - A case study in Karei-Deshe experimental cattle range in northern Israel. Ecosystem Services. 2017; 24:16-27. https://doi.org/10.1016/j.ecoser.2017.01.002
7. Estelrich HD, Martin F, Ernst RD. Posición de las coronas como mecanismo para tolerar el pastoreo en especies forrajeras del pastizal bajo en la región semiárida central de Argentina. Archivos de Zootecnia. 2016; 65(251):381-388.
8. Fabio L, Armbrecht I, Calle Z. Agriculture, Ecosystems and Environment Silvopastoral systems and ant diversity conservation in a cattle-dominated landscape of the Colombian Andes. "Agriculture, Ecosystems and Environment. 2013; 181:188-194. https://doi.org/10.1016/j.agee.2013.09.011
9. Farfan R, San Martin F, Duran A. Recuperación de praderas degradadas por medio de clausura temporal. Rev Inv Vet Perú. 2010; 11(1):77-81.
10. Fedrigo JK, Ataide PF, Filho JA, Oliveira LV, Jaurena, M, Laca EA. *et al*. Temporary grazing exclusion promotes rapid recovery of species richness and productivity in a long-term overgrazed Campos grassland. Restoration Ecology. 2017; 26(4):677-685. https://doi.org/10.1111/rec.12635
11. Ferrer C, Barrantes O, Broca A. La noción de biodiversidad en los ecosistemas pascícolas españoles. Pastos. 2011; 31(2):129-184.
12. Florez A. Manual de manejo de pastos y forrajes alto andinos. Universidad Nacional Agraria La Molina. Lima, 2005, 69.
13. Gallego F, Lezama F, Pezzani F, López-Mársico L, Leoni E, Mello AL, *et al*. Estimación de la productividad primaria neta aérea y capacidad de carga ganadera: un estudio de caso en Sierras del Este, Uruguay. *Agrociencia* Urugua. 2017; 21:120130.
14. Gartzia M, Pérez-Cabello F, Bueno CG, Alados CL. Physiognomic and physiologic changes in mountain grasslands in response to environmental and anthropogenic factors. *Applied Geography*. 2016; 6:1-11. https://doi.org/10.1016/j.apgeog.2015.11.007
15. Guillen A, Rodríguez C, Lugo O, Aguilar J, Acuña M. Pérdida de Biodiversidad: Causas y Efectos. International Journal of Good Conscience. Agosto. 2015; 10(2):156-174.
16. Hinojosa L, Napoléone C, Moulery M, Lambin EF. The "mountain effect" in the abandonment of grasslands: Insights from the French Southern Alps. *Agriculture*, Ecosystems and Environment. 2016; 221:115-124. https://doi.org/10.1016/j.agee.2016.01.032
17. Hu Y, Nacun B. An analysis of land-use change and grassland degradation from a policy perspective in Inner Mongolia, China, 1990-2015. Sustainability *(*Switzerland*)*. 2018, *10*(11). https://doi.org/10.3390/su10114048
18. Krause MS, Nkonya E, Griess VC. An economic valuation of ecosystem services based on perceptions of rural Ethiopian communities. *Ecosystem Services*. 2017; 26:37-44. https://doi.org/10.1016/j.ecoser.2017.06.002

19. Lawley V, Lewis M. Clarke K, Ostendorf B. Site-based and remote sensing methods for monitoring indicators of vegetation condition: An Australian review. *Ecological Indicators*. 2016; 60:1273-1283. https://doi.org/10.1016/j.ecolind.2015.03.021
20. Lok S. Indicadores de sostenibilidad para el estudio de pastizales. Revista cubana de Ciencia Agrícola. 2010; 44(4):333-344.
21. Martínez-Hernández J, Arriaga-Jordán CM, González-Rebeles Islas C, & Estrada Flores JG. Evaluación de la productividad primaria durante la época de secas en el área de protección de Flora y Fauna "Nevado de Toluca" México. Tropical and Subtropical Agro ecosystems. 2014; 17(2):299-302.
22. McGinlay J, Gowing DJG, Budds J. The threat of abandonment in socio-ecological landscapes: Farmers' motivations and perspectives on high nature value grassland conservation. Environmental Science and Policy. 2017; 69:39-49. https://doi.org/10.1016/j.envsci.2016.12.007
23. Pan Y, Wu J, xi Luo L, Ming Tu. Y. li Yu C. qun Zhang, X *et al*. Climatic and geographic factors affect ecosystem multi functionality through biodiversity in the Tibetan alpine grasslands. Journal of Mountain Science. 2017; 14(8):1604-1614. https://doi.org/10.1007/s11629-016-4242-6
24. Ren Y, Lü Y, Fu B. quantifying the impacts of grassland restoration on biodiversity and ecosystem services in China: A meta-analysis. Ecological Engineering. 2016; 95:542-550. https://doi.org/10.1016/j.ecoleng.2016.06.082
25. Ribeiro S, Fernandes JP, Espírito-Santo MD. Diversity and floristic patterns of Mediterranean grasslands: the relative influence of environmental and land management factors. Biodiversity and Conservation. 2014; 23(12):2903-2921. https://doi.org/10.1007/s10531-014-0754-y
26. Rolando JL, Turin C, Ramírez DA, Mares V, Monerris J, Quiroz R. Key ecosystem services and ecological intensification of agriculture in the tropical high-Andean Puna as affected by land-use and climate changes. Agriculture, Ecosystems and Environment. 2017. https://doi.org/10.1016/j.agee.2016.12.010
27. Salvador S, Corazzin M, Piasentier E, Bovolenta S. Environmental assessment of small-scale dairy farms with multi functionality in mountain areas. Journal of Cleaner Producción. 2016; 124:94-102. https://doi.org/10.1016/j.jclepro.2016.03.001
28. Squeo FA, Cepeda J, Olivares NC, Arroyo MT. Interacciones eológicas en la alta montaña del Valle del Elqui. Interacciones Ecologicas. 2006; 1:69-103.
29. Suárez Duque D, Acurio C, Chimbolema S, Aguirre X. Análisis del carbono secuestrado en humedales Alto andinos de dos áreas protegidas del ecuador TT - Análisis of carbón secuestración in two andean Weiland protected áreas Ecuador. Ecología Aplicada. 2016; 15(2):171-177. https://doi.org/10.21704/rea.v15i2.756
30. Villa-Herrera A, Ortiz-Acosta S, Pérez-Hernández M, Rojas-Montes CH. Estimación de la capacidad de carga animal en agostaderos usando un índice de vegetación de pendientes normalizados. *Agrociencia*. 2014; *48*(6): 599-614.
31. Wang Z, Deng X, Song W, Li Z, Chen J. What is the main cause of grassland degradation? A case study of grassland ecosystem service in the middle-south Inner Mongolia. Catena 2017; 150:100-107. https://doi.org/10.1016/j.catena.2016.11.014
32. Wiesmair M, Otte A, Waldhardt R. Relationships between plant diversity, vegetation cover, and site conditions: implications for grassland conservation in the Greater Caucasus. Biodiversity and Conservation. 2017; 26(2):273-291. https://doi.org/10.1007/s10531-016-1240-5
33. Yaranga R. Diversidad florística en la subcuenca del río Achamayo, Informe final, Instituto Especializado de Investigación de la Facultad de Zootecnia – UNCP, 2012, 25.
34. Yaranga Raúl, Custodio M, Chanamé F, Pantoja R. Diversidad florística de pastizales según formación vegetal en la subcuenca del río Shullcas, Junín, Perú. Scientia Agropecuaria. 2018; 9(4):511-517. https://doi.org/10.17268/sci.agropecu.2018.04.06
35. Zhang J, Zhang L, Liu W, Qi Y, Wo X. Livestock-carrying capacity and overgrazing status of alpine grassland in the Three-River Headwaters region, China. Journal of Geographical Sciences. 2014; 24(2):303-312. https://doi.org/10.1007/s11442-014-1089-z
36. Zhao J, Li X, Li R, Tian L, Zhang T. Effect of grazing exclusion on ecosystem respiration among three different alpine grasslands on the central Tibetan Plateau. Ecological Engineering, 2016; 94:599-607. https://doi.org/10.1016/j.ecoleng.2016.06.112