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Research Article

Species of the Poaceae family suitable for Andean livestock farming in the Peruvian Andes reported in GBIF and local studies

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Abstract

Andean grassland ecosystems are covered by a mega-vascular floristic diversity constituted by families such as *Poaceae, Rosaceae, Asteraceae, Plantaginaceae, Fabaceae, and Cyperaceae,* among the most important ones that include suitable species for Andean Livestock feeding such as sheep, cattle, and South American camelids. However, the accelerated degradation of ecosystems and the extinction of several important species, have put it in our interest to know better the spatio-temporal distribution of these species as a starting point for spatio-temporal monitoring. With this purpose, we compiled information on those identified as D species in the Poaceae family, from thesis studies and published scientific articles. We also examined the record and spatial distribution of D species of this family in the Global Biodiversity Information System (GBIF) corresponding to the Sierra region of Peru. Specific geo-processed maps were generated after data curation. It was found that there are 63 D species included in the genus: *Agrostis, Agropirum, Bromus, Calamagrostis, Dissanthelium, Festuca, Hordeum, Muhlenbergia, Nasella, Paspalum, Poa, Stipa, Trisetum* and *Vulpia*, of which only 52 species are registered in GBIF, noting the concentration of records in places of greater tourist interest and with funded research projects such as the Huascaran National Park and others. The few studies on natural grassland species in Peru and the low spatial coverage of the species recorded in GBIF still limit the generation of adequate monitoring strategies.

Introduction

Andean grassland ecosystems are covered by a mega-vascular floristic diversity constituted by families such as *Poaceae*, *Rosaceae*, *Asteraceae*, *Plantaginaceae*, *Fabaceae*, *and Cyperaceae*, among the most important ones that include suitable species for Andean Livestock feeding such as sheep, cattle, and South American camelids. However, the accelerated degradation of ecosystems and the extinction of several important species, have put it in our interest to know better the spatio-temporal distribution of these species as a starting point for spatio-temporal monitoring. For this purpose, we compiled information on those identified as D species in the Poaceae family, from thesis studies and published scientific articles. We also examined the record and spatial distribution of D species of this family in the Global Biodiversity Information System (GBIF) corresponding to the Sierra region of Peru.

Specific geo-processed maps were generated after data curation. It was found that there are 63 D species included in the genus: *Agrostis*, *Agropirum*, *Bromus*, *Calamagrostis*, *Dissanthelium*, *Festuca*, *Hordeum*, *Muhlenbergia*, *Nasella*, *Paspalum*, *Poa*, *Stipa*, *Trisetum* and *Vulpia*, of which only 52 species are registered in GBIF, noting the concentration of records in places of greater tourist interest and with funded research projects such as the Huascaran National Park and others. The few studies on natural grassland species in Peru and the low spatial coverage of the

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species recorded in GBIF still limit the generation of adequate monitoring strategies.

This database is fed by authorized entities and scientists collecting species anywhere in the world under strict codification in accordance with GBIF formats; however, due to some limitations suffered by the responsible entities and the lack of knowledge of the people dedicated to the knowledge and collection of species, this database does not contain the records of many species or, if they are, at least the spatial distribution information is not complete [1].

Recent publications on species monitoring from the database globally were conducted in Panama by Leung, et al. [2], using sightings and retained species datasets, on Amami-Oshima Island, Tokunoshima Island, and northern Okinawa Island by Hironori, et al. [3] who used the data as a reference for further monitoring of plant diversity of the natural World Heritage site; also Qian, et al. [1] who evaluated the completeness of GBIF-derived fern species lists at a grid scale and at a larger spatial scale, showing that the completeness of GBIF species sampling is low (< 40%), this information let us understand that even the global biodiversity database is not complete, both in richness and spatial distribution. Although Darwin Core (DwC) as a TDWG standard has indexed more than 2 billion records from 70,147 datasets, with more than 1561 organizations in 59 countries as of January 2020. Darwin Core is a standardized language that applies unique Internationalized Resource Identifiers (IRIs) to each item assigned as a metadata element, in addition to a tag and definition [4].

On the side of the suitable species (D) for Andean livestock, are those that are highly consumed and (PD) little consumed [5], being the species of the *Poaceae* family the most important and abundant [6-10]. Among the *Poaceae* species reported at the level of the main Andean regions of Peru, we have from Carla [6], who found in the Apas sector of Huancaya-Yauyos, suitable species for alpacas and llamas: *Calamagrostis vicunarum, Jarava ichu, Bromus lanatus, Festuca dolichophylla, Aciachne pulvinata, Muhlenbergia peruviana, Calamagrostis tarmensis, Dissanthelium mathewsii, Calamagrostis glacialis*. Onofre M.I. [7] in Moyobamba, Canchayllo-Jauja for sheep: *Calamagrostis brevifolia* J. Presl. *Calamagrostis jamesonii* Steud. *Calamagrostis vicunarum* Wedd. In the same district, Trillo F. [8] conducted revegetation studies with *Festuca dolichophylla* and *F. humilior*, because they are very important species in animal feed; in bofedal de Chacamarca Junín, Galarza P.V and Jorge J.V [11] found *Poaceae* D and PD species for sheep: *Calamagrostis eminens* (J. Presl) Steud, *Calamagrostis jamesonii* Steud, c (Wedd.) Pilg, *Poa aequigluma* Tovar, Poa spicigera Tovar, *Polypogon interruptus* Kunth. Capuñay K. S. [10] presented the diet composition of vicuñas in San Cristóbal de la Provincia Lucanas in Ayacucho: *Nassella sp. Jarava pungens, Muhlenbergia peruviana, Festuca rigescens, Aciachne sp, Calamagrostis vicunarum, Poa sp*. However, many studies reported in natural grasslands made little mention of identified D species and in other cases, the location of the species was not georeferenced, which hinders adequate geoprocessing to model the spatial distribution [12].

In this context, the research began by posing the following questions: Do the studies carried out on natural grasslands, which refer to the presence of suitable species (D) of the *Poaceae* family for livestock feeding in the Peruvian Andes, provide sufficient information to model their spatial distribution? Does the database in the Global Biodiversity Information Infrastructure (GBIF) allow modeling the spatial distribution of suitable species (D) of the *Poaceae* family for livestock feeding in the Peruvian Andes? For this reason, and with the intention of mapping the spatial distribution of the most important species in Andean Livestock feed, the following objectives were proposed: Compile the presence of suitable species (D) of the *Poaceae* family for livestock feeding in the Andean region of Peru, based on published theses and research articles. Extract from the Global Biodiversity Information Infrastructure (GBIF) database the suitable species (D) of the *Poaceae* family for livestock feeding in the Peruvian Andes. Geoprocess the data of suitable species (D) for livestock feeding in the Peruvian Andes for its presentation in maps.

Material and methods

Data collection techniques

The research was carried out using secondary information that reaches the Peruvian Andes, where the Andean grassland ecosystems are located. These ecosystems are made up of plant communities composed mostly of herbaceous species, others with shrubs and sparsely with trees. They are present in large areas, which, according to the Food and Agriculture Organization of the United Nations - FAO, are mainly used for extensive livestock grazing [13]. From the physiographic point of view, this scenario of the Peruvian Andes is characterized by diverse relief geoforms such as mountain ranges, mountain slopes, foothills, hollows, plains, hills, valleys, plateaus, cliffs, etc., according to Villota's conception in 1997. These geoforms are related to the characteristics of the soil and climate, and as such predispose the type of vegetation that characterizes each of the geomorphological units [14].

These ecosystems, due to their bioclimatic characteristics and altitude since the conception of Javier Pulgar Vidal in 1938, are classified as: paramo, those Andean areas ranging from 3000 to 3600 meters altitude, characterized by being very humid and foggy, whose location runs from Piura and Cajamarca in Peru through the mountain ranges of Ecuador to the mountain ranges of Merida in Venezuela and Santa Marta in Colombia [15]; Jalca, part of the mountain ranges of Cajamarca, Lambayeque and Amazonas, which characterizes a state of transition between páramo and puna, with an absence of snow-capped mountains and gently sloping hillsides; Puna, those areas that are located in the mountain ranges between 3800 and 4800 meters altitude, with semi-arid characteristics, due to the low annual rainfall they receive, with areas of plains to steep and steep, which in the forest conception calls it "Andean pajonal" [16], are located from the Ancash mountain ranges through the central and southern Andes of Peru, Bolivia and Chile [17]. All of them are characterized by a vegetation cover typical of Andean grasslands, which are the basis of Andean livestock feed [18].

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The collection of information was carried out in three phases:

- As a first phase, we searched for publications on the desirability of natural grassland species for Andean livestock: South American camelids, sheep, and cattle, reported in the repositories of universities in Peru and academic Google. The information obtained was systematized in a table, selecting those publications that report on the identity of suitable species (D) for Andean domestic animals. Based on this information, a second table was constructed containing a) the identity of the species, b) the place where the research work was carried out, c) the geographic coordinates of the work site, and d) the altitude of the site.

- Secondly, the database was accessed by Elsevier, Crossref, Science Direct, and others to download scientific articles published in the various indexed journals containing the information referred to in the first phase, which served to complement the information in the tables referred to.

- Thirdly, the information was downloaded from the Darwin Core database of the Global Biodiversity Information Infrastructure - GBIF [19], taking into consideration the genus of natural grasses identified as suitable.

Data processing techniques

The procedure for data processing was:

- The data obtained and recorded in the tables were validated for their relevance to the organized structure of the data, eliminating those that did not comply at least with the identity of the suitable species and location of the research conducted.

- From the data downloaded from the Darwin Core of the GBIF, curatorship processes were carried out using the Rstudio vs 4.1.2 software, considering: a) species D, eliminating all those that did not correspond to the species identified as suitable, b) duplicity, eliminating duplicate location points, and c) geospatial, eliminating those points whose coordinates were located outside the Andean area [20].

- For the elaboration of the distribution map of the location points of the D species, a table was generated with validated data mainly consisting of D species, UTM 18S coordinates, and altitude. These data were uploaded to ArcGis Pro *vs.* 3.2.0 using the command "Geoprocessing >XY Table to Point", then converted to an SHP vector layer using the command "Geoprocessing >Feature class to Feature class >parameters". The base map that helped visualize the location of the points was the "World Topographic Map" and "World Hillshade", in addition to a layer of the national boundary of Peru that remained active during the mapping of all species.

Results

Suitable species (D) identified for the 5 types of Andean livestock

Sixty-three species D of the *Poaceae* family were compiled as suitable species in Andean livestock feed, including 4 species of the genus *Agrostis*, 1 of *Agropirum*, 3 of *Bromus*, 17 of *Calamagrostis*, 4 of *Disanthelium*, 12 of *Festuca*, 1 of *Hordeum*, 3 of *Muhlenbergia*, 1 of *Nassella*, 1 of *Paspalum*, 7 of *Poa*, 7 of *Stipa*, 1 of *Trisetum* and 1 of *Vulpia* (Table 1); which have differences in their suitability against the 5 Andean livestock species: Sheep, cattle, domesticated alpaca (Lama pacos), domesticated llama (Lama glama) and wild vicuña (Vicugna vicugna), it was observed that only 5 species of grasses are suitable for all the referred livestock. Of the total number of species identified as D species, 29% are suitable for cattle, 27% for alpacas, 25% for sheep, 15% for llamas, and only 4% for vicuñas.

Publications that identified the presence of suitable species for Andean livestock in the Peruvian Andes

Twenty-three publications have been found that have reported the identity of D species of the *Poaceae* family in the Andes of Peru (Table 2). The department of Junín had the largest number of studies were made with 30.44% of the publications made in 7 places, followed by the departments of Pasco with 13.04% in 3 places, then Tacna, Puno, Cusco, and Ancash with 8.70% in 2 places in each department, and finally, the remaining 4 regions have 17.39% of publications made in only one place per department. The most reported natural grass species were: *Calamagrostis vicunarum* in 17% of studies, *Festuca dolichophylla* in 8.57%, and *Bromus lanatus* in 7.61%. The details of the table are shown in the appendix (Table 5).

Suitable species (D) of the family Poaceae recorded in the GBIF database

In the GBIF database, 8352 records were found in 11 genera, of which 1844 records of D species were found, corresponding to 22% of the total number of records (Table 3). Once the duplicate records and those without coordinate information were curated, 1149 valid records were obtained, equivalent to 14% of the total number of records. Species of the genus *Poa* had the highest number of records (20%), followed by *Sipa* (18%), *Calamagrostis* (15%), and *Bromus* (14%), making them the most important genus in the database.

The record of the genus ***Dissanthelium*** is not very specific, as it is only registered as "***Dissanthelium trim***" and accepted as ***Poa*** L; also, the genus ***Muhlenbergia*** is reported as "***Bromus***", likewise the species ***Vulpia megalura*** is not registered for the Peruvian Andes, so they were not taken into consideration in Table 3.

Spatial distribution of the main D species according to genus in the Peruvian Andes

Of the 11 genera of natural grasses corresponding to the suitable species (D) of the *Poaceae* family for Andean livestock, the genus *Calamagrostis* (Figure 1a) was the most reported, with

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Table 1: Species D of the Poaceae family suitable for Andean livestock.

N°	Species D	Cattle	Sheep	Alpacas	Vicuñas	Llamas
1	*Agrostis breviculmis*		D	D	D	
2	*Agrostis sp*		D	D		
3	*Agrostis foliata*	D	D	D		
4	*Agrostis haenkeana*			D		
5	*Agropirum breviaristatum*	D	D	D		
6	*Bromus catharticus*	D	D	D	D	D
7	*Bromus lanatus*	D	D	D	D	D
8	*Bromus pitensis*	D	D	D	D	D
9	*Calamagrostis antoniana*	D	D	D		
10	*Calamagrgostis brevifolia*	D				
11	*Calamagrostis curvula*	D		D		D
12	*Calamagrostis chrysanta*	D				D
13	*Calamagrsotis densiflora*			D		
14	*Calamagrostis heterophylla*	D	D	D		
15	*Calamagrostis intermedia*	D				D
16	*Calamagrostis jamesoni*	D				D
17	*Calamagrostis ovata*	D				D
18	*Calamagrostis recta*			D		
19	*Calamagrostis rigescens*	D				D
20	*Calamagrostis rigida*	D				D
21	*Calamagrostis spiciformis*	D				D
22	*Calamagrostis sp*					D
23	*Calamagrostis tarmensis*	D		D		
24	*Calamagrostis violacea*		D	D		
25	*Calamagrostis vicunarum*		D	D		
26	*Dissanthelium calicynum*		D	D		
27	*Dissanthelium rahuii*		D	D		
28	*Dissanthelium semitectum*		D	D		
29	*Dissanthelium sp*	D	D	D		
30	*Festuca casapaltensis*	D	D	D		
31	*Festuca dolichophylla*	D	D	D		D
32	*Festuca distichovaginata*	D				
33	*Festuca huamachusesis*	D	D	D		
34	*Festuca inarticulada*	D				
35	*Festuca peruviana*	D	D	D		
36	*Festuca rigidifolia*	D	D	D		
37	*Festuca rigescens*	D	D			D
38	*Festuca sedifolia*	D				
39	*Festuca tarmensis*			D		
40	*Festuca tenuiculmis*		D	D		
41	*Festuca weberbaueri*	D				
42	*Hordeum muticum*	D	D	D	D	D
43	*Muhlenbergia fastigiata*		D	D		
44	*Muhlenbergia ligularis*		D	D		
45	*Muhlenbergia peruviana*		D	D		
46	*Nassella brachyphylla*		D		D	D
47	*Paspalum penicillatum*		D	D		
48	*Poa aequigluma*	D				
49	*Poa annua*	D				
50	*Poa asperiflora*	D				
51	*Poa gymnantha*	D	D	D		
52	*Poa perligulata*	D	D	D		D
53	*Poa pardoana*	D	D	D		
54	*Poa spicigera*	D	D	D		
55	*Stipa brachyphylla*	D	D	D		D
56	*Stipa hans-meyerii*	D	D	D		D
57	*Stipa huallancaensis*	D	D	D		
58	*Stipa ichu*	D				D
59	*Stipa mucronata*	D	D	D		D
60	*Stipa obtusa*	D				D
61	*Stipa vargasii*	D	D	D		
62	*Trisetum spicatum*	D	D	D		
63	*Vulpia megalura*	D	D	D	D	D

Table 2: Regions and places where studies on species D of the family Poaceae were carried out.

Study source regions	N° Publications	Places where studies were conducted
Huancavelica	1	Lachocc
Huánuco	1	Lauricocha
Apurimac	1	Ocrabamba
Tacna	2	Ancomarca, Palca
Puno	2	Chila, Carolina
Junín	7	Acopalca (2), Canchayllo (2), Lomo Largo, Vista Alegre, Quero
Cusco	2	Marampaqui, Pinaya
Ancash	2	Cordillera Blanca, Canray Grande
Arequipa	1	Pampa Cañahuas
Pasco	3	Rancas, Conocancha, Ninacaca
Lima	1	Tomas

13 species whose names are shown in Table 4, distributed in the Andean region, showing the highest number of reports in the departments of Cajamarca, Ancash (Cordillera Blanca), Lima, Junín, Cusco, and Arequipa, with the species *Calamagrostis vicunarum* (Wedd) Pilg being the most reported. The genus *Festuca* is reported with 10 species (Figure 1b), with reports concentrated in the department of Ancash and fewer reports in Lima, Huancavelica, and Arequipa, with *Festuca dolychophylla* Pilg being the most reported. The genus *Poa* is reported with 8 species, with the most reported in Ancash, Cajamarca, Huancavelica, Ayacucho, Junín, Cusco, and Arequipa, with the species *Poa gymnantha* Pilg being the most reported (Figure 1c).

The genus *Nassella* is reported in 5 species, with the most reported spatially in Ancash, Cajamarca, Lima, and Cusco (Figure 1d), with the species Nassella pubiflora (Trin. & Rupr.) E. Desv is the most reported. The genus *Paspalum* with 5 species is most reported in the departments of Ancash, Cajamarca, and Cusco (Figure 1e), with the species *Paspalum pygmaeum* Hack as the most reported. The genus *Bromus* has 3 species reported in the departments of Cajamarca, Ancash, Lima, Huancavelica, Ayacucho, Cusco, Arequipa, Moquegua, and Tacna (Figure

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Table 3: Sequence of information on the total number of species recorded in GBIF and the result of the curation: D species, duplicate records, and others with incomplete information such as coordinates.

Genus	GBIF Records	Species D	% Species D	Duplicate records	Incomplete information*	Valid records	% Sp-valid
Agrostis	352	80	23%	9	4	67	6%
Bromus	501	228	46%	62	8	158	14%
Calamagrostis	1243	318	26%	143	1	174	15%
Festuca	1012	167	17%	58	1	108	9%
Hordeum	2020	33	2%	10	1	22	2%
Nassella	645	145	22%	51	3	91	8%
Paspalum	544	49	9%	11	5	33	3%
Poa	1426	441	31%	204	7	230	20%
Stipa	458	312	68%	100	7	205	18%
Trisetum	131	64	49%	10	0	54	5%
Vulpia	20	7	35%	0	0	7	1%
Total	8352	1844	22%	658	37	1149	14%

* The records do not have geospatial coordinates information.

Table 4: Poaceae suitable species for Andean Livestock and number of records by genus found in GBIF.

Calamagrostis genus - Species D	Records	Festuca genus - Species D	Records
Calamagrostis antoniana (Griseb.) Hitchc	4	*Festuca casapaltensis* Ball	30
Calamagrostis curvula (Wedd.) Pilg	6	*Festuca dolichophylla* J.Presl	24
Calamagrostis densiflora (J.Presl) Steud.	7	*Festuca huamachucensis* Infantes	7
Calamagrostis heterophylla (Wedd.) Pilg	23	*Festuca humilior* Nees & Meyen	1
Calamagrostis intermedia (J.Presl) Steud	13	*Festuca inarticulata* Pilg	2
Calamagrostis jamesonii Steud	1	*Festuca peruviana* Infantes	8
Calamagrostis recta (Kunth) Trin. ex Steud	34	*Festuca rigescens* (J.Presl) Kunth	13
Calamagrostis rigescens (J.Presl) Scribn	17	*Festuca rigidifolia* Tovar	15
Calamagrostis rigida (Kunth) Trin. ex Steud	14	*Festuca setifolia* Steud. ex Griseb	2
Calamagrostis spicigera J.Presl	1	*Festuca weberbaueri* Pilg	6
Calamagrostis tarmensis Pilg	10	Nassella genus- Species D	Records
Calamagrostis vicunarum (Wedd.) Pilg	43	*Nassella brachyphylla* (Hitchc.) Barkworth	15
Calamagrostis violacea Wedd	1	*Nassella depauperata* (Pilg.) Barkworth	3
Poa genus-Species D	Records	*Nassella meyeniana* (Trin. & Rupr.) Parodi	7
Poa aequigluma Tovar	31	*Nassella mucronata* (Kunth) R.W.Pohl	16
Poa annua L	40	*Nassella pubiflora* (Trin. & Rupr.) É.Desv	48
Poa candamoana Pilg	29	Paspalum genus- Species D	Records
Poa gilgiana Pilg	5	*Paspalum penicillatum* Hook.f	8
Poa gymnantha Pilg	85	*Paspalum peruvianum* Mez	1
Poa pardoana Pilg	10	*Paspalum pilgerianum* Chase	2
Poa perligulata Pilg	7	*Paspalum pygmaeum* Hack	17
Poa spicigera Tovar	22	*Paspalum tuberosum* Mez	5
Bromus genus-Species D	Records	Agrostis genus- Species D	Records
Bromus catharticus Vahl	66	*Agrostis breviculmis* Hitchc	63
Bromus lanatus Kunth	62	*Agrostis foliata* Hook.f.	8
Bromus pitensis Kunth	24	Hordeum genus - Species D	Records
Stipa genus-Species D	Records	*Hordeum muticum* J.Presl	22
Stipa hans-meyeri Pilg	70	*Vulpia megalura (Nutt.)* Rydb	7
Stipa ichu (Ruiz & Pav.) Kunth	101	Trisetum genus - Species D	Records
Stipa obtusa (Nees & Meyen) Hitchc	34	*Trisetum spicatum* (L.) K.Richt	51

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1f), with the species *Bromus catharticus* Vahl being the most reported; the genus *Stipa* has 3 species reported in Ancash, La Libertad, Cusco, Ayacucho, and Arequipa (Figure 1g) with the species *Stipa ichu* (Ruiz & Pav.) Kunth as the most reported; the genus *Agrostis* with 2 species with the most reported in the departments of Ancash, Lima, and Cusco; the species *Agrostis breviculmis* Hitch as the most reported; and finally the genus *Hordeum*, Trisetum and Vulpia with only one species each (Figure 1j,1k).

Comparing the number of records found in the GBIF database with 1141 records and those compiled from studies carried out in Peru and published in theses and scientific articles with 105 records, the difference observed is very wide. On the other hand, at least 17 species were not identified or reported in the local studies: *Agrostis foliata* Hook.f, *Calamagrostis antoniana* (Griseb.) Hitchc, *Calamagrostis densiflora* (J. Presl) Steud, *Calamagrostis intermedia* (J.Presl) Steud, *Calamagrostis spicigera* J. Presl, *Festuca casapaltensis* Ball, *Festuca inarticulata* Pilg, *Festuca setifolia* Steud. Ex Griseb. *Festuca weberbaueri* Pilg, *Nassella mucronata* (Kunth) R.W. Pohl, *Nassella pubiflora* (Trin. & Rupr.) É. Desv. *Paspalum penicillatum* Hook.f, *Paspalum peruvianum* Mez, *Paspalum tuberosum* Mez. *Poa pardoana* Pilg, *Poa spicigera* Tovar, *Stipa obtusa* (Nees & Meyen) Hitchc and *Vulpia megalura* (Nutt.) Rydb.

Discussion

Poacae family species

Natural grass species of the *Poaceae* family are the most successful among other herbaceous plants on the planet and are found in all climatic environments, including subalpine, xerophytic, aquatic, and geographic environments in the Andes and high-elevation regions, covering about 20% of the planet's

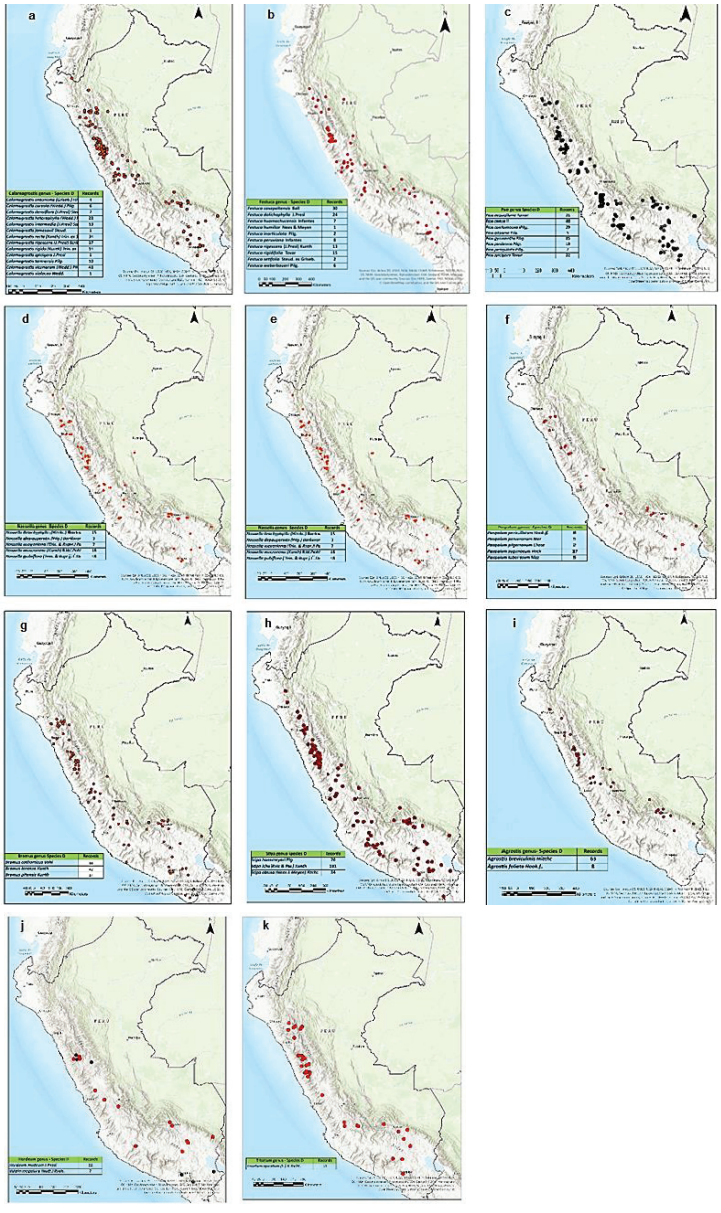

Figure 1: Spatial distribution of suitable species for Andean Livestock recorded in GBIF, in the Andean area of Peru.
Source: GBIF.org (01 August 2023) GBIF Occurrence downloaded from https://doi.org/10.15468/dl.hqme3u

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land surface, making them ecological hegemons as an essential ecological resource and a staple diet for herbivores [5,21-23], they also contribute to the production and maintenance of soil texture, continuously providing humus to the soil, satisfying nutrient needs and increasing primary production [22,24]. *Poaceae* species, especially *Calamagrostis* and *Festuca*, have the anatomical features of roots that are adapted to drought or flooding [25], in addition to the involute leaves and hollow stems that are adapted to restrict plant transpiration, through which they have greater capacity to adapt to the divergent conditions of the mountain range, despite the transformation that they have been suffering due to the effects of agriculture, overgrazing and mining [18,26]; however, some species such as *Festuca dolichophylla* present moderate vegetation cover in the upper and middle zones of the microbasin and low vegetation cover in the lower altitude zone due to soil, temperature and altitude conditions [24,27].

Characteristics of suitable species (D) for Andean livestock

It has been observed that not all families or species have been reported as suitable for Andean livestock (Table 1), due to the diversity in the preference they have based on the anatomical adaptation in the mouth to ingest natural grasses [5], the ecological interaction of the animal with the morphology and tissue structure of grasses and the nutrient content that are key factors in the feeding behavior of grazing animals [28-30]; likewise, grass height, forage mass per unit volume, leaf lamina fibrosity, spatial arrangement of preferred plant tissues, presence of defoliation barriers and dry matter content play an important role in intake preference [21,28].

Local publications on species D

While it is true that there are many studies and publications related to natural grasslands, both in composition, floristic diversity, and grazing in the Andean region of Peru and neighboring countries, there are very few (Table 2) that have ventured into the issue of species identification in relation to their suitability for livestock [6-8,10,11]; in others, they only studied some species in particular, such as *Festuca dolichophylla*, due to its importance in livestock feeding [27]. There are few publications related to research carried out by universities with professional careers involved in the management of grasslands with Andean livestock grazing: cattle, sheep, alpacas, llamas, and vicuñas [18], in which most of the data were not georeferenced, leaving a deep gap in the possibilities of geographic modeling or ecological niches [12]. Meanwhile, the GBIF database has numerous species recorded (Table 3) due to the report made on the species identified by various sources such as research entities, museums, and citizen science, which is why there are many duplicate data and invalid georeferencing and other without this detail, as well as many records with ambiguous or unclear identity, which confirm that the completeness of the sample is less than 40%, i.e. low [2-4] i.e. the information stored in the GBIF is not yet complete [1], as mentioned in a footnote to Table 3. However, this database is increasingly used to initiate processes of geographic reconnaissance and local environmental conditions, as a basis for species-specific habitat analysis that allows the modeling of ecological niches. This requirement is important for the Puna region of Peru, where it is necessary to reinforce the approach of entities that propose restoration projects for degraded grassland ecosystems with livestock interest [31-33].

Geographical distribution of suitable species

The geographic distribution of species D of the *Poaceae* family (Figure 1) is widespread in the Puna region, with a greater concentration of records in some places closely related to ecotourism activity, such as the Cordillera Blanca del Huascarán in the department of Ancash, others in Cajamarca, Cusco, Huancavelica, Ayacucho, and Arequipa, with very little information in places with little Andean tourist attraction such as Puno, Apurímac, Junín, Cerro de Pasco, La Libertad, Piura, and others [34]. However, all the species of interest in this study are located in the Puna region of the Andean Cordillera, due to their adaptation to climatic, edaphic, and anthropogenic effects [21,35], influenced by topography and elevation [21,36], to the complex and rugged topographic factor, coupled with significant latitudinal and altitudinal gradients with physical and chemical soil properties of low agro-ecological value and low nitrogen availability [37-40].

The greater diversity of species shown by the genera *Calamagrostis* and *Festuca* is due to the fact that these genera have species of wide diversity in their morphological structure with growth heights ranging from a few centimeters to the presence of tall species with abundant bushes whose heights can exceed 100 cm; these characteristics give them a better ability to adapt to the very heterogeneous environmental conditions of the Andean Cordillera [41]; whereas, the genus with few species are less heterogeneous in their morphological structure and plant size, which also restrict their habitat to sites with a certain environmental homogeneity, thus their presence in more specific habitats [37,41,42].

Conclusion

The Poaceae family of natural grasses in the Andean region has the largest number of suitable species that make up the basic diet of Andean livestock, in addition to contributing to the production and maintenance of soil texture, humus, and nutrients. However, local information from studies carried out at different universities on the identification of suitable species in the *Poaceae* family of Andean natural grasses is very scarce, barely reaching 105 records, and most of them were not georeferenced, which does not allow geoprocessing to identify specific habitats and ecological niches for each species of interest. Not all the species cataloged as suitable for cattle are preferred by the four Andean cattle species, but each one shows a particular preference for some species.

Although it is true that there is a huge amount of data recorded in the GBIF, very few species of this family are suitable for livestock feed, so only an average of 22% of the species recorded in the GBIF fall into this category, many of them with duplicate records or with invalid geographic positioning information, an aspect that highlights the low completeness of the record in natural grasslands. The geospatial distribution

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of D species is mostly concentrated in places of major tourist attractions such as the Cordillera Blanca of Ancash and others such as Cajamarca, Cusco, and Arequipa, which leads to urgent tasks of identification and registration of species in the Darwin Core of GBIF, to contribute to the expansion of the database to facilitate modeling work of ecological niches for each species in particular and build spatial information for sustainable restoration programs of degraded areas.

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(Appendix (Table 5))

References

1. Qian H, Zhang J, Jiang MC. Global patterns of fern species diversity: An evaluation of fern data in GBIF. Plant Divers. 2021 Oct 27;44(2):135-140. doi: 10.1016/j.pld.2021.10.001. PMID: 35505988; PMCID: PMC9043408.

2. Leung B, Hudgins EJ, Potapova A, Ruiz-Jaen MC. A new baseline for countrywide α-diversity and species distributions: illustration using >6,000 plant species in Panama. Ecol Appl. 2019 Apr;29(3):e01866. doi: 10.1002/eap.1866. Epub 2019 Mar 8. PMID: 30706569.

3. Toyama H, Totsu K, Tagane S, Aiba SI, Ugawa S, Suzuki E, Yamazaki K, Fuse K, Takashima A, Toyama N, Kadoya T, Takeuchi Y. A dataset for vascular plant diversity monitoring for the natural World Heritage site on Amami-Oshima Island, Tokunoshima Island, and the northern Okinawa Island, Ecologycal Research. 2022; 7(5): 676-682. https://doi.org/10.1111/1440-1703.12340

4. Popović M, Vasić N, Koren T, Burić I, Živanović N, Kulijer D, Golubović A. Biloger: an open platform for collecting biodiversity data. Biodivers Data J. 2020 Jun 11;8:e53014. doi: 10.3897/BDJ.8.e53014. PMID: 32581636; PMCID: PMC7303222.

5. Flowers ER. Climate change: high Andean grasslands and food security. Magazine of Glaciers and Mountain Ecosystems /Climate change: high Andean grasslands and food security. Magazine of Glaciers and Mountain Ecosystems/.2016. https://www.inaigem.gob.pe/wp-content/uploads/2019/06/Revista-No.-5.pdf

6. Carla JC. Ecological restoration of high Andean grasslands to improve natural pastures in the Apas sector, Huancaya, Yauyos. Catholic University Sedes Sapianteae, Faculty of Environmental Engineering, Undergraduate Thesis/ Ecological restoration of high Andean grasslands for the improvement of natural pastures in the sector Apas, Huancaya, Yauyos. Catholic University Sedes Sapianteae, Faculty of Environmental Engineering, Undergraduate thesis/. 2020; 154. URI https://hdl.handle.net/20.500.14095/807.

7. Onofre CI. Diagnosis of the environmental condition of the Moyobamba wetland through an agrostological study, Canchayllo district, Jauja province. Universidad Católica Sedes Sapianteae, Faculty of Agrarian Engineering, Undergraduate Thesis/Diagnosis of the environmental condition of the Moyobamba wetland through an agrostological study, district of Canchayllo, province of Jauja. Universidad Católica Sedes Sapianteae, Faculty of Agrarian Engineering, Undergraduate Thesis/.2020; 117. URI https://hdl.handle.net/20.500.14095/859

8. Trillo SF. Autoecology of Festuca dolichophylla-Festuca humilior, and response to NPK addition in the Peruvian Puna. Thesis to opt for the degree of Doctor / Autoecology of Festuca dolichophylla-Festuca humilior, and response to NPK addition in the Peruvian Puna. Thesis for opting for the degree of Doctor/. UNALM. Lima. 2021; 108.

9. George JB, Galarza PV. Assessment of the conservation status of the Moya sector bofedal in the Chacamarca Historical Sanctuary, Junín. Catholic University Sedes Sapientiae, Faculty of Agricultural Engineering /Assessment of the conservation status of the Moya sector bofedal in the Chacamarca Historical Sanctuary, Junín. Catholic University Sedes Sapientiae, Faculty of Agricultural Engineering. 2020; 59. https://hdl.handle.net/20.500.14095/989

10. Capuñay K. Diet composition of vicuñas (Vicugna vicugna) using fecal microhistology techniques./Composition of the diet of vicuñas (Vicugna vicugna) using fecal microhistology techniques. repositorio.lamolina.edu.pe. 2022. https://repositorio.lamolina. edu.pe/handle/20.500.12996/5588

11. Galarza PV, George JV. The Moya Sector Wetland in the Historical Sanctuary of Chacamarca, Junín. Catholic University Sedes Sapianteae, Faculty of Agrarian Engineering, Undergraduate Thesis /Assessment of the conservation status of the Moya sector bofedal in the Chacamarca Historical Sanctuary, Junín. Catholic University Sedes Sapianteae, Faculty of Agricultural Engineering, Undergraduate thesis/. 117. https://hdl.handle.net/20.500.14095/989

12. Ivanova NV, Shashkov MP. The possibilities of using GBIF data in ecological research /The possibilities of using GBIF data in ecological research. Russ J Ecol. 2021; 52: 1-8. https://doi.org/10.1134/S1067413621010069

13. Gibson D. Grasses and grassland ecology. Carbondale: Oxford University Press. 2009.

14. Serrato P. Physiographic classification of the terrain based on the inclusion of new conceptual elements. Geographic Perspective / Physiographic classification of the terrain based on the inclusion of new conceptual elements. Geographic Perspective. 2009; 14: 181-2018.

15. Cuesta F, Muriel P, Beck S, Meneses R, Halloy S, Salgado S, Becerra M. Biodiversity and climate change in the Tropical Andes /Biodiversity and climate change in the Tropical Andes/. Quito: CONDESAN. 2012.

16. MINAM. National vegetation cover map. Descriptive memory. Lima: Ministry of the Environment. General Directorate of Evaluation, Valuation and Financing of Natural Heritage /National vegetation cover map. Descriptive memory. Lima: Ministry of the Environment. General Directorate of Evaluation, Valuation and Financing of Natural Heritage. 2015. https://www.gob.pe/institucion/minam/informes-publicaciones/2674-mapa-nacional-de-cobertura-vegetal-memoria-descriptiva

17. Hofstede R, Calles J, López V, Polanco R, Torres F, Uloa J, Cerra M. The Andean paramos (What do we know? State of knowledge about the impact of climate change on the paramo ecosystem /The Andean paramos (What do we know? State of knowledge about the impact of climate change on the paramo ecosystem. Quito: International Union for Conservation of Nature and Natural Resources. 2014. https://portals.iucn.org/library/sites/library/files/documents/2014-025.pdf

18. Yaranga RM. Andean grassland ecosystems. HIGH MOUNTAIN RESEARCH CENTER, National University of Central Peru. Huancayo /Andean grassland ecosystems. HIGH MOUNTAIN RESEARCH CENTER, National University of the Center of Peru. Huancayo. 2019; 115. ISBN: 978-612-4697-4-0

19. Mahapatra A, Sundar D, Sahu D. Advances in Agriculture and Allied Eechnologies. Akinik publications. 2022; 276. Book DOI: https://doi.org/10.22271/ed.book.1919.

20. Helena K, Karen B, Eija H. Enriching the Notion of Data Curation in E-Science: Data Managing and Information Infraestructuring in the Long Term Ecological Research (LTER) Network. Computer Supported Cooperative Work. 2006; 15: 321-358. 10.1007/s10606-006-9023-2.

21. Scrivanti LR, Anton AM. Impact of climate change on the Andean distribution of Poa scaberula (Poaceae). Flora, Elsevier. 2021. https://www.sciencedirect.com/science/article/pii/S036725302100044X

22. Majeed M, Tariq A, Haq SM, Waheed M, Anwar MM. A detailed ecological exploration of the distribution patterns of wild Poaceae from the Jhelum District (Punjab), Pakistan. Sustainability. 2022. mdpi.com, https://www.mdpi.com/2071-1050/14/7/3786

Citation: Yaranga Cano RM, Orellana JA, Pizarro SE (2024) Species of the Poaceae family suitable for Andean livestock farming in the Peruvian Andes reported in GBIF and local studies. Glob J Ecol 9(1): 057-065. DOI: https://dx.doi.org/10.17352/gje.000097

23. Jamil MD, Waheed M, Akhtar S, Bangash N. Invasive plants diversity, ecological status, and distribution pattern in relation to edaphic factors in different habitat types of district Mandi Bahauddin, Punjab, Pakistan. Sustainability. 2022. mdpi.com, https://www.mdpi.com/2071-1050/14/20/13312

24. Scrivanti LR, Anton AM. Spatial distribution of Poa scaberula (poaceae) along the andes. Heliyon. 2020 Oct 16;6(10):e05220. doi: 10.1016/j.heliyon.2020.e05220. PMID: 33102846; PMCID: PMC7575845.

25. Yamauchi T, Pedersen O, Nakazono M, Tsutsumi N. Key root traits of Poaceae for adaptation to soil water gradients. New Phytol. 2021 Mar;229(6):3133-3140. doi: 10.1111/nph.17093. Epub 2020 Dec 20. PMID: 33222170; PMCID: PMC7986152.

26. Sirimarco X, Villarino S, Barral MP, Puricelli M, Laterra P. Transformation of tall-tussock grasslands and soil water dynamics in the Flooding Pampa. Sci Total Environ. 2023 Oct 20;896:165362. doi: 10.1016/j.scitotenv.2023.165362. Epub 2023 Jul 5. PMID: 37419336.

27. Peace EDP, Rebaza LUM. Conservation status of the Festuca Dolichophylla species in the tropical micro basin, Candarave province, Tacna region, Peru-2 Science, Technology and sky.org.bo, 2022. http://www.sky.org.bo/sky.php?pid=S2225-87872022000200179&script=sci_abstract&tlng=en

28. Dias-Silva TP, Abdalla FAL. Sheep and goat feeding behavior profile in grazing systems. Acta Scientiarum. Animal Sciences, SciELO Brasil. 2020. https://www.scielo.br/j/asas/a/BYpBCZKj9b4RRWfQwLRdjnQ/

29. Molnár Z, Kelemen A, Kun R, Máté J. Knowledge co-production with traditional herders on cattle grazing behaviour for better management of species-rich grasslands. Journal of Applied Wiley Online Library. 2020. https://doi.org/10.1111/1365-2664.13664

30. Bakhshi J, Javadi SA, Tavili A, Arzani H. Study on the effects of different levels of grazing and exclosure on vegetation and soil properties in semi-arid rangelands of Iran. Acta Ecologica Sinica, Elsevier. 2020. https://www.sciencedirect.com/science/article/pii/S1872203219301544

31. Mosquera GM, Marín F, Stern M, Bonnesoeur V, Ochoa-Tocachi BF, Román-Dañobeytia F, Crespo P. Progress in understanding the hydrology of high-elevation Andean grasslands under changing land use. Sci Total Environ. 2022 Jan 15;804:150112. doi: 10.1016/j.scitotenv.2021.150112. Epub 2021 Sep 4. PMID: 34520909.

32. Vásquez HV, Puscán MMH, Bobadilla LG. Evaluation of pasture degradation through vegetation indices of the main livestock micro-watersheds in the Amazon region (NW Peru). Environmental and Elsevier. 2023. https://www.sciencedirect.com/science/article/pii/S2665972723000922

33. Young KR, Alata E, Chimner RA, Boone RB, Bowser G. Ecological Change and Livestock Governance in a Peruvian National Park. Land. 2023. mdpi.com, https://www.mdpi.com/2073-445X/12/11/2051

34. GBIF.org. GBIF Occurrence Download. 2022. https://doi.org/10.15468/dl.pm53un

35. Waheed M, Haq SM, Arshad F, Bussmann RW, Iqbal M. Grasses in semi-arid lowlands—community composition and spatial dynamics with special regard to the influence of edaphic factors. Sustainability. 2022. mdpi.com, https://www.mdpi.com/2071-1050/14/22/14964

36. Lemmer J, Andrzejak M, Compagnoni A. Climate change and grassland management interactively influence the population dynamics of Bromus erectus (Poaceae). Basic and Applied Elsevier. 2021. https://www.sciencedirect.com/science/article/pii/S1439179121001080

37. Huarcaya RP. Spatial distribution of useful Andean plants and their vulnerability to climate change. 2020. kew.iro.bl.uk. https://kew.iro.bl.uk/downloads/82204663-0f2c-4ba8-9245-1d7f2a830888

38. Kaltrina R, Kristi B, Dea Z, Lulezim S. Alpine ecology, plant biodiversity and photosynthetic performance of marker plants in a nitrogen gradient induced by Alnus bushes. Ecology. 2020. bmcecol.biomedcentral.com, https://doi.org/10.1186/s12898-020-00292-9

39. Qi-peng Z, Jian W, Qian W. Effects of abiotic factors on plant diversity and species distribution of alpine meadow plants. Ecological Informatics. 2021; 61: 101210. ISSN 1574-9541, Elsevier BV, https://doi.org/10.1016/j.ecoinf.2021.101210

40. Zhang H, Zha T, Yu Y, Zhang Z, Zhang X. Functional vegetation community responses to soil and topographic factors in the Loess Plateau of China. Land Degradation & Wiley Online Library. 2023. https://doi.org/10.1002/ldr.4849

41. Yaranga R, Rojas AF, Vuure A. Andean Grassland Species: Net Aerial Primary Productivity, Density, Ecomorphological Indices, and Soil Characteristics. Journal of Ecological. 2021. lirias.kuleuven.be, https://lirias.kuleuven.be/retrieve/690594

42. Tina C, Oliveras I. Nature of Alpine Ecosystems in Tropical Mountains of South America. Encyclopedia of the World's Biomes. 2019; 282-291. https://doi.org/10.1016/B978-0-12-409548-9.12481-9.

Citation: Yaranga Cano RM, Orellana JA, Pizarro SE (2024) Species of the Poaceae family suitable for Andean livestock farming in the Peruvian Andes reported in GBIF and local studies. Glob J Ecol 9(1): 057-065. DOI: https://dx.doi.org/10.17352/gje.000097