Journal of Namibian Studies, 33 S2(2023): 2006–2025 ISSN: 2197-5523 (online)

CLASSIFICATION, COMPOSITION AND FLORISTIC DIVERSITY IN NATURAL GRASSLANDS TO DIFFERENT STRATA IN THE PROTECTED AREA ICHUBAMBA YASEPAN, THROUGH GEOSTATISTICAL ANALYSIS

Guicela Margoth Ati Cutiupala[1], Josselyn Michelle Shucad Shunta[2*], Maritza Lucia Vaca Cárdenas[3], Hernán Eriberto Chamorro Sevilla[1], Miguel Ángel Guallpa Calva[1], Shirley Dayana Horna Durán[2], Norma Ximena Lara Vásconez[2], Diego Francisco Cushquicullma Colcha[4]

[1]Facultad de Recursos Naturales, Escuela Superior Politécnica de Chimborazo, Panamericana Sur, Km 1 ½, Riobamba EC-060155, Ecuador; guicela.ati@espoch.edu.ec , https://orcid.org/0000-0002-9779-2758; hernan.chamorro@espoch.edu.ec ; https://orcid.org/0000-0002-8531-7116 ; miguel.guallpa@espoch.edu.ec ; https://orcid.org/0000-0001-5392-036X

[2]Investigador Independiente, Riobamba EC-060155, Ecuador; *Correspondencia: josselinshucad97@gmail.com (JMSS)https://orcid.org/0000-0002-6583-9320; dayahorna40@gmail.com, https://orcid.org/0000-0002-6189-3725, xnormalara@yahoo.com , https://orcid.org/0000-0001-8381-0401

[3]Facultad de Ciencias Pecuarias, Escuela Superior Politécnica de Chimborazo, Panamericana Sur, Km 1 ½, Riobamba EC-060155; maritza.vaca@espoch.edu.ec ; https://orcid.org/0000-0003-4474-4354

[4]Universidad de Granada, Avenida de Fuente Nueva, s/n, 18071-Granada-España; diegofc10@correo.ugr.es; https://orcid.org/0000-0001-6265-8164

Abstract

The ecosystems of the páramos are home to a high number of endemic species that are the result of extraordinary events of radiation, diversification and geographical isolation, the presence or absence of some plant species of the páramo are due to the adaptation to physical or environmental variables, the natural grasslands enjoy characteristics that make them unique and of great ethnobotanical importance, since they provide very appreciable ecosystem services, therefore, the floristic diversity to different strata in the natural grasslands of the Ichubamba Yasepan protected area was analyzed. For this two different altitudes ranging from 3440 m.a.s.l. to 3840masl were taken.

To collect data from the floristic inventory, part of the proposed methodology of the GLORIA Research Project was applied, in which 5x5 m quadrants were implanted randomly at every 400 m of altitude and subquadrants of 1x1 m. In each quadrant, samples of the plant species that were found in the study area were collected, which were taken to the ESPOC herbariumfor the respective taxonomic identification and quantification of floristic diversity. A database was elaborated and the analysis of principal components was applied and it was carried out by the estimation method thatc entraliza the variables by subtracting from each value the mean of the variable to which it belongs, the Biplot type was also used: Normalized main row (RMP- Biplot) and Cluster K-means. Therefore, we worked with the free software Multbiplot.

The results obtained showed at the height of 3840 m.s.n.m 16 families and 23 species were registered, the species that presents the highest numerical value with respect to DR%, FR% and IVI is Calamagrotis intermedia. At the height of 3440 m.a.s.l. they registered 11 families and 19 species, the species that presents the highest numerical value in DR%, FR% and IVI is Lachemilla orbiculata, with greater dominance. According to the Simpson dominance index at 3840 m.a.s.l. it has a high diversity and the Shannon index showed that there is a medium diversity. It is concluded according to the Simpson dominance index at the height of 3440 m.a.s.l. has a high diversity and the Shannon index indicates that there is a medium diversity. According to Sorensen shows that the two altitudinal ranges studied is similar and finally for the analysis of the main components plant species of stratum 3840 m.a.s.l. They have high values in terms of coverage which indicates that the vegetation cover of the stratum with a height of 3840 meters above sea level is more abundant and more diverse for axis 1 represents 61.13% of the analysis and axis 2 represents 28.63%.

Keywords: Simpson, Sorensen, Ichubamba Yasepan, Floristic diversity, Altitudinal, Overgrazing.

1. Introduction

The importance of páramos ecosystems lies in their ability to store and regulate water In Ecuador, páramos have an average altitude of 3 300 m. s.n.m., and covers 7% of the territory andcuatorian that receive from rainfall(1) Studies of páramo species have historically been neglected, despite the importance of these complex ecological systems in terms of the ecosystem services they provide. (2).

A total of 1,524 species have been registered for the páramos of Ecuador, being for this ecosystem and in relation to its size, the country with the most diverse flora of the Andean region. (3) They are lands considered as great water modifiers that help in times of drought and during the summers that the water retained at those altitudes is contributed by runoff and gradually to the lowlands, since in these areas are where rivers, streams, aqueducts or streams are generated. (4)

Paramo plants have truly spectacular adaptations to withstand low night temperatures, high solar radiation during the day, low availability of nutrients in the soil and in some cases, seasonal drought conditions (5). It has a very extreme meteorology, during the day high irradiation, presence of fog, high humidity and at night low temperatures; The beings that intend to live in the páramo are forced to evolve in order to adapt to this ecosystem; It is for this reason that in the páramo we find plants and some animals that are not found in any other habitat in the world. (6)

The province of Chimborazo, with an area of 648,124 hectares, has a little more than 246,000 hectares of eco páramo system (that is, 38% of the surface of the province), and another 49571.16 hectares of Andean and high Andean forest (that is, 8%). (7) In particular, the relationship between diversity and stability in ecosystems has attracted much attention from researchers and generated a great deal of discussion (8).

The duration of each season and the exact months in which they occur vary according to the conditions of each place. The vegetation of the páramo is able to prevent floods when water is abundant and droughts when it is scarce, as well as to reduce the erosive impact of the soil. The flora we find has evolved to the extreme conditions present in the ecosystem (9). The conservation of the area maintains the key functions of the ecosystem in order to promote the appreciation of intangible services, both regulatory and cultural. (10)

The Ministry declared the páramos of the Ichubamba Yasepan community belonging to the Guamote canton, Chimborazo province; as the second private protected area nationwide and the 60th in the country. Protected areas aim to conserve areas of enormous importance or that are in danger of threat. Each protected area is created in order to ensure the conservation of an ecosystem and the conservation of wildlife. (11)

The Ecuadorian páramos are mostly humid. The annual rainfall that falls on them is between 500 and 2,000 mm, resulting in the growth of natural vegetation and pastures. (12). Ecosystem services are the benefits for society This concept makes it possible to explicitly address the interdependence of human well-being and the maintenance of the proper functioning of ecosystems (13).

The páramo de Cebadas has great importance because it is considered a key territory for the provision of the most important environmental service that is the water supply should expand its coverage taking into account priority conservation areas, places that are strategic and that meet the requirements to be considered as protected areas. The páramos present an evident pressure on the part of these communities since due to the lack of land they transform these soils for agriculture and pastures for the grazing of animals (14).

The páramos of Ecuador notes that altitudinal gradients involve macroclimatic changes that can affect diversity. (15) Floristic diversity and composition are the most important attributes for differentiating or characterizing each plant complex and/or community. (16)

As a result of human actions, the structure and functioning of the world's ecosystems changed more rapidly in the second half of the twentieth century than at any other time in human history. (17) . High-altitude ecosystems are characterized by sparse vegetation with scattered woody species and wetlands Climate variability and plant productivity is critical to understanding the functioning of these ecosystems and the potential consequences of future climate scenarios. However, such quantitative analyses are scarce due to the scarcity of instrumental climate data and ecological field monitoring (18).

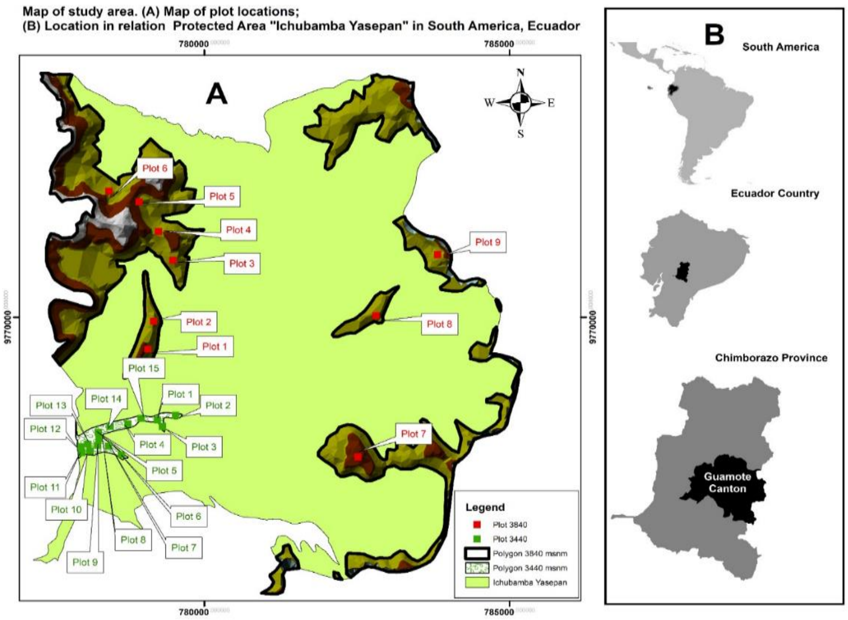
2. Materials and methods

For a better purchase, the methodological process was carried out by two methods the first section will have a qualitative and quantitative approach because the existing flora in the altitudinal range between 3840 and 3440 meters above sea level will be identified. At the same time, the number of existing individuals by family, genus and species was counted, which will allow us to know the ecological importance, in the second part the statistical analysis developed to contribute with truthful information and respond to the research is detailed.

2.1 Area of study

This study was carried out in the parish of Cebadas, Guamote canton, province of Chimborazo, specifically in the Páramos of the Ichubamba Yasepan Agricultural Production Cooperative, which is located at km 25 of the Riobamba-Macas road, near the Reten Ichubamba community. According to the ecosystem classification system of continental Ecuador of 2013, the geographical coordinates in UTM WGS84 are x:780159,4, y:9769592,0.

Figure 1. Location of the study area of the Ichubamba Yasepan páramo in the parish of Cebadas, Guamote canton, province of Chimborazo



2.2 Climatic characteristics

According to data from INAMHI (2015), in relation to temperature it is determined that, in the months of June, July, August and September there is a decrease in temperature below 7 degrees Celsius, while the months of October, November, December, January, February, March, April and May stand out temperatures above 7 ° C, the average annual temperature is 7.2°C. According to Sierra (1999) The territory of the Agricultural Cooperative Ichubamba Yasepan Herbaceous páramo of grassland and pads.

2.3 Evaluation methodology

Using the Arc Gis 10.8 software, the surface of the protected area was calculated, which is located at 3440 meters above sea level, having a total of 41.23 ha then 5 cells were created, for the second stratum at 3840 meters above sea level with a total of 1019.67 ha samples were taken creating 41 quadrants the sample was calculated statistically. The criterion proposed by De la Hoz Rodríguez et al. (19) was used to determine the number of sample units, in terms of error we worked with 5 % (error) and 95 % (certainty), as shown in Table 1.

For this purpose, the following formula was used:

$$n = \frac{N\,(p * q)}{(N-1)\,\left(\frac{e}{z}\right)^2 + (p * q)}$$

Table 1: Determination of the number of sample units

n= sample size	
N= Universe	41
p= Occurrence (0.5)	0.5
q= Non-occurrence (0.5)	0,5
e= error (0,05)	0,05
z= Confidence 1.96	1,96
Value	

2.4 Species collection

The collection was carried out within the framework of the non-marketing flora collection permit No. 1345. For the present work, part of the proposal of the Research Project GLORIA adapts to Andean ecosystems was applied, facilitating better results in high areas. (20). Ten quadrants of 5 x 5 m were established randomly every 1000 m altitude. Each quadrant was divided into subquadrants of 1 x 1 m.

For the collection of species in each quadrant, the GLORIA plot methodology was applied, each plot had an area of 25 m2, which were established in a square of 5 x 5 m. To trace the plot, the theoretical starting point was located with the help of the Gaia GPS program.

2.4.1Herborization Process

To have a herbarium specimen it is required to follow certain rules included in the following order:

2.4.2 Drying

For the process of drying and pressing the samples served to eliminate the water inside them, for this its longevity will be conditioned, as well as the quality of the same, the first step to avoid its decomposition and destruction by infective agents (insects, molds, bacteria). The specimens must have their corresponding recognition label.

2.4.3 Pressing

The samples were placed on a sheet of filter paper or newspaper and the different sheets are placed on top of each other in an orderly manner, introducing several newspapers for the extraction of moisture. For this, presses formed by two wooden plates were used, between which the stacked sheets are placed, and which are tightened, by means of ropes.

2.4.4 Identification

The collected samples were identified in the ESPOCH Herbarium. For more information on the species found, the Catalogue of Vascular Plants was reviewed. (21) With the information obtained, importance values were determined by species, relative density and relative frequency in each stratum.

Once the data were collected, the following values were determined: Relative abundance, frequency, importance value of species and families, and Simpson, Shannon-Weaver, Sorencen and Percentage of similarity between communities.

The Simpson and Shannon-Weaver diversity index was determined using the following formulas.

Simpson Index:

$$\mathbf{ISD} = 1 - \sum (\mathrm{pi})^2$$

IDS = Simpson Diversity Index

$(Pi)^2$ = Proportion of individuals squared

Índice de Shannon –Weaver:

$$\boldsymbol{H} = -\sum_{i=1}^{s} (pi)(longnPi)$$

Pi= is the proportion and individuals that constitute the species

The values obtained within each plot by altitude were compared through the calculation of the Sorensen Similarity Index, to verify the relationship or variation of results and determine whether or not altitude influences them.

Sorensen Similarity Index

$$\boldsymbol{ISS} = \frac{2C}{A+B} X\ 100$$

ISS = Sorensen Similarity Index

A= Number of species in sample A

B= Number of species in sample B

C= Number of species shared between sampling A and B

These ecological parameters allowed to establish the diversity within each altitudinal range and between them. In addition, the exclusivity of the species was determined, considering for this work that those species that were found in a single altitudinal range are exclusive.

For the determination of floristic diversity, indices were applied with average values of large amounts of data obtained in the field. The Simpson and Shannon-Weaver diversity index was determined.

The values obtained within each plot by altitude were compared through the calculation of the Sorensen Similarity Index, to verify the relationship or variation of results and determine whether or not altitude influences them.

2.5. Statistical analysis

Subsequently, the principal component analysis was used in the case of continuous variables and its purpose is to reduce the number of variables representing the data matrix in a dimensionality lower than the original, it was also carried out by the estimation method that centralizes the variables by subtracting from each value the mean of the variable to which it belongs. With this it is achieved that all the variables have zero mean, the type of Biplot was also used: Main row normalization (RMP-Biplot) and then a K-means cluster was made which is an unsupervised classification algorithm (clusterization) that groups objects into k groups based on their characteristics, consiste in classify Similar objects into different groups, i.e. the partitioning of a set of data into subsets, the same ones that have similar characteristics (22). For which the free software Multbiplot was used.

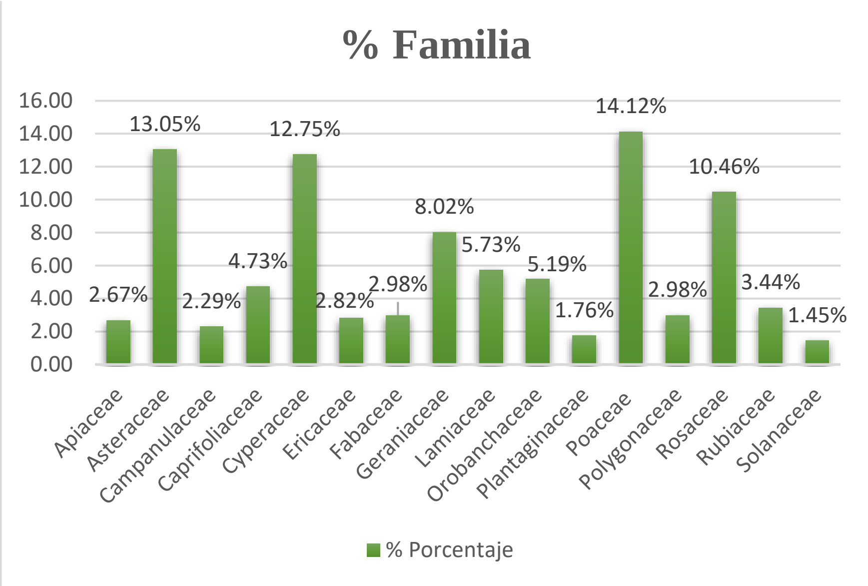
For the analysis of principal components and cluster, the variables height, importance value index -IVI, coverage and individuals of the two strata A and B were used.

3. Result

3.1. Sampling height 3840 meters above sea level

For stratum A (3840 masl) the processing was carried out and the survey of 11 plots was obtained, in which samples of terrestrial vascular plants were collected, corresponding to 16 botanical families, 23 species.

Figure 2. Percentage of family height 3840 masl

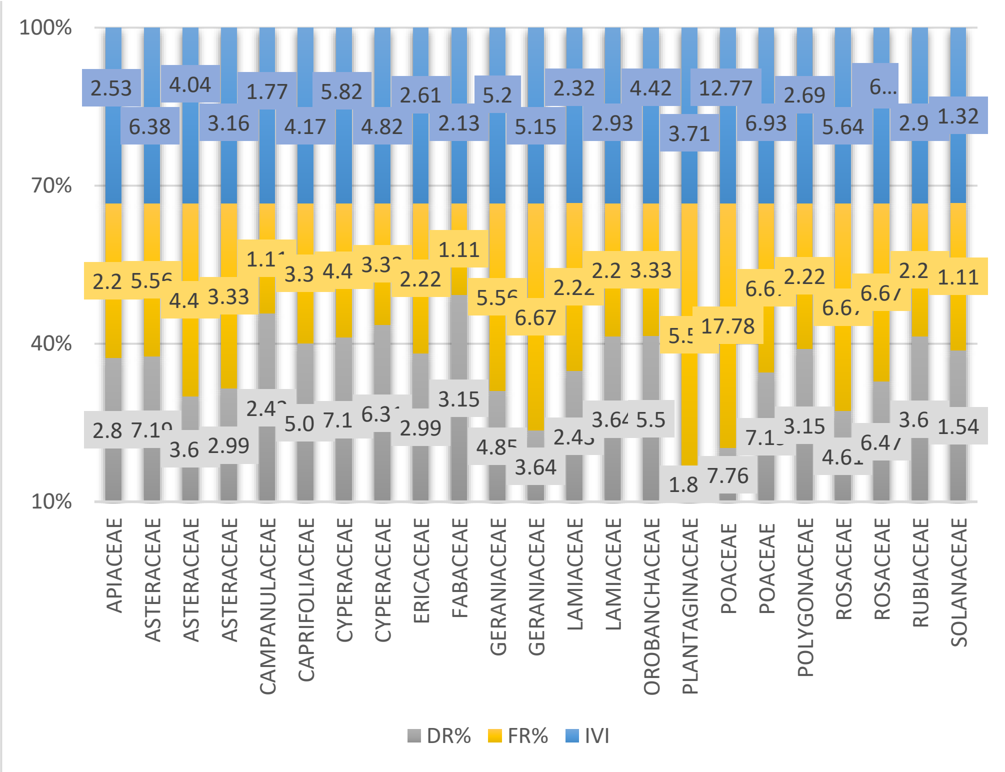


The families recorded in the páramo ecosystem at the height of 3840 m.a.s.l., which present a greater number of species are: Poaceae (14.12%) with 2 species, Asteraceae (13.05%) with 3 species, Cyperaceae (12.75%) with 2 species, Geraniaceae (8.02%) with 2 species, Rosaceae (10.46%) with 2 species, Lamiaceae (5.73%) with 2 species, Orobanchaceae (5.19%) with 1 species, Caprifoliaceae (4.73%) with 1 species, Rubiaceae (3.44%) with 1 species, Fabaceae (2.98%) with 1 species, Polygonaceae (2.98%) with 1 species, Ericaceae (2.89%) with 1 species, Apiaceae (2.67%) with 1 species, Campanulaceae (2.29%) with 1 species, Plantaginaceae (1.76%) with 1 species, and Solanaceae (1.45%) with 1 species.

3.1.1. Vegetation in the altitude range 3840 meters above sea level

For stratum B vegetation in the altitude range 3840 masl, with thedata obtained in the field, the relative values of density, relative frequency and importance value index (IVI) were calculated, as shown in Figure 3

Figure 3. Value of Importance of the species at the altitude 3840 masl



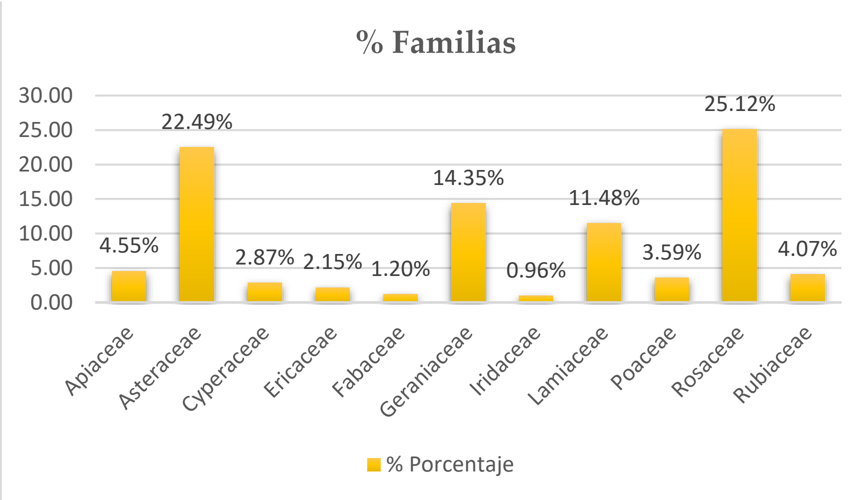
The illustration shows that at 3840 m.a.s.l. 16 botanical families and 23 species were recorded. The family with the largest number of individuals was Poaceae with 16 individuals of the species Calamagrotis intermedia, and Agrostis perennans with 6 individuals giving a total of 22 species of that family, Asteraceae presented three species that are: Diplostephium ericoides with 5 individuals; Diplostephium antisanense Hieron with 4 individuals and Gynoxis halli hieron with 3 individuals giving a total of 12 species, Cyperaceae showed two species that are: Carex pichinchensis with 4 individuals and Cyperus sp with 3 individuals giving a total of 7 species belonging to this family, Geraniaceae presented two species that are: Geranium laxicaule with 5 individuals and Geranium diffudum with 6 individuals giving a total of 11 species belonging to this family, Rosaceae presented 6 individuals of the species Lachemilla orbiculata, and 6 individuals of the species Acaena elongata resulting in 12 species of the family in mention, The family Apiaceae presented the species Daucus montanus with 2 individuals; Lamiaceae presented two species: Stachys elliptica with 2 individuals and Clinopodium nubigenum with 2 individuals giving a total of 4 species, the families Polygonaceae, Ericaceae and Rubiaceae presented the species Rumex acetosella, Vaccinium floribundum and Galium hypocarpium with 2 individuals, Plantaginaceae presented the species Plantago australis with 5 individuals, the families Campanulaceae, Fabaceae and Solanaceae presented the following species respectively Centropogon solissi, Medicago polymorpha, and Solanum nigrescens each with 1 individuals, individuals, the families Caprifoliaceae presented the following species Valeriana rigida with 3 individuals respectively.

The floristic composition was established by quantifying the importance value index (IVI) of the species; It consists of the sum of the relative values of density, frequency and dominance and indicates the relative ecological importance of plant species (23–25). In this case Calamagrostis intermedia is shown with 12.77 which indicates that it obtains the greatest dominance in this ecosystem.

3.2. Sampling height 3440 meters above sea level

For stratum B, height 3440 meters above sea level andcarried out the survey of 9 plots distributed randomly, in it samples of terrestrial vascular plants were collected, corresponding to 11 botanical families, 19 species

Figure 4. Family percentage according to the number of species 3440 masl.

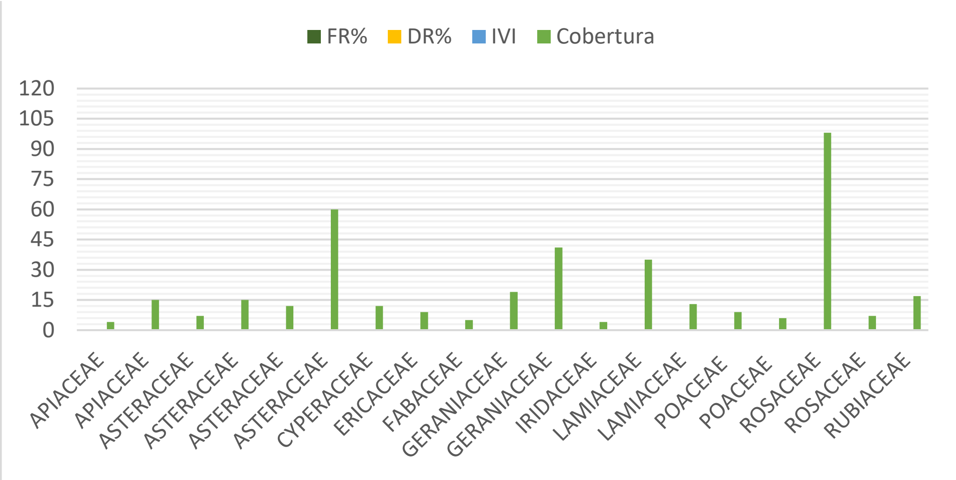


The families recorded in the páramo ecosystem that present a greater number of species are: Rosaceae (25.12%) with 2 species, Asteraceae (22.49%) with 4 species, (11.48%) with 2 species, Geraniaceae (14.35%) with 2 species, Apiaceae (9.81%) with 4 species, Rubiaceae (4.07%) with 1 species, Poaceae (3.59%) with 2 species, Cyperaceae (2.87%) with 1 species, Ericaceae (2.15%) with 1 species, Fabaceae (1.20%) with 1 species and Iridaceae (0.96%) with 1 species.

3.2.1. Vegetation in the altitude range 3440 meters above sea level

With the data taken in the field, the relative values of density, relative frequency and importance value index (IVI) were calculated.

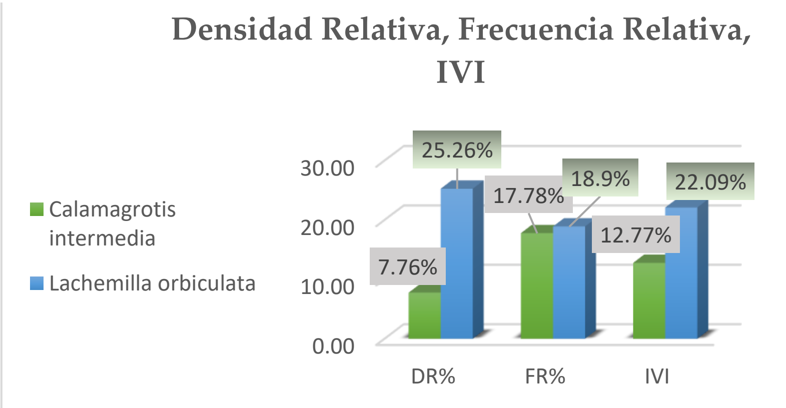
Figure 5. Value of Importance of the species at altitude 3440 masl



The vegetation in the altitudinal range 3440 masl el IVI represents the sum of the values of relative density + relative frequency; used to compare the representation of the species, in this case Lachemilia orbiculata is shown with 22.09 which indicates that it obtains the greatest dominance in this ecosystem.

3.2.2 Comparison between species and heights

Figure 6. Relative density, relative frequency and IVI at both heights



It shows that, at the height 3440 m.a.s.l. and the species that presents the highest numerical value in DR%, FR% and IVI is Lachemilla orbiculata, with greater dominance, it is a pioneer and creeping herb. They are abundant in places where there was grazing, has medicinal properties for man and secondary metabolites have a high level of importance to cure asthma, cancer, diabetes and other diseases.

At the altitude 3840 m.a.s.l. the species that presents the highest numerical value in DR%, FR% and IVI is Calamagrotis intermedia, this herb is known locally as "straw" and is used as fodder for livestock. It is also cut and used for the construction of huts, roofs and baskets.

3.3 I calculate diversity indices

3.3.1 Simpson and Shannon indices height 3840 m

In relation to the height of the stratum 3840 m.a.s.l., by the Simpson method the value of the result is, 0.93 index considering that there is a high diversity, instead the Shannon index is 2.90 which means that there is an average diversity, these values coincide with the research(26), where the Simpson Index results in, 0.9522 and the Shannon index presents an average diversity with 3.132 in the sample.

3.3.2 Simpson and Shannon indices height 3440 m

In relation to the height of 3440 m.a.s.l., by the Simpson method the value of the result is, 0.92 index considering that there is a high diversity, between species richness and abundance, or number of individuals per species in any given place (27), instead the Shannon index is 2.75 which means that there is an average diversity.

The diversity indices calculated in the two altitudinal ranges are similar, the Simpson diversity is between the values of 0.92 and 0.93 and the Shannon index ranges between 2.75 and 2.90, these values imply that the Ichubamba Yasepan paramo has high diversity in the two altitudes.

3.3.3 Sorensen index

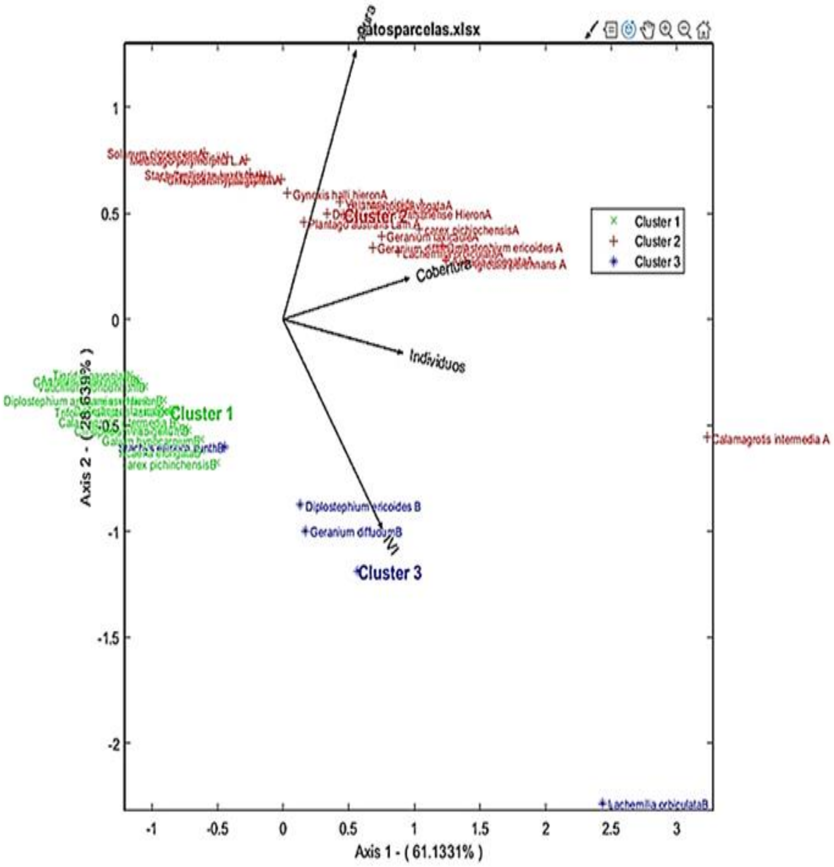
The Sorensen Index shows that the similarity between the two altitudinal ranges studied is similar; the range of 3840-3440 meters above sea level presents a greater similarity with 90% and 19 species in common.

Table 2: Species similarity between the two heights

Sorensen index				
Altitudinal range	**Common species**	**Calculated value**	**Reference value**	**Interpretation**
3840-3440 masl	19	90%	0,67-1	Floristically similar

3.3.4 Principal component analysis

Figure 6. Representation of the different variables of strata A and B



This representation not only shows the summarized information, but also the correlations between individuals and variability simultaneously (28). Axis 1 represents 61.13% of the analysis and axis 2 represents 28.63%. Graphical representations are not only used to describe a data matrix, but also after a multivariate analysis of thedata matrices being worked with(29).

The first component explains most of the variance in the data, the variables individuals and coverage on axis 1 have large positive influences that considerably affect component 1, on axis 2 the height variable has a large positive influence and the variable index value of importance -IVI has a negative influence.

The variables vegetation cover and number of individuals have a high correlation, that is, the greater the number of individuals, the greater the vegetation cover of grasslands A (3840 masl) and B (3440 masl).

4. Discussion

Regarding the research on floristic diversity at different altitudes in the páramo of the Ichubamba Yasepan protected area, 19 species of herbaceous paramo were found, which coincides with the research carried out by Caranqui et al. (30)in the moors of Ichubamba in 2019, where he finds 17 species of which 12 are herbaceous paramo, concluding that there is a similar number of species.

At the height of 3840 meters above sea level it can be seen that the Poaceae family has a high percentage (14.12%) followed by the Asteraceae family, which agrees with Beltrán et al. (31) in his research carried out at the Guandera Research Station, which states that the moors of the eastern mountain range of the province of Carchi and that belong to the physiographic unit called "Páramos del Norte de la Cordillera Real Oriental" are related families and species in the altitudinal range of 3,800 to 3,850 m.a.s.l.

The most representative values in the altitudinal range of 3840 meters above sea level, have the family Poaceae and Asteraceae which agrees with the "Floristic study of the southern pajonal moors of Ecuador", in which it is stated that Asteraceae and Poaceae usually occupy the first places, in accordance with the dominance of these families in the moors. (32) Affirming Villareal et al. (33), for in the study of Andean páramos Ecuador, registering 41 species of plants belonging to 18 families, of which the most representative families were Asteraceae and Poaceae.

With the data taken in the field at the height of 3840 meters above sea level, we proceeded to calculate relative values with respect to density, relative frequency and importance value index (IVI), giving agreement with what Izco et al states. (32) where it states that, in the southern grasslands of Ecuador, the families Poaceae and Asteraceae are the richest families in genera, followed by a group of families (Cyperaceae, Rosaceae, Geraniaceae, Apiaceae) that also occupy relevant places in other localities.

As for the coverage to the coincides with the study, since in the area of the Carihuayrazo that was studied within the altitudinal range 3,800 to 4,000 meters above sea level. (31) and that, in our study corresponds to the height of 3840 meters above sea level, the largest corresponding data is Calamagrostis intermedia and belongs to the plant formation of herbaceous moor. Comparing with the floristic study in the páramo ecosystem of the Galgalán ravine, Atillo community, with rope with Caguana et al. (34) the species that stands out most at the altitude of 3780-3880m.a.s.l. is the intermediate Calamagrostis.

The relative density indicates the number of specimens per sample unit that is not directly related to the area, in this study the species that has a higher density with respect to the total number of individuals of all species within the first altitudinal range (3,840 m.a.s.l.) is Calamagrostis intermedia with 7.76%, this does not resemble (35) . According to paramo studies, landscape studying, habilitated, managed and institutionalized among the (3,500-4,000) is characterized by a continuous coverage of vegetation, usually 100%. Where it is found mainly by grasslands of the genera Calamagrostis intermedia. (36) where the highest value of relative density has Lachemilla orbiculata with 55.37%, constituting the most important species at 3,600-3,800 meters above sea level, perhaps due to a variation in geographical location the páramo of Ichubamba Yasepan is located in the foothills towards the eastern margin of the Sangay National Park while the páramo of Chibuleo is located in the western foothills of the Andean mountain range.

The relative frequency indicates the relationship of the absolute records of a species and gel number togsuch of records of all species in this altitudinal range presents Calamagrostis intermediate 17.78%, very similar to (35) in which it is observed that the most important species at 3,800-4,000 m.a.s.l. is Calamagrostis intermedia with 19.41%, because it has the highest values in relative frequency with 5.19%.

With respect to the height of 3440 meters above sea level it can be observed that the Rosaceae family has a high percentage followed by the Asteraceae family, According to studies conducted by Smith & Cleef, (37), in the altitudinal range of 3400 to 3500 meters above sea level the most representative families are Rosaceae, Asteraceae and Geraniaceae. According to Ramírez (38) and Caranqui et al. (39), confirms the dominance of the family Asteraceae in genus and species.

TheRosaceae family is represented by the species Lachemilla orbiculata in a high percentage, which agrees with Vargas (40), which mentions that in this altitudinal range the species Lachemilla orbiculata this species is found especially in altered areas and grazing, its presence could be due to the presence of disturbance caused by grazing of cattle and horse.

The species Lachemilla orbiculata presents high values in terms of coverage and number of individuals, this resembles Acosta-Solís, M. (41), in the investigation carried out at the altitude of 3 500 meters above sea level in which the family Rosaceae is found, represented by the species Lachemilla orbiculata that dominates both in number of species and in coverage.

The highest relative frequency in this altitudinal range is presented by Lachemilia orbiculata with 18.92 %, which coincides with the research by (35) where the highest frequency in this altitudinal range is presented by Geranium reptans with 33.33%, followed by Lachemilla orbiculata with 25%, which means that the values obtained are within the range. The floristic composition of the páramo depends on successional dynamics and altitudinal and topographic variability, and, with increasing altitude, composition changes and plant diversity decreases. (42). It indicates that the lower the altitude, the greater the number of species and the higher the higher the number of species (43).

The individuals that project near the arrowhead of the vector that represents a variable, are individuals with high values in that variable, in this context the species Lachemilia orbiculata, Diplostephium ericoides and Geranium diffudum of stratum B have the highest values of IVI, in the case of Calamagrotis intermedia has the largest number of individuals in stratum A.

Knowing that the proximity between the points that represent the individuals indicates that they have a similar profile in the variables that are well represented in the factorial plane under study, we can appreciate 3 groups, the first characterized by species of stratum B with average values of the IVI, with a second group with species with high coverage characterized by greater diversity of families and species characteristic of height 3840 and a third group that has high IVI values representing species characteristic of stratum B. The height variable has the highest weighting in correspondence analysis.

5. Conclusions

The protected area Ichubamba Yasepan houses a great variety of flora distributed in the altitudinal range of 3840 and 3440 m.a.s.l. For stratum A of 3840 m.a.s.l., 16 botanical families and 24 species were identified, the species that presents the highest numerical value in DR%, FR% and IVI is Calamagrotis intermedia, For stratum B of 3440 m.s.n.m it can be observed that, the Rosaceae family presents a high percentage followed by the Asteraceae family, in addition to that it presents quantitative values with respect to density, the species that presents the highest numerical value in DR%, FR% and IVI is Lachemilla orbiculata, with greater dominance.

In relation to the Simpson index at the height of 3840 m.a.s.l., the value of the result is, 0.94 index considering that there is a high diversity, instead the Shannon index is 3.01 which means that there is an average diversity.

For the Shannon index at the height of 3440 meters above sea level, the value of the result is, 0.92 index considering that there is a high diversity, instead the Shannon index is 2.75 which means that there is an average diversity.

In relation to the analysis of the main components, the vector with the highest weighting of variables is the height, which indicates that there are differences between the composition and structure in the two strata A and B, the plant species of stratum A of 3840 masl tienen greater number of individuals and vegetation cover with a dominance of the species of Calamagrotis intermedia , while in stratum B the species Lachemilla orbiculata, has a high value in terms of IVI since in the lower zone there are alterations to the vegetation cover by grazing cattle and the species in question is displacing the native species.

Bibliography

1.Carrillo-Rojas G, Silva B, Rollenbeck R, Célleri R, Bendix J. The breathing of the Andean highlands: Net ecosystem exchange and evapotranspiration over the páramo of southern Ecuador. Agric For Meteorol. 15 de noviembre de 2018;265:30-47.

2.Tang J, Körner C, Muraoka H, Piao S, Shen M, Thackeray SJ, et al. Emerging opportunities and challenges in phenology: a review. Ecosphere. 2016;7(8):e01436.

3.Sklenář P, Balslev H. Superpáramo plant species diversity and phytogeography in Ecuador. Flora - Morphol Distrib Funct Ecol Plants. 6 de septiembre de 2005;200(5):416-33.

4.Ovacen. Moor; Climate, flora, fauna and characteristics | OVACEN [Internet]. 2018 [cited January 28, 2023]. Available in: https://ecosistemas.ovacen.com/bioma/paramo/

5.Llambí LD, Soto-W. A, Célleri R, Bièvre B de, editors. Ecology, hydrology and moorland soils: Andean Páramo Project. Quito: Andean Páramo Project; 2012. 283 p. (Andean Páramos).

6.Morocho CC, Chuncho G. Páramos del Ecuador, importancia y afectaciones: Una revision. Zero Latid Forests. 2019 Dec 31;9(2):71-83.

7.Bustamante M, Alban M, Arguello M. LOS PARAMOS DE CHIMBORAZO. 2011;

8.Badii MH, Landeros J, Cerna E. Patrones de asociación de especies y sustentabilidad (Species association patterns and sustainability). Daena Int J Good Conscience. 2008;3(1):632-60.

9.Hofstede R, Coppus R, Vásconez PM, Segarra P, Wolf J. THE STATE OF CONSERVATION OF THE PÁRAMOS DE PAJONAL IN ECUADOR. 2002;

10.Paruelo JM. The functional characterization of ecosystems using remote sensors. 2008;

11.SpectatorCH. Ichubamba Yasepan is the 60th protected area in Ecuador [Internet]. THE CHIMBORAZO SPECTATOR. 2020 [cited January 28, 2023]. Available in: https://elespectadorchimborazo.com/ichubamba-yasepan-es-el-area-protegida-60-en-ecuador/

12.Camacho M. The Ecuadorian páramos: characterization and considerations for their conservation and sustainable use. Rev An. 2014-1(372):77-92.

13.Balvanera P. Ecosystem services supplied by tropical forests. Ecosistemas. 2012;21(1-2):136-47.

14.GAD BARLEY. GOBIERNO AUTONOMO DESCENTRALIZADO PARROQUIAL RURAL DE CEBADAS [Internet]. 2015. Available from: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://app.sni.gob.ec/sni-link/sni/PORTAL_SNI/data_sigad_plus/sigadplusfinaldocument/0660818930001_PDyOT%20Consolidado_final_29-10-2015_23-07-05.pdf

15. González Y, Aragón G, Benítez A, Prieto M. Changes in soil cryptogamic communities in tropical Ecuadorean páramos. Community Ecol. 1 Apr 2017;18(1):11-20.
16. Whittaker RH. Communities and ecosystems [Internet]. 2d ed. New York: Macmillan; 1975 [citado 31 de enero de 2023]. 385 p. Disponible en: http://bvbr.bib-bvb.de:8991/F?func=service&doc_library=BVB01&local_base=BVB01&doc_number=001280348&line_number=0001&func_code=DB_RECORDS&service_type=MEDIA
17. Corvalán C, Hales S, McMichael AJ, Millennium Ecosystem Assessment (Program), World Health Organization, editores. Ecosystems and human well-being: health synthesis. Geneva, Switzerland: World Health Organization; 2005. 53 p. (Millennium ecosystem assessment).
18. Carilla J, Grau HR, Paolini L, Mariano M. Lake Fluctuations, Plant Productivity, and Long-Term Variability in High-Elevation Tropical Andean Ecosystems. Arct Antarct Alp Res. mayo de 2013;45(2):179-89.
19. Editorial Team. Simpson Index: Formula, Interpretation and Example [Internet]. Lifeder. 2020 [cited January 28, 2023]. Available in: https://www.lifeder.com/indice-simpson/
20. Pauli H, Gottfried M, Hohenwallner D, Reiter K, Grabherr G. Manual for GLORIA project fieldwork. Approach to the study of the peaks.
21. Jørgensen P, Neil D, León-Yánez S. MBG: Research: Ecuador: Catalogue of the Vascular Plants of Ecuador [Internet]. 1999 [citado 29 de enero de 2023]. Disponible en: http://www.mobot.org/mobot/research/ecuador/introductionsp.shtml
22. Vicente Villardon JL. MultBiplot | José Luis Vicente Villardón. April 10, 2013;
23. Curtis JT. The Vegetation of Wisconsin: An Ordination of Plant Communities. 1st edition. Madison: University of Wisconsin Press; 1959. 704 p.
24. Finol-Urdaneta H. New parameters to be considered in the structural analysis of tropical virgin forests. Rev For Venez [Internet]. 1972 [citado 25 de enero de 2023]; Disponible en: https://scholar.google.com/scholar_lookup?title=New+parameters+to+be+considered+in+the+structural+analysis+of+tropical+virgin+forests&author=Finol-Urdaneta%2C+H.&publication_year=1972
25. Mueller-Dombois D, Ellenberg H. Aims and methods of vegetation ecology. New York: Wiley; 1974. 547 p.
26. Toalombo-Quiquintuña EV, Lara-Vásconez NX, Caranqui-Aldaz JM, Cushquicullma-Colcha DF. The páramos of the protected area ichubamba yasepan: an approach to its structure, composition and state of conservation. 2022;7(12).
27. Smith TM, Smith RL. Ecology. 6th ed., reimp. Madrid [etc.]: Pearson; 2010.
28. Cardenas O, P G, L VVJ. Biplot methods: evolution and applications. Rev Venez Analysis Coyunt. 2007; XIII(1):279-303.
29. Torres-Salinas D, Robinson-García N, Jiménez-Contreras E, Herrera F, López-Cózar ED. On the use of biplot analysis for multivariate bibliometric and scientific indicators. J Am Soc Inf Sci Technol. 2013;64(7):1468-79.
30. Caranqui J, Lozano P, Reyes J, Caranqui J, Lozano P, Reyes J. Composition and floristic diversity of the páramos in the Chimborazo Fauna Production Reserve, Ecuador. UTE approach. 2016 Mar;7(1):33-45.

31.Beltrán K, Salgado S, Cuesta F, León-Yánez S, Romoleroux K, Ortiz E, et al. Spatial distribution, ecological systems and floristic characterization of the páramos in Ecuador. 2009;

32.Izco J, Pulgar Í, Aguirre Z, Santin F. Floristic study of the southern pajonal páramos of Ecuador. Rev Peru Biol. 2007 Dec;14(2):237-46.

33.Villarreal A, Zambrano-Cevallos R, Brito J, Burneo SF. Movement and habitat use of three high Andean rodent species (Cricetidae: Sigmodontinae) in Andean páramos of Ecuador. Neotropical Biodivers. 31 de diciembre de 2022;8(1):343-58.

34.Caguana-Muyolema JA, Román-Cáceres DA, Cevallos-Rodríguez JP, Roman-Robalino DA. Floristic study in the páramo ecosystem of the Galgalán ravine, Atillo community. Polo Conoc. 2020 Jul 22;5(7):1020-42.

35.Pujos L. FLORISTIC DIVERSITY AT DIFFERENT ALTITUDES IN THE PÁRAMO ECOSYSTEM OF THREE COMMUNITIES OF THE SECOND DEGREE ORGANIZATION UNION OF ORGANIZATIONS OF THE CHIBULEO PEOPLE [Internet]. [Riobamba]: Chimborazo Polytechnic High School; 2013. Available in: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://dspace.espoch.edu.ec/bitstream/123456789/2792/1/33T0114%20.pdf

36.Mena Vásconez P, Castillo A, editors. Páramo: landscape studied, inhabited, managed and institutionalized. Quito: ECOBONA; 2011. 386 p.

37.Smith JMB, Cleef AM. Composition and Origins of the World's Tropicalpine Floras. J Biogeogr. 1988;15(4):631-45.

38.Ramirez M. FLORISTIC DIVERSITY AT DIFFERENT ALTITUDES IN THE PÁRAMO ECOSYSTEM IN SEVEN COMMUNITIES OF THE UNOCANT S.O. [Internet]. [Riobamba]: Chimborazo Polytechnic High School; 2013. Available from: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://dspace.espoch.edu.ec/bitstream/123456789/2790/1/33T0112%20.pdf

39.Cranqui J, Haro W, Salas F, Palacios C. DIVERSITY AND SIMILARITY OF THE PÁRAMOS OF THE PROVINCE OF CHIMBORAZO IN ECUADOR - PDF Free download [Internet]. [cited 1 February 2023]. Available in: https://docplayer.es/49080419-Diversidad-y-similitud-de-los-paramos-de-la-provincia-de-chimborazo-en-ecuador.html

40.Vargas O. EFFECT OF GRAZING ON VEGETATION STRUCTURE IN A HUMID PARAMO OF COLOMBIA. 2002;

41.Acosta-Solis M. Los paramos andinos del Ecuador [Internet]. Quito (Ecuador) Publicaciones Cientificas MAS; 1984 [cited 6 February 2023]. Available in: https://scholar.google.com/scholar_lookup?title=Los+paramos+andinos+del+Ecuador&author=Acosta-Solis%2C+M.&publication_year=1984

42.Montalvo J, Minga D, Verdugo A, López J, Guazhambo D, Pacheco D, et al. Morphological-functional traits, tree diversity, growth rate and carbon sequestration in polylepis species and ecosystems of Southern Ecuador. Ecol Austral. 2018;28(1):249-61.

43.Bhattarai KR, Vetaas OR. Can Rapoport's rule explain tree species richness along the Himalayan elevation gradient, Nepal? Divers Distrib. 2006;12(4):373-8.