UNIVERSIDADE FEDERAL DE SÃO CARLOS
CENTRO DE CIÊNCIAS BIOLÓGICAS E DA SAÚDE
PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA E RECURSOS NATURAIS

Edna Viviana Calpa Anaguano

Mountain ranges and geographical isolation increase bird taxonomic but not phylogenetic beta diversity in the megadiverse Paramo ecosystems

São Carlos – SP

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Dissertação apresentada ao Programa de Pós-Graduação em Ecologia e Recursos Naturais da Universidade Federal de São Carlos como parte dos requisitos para a obtenção do título de Mestre em Ecologia e Recursos Naturais.

Orientador: Prof. Dr. Fernando Rodrigues da Silva

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UNIVERSIDADE FEDERAL DE SÃO CARLOS

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Assinaturas dos membros da comissão examinadora que avaliou e aprovou a Defesa de Dissertação de Mestrado do candidato Edna Viviana Calpa Anaguano, realizada em 29/08/2019:

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Certifico que a defesa realizou-se com a participação à distância do(s) membro(s) Augusto João Piratelli, Andrea Larissa Boesing e, depois das arguições e deliberações realizadas, o(s) participante(s) à distância está(ao) de acordo com o conteúdo do parecer da banca examinadora redigido neste relatório de defesa.

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FORMATAÇÃO:

Este trabalho segue as exigências do Regimento Interno do Programa de Pós-Graduação em Ecologia e Recursos Naturais (PPGERN) da universidade Federal de São Carlos – UFSCAR (http://www.ppgern.ufscar.br/). A dissertação foi regida no formato de artigo científico para apreciação no periódico *Journal of Biogeography* JBI-19-0396. Contudo, realizamos algumas alterações em relação as normas descritas pela *Journal of Biogeography* que julgamos melhorar a apresentação da dissertação. São elas: i) acrescentamos ao artigo um resumo redigido em português; e ii) inserimos as figuras e tabelas no final do artigo. Nos apêndices é possível encontrar todo o material suplementar.

Sumário

Resumo

Compreender a biodiversidade atual das regiões montanhosas neotropicais requer conhecimento de suas condições históricas e ecológicas. Neste estudo, avaliamos como a elevação andina, as oscilações climáticas quaternárias, o clima atual e o isolamento geográfico estão associados à distribuição espacial da beta (β) -diversidade taxonômica e filogenética das aves nos ecossistemas de Paramo, na cordilheira dos Andes, no sudoeste da Colômbia. Utilizamos dados de ocorrência para 175 espécies de aves registradas em 11 Paramos, calculamos a β-diversidade taxonômica (TβD) usando o índice de Simpson, e a β-diversidade filogenética (PβD) usando o $\text{PhyloSor}_{\text{Turn}}$. Fizemos um gráfico de linhagem através do tempo (LLT) para avaliar a associação entre a riqueza de espécies de aves e a fase final de elevação andina e oscilações climáticas quaternárias. Também utilizamos um procedimento de seleção de modelos com Modelos Lineares Generalizados para gerar modelos concorrentes que explicam a variação nas distribuições TβD e PβD. Observamos que dois terços das espécies de aves nos ecossistemas de Paramo são recentes e surgiram após o Mioceno tardio/Plioceno inicial. Nossos resultados indicam que a β-diversidade taxonômica média foi quatro vezes maior do que a β-diversidade filogenética média indicando que as comunidades de Paramo estão abrigando diferentes espécies de aves, mas estão intimamente relacionadas (por exemplo, os mesmos gêneros). Locais com alta diferença de distribuição altitudinal e geograficamente isolados apresentaram maior β-diversidade taxonômica e β -filogenética do que Paramos com distribuição altitudinal semelhante e próximos uns dos outros. Por tanto, a fase final da elevação dos Andes impactou a especiação aviária no ecossistema de Paramo, refletindo em altos valores de β-diversidade taxonômica, mas não β-diversidade filogenética. Além disso, as oscilações climáticas quaternárias podem ter facilitado a dispersão de aves entre localidades próximas, contribuindo para a associação de TβD e PβD ao isolamento geográfico (por exemplo, decadência de distância de similaridade). Os nossos resultados demonstraram que a integração das diferentes facetas da diversidade β em um quadro de ecologia de comunidades, fornece novas perspectivas para compreender os fatores históricos e ecológicos responsáveis pela geração de padrões de distribuição de espécies.

Palavras-chave: Elevação dos Andes, barreiras, biogeografia, dispersão, diversificação, Pleistoceno.

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Mountain ranges and geographical isolation increase bird taxonomic but not phylogenetic beta diversity in the megadiverse Paramo ecosystems

Short running title: Taxonomic and phylogenetic bird β-diversity

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Abstract

Aim. Understanding present-day biodiversity of Neotropical mountain regions requires knowledge of its historical and ecological conditions. We evaluated how Andean uplift, Quaternary climatic oscillations, current climate, and geographical isolation are associated to the spatial distribution of taxonomic and bird phylogenetic beta (β) diversity in the Paramo ecosystems.

Location. Andes mountains in southwestern Colombia

Methods. Using point occurrence data for 175 bird species recorded in 11 Paramos, we calculated taxonomic β-diversity (TβD) using Simpson index, and phylogenetic β-diversity (PβD) using $PhyloSor_{turn}$. We made a lineage through time (LLT) plot to evaluate the association between bird species richness and the final phase of Andean uplift and Quaternary climatic oscillations. We also used a model selection procedure with Generalized Linear Models to generate competing models that explain the variation in TβD and PβD distributions.

Results. Two thirds of the bird species in the Paramo ecosystems are recent and emerged after the late Miocene/early Pliocene. The average taxonomic β-diversity was four times higher than the average phylogenetic β-diversity indicating that Paramo assemblages are harboring different bird species, but they are closely related (e.g., same genera). Furthermore, places with high altitudinal range difference and geographically isolated had higher taxonomic and phylogenetic β-diversity than Paramos with similar altitudinal ranges and close to each other.

Main conclusions. The final phase of the Andes uplift impacted avian speciation in the Paramo ecosystem, reflecting in high values of taxonomic β-diversity, but not phylogenetic β-diversity. The Quaternary climatic oscillations might have facilitated bird dispersal between close localities contributing to the association of TβD and PβD to geographical isolation (e.g. distance decay of similarity). Our results demonstrated that the integration of different facets of β-diversity into a community ecology framework provides new insights to understand historical and ecological factors responsible for generating patterns of species distribution.

Keywords: Andes uplift, barriers, biogeography, dispersal, diversification, Pleistocene.

Introduction

A key challenge in ecological research is to integrate diversity measures to provide different perspectives on ecological and historical factors that structure communities (Ricklefs, 1987; Wiens & Donoghue, 2004; Vellend, 2010; Weber, Wagner, Best, Harmon, & Matthews 2017). There is increasing interest in using multiple facets (taxonomic, functional and/or phylogenetic) of beta(β)-diversity (Anderson et al., 2011) to infer the relative importance of historical isolation and environmental conditions in shaping present-day patterns of species distributions (Graham & Fine, 2008; Swenson, 2011; Swenson et al., 2012; Qian, Swenson, & Zhang, 2013; Da Silva, Almeida-Neto, & Arena, 2014; Weinstein et al., 2014), especially in regions with high levels of endemism and diversification, such as mountain ranges in the Neotropics.

The Paramo is an exclusive ecosystem in the tropical Andes of South America and one of the most biodiverse *hotspots* of the planet (Myers, Mittermeier, Mittermeier, da Fonseca, & Kent, 2000). This ecosystem constitutes of highland grasslands above the forest tree-line at isolated mountain-tops above 2,800 and 4,700 m (Madriñán, Cortés, & Richardson, 2013; Hazzi, Moreno, Ortiz-Movliav, & Palacio, 2018). Paramo ecosystem is an excellent study system for evaluating the spatial distribution of taxonomic and phylogenetic β-diversity because the final uplift of the Andes in conjunction with the Pleistocene climatic oscillation had a strong effect on the diversification of Andean biota due to vicariance and dispersal with subsequently isolation (Van der Hammen, 1974; Fjeldsa, Bowie, & Rahbek, 2012; Madriñán et al., 2013; Hazzi et al., 2018).While the final phase of the Andean uplift during the late Miocene/early Pliocene (Gregory-Wodzicki, 2000) created isolated "sky islands" surrounded by drier valleys which act as dispersal barriers (Hazzi et al., 2018), the Quaternary climate change caused repetitive range expansion and contraction, allowing down-slope migration through the drier valleys (Van der Hammen, 1974; Hooghiemstra, Wijninga, & Cleef, 2006; Hazzi et al., 2018). However, little is known about the mechanisms underlying the distribution of alternative facets of β-diversity at regional scale for this megadiverse region (see Weinstein et al., 2014 for hummingbird group). For example, we are not aware if two Paramo assemblages having a completely different species composition (i.e. high taxonomic β-diversity) harbor closely-related species (i.e. low phylogenetic β-diversity) due to allopatric speciation and subsequent dispersal or if they harbor completely different lineages (high phylogenetic β-diversity; Graham & Fine, 2008) due to *in situ* speciation (Fig. 1).

Here, we tested the relative importance of historical and ecological factors on the spatial distribution of birds' taxonomic and phylogenetic β-diversity in 11 Paramo ecosystems of southwestern Colombia. We expect to find high taxonomic β-diversity between assemblages due to the drier valleys created by the Andean uplift that increased speciation rate and endemism in the region (e.g. Hoorn et al. 2010; Fjeldsa et al., 2012; Jetz et al., 2012; Quintero & Jetz, 2018; Fig. 1). Conversely, we expect to find low phylogenetic β-diversity between assemblages due to Pleistocene climatic oscillation that facilitated the migration of different bird lineages through the drier valleys (Van der Hammen, 1974; Hazzi et al., 2018; Fig. 1). Considering the premises that allopatric speciation of species distributions that were formerly continuous and subsequent dispersal during Quaternary, we expect to find an association between the spatial distribution of taxonomic and phylogenetic β-diversity values with geographical isolation between Paramos (e.g. distance decay of similarity; Nekola & White, 1999). Lastly, although environmental filters (i.e. abiotic factors that prevent the establishment or persistence of species in a particular location) are important predictors of spatial distribution of bird β-diversity along elevational gradients (e.g., Herzog, Kessler, & Bach, 2005; Fjeldsa et al., 2012), we expect that current climatic conditions will not be associated with spatial distribution of taxonomic and phylogenetic β-diversity due to our spatial extent that limits the environmental variation between localities.

Materials and Methods

Study area

We used data from a large project of the Universidad de Nariño, Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (2016, http://doi.org/10.15472/zmnvox). Bird occurrences were recorded in 11 Paramos in the Andes mountain range over the Colombian massif and "Knot of the Pastos" (see Supplementary Material Fig. S1 and Table S1). In each Paramo, four sampling stations were delimited along an altitudinal transect (Fig. S1). The stations were distributed over four altitudinal zones typical of the Paramos (1) Paramo proper (3500-4100m) where grasses, "frailejones" (Asteraceae: Espeletiinae) and shrub vegetation predominate, (2) Low paramo or sub-paramo (3200-3500m) where shrub vegetation predominates and scrub (3) High andean-strip (2800-3200m) characterized by having vegetation with high forests (Rangel, 2000). Samplings were carried out from 7 to 9 days in each Paramo from January to July 2015 using: i) visual and auditory detection carried out during the peaks of activity from 5:30 to 9:30 hours and from 15:30 to 18:30 hours, on 6 count points of 25 meters radius in dense habitats (high Andean forest and dense shrubs) and 50 meters of radius in low shrubs and grasslands, whose central points were separated every 150 meters from each other; and ii) mist nets (12m x 2.5m and 32mm mesh eye) placed between the counting points in order to maintain the altitude level between stations. Nets were inspected between 6 to 18 hours (Marín, 2013).

Current and past climatic predictors

We obtained climatic variables of the last glacial maximum (LGM) 22,000 years ago (Community Climate System Model - CCSM4) and current climate from WorldClim (Hijmans, Cameron, Parra, Jones, & Jarvis, 2005; https://www.worldclim.org/) at a resolution of 2.5' (Table S2). We selected eight climatic variables based on previous studies that evaluated Andean bird distributions (e.g. Buermann et al., 2008; Graham, Parra, Rahbek, & McGuire, 2009; Leprieur et al., 2012; Table S2): Annual Mean Temperature (AMT), Mean Diurnal Range (MDR), Temperature seasonality (TS), Temperature Annual Range (TAR), Annual Precipitation (AP), Precipitation Seasonality (PS), Precipitation of Warmest Quarter (PWQ), Precipitation of Coldest Quarter (PCQ). We used elevation of the first and fourth stations (Fig. S1) to determine maximum altitude (MAAL- station 1), minimum altitude (MIAL- station 4), and altitudinal range (difference between MAAL and MIAL: RAAL).

Taxonomic and phylogenetic beta diversity

Taxonomic beta diversity (TβD). We calculated TβD between bird communities using the Simpson dissimilarity index (Lennon, Koleff, Greenwood, & Gaston, 2001). βsim is one of the most used measures to describe spatial turnover because it is not sensitive to differences in species richness between localities (Lennon et al., 2001). When all species are shared βsim = 1, and when no species is shared βsim= 0.

Phylogenetic beta diversity (PβD). We pruned the time-calibrated tree proposed by Jetz et al. (2012, https://birdtree.org/) to include the bird species found in our study sites. Only three species (*Arremon assimilis, Arremon atricapillus,* and *Scytalopus opacus*) from our data set were not present in the tree proposed by Jetz et al. (2012). Thus, we inserted these species as polytomies at genus level (Fig. 2). We calculated phylogenetic turnover using $PhyloSor_{Turn}$ that refers to the diversity generated by the replacement of lineages between communities (Leprieur et al., 2012). $PhyloSor_{Turn}$ = 1 indicates that two communities do not share any branch in the phylogenetic tree, and $PhyloSor_{Turn}$ = 0 indicates that two communities share all branches of the phylogenetic tree. We calculated a standardized effect size (SES) for PβD. SES values greater than 1.96 indicate a higher PβD than expected by TβD, while SES values below -1.96 indicate a lower PβD than expected by TβD (Leprieur et al., 2012). We also made a lineage through time (LLT) plot to evaluate the association between the number of bird species richness recorded in the Paramo assemblages to Andean uplift and Quaternary climatic oscillations.

Association between climatic conditions (current-historical), altitude, and geographic distance to taxonomic and phylogenetic β-diversity.

We performed a Principal Component Analysis (PCA) to reduce the dimensionality of altitudinal data (MAAL, MIAL and RAAL), current (AMT, MDR, TS, TAR, AP, PS, PWQ and PCQ) and last glacial maximum period (AMT, MDR, TS, TAR, AP, PS, PWQ and PCQ) climate variables. We found that 73% of variations in climate and altitudinal data were explained by the first two axes of the PCA (Table S3). Then, we used the pairwise Euclidean distance based on PC1 and PC2 to calculate environmental distance between sites. We measured geographic isolation by calculating Euclidean distance among all localities. Then, we used Generalized Linear Models (GLM) to generate competing models to explain the variation in TβD and PβD distributions. We entered these in a model selection procedure using Akaike's information criterion, corrected for small sample sizes (AICc, Burnham & Anderson, 1998). We also used Akaike weights (wAICc) to evaluate model support, which express the weight of evidence favoring a given model as the best one in the set (Burnham & Anderson, 1998). All analyzes were performed using the packages 'betapart' (Baselga et al., 2018), 'vegan' (Oksanen et al., 2019), 'picante' (Kembel et al., 2010) and 'ape' (Paradis et al., 2018) in R v. 3.4.3 (R Core Team, 2018).

Results

We recorded 175 bird species in the 11 Paramos. Interestingly, two thirds of the species arose after the late Miocene/early Pliocene (Fig 2). The average TβD (Mean = 0.44, SD = 0.07, Min = 0.29, Max = 0.60) was four times higher than the average PβD (Mean = 0.11, SD = 0.04, Min = 0.02, Max = 0.22; Fig. 2). These results indicate that the Paramo assemblages are harboring different, but closely- related bird species. Comparing the observed values of the PβD with those obtained by the null model (SES) indicated that only two of the 55 PβD values were different from expected by TβD (Fig. S2). Models containing altitude and geographic isolation were the best ones, explaining 64% and 30% of the spatial distribution of TβD and PβD, respectively (Table 1; Fig. 3). Paramos with different altitudinal ranges and far apart from each other had higher TβD and PβD (Fig. 3).

Discussion

We found that two thirds of the bird species emerged after the late Miocene/early Pliocene, indicating that the final phase of the Andean uplift has an important role in bird speciation in the Paramo ecosystems. Although the diversification rate of birds has increased from about 50 million years ago to near present, there is also large geographical variation in diversification rates with bird assemblages in Asia, North America, and southern South America containing a disproportionate number of species from recent radiations (Jetz et al. 2012). These young radiations are mostly related to mountainous regions that are centers of endemism and speciation as a result of geological and orogenetic history that presumably created dispersal barriers to organisms (Hoorn et al. 2010; Fjeldsa et al., 2012; Graham et al., 2014; Badgley et al., 2017; Antonelli et al., 2018). The influence of Andean mountain ranges became more evident when we observed the variation of phylogenetic and taxonomic β-diversity between bird assemblages. Lower phylogenetic β-diversity relative to taxonomic β-diversity is consistent with species being replaced by closely-related ones and usually results from recent geographic isolation of historically connected assemblages (Weinstein et al., 2014). Graham et al. (2009), evaluating hummingbird communities in the Andes, and Qian et al. (2013), evaluating regional floras at North America, also found that despite the large differences in species composition, each community is largely composed of the same phylogenetic components (i.e. the same genera and families). Taken together, these results indicate strong signatures of mountain chains and dispersal limitation on taxonomic and phylogenetic β-diversity of bird assemblages on Paramo ecosystems.

We found that variation in taxonomic and phylogenetic β-diversity of bird assemblages was associated to differences in elevation and geographic isolation among Paramo ecosystems. It is not only the role of the Andean uplift on diversification patterns of avian that is well established in the literature (Hoorn et al. 2010; Fjeldsa et al., 2012; Quintero & Jetz 2018), but also the variation in bird species richness and composition along elevational gradients (Terborgh, 1977; Rahbek 1995; Kattan & Franco, 2004; Herzog et al., 2005). It has been suggested that habitat specialization is one of the most important factors determining the distribution of birds along elevational gradients (Terborgh, 1977; McCain 2009; Fjeldsa et al., 2012). This is because elevational gradients promote a diversity of ecosystems with each ecosystem having its share of specialized birds (Terborgh, 1977; Herzog et al., 2005; Fjeldsa et al., 2012). Thus, the greater the difference in elevation between localities the greater the landscape heterogeneity associated to replacement of specialized and small-ranged species (Terborgh, 1977; Fjeldsa et al., 2012).

The pattern of distance decay of similarity observed to taxonomic and phylogenetic β-diversity in the Paramo assemblages could be related to the recent dispersal during Quaternary climatic oscillation with subsequently isolation. For example, Van der Hammen (1974) described that between 21,000 yr BP and 14,000 yr BP there was a very cold but dry period during which the Paramo ecosystem covered a much greater area than it does today, and that many of the currently isolated Paramos were then united. Recent studies have suggested that dispersal across the Andes occurring after major uplift episodes is one of the major driver of Neotropical bird distribution (Smith et al. 2014; Cadena, Pedraza, & Brumfield, 2016; Oswald, Overcast, Mauck, Andersen, & Smith 2017). Thus, although we did not find an association between facets of bird β-diversity and climatic conditions of LGM, it is possible that some areas may be presently unsuitable for the dispersal of birds across the Paramos, but under past climatic conditions they were substantially more likely to allow for ecological connectivity of populations between close localities.

Our results demonstrated that integration of different facets of β-diversity into community ecology can provide new ways to understand evolutionary and ecological factors of species distribution (Graham & Fine, 2008; Weinstein et al., 2014; Penone et al., 2016). We found support for most of our a priori expectations about the relationship between the taxonomic and phylogenetic β-diversity distributions and historical and ecological predictors. We showed that the final phase of Andes uplift had an important role in the avian speciation in the Paramo ecosystem, contributing to high taxonomic β-diversity, but not phylogenetic β-diversity across bird assemblages. Furthermore, Pleistocene climatic oscillations might have facilitated the bird dispersal between close localities contributing to the association of taxonomic and phylogenetic β-diversities to geographical isolation.

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Tables

Table 1. The five best generalized linear models (GLM) predicting the relationship between taxonomic (TβD) and phylogenetic (PβD) beta diversity (response variables) of bird assemblages and altitudinal data, geographical isolation and current and last glacial maximum period (LGM) climatic conditions on 11 Paramos distributed in the department of Nariño, Colombia. df = degree of freedom, logLik = maximum likelihood, AICc = Akaike's information criterion corrected by small samples, ΔAICc = difference in Akaike's information criterion, weight = AICc weight, %DE = proportion of deviance accounted for by the model.

Taxonomic β-diveristy (TβD)	**df**	**logLik**	**AICc**	**ΔAICc**	**weight**	**%DE**
Altitudinal + Geographical isolation	4	91.2	-173.7	0	0.88	63.8
Altitudinal + Geographical isolation + Current climate + LGM climate	6	91.7	-169.7	4	0.12	64.4
Altitudinal	3	82.9	-159.3	14.4	<0.001	50.9
Altitudinal + Current climate	4	83.6	-158.4	15.3	<0.001	52.2
Altitudinal + LGM climate	4	83.3	-157.9	15.8	<0.001	51.7
Phylogenetic β-diveristy (PβD)	**df**	**logLik**	**AICc**	**ΔAICc**	**weight**	**%DE**
Altitudinal + Geographical isolation	4	101.7	-194.5	0	0.47	29.8
Altitudinal + Geographical isolation + Current climate + LGM climate	6	104.1	-194.4	0.1	0.446	35.8
Geographical isolation + Current climate	4	98.4	-189	5.5	0.02	22.4
Altitudinal	3	97.3	-188.1	6.4	0.01	17.8
Geographical isolation	3	97	-187.4	7.1	0.01	16.8

Figures

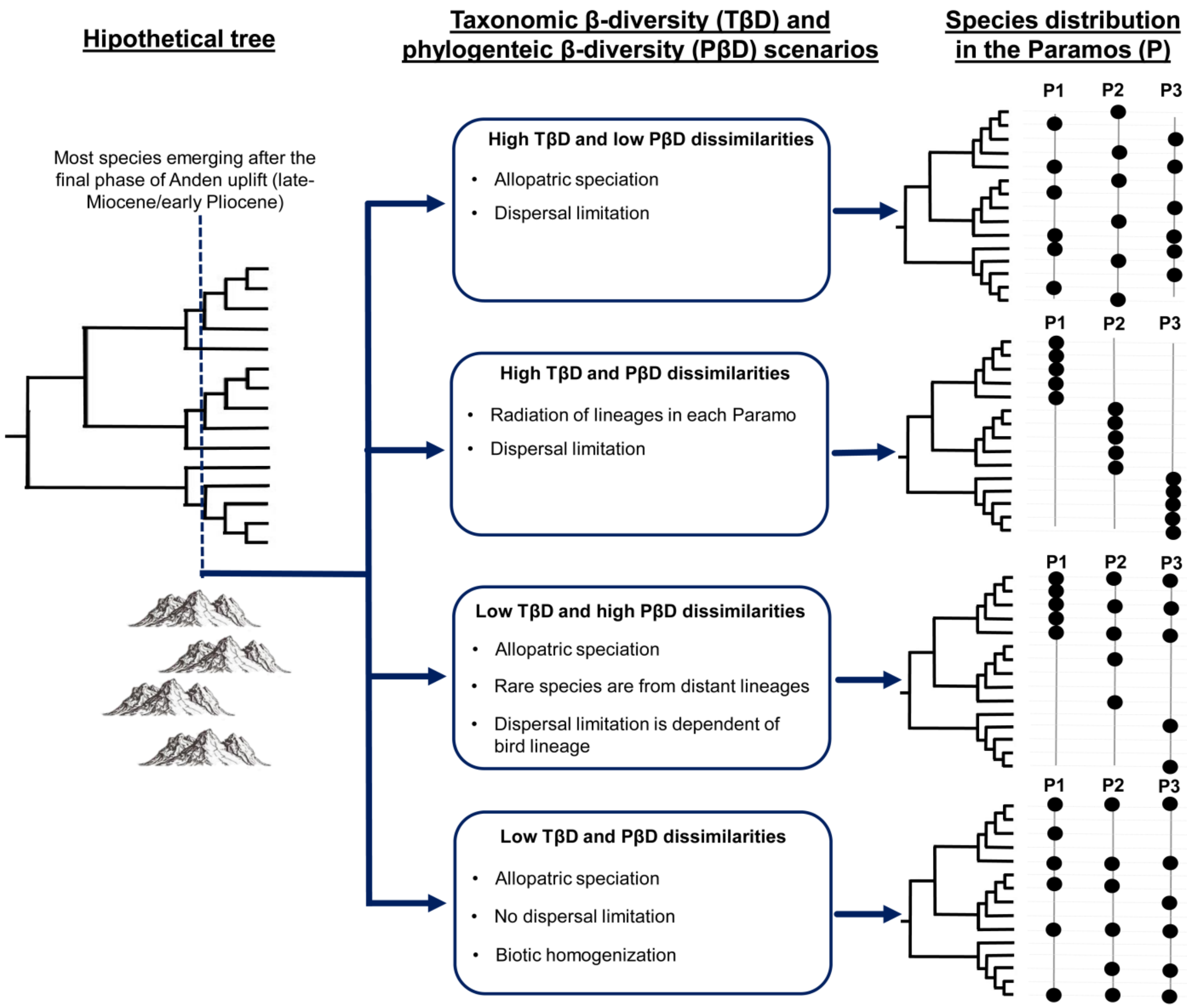

Figure 1. In the left corner, hypothetical phylogeny showing the relationship among bird species. Dashed blue line represents the final phase of the Andean uplift (late Miocene/early Pliocene – 7.0 m.y.a.). In the middle, framework describing the possible mechanisms related to spatial distribution of taxonomic (TβD) and phylogenetic (PβD) beta diversities evaluated across Paramo ecosystems. In the right corner, distribution of bird species in three hypothetical Paramo assemblages based on previously scenarios.

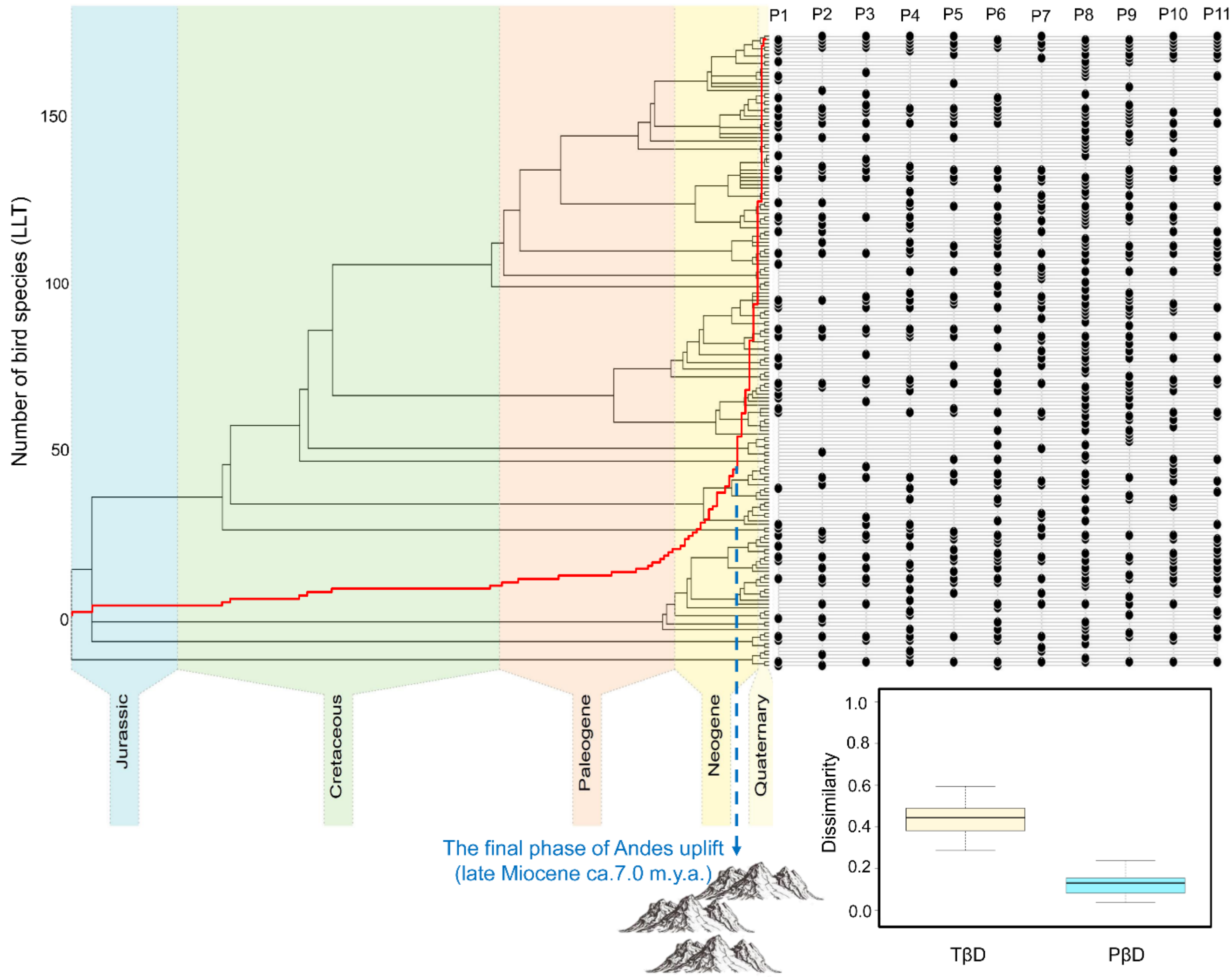

Figure 2. Time-calibrated tree (Jetz et al 2012) of the 175 bird species that occurred in the 11 Paramos (P1 to P11, black circles). Red line in the tree represents the lineage through time (LTT). Dashed blue line represents the estimated period of the final phase of the Andes uplift (late Miocene ca. 7.0 million years ago). At least, 100 lineages split after this period. Boxplot is showing the total taxonomic (TβD) and phylogenetic (PβD) beta diversity of the 11 assemblages.

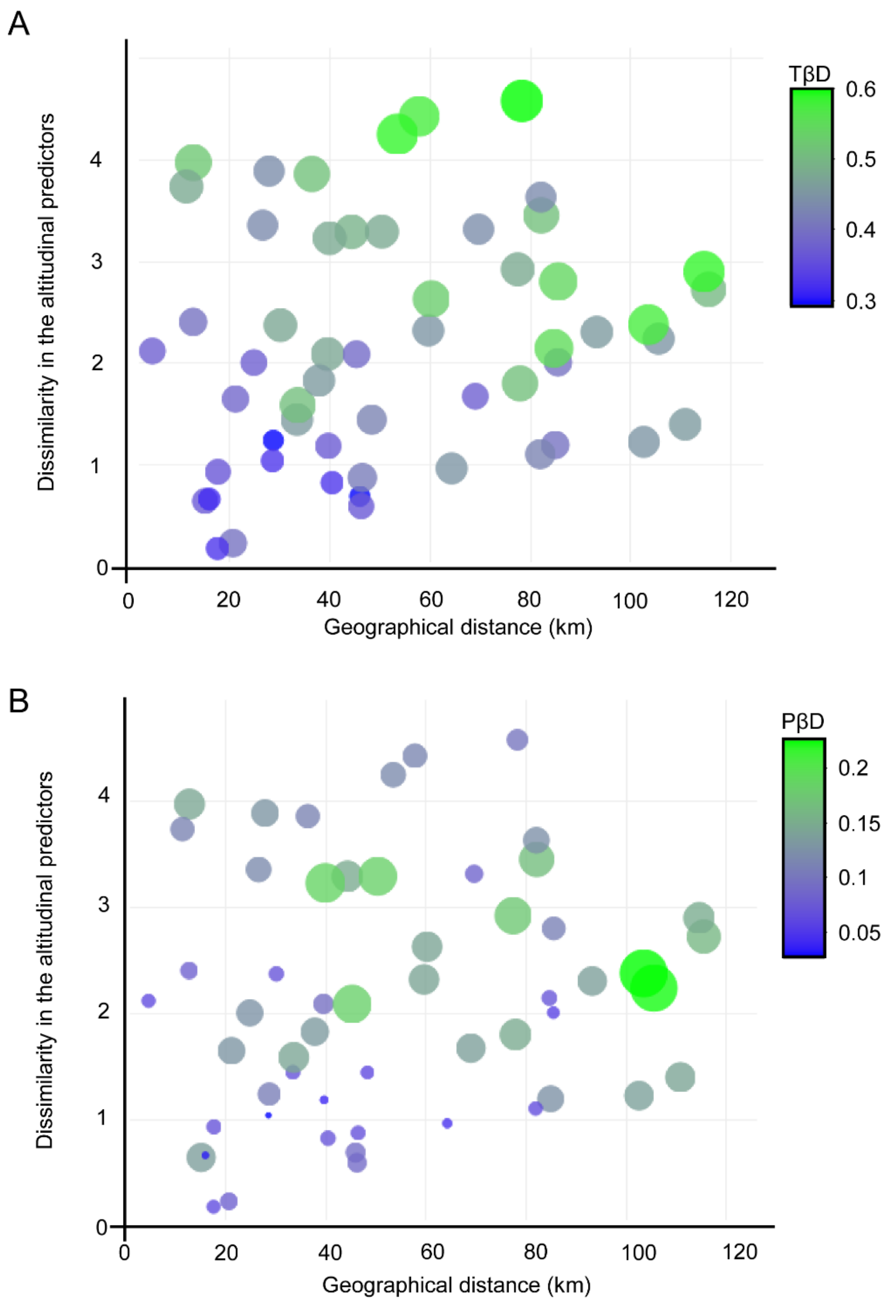

Figure 3. Distribution of taxonomic (TβD - A) and phylogenetic (PβD - B) beta diversity values of bird assemblages along altitudinal predictors (Y axis) and geographical isolation (X axis) among the Paramo ecosystems. Sizes and colors represent the gradient of TβD and PβD values. Paramos with different altitudinal predictors and far apart showed higher TβD and PβD values than localities with similar altitudinal predictors and close each other.

Appendix

SUPPLEMENTARY INFORMATION

Mountain ranges and geographical isolation increase bird taxonomic but not phylogenetic beta diversity in the megadiverse Paramo ecosystems

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Journal of Biogeography

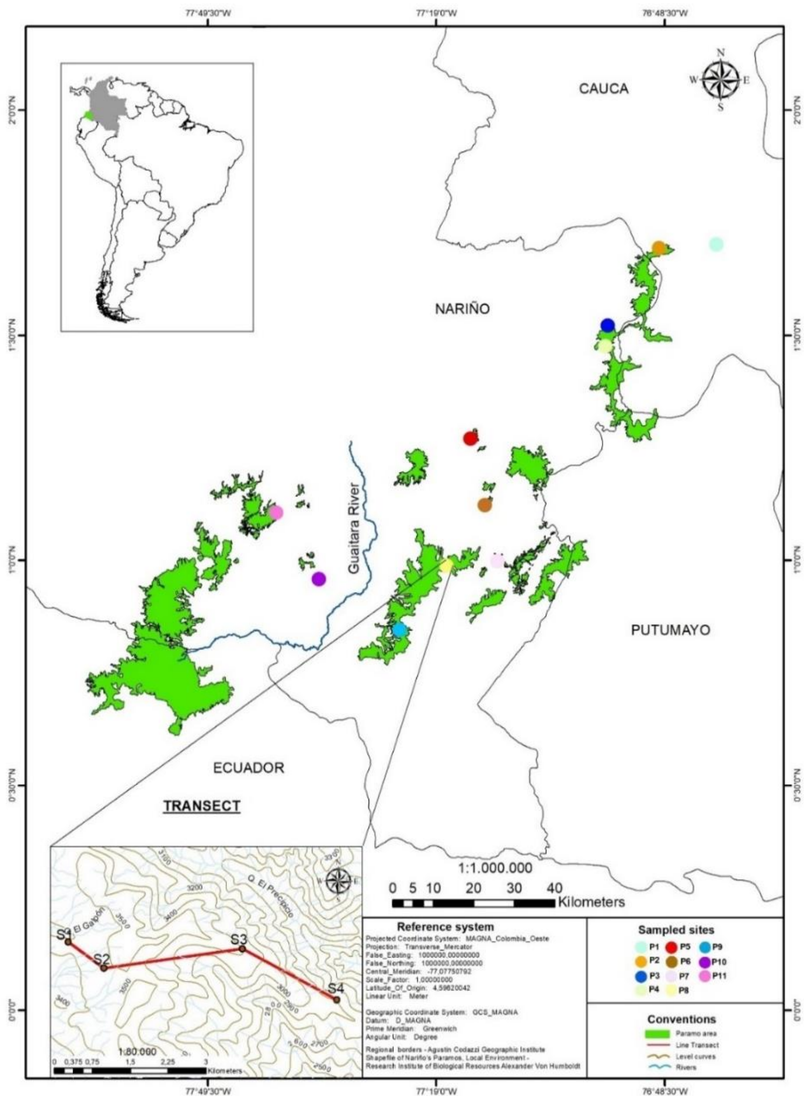

Figure S1. Study area. Location of the 11 Paramos (colored points) distributed in the department of Nariño, Colombia. Highlighted in the lower left corner is an illustration of the four transects sampled in each Paramo ecosystem.

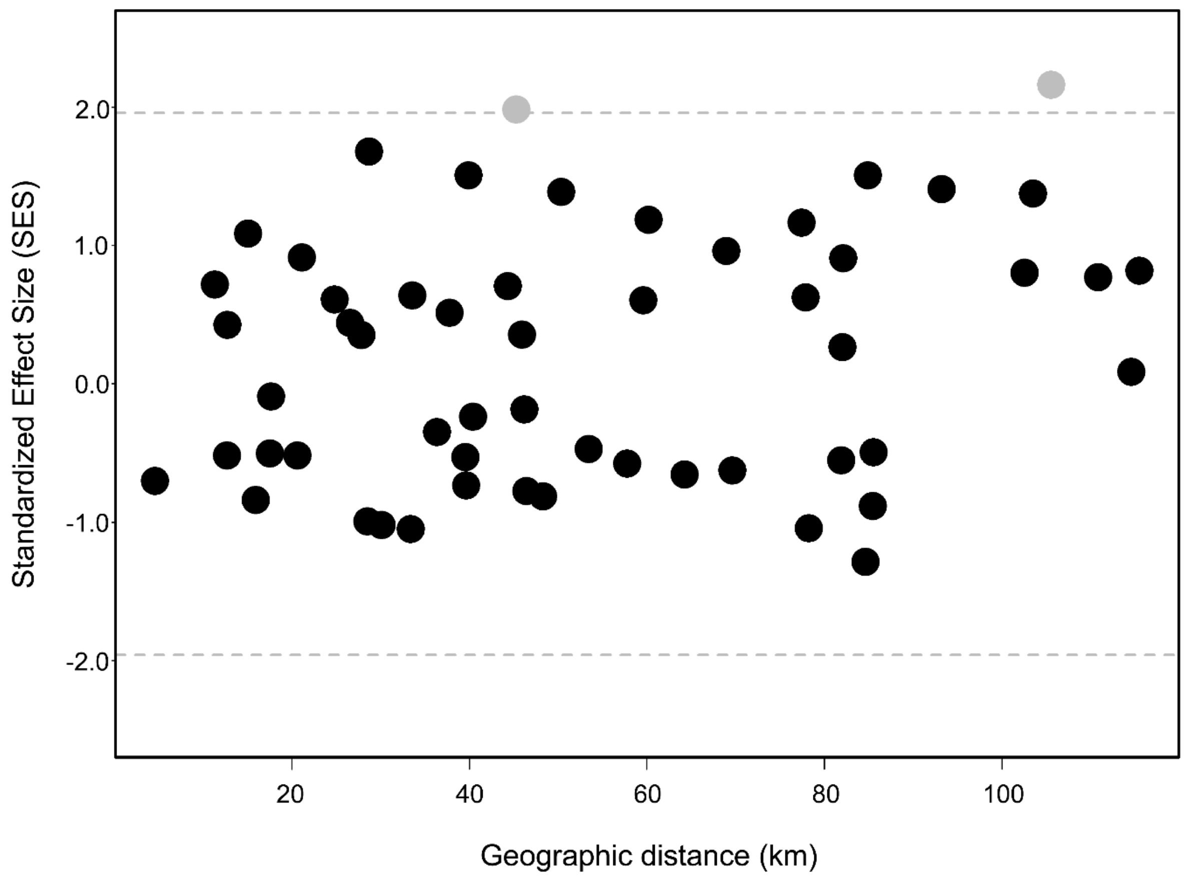

Figure S2. Standardized effect size (SES) for phylogenetic β-diversity (PβD) among 11 Paramo ecosystems distributed in the department of Nariño, Colombia. Values between dashed-gray lines indicate that PβD have no difference with respect to null expectation. Gray circles indicate SES higher than expected by Taxonomic β-diversity (TβD).

Table S1. List of bird species recorded in 11 Paramo ecosystems distributed in the department of Nariño, Colombia. Data obtained from the Universidad de Nariño, Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (2016, http://doi.org/10.15472/zmnvox).

Order	Family	Specie	Common Names English	Paramos										
				P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Galliformes	Cracidae	*Penelope montagnii*	Andean Guan	1	0	1	1	1	1	1	1	1	1	1
Galliformes	Cracidae	*Chamaepetes goudotii*	Sickle-winged Guan	1	1	0	0	0	1	0	0	0	0	0
Anseriformes	Anatidae	*Merganetta armata*	Torrent Duck	0	0	0	0	0	0	0	1	0	0	0
Anseriformes	Anatidae	*Anas flavirostris*	Yellow-billed Teal	0	1	0	1	0	0	0	0	0	0	0
Anseriformes	Anatidae	*Anas georgica*	Yellow-billed Pintail	0	0	0	1	0	0	1	0	0	0	0
Pelecaniformes	Ardeidae	*Nycticorax nycticorax*	Black-crowned Night-Heron	0	0	0	0	0	0	1	0	0	0	0
Pelecaniformes	Phalacrocoracidae	*Phalacrocorax brasilianus*	Neotropic Cormorant	0	0	0	0	0	0	0	1	0	0	0
Accipitriformes	Cathartidae	*Coragyps atratus*	Black Vulture	1	0	1	1	0	0	0	0	0	0	1
Falconiformes	Falconidae	*Phalcoboenus carunculatus*	Carunculated Caracara	0	0	0	0	1	1	0	1	0	1	1
Falconiformes	Falconidae	*Falco sparverius*	American Kestrel	0	0	0	0	0	0	0	0	0	1	0
Accipitriformes	Accipitridae	*Circus cinereus*	Cinereous Harrier	0	0	0	0	0	0	1	0	0	0	0
Accipitriformes	Accipitridae	*Accipiter striatus*	Sharp-shinned Hawk	0	0	1	0	0	0	1	0	0	0	0
Accipitriformes	Accipitridae	*Leucopternis princeps*	Barred Hawk	0	0	0	0	0	0	0	1	0	0	0
Accipitriformes	Accipitridae	*Buteo magnirostris*	Roadside Hawk	0	0	0	0	0	1	0	0	0	1	0
Accipitriformes	Accipitridae	*Buteo albicaudatus*	White-tailed Hawk	0	0	0	0	0	0	0	0	0	1	0
Accipitriformes	Accipitridae	*Spizaetus melanoleucus*	Black-and-White Hawk-Eagle	0	0	0	0	0	1	0	1	0	0	0
Charadriiformes	Charadriidae	*Vanellus chilensis*	Southern Lapwing	1	0	0	1	0	0	1	0	0	0	0
Charadriiformes	Scolopacidae	*Gallinago nobilis*	Noble Snipe	0	1	0	0	1	0	0	0	0	0	0
Columbiformes	Columbidae	*Patagioenas fasciata*	Band-tailed Pigeon	1	1	1	1	1	1	1	1	1	1	1
Columbiformes	Columbidae	*Patagioenas subvinacea*	Ruddy Pigeon	0	0	0	0	0	0	0	0	1	0	0

Columbiformes	Columbidae	*Zenaida auriculata*	Eared Dove	1	0	1	1	0	1	0	0	0	1	0
Psittaciformes	Psittacidae	*Aratinga wagleri*	Scarlet-fronted Parakeet	0	0	0	0	0	0	0	1	0	0	0
Psittaciformes	Psittacidae	*Leptosittaca branickii*	Golden-plumed Parakeet	0	1	0	0	0	0	0	0	0	0	0
Psittaciformes	Psittacidae	*Pionus menstruus*	Blue-headed Parrot	0	0	0	0	0	0	1	0	0	0	0
Psittaciformes	Psittacidae	*Pionus tumultuosus*	Speckle-faced Parrot	0	0	0	0	0	1	0	1	0	0	0
Psittaciformes	Psittacidae	*Amazona mercenaria*	Scaly-naped Parrot	0	0	0	0	0	0	0	0	1	0	0
Psittaciformes	Psittacidae	*Amazona farinosa*	Southern Mealy Parrot	0	0	0	0	0	0	0	0	1	0	0
Strigiformes	Strigidae	*Megascops choliba*	Tropical Screech-Owl	1	0	0	1	0	0	0	0	0	0	0
Strigiformes	Strigidae	*Bubo virginianus*	Great Horned Owl	0	0	0	0	0	0	0	0	0	0	1
Strigiformes	Strigidae	*Glaucidium jardinii*	Andean Pygmy-Owl	0	0	0	1	0	1	0	1	1	1	0
Strigiformes	Strigidae	*Asio stygius*	Stygian Owl	0	0	0	0	0	0	0	0	1	0	0
Caprimulgiformes	Caprimulgidae	*Caprimulgus longirostris*	Band-winged Nightjar	0	0	0	1	0	1	0	1	0	0	1
Apodiformes	Apodidae	*Streptoprocne zonaris*	White-collared Swift	0	1	0	0	0	1	0	1	0	0	0
Apodiformes	Apodidae	*Chaetura pelagica*	Chimney Swift	0	0	0	0	0	0	0	1	0	0	0
Apodiformes	Trochilidae	*Doryfera ludovicae*	Green-fronted Lancebill	1	1	0	0	0	0	0	0	0	0	0
Apodiformes	Trochilidae	*Colibri thalassinus*	Mexican Violet-ear	0	0	0	1	0	0	0	0	0	0	1
Apodiformes	Trochilidae	*Colibri coruscans*	Sparkling Violet-ear	0	0	0	1	0	0	0	0	1	0	1
Apodiformes	Trochilidae	*Adelomyia melanogenys*	Speckled Hummingbird	0	0	0	1	0	0	0	0	0	0	0
Apodiformes	Trochilidae	*Aglaeactis cupripennis*	Shining Sunbeam	0	0	0	0	1	0	0	1	0	1	1
Apodiformes	Trochilidae	*Lafresnaya lafresnayi*	Mountain Velvetbreast	0	1	1	1	0	1	0	1	0	1	1
Apodiformes	Trochilidae	*Coeligena coeligena*	Bronzy Inca	0	0	0	1	0	0	0	0	0	0	0
Apodiformes	Trochilidae	*Coeligena torquata*	Collared Inca	1	1	1	0	1	1	1	0	1	1	0
Apodiformes	Trochilidae	*Coeligena lutetiae*	Buff-winged Starfrontlet	1	0	0	0	1	1	1	1	1	1	1
Apodiformes	Trochilidae	*Ensifera ensifera*	Sword-billed Hummingbird	0	0	0	0	0	1	0	1	0	1	1
Apodiformes	Trochilidae	*Pterophanes cyanopterus*	Great Sapphirewing	0	0	0	0	1	0	0	0	0	0	1
Apodiformes	Trochilidae	*Heliangelus exortis*	Tourmaline Sunangel	0	1	1	0	0	1	1	1	1	1	0
Apodiformes	Trochilidae	*Eriocnemis vestita*	Glowing Puffleg	1	1	1	1	1	1	1	1	1	1	0
Apodiformes	Trochilidae	*Eriocnemis mosquera*	Golden-breasted Puffleg	0	1	1	0	1	1	0	1	0	1	1

Apodiformes	Trochilidae	*Eriocnemis derbyi*	Black-thighed Puffleg	0	0	0	0	0	1	0	0	0	0	1
Apodiformes	Trochilidae	*Haplophaedia aureliae*	Greenish Puffleg	1	0	0	1	0	0	0	0	0	0	0
Apodiformes	Trochilidae	*Lesbia victoriae*	Black-tailed Trainbearer	0	0	0	1	0	0	0	0	0	0	1
Apodiformes	Trochilidae	*Lesbia nuna*	Green-tailed Trainbearer	0	0	0	0	1	0	1	0	0	0	1
Apodiformes	Trochilidae	*Ramphomicron*	Purple-backed Thornbill	0	0	0	0	0	0	0	0	1	0	0
Apodiformes	Trochilidae	*Metallura williami*	Viridian Metaltail	0	0	0	0	0	0	0	0	1	0	0
Apodiformes	Trochilidae	*Metallura tyrianthina*	Tyrian Metaltail	1	1	1	1	1	1	1	1	1	1	1
Apodiformes	Trochilidae	*Chalcostigma herrani*	Rainbow-bearded Thornbill	0	1	1	0	1	1	0	1	0	1	0
Apodiformes	Trochilidae	*Opisthoprora euryptera*	Mountain Avocetbill	0	0	0	0	0	0	0	1	0	0	0
Apodiformes	Trochilidae	*Chaetocercus mulsant*	White-bellied Woodstar	0	0	0	0	0	1	0	0	0	0	0
Trogoniformes	Trogonidae	*Trogon personatus*	Masked Trogon	0	1	0	0	0	1	1	1	0	0	0
Piciformes	Ramphastidae	*Aulacorhynchus prasinus*	Emerald Toucanet	0	1	1	1	0	0	0	0	1	0	0
Piciformes	Ramphastidae	*Andigena hypoglauca*	Grey-breasted	0	0	0	0	1	1	1	1	0	1	1
Piciformes	Picidae	*Veniliornis dignus*	Yellow-vented Woodpecker	0	0	0	0	0	0	0	0	0	1	0
Piciformes	Picidae	*Veniliornis nigriceps*	Bar-bellied Woodpecker	0	0	1	0	0	0	0	0	0	0	0
Piciformes	Picidae	*Campephilus pollens*	Powerful Woodpecker	0	0	0	0	1	1	0	1	0	1	0
Passeriformes	Tityridae	*Pachyramphus versicolor*	Pachyramphus versicolor	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Cotingidae	*Ampelion rubrocristatus*	Red-crested Cotinga	0	0	1	1	0	0	0	0	0	1	1
Passeriformes	Cotingidae	*Pipreola riefferii*	Green-and-black Fruiteater	0	0	0	0	0	1	0	1	0	0	0
Passeriformes	Cotingidae	*Pipreola arcuata*	Barred Fruiteater	0	0	0	0	0	0	0	0	1	0	0
Passeriformes	Tyrannidae	*Phyllomyias nigrocapillus*	Black-capped Tyrannulet	0	0	0	0	0	0	1	1	1	0	0
Passeriformes	Tyrannidae	*Elaenia albiceps*	White-crested Elaenia	0	0	1	1	0	0	0	0	0	0	0
Passeriformes	Tyrannidae	*Elaenia frantzii*	Mountain Elaenia	1	1	1	1	1	1	0	0	0	0	0
Passeriformes	Tyrannidae	*Elaenia pallatangae*	Sierran Elaenia	1	1	0	1	1	0	1	1	1	1	1
Passeriformes	Tyrannidae	*Anairetes agilis*	Agile Tit-Tyrant	0	0	0	0	0	0	0	1	1	0	0
Passeriformes	Tyrannidae	*Anairetes parulus*	Tufted Tit-Tyrant	0	0	0	0	0	0	1	0	0	0	0
Passeriformes	Pipromorphidae	*Pseudotriccus ruficeps*	Rufous-headed Pygmy-Tyrant	1	0	0	0	0	0	1	1	1	1	1
Passeriformes	Tyrannidae	*Zimmerius chrysops*	Golden-faced Tyrannulet	0	0	0	0	0	1	0	1	0	0	0

Passeriformes	Pipromorphidae	*Mionectes oleagineus*	Ochre-bellied Flycatcher	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Pipromorphidae	*Hemitriccus granadensis*	Black-throated Tody-Tyrant	1	0	0	0	1	0	1	0	0	0	0
Passeriformes	Tyrannidae	*Pyrrhomyias cinnamomeus*	Cinnamon Flycatcher	0	0	1	0	0	0	0	0	0	0	0
Passeriformes	Tyrannidae	*Contopus fumigatus*	Smoke-colored Pewee	0	0	0	0	0	0	1	0	0	0	0
Passeriformes	Tyrannidae	*Agriornis montanus*	Black-billed Shrike-Tyrant	0	0	0	0	0	0	0	1	1	0	0
Passeriformes	Tyrannidae	*Myiotheretes fumigatus*	Smoky Bush-Tyrant	0	0	0	0	0	0	0	1	1	1	0
Passeriformes	Tyrannidae	*Ochthoeca frontalis*	Crowned Chat-Tyrant	1	0	0	0	1	0	0	1	0	1	0
Passeriformes	Tyrannidae	*Ochthoeca diadema*	Yellow-bellied Chat-Tyrant	1	0	1	1	0	1	1	1	1	1	1
Passeriformes	Tyrannidae	*Ochthoeca rufipectoralis*	Rufous-breasted Chat-Tyrant	0	0	0	1	0	1	0	0	1	0	0
Passeriformes	Tyrannidae	*Ochthoeca fumicolor*	Brown-backed Chat-Tyrant	1	1	1	1	1	0	1	0	1	0	0
Passeriformes	Tyrannidae	*Ochthoeca leucophrys*	White-browed Chat-Tyrant	0	0	1	0	1	0	1	1	1	0	0
Passeriformes	Tyrannidae	*Myiodynastes chrysocephalus*	Golden-crowned Flycatcher	0	0	0	0	0	0	0	0	1	0	0
Passeriformes	Tyrannidae	*Tyrannus melancholicus*	Tropical Kingbird	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Thamnophilidae	*Thamnophilus unicolor*	Uniform Antshrike	0	0	0	0	0	0	0	0	1	0	0
Passeriformes	Rhinocryptidae	*Scytalopus unicolor*	Unicolored Tapaculo	0	0	0	0	0	0	0	0	0	1	0
Passeriformes	Rhinocryptidae	*Scytalopus latrans*	Blackish Tapaculo	0	0	0	0	0	0	0	0	1	1	0
Passeriformes	Rhinocryptidae	*Scytalopus opacus*	Paramo Tapaculo	0	0	0	0	0	1	0	1	1	0	0
Passeriformes	Rhinocryptidae	*Scytalopus canus*	Paramillo Tapaculo	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Grallariidae	*Grallaria ruficapilla*	Chestnut-crowned Antpitta	1	0	0	1	1	1	1	0	0	1	1
Passeriformes	Grallariidae	*Grallaria rufula*	Rufous Antpitta	1	0	0	0	1	0	0	1	0	0	0
Passeriformes	Grallariidae	*Grallaria quitensis*	Tawny Antpitta	0	0	0	0	0	0	1	1	1	0	1
Passeriformes	Furnariidae	*Schizoeaca fuliginosa*	White-chinned Thistletail	1	1	0	0	0	0	0	1	1	0	0
Passeriformes	Furnariidae	*Synallaxis azarae*	Azara's Spinetail	1	1	1	1	1	1	1	0	1	1	1
Passeriformes	Furnariidae	*Hellmayrea gularis*	White-browed Spinetail	0	0	0	1	0	1	0	1	1	1	0
Passeriformes	Furnariidae	*Margarornis squamiger*	Pearled Treerunner	1	0	0	0	0	0	0	1	1	0	0
Passeriformes	Furnariidae	*Pseudocolaptes*	Streaked Tuftedcheek	1	0	0	0	0	0	0	0	0	0	0
Passeriformes	Scleruridae	*Sclerurus caudacutus*	Black-tailed Leaftosser	0	0	0	0	0	0	0	1	1	0	0
Passeriformes	Dendrocolaptidae	*Dendrocolaptes picumnus*	Black-banded Woodcreeper	0	0	1	0	0	0	0	0	0	0	0

Passeriformes	Vireonidae	*Vireo leucophrys*	Brown-capped Vireo	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Corvidae	*Cyanolyca pulchra*	Beautiful Jay	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Corvidae	*Cyanocorax yncas*	Inca Jay	0	0	0	0	0	1	0	0	0	0	0
Passeriformes	Hirundinidae	*Riparia riparia*	Sand Martin	0	0	0	0	0	0	1	0	0	0	0
Passeriformes	Hirundinidae	*Pygochelidon cyanoleuca*	Blue-and-white Swallow	0	0	0	0	0	1	1	0	0	0	1
Passeriformes	Hirundinidae	*Notiochelidon murina*	Brown-bellied Swallow	0	0	0	1	1	1	1	1	1	1	1
Passeriformes	Hirundinidae	*Hirundo rustica*	Barn Swallow	0	0	0	0	0	0	1	0	0	0	0
Passeriformes	Troglodytidae	*Cinnycerthia unirufa*	Rufous Wren	0	0	0	0	1	1	0	1	1	1	1
Passeriformes	Troglodytidae	*Cistothorus platensis*	Grass Wren	0	0	0	0	0	1	0	1	0	0	0
Passeriformes	Troglodytidae	*Troglodytes aedon*	House Wren	0	0	0	0	0	1	0	0	0	0	0
Passeriformes	Troglodytidae	*Troglodytes solstitialis*	Mountain Wren	1	1	0	0	0	1	1	0	0	1	1
Passeriformes	Troglodytidae	*Henicorhina leucophrys*	Grey-breasted Wood-Wren	0	1	0	1	0	0	0	1	0	0	1
Passeriformes	Turdidae	*Catharus ustulatus*	Swainson's Thrush	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Turdidae	*Turdus chiguanco*	Chiguanco Thrush	0	0	0	0	0	0	0	0	1	0	1
Passeriformes	Turdidae	*Turdus fuscater*	Great Thrush	1	1	1	1	1	1	1	1	1	1	1
Passeriformes	Turdidae	*Turdus serranus*	Glossy-black Thrush	0	0	0	1	0	0	0	0	0	0	0
Passeriformes	Cinclidae	*Cinclus leucocephalus*	White-capped Dipper	1	0	0	0	0	0	0	0	0	0	0
Passeriformes	Parulidae	*Dendroica fusca*	Blackburnian Warbler	0	0	0	1	0	0	0	0	0	0	0
Passeriformes	Parulidae	*Myioborus miniatus*	Slate-throated Redstart	0	0	0	0	0	0	1	1	0	0	0
Passeriformes	Parulidae	*Myioborus melanocephalus*	Spectacled Redstart	0	0	0	1	1	1	1	1	1	1	1
Passeriformes	Parulidae	*Myioborus ornatus*	Golden-fronted Redstart	1	1	0	1	0	0	0	0	0	0	0
Passeriformes	Parulidae	*Basileuterus luteoviridis*	Citrine Warbler	1	0	0	0	0	1	1	1	1	1	0
Passeriformes	Parulidae	*Basileuterus nigrocristatus*	Black-crested Warbler	1	1	1	1	0	1	0	1	1	1	0
Passeriformes	Parulidae	*Basileuterus coronatus*	Russet-crowned Warbler	0	1	0	1	0	0	0	1	0	0	0
Passeriformes	Parulidae	*Basileuterus tristriatus*	Three-striped Warbler	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Icteridae	*Cacicus chrysonotus*	Cacicus chrysonotus	0	0	0	0	0	0	1	0	0	0	0
Passeriformes	Icteridae	*Amblycercus holosericeus*	Yellow-billed Cacique	0	0	0	0	0	0	1	1	1	0	0
Passeriformes	Icteridae	*Icterus chrysater*	Yellow-backed Oriole	0	0	0	1	0	0	0	1	0	0	0

Passeriformes	Passerellidae	*Zonotrichia capensis*	Rufous-collared Sparrow	1	1	1	1	1	1	1	0	1	1	1
Passeriformes	Thraupidae	*Phrygilus unicolor*	Plumbeous Sierra-Finch	0	0	0	0	1	0	0	1	1	1	1
Passeriformes	Thraupidae	*Piezorina cinerea*	Cinereous Finch	0	0	0	0	1	0	0	0	0	0	0
Passeriformes	Thraupidae	*Catamenia inornata*	Plain-colored Seedeater	0	0	0	0	0	0	1	0	1	1	1
Passeriformes	Passerellidae	*Arremon torquatus*	Stripe-headed Brush-Finch	1	0	0	0	0	0	0	1	0	0	0
Passeriformes	Passerellidae	*Arremon assimilis*	Gray-stripped Brush-Finch	0	0	1	0	0	0	0	0	0	0	0
Passeriformes	Passerellidae	*Arremon atricapillus*	Black-headed Brush-Finch	0	0	1	0	0	0	0	0	0	0	0
Psittaciformes	Passerellidae	*Atlapetes albinucha*	White-naped Brush-Finch	0	0	0	0	0	1	0	0	0	0	0
Psittaciformes	Passerellidae	*Atlapetes pallidinucha*	Pale-naped Brush-Finch	0	0	0	0	1	0	1	1	1	0	1
Psittaciformes	Passerellidae	*Atlapetes latinuchus*	Rufous-naped Brush-Finch	0	1	0	1	0	0	0	0	0	0	0
Psittaciformes	Passerellidae	*Atlapetes leucopis*	White-rimmed Brush-Finch	0	0	0	0	0	0	0	1	1	0	0
Psittaciformes	Passerellidae	*Atlapetes schistaceus*	Slaty Brush-Finch	1	1	1	1	1	1	1	1	1	1	1
Passeriformes	Thraupidae	*Urothraupis stolzmanni*	Black-backed Bush-Tanager	0	0	0	0	0	0	0	0	1	1	0
Passeriformes	Thraupidae	*Sericossypha albocristata*	White-capped Tanager	0	1	0	0	0	0	0	0	0	0	0
Passeriformes	Thraupidae	*Creurgops verticalis*	Rufous-crested Tanager	0	0	0	0	0	0	0	0	1	0	0
Passeriformes	Thraupidae	*Hemispingus atropileus*	Black-capped Hemispingus	1	0	0	0	0	0	0	1	0	0	1
Passeriformes	Thraupidae	*Hemispingus verticalis*	Black-headed Hemispingus	0	0	1	0	0	0	0	1	0	0	0
Passeriformes	Thraupidae	*Cnemoscopus rubrirostris*	Grey-hooded Bush-Tanager	1	0	0	0	0	0	0	0	0	0	0
Passeriformes	Thraupidae	*Thlypopsis ornata*	Rufous-chested Tanager	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Thraupidae	*Thraupis cyanoptera*	Azure-shouldered Tanager	0	0	0	0	0	0	0	0	1	0	0
Passeriformes	Thraupidae	*Thraupis cyanocephala*	Blue-capped Tanager	0	0	0	0	0	1	0	0	0	0	0
Passeriformes	Thraupidae	*Buthraupis montana*	Hooded Mountain-Tanager	1	1	0	0	1	1	0	1	1	0	0
Passeriformes	Thraupidae	*Buthraupis wetmorei*	Masked Mountain-Tanager	0	0	1	0	0	0	0	0	1	0	0
Passeriformes	Thraupidae	*Anisognathus lacrymosus*	Lacrimose Mountain-Tanager	1	1	1	1	1	1	0	1	1	0	0
Passeriformes	Thraupidae	*Anisognathus igniventris*	Scarlet-bellied	0	1	1	1	1	1	0	1	1	1	1
Passeriformes	Thraupidae	*Chlorornis riefferii*	Grass-green Tanager	1	0	0	0	0	1	0	0	0	0	0
Passeriformes	Thraupidae	*Dubusia taeniata*	Buff-breasted	0	0	1	0	0	0	0	1	0	0	0
Passeriformes	Thraupidae	*Iridosornis rufivertex*	Golden-crowned Tanager	1	1	1	0	1	0	0	1	1	1	0

Passeriformes	Thraupidae	*Tangara labradorides*	Metallic-green Tanager	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Thraupidae	*Tangara nigroviridis*	Beryl-spangled Tanager	1	0	0	0	0	0	0	0	0	0	0
Passeriformes	Thraupidae	*Tangara vassorii*	Blue-and-black Tanager	1	1	1	1	1	1	0	1	1	1	1
Passeriformes	Thraupidae	*Conirostrum sitticolor*	Blue-backed Conebill	1	0	0	0	0	0	0	1	1	0	0
Passeriformes	Thraupidae	*Conirostrum albifrons*	Capped Conebill	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Thraupidae	*Diglossa albilatera*	White-sided Flowerpiercer	1	1	1	1	0	1	0	1	1	1	1
Passeriformes	Thraupidae	*Diglossa lafresnayii*	Glossy Flowerpiercer	1	1	1	1	1	1	1	1	1	1	1
Passeriformes	Thraupidae	*Diglossa humeralis*	Black Flowerpiercer	0	1	1	1	1	0	1	0	0	1	1
Passeriformes	Thraupidae	*Diglossa caerulescens*	Bluish Flowerpiercer	1	0	0	1	0	0	0	0	0	0	0
Passeriformes	Thraupidae	*Diglossa cyanea*	Masked Flowerpiercer	1	1	1	1	1	1	1	1	1	1	1
Passeriformes	Passerellidae	*Chlorospingus ophthalmicus*	Common Bush-tanager	0	0	0	0	0	0	0	0	1	0	0
Passeriformes	Thraupidae	*Catamblyrhynchus diadema*	Plushcap	0	0	0	0	0	0	0	1	1	0	0
Passeriformes	Cardinalidae	*Piranga rubra*	Summer Tanager	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Cardinalidae	*Piranga rubriceps*	Red-hooded Tanager	0	0	0	0	0	0	0	1	0	0	0
Passeriformes	Cardinalidae	*Pheucticus aureoventris*	Black-backed Grosbeak	0	0	0	0	0	0	0	0	0	1	0

Table S2. Environmental descriptors of the 11 Paramo ecosystems sampled in the department of Nariño, Colombia. Minimum altitude (MIAL; m), Maximum altitude (MAAL; m), Altitudinal range (RAAL; m), Annual Mean Temperature (AMT; °C*10), Mean Diurnal Range (MDR; °C*10), Temperature seasonality (TS; °C*10), Temperature Annual Range (TAR; °C*10), Annual Precipitation (AP; mm), Precipitation Seasonality (PS; mm), Precipitation of Warmest Quarter (PWQ; mm), Precipitation of Coldest Quarter (PCQ; mm).

	Geographical coordinates		Atitudinal data			Current climate								Last Glacial Maximum (LGM)							
Sites	Latitude	Longitude	MIAL	MAAL	RAAL	AMT	MDR	TS	TAR	AP	PS	PWQ	PCQ	AMT	MDR	TS	TAR	AP	PS	PWQ	PCQ
P1	1.701	-76.693	2677	3188	511	116	93	337	103	1901	16	524	463	99	407	94	122	353	17	101	561
P2	1.692	-76.820	2978	3606	628	86	86	392	97	2312	22	640	619	70	454	64	138	357	22	71	798
P3	1.52	-76.935	3003	3604	601	86	84	359	93	2415	22	679	643	71	466	64	143	382	23	71	844
P4	1.475	-76.940	2618	3381	763	87	84	392	93	2465	23	691	672	71	463	65	143	410	25	71	874
P5	1.269	-77.240	3280	3520	240	105	84	358	93	1781	18	530	386	91	387	85	116	335	18	91	551
P6	1.122	-77.208	3198	3551	353	105	85	400	95	1789	19	515	462	91	350	84	112	409	21	92	585
P7	0.997	-77.180	2798	2819	21	111	87	440	99	1666	22	469	460	97	307	90	98	434	23	98	541
P8	0.987	-77.293	3078	3504	426	77	83	466	95	1875	21	544	495	63	340	56	108	446	22	64	597
P9	0.844	-77.397	2909	3400	491	90	87	468	100	1564	18	458	395	76	294	68	94	473	19	77	462
P10	0.956	-77.577	3171	3408	237	108	93	427	105	1100	24	337	194	95	177	88	55	427	26	88	320
P11	1.104	-77.672	3202	3415	213	80	85	331	94	1493	25	475	254	67	254	62	74	337	26	62	481

Table S3. Analysis summary of the three Principal Component Analysis (PCA) performed for the altitudinal predictors and current and Last Glacial Maximum climatic conditions of 11 Paramo ecosystems in the department of Nariño, Colombia. Altitudinal data - MIAL = Minimum altitude (m), MAAL = Maximum altitude (m), RAAL = Altitudinal range (m); Current and Last Glacial Maximum (LGM) climate predictors - AMT = Annual Mean Temperature (°C*10), MDR = Mean Diurnal Range (°C*10), TS = Temperature seasonality (°C*10), TAR = Temperature Annual Range (°C*10), AP = Annual Precipitation (mm), PS = Precipitation Seasonality (mm), PWQ = Precipitation of Warmest Quarter (mm), PCQ = Precipitation of Coldest Quarter (mm). In bold, the predictors with highest values correlated with the axis of PCA.

	Current climate		Last Glacial Maximum (LGM)			Altitudinal data		
	PC1	PC2		PC1	PC2		PC1	PC2
AMT	-0.311	**-0.483**	AMT	**-0.439**	-0.286	MAAL	**0.803**	0.075
MDR	**-0.393**	-0.301	MDR	0.357	**-0.437**	MIAL	0.483	-**0.661**
TS	-0.101	0.282	TS	-0.433	-0.297	RAAL	0.346	**0.745**
TAR	-0.414	-0.185	TAR	0.355	-0.428			
AP	0.435	-0.296	AP	-0.080	0.256			
PS	0.067	**0.572**	PS	0.099	**0.429**			
PWQ	**0.457**	-0.225	PWQ	-0.399	-0.366			
PCQ	0.403	-0.306	PCQ	**0.434**	-0.263			
Proportion of variance	0.531	0.204		0.482	0.326		0.511	0.488
Cumulative prop.	0.531	0.736		0.482	0.808		0.511	1.000