FunAndes – A functional trait database of Andean plants

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We introduce the FunAndes database, a compilation of functional trait data for the Andean flora spanning six countries. FunAndes contains data on 24 traits across 2,694 taxa, for a total of 105,466 entries. The database features plant-morphological attributes including growth form, and leaf, stem, and wood traits measured at the species or individual level, together with geographic metadata (i.e., coordinates and elevation). FunAndes follows the field names, trait descriptions and units of measurement of the TRY database. It is currently available in open access in the FIGSHARE data repository, and will be part of TRY’s next release. Open access trait data from Andean plants will contribute to ecological research in the region, the most species rich terrestrial biodiversity hotspot.

Background & Summary

Functional traits are measurable properties of a plant describing its structure, function or life history strategy that determine species responses to biotic and abiotic environmental conditions across scales of biological complexity, from communities to ecosystems1–4. Exploring variation in plant functional traits provides key insights into plant species distribution, community assembly mechanisms, evolutionary strategies, and ecosystem level potential responses to global environmental change5–13. Global databases of plant functional traits currently feature an unprecedented amount of trait information that supports scientific work on plant functional ecology, including BIEN14, GIFT15, and TRY16,17. Yet, the geographical coverage of trait measurements still remains limited for highly diverse tropical areas, especially in mountainous regions15,16.

The tropical Andes is a major hotspot of global biodiversity and endemism. With about 2% of the terrestrial area of the planet, it holds 10% of the species of vascular plants18–20. However, trait information for Andean plants is underrepresented in global plant trait databases. These information gap limits our understanding of variation in plant trait composition and diversity at regional, continental, and global scales. Synthesizing and harmonizing trait measurements from remote and understudied areas is critical for global and regional data archiving initiatives21, and for advancing empirical biodiversity research. Here, we present the FunAndes database, a compilation of plant functional traits in the tropical Andes (Fig. 1). The records in FunAndes stem from 18 unpublished datasets contributed by different research groups conducting fieldwork in the region. FunAndes follows the structure and terminology of the TRY database, and is available in the FIGSHARE data repository22.

In total, FunAndes contains 105,466 records of 24 traits, covering 2,694 Andean (morpho-) species in 670 genera and 175 families. Assembling FunAndes encompassed the following steps: 1) developing a TRY-based format for data contributors, 2) revising comparability among protocols used for trait data collection, 3) checking trait measurement units for each contributed dataset, 4) detecting and deleting suspicious or erroneous trait measurements, 5) compiling the contributed data into a unique source with common taxonomic names, units, and terminology. To our knowledge, FunAndes is the first open access trait database of the Andean flora, filling a substantial gap in global functional trait data. We hope that providing a standardized and curated database on Andean plant traits will encourage plant trait ecological research in Andean ecosystems, as well as comparative studies across tropical regions.

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Methods

**Primary sources.** We first developed a basic data template containing trait names, trait descriptions and units of measurement, together with information (e.g., site coordinates and collection dates, number of samples collected). This template was distributed to potential data contributors, scientists collecting vascular plant functional trait data mainly in tropical forests of the Andean region. Filled templates were returned to the writing team, and FunAndes was assembled from 18 distinct datasets containing field data of Andean plant traits (Tables 1 and 2).

**Trait definitions and protocols.** Trait definitions and trait units of measurement in FunAndes follow those of the TRY database, for a total of 24 plant traits, two categorical and 22 numerical (Table 3). All trait data contributed to FunAndes were obtained from individuals growing in natural vegetation, following standard and comparable methods\(^2\). Furthermore, traits were measured mostly in adult individuals, never in seedlings or saplings. Leaf traits were quantified from exposed mature leaves in the plant canopy. A summary of trait geographical representation in FunAndes is presented in Fig. 1. A comparison between trait data in FunAndes and TRY version 5\(^17\) is presented in Table 4.

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### Table 1. Species and trait observations per country in FunAndes.

| Country       | SpeciesNames (n) | Trait observations (n) | Trait observations (%) |
|---------------|------------------|------------------------|------------------------|
| 1 Argentina   | 97               | 1457                   | 1.38                   |
| 2 Bolivia     | 692              | 19,463                 | 18.45                  |
| 3 Colombia    | 294              | 7,150                  | 6.78                   |
| 4 Ecuador     | 1170             | 50,401                 | 47.79                  |
| 5 Peru        | 1287             | 26,372                 | 25.01                  |
| 6 Venezuela   | 27               | 623                    | 0.59                   |
| **Total**     | **NA**           | **105,466**            | **100**                |

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**Fig. 1** Geographic distribution of plant traits in FunAndes and TRY version 5\(^17\) in 1-degree cells (~1 km). Montane sites above 500 m of elevation and buffer areas of 50 km below such elevation show density distribution of the most representative plant traits in FunAndes and TRY along the latitudinal gradient.

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Database structure. The database contains 24 fields to provide contextual information about data collection, including association of trait data to permanent vegetation plots, site coordinates and collection dates; and information about the trait value provided (e.g., if the value provided is a single observation or an average of trait measurements) (Table 5).

Harmonization. We followed various steps to ensure the quality of the data before adding a contributed dataset to FunAndes. Our workflow consisted of a series of operations, including generating dataset IDs for...
each contributed dataset, harmonizing data into common measurement units, translating terms (trait values) for categorical variables, verifying and correcting collection coordinates, and identifying erroneous trait data measurements. Each data contributor was contacted to double check methods used for trait collection, correct or eliminate suspicious trait values. Finally, duplicates were removed to create the final version of the database. All steps taken toward data standardization were done in R\textsuperscript{16} using built-in functions and the package ‘dplyr’\textsuperscript{25}.

**Taxonomy.** Species names standardization was conducted with the R package ‘LCVP’ of The Leipzig Catalogue of Vascular Plants\textsuperscript{18}. Original species names were compared to LCVP names by searching for matches. Non-matches (mainly caused by incorrect spelling) were revised by an expert in Andean flora (J.H.), and corrected following LCVP. The final FunAndes database reports both the original and the updated taxon name alongside each trait record. For each morphospecies, higher taxonomic affiliations obtained from the LCVP were included.

**Data Records**

**Access.** FunAndes database is stored and available for direct download from the FIGSHARE data repository\textsuperscript{22} and will become available from the TRY Plant Trait Database in the next release (https://www.try-db.org).

**Data coverage.** FunAndes includes 105,466 trait records for 24 traits of 2,694 Andean morpho-species in 670 genera and 175 taxonomic families. Therefore, FunAndes presents trait information for roughly nine percent of the ~30,000 species of vascular plants estimated to occur in the Tropical Andes\textsuperscript{20,26}. Three traits of FunAndes (plant growth form, leaf compoundness, specific leaf area) make up half of the records in the database (Table 4).

![Table 4. Plant functional traits in FunAndes in comparison to TRY version \textsuperscript{517} for the Andean region.](https://www.nature.com/scientificdata)

| Trait | FunAndes | TRY |
|-------|----------|-----|
|       | Number of Project IDs | Entries | Entries identified to genus or species level | Species | Entries |
| Bark thickness | 2 | 1242 | 1232 | 340 | 0 |
| Leaf aluminium (Al) content per leaf dry mass | 2 | 1712 | 1689 | 402 | 318 |
| Leaf area (in case of compound leaves: leaf, petiole excluded) | 2 | 686 | 670 | 162 | 0 |
| Leaf area (in case of compound leaves: leaf, petiole included) | 10 | 8512 | 6399 | 1534 | 0 |
| Leaf area per leaf dry mass (specific leaf area, SLA or 1/LMA): petiole, rachis and midrib excluded | 2 | 681 | 665 | 161 | 247 |
| Leaf area per leaf dry mass (specific leaf area, SLA or 1/LMA): petiole included | 14 | 16458 | 15577 | 2423 | 0 |
| Leaf calcium (Ca) content per leaf dry mass | 3 | 2289 | 2213 | 558 | 318 |
| Leaf carbon (C) content per leaf dry mass | 5 | 2785 | 2700 | 654 | 882 |
| Leaf carbon (C) isotope signature (delta 13 C) | 2 | 259 | 257 | 72 | 68 |
| Leaf compoundness | 18 | 18570 | 17642 | 2600 | 423 |
| Leaf dry mass per leaf fresh mass (leaf dry matter content, LDMC) | 6 | 2058 | 2049 | 403 | 68 |
| Leaf magnesium (Mg) content per leaf dry mass | 2 | 2096 | 2023 | 519 | 318 |
| Leaf nitrogen (N) content per leaf dry mass | 6 | 2853 | 2768 | 669 | 1698 |
| Leaf nitrogen (N) isotope signature (delta 15 N) | 2 | 259 | 257 | 72 | 0 |
| Leaf phosphorus (P) content per leaf dry mass | 4 | 2378 | 2302 | 577 | 1566 |
| Leaf potassium (K) content per leaf dry mass | 2 | 2170 | 2096 | 523 | 318 |
| Leaf texture (sclerophylly, physical strength, toughness) | 7 | 8200 | 7414 | 1779 | 257 |
| Plant growth form | 17 | 18780 | 17818 | 2657 | 2064 |
| Stem conduit cross-sectional area (vessels and tracheids) | 1 | 933 | 912 | 367 | 3 |
| Stem conduit density (vessels and tracheids) | 1 | 930 | 909 | 367 | 0 |
| Stem dry mass per stem fresh volume (stem specific density, SSD, wood density) branch | 8 | 8418 | 7625 | 1795 | 0 |
| Stem dry mass per stem fresh volume (stem specific density, SSD, wood density) sapwood | 5 | 2845 | 2814 | 683 | 0 |
| Wood (sapwood) specific conductivity (stem specific conductivity) | 1 | 929 | 908 | 367 | 3 |
| Total | 105,466 | 100,346 | 8551 |

Table 4. Plant functional traits in FunAndes in comparison to TRY version \textsuperscript{517} for the Andean region.
observations are grouped mainly around 500, 1,000, 2,000 and 3,000 m of elevation (Fig. 2a). The data is widely distributed along a gradient of mean annual temperature, but clustered toward lower values of total mean annual precipitation (Fig. 2b).

The five most represented plant functional traits in FunAndes - plant growth form, leaf compoundness, specific leaf area (SLA), wood density, leaf thickness - are homogeneously distributed in the tree phylogeny (Fig. 3).

TRY version 5.23 hosts 8,548 entries for Andean plants, corresponding to 1,123 species, and 15 of the 24 functional traits held in FunAndes (Table 4). FunAndes, therefore, will increase available trait data by a factor of 12, and at least double the current representation of traits per species in TRY. In consequence, FunAndes is a substantial contribution to plant functional trait data availability for the Andean region.

| Number | Field          | Definition                                                                 |
|--------|----------------|-----------------------------------------------------------------------------|
| 1      | Project_ID     | Project name of the contributed dataset                                      |
| 2      | Plot_ID        | Plot identification code                                                     |
| 3      | Plant_ID       | Plant identification code or voucher                                         |
| 4      | Sample_ID      | Sample number                                                               |
| 5      | SpeciesOriginal| Species of the plant in the original dataset                                 |
| 6      | OrderLCVP      | Taxonomic order provided by the Leipzig Catalogue of Vascular Plants         |
| 7      | FamilyLCVP     | Taxonomic family provided by the Leipzig Catalogue of Vascular Plants        |
| 8      | GenusLCVP      | Taxonomic genus provided by the Leipzig Catalogue of Vascular Plants         |
| 9      | SpeciesLCVP    | Taxonomic species provided by the Leipzig Catalogue of Vascular Plants       |
| 10     | Long           | Longitude in decimal degrees                                                 |
| 11     | Lat            | Latitude in decimal degrees                                                  |
| 12     | Elevation      | Elevation in m                                                              |
| 13     | Country        | Country                                                                      |
| 14     | Collection_year| Year of collection                                                           |
| 15     | ValueKindName  | Value kind (single measurement, mean, median, etc.)                         |
| 16     | SpeciesName    | Revised species name                                                         |
| 17     | OrigValueStr   | Trait value                                                                  |
| 18     | OriginalName   | Trait name following TRY                                                     |
| 19     | OrigUnitStr    | Trait units                                                                  |
| 20     | LastName       | Last Name of the PI contributing the dataset                                |
| 21     | FirstName      | First Name of the PI contributing the dataset                               |
| 22     | Email          | Email of the PI of the contributed dataset                                   |
| 23     | Dataset        | Identifier of the dataset in TRY (FunAndes)                                  |
| 24     | Observation_ID | Unique identifier of each observation in FunAndes                            |

Table 5. Definitions of fields in the FunAndes database.

Fig. 2 Distribution of plant trait data in FunAndes along gradients of (a) elevation, (b) Mean annual temperature and Mean total annual precipitation. Climatic variables were extracted from the Chelsa climate database27.
Technical Validation
For each contributed dataset we visually inspected all data and metadata producing histograms of each trait value to identify outliers or mistaken measures. In most cases, extreme values were discussed with data contributors to make decisions toward correcting or eliminating erroneous observations. With the final version of the database, histograms were produced once again to check for outliers or mistaken values.

Usage Notes
The data can be downloaded from the FIGSHARE data repository under the terms of Creative Commons Zero (CC0) waiver. We also provide FunAndes database in the TRY Plant Trait Database (https://www.try-db.org). Users of FunAndes data are invited to cite this publication: Báez et al. xx. FunAndes – A functional trait database of Andean plants. Scientific Data. 00:00-00, and the accompanying FIGSHARE dataset22.

Code availability
The contributed datasets were provided in Excel spreadsheets (Microsoft Office 2013), therefore no code is available for this step. Scripts to conduct taxonomic standardization using the LCVP, to plot environmental distribution, and trait representation in the plant phylogeny are available at FIGSHARE22. The scripts were developed in R.

Received: 24 March 2022; Accepted: 8 August 2022;
Published online: 20 August 2022
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Acknowledgements

This work was possible thanks to funding from the Living Earth Collaborative (LEC) at Washington University in St. Louis, for the working group ‘A synthesis of patterns and mechanisms of diversity and forest change in the Andes: A global biodiversity hotspot’ (organized by JST, IAM, and SB), and by the German Centre for Integrative Biodiversity Research (iDiv), for the working group ‘Andes: Tree diversity, composition and carbon storage in Andean tropical montane forests’ (organized by LC and MJM). The authors are grateful to Jens Katteg for making the TRY data presented in this paper. AA-Q thanks the Herbario Nacional de Bolivia, the German Academic Exchange Service (DAAD) and DFG for funding (HE3041/20-1); to Ricardo Sonco and Marcelo Reguerin, Arely Palabral, Heike Heklau, and the Chulumani community. SB thanks the financial support of the Alexander von Humboldt Foundation through a Georg Foster Fellowship; SB, MB and HV acknowledge VLIR-UOS grants COFOREC (EC2018SIN223A103) and COFOREC II (EC2020SIN279A103). GBD was funded through a PhD grant by the Spanish Ministry of Education (MINEDU; FPU14/05303) and is indebted to Alex Nina, Jorge Armijos, Gonzalo Bañares, José Sánchez, Ángel Delso, Anselmo Vergaray, “Rosho” Tamayo, Reynierio Ishuiza, and national parks ranger for assistance in the field. CB thanks CONICET, Argentina, for a Doctoral Scholarship. LC and MJM were partly funded through projects CGL2013-45634-P, CGL2015-72431-EXP, CGL2016-75414-P, PID2019-105064GB-100, and S2018-EMT-4 338. JGA and CBS acknowledge Luis Torres, Mara Paneghel, Inigo Gomez, Maaike Pyck, Manuel Marca, Daniel Irygoin, Pihre Maceda and Pontificia Universidad Católica de Perú (PUCP). JH thanks DFG (projects HO3296/2, HO3296/4, HO3296/6) and the Erasmo Go International Plus Program for funding and Katherine Angelo-Schipper, Michel Edelmann, Julius Joosten, Julia Falk, Roman Link, Johanna Lindemann, Stephanie Lorenz, Phillip Obst, Jaime Peña,
Bernhard Schuldt, Julia Siegel and Sebastian Wagner for field and lab assistance. OJ thanks the Vicerrectorado de Investigación de la Universidad de Cuenca, Ecuador. NN thanks the support of Instituto Alexander von Humboldt, Pontificia Universidad Javeriana, Programa de Bosques Andinos and Jardín Botánico de Bogotá. BS-N, CG-D, SS, RL-C acknowledge the support of Instituto de Investigación de Recursos Biológicos Alexander von Humboldt for financing the project, to the research group Biodiversidad de Alta Montaña (BAM) and William Ariza, Christian Beltran, Camilo Dumar, Janis Morales, Andrés Otaolara, and Abelardo Rodríguez-Bolaños. BC-N, CM, SC-M acknowledge the financial and technical support of the Instituto Alexander von Humboldt to obtain the plant trait data. JST and JAM acknowledge the support of the National Science Foundation (DEB 0101775, DEB 0743457, DEB 1836533); the National Geographic Society (NGS 7754-04 and NGS 8047-06); the International Center for Advanced Renewable Energy and Sustainability (I-CARES) at Washington University in St. Louis; the Taylor and Davidson families; Dirección General de Biodiversidad, the Bolivian Park Service (SERNAP). EV thanks the Corkery Family Fund and the Center for Sustainable Forestry at Pack Forest, both from University of Washington, USA for funding support during his PhD program, and the financial support from the ‘Bosques Andinos’ Initiative (http://www.bosquesandinos.org/) that was important for the collection of trait data at San Eusebio. Data collection in Peru was supported by NSF LTREB DEB 1754647, the Gordon and Betty Moore Foundation’s Andes to Amazon initiative, and RAINFOR. We thank the Open Access Publication Funds of University of Göttingen.

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L.C., J.H., M.J.M. and S.B. conceived the idea. S.B., L.C., M.J.M., J.A.M. and J.S.T. obtained funding and coordinated the L.E.C. and iDiv workshops. L.C., S.B., J.H. and K.P. compiled the data sets and performed data quality checks. L.C., S.B., J.H. and K.P. conceived and developed the figures. S.B., J.H. and L.C. wrote the manuscript. The rest of authors (ordered alphabetically) contributed data, revised and agreed on the final version of the manuscript.

Competing interests
The authors declare no competing interests.

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