Royal
Botanic Garden
Edinburgh

THE UNIVERSITY
of EDINBURGH

An Annotated Checklist of Apocynaceae in the Marañón Seasonally Dry Tropical Forest (Peru)

Yawei Cao

August 2021

Thesis submitted in partial fulfillment for the MSc in the Biodiversity and Taxonomy of Plants

Abstract

Apocynaceae species include non-woody and woody species. The non-woody species are mostly with climbing habits, which are easy to distinguish from other climbing plant families by the opposite leaves and white latex. The Marañón seasonally dry tropical forest in Peru is considered a hotspot because it has many diversities and endemism. However, the previous studies in the Marañón SDTF are mainly plot-based for collecting woody species and maybe lose many diversities of other life form species. The ongoing construction of hydroelectric dams in the Marañón SDTF will also destroy the unique diversity. This study aims to produce an annotated checklist of Apocynaceae in the Marañón seasonally dry tropical forest in Peru. The annotated checklist includes nomenclature, synonyms, species description, specimen examined, altitude, distribution maps and illustrations. The examined specimens were from Royal Botanical Garden Edinburgh (E) and online herbarium databases (MO, NYBG, etc). Results showed there are 33 species from 18 genera and six unknown genera. Of these, 28 species were from our checklist, and five species were from the previous checklist. The distribution maps showed a concentrated distribution in the northern SDTF of most species, and a dense distribution in the southern SDTF of species endemic to Peru. Future work is needed to identify the unknown species and conserve the special plant diversity in the Marañón SDTF.

Keywords Apocynaceae, annotated checklist, Marañón seasonally dry tropical forest, endemism, USM

Acknowledgements

I would like to express my deepest appreciation to my principal supervisor Zoë A. Goodwin, who has helped me understand the whole project, taught me how to use BRAHMS and QGIS, how to search literature efficiently and motivated me a lot to finish this project. I am extremely grateful to join this project and finish it with Zoë A. Goodwin. During the working together period, I was inspired a lot by Zoë A. Goodwin and started to enjoy the taxonomic process. I would like to extend my sincere thanks to everyone in LATAM Team (Latin American botany & Solanaceae). Many thanks to Tiina Särkinen, Peter Moonlight, Edeline Gagnon, thank you for their kindly help in teaching us how to write every part of a thesis and the feedback on our results! I would also thank my classmates for giving feedback on my thesis.

I also had the great pleasure of meeting with Sally, Zhaoying, Xixuan and my other friends, who support me and inspire me to successfully finish my Master life. Thank you to my parents for understanding and supporting me to study at the University of Edinburgh and Royal Botanical Garden.

Content

List of Tables

List of Figures

1 Introduction

1.1 Background

The global biodiversity is crisis currently because of the climate change, human impacts and low level of protected areas (Linares-Palomino *et al*., 2011). The extinction rates of species are increasingly high and the number of extinct species are underestimated by the IUCN (Pimm *et al.*, 2014). Some special ecosystem that have great biodiversity, are also important for the global forestry ecosystem and food security (Murphy and Lugo, 1986), such as rainforests, savanna, grasses, and dry forests. These ecosystems are important to have a further study and protected.

1.1.1 The Importance of Dry Forests

Dry forests are an important biome with a wide and scattered distribution in the American Tropics. It comprises less than half of the global forests, but shows considerable richness of biodiversity and endemism levels. They comprise 42 percent of the global tropical ecosystem and are considered as the second largest type of tropical system globally (Miles *et al.*, 2006). Despite the great importance, dry forests are ranked as a highly threatened ecosystem due to natural and human disturbance (Miles *et al.*, 2006; Marcelo-Peña *et al.*, 2016). Conversion of dry forests into land of agriculture, infrastructure construction and pasture has resulted in ecosystem fragmentation and a loss of 48.3% of original extent in Amazonas and Cajamarca (Dryflor *et al.*, 2016; Figueroa *et al.,* 2016). Furthermore, this ecosystem is relatively understudied and poorly protected compared to other ecosystem (Pennington and Ratter, 2006; Dimson and Gillespie, 2020). The conservation strategies of dry forests, however, lack of consideration for floristic patterns across the Tropical America. The areas of high endemic species richness (e.g., Peruvian inter-Andean valleys) are in critical conditions (Pennington and Ratter, 2006). Modified conservation and protection strategies for the unique diversity in dry forests are urgently needed to halt the global biodiversity crisis.

1.1.2 The Definition of Seasonally Dry Tropical Forests

What are dry tropical forests? Several authors have defined dry tropical forests by using similar or different factors. Holdridge (1967) defined dry tropical or subtropical forests as

occurring in a frost-free environment with prominent dry months and low annual rainfall. Following Holdridge, Lugo *et al.*(2016) expanded the definition of dry tropical forests to include woodlands with a higher rainfall range than standard criteria, but still with a prolonged dry season. (Mooney *et al*., 1995) included precipitation seasonality in the definition of DTFs as a characteristic in defining the forests occurring in tropical regions. (Sánchez-Azofeifa *et al.*, 2005) used vegetation type to describe the dry tropical forests that nearly 50% of trees are drought deciduous, with > 25℃ mean annual temperature, 700 – 2000 mm annual precipitation and more than three dry months (precipitation <100 mm per month). Pennington *et al.* (2006) used seasonality and a broader concept of vegetation to interpret dry tropical forests, including the forests growing in grasslands, savanna and shrublands ecosystem; from tall trees in humid forests to cactus forest in the driest environment.

There are also other terms and definitions used for this ecosystem, such as succulent biome (with rich succulent and poor grass), semideciduous or deciduous forest (the longevity of leaves), dry or subhumid forest (the limited annual rainfall) and seasonally dry tropical forest (the extreme seasonality) (Murphy and Lugo, 1995). This study used the broad concept defined by Dryflor *et al.* (2016) as seasonal dry tropical forest (SDTF), which is tree-dominated (> 50% deciduous trees in frost- free areas), with a continuous canopy, and includes cactus scrub, thorn woodland and a sparse grassland and the dry months are extreme long (3 – 6 months with < 100 mm precipitation per month).

1.1.3 Seasonally Dry Tropical Forest vs Savanna Ecosystem

The relationships of seasonally dry tropical forests and savannas are quite complicated, and vegetation type is useful for distinguishing them. SDTFs typically grow on fertile soil, with moderate to high nutrients and pH content, and a small amount of aluminium (Pennington and Ratter, 2006). The mean annual temperature in dry forests is higher than 25 degrees Celsius, and the rainfall ranges from 700 to 2000 mm, mostly less than 1800 mm (Dryflor *et al.*, 2016; Dirzo *et al.*, 2011). The extremeness of seasonality is a distinctive character of SDTFs, with alternating rainy seasons and extended dry months. The dry season lasts for 3 to 8 months, with less than 100 mm precipitation per month (Prieto-Torres *et al.,* 2020). Savannas are in

similar seasonally climatic conditions but tend to grow on poorer, acidic soils, with sclerophyllous, evergreen trees (Sarmiento, 1992). SDTFs have a sparse herb layer with few grasses, in contrast to savannas with dominant xeromorphic and fire- tolerant grasses.

1.1.4 The Biodiversity in Seasonally Dry Tropical Forests

The primary growth forms of species growing in SDTF include woody plants (trees and shrubs), herbaceous plants, epiphytes and lianas. Some woody species from genera such as Leguminosae are studied mostly (Hughes *et al.*, 2004; Lewis *et al.*, 2010; Särkinen *et al.*, 2011; Gagnon *et al.*, 2015). The main growth types of plants are evergreen and deciduous in SDTFs. Compared with the evergreen forms in wet or tropical forests, evergreen trees in dry forests never drop their leaves but turn them over every year. Deciduous trees that drop their leaves during the dry seasons are dominant in SDTFs. Plants with leafless growth form can reduce the evaporative demand and increase the water storage in their Stem or trunks. During the wet seasons, the deciduous species renew their canopy (Gentry, 1995). The near absence of epiphytes and the existence of small climbers are two essential components of dry forests (Gentry, 1995). The climbing species includes vines and lianas and constitute about 20% of the vegetation in the American tropical lowland area. In SDTFs, lianas are the common form of climbers (Gentry and Dodson, 1987a, Gentry, 1991).

Species in SDTFs have distinct morphologies in contrast with those in rainforests. The reproductive characters are unique in dry forests. Most woody species have conspicuous flowers, specialist pollinators (e.g., bats, hawkmoths and medium-sized bees) and wind – dispersed seeds (Gentry, 1995). Because of the combination of showy zygomorphic flowers and wind- dispersed seeds, Leguminosae and Bignoniaceae are two predominant families in SDTFs, respectively (Gentry, 1995). Leguminose is considered as the family with richest species (Sarkinen *et al.*, 2011). While the order of dominant families is much diverse after the Leguminosae (Pennington and Ratter, 2006). The second one includes Euphorbiaceae (in Mexico and Brazilian caatings) and Cactaceae (in Peru). The third one includes Cactaceae (in Brazilian caatings), Rubiaceae (in the south- east Brazilian) and Bignoniaceae (in Peru). Some species are also thorn- dominated, which flower during the transition from wet to dry seasons (Bullock *et al*., 1995).

1.2 Seasonally Dry Tropical Forests in American Tropics

Seasonally dry tropical forests in the American Tropics constitute 66.7% of the global dry tropical forests, distributed from Argentina to Mexico and across the Caribbean (Aguirre *et al*., 2006) **(Figure 1)**. SDTFs in the Andes are smaller and isolated, separated in southern Colombia, Ecuador, northern Peru, and Bolivia (Pennington and Ratter, 2006). In terms of species diversity and endemism, however, the tropical Andes are recognized as one of five leading biodiversity hotspots, with a total of 45,000 endemic plants (Myers *et al.*, 2000; Pennington *et al.*, 2010; Särkinen *et al.*, 2012). The tropical Andes comprise about 15% of the global plant species and experience a rapid habitat loss, with only 1% of the world's land area. The small inter-Andean valleys between the Eastern and Western Andean Cordilleras in Peru have a high level of endemic flora and are important for research of SDTFs conservation (Marcelo- Peña *et al.*, 2016). Seasonally dry tropical forests restricted between the rain shadowed inter- Andean valleys, and the Pacific coast (0 – 2500 m) is one of the three broad biomes of the true Andes (Särkinen *et al.*, 2012).

1.3 Seasonally Dry Tropical Forests in the Marañón Valley

1.3.1 The Marañón Seasonally Dry Tropical Forests

Peru is situated on the western coast of South America and bordered to the north by Ecuador, Colombia, to the east by Brazil, Bolivia, and to the south, by Chile. The annual temperature in north- western Peru is 23.4 – 25°C (< 600 m) or 24.8 – 25.4°C (> 700 m), and the mean annual precipitation is 162 – 793 mm (below 600 m) or 567 – 1019 mm (above 700 m) (Pennington and Ratter, 2006). In Peru, SDTFs are scattered in the north coast, the inter-Andean valleys and east of the Andes (Linares-Palomino and Pennington, 2007). The

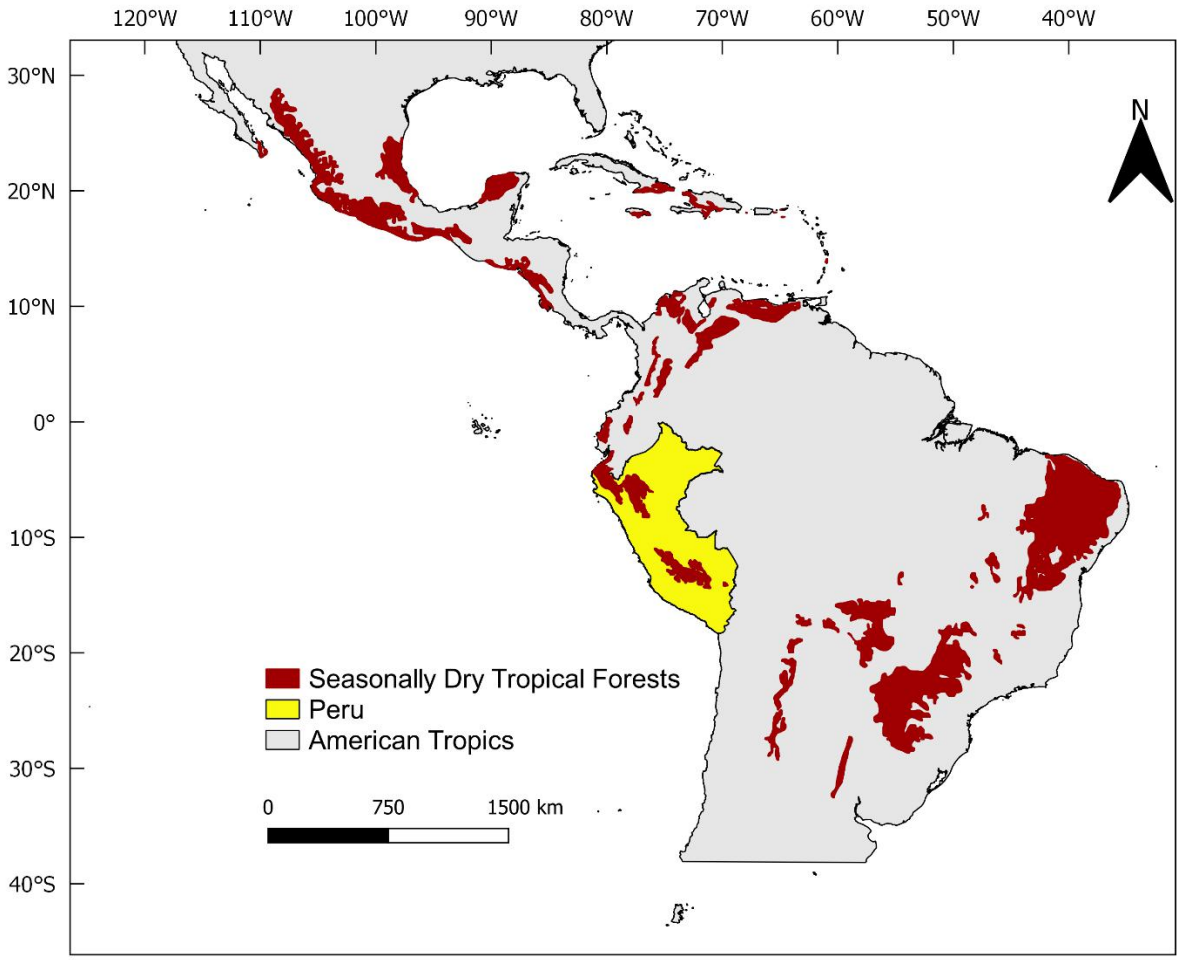

Figure 1 The distribution of SDTFs across Tropical America and the location of Peru. SDTFs (following Dryflor 2016) in maroon, Peru in yellow.

Peruvian dry forests harbour up to 33% to 38% endemic woody species (Linares-Palomino, 2006).

Among the inter-Andean STDFs, the Marañón SDTF at the meeting point of the northern and central Andes in northwest Peru is the largest one, comprising about 373,000 hectares and represents 0.51% of national territory (MINAM, 2011). It is found in the upper Marañón watershed and goes through the regions of Amazonas, Cajamarca, Piura, Lambayeque, La Libertad, Ancash and Huanuco **(Figure 2, Figure 4)** (Marcelo- Peña *et al.*, 2016).

The Marañón SDTF is quite long, and the southern areas are narrow. The altitude of the Marañón SDTF is between 400 – 2300 m, mainly within the 2,300 m contour of the Marañón valley. In the northeast of the upper Marañón watershed, the Marañón SDTF has a rapid transition to Amazonian rainforests, and the Rio Marañón river also goes out into the

Amazonian basin.

The climate in the Marañón valley is extremely dry because of its special location related to the eastern leeward trade winds and the circulation system of cold air masses of the central lowest valleys (Killeen *et al.*, 2007). Additionally, evapotranspiration is increased because of high temperature and low level of cloudiness. Relative humidity is up to 73% in April and down to 37% in August (Marcelo- Peña *et al.*, 2016). As for geology, the Marañón valley mostly consists of the Mesozoic- Cenozoic sedimentary rocks. Some areas are composed of sharp limestone peaks with cliffs occurring amongst large scarves of limestone and sandstone layers (Marcelo- Peña *et al.*, 2016). Based on Zamora and Bao (1972), the Marañón dry forests are found on a mix of sandstone and calcareous rocks making the soils fertile (Pennington and Ratter, 2006) and encouraging increased agriculture.

1.3.2 The Diversity and Endemism in the Marañón SDTF

The SDTF in the upper Marañón watershed are rich in woody species, and an updated checklist of it presents 440 species of woody plants, with 33% endemism which are higher than other Neotropical ecosystem (Marcelo-Peña *et al.*, 2016). The Marañón SDTF includes 78% of generic diversity in only 3750 km^2, representing an excellent woody floral of the Peruvian SDTFs. Marcelo-Peña *et al.* (2016) indicated that the Marañón SDTF has a wide diversity of endemism in plant community composition in southern and northern regions and varies significantly among different elevational zones. The focused area of species turnover is in the narrow region between Cajamarca and Amazonas. Compared with other SDTFs, the Marañón SDTF is dominated by abundant endemic, but globally rare species (Marcelo-Peña *et al.*, 2016). Many endemic species in the Marañón SDTF are only recorded in the last few decades, and new endemic species continue to be collected and recorded, which indicate a poorly collected status in the Marañón SDTF. In Lewis *et al.* (2010), the three new endemic legumes provide evidence that the upper Marañón SDTF is an under-collected diversity hotspot in the inter- Andean SDTF.

To protect the underestimated biodiversity in the Marañón SDTF, a conservation area of the Marañón seasonally dry tropical forests (approximately 13929.12 acres) have been

established. The value of conserving the Marañón SDTF is not only in its richness of endemic species, but also for the fact that it is a dry area surrounded by tropical biomes (Marcelo-Peña *et al.*, 2016). Therefore, it is an excellent area for studying the adaptation, resistance, and tolerance of rich endemism in the past and future. Because of the successful survival of locally endemic species during the Pleistocene several million years ago, the endemism in the Marañón SDTF should be considered an important area to study and predict in the face of future biodiversity crisis (Pennington *et al.*, 2010).

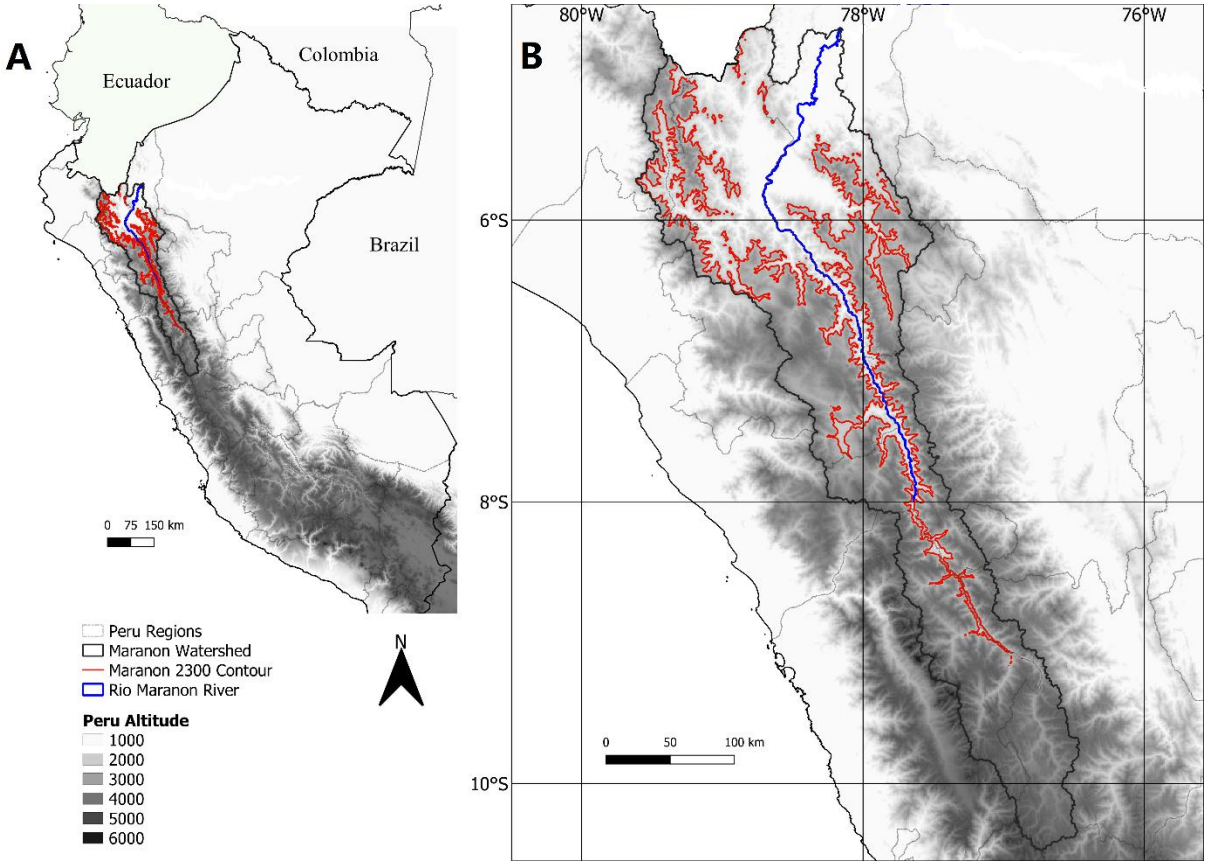

Figure 2 The upper Marañón watershed, 2,300 m contour of the Marañón valley in Peru, and the Rio Marañón river, with the altitude of Peru. **A** The position of the upper Marañón watershed, 2,300 m contour and the Rio Marañón river through the Marañón SDTF and the geography of the adjacent countries, Ecuador, Colombia and Brazil **B** The altitude and longitude of the upper Marañón watershed, 2,300 m contour and the Rio Marañón river of the Marañón SDTF.

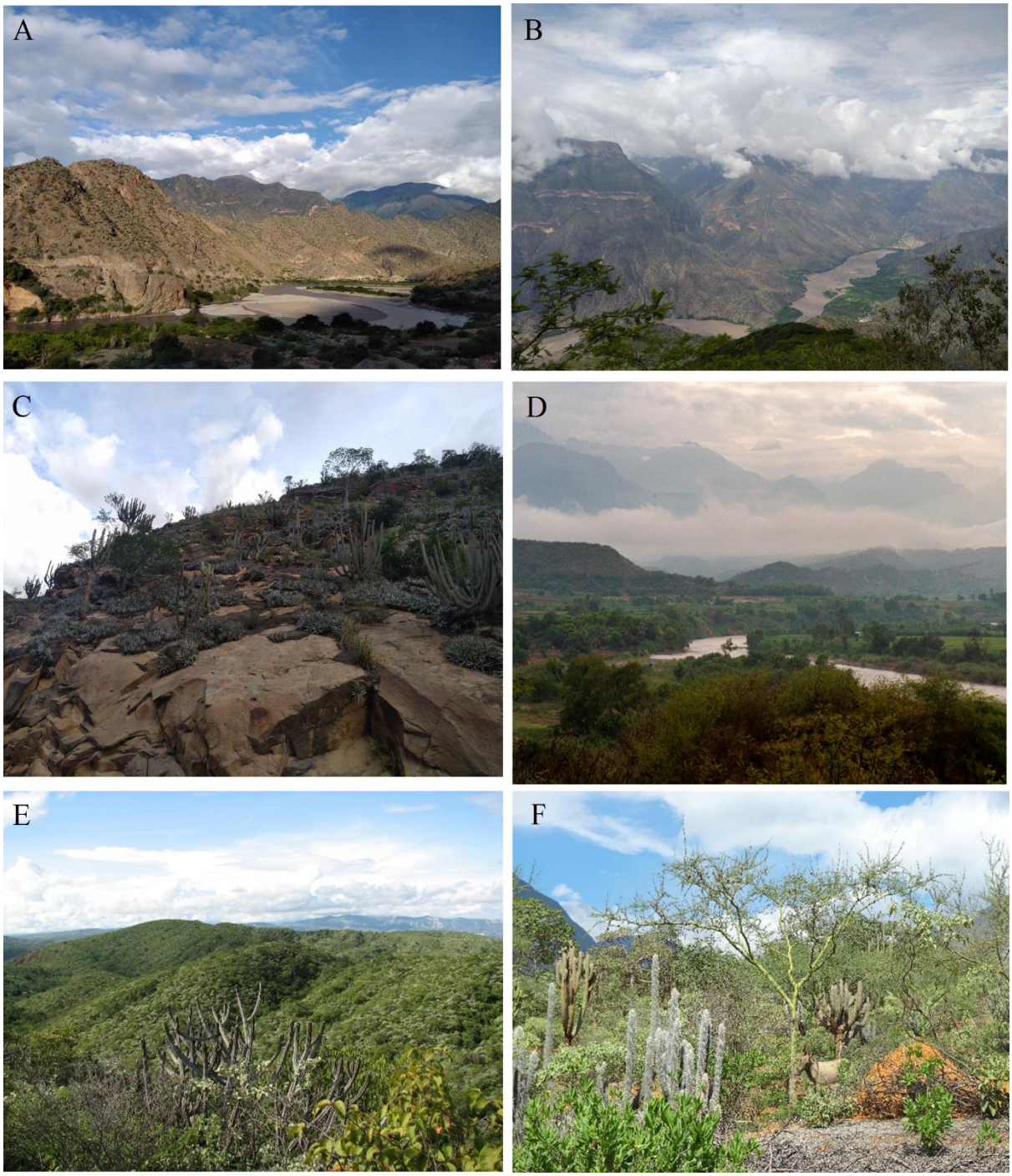

Figure 3 The landscape and vegetation of the Marañón seasonally dry tropical forests, Peru. **A** The landscape of the Marañón SDTF near Balsas **B** The landscape of the Marañón SDTF near Ucuncha **C** The succulent plants growing in the rocks in the Marañón SDTF near Balsas **D** The evergreen plants in flat areas and low elevation of Marañón SDTF (photo taken by P. Moonlight) **E** The vegetation type and evergreen landscape in the Marañón SDTF (photo taken by T. Särkinen) **F** The vegetation type and grazing in the Marañón SDTF.

1.4 Apocynaceae in the Marañón Valley

1.4.1 Introduction to Apocynaceae Juss.

Apocynaceae Juss. consists of 370 genera and 4500 species, ranked as one of the ten largest angiosperm families (APG IV, 2016). The various growth forms, including canopy trees, epiphytes, vines and lianas, perennial herbs and cactoid succulents, reflect the wide range and habitats they occupy. The distinctive combination characters of Apocynaceae are simple, usually opposite leaves, occasionally whorled or alternate, with abundant latex, mostly common white, or yellowish, reddish in some genera (Endress *et al.*, 2018).

The early classification system of Apocynaceae dates back to 1810 when Robert Brown firstly split the Asclepiadeae (Asclepiadaceae) out of the Jussieu (1789) Apocineae (Apocynaceae), because of the absence of a translator in Apocineae. With development of molecular genetics, the relationship between Apocynaceae and Asclepiadaceae has been reconsidered and assessed. Through the combination of available morphological characters and molecular evidence, Endress and Bruyns (2000) reunited the two families as Apocynaceae and accepted five subfamilies: Rauvolfioideae, Apocynoideae, Periplocoideae, Secamonoideae and Asclepiadoideae (Endress *et al.*, 2014).

1.4.2 Introduction to Climbing Apocynaceae

Apocynaceae are primarily woody species, and the lianas and vines are the predominant growth forms in the *Allamanda* Linnaeus, *Anemotrochus* Mangelsdorff, *Cryptostegia* R. Brown etc. (Endress *et al.*, 2018). The climbing Apocynaceae in this study are defined with woody or non- woody roots that cannot grow upright independently. The Stem of climbers are twisted to climb up trees and support themselves.

Climbing Apocynaceae has simple, opposite or verticillate leaves. Venation is pinnate or mid-rib dominant. The milky latex and colleters are distinctive characters that distinguished them from climbers in other families (Morillo and Liede-Schumann, 2021). In some species of *Mandevilla* Lindl., the small and black or brown colleters are observed along the conjunction of adaxial lamina and petioles (Endress *et al.*, 2018). Climbers have well-developed vascular system and roots and are an abundant and diverse plant group, comprising about 25% of the species diversity in tropical dry forests (Schnitzer and Bongers, 2002).

Due to their biomechanical habit, they have an advantaged growth status than trees during dry seasons in tropical forests. Climbers play an important role in forest ecology for the process of carbon sequestration and whole- forest transpiration (Schnitzer and Bongers, 2002). While the climbing Apocynaceae in seasonally dry tropical forests are still poorly collected and understudied.

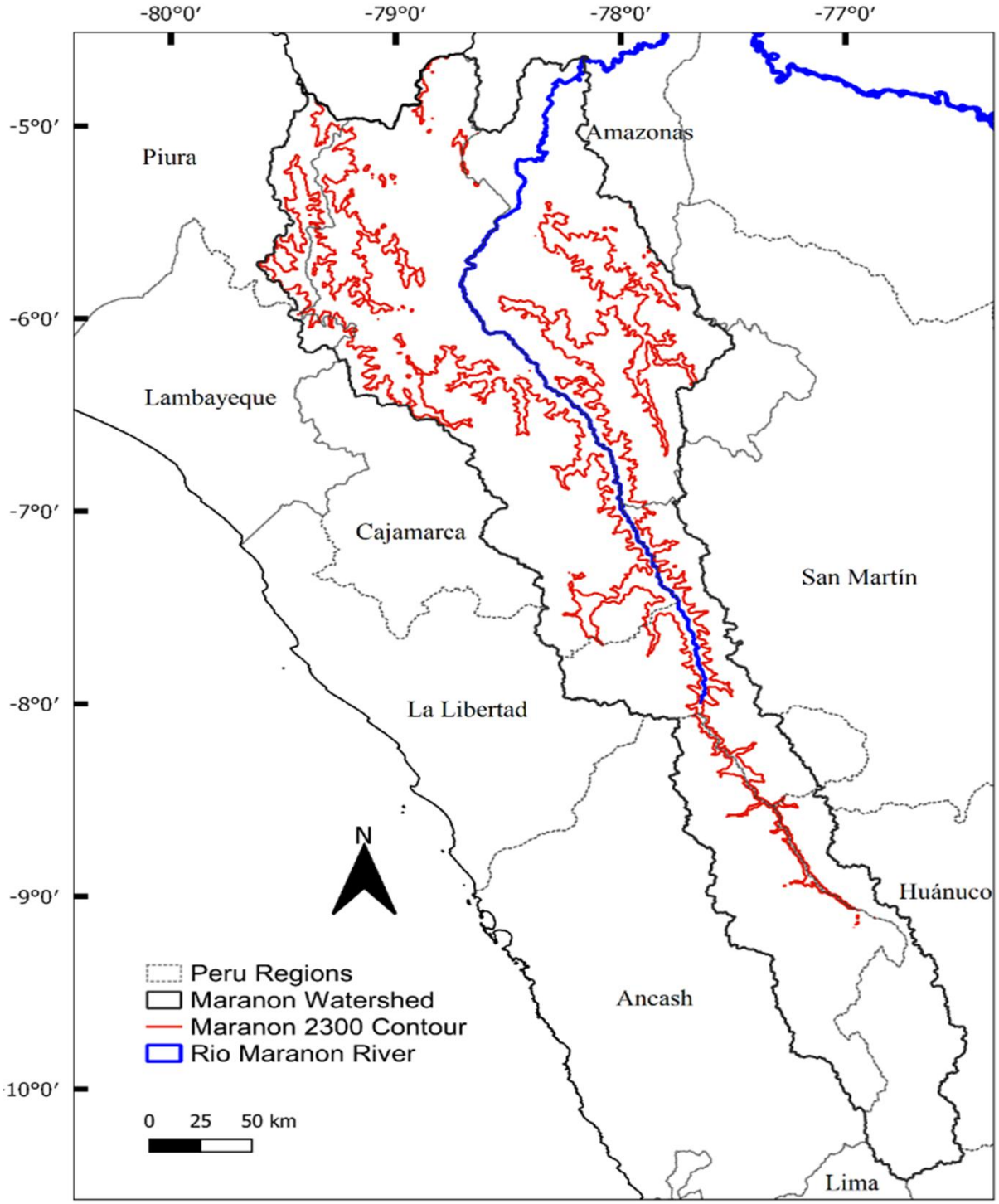

Figure 4 The altitude and longitude of the upper Marañón watershed and 2,300 m contour of

the Marañón valley, and the Rio Marañón river through the Marañón SDTF, with adjacent regions that cross the Marañón SDTF.

1.5 Previous Work on the Flora of the Maranon SDTF

1.5.1 Woody species plots

The plot-based method is defined as undertaking and surveying fieldwork within fixed area plots, 1 ha (100 m × 100 m). Plot-based is a most commonly used method in previous research of tropical dry forests (Dryflor *et al.*, 2016; Marcelo-Peña *et al.*, 2019; Moonlight *et al.*, 2021), such as the DRYFLOR Plot Protocol, which is produced to provide an efficient and rapid data collection of dry tropics and improve the studies of forests (Moonlight *et al.*, 2021). It is important for long-term monitoring of ecology and diversity in the studied area (Baker *et al.*, 2017). Woody species are easy to record and trace in a long-term study, and they are also a dominant component of dry forests, with many diversities. Many research studied the woody species within limited families, such as Leguminosae (Lewis *et al.*, 2010; Särkinen *et al.*, 2011; Marcelo-Peña, Santini and Tomazello Filho, 2019). In order to have a broad interpretation of the biodiversity and endemism in the Marañón SDTF, this study is focused on the general collecting of Apocynaceae.

The previous field work in the Marañón SDTF are also based on the plots and only for woody species (Lewis *et al.*, 2010; Marcelo-Peña *et al.*, 2016; Valqui *et al.*, 2021). For the Apocynaceae in the Marañón SDTF, five species were found and recorded in a recent research (Marcelo-Peña, 2010). These five species include four woody species and one perennial herb *Asclepias curassavica* L. **(Table 1)**. Although previous studies in the Marañón SDTF were mainly focus on woody plants in plots, a few climbing Apocynaceae species were recorded (e.g., *Ruehssia oligantha* (K.Schum.) Liede & H.A.Keller and *Mesechites acuminatus* (Ruiz & Pav.) Müll.Arg.) (Marcelo-Peña *et al.*, 2016).

Table 1 Woody species known from the Marañón SDTF before this study

Species
1 *Allamanda weberbaueri* Markgr.

Marcelo Peña, J. L., 2010
2 *Aspidosperma polyneuron* Müll.Arg. Marcelo Peña, J. L., 2010
3 *Rauvolfia tetraphylla* L. Marcelo Peña, J. L., 2010
4 *Vallesia glabra* (Cav.) Link Marcelo Peña, J. L., 2010
5 *Asclepias curassavica* L.

1.5.2 The Marañón Project and Collections

The new collections from the first field season of the *Increasing knowledge of dry and montane ecosystem across Peru* project, were funded by the Newton-Paulet Fund (project number 418235692) through the British Council in conjunction with assistance of the British Embassy in Lima. This collection project was taken between January and May in 2020, and the majority collections were from regions, La Libertad, Amazonas. The landscape of collecting areas is diverse (**Figure 3A B C)**. Main collectors in this project include Paúl Gonzáles, Asunción Cano, Tiina Särkinen, Zoë Goodwin, Niels Valencia, Inés Sachahuamán and José Luis Marcelo- Peña.

1.5 Aims and Objectives

This research aims to gather and record the endemic species and create an annotated checklist of Apocynaceae species in the Marañón seasonally dry tropical forest, with nomenclature, synonyms, species description, examined specimens, distribution maps, altitude and illustrations. The main objectives of this research are:

1. Do a literature review of dry forests in American Tropics and the Marañón valley, and non- woody and woody Apocynaceae species in the Marañón seasonally dry tropical forest.
2. Assess the Apocynaceae species occurred in the Marañón SDTF and examine the herbarium specimens and digitized herbarium specimens from the Marañón SDTF.
3. Resolve the nomenclature and synonyms of Apocynaceae species from the Marañón

SDTF.

4. Produce the checklists in BRAHMS and distribution maps in QGIS.

2 Materials and Methods

2.1 Species name

The prior list of climbing Apocynaceae species distributed in the Marañón seasonally dry tropical forests includes species determined by Paúl Gonzáles and additional species checked in taxonomy literatures **(Table 2)** (Liede-Schumann and Meve, 2013; Liede-Schumann and Keller, 2020)**.** The species names were checked in Tropicos and Plants of the World Online.

Table 2 Prior list of Apocynaceae species distributed in the Marañón SDTF

Species
1 *Blepharodon salicinum* Decne.
2 *Ditassa weberbaueri* Schltr.
3 *Fischeria stellata* (Vell.) E.Fourn.
4 *Funastrum clausum* (Jacq.) Schltr.
5 *Jobinia peruviana* Liede & Meve.
6 *Jobinia formosa* (N.E.Br.) Liede & Meve.
7 *Mandevilla callacatensis* Markgr.
8 *Ruehssia cundurango* (Rchb.f.) Liede & H.A.Keller.
9 *Ruehssia oligantha* (K.Schum.) Liede & H.A.Keller.
10 *Metastelma mathewsii* Rusby.
11 *Orthosia calycina* Liede & Meve.
12 *Oxypetalum dombeyanum* Decne.
13 *Oxypetalum retusum* (Markgr.) Goyder.
14 *Peruviasclepias aliciae* (Morillo) Morillo.
15 *Philibertia solanoides* Kunth.
16 *Prestonia mollis* Kunth.
17 *Ruehssia macrophylla* (Humb. & Bonpl. ex Schult.) H.Karst.

18 *Tassadia berteroanum* (Spreng.) W.D.Stevens.

2.2 Specimens

The studied specimens were from three different resources, the herbarium specimens at Edinburgh (E), digitised herbarium specimens from online herbaria and the photographs of living plants. In this study, all specimen information was databased in the Botanical Research and Herbarium Management System (BRAHMS v7.9.14 available at https://herbaria.plants.ox.ac.uk/bol/) and supplemented the USM dataset.

2.2.1 Herbarium Specimens at E

Herbarium specimens were obtained from the Royal Botanical Garden Edinburgh and consisted of three parts. The first part of herbarium specimens were collections from the *Increasing knowledge of dry and montane ecosystem across Peru* project. The herbarium specimens were attached with labels (collection regions and notes, coordinates, plants descriptions, collectors, etc). The second part was collected by Tiina Särkinen *et al.* in 2008 as part of her PhD thesis (Särkinen, 2010). The third part of specimens was made by Toby Pennington *et al*. There were 31 specimens studied in the E Herbarium. Some woody Apocynaceae species conserved at E were studied in this research (*Aspidosperma polyneuron* Müll. Arg. *T. Särkinen 3110* and *Rauvolfia tetraphylla* L. *P. Gonzales 6353*). Measurements and examination were taken using a ruler and microscope in the E Herbarium.

2.2.2 Digitised Herbarium Specimens

Digital specimens were downloaded from Tropicos, New York and other websites **(Table 2)**. Specimens in Tropicos were filtered by species name, country (Peru) and upper political regions (Piura, Amazonas, Ancash, Cajamarca, Huanuco and La Libertad). Specimens downloaded from NYBG were searched for scientific name and regions in Peru through advanced search or through OCR text search, as many digitised specimens were only recorded with images. The examination and measurement of digitised herbarium specimens were taken in IrfanView 64-bit.

2.2.3 Photographs of Living Plants

Photographs for examination were from collection photos taken by Paúl Gonzáles, Zoë

Goodwin in 2020 Peru project and Hervé Vandrot and Tiina Särkinen in 2018. Measurements were taken using the measurement tool in IrfanView 64-bit.

Table 3 The websites used in searching for digital specimens

Website
JSTOR https://plants.jstor.org/
Tropicos https://www.tropicos.org/
Naturalis https://bioportal.nat – uralis.nl/
New York http://sweetgum.nybg.org/science/vh/
Field Museum https://collections – botany.fieldmuseum.org/list
University of Michigan https://lsa.umich.edu/herbarium/databases.html
Berlin http://ww2.bgbm.org/herbarium/default.cfm
Muséum National d'Histoire Naturelle https://science.mnhn.fr/institution/mnhn/collection/p/item/search/form?lang=en_US
Global Biodiversity Information Facility portal (GBIF) https://www.gbif.org/
Plants of the World Online http://www.plantsoftheworldonline.org/
World Checklist of Selected Plant Families (WCSP) http://wcsp.science.kew.org/home.do

2.2.4 The Marañón Project and Collections

In this study, the herbarium specimens of Apocynaceae from Peru were mainly collected by

Paúl Gonzáles and Zoë Goodwin from 2008 to 2020. The new collections of Apocynaceae from Peru project in the Marañón SDTF were collected in 2020. All new collections were recorded in the USM dataset.

2.2.5 USM Dataset

The Universidad Nacional Mayor de San Marcos (USM) (Index Herbariorum), located in Lima, Peru, is for national collection of Peru and specialised in collecting in the Tropical Amazon Basin and Andes of Peru and records about 80,0000 specimens. The USM dataset is based on the digitised specimens held at USM. The specimens – rich families in USM dataset includes Asteraceae (17,444), Solanaceae (16,895), Melastomataceae (1,207), Poaceae (1,161) and Apocynaceae (432). The prior USM dataset includes 115 specimens of Apocynaceae. The completed USM dataset includes 377 specimens of 84 species of Apocynaceae from 33 genera.

2.3 Character Scoring

The preliminary vegetative characters were selected by examining the herbarium specimens and photographs, typically including the visible and typical characters such as growth form, shape, size etc. Further characters were added by referencing the protologue and published checklists (Liede-Schumann and Meve, 2013; Lucena *et al*., 2017; Ordas *et al.*, 2019; Wood and Clegg, 2021). Some commonly used characters in the species descriptions were added. Some distinctive characters for climbing Apocynaceae were further examined by using key literature (Floral of Peru, Checklist of Peru). The terminology used in characters scoring and species description based on *The Kew Plant Glossary: an illustrated dictionary of plant terms (Second Edition),* edited by H. Beentje and illustrated by J. Williamson (Beentje, 2016). Because of the restriction of Covid-19, the colleters, androecium and gynoecium are difficult to examined through the specimens and photos and omitted from the character matrix. A list of examined characters is found in **Table 3**.

For some old collected species only with the type specimens, the measurement and description were based on the image viewer of JSTOR Global Plants and the protologues (*Ditassa weberbaueri* Schltr., *Jobinia peruviana* Liede & Meve., *Metastelma mathewsii* Rusby., *Orthosia calycina* Liede & Meve., *Oxypetalum dombeyanum* Decne., *Oxypetalum*

retusum (Markgr.) Goyder.). For species *Jobinia peruviana* Liede & Meve. without any available specimen image on JSTOR, no measurement was taken out and the descriptions only based on the protologue in the published revision.

The process of character examination for newly collected species used physical specimens at E and live photos. A character matrix was built by the measurements of vegetative and reproductive characters.

Table 4 Vegetative and reproductive characters of specimens studied for building the character matrix

Vegetative Characters	**Reproductive Characters**
Growth form	Inflorescence position (terminal, axillary etc.)
Stem shape	Inflorescence type (cyme, fascicle, umbel etc.)
Stem surface (glabrous or pubescent)	Peduncle length
Leaf colour	Pedicel length
Leaf arrangement	Corolla colour
Leaf shape (ovate, lanceolate, linear etc.)	Corolla shape (rotate, cupuliform etc.)
Leaf apex (acute, attenuate, acuminate etc.)	Calyx colour
Leaf base (cuneate, attenuate, cordate etc.)	Calyx shape
Leaf texture	Fruit shape (turbinate)
Leaf venation (mid – rib dominant, pinnate)	Fruit size
Leaf size	
Petiole shape	
Petiole length	

2.4 Checklist production

The checklist was managed and produced in the BRAHMS. The information of checklist was listed in the **Table 4**.

2.4.1 Synonyms and Type Specimens

Synonyms were checked in two databases. One database was the World Checklist of Selected Plant Families (WCSP), an online database of accepted scientific name and synonyms of selected plant families that maintained by Royal Botanical Garden, Kew. The other database was Plants of the World Online, also published by Kew, with accessible information of all known seed plants by 2020. The image and information of type specimens were searched for on JSTOR and relevant taxonomic literature. The holotype and isotype specimens presented on JSTOR Global Plants were selected by comparing the information with their protologues.

2.4.2 Occurrence data

Occurrence data of some specimens were searched for in GBIF and filtered by scientific name, country, and location (including coordinates). The downloaded specimens were split into two groups depending on the present coordinates and absent coordinates. Specimens with coordinates were checked in Google Earth and Google Map and filtered against the upper Marañón watershed and elevation (< 2300 m). Specimens without coordinates were scored by checking the locality notes and geography to produce the likelihood that they occurred in the Marañón dry forests.

2.4.3 Species Distribution Mapping

To do the species distribution mapping in the Marañón SDTF, the occurrence data of species were extracted from BRAHMS in csv file. All extracted specimen data had clear coordinates and distributed in the upper Marañón watershed and the Marañón SDTF (< 2300 m). The shapefiles listed in **Table 5** were used for producing the maps of species distribution in the Marañón SDTF. The maps were produced in QGIS 3.10.9 (http://qgis.org/en/site/forusers/download.html).

2.4.4 Illustrations

Illustrations include images found in Tropicos and photographs taken by Paúl Gonzáles, Peter Moonlight, Tiina Särkinen and Zoë Goodwin.

Table 5 The format of climbing Apocynaceae in the Marañón dry forests annotated checklist

Checklist

Scientific name with authority
Protologue
Type citation
Synonyms and protologue
Species descriptions or identification notes
List of examined specimens (major area, minor area, gazetteer, collectors, collection date, collection number, duplicates)
Altitude
Distribution map
Illustrations

Table 6 The shapefiles for producing the maps of species distribution in the Marañón dry forests and seasonally tropical dry forests distribution in American Tropics

Shapefiles (.shp)	
2,300 m contour of the Marañón valley (2300_Marañón_Contour.shp)	
Upper Marañón Watershed (Marañón_Top.shp)	
Altitude of Peru (PER_alt.brp)	
Rio Marañón River (Rio_navegables.shp) The Humanitarian Data Exchange (https://data.humdata.org/dataset/hidrografia – de – peru)	
Peru Administrative Regions	Regions (PER_adm1)
	Provinces (PER_adm2)
	Districts (PER_adm3)
Peru Neighbour Countries	Bolivia (BOL_adm0)
	Brazil (BRA_adm0)
	Colombia (COL_adm0)
	Chile (CHL_adm0)
	Ecuador (ECU_ adm0)
Schematic dry forest distribution (america.shp, seasonally_dryfo.shp) DRYFLOR (http://www.dryflor.info/data)	

3 An Annotated Checklist of Apocynaceae from the Marañón Seasonally Dry Tropical Forest

1. *Blepharodon salicinum* Decne., Prodr. 8: 604. 1844.

Peru: *E. F. Poeppig 1420* (isotype P). Bolivia: Espirito Santo, *1275* (isosyntype MO).

Ditassa trivialis E. F. Poepp & Endl., Nov. Gen. Sp. Pl. 3: 68. 1845.

Blepharodon triviale (E. F. Poepp & Endl.) K. Schumann., Nat. Pflanzenfam. 4(2): 243. 1895.

Vailia mucronata Rusby, Bull. Torrey Bot. Club 25: 542. 1898.

Blepharodon bolivianum Malme, Ark. Bot. 25A(7): 17. 1932.

Vailia salicina (Decne.) Morillo, Acta Bot. Venez. 20(2): 21. 1997.

IDENTIFICATION NOTES: Perennial herb. Stem erect. Round and smooth. Leaves in opposite pairs, petioles short and thin, 6 mm long; lamina dries dark green above, pale grey underside, 33.6 (- 72) X 6 (- 14) mm, lanceolate to linear oblong, with attenuate apex and obtuse leaf base; venation 12 – 13 pinnate. Inflorescence axillary, umbel. Corolla lobes deltate, smooth.

SPECIMENS EXAMINED: Amazonas: Bagua, Aramango, *R. Vásquez et al. 27418* (MO); Luya, Camporedondo, *J. Campos de la Cruz et al. 3684* (MO); **Cajamarca**: San Ignacio *J. Campos de la Cruz et al. 6284* (MO); *J. Campos de la Cruz* & *Z. Garcia 4023* (MO); *J. Campos de la Cruz* & *M. López M 2552* (MO); *S. Leiva González et al. 1663* (MO); *V. Quipuscoa S 366* (MO); *E. F. Rodríguez* & *S. Leiva González 2126* (MO).

ALTITUDE: 243 – 1950 m.

DISTRIBUTION: Bolivia, Brazil North, Colombia, Peru **(Figure 5A)**.

2. *Ditassa weberbaueri* Schltr., Bot. Jahrb. Syst. 37: 613–614 1906

Peru: Amazonas, Chachapoyas, Balsas, *A. Weberbauer 4276* (holotype B).

IDENTIFICATION NOTES: Perennial herb or twinning vines, up to 50 cm tall. Stem elongate zigzag, pubescent. Leaves loose, erect, subsessile, lamina obovate, or obovate to oblong, 5 (- 7) X 3 (- 5) mm, with generally apiculate apex. Inflorescence axillary, fascicle. Calyx lobes ovate, obtuse, glabrous. Corolla almost twice as shorter, sub- rotate, up to a third of the base 5- lobed c. 1.5 mm long, corolla lobes oblong blunt, smooth.

ALTITUDE: 2000 – 2100 m.

DISTRIBUTION: Endemic to Peru **(Figure 5A)**.

3. *Fischeria stellata* (Vell.) E. Fourn., Fl. Bras. 6(4): 301 188

Peru: *H. Ruiz* & *J. A. Pavón s.n.* (isotypes MO, MO). Brazil: Serra d'Orgaos, *J. Lhotsky 139* (isotype MO). Brazil: Serra de Cujaba, *Silva Manso* & *J. Lhotsky 12* (holotype MO). Brazil: Jacobina, *Blanchet 3645* (isotype MO).

Fischeria acuminata Decne., Prodr. 8: 600. 1844.

Fischeria calycina Decne., Prodr. 8: 600. 1844.

Fischeria martiana Decne., Prodr. 8: 601. 1844.

Fischeria multiflora Decne., Prodr. 8: 601. 1844.

Fischeria peruviana Decne., Prodr. 8: 601. 1844.

Fischeria propinqua Decne., Prodr. 8: 601. 1844.

Fischeria rotundifolia Decne., Prodr. 8: 601. 1844.

Fischeria riedelii E. Fourn., Fl. Bras. 6(4): 299. 1885.

Fischeria warmingii E. Fourn., Fl. Bras. 6(4): 299. 1885.

Fischeria boliviana S. F. Blake, J. Wash. Acad. Sci. 14(13): 292. 1924.

Fischeria subaequalis S. F. Blake, Contr. U.S. Natl. Herb. 20: 530. 1924.

IDENTIFICATION NOTES: Perennial herb, 3 – 20 cm tall. Stem densely glandular pubescent. Leaves in opposite pairs, lamina ovate, 131 X 85 mm, with mucronate apiculate apex and cordate base, pubescent, venation 5 – 6 pinnate, colleters present. Inflorescence axillary cymes, panicle multiflorous, 10 – 12 flowered, peduncle 150 mm long, pedicle 28 mm long, pubescent. Calyx lobes lanceolate, pubescent. Corolla rotate-campanulate, white greenish, lobes incurved.

SPECIMENS EXAMINED: *H. Ruiz* & *J. A. Pavón s.n.* (FI, MO); **Cajamarca**: San Ignacio, San José de Lourdes, *J. Campos de la Cruz* & *R. Vásquez 6450* (MO); *C. Díaz S et al. 10551A* (MO).

ALTITUDE: 100 – 2010 m.

DISTRIBUTION: Argentina Northeast, Bolivia, Brazil North, Brazil Northeast, Brazil South, Brazil Southeast, Brazil West-Central, Colombia, Ecuador, Paraguay, Peru **(Figure 5A)**, Trinidad-Tobago, Venezuela

4. *Funastrum clausum* (N. Jacquin) Schltr., Repert. Spec. Nov. Regni Veg. 13(363/367): 283 1914

Peru: *H. Ruiz* & *J. A. Pavón s.n.* (isotype MO).

Cynanchum clausum N. Jacquin, Select. Stirp. Amer. Hist.: 87. 1763.

Asclepias viminalis Sw., Prodr.: 53. 1788.

Sarcostemma clausum (N. Jacquin) Schult., Syst. Veg. (ed. 15 bis) 6: 114. 1820.

Sarcostemma crassifolium Decne., Prodr. 8: 540. 1844.

Sarcostemma bifidum E. Fourn., Fl. Bras. 6(4): 235. 1885.

Sarcostemma gardneri E. Fourn., Fl. Bras. 6(4): 233. 1885.

Sarcostemma pallidum E. Fourn., Fl. Bras. 6(4): 235. 1885.

Sarcostemma pedunculatum E. Fourn., Fl. Bras. 6(4): 235. 1885.

Sarcostemma schottii E. Fourn., Fl. Bras. 6(4): 235. 1885.

Sarcostemma glaziovii K. Schumann., Bot. Jahrb. Syst. 25(Beibl. 60): 19. 1898.

Cynanchum mexicanum Brandegee, Univ. Calif. Publ. Bot. 4: 380. 1913.

Funastrum fragile Rusby, Mem. New York Bot. Gard. 7(3): 332. 1927.

Funastrum seibertii Woodson, Ann. Missouri Bot. Gard. 24(2): 199. 1937.

IDENTIFICATION NOTES: Perennial herb. Latex white. Young Stem round, striate and glabrous, old Stem angular, green. Leaves in opposite pairs, petioles short and thin, with a narrow groove above, 3 – 5 mm long; lamina pale green, held reflexed on petiole, 22 – 48 X 5 – 8 mm long, long lanceolate to linear, with an acuminate apex and a rounded base, papery; venation mid-rib prominent, pinnate. Inflorescence axillary, fascicle, 7 – 9 flowered, peduncle 27 mm long, pedicle 10 mm long. Calyx lobes 2 mm long, narrowly deltate, yellow- green. Corolla pubescent, rotate, corolla lobes basally fused, ca. 4 X 3 mm, cream outside and white inside. Corona white, five spheres at the centre. Fruits and seeds unknown.

SPECIMENS EXAMINED: Amazonas: *H. van der Werff et al. 14586* (MO); Bagua, *R. Castro et al. 17411* (MO); *H. van der Werff et al. 16348* (MO); **Cajamarca**: *H. van der Werff et al. 15155* (MO); Jaén, *R. Castro et al. 19696* (MO); *P.C. Hutchison* & *J.K. Wright 3561* (N/A); *F. Woytkowski 5587* (MO); Chamaya, *J. Mostacero L et al. 2310* (MO); San Ignacio, *J. Campos de la Cruz* & *O. Díaz 2341* (MO); **La Libertad**: Pataz, *P. Gonzáles 7130* (CPUN, E,

MO, MOL, QCA, USM).

ALTITUDE: 25 – 3700 m.

DISTRIBUTION: Argentina Northeast, Argentina Northwest, Bahamas, Belize, Bolivia, Brazil North, Brazil Northeast, Brazil South, Brazil Southeast, Brazil West-Central, Cayman Is., Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Florida, French Guiana, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico Central, Mexico Gulf, Mexico Northeast, Mexico Northwest, Mexico Southeast, Mexico Southwest, Nicaragua, Panamá, Paraguay, Peru **(Figure 5B)**, Suriname, Texas, Trinidad-Tobago, Uruguay, Venezuela, Venezuelan Antilles, Windward Is.

5. *Jobinia peruviana* Liede & Meve, Ann. Missouri Bot. Gard. 99(1): 62. 2013.

Peru: Amazonas, Chachapoyas, Balsas, *P. C. Hutchison & J. K. Wright 5439* (holotype S, isotype USM).

IDENTIFICATION NOTES: Perennial herb, up to 50 cm high. Latex white. Stem slender, round, smooth and glabrous, green. Leaves in opposite pairs, petioles short and thin, 1 – 2 mm long; lamina 8 – 14 X 1.4 – 1.7 mm long, liner, with an obtuse to acute apex and a cuneate leaf base, glabrous, mid-rib venation prominent, secondary veins obscure. Inflorescence axillary, fascicle, 1 – 4 flowered, peduncle sessile or subsessile (-2 mm), pedicel 2.5 – 3.5 mm long. Calyx basally fused, yellow to green, narrowly deltate, lobes to c. 1.5 mm long. Corolla rotate, yellow to greenish yellow abaxially, 5 lobes basally fused, slenderly triangular, with acute apex, corona tubular. Follicles always twinning, with a sharp angle between them, generally solitary by abortion, fusiform with a long- attenuated beak, light brown, glabrous.

SPECIMENS EXAMINED: Amazonas: Chachapoyas *P. C. Hutchison 5439* (S, USM);

ALTITUDE: 800 m.

DISTRIBUTION: Endemic to Peru **(Figure 5B)**.

6. *Jobinia formosa* (N.E. Br.) Liede & Meve, Ann. Missouri Bot. Gard. 99(1): 61. 2013.

Peru: Arequipa, *H, Guilaume s.n.* (syntype K); *H, Guilaume s.n.* (isolectotype K); *R, Pearce 84* (syntype K); Ayacucho, Huanta, *R, Pearce, s.n.* (syntype K). Ecuador: *Pavon s.n.* (syntype K).

Cynanchum ecuadorense Schltr., Beibl. Bot. Jahrb. Syst. 78: 15. 1904

Cynanchum eurystephanum Malme, Ark. Bot. 25A(7): 7. 1933

Cynanchum formosum N.E. Br., Bull. Misc. Inform. Kew 1895: 112. 1895

IDENTIFICATION NOTES: Perennial herb. Stem round and thin. Leaves in opposite pairs, with long and thin petioles; lamina lanceolate, with an acuminate apex and a cordate base; venation 4 – 5 pinnate. Inflorescence axillary, compound umbel. Corolla yellow, lobes linear with acute apex.

ALTITUDE: 2438 – 2743 m.

DISTRIBUTION: Bolivia, Ecuador, Peru

7. *Mandevilla callacatensis* Markgr., Notizbl. Bot. Gart. Berlin- Dahlem 9: 83. 1924.

Peru: *A. Weberbauer 7128* (isotype F).

IDENTIFICATION NOTES: Perennial herb. Stem round and thin. Leaves in opposite pairs, petioles long and thin, 8 – 21 mm; lamina dried olive green, ovate to elliptic, with an attenuate to acuminate apex and subcordate- rounded- cuneate leaf base, membranaceous, 40 – 75 X 20 – 45 mm; venation pinnate, 5 – 6 secondary veins strongly ascending, domatia in nerve axils. Inflorescence axilliary or terminal on side shoots, raceme, 6 – 8 flowered, peduncle 25 mm, pedicle 15 mm. Calyx green, narrowly deltate, lobes ca. 4 mm. Corolla tube red to green, corolla lobes white outside, corolla lobes yellow inside, long narrow corolla tube, corolla lobes fused halfway and flare at apex, 35 X 12 mm.

SPECIMENS EXAMINED: Amazonas: Chachapoyas, *H. van der Werff 14690* (USF); Luya *J. Campos de la Cruz 3721* (USF); Camporedondo, *C. Díaz 3538* (USF); *C. Díaz 3543* (USF); **Ancash**: Huaraz, Pampas, *P. Gonzáles 2006* (USM); **Cajamarca**: *A. Vásquez 14* (E); Celendín, *P. Gonzáles 5227* (E, USM); *P. Gonzáles 5258* (CPUN, E, MO, MOL, USM); San Ignacio, San José de Lourdes, *R. Vásquez 26134* (F); **La Libertad**: Bolívar, Longotea, *P. Gonzáles 5641* (CPUN, E, MO, MOL, QCA, USM).

ALTITUDE: 1100 – 2600 m.

DISTRIBUTION: Endemic to Peru **(Figure 5B).**

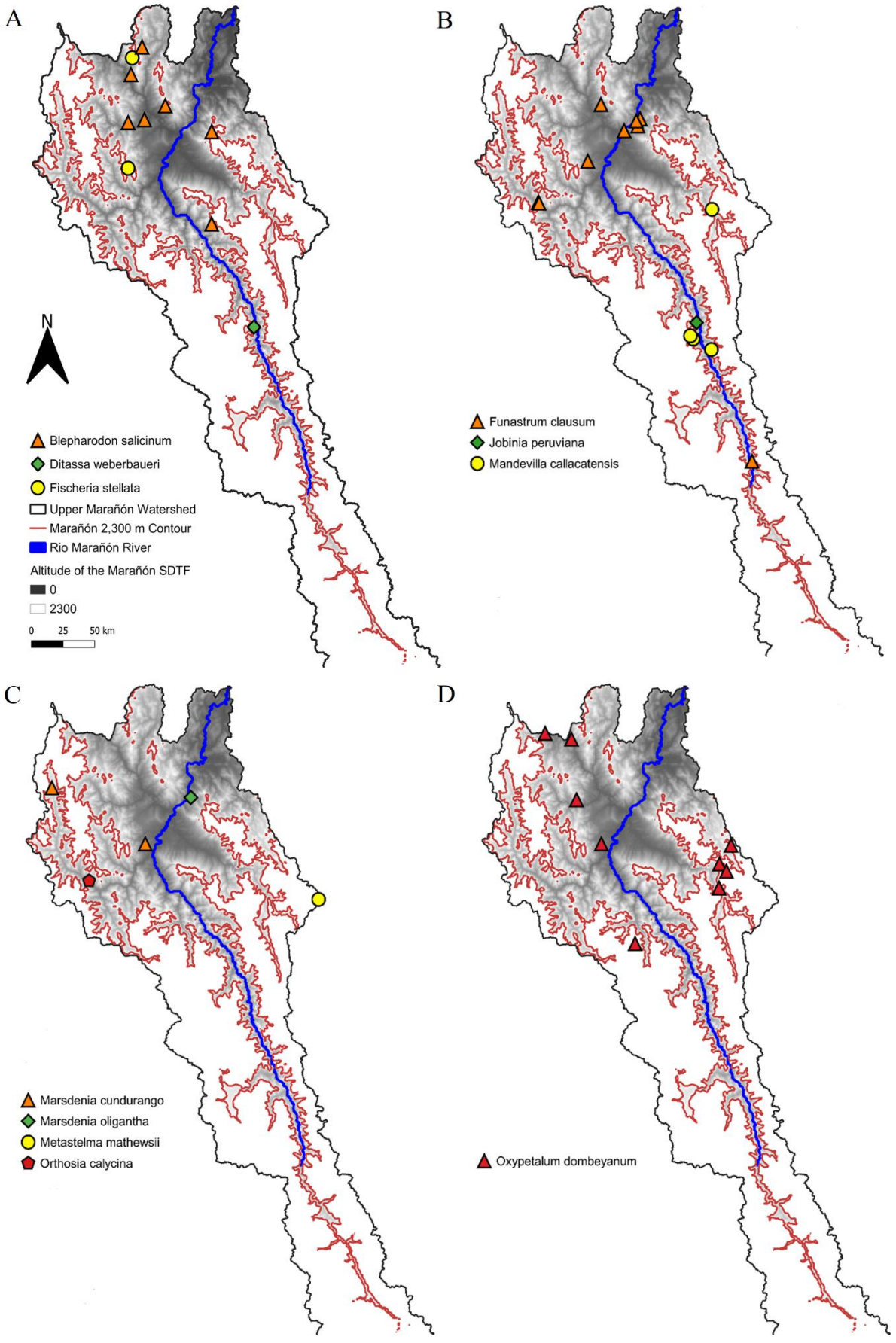

Figure 5 A Distribution of *Blepharodon salicinu**m**,* *Ditassa weberbaueri**,*** *Fischeria stellata**.***

B Distribution of *Funastrum clausum, Jobinia peruviana, Mandevilla callacatensis*. **C** Distribution of *Marsdenia cundurango, Marsdenia oligantha*, *Metastelma mathewsii, Orthosia calycina* **D** Distribution of *Oxypetalum dombeyanum.*

8. *Ruehssia cundurango* (Rchb.f.) Liede & H.A. Keller., Bot. Zeitung (Berlin) 30: 552 1872
Peru: Madre de Dios, *R. B. Foster 12115* (holotype F, isotype MO).
Pseudoruehssia cundurango (Rchb. f.) Schltr., Compt. Rend. Hebd. Séances Acad. Sci. 74: 883. 1872.
Marsdenia reichenbachii Triana, Bull. Soc. Bot. France 20: 36. 1873.
Pseudomarsdenia equatoriensis Ruschenb., Rep. Orig. & Therap. Prop. Cundurango: 15. 1873.
Gonolobus cundurango Triana, Bot. Jahrb. Syst. 50: 143. 1913.
IDENTIFICATION NOTES: Perennial herb, up to 20 cm high. Latex white. Stem rounded, old Stem angular, glabrous. Leaves in opposite pairs, petioles long and thin, with many adaxial colleters at the base; lamina sub- obicular to ovate, with acuminate apex and subcordate base, venation 4 – 8 pinnate. Inflorescence axillary, racemose cymes, 30 to 50 flowered, peduncle short or sessile. Calyx lobes suborbicular or ovate, small; corolla rotate, lobes, yellow to green, with five scales on the corolla throat. Follicles smooth, ovate, with thick pericarp, 8 – 30 cm long, 1 to 2; Seeds ovate, winged.
SPECIMENS EXAMINED: Cajamarca: Jaén, *C. S. Díaz 2082* (MO); *C. S. Díaz 2082* (NY); *H. van der Werff 16391* (MO); **Piura**: Huancabamba, *C. Díaz 3160* (MO).
ALTITUDE: 750 – 1500 m.
DISTRIBUTION: Colombia, Ecuador, Peru **(Figure 5C).**

9. *Ruehssia oligantha* (K. Schum.) Liede & H.A. Keller., Verh. Bot. Vereins Prov. Brandenburg 47: 189 1905
Peru: *E. Ule 6603* (possibly a type F).
IDENTIFICATION NOTES: Shrub. Climbing Stem sub- carnose (fleshy/succulent), terete, glabrous. Leaves in opposite pairs, with petioles slightly winged; lamina oblong or oblong –

lanceolate, with acute apex and attenuate base, glabrous. Inflorescence axillary, short interrupted spike with aggregated bracts, interrupted by extra- axillary peduncles. Calyx lobes sub – circular minutely cililate. Corolla yellowish- green, campanulate – rotate, outwardly smooth rounded lobes, within densely spreading hairs.

SPECIMENS EXAMINED: Amazonas: Bagua, *H. van der Werff 16355* (MO); **Cajamarca**: Jaén, *H. van der Werff 16395* (MO).

ALTITUDE: 500 – 750 m.

DISTRIBUTION: Endemic to Peru **(Figure 5C)**.

10. *Metastelma mathewsii* Rusby, Bull. Torrey Bot. Club 25: 497–498 1898

IDENTIFICATION NOTES: Perennial herb. Stem round and thin, smooth. Leaves in opposite pairs, with short and thin petioles; lamina olive green, lanceolate, with a mucronate apiculate apex and attenuate base; venation mid- rib dominant. Inflorescence axillary, fascicle. Corolla small, yellow.

SPECIMENS EXAMINED: Amazonas: Chachapoyas *Mathews, A 3144* (NY).

ALTITUDE: 1850 m.

DISTRIBUTION: Bolivia, Peru **(Figure 5C)**.

11. *Orthosia calycina* Liede & Meve, Novon 18(2): 204. 2008.

Peru: Near the mouth of the Chichipe den Marañon, *A. Weberbauer 6227* (isolectotype GH).

Metastelma calycinum Schltr., Beibl. Bot. Jahrb. Syst. 119: 1 (1916)

Cynanchum calycinum (Schltr.) Morillo, Ernstia 2: 68 (1992)

IDENTIFICATION NOTES: Twinning vines. Latex white, strong odour smell. Stem long and thin. Leaves frequently distichous, rarely decussate; petioles short and thin; lamina narrow, oblong or ovate, with mucronate apiculate apex and attenuate base, colleters present (mostly with 2); venation 4 – 5 pinnate. Inflorescence axillary, umbel, 4 to 6 flowered, (sub-) sessile. Calyx large, as long as corolla lobes; corolla rotate, cyathiform, campanulate or urceolate, 1 – 2.5 mm long, usually white, cream and yellow, lobes oblong to lanceolate; gynostegial corona of staminal lobes, small, fused up to ¾ of length.

SPECIMENS EXAMINED: Cajamarca: *M. Weigend 7530* (B).

ALTITUDE: 400 m.

DISTRIBUTION: Endemic to Peru **(Figure 5C)**.

12. *Oxypetalum dombeyanum* Decne., Prodr. 8: 583 1844

Peru: Chili et pérou (Cochero), *J. Dombey s.n.* (holotype P, isotypes F, P, P).

Gothofreda dombeyana (Decne.) Kuntze., Revis. Gen. Pl. 2: 420. 1891.

IDENTIFICATION NOTES: Perennial herb. Stem pubescent, branched. Leaves ovate, often pubescent, densely hairy; lamina oblong. Corolla lobes linear, with twisting of the corona.

SPECIMENS EXAMINED: Amazonas: *H. van der Werff et al. 14681* (MO); *H. van der Werff et al. 14729* (MO); *H. van der Werff et al. 15165* (MO); Bongará *A. H. Gentry; Smith, DN 45212* (MO); *D. N. Smith & J. M. Cabanillas Soriano 7105* (MO); **Cajamarca**: Cutervo, Sócota, *A. López M & A. Sagástegui 5321* (MO); Jaén, *E. M. Ortíz V 1196* (AMAZ,HUT,M); San Ignacio, *J. Campos de la Cruz et al. 3874* (MO); *J. Campos de la Cruz & Z. Garcia 3968* (MO); *J. Campos de la Cruz & J. Pezantes 4084* (MO,SPF); *S. Leiva González et al. 1598* (MO).

ALTITUDE: 690 – 2134 m.

DISTRIBUTION: Bolivia, Peru **(Figure 5D)**.

13. *Oxypetalum retusum* (Markgr.) Goyder, Kew Bull. 59: 303 2004

Peru: *H. Ruiz & J. A. Pavón 5/95* (lectotype MO).

Macroscepis retusa Markgr., Notizbl. Bot. Gart. Berlin – Dahlem 11(108): 787. 1933.

Metoxypetalum retusum (Markgr.) Morillo, Ernstia, ser. 2 3(3- 4): 146. 1994.

Metoxypetalum vogelii Morillo, Ernstia, ser. 2 3(3- 4): 146. 1994.

IDENTIFICATION NOTES: Perennial herb. Latex white. Stem round and thin, pubescent. Leaves in opposite pairs; lamina ovate, with acuminate apex and cordate base, pubescent; venation 4 – 5 pinnate. Inflorescence axillary, 2 to 3 flowered.

ALTITUDE: 1800 – 2250 m.

DISTRIBUTION: Bolivia, Peru

14. *Peruviasclepias aliciae* (Morillo) Morillo, Pittieria 39: 233. 2015.

Matelea aliciae Morillo, Anales Jard. Bot. Madrid 43: 238–9 1986

IDENTIFICATION NOTES: Twinning vines or sub- shrub, erect, 0.4 – 1.5 m long. Stem scarred, glauco- villous. Leaves in opposite pairs; lamina 20 – 45 mm long, with cordate base. Inflorescence 6 – 12 (- 24) flowered. Corolla yellowish green, salver- shaped or short-campanulate. Corona 5- lobed in the corolla throat, opposite the anthers.

DISTRIBUTION: Endemic to Peru

15. *Philibertia solanoides* C. S. Kunth, Nov. Gen. Sp. (quarto ed.) 3: 196–197, pl. 230 1818 [1819]

Peru: *F. W. H. A. von Humboldt & A. Bonpland s.n.* (holotype P).

Sarcostemma quadriflorum Decne., A. P. de Candolle, Prodr. 8: 542. 1844

Sarcostemma gilliesii Decne., A. P. de Candolle, Prodr. 8: 542. 1844

Sarcostemma marsupiflorum Decne., A.P.de Candolle, Prodr. 8: 542. 1844

Sarcostemma quadriflorum Decne., A. P. de Candolle, Prodr. 8: 542. 1844

Sarcostemma solanoides (C. S. Kunth) Decne., A. P. de Candolle, Prodr. 8: 542. 1844

Sarcostemma variifolium Decne., A. P. de Candolle, Prodr. 8: 541. 1844

Blepharodon rahmeri Philippi, Anales Mus. Nac. Santiago de Chile: 52. 1891.

Oxystelma solanoides (C. S. Kunth) K. Schumann., H. G. A. Engler & K. A. E. Prantl, Nat. Pflanzenfam. 4(2): 229. 1895

Philibertia weberbaueri Schltr., Bot. Jahrb. Syst. 37: 607. 1906

Philibertia hastata (Decne.) Schltr., Repert. Spec. Nov. Regni Veg. 13: 282. 1914

Philibertia marsupiflora (Decne.) Schltr., Repert. Spec. Nov. Regni Veg. 13: 282. 1914

Philibertia quadriflora (Decne.) Schltr., Repert. Spec. Nov. Regni Veg. 13: 282. 1914

Philibertia variifolia (Decne.) Schltr., Repert. Spec. Nov. Regni Veg. 13: 283. 1914

Philibertia obtusiuscula Malme, Ark. Bot. 25A(7): 16. 1933

Philibertia rahmeri (Phil.) Malme, Ark. Bot. 26A(4): 41. 1934.

Philibertia obtusata Malme, Ark. Bot. 26A(4): 41. 1934

IDENTIFICATION NOTES: Perennial herb. Stem twinning, up to 2 m long. Latex white. Whole plant minutely pubescent with white hairs. Leaves in opposite pairs, with petiole 10 to 17 mm long; lamina always triangular, with an attenuate apex and a deeply cordate base,

green above and densely pubescent beneath, white; venation 4 to 5 pinnate. Inflorescence extra- axillary, solitary umbels, 8 to 10 flowered; peduncle up to 50 mm long; pedicels 15 mm long. Calyx lobes 3 mm long, pubescent. Corolla greenish yellow, 5 – 8 X 8 – 12 mm, minutely pubescent outside, glabrous inside, with curved margins.

SPECIMENS EXAMINED: Amazonas: *H. van der Werff et al. 14646* (MO); *H. van der Werff et al. 14660* (MO); *H. van der Werff et al. 25618* (MO); Chachapoyas, *P. Gonzáles 5455* (E,USM); Balsas, *P. Gonzáles 5607* (CPUN,E,MO,MOL,QCA,USM); **Cajamarca**: *F. Woytkowski 5738* (MO); Cajabamba, Sitacocha, *J. L. Marcelo- Peña 11103* (E,MO,MOL,USM); **La Libertad**: Bolívar, *P. Gonzáles 5914* (E,USM); Pataz, *P. Gonzáles 6924* (E, MO, MOL, USM).

ALTITUDE: 170 – 4850 m.

DISTRIBUTION: Bolivia, Chile North, Ecuador, Peru **(Figure 6A)**.

16. *Prestonia mollis* C.S. Kunth, Nov. Gen. Sp. (quarto ed.) 3: 221, pl. 242 1818 [1819]

Peru: Cajamarca, Jaén, Maranon, *A. Bonpland* & *F. W. H. A. von Humboldt3608* (holotype P).

Haemadictyon pallidum A. DC. var. *genuinum*

Haemadictyon pallidum A. DC. var. *velutinum* Van Heurck

Haemadictyon pallidum A. DC. var. *velutina* Van Heurck

Prestonia glabrata C. S. Kunth, Nov. Gen. Sp. (quarto ed.) 3: 222. 1818 [1819].

Haemadictyon pallidum A. DC., Prodr. 8: 428. 1844.

Haemadictyon molle (C. S. Kunth) A. DC., Prodr. 8: 427. 1844.

Haemadictyon glabratum A. DC., Prodr. 8: 427. 1844.

Haemadictyon tomentellum G. Benth., Bot. Voy. Sulphur: 126. 1844 [1845].

Prestonia ecuadorensis K. Schumann., Nat. Pflanzenfam. 4(2): 188. 1895.

Prestonia weberbaueri Markgr., Notizbl. Bot. Gart. Berlin- Dahlem 9: 89. 1924.

IDENTIFICATION NOTES: Perennial herb. Latex white. Stem minutely pubescent when young, sparse in old Stem. Leaves in opposite pairs; petioles long and thin, slightly red; lamina narrowly elliptic to oblanceolate, with long acuminate apex and cuneate or truncate base, sparsely pubescent abaxially, mid- rib predominant, secondary veins obscure beneath, without colleters. Inflorescence axillary, cyme, 2 or 3 branched, 5 to 6 flowered, pubescent,

Calyx narrowly ovate, free. Corolla yellow, salver- shaped, pubescent outside, long tube, slightly expanded toward the mouth, annular corona, thicken, 5- lobed, obliquely obovate. Follicles unknown.

SPECIMENS EXAMINED: Amazonas: *R. Rojas & R. Vásquez 779* (AMAZ, HUT, M); *H. van der Werff et al. 14584* (MO); *H. van der Werff et al. 14703* (MO); Bagua, *P. J. Barbour 4272* (MO); *R. Castro et al. 17408* (IBE); *P. C. Hutchison & J. K. Wright 6766* (MO); *P. C. Hutchison & J. K. Wright 6766* (NY); *R. Rojas & R. Vásquez 747* (AMAZ, HUT, M); Bongará *A. H. Gentry et al. 61297* (MO); *R. Vásquez & R. Rojas 26495* (MO); Chachapoyas, *R. W. Bussmann et al. 16813* (BRIT, K, MO); *R. W. Bussmann et al. 17706* (MO); *A. López 3158* (NY); *A. Sagastegui 7489* (NY); *D. N. Smith & J. M. Cabanillas Soriano 7049 (MO);* Balsas, *R. Ferreyra 13352* (MO); Chuquibamba, *P. Gonzáles 6056* (CPUN, E, MO, MOL, USM); Utcubamba, *H. van der Werff et al. 16415* (MO); **Cajamarca:** *T. B. Croat 58365A* (MO); *A. H. Gentry 22733* (MO); *I. Shonle 30* (N/A); Cajabamba, Sitacocha, *P. Gonzáles 6128* (E, USM); Celendin, *D. N. Smith & I. Sánchez Vega 4331* (MO); Jaén, *Benson 20* (MO); *G. Edwin 3733* (NY); Jaén, *R. Ferreyra 13695* (MO); *P. C. Hutchison 1406* (N/A); *P. C. Hutchison 1406* (NY); *P. C. Hutchison & J. K. Wright 3526* (N/A); *T.C. Plowman et al. 14234* (MO); *J. Schunke V & G. Edwin 3733* (MO); *C. Vargas C 10428* (MO); Chamaya, *R. Rojas 0919* (MO); Colasay, *R. Vásquez et al. 27207* (MO); Colasay, *F. Woytkowski 6849* (MO); Colasay, *F. Woytkowski 7036* (MO); *Goodspeed, TH 1406* (NY); Pucará, *F. Woytkowski 5662* (MO); San Ignacio, *J. Campos de la Cruz 6216* (MO,NY); *J. Campos de la Cruz & P. Díaz 2628* (MO); *J. Campos de la Cruz & P. Díaz 2672* (MO); *J. Campos de la Cruz & P. Díaz 2691* (MO); *J. Campos de la Cruz & J. Pezantes 4091* (MO); *J. Campos de la Cruz & W. Vargas 6342* (MO); *E. F. Rodríguez Rodríguez & J. Campos de la Cruz 1852* (MO); *R. Vásquez & J. Campos de la Cruz 26118* (MO); *R. Vásquez et al. 20831* (N/A); *R. Vásquez & R. Rojas 25203* (MO); Huarango, *J. Campos de la Cruz & O, Díaz 2027* (N/A); **La Libertad:** Bolívar, *R. W. Bussmann et al. 16679* (BRIT,K,MO); Bambamarca, *P. Gonzáles 6399* (CPUN, E, MO, MOL, USM); **Lambayeque:** Lambayeque, *P. C. Hutchison & J. K. Wright 3418* (MO); **Piura:** Huancabamba, *N. Angulo 2119* (NY); **Tumbes:** *A. H. Gentry & C. Díaz S 58213* (MO); Zarumilla, *C. Díaz S et al. 5156* (N/A); *C. Díaz S et al. 7505* (N/A).

ALTITUDE: 280 – 2900 m.

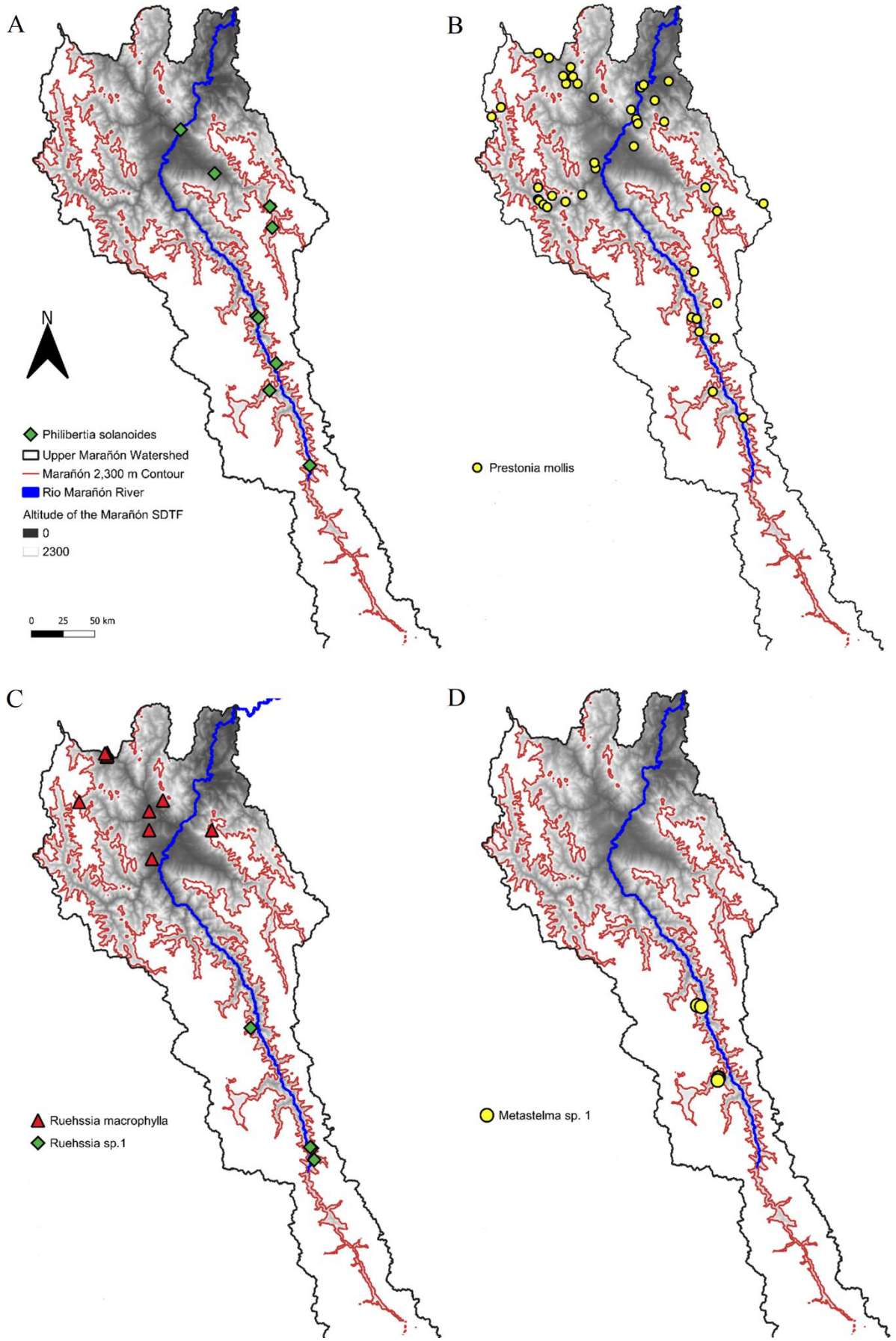

Figure 6 A Distribution of *Philibertia solanoides* **B** Distribution of *Prestonia mollis* **C**

Distribution of *Ruehssia macrophylla* and *Ruehssia sp. 1* **D** Distribution of *Metastelma sp. 1.*

DISTRIBUTION: Colombia, Ecuador, Panamá, Peru **(Figure 6B).**

17. *Ruehssia macrophylla* (Humb. & Bonpl. ex Schult.) H. Karst., Verh. Vereins. Beförd. Gartenbaues Königl. Preuss. Staaten 19: 305. 1849.

Asclepias macrophylla Humb. & Bonpl. ex Schult., Syst. Veg., ed. 15 bis 6: 86. 1820

Marsdenia macrophylla (Humb. & Bonpl. ex Schult.) E. Fourn., Fl. Bras. 6(4): 321. 1885.

Marsdenia maculata Hook., Bot. Mag. 73: t. 4299. 1847

Marsdenia warmingii E. Fourn., Fl. Bras. 6(4): 323. 1885

Ruehssia estebanensis H. Karst., Verh. Vereins Beförd. Gartenbaues Königl. Preuss. Staaten 19: 305. 1849

Ruehssia glauca H. Karst., Linnaea 28: 424. 1857

Ruehssia pubescens H. Karst., Linnaea 28: 424. 1857

Ruehssia purpurea Schltr., Linnaea 26: 669. 1855

Marsdenia macrophylla (Humb. & Bonpl. ex Schult.) E. Fourn., Fl. Bras. 6(4): 321. 1885

IDENTIFICATION NOTES: Perennial herb; Stem pubescent when young. Leaves with long and thin petiole, pubescent; lamina elliptic, with cuspidate or rounded apex and cuneate or slightly cordate base, margins revolute, colleters present at the base of the main vein, semi-fleshy, glabrous above, glabrescent beneath. Inflorescence axillary, umbelliform, 10 – 25 flowers; peduncle puberulent, glabrescent; pedicels, puberulent. Calyx lobes broadly obovate to orbicular, with obtuse to rounded apex, margins ciliate. Corolla campanulate or tubular, vinaceous to reddish above, greenish cream, glabrous underneath; corolla lobes oblong, recurved, with an obtuse to rounded apex, margins ciliate. Corona lobes narrowly triangular to lanceolate, a lower portion fused to the anther, free upper portion, not exceeding the apex of the style-head.

SPECIMENS EXAMINED: Cajamarca: Jaén, *F. Woytkowski 5594* (MO); Colasay, *F. Woytkowski 6850* (MO); San Ignacio, *R. Castro 19811* (MO); *J. de la Cruz 3214* (MO); *J. de la Cruz 3236* (MO); *J. de la Cruz 6198* (MO); *R. Vásquez 25114* (MO); Chirinos, *J. de la Cruz 2133* (MO); *J. de la Cruz 2497* (MO); Huarango, *J. de la Cruz 2975* (MO); Namballe, *E.*

Rodríguez 1636 (MO); San José de Lourdes, *J. de la Cruz 2613* (MO).

ALTITUDE: 500 – 2500 m.

DISTRIBUTION: Argentina Northeast, Bolivia, Brazil North, Brazil Northeast, Brazil South, Brazil Southeast, Brazil West- Central, Colombia, Costa Rica, Ecuador, Guyana, Leeward Is., Mexico Gulf, Mexico Northeast, Mexico Southeast, Mexico Southwest, Nicaragua, Panamá, Paraguay, Peru **(Figure 6C)**, Suriname, Trinidad- Tobago, Venezuela, Windward Is.

18. *Tassadia berteroana* (Spreng.) W. D. Stevens, Phytologia 64(5): 335 1988

Oxypetalum berteroanum Spreng., Syst. Veg. [Sprengel] 1: 854. 1825 [1824].

Metastelma stenolobum Decne., Prodr. 8: 515. 1844.

Metastelma berteroanum (Spreng.) Decne., Prodr. 8: 515. 1844.

Cynanchum stenolobum (Decne.) Morillo, Ernstia 4: 19. 1981.

IDENTIFICATION NOTES: Perennial herb. Stem round and thin, branched, smooth. Leaves in opposite pairs, with short and thin petioles; lamina narrowly ovate, with a mucronate apiculate apex and a rounded base; venation 4 – 5 pinnate. Inflorescence axillary, umbel. Corolla small, lobes linear.

ALTITUDE: 780 – 1400 m.

DISTRIBUTION: Bolivia, Brazil North, Brazil South, Brazil Southeast, Brazil West – Central, Colombia, Guyana, Paraguay, Peru, Suriname, Venezuela

NOTES: It has two different accepted names in two online databases. *Tassadia berteroana* (Spreng.) W. D. Stevens is accepted in Tropicos, and in Plants of the World Online, *Tassadia berteroanum* (Spreng.) W. D. Stevens is accepted. The same authorship and protologue indicate they might be the same species but with problematic names. Because the protologue Phytologia 64: 335 (1988) used as the scientific name, in this study, we cited *Tassadia berteroanum* in the annotated checklist.

19. *Ruehssia sp. 1*

IDENTIFICATION NOTES: Shrub slant, 1 – 2.5 m high, sparsely branched. White latex. Stem smooth, short pubescent, basally woody, with greyish bark, shoots herbaceous, green. Leaves in opposite pairs, petioles short, thin, 7 – 9 mm long, colleters absent; leaf blades 22 –

40 (- 85) X 12 – 20 (- 37) mm, lanceolate, with an attenuate apex and leaf base, minutely mucronate, pubescent abaxially venation 4 – 6 pinnate. Inflorescence axillary, fascicle, 2 – 8 flowered, peduncle 7 mm long, pedicel 3 mm long. Calyx entirely free to basally fused, rotate, slenderly triangular, lobes 2 mm, slenderly elliptic, apically acute, yellow to green. Corolla 3 X 5 mm; corolla lobes basally fused, c. 2 X 3 mm, slenderly triangular, apically acute, horizontal to declined, mostly cream, little white inside. Follicles unknown. Seeds unknown. **(Figure 7).**

SPECIMENS EXAMINED: Cajamarca: Celendín *P. Gonzáles 5172* (CPUN, E, MO, MOL, QCA, USM); *P. Gonzáles 5240* (E, USM); **La Libertad**: Pataz, *P. Gonzáles 6839* (CPUN, E, MO, MOL, QCA, USM); *P. Gonzáles 6991* (E, USM); *P. Gonzáles 7090* (E, USM); *J. L. Marcelo-Peña 11201* (CPUN, E, MO, MOL, QCA, USM).

ALTITUDE: 1631 – 2071 m.

Distribution: Peru **(Figure 6C).**

20. ***Metastelma sp. 1***

IDENTIFICATION NOTES: Twining perennial vine to 1.5 m. Latex white. Stem slender, round, glabrous, green. Leaves in opposite pairs, sometimes clustered on short lateral branches, petioles 1 – 2.5 mm long; lamina 18 – 52 X 1 – 2 mm, narrowly liner to apparently filiform, rolled underneath, with an attenuate apex and a truncate leaf base, glabrous, mid – rib venation deep grooved, secondary veins obscure. Inflorescence in extra – axillary clusters, fascicle, 3 – 7 flowered, peduncle up to 2 mm long, pedicel 2 mm long. Calyx green, slenderly triangular, lobes to c. 2 mm long. Corolla pale green outside, white inside, glabrous outside, inner lobes pubescent with white hairs, lobes divided almost to the base, suberect or somewhat spreading apically, 2 mm long, lanceolate, with acuminate apex, the central portion of each lobe densely pubescent. Follicles generally solitary by abortion, 37 – 53 X 5 – 6 mm long, fusiform with a long – attenuated beak, glabrous. Seeds unknown. **(Figure 9).**

Figure 7 Pubescent leaves and fascicle inflorescence of *Ruehssia sp. 1.*

SPECIMENS EXAMINED: Cajamarca: Cajabamba, Sitacocha, *P. Gonzáles 6184* (E, USM); *P. Gonzáles 6223* (CPUN, E, MO, MOL, QCA, USM); *P. Gonzáles 6266* (E, USM); Celendín, Utco, *P. Gonzáles 5152* (E, MO, MOL, USM); *P. Gonzáles 5393* (CPUN, E, MO, MOL, QCA, USM).

ALTITUDE: 1325 – 2000 m.

Distribution: Peru **(Figure 6D).**

Figure 8 Twinning vines and rolled leaves of *Metastelma sp. 1*.

21. *Matelea sp. 1*

IDENTIFICATION NOTES: Perennial twinning herbs. Stem round, pubescent. Leaves in opposite pairs, with long petioles; lamina pubescent, margins ciliate, venation pinnate. Inflorescence axillary, fascicle, pubescent. Corolla pale green outside, with yellow to brown hairs, brown inside. Corona absent. Fruits ovoid with acute apex, with spines **(Figure 9).**

SPECIMENS EXAMINED: Cajamarca: San Ignacio, *H. Vandrot 211* (E).

ALTITUDE: 472 m.

DISTRIBUTION: Peru **(Figure 14A).**

Figure 9 Pubescent leaves, brown inflorescence and unique fruit of *Matelea sp. 1.*

22. *Jobinia sp. 1*

IDENTIFICATION NOTES: Perennial herb to 1.5 m. Latex white. Stem slender, round, smooth and glabrous, green. Leaves in opposite pairs, petioles short and thin, 2 – 3 mm long; lamina 10 – 19 X 2 – 3 mm long, liner, with a obtuse to acute apex and a cuneate leaf base, glabrous, mid – rib venation prominent, secondary veins obscure. Inflorescence axillary, fascicle, 1 – 2 flowered, peduncle 2 – 3 mm long, pedicel 7 – 13 mm long. Calyx yellow to green, narrowly deltate, lobes to c. 1.5 mm long. Corolla yellow, 5 large yellow corolla lobes divided almost to the base, flaring at mouth and clearly imbricate aestivation, 3 mm long, corona white, plicated. Follicles generally solitary by abortion, 21 – 42 X 2 – 4.5 mm long, fusiform with a long – attenuated beak, glabrous. Seeds unknown. **(Figure 10).**

SPECIMENS EXAMINED: La Libertad: Sánchez Carrión, Sartimbamba, *P. Gonzáles 6430* (CPUN, E, MO, MOL, QCA, USM); *P. Gonzáles 6436* (CPUN, E, MO, MOL, QCA, USM).

ALTITUDE: 1131 – 1180 m.

DISTRIBUTION: Peru **(Figure 14A).**

Figure 10 Climbing habit, twin follicles and corolla of *Jobinia sp. 1.*

23. ***Apocynaceae sp. 1***

IDENTIFICATION NOTES: Perennial herb. Stem slender, angular, smooth and glabrous, green, partly woody. Leaves in opposite pairs, petioles caniculate, slightly winged, 8 – 13 mm long; lamina green, 70 – 115 X 7 – 16 mm, liner, with an attenuate apex and an acute base, folded toward the centre, membranaceous; mid – rib venation prominent, with 5 – 6 ascending secondary veins. Inflorescence terminal, with one axillary and one terminal set of dense fascicles, 15 – 28 flowered, peduncle 47 – 75 mm long, pedicle 2 – 3 mm long. Calyx green with red margins, rounded deltoid, lobes to c. 1.5 mm long. Corolla red outside and yellow to orange inside, cupiliform, 3 – 4 X 5 mm long. Fruits and seeds unknown. **(Figure 11).**

SPECIMENS EXAMINED: Cajamarca: Cajabamba, Sitacocha, *P. Gonzáles 6221* (E, USM); *P. Gonzáles 6278* (E, USM); **La Libertad**: Pataz, *P. Gonzáles 7249* (E, USM).

ALTITUDE: 1243 – 2000 m.

DISTRIBUTION: Peru **(Figure 14A).**

Figure 11 Terminal inflorescence and folded leaves of *Apocynaceae sp. 1.*

24. ***Apocynaceae sp. 2***

IDENTIFICATION NOTES: Perennial herb. Stem slender, round, smooth and glabrous, green. Leaves in opposite pairs, petioles long and thin, flattened above and slightly winged, 16 – 20 mm long; lamina green, 110 – 116 X 35 – 39 mm, lanceolate, with an attenuate apex and an obtuse base, membranaceous; venation 5 – 6 pinnate. Inflorescence axillary, spiral raceme, peduncle 65 mm long. Corolla, fruits, and seeds unknown. **(Figure 12)**

SPECIMENS EXAMINED: Amazonas: Chachapoyas, Chuquibamba, *J. L. Marcelo-Peña, 11012* (E, MOL, USM).

ALTITUDE: 890 m.

DISTRIBUTION: Peru **(Figure 14A).**

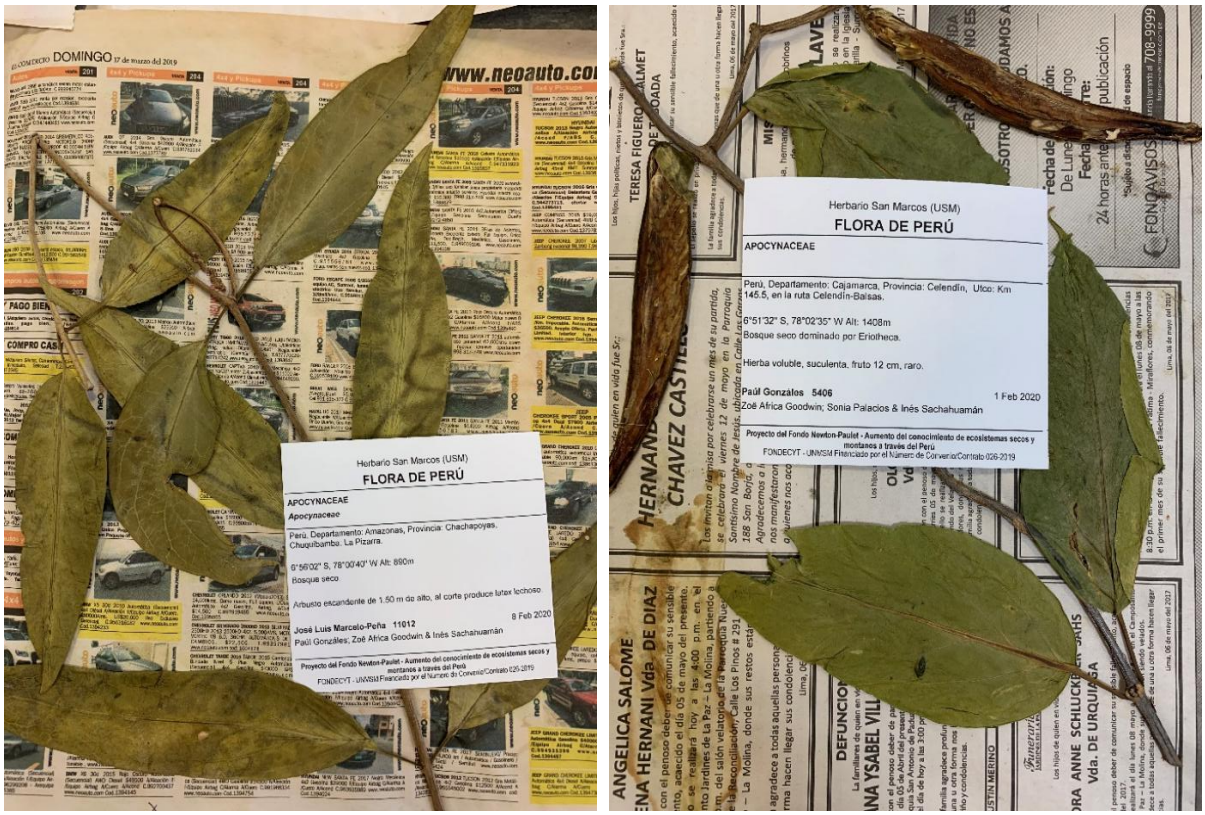

Figure 12 Lanceolate leaves and big fruits of *Apocynaceae sp. 2*.

25. ***Apocynaceae sp. 3***

IDENTIFICATION NOTES: Perennial herb, succulent. Stem slender, round, smooth and glabrous, brown, woody. Leaves in opposite pairs, petioles long and thin, slightly winged, 20 – 25 mm long; lamina green, pale green below, 130 X 50 – 58 mm, lanceolate, with a caudate apex and a rounded base, papery; venation 6 – 7 pinnate. Inflorescence axillary, peduncle 75 mm long, pedicle 10 mm long. Fruits lanceolate, 115 X 15 mm. Seeds unknown.

SPECIMENS EXAMINED: Cajamarca: Celendín, Utco, *P. Gonzáles 5406* (E, USM).

ALTITUDE: 1408 m.

DISTRIBUTION: Peru **(Figure 14B).**

26. ***Apocynaceae sp. 7***

IDENTIFICATION NOTES: Perennial herbs. Stem round and thin, pubescent. Leaves in opposite pairs, with long and thin petioles; lamina lanceolate with an acute apex and rounded base, pubescent; venation pinnate. Inflorescence axillary, fascicled, 4 – 5 flowered. Calyx

lobes green, narrowly deltate. Corolla lobes with a purple stripe in the middle. Corona white. Fruits turbinate, pubescent.

SPECIMENS EXAMINED: Cajamarca: Jaén, *H. Vandrot 203* (E).

ALTITUDE: 800 m.

27. ***Apocynaceae sp. 8***

IDENTIFICATION NOTES: Perennial herbs. Stem rounded and thin, branched, glabrous. Leaves in opposite pairs, petioles short to sessile, lamina narrowly lanceolate, with an acute apex and attenuate base, mid – rib dominant. Inflorescence fascicled, axillary, 6 – 8 flowered. Calyx lobes green, linear, with acute apex, longer than corolla lobes. Corolla green, oblong, obtuse apex. Corona present.

SPECIMENS EXAMINED: Cajamarca: Jaén, *H. Vandrot 208* (E);

ALTITUDE: 800 m.

DISTRIBUTION: Peru **(Figure 14A).**

28. ***Apocynaceae sp. 9***

IDENTIFICATION NOTES: Stem glabrous. Leaves in opposite pairs; lamina succulent, venation invisible. Inflorescence axillary, with one axillary and one terminal set of dense fascicles, 12 – 19 flowered. Calyx green with red margins, rounded deltoid. Corolla lobes with red outside apex and yellow inside lobes, cupiliform, with white hairs in the throat. Corona yellow, 5- lobed. **(Figure 13).**

SPECIMENS EXAMINED: Cajamarca: Jaén, *H. Vandrot 202* (E).

ALTITUDE: 800 m.

Figure 13 Succulent leaves and axillary inflorescence of *Apocynaceae sp. 9.*

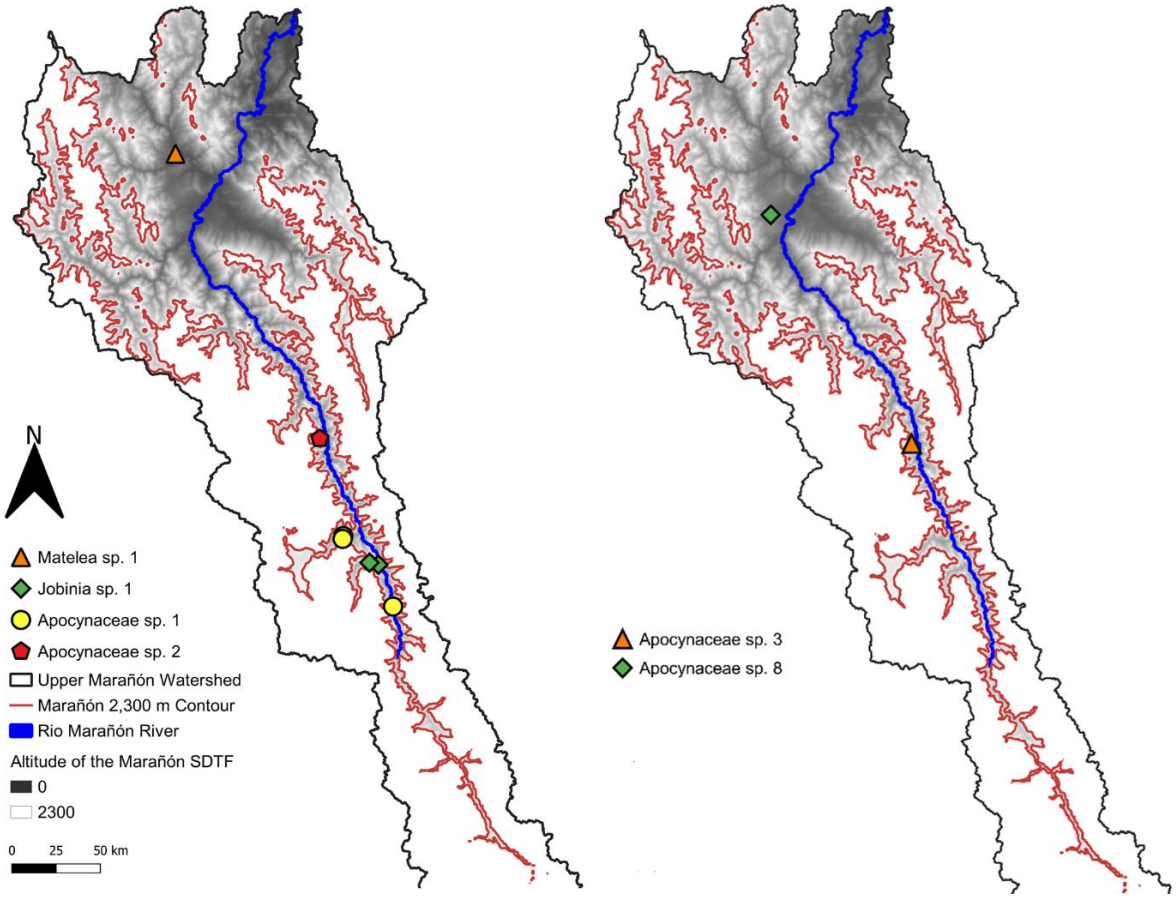

Figure 14 A Distribution of Matelea sp. 1, Jobinia sp. 1, Apocynaceae sp. 1, Apocynaceae sp.

2 **B** Distribution of Apocynaceae sp. 3, Apocynaceae sp. 8.

4 Results

The Marañón seasonally dry tropical forest was found to contain 33 species of Apocynaceae **(Table 7)** that 5 species are previously known from published checklist, and 28 species are known in our checklist. Of the 33 species, 28 species from 13 genera and six unknown genera include climbers and shrub, and further five species include four woody species and one perennial herb. Two climbing species are endemic to the Marañón dry forest, and seven species are endemic to Peru **(Table 8)**. Examination of Apocynaceae species included 152 specimens in total **(Table 7).**

4.1 Endemic Species

There are seven species endemics to Peru, one of them is woody species *Allamanda weberbaueri* Markgr. Of the seven species, two species are endemic to the Marañón SDTF. The distribution of endemic species are scattered in nouthern Marañón SDTF, but dense in the southern areas **(Table 8, Figure 15)**. The elevation of endemic species is from 400 to 2100 m.

Table 7 Apocynaceae species known from the Marañón SDTF, Peru, with numbers of specimens or number of photographs examined. Live plant photos available Y=Yes, N=No in parathesis. Unknown or uncertain species in bold.

Species	**# of Specimens (Photos Y/N)**
1 *Blepharodon salicinum* Decne.	9 (N)
2 *Ditassa weberbaueri* Schltr.	1 (N)
3 *Fischeria stellata* (Vell.) E. Fourn.	2 (N)
4 *Funastrum clausum* (Jacq.) Schltr.	10 (N)
5 *Jobinia peruviana* Liede & Meve.	1 (N)
6 *Jobinia formosa* (N.E.Br.) Liede & Meve.	0 (N)
7 *Mandevilla callacatensis* Markgr.	10 (N)
8 *Ruehssia* cundurango (Rchb.f.) Liede & H.A. Keller	4 (N)

9 *Ruehssia oligantha* (K. Schum.) Liede & H.A. Keller	2 (N)
10 *Metastelma mathewsii* Rusby	1 (N)
11 *Orthosia calycina* Liede & Meve.	1 (N)
12 *Oxypetalum dombeyanum* Decne.	11 (N)
13 *Oxypetalum retusum* (Markgr.) Goyder.	1 (N)
14 *Peruviasclepias aliciae* (Morillo) Morillo.	0 (N)
15 *Philibertia solanoides* Kunth.	10 (N)
16 *Prestonia mollis* Kunth.	60 (N)
17 *Ruehssia macrophylla* (Humb. & Bonpl. ex Schult.) H. Karst.	12 (N)
18 *Tassadia berteroanum* (Spreng.) W.D. Stevens.	0 (N)
19 ***Ruehssia sp. 1***	6 (N)
20 ***Metastelma sp. 1***	5 (N)
21 ***Matelea sp. 1***	2 (Y)
22 ***Jobinia sp. 1***	2 (N)
23 ***Apocynaceae sp. 1***	3 (N)
24 ***Apocynaceae sp. 2***	1 (N)
25 ***Apocynaceae sp. 3***	1 (N)
26 ***Apocynaceae sp. 7***	3 (Y)
27 ***Apocynaceae sp. 8***	3 (Y)
28 ***Apocynaceae sp. 9***	4 (Y)
29 *Allamanda weberbaueri* Markgr.	0 (N)
30 *Aspidosperma polyneuron* Müll.Arg.	0 (N)
31 *Rauvolfia tetraphylla* L.	0 (N)
32 *Vallesia glabra* (Cav.) Link	0 (N)
33 *Asclepias curassavica* L.	0 (N)

Table 8 Species in the annotated checklist which are endemic to Peru (7) and species which are endemic to the Marañón SDTF (bold).

Endemic Species	**Altitude**

1 ***Ditassa weberbaueri* Schltr.**	2000 – 2100 m
2 ***Jobinia peruviana* Liede & Meve.**	800 m
3 *Ruehssia oligantha* (K. Schum.) Liede & H.A. Keller.	500 – 750 m
4 *Orthosia calycina* Liede & Meve.	400 m
5 *Mandevilla callacatensis* Markgr.	1100 – 2100 m
6 *Peruviasclepias aliciae* (Morillo) Morillo.	unknown
7 *Allamanda weberbaueri* Markgr.	1770 – 1927 m

4.2 Species name

4.2.1 Synonyms

The number of synonyms varies enormously between species; a few species have many synonyms, and most species have few or no synonyms. Three species have more than ten synonyms (*Funastrum clausum* (Jacq.) Schltr., *Philibertia solanoides* Kunth., *Fischeria stellata* (Vell.) E. Fourn.) and most species have less than five synonyms. The species has most synonyms is *Funastrum clausum* (79). There are five species with no synonyms, *Ditassa weberbaueri* Schltr., *Jobinia peruviana* Liede & Meve., *Mandevilla callacatensis* Markgr., *Ruehssia oligantha* (K. Schum.) Liede & H.A. Keller and *Metastelma mathewsii* Rusby. **(Table 9).**

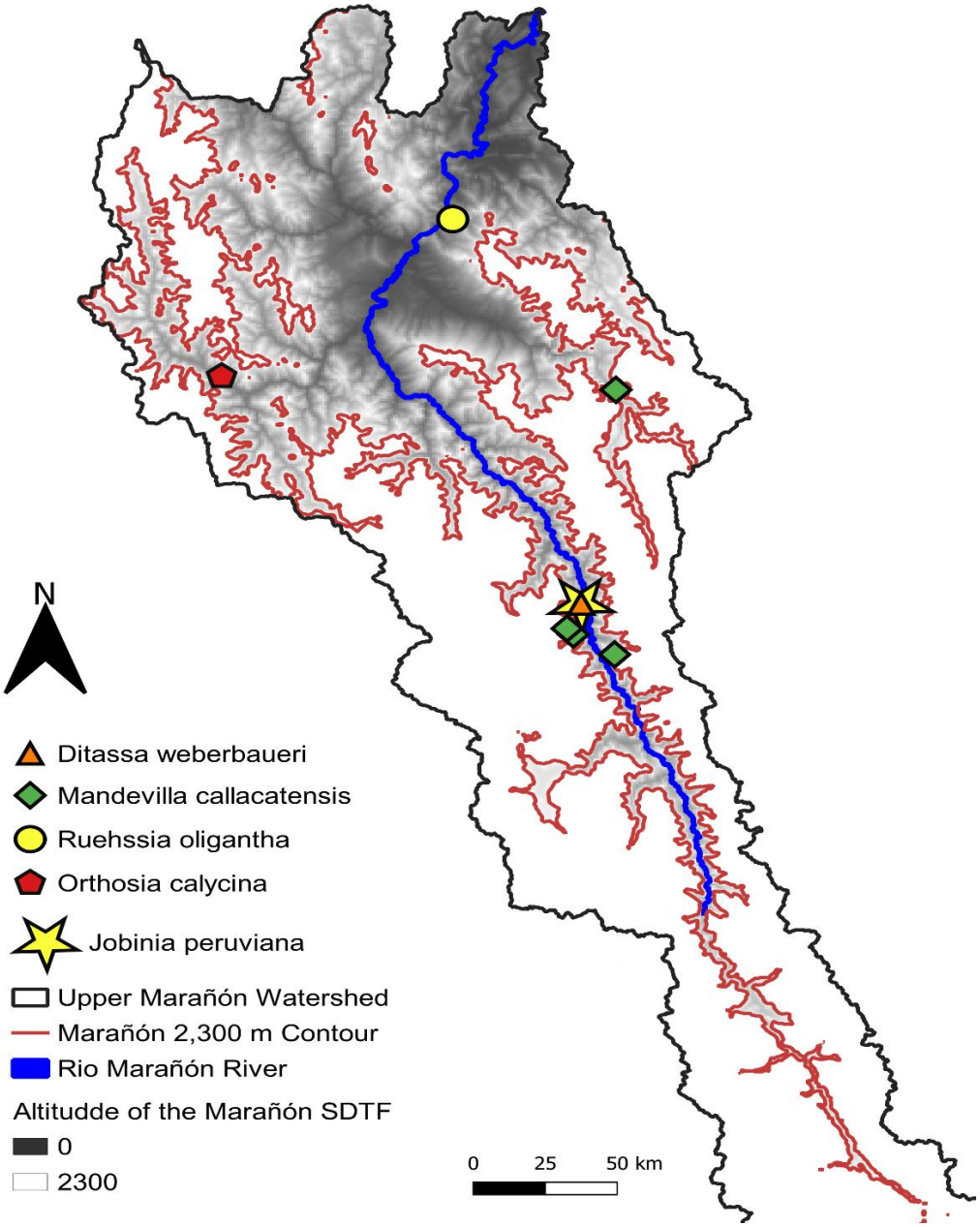

Figure 15 The distribution of species endemic to the Marañón SDTF and Peru.

Table 9 The synonyms number per known species of climbing Apocynaceae in the Marañón SDTF, Peru

Species	**Synonyms**
1 *Blepharodon salicinum* Decne.	5
2 *Ditassa weberbaueri* Schltr.	0
3 *Fischeria stellata* (Vell.) E. Fourn.	11

4 *Funastrum clausum* (Jacq.) Schltr.	79
5 *Jobinia peruviana* Liede & Meve.	0
6 *Jobinia formosa* (N.E.Br.) Liede & Meve.	3
7 *Mandevilla callacatensis* Markgr.	0
8 *Ruehssia* cundurango (Rchb.f.) Liede & H.A. Keller	4
9 *Ruehssia oligantha* (K. Schum.) Liede & H.A. Keller	0
10 *Metastelma mathewsii* Rusby	0
11 *Orthosia calycina* Liede & Meve.	1
12 *Oxypetalum dombeyanum* Decne.	1
13 *Oxypetalum retusum* (Markgr.) Goyder.	3
14 *Peruviasclepias aliciae* (Morillo) Morillo	1
15 *Philibertia solanoides* Kunth.	16
16 *Prestonia mollis* Kunth.	7
17 *Ruehssia macrophylla* (Humb. & Bonpl. ex Schult.) H. Karst.	9
18 *Tassadia berteroanum* (Spreng.) W.D. Stevens.	5

4.3 Useful Characters

Leaf shape, leaf venation, inflorescence type and corolla shape are found to be most useful characters for identifying unknown species.

4.4 Collecting Area and Species Distribution

Most species were distributed in the northern Marañón SDTF, in regions San Ignacio, Jaén and Chachapoyas and fewer species have been collected from the southern SDTF. In the southern parts, some species were collected nearest and showed an overlapped coordinate on the maps. The distribution of endemic species is dense in the southern parts of the SDTF **(Figure 15).**

Botanical collecting in the Marañón SDTF has focused on the northern SDTF, the most collected regions are Cajamarca (88) and Amazonas (42), and to a lesser extent La Libertad (13) **(Figure 16 A).** The most collected provinces are San Ignacio (36), Jaén (30) and Chachapoyas (15) **(Figure 16 B)**.

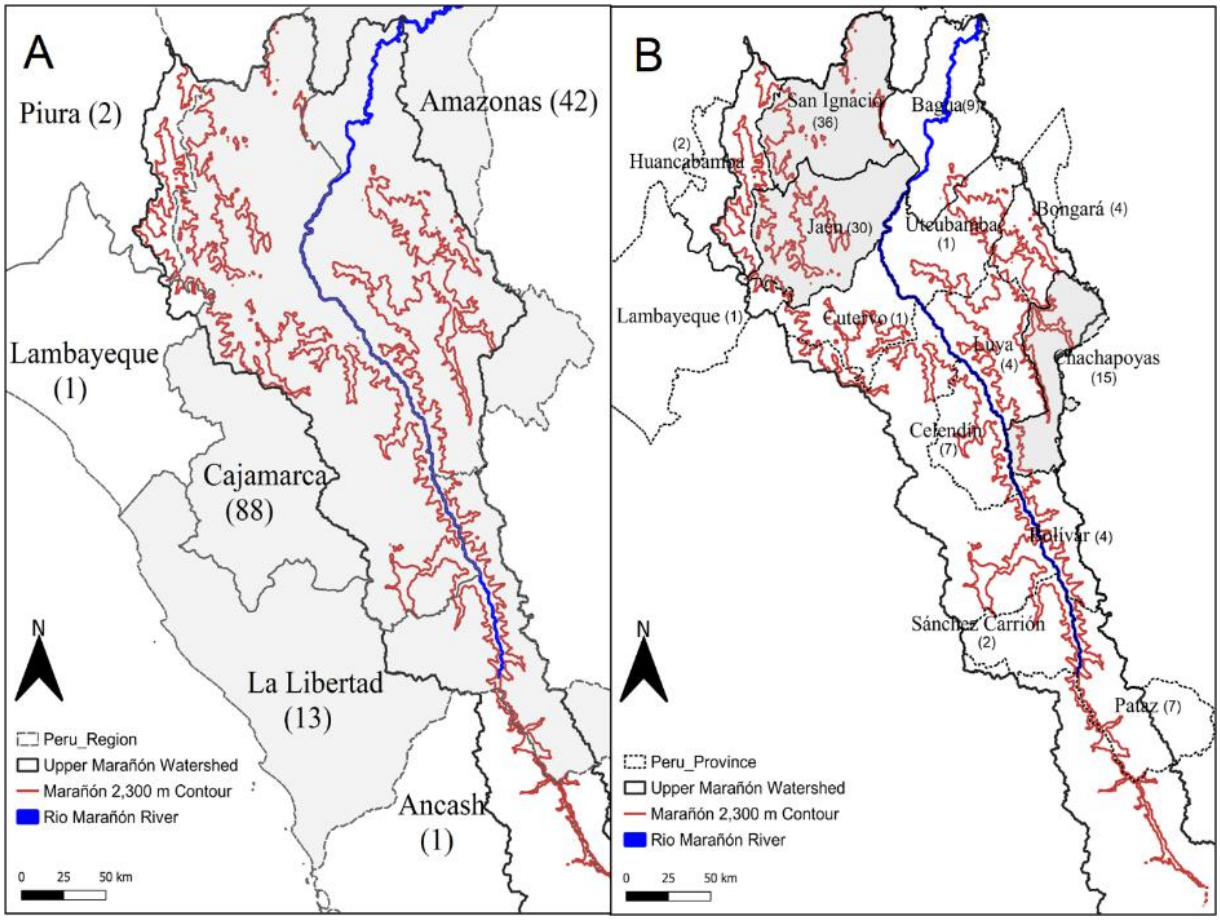

Figure 16 A Number of specimens collected in each Peruvian region **B** Number of specimens collected in each Peruvian province**.**

5 Discussion

This study has produced an annotated checklist of climbing Apocynaceae of the Marañón seasonally dry tropical forests in Peru. This annotated checklist presented the checked nomenclature and synonyms with protologues, full species description, specimen information occurred in the Marañón SDTF, altitude, distribution, distribution map and illustrations for 33 species. The annotated checklist represents the first extensive study of Apocynaceae in the Marañón SDTF, which is useful for a preliminary identification of Apocynaceae in the field and increases our knowledge of the amount and varieties of Apocynaceae species and endemic species in the Marañón SDTF. The annotated checklist is also an important reference for producing updated taxonomic review.

5.1 Species

The result showed there are 28 species from 13 genera and six unknown genera of climbing Apocynaceae from the Marañón SDTF. Of these, 18 species are known, four species are known in genera and six species are unknown. The unknown species need further studied with more specimens and taxonomy review.

5.1.1 Unknown Species and Potential New Species

There are ten unknown species, with four certain genera and six unknown species. For the four species with certain genera, they were primarily identified by P. Gonzáles and Z. A. Goodwin in the field collection. *Metastelma sp. 1* has the uniquely rolled linear leaves compared with other species occurred in Peru, Bolivia and Ecuador. A species from Ecuador, *Metastelma quitense* has the similar leaves to our collections. However, the image is in a poor quality and the protologue has no description of the leaf shape so it was not possible to confirm the identity as this species. A specimen collected by Max Weigend in 2003 from San Miguel, Cajamarca, in 1190 m (*M. Weigend 7464* B100112917) may be *Metastelma sp. 1*, with clearly rolled leaves and fascicle Inflorescence **(Figure 17)**.

For *Jobinia sp. 1*, almost all morphological characters of it accord with *Jobinia peruviana*, except the shape of corolla lobes. *Jobinia sp. 1* has oblong corolla lobes with retuse apex, while the apex of corolla lobes of *Jobinia peruviana* is acute. According to the morphological characters, *Jobinia sp. 1* is possible a new species and needs further collections and study.

The most useful identification characters of *Matelea sp. 1* are densely pubescent stem and leaves, and fruit shape. The corolla is quite flat and papery, with brown hairs outside, which looks similar with the corolla shape of *Matelea.* The microscopic characters of *Matelea* are important for identification to species level, such as apically ligulate staminal segments. Recently, these microscopic characters are used to split *Matelea* into lots of similar looing genera. However, these characters are impossible to check through the images.

Because of the limitation of Covid – 19, the identifications are relying on images of herbarium specimens, or photos of the living plants, which are blurred sometimes. And the identification work is also limited in the E herbarium. With these limitations, although the other six unknown species have special and distinctive characters individually, they still need a further study for a genera identification first.

Figure 17 Rolled leaves and fascicle inflorescence of *Metastelma sp. 1.* **A** M. Weigened 7464 (B), **B** Paúl Gonzáles 6223 (E)

Another possible reason for the unidentified species is the various collecting ages and habitats. Morphologies always various with different habitats or ages, so accessibility to more

specimens is beneficial for having an accurate and efficient identification of species. More work in the herbarium and visit to external overseas herbarium with key collections are important for taxonomy work, for example, Missouri Botanical Garden (MO) and Universidad Nacional Mayor de San Marcos (USM) (Vorontsova *et al.*, 2021).

5.2 Nomenclature

5.2.1 Synonyms

Results showed a great difference in the number of synonyms for each species. Three species, *Funastrum clausum, Philibertia solanoides, Fischeria stellata*, have more than ten synonyms and *Funastrum clausum* has the most synonyms (79). The large number of synonyms is one obstacle for an accurate estimation of number of plant species. The high number of synonyms will cause the overestimate of species number, especially for extinct and endemic species.

In this study, the total number of climbing species was overestimated firstly because of the large numbers of synonyms of some species, such as *Funastrum clausum*. The high number of synonyms is also difficult for putting a checklist together. For the increasing number of synonyms, one possible reason is the estimation of synonyms based on floral accounts and annotated checklist rather than protologues and monographs, which results in overestimating the number of species and underestimating the synonyms (Scotland and Wortley, 2003). Scotland and Wortley (2003) estimated 78% of accepted names (223,300) were synonyms. Solving the confusion of high number of synonyms is an essential work for the development of taxonomy and conservation.

The high number of synonyms will also cause the low number of specimens of the accepted name. The specimens recorded in different synonyms are difficult finding and producing checklist. This study mainly used JSTOR to find the specimens that recorded in different synonyms. It is clearer and more visible to examine the morphological characters of specimens and compare with the type specimen.

5.3 Herbarium Studies

Herbarium specimens are important resources for fully understanding the diversity and distribution of species and endemism (Marcelo-Peña et al., 2016). In this study, the character

scoring for identifying species and making maps of endemism and species distribution were all based on the physical and digitized herbarium specimens.

5.3.1 Character Scoring

The important morphological characters include vegetative and reproductive characters. The full described characters are mainly for vegetative characters, such as Stem, petioles, lamina. The reproductive characters exclude gynoecium and androecium of all species, and corona of part of the species. Because of the limited access to the herbarium, this research was mainly based on the digitised specimens from MO, NY and JSTOR. The advantages were it was convenient to access the digitised specimens from several different herbariums and download the specimen data to compare and record. On the other hand, some morphological characters were impossible to examine through the images. For example, gynoecium and androecium which are important characters for identifying similar species and used in keys of many taxonomic literature (Liede-Schumann and Meve, 2013; Morillo and Liede-Schumann, 2021), are impossible to be examined through digital specimens. Even with physical specimens examined at E, the inner structure of the corona, was impossible to observe and measure of some species with tiny flowers (*Jobinia sp. 1* and *Metastelma sp. 1*) because of the limitation of light microscope.

Examination of vegetative characters were also limited by the poor quality of images and the arrangement of plants in the sheet, because the apex and base of leaves are sometimes folded and hard to describe. The hard work with digitised specimens implicates the importance in a proper arrangement of plants when making specimens and the high quality of digitization for future research.

5.3.2 Species Distribution

This study shows an unevenly distribution of climbing Apocynaceae species in the Marañón SDTF, with a high density of species occurrences was found in the northern regions San Ignacio, Jaén and Chachapoyas. The endemic species to Peru and Marañón SDTF are distributed in Celendin. Complete species distribution maps are still needing additional specimen data, but the maps are still a significant step to increase our knowledge of the species and endemism distribution in the Marañón SDTF.

5.3.3 Endemic Species

In addition to woody species, the specimen data shows low distribution of endemism. Of the three endemic species in the Marañón SDTF, *Ditassa weberbaueri* Schltr., *Jobinia peruviana* Liede & Meve and *Allamanda weberbaueri* Markgr., the first two just has one occurrence point. *Ditassa weberbaueri* only has the type specimen from the valley of the Marañón river over Balsas. It distributes in a higher latitude, about 2000 – 2100 m, and possible grows in the Mimosoid forest zone, below the cloud forest. Species *Jobinia peruviana* was recently described in Liede-Schumann and Meve (2013) and was found in the river cliffs of the Marañón opposite Balsas. Because of the dramatic landscape in the Marañón SDTF, some areas contains the vertical cliffs and sharp limestone peaks, it is difficult to have a dense collection in these areas (Marcelo-Peña *et al.*, 2016; Valqui *et al.*, 2021). The specialised geography and elevation implicate that there may be more rare and endemic species are still unknown and not collected in the Marañón SDTF.

Previous plots – based study only recorded five known species of Apocynaceae, one of which is endemic to the Marañón SDTF (Marcelo Peña, 2010). Thus, the checklist presented here provides a 100% increase in the number of endemic species in the Marañón SDTF. This study increases the number of known species from five to 33, which shows a great endemism in the Marañón SDTF. The increasing endemic species indicates the plots-based collecting of woody species will lose many diversities of other life forms, such as lianas, vines, and other climbing species, and cause an underestimate of species diversity. It is important to consider general collecting of other life forms in the plots-collecting, not only of woody plants. The general collecting can increase our understanding of endemism and diversity in the Marañón SDTF.

5.4 Threats and Conservation in the Marañón SDTF

This study supports the prediction of the representative diversity of the Marañón SDTF in Peruvian SDTF, with an extension of only 3750 km^2, and indicates the Marañón SDTF needs a prior conservation (Marcelo-Peña *et al.*, 2016). Previous study in the Marañón SDTF showed an extreme richness of endemic woody species (33%) (Marcelo-Peña *et al.*, 2016). Many studies also described new endemic species in the Marañón SDTF, such as Leguminosae (Hughes *et al.*, 2004; Lewis *et al.*, 2010), Polygonaceae (Pendry, 2004) and

Cactaceae (Hoxey, 2014). These findings indicate a richness of endemic species in the Marañón SDTF, which are still poorly known and understudied. The other discoveries of endemic species in the Marañón SDTF of birds, reptiles and mammals, further demonstrates that it is necessary to concern about the unique diversity and endemism there (Stattersfield, 1998; Koch *et al*., 2006; Venegas *et al.*, 2008; Koch *et al.*, 2018; Valqui *et al.*, 2021; Birds: http://datazone.birdlife.org/eba/factsheet/49).

Despite many studies showed the high endemism and biodiversity of plants and animals in the Marañón SDTF, the SDTF is still lacking protection. The Marañón SDTF was disrupted by many factors, such as agriculture, livestock, infrastructure construction and population growth. A recent, further threat is the establishment of 15 hydroelectric dams in progress, which is slated for the Rio Marañón River and flood several kilometres of SDTF along the river (Finer & Jenkins, 2012; Marcelo-Peña *et al.*, 2016). Both downstream and upstream of dam have ecological impacts, such as change the biological function and structure of rivers, cause the isolation of organisms and decrease the biodiversity (Greathouse *et al.*, 2006). The single occurrence of endemic species *Jobinia peruviana* from river cliffs is possibly caused by the dams.

The special species and endemism distribution patterns in the Marañón SDTF are notable among Peruviana SDTF, but still lack of conservation protection. In study presented here, the distribution maps and altitude data provided in the annotated checklist are an important reference for planning the conservation areas. Morawetz and Raedig (2007) identified the Marañón SDTF as one of the most important conservation centres of American Tropics. All evidence demonstrates a critical and urgent conservation status of the Marañón SDTF. The Marañón SDTF is considered as a hotspot, which means areas with high level of endemism but experience destructions (Myers *et al.*, 2000). The special plant diversity and endemism in the Marañón SDTF show its important conservation status for relieving global biodiversity crisis.

6 Conclusion

This study aims to produce an annotated checklist of Apocynaceae in the Marañón seasonally dry tropical forests in Peru. In addition to the previous five species known from the published checklist, there are 33 species in total, including both woody and non-woody species. The ten

unknown species have distinctive characters and look unique. They are possible the new species and endemic to the Marañón SDTF. Furthermore, the ten unknown species need to be identified and possible repetitive collected in future work.

In the long term, the collecting work in the Marañón SDTF should include other life forms to have a full understanding of species diversity and endemism. The conservation of the Marañón SDTF for the unique vegetation types is urgent and important for relieving the global biodiversity crisis.

References

Aguirre, Z., Linares-Palomino, R. & Kvist, L. P. (2006) 'Especies leñosas y formaciones vegetales en los bosques estacionalmente secos de Ecuador y Perú', *Arnaldoa*, 13(2), pp. 324–350.

Baker, T. R. *et al.* (2017) 'Maximising Synergy among Tropical Plant Systematists, Ecologists, and Evolutionary Biologists', *Trends in Ecology & Evolution*, 32(4), pp. 258–267.

Beentje, H. J. (2016) *The Kew plant glossary: an illustrated dictionary of plant terms*. 2nd ed. Richmond (GB): Kew publishing.

Bullock, S. H., Mooney, H. A. & Medina, E. (eds) (1995) *Seasonally Dry Tropical Forests*. Cambridge: Cambridge University Press.

Dimson, M. & Gillespie, T. W. (2020) 'Trends in active restoration of tropical dry forest: Methods, metrics, and outcomes', *Forest Ecology and Management*, 467, p. 118150.

Dirzo, R. *et al.* (2011) 'Seasonally Dry Tropical Forests: Ecology and Conservation', p. 407.

Dryflor *et al.* (2016) 'Plant diversity patterns in neotropical dry forests and their conservation implications', *Science*, 353(6306), pp. 1383–1387.

Endress, M. E. *et al.* (2018) Apocynaceae: Apocynaceae Jussieu, Gen. Pl. 143 (1789) (Apocinae), nom. cons', in *Flowering Plants. Eudicots*. Cham: Springer International Publishing. pp. 207–411.

Endress, M. E. & Bruyns, P. V. (2000) 'A revised classification of the Apocynaceae s.l.', *The Botanical Review*, 66(1), pp. 1–56.

Endress, M. E., Liede-Schumann, S. & Meve, U. (2014) 'An updated classification for Apocynaceae', *Phytotaxa*, 159(3), p. 175.

Figueroa, J., Stucchi, M. & Rojas-VeraPinto, R. (2016) 'Modelación de la distribución del oso andino Tremarctos ornatus en el bosque seco del Marañón (Perú)', *Revista Mexicana de Biodiversidad*, 87.

Finer, M. & Jenkins, C. N. (2012) 'Proliferation of Hydroelectric Dams in the Andean Amazon and Implications for Andes-Amazon Connectivity', *PLoS ONE*, 7(4), p. e35126.

Gagnon, E. *et al.* (2015) 'A new cryptic species in a new cryptic genus in the Caesalpinia group (Leguminosae) from the seasonally dry inter-Andean valleys of South America', *Taxon*, 64(3), pp. 468–490.

Gentry, A. H. (1995) ‘Diversity and floristic composition of neotropical dry forests’, in Bullock, S. H., Mooney, H. A., & Medina, E. (eds) *Seasonally Dry Tropical Forests*. 1st edn. Cambridge University Press, pp. 146–194.

Greathouse, E. A. *et al.* (2006) ‘Indirect Upstream Effects of Dams: Consequences of Migratory Consumer Extirpation in Puerto Rico’, *Ecological Applications*, 16(1), pp. 339–352.

Hoxey, P. (2014) ‘A new cliff dwelling species of Espostoa Br. & R.(Cactaceae) from northern Peru’, *Bradleya*, 2014(32), pp. 36–43.

Hughes, C. E. *et al.* (2004) ‘Maraniona. A New Dalbergioid Legume Genus (Leguminosae, Papilionoideae) from Peru’, *Systematic Botany*, 29(2), pp. 366–374.

Killeen, T. J. *et al.* (2007) ‘Dry Spots and Wet Spots in the Andean Hotspot’, *Journal of Biogeography*, 34(8), pp. 1357–1373.

Koch, C. *et al.* (2018) ‘Annotated checklist and key to the species of amphibians and reptiles inhabiting the northern Peruvian dry forest along the Andean valley of the Marañón River and its tributaries’, *Zootaxa*, 4385(1), p. 1.

Koch, C., Venegas, P. & Böhme, W. (2006) ‘A remarkable discovery: Description of a big-growing new gecko (Squamata: Gekkonidae: Phyllopezus) from northwestern Peru’, *Salamandra*, 42, pp. 145–150.

Lewis, G. P. *et al.* (2010) ‘Three new legumes endemic to the Marañón Valley, Perú’, *Kew Bulletin*, 65(2), pp. 209–220.

Liede-Schumann, S. & Keller, H. A. (2020) ‘New combinations in Ruehssia for the South American species of Marsdenia (Apocynaceae-Asclepiadoideae)’, *Phytotaxa*, 471(3), pp. 283–289.

Liede-Schumann, S. & Meve, U. (2013) ‘The Orthosiinae Revisited (Apocynaceae, Asclepiadoideae, Asclepiadeae)’, *Annals of the Missouri Botanical Garden*, 99(1), pp. 44–81.

Linares-Palomino, R. (2006) ‘Phytogeography and Floristics of Seasonally Dry Tropical Forests in Peru’, in, pp. 257–279.

Linares-Palomino, R., Oliveira-Filho, A. T. & Pennington, R. T. (2011) ‘Neotropical Seasonally Dry Forests: Diversity, Endemism, and Biogeography of Woody Plants’, in

Dirzo, R. et al. (eds) *Seasonally Dry Tropical Forests*. Washington, DC: Island Press/Center for Resource Economics, pp. 3–21.

Linares-Palomino, R. & Pennington, R. (2007) 'Lista anotada de plantas leñosas en bosques estacionalmente secos del Perú: Una nueva herramienta en Internet para estudios taxonómicos, ecológicos y de biodiversidad', *Arnaldoa*, 14, pp. 149–152.

Lucena, D. da S., Lucena, M. de F. de A. & Alves, M. (2017) 'Climbers from two rock outcrops in the semi-arid region of Brazil', *Check List*, 13(5), pp. 417–427.

Lugo, A.E., E. Medina, J.C. Trejo-Torres, & E. Helmer. 2006. Botanical and ecological resilience of Antillean dry forests. In *Neotropical Savannas and Seasonally Dry Forests: Plant Diversity, Biogeography, and Conservation*, ed. R.T. Pennington, G.P. Lewis, and J.A. Ratter, 359–81. Boca Raton, FL: CRC Press.

Marcelo Peña, J. L. (2010) *Guia Ilustrada De La Flora Lenhosa De Los Bosques Estacionalmente Secos De Jaén, Perú*.

Marcelo-Peña, J. L. *et al.* (2016) 'Identifying Conservation Priority Areas In The Marañón Valley (Peru) Based On Floristic Inventories', *Edinburgh Journal of Botany*, 73(1), pp. 95–123.

Marcelo-Peña, J. L., Santini, L. & Tomazello Filho, M. (2019) 'Wood anatomy and growth rate of seasonally dry tropical forest trees in the Marañón River Valley, northern Peru', *Dendrochronologia*, 55, pp. 135–145.

Miles, L. *et al.* (2006) 'A Global Overview of the Conservation Status of Tropical Dry Forests', *Journal of Biogeography*, 33(3), pp. 491–505.

MINAM (2011) *El Perú de los bosques*. Primera edición. San Isidro, Lima, Perú: Ministerio del Ambiente.

Mooney, H. A., Bullock, S. H. & Medina, E. (1995) 'Introduction', in Bullock, S. H., Mooney, H. A., and Medina, E. (eds) *Seasonally Dry Tropical Forests*. 1st edn. Cambridge University Press, pp. 1–8.

Moonlight, P. W. *et al.* (2021) 'Expanding tropical forest monitoring into Dry Forests: The DRYFLOR protocol for permanent plots', *PLANTS, PEOPLE, PLANET*, 3(3), pp. 295–300.

Morawetz, W. & Raedig, C. (2007) 'Angiosperm Biodiversity, Endemism and Conservation

in the Neotropics', *Taxon*, 56(4), pp. 1245–1254.

Acevedo-Rodríguez, P. et al. (2015 onwards). Lianas and climbing plants of the Neotropics." https://naturalhistory.si.edu/research/botany/research/lianas-and-climbing-plants-neotropics

Murphy, P. G. & Lugo, A. E. (1995) 'Dry forests of Central America and the Caribbean', in Bullock, S. H., Mooney, H. A., and Medina, E. (eds) *Seasonally Dry Tropical Forests*. 1st edn. Cambridge University Press, pp. 9–34.

Myers, N. *et al.* (2000) 'Biodiversity hotspots for conservation priorities', *Nature*, 403(6772), pp. 853–858.

Ordas, J. A. D. *et al.* (2019) 'A checklist of Rubiaceae species from Eastern Samar, Visayas, Philippines', *Check List*, 15(2), pp. 295–312.

Pennington, R. T. *et al.* (2010) 'Contrasting plant diversification histories within the Andean biodiversity hotspot', *Proceedings of the National Academy of Sciences of the United States of America*, 107(31), pp. 13783–13787.

Pennington, R. T. & Ratter, J. A. (2006) *Neotropical Savannas and Seasonally Dry Forests: Plant Diversity, Biogeography, and Conservation*. CRC Press.

Pimm, S. L. *et al.* (2014) 'The biodiversity of species and their rates of extinction, distribution, and protection', *Science*, 344(6187), pp. 1246752–1246752.

Prieto-Torres, D. A., Lira-Noriega, A. & Navarro-Sigüenza, A. G. (2020) 'Climate change promotes species loss and uneven modification of richness patterns in the avifauna associated to Neotropical seasonally dry forests', *Perspectives in Ecology and Conservation*, 18(1), pp. 19–30.

Sánchez-Azofeifa, G. A. *et al.* (2005) 'Research Priorities for Neotropical Dry Forests', *Biotropica*, 37(4), pp. 477–485.

Sarkinen, T. E. (2010) *Historical assembly of seasonally dry tropical forest diversity in the tropical andes.* PhD Thesis, University of Oxford.

Sarkinen, T. *et al.* (2011) 'Forgotten forests - issues and prospects in biome mapping using Seasonally Dry Tropical Forests as a case stud y', *BMC Ecology*, 11, pp. 27–27.

Särkinen, T. *et al.* (2012) 'Evolutionary islands in the Andes: persistence and isolation explain high endemism in Andean dry tropical forests', *Journal of Biogeography*, 39(5), pp.

884–900.

Särkinen, T. E. *et al.* (2011) ‘Underestimated endemic species diversity in the dry inter-Andean valley of the Río Marañón, northern Peru: An example from Mimosa (Leguminosae, Mimosoideae)’, *Taxon*, 60(1), pp. 139–150.

Sarmiento, G. (1992) A conceptual model relating environmental factors and vegetation formations in the lowlands of tropical South America. In *Nature and Dynamics of Forest-Savanna Boundaries*, ed. P. Furley, J. Ratter, and J. Proctor, 583–601. London: Chapman and Hall.

Schnitzer, S. A. & Bongers, F. (2002) ‘The ecology of lianas and their role in forests’, *Trends in Ecology & Evolution*, 17(5), pp. 223–230.

Scotland, R. W. & Wortley, A. H. (2003) ‘How many species of seed plants are there?’, *TAXON*, 52(1), pp. 101–104.

Stattersfield, A. J. (1998) *Endemic Bird Areas of the World: Priorities for Biodiversity Conservation*. BirdLife International.

The Angiosperm Phylogeny Group *et al.* (2016) ‘An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV’, *Botanical Journal of the Linnean Society*, 181(1), pp. 1–20.

Valqui, B. K. G. *et al.* (2021) ‘Endemism of woody flora and tetrapod fauna, and conservation status of the inter-Andean Seasonally Dry Tropical Forest of the Marañón valley’, *Global Ecology and Conservation*, 28, p. e01639.

Venegas, P. J. *et al.* (2008) ‘Two New Sympatric Species of Leaf-Toed Geckos (Gekkonidae: Phyllodactylus) from the Balsas Region of the Upper Marañon Valley, Peru’, *Journal of Herpetology*, 42(2), pp. 386–396.

Vorontsova, M. S. *et al.* (2021) ‘Inequality in plant diversity knowledge and unrecorded plant extinctions: An example from the grasses of Madagascar’, *PLANTS, PEOPLE, PLANET*, 3(1), pp. 45–60.

Wood, J. R. I. & Clegg, R. (2021) ‘Jacquemontia (Convolvulaceae) in Bolivia and Peru’, *Kew Bulletin*.

Websites

Flora of Peru

https://www.biodiversitylibrary.org/item/19687#page/371/mode/1up

Checklist of Peru

http://legacy.tropicos.org/Project/PEC