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**Taxonomic Revision and Morphometric Analysis of Selected *Anthurium* (Araceae)
Species from Bolivia and Peru**

Daniel M. Tarazona Ocaña

B. S. Forestry and Forest Sciences, Universidad Nacional Agraria La Molina, 2019

A Thesis submitted to The Graduate School at the University of Missouri - St. Louis in partial
fulfilment of
the requirements for the degree
Master of Science in Biology
with and emphasis in Ecology, Evolution and Systematics

December
2022

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ACKNOWLEDGMENTS

I would like to start by thanking the staff and students of the Department of Biology of the University of Missouri – St. Louis. The quality of education I received during these last two years could not have been of higher level. Special thanks go towards Nathan Muchhala, Bethany Zolman, Wendy Olivas, Fred Inglis, Lon Chubiz, Aimee Dunlap, Sarah Miller, Zuleyma Tang-Martínez, and Peter Stevens, all of them professors or former professors from this excellent department.

The Whitney R. Harris World Ecology Center provided me with financial support for my studies. I am very grateful for making this possible, particularly Patricia Parker for the constant support and correspondence during these two years.

I would also like to thank the staff at the Missouri Botanical Garden (MBG). I spent most of the time doing my research at the Bayer Building and the people I met there taught me valuable lessons both regarding science and personal matters. Many thanks to Rosa Ortiz, John Pruski, Mary Merello, John MacDougal, Carolina Romero, Ivan Jiménez, Patricia Barberá, Alba Arbeláez, Peter Hoch, Charlotte Taylor, Carmen Ulloa, Lauren Boyle, Armand Randrianasolo, Tom Croat, Tyler Hughes, and Jordan Teisher.

I specially want to thank MBG Assistant Scientist and my advisor for this thesis, Dr. Mónica Carlsen, for being extremely patient and understanding with me during these last two years. She ultimately contributed to my formation as a researcher and scientist and kept pushing me to achieve more even when I had lost hope. For that, I will be forever in debt with her. ¡Muchas gracias, doctora!

I would also like to thank my friends and family in Peru for their constant support over these years: my friends from high school, Joaquin Dias, Luis Felipe Onchi, Stefano Drozd, Kevin Khamsi, Fernanda Acosta, and Sofía Ruso, their friendship remained true and unconditional, and it feels like time did not pass at all. My friends from the National Agrarian University, “Los que sí la hacen” and the “Clan CPF”, who made the long working nights bearable by providing laughter and comradeship ¡Vuela alto, Marita!

I am uniquely grateful to my friends here in St. Louis: Patrick Ross, Giulia de Gennaro, Belen Alvestegui, Estefania Fernández, Briana Robertson, Rachel Brant, Jeremy Howard, Patricia Mendoza, Rieka Yu, Andrea Trigueros, Ketra Oketcho, Shikha Grover, Danish Gul, Tabish Gul, Benish Michael, Jhan Salazar, Jordan Hathaway, George Todd, Raj Prasai, Sebastian Forward,

Jordan Hathaway, and Becky Hansis-O'Neill. You guys are amazing! I did nothing to deserve your friendship and yet I have it. I am truly blessed. Thank you very much from the bottom of my heart. Additionally, I would like to thank Nieves Dávila, a special person in my life. Nieves, you were nothing but patient with me even when I did not deserve it.

Finally, I would like to thank my mother, Rosa Ocaña, for being nothing but supportive and patient during my time here as a graduate student. Mom, this would have never been possible without your help. I have said it a million times and I will say it again: Te amo, mami.

ABSTRACT

The genus *Anthurium* (Araceae) consists of around 1,200 species distributed in the Neotropics, particularly in Central and South America. The montane forests in the eastern flank of the Andes, ranging from northern Ecuador to central Bolivia; hereafter, the East Andes Gradient region, are particularly rich in terms of species diversity, and include an understudied group of *Anthurium* species endemic to the region. Within this group of species, some taxa are difficult to distinguish from each other mainly due to the lack of identification keys, incomplete species descriptions and unknown synonyms. In this study, a combination of traditional taxonomic techniques and linear morphometric was used to better delimit species within the East Andes Gradient region. A total of 135 morphological characters, including leaf, reproductive, qualitative and quantitative characters were measured for more than 100 herbarium specimens from the Missouri Botanical Garden herbarium. This revision of *Anthurium* species occurring in the East Andes Gradient region includes a total of 24 species and 1 subspecies. Standardized descriptions, photographs and distribution maps are presented for each taxa. Additionally, summary descriptions of each section considered in this study are also included. Considerations regarding similar species and how to distinguish them are provided to avoid confusion while identifying herbarium specimens from the region. Identification keys to all species and all sections included in this revision are also provided.

Key words: *Anthurium*, Araceae, Andes, taxonomy, revision, morphometrics, Peru, Bolivia.

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INTRODUCTION

The genus *Anthurium* is one of the early divergent lineages of the family Araceae (Cusimano, et al., 2011), and it is characterized by having bisexual flowers distributed along a uniform spadix with a subtending, usually colorful, spathe that is open during anthesis (Mayo, Bogner, & Boyce, 1997). *Anthurium* includes more than 1,200 Neotropical species (POWO, 2022) ranging from southern Mexico to northern Argentina and grouped in 22 sections based on their observable morphological characteristics (Carlsen & Croat, A Molecular Phylogeny of the Species-Rich Neotropical Genus Anthurium (Araceae) based on Combined Chloroplast and Nuclear DNA, 2013). Despite ongoing studies, the taxonomy of this genus is still complicated and far from being completed. Several studies (Croat & Sheffer, The Sectional Groupings of Anthurium (Araceae), 1983; Carlsen & Croat, Taxonomic Revision of Anthurium section Semaephyllium (Araceae), 2007; Mantovani & Pereira, 2005; Carlsen & Croat, An Analysis of the Sectional Classification of Anthurium (Araceae): Comparing Infrageneric Groupings and their Diagnostic Morphology with a Molecular Phylogeny of the Genus, 2019; Reimuth & Zotz, 2020; Hammes, 2022) have tried to sort out the correct placement of species within sections and to provide a complete and solid taxonomic framework for the genus based on phylogenetic, morphological, and biogeographical analyses. Despite these efforts, much work is still needed to better understand the basic taxonomy of the species in *Anthurium*, especially in areas of high species diversity.

In the most recent molecular phylogeny of the genus *Anthurium* (Carlsen & Croat, A Molecular Phylogeny of the Species-Rich Neotropical Genus Anthurium (Araceae) based on Combined Chloroplast and Nuclear DNA, 2013), 102 species were included, and the results revealed strong monophyletic groups and the polyphyletic nature of most sections within the genus. A comparison of these phylogenetic results with morphological characters used to describe sections in *Anthurium* (Carlsen & Croat, An Analysis of the Sectional Classification of Anthurium (Araceae): Comparing Infrageneric Groupings and their Diagnostic Morphology with a Molecular Phylogeny of the Genus, 2019) showed that only a few of the sections, such as *Andiphilum*, *Calomystrum*, *Multinervia*, *Leptanthurium*, *Tetraspermium*, *Dactylophyllium*, and *Polyphyllium*, are monophyletic and can be easily characterized by a set of morphological synapomorphies not found elsewhere in the genus. However, the majority of the sections, for example, *Belonchium*, *Pachyneurium*, *Decurrentia*, *Cardiolonchium*, *Digitinervium*, *Porphyrochitonium*, and others, appeared to be polyphyletic (Carlsen & Croat, An Analysis of the Sectional Classification of Anthurium (Araceae): Comparing Infrageneric Groupings and their

Diagnostic Morphology with a Molecular Phylogeny of the Genus, 2019) and the morphological characters used in their delimitation are clearly homoplastic. This study was particularly important in demonstrating that the morphological characters used to group *Anthurium* species did not correspond with the evolutionary history of the species in the genus or with the monophyletic groups strongly supported in the phylogeny. Furthermore, these phylogenetic studies have also discovered smaller monophyletic groups that had not been previously recognized as sections within *Anthurium*. For example, a newly revealed and strongly supported clade (Clade 12 in Carlsen & Croat 2013, 2019) included only a pair of species, *A. willifordii* Croat and *A. besseae* Croat, which had been previously assigned to sections *Pachyneurium* and *Cardiolonchium*, respectively. These two species are distributed in the montane forests of the eastern flank of the Andes, are endemic to small areas in Peru and Bolivia and have velvety leaf surfaces. Other *Anthurium* species also share this geographic distribution and some of the morphological characters found in the species grouped in Clade 12 but have not been sampled in phylogenetic analyses yet, therefore, their sectional placement is still uncertain.

Phylogenies are a powerful tool for sorting species and determining evolutionary relationships among them. Once monophyletic groups of species are identified with the help of molecular data, then traditional taxonomic studies can be carried out in a more efficient way. Moreover, the study of morphological characters in combination with morphometric approaches could be used to better understand species limits and help resolve the taxonomy of species that are hard to distinguish from each other. Morphometrics are useful to quickly discriminate between individuals and establish morphogroups based on lineal, surface, or spatial measurements. Morphometrics are also a more objective technique in comparison to the classical morphological quantitative and qualitative descriptions (See, et al., 2016) and allow subtle differences in sizes and shapes to become evident using factor or cluster analysis methods. While the use of linear and geometric morphometrics is very common on animal studies, there are also multiple applications in plant studies (Pimentel Pereira, Estévez Pérez, & Sahuquillo Balbuena, 2007; Hošková, Pokorná, Neustupa, & Pokorný, 2020). In particular, in *Anthurium*, geometric morphometrics have been previously used to determine the variability within and between populations of Brazilian *Anthurium* species in the Atlantic and Amazonian rainforests (Andrade, Mayo, Kirkup, & Van den Berg, 2010). Linear morphometrics could thus be potentially useful for taxa delimitation in *Anthurium* within species complexes, such as those likely occurring in regions of high species diversity.

Species in *Anthurium* tend to have very distinct geographic distributions, in fact, a study by Reimuth and Zotz (The biogeography of the megadiverse genus *Anthurium* (Araceae), 2020) revealed a number of biogeographic regions in the Neotropics that differ in their *Anthurium* floras. Among the most diverse regions delimited in that study, was “Region #7” (Reimuth & Zotz, 2020), roughly corresponding to the montane forests of the eastern flank of the Andes between Ecuador and Bolivia (hereafter, East Andes Gradient region). As previously noted, Clade 12 of Carlsen & Croat (A Molecular Phylogeny of the Species-Rich Neotropical Genus *Anthurium* (Araceae) based on Combined Chloroplast and Nuclear DNA, 2013) *Anthurium* phylogeny is restricted to this region, with species distributed between Peru and Bolivia. Even though species checklists are available for all three countries in this region (Brako & Zarucchi, 1993; Jorgensen, Nee, & Beck, 2014), complete taxon descriptions, identification keys and comprehensive synonym lists are still lacking. Therefore, this study aimed to update and provide detailed botanical descriptions for selected species within the East Andes Gradient region and to determine the taxonomical status for taxa particularly difficult to discriminate within species complexes via the usage of linear morphometrics in combination with Principal Components Analysis and K-means clustering algorithm.

OBJECTIVES

The overall goal of this study was to generate a complete taxonomic revision of selected species of *Anthurium* (Araceae) from Peru and Bolivia using a combination of linear morphometrics and traditional morphological techniques. More specifically, this study aims to:

- a) Better delimit species complexes using morphometric analyses.
- b) Produce a taxonomic identification key that will help distinguish all selected species.
- c) Update taxonomic descriptions for all *Anthurium* species recognized in this study.

MATERIALS AND METHODS

Study area - Geographical delimitation

This study focused on the species from the Montane Forests of the Eastern Flank of the Andes, also known as the East Andes Gradient (EAG) region. This region is here defined as the montane rainforests ranging from 400 m to 2500 m in elevation which are delimited to the North by the Ecuadorian province of Napo, to the East by the lowland Amazonian rainforests that occur below 400 m in elevation, to the South by the Bolivian department of Cochabamba, and to the West by the forests that occur above 2500 m in elevation in the Andes mountains. The EAG region is an *Anthurium* bioregion roughly comparable to Region #7 defined by Reimuth & Zotz (The biogeography of the megadiverse genus *Anthurium* (Araceae), 2020). However, it differs from the latter by excluding the Pacific rainforests in the Northern coast of Peru and Southern coast of Ecuador and any part of Argentina. The key characteristic of the EAG region is the presence of the Andes mountains. The gradient that they produce to the East is particularly rich in flora and differs in species composition from the rest of the Amazonian lowlands (below 400 m in elevation).

Species selection

Species to include in this study were selected based on their geographic distribution. Initially, a list of all *Anthurium* species which occurred in either Bolivia or Peru was compiled using country level checklists (Jorgensen, Nee, & Beck, 2014) (Brako & Zarucchi, 1993). Species with broad distribution ranges that extended into Central America and/or Argentina, were excluded based on our geographic delimitation of the EAG region and prioritization of regional endemics and montane forest representatives of the genus. Additionally, all species that were included in Carlsen & Croat's phylogeny (2013, 2019) and belong to well supported clades, corresponding to already established sections, were also removed from the list, with the exception of *Anthurium besseae* and *Anthurium willifordii* which formed the well-supported Clade 12, a regional, monophyletic, and understudied clade endemic to Peru and Bolivia (Carlsen & Croat, An Analysis of the Sectional Classification of *Anthurium* (Araceae): Comparing Infrageneric Groupings and their Diagnostic Morphology with a Molecular Phylogeny of the Genus, 2019). In very few occasions, included species could also be found in the lowlands of the Amazonian rainforest of the Loreto department in Peru, the Acre state in Brazil, and the Pando and La Paz departments in Bolivia. Based on the combination of these criteria, a total of 35 *Anthurium* species were

determined to occur exclusively, or mostly, within the EAG region, and therefore included in this study.

After gathering all available herbarium samples for these species, unfortunately, due to lack of samples, the following species could not be included in this study: *Anthurium barclayanum* Engl., *A. cainarachense* Engl., *A. carneospadix* Engl., *A. conjunctum* K. Krause, *A. idmense* K. Krause, *A. peltatum* Poepp., *A. macbridei* K. Krause, *A. schunkei* K. Krause, *A. siccisilvarum* K. Krause and *A. simpsonii* Croat.

After removing all species without available samples, the final list of remaining species of *Anthurium* to be included in this study comprised 25 taxa, including 24 species and one subspecies. As shown below:

- *Anthurium acebeyae* Croat
- *Anthurium basirotundum* Croat
- *Anthurium beckii* Croat & Acebey
- *Anthurium besseae* Croat
- *Anthurium coripatense* N.E. Br. ex Engl.
- *Anthurium dombeyanum* Brongn. ex Schott
- *Anthurium galactospadix* Croat
- *Anthurium huallagense* Engl.
- *Anthurium huanucense* Engl.
- *Anthurium incurvatum* Engl.
- *Anthurium knappiae* Croat
- *Anthurium latissimum* Engl.
- *Anthurium lechlerianum* Schott
- *Anthurium llewelynii* Croat
- *Anthurium manuanum* Croat
- *Anthurium monzonense* Engl.
- *Anthurium oxycarpum* Poepp.
- *Anthurium reflexinervium* Croat
- *Anthurium regale* Linden
- *Anthurium soukupii* Croat
- *Anthurium superbum* subsp. *superbum* Madison
- *Anthurium superbum* subsp. *brentberlinii* Croat
- *Anthurium weberbaueri* Engl.
- *Anthurium willifordii* Croat
- *Anthurium yungasense* Croat & Acebey

Herbarium specimens

A total of 146 herbarium specimens representing the 25 taxa included in this study and housed at the Missouri Botanical Garden herbarium (MO) were examined and annotated. Loans from other herbaria were unavailable due to restrictions imposed by the COVID-19 pandemic.

Standard herbarium methods, primarily observation under a dissecting microscope, were used to identify potentially useful morphological characters for species delimitation. When at

least three morphological characters were constant among certain specimens and different from other groups, these specimens would be considered a species (Carlsen & Croat, Taxonomic Revision of *Anthurium* section *Semaephyllum* (Araceae), 2007). These characters could include differences in sizes, lengths, and other morphometrics, but they would have to include at least one qualitative difference (e.g., the absence of a certain organ, the presence of an extra pair of veins, the color of a particular part, etc.). If only morphometric characteristics were differentiating two groups of specimens, these would not be considered species but rather subspecies.

Species descriptions followed Croat and Bunting (Standardization of *Anthurium* descriptions, 1979). All descriptions were made based on dried herbarium material, digital pictures, and photographs. The description of *A. willifordii* was based on both dried and living material. Characteristics that were observed only once (i.e., rare within a species) were noted between parentheses. Colors were taken from specimen labels when available or from dried material, with the corresponding indication.

Measurements of morphological characters

One hundred and thirty-five morphological characters, which included 69 leaf/stem characters and 58 reproductive characters, were examined for the purposes of this study (see appendix 1). Out of those, 85 were qualitative and the rest were quantitative. To avoid confusions regarding the measurement of certain characters, details on how to measure them are provided below:

Petiole and peduncle length were measured from the base, at the insertion in the stem, to the start of the leaf blade (for petioles) or the start of the spathe (for peduncles). Geniculum length was measured from the insertion of the leaf blade into the petiole until the end of the geniculum. Petiole, peduncle and geniculum width was measured at the middle of their lengths. Blade length was measured from the insertion of the petiole in the blade to the apex, for species with leaf blades with no lobes, and from the lowest point of any lobe to the apex, for species with lobed leaf blades. Blade width was measured perpendicular to the length of the blade at the widest point. Lobe length was measured perpendicularly from a horizontal line at the insertion of the petiole in the blade until the farthest point of any lobe. Spathe length was measured from its apex to the stipe, if present, or to the base of the spadix. Spathe width was measured perpendicular to the length of the spathe, at the widest point. Spadix length was measured from the apex to the lowest visible flower. Spadix width was measured perpendicularly at the middle of its length. Stipe length was measured from the lowest flower in the spadix to the start of the

spathe. Stipe width was measured perpendicularly at the middle of its length. The number of visible flowers on a spiral is the number of flowers that can be seen from a lateral plane. Flower length was measured between the most extreme parts of opposite tepals in the longitudinal axis of the spadix. Flower width was measured between the most extreme parts of opposite tepals in the perpendicular axis of the spadix. Stigma width was measured perpendicularly to its axis, while all other floral distances (pistil length, stigma length, stamen length, anther length and anther width) were measured on their own longitudinal axes.

After careful examination of all herbarium specimens, two pairs of taxa were selected for a linear morphometrics analysis based on the strong similarities among their representative specimens. The linear morphometric analysis was performed on the following two pairs of taxa, *Anthurium coripatense* – *Anthurium yungasense* and *Anthurium superbum* subsp. *superbum* – *Anthurium superbum* subsp. *brentberlinii*, using R v.4.2.1 software (R Core Team, 2022). This approach was taken because the range of variation in sizes and shapes that existed between individuals of each pair of taxa had no visible patterns useful to distinguish them using classical morphological descriptions. Specimens of these two pairs of taxa also lacked qualitative differences between them that could be used to unequivocally assign them to a particular taxon.

A subset of the original 135 morphological characters measured above for species delimitation was used in the linear morphometrics analyses. This subset included only quantitative characters and were taken from vegetative organs exclusively (i.e., leaf blades and leaf petioles). Reproductive characters were not considered due to the inconsistency in inflorescence size and conflicts determining equivalent phenological status among samples. These subsets of characters (see appendices 4 and 5) were chosen for morphometric analyses with the goal of finding the most amount of variation between individuals and distinguishing well-delimited clusters or classes in the analyses, therefore, characters with none to little variation among the specimens studied were excluded. In addition, these morphometric characters were easy to measure with accuracy and were present in all specimens, in order to avoid unnecessary missing data that could lower the analytical power of the analyses. At the end, 13 characters were included in the morphometric analysis of *Anthurium coripatense* – *Anthurium yungasense* and 11 characters were used in the analysis of *Anthurium superbum* subsp. *superbum* – *Anthurium superbum* subsp. *brentberlinii*.

Among the morphometric characters, two new ones, Oblongivity and Curvature, are here defined and proposed as important variables for species delimitation within the genus *Anthurium*.

Oblongivity is defined as the ratio between the trapezium of the first third of the leaf and the rectangle of the first third of the leaf. The trapezium of the first third of the leaf is defined as the trapezium formed by having the width measured at the limit between the upper and middle thirds of the leaf blade and the width measured at half the blade length as parallel sides. The rectangle of the first third of the leaf is defined as the rectangle formed by having the width measured at half the blade length as one pair of parallel sides and the same height of the trapezium at the first third as the other pair of parallel sides (see Figure 1). The mathematical expression for Oblongivity is shown below:

$$Ob = \frac{(a + b)}{2b}$$

Where (Figure 1):

- a: Width measured at the limit between the upper and middle thirds of the leaf blade
- b: Width measured at half the blade length

Similarly, the primary vein curvature index is here defined as a measurement used only to compare veins' curvatures between individuals. It is here defined as the ratio between the length a primary vein and that primary vein displacement (Figure 1). The mathematical expression for Curvature is shown below:

$$C = \frac{L}{r}$$

Where (Figure 1):

- L: Length of a primary vein
- r: Length of the primary vein's displacement

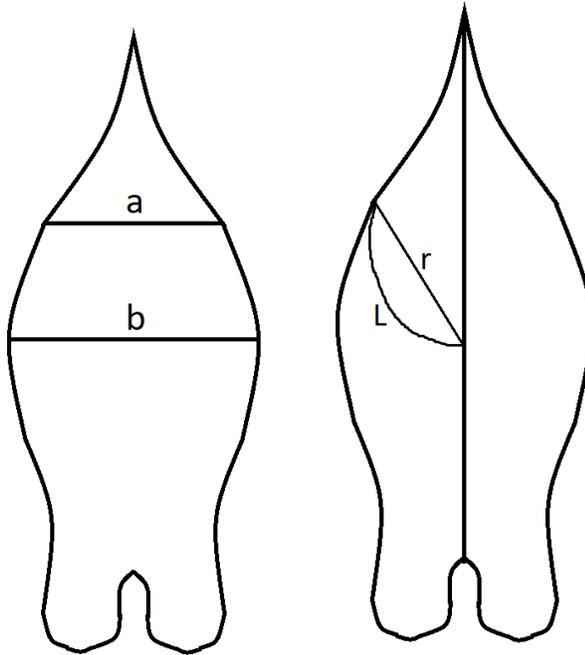


Figure 1. Measurements used to calculate Oblongivity (Ob) and Curvature (C). a: Width measured at the limit between the upper and middle thirds of the leaf blade, b: Width measured at half the blade length. L: Length of a primary vein, r: displacement of a primary vein.

To visualize the presence of morphogroups, both a Principal Components Analysis (i.e. factor analysis algorithm) and a K-means clustering analysis were performed using R v.4.2.1. The central idea of a Principal Component Analysis (PCA) is to reduce the dimensionality of a data set consisting of a large number of interrelated variables, while retaining as much as possible of the variation (Mishra, et al., 2017). In other words, a PCA is a way of identifying patterns in the data and expressing the data in such a way as to highlight their similarities and differences, with no a priori selection of groups or classes. On the other hand, the K-means clustering algorithm is a partitional clustering algorithm that divides the data set into a pre-established number of groups or clusters. According to Vora & Oza (A Survey on K-mean Clustering and Particle Swarm Optimization, 2013), K-means clustering is widely used to minimize squared distances between feature values of two points residing in the same cluster. The key and practical difference between these two methods is that a PCA provides an unbiased and objective analysis when trying to look for clusters of data while the K-means algorithm attacks the problem from the other side by confirming, or denying, if a certain number or clusters within a data set make sense in terms of

similarity. For the purposes of this study, all K-means runs considered the existence of only two groups as each pair of taxa was evaluated separately and included 500 seeds (k=2; seed=500).

Species distribution maps

Geographic coordinates were taken from specimen labels in herbarium vouchers as well as from the Missouri Botanical Garden's Tropicos database (Missouri Botanical Garden, 2022) to generate species distribution maps using QGIS v3.16.10 (QGIS.org, 2022).

RESULTS

Morphometric analysis

In this section, the results and discussion for the morphometrics analysis are presented. In general, in all plots (i.e., PCA and K-means) each specimen included in the analysis is identified by a letter code followed by a number which indicate the species to which the specimen belongs to and the particular order in which they were measured. In the PCA plot, red vectors indicate variables and their tendencies, and the axes correspond to the principal component 1 (PC1 - x axis) and the principal component 2 (PC2 - y axis), including the percentage of variance explained by each principal component in parenthesis. In the K-means graph classes are noted by different colors, blue (class 1) and red (class 2), and the axes correspond to the principal component 1 (x axis) and principal component 2 (y axis).

Case 1: Taxon delimitation at the subspecies level - *Anthurium superbum* subsp. *superbum* vs *Anthurium superbum* subsp. *brentberlinii*

Anthurium superbum subsp. *superbum* and *Anthurium superbum* subsp. *brentberlinii* are two subspecies proposed within *Anthurium superbum*. These two taxa do not share geographic distribution, as the typical subspecies occurs in Ecuador while subspecies *brentberlinii* is endemic to Peru. Croat (A Revision of *Anthurium* section *Pachyneurium* (Araceae), 1991) describes differences in leaf blade width (12 – 18 cm for *A. superbum* subsp. *superbum* and 9 – 17 cm for *A. superbum* subsp. *brentberlinii*), stem width (3 – 4 cm for *A. superbum* subsp. *superbum* and 0.7 – 1.4 cm for *A. superbum* subsp. *brentberlinii*) and length (4 – 8 cm for *A. superbum* subsp. *superbum* and 16 cm on average for *A. superbum* subsp. *brentberlinii*), and spadix length (8 – 15 cm for *A. superbum* subsp. *superbum* and 5 – 7 cm for *A. superbum* subsp. *brentberlinii*), however these dissimilarities were not always easily observable among the specimens studied. To verify the existence of two different groups within *Anthurium superbum*, a linear morphometric analysis was performed using 11 morphometric variables taken from the leaves of these species (see appendix 2).

The graph visualizing the results of the PCA of the two subspecies of *Anthurium superbum* (Figure 2) indicates that the first principal component (PC1) accounts for the majority of variation among the data set (45.93%) while PC2 accounts for 25.54%. Additionally, the variables used in the analysis, represented by the red vectors, are grouped into three main directions almost equidistant from one another, therefore, these variables do not co-vary with each other, thus, the specimens analyzed are not just different in incremental dimensions. Results from the PCA

indicated the presence of significant differences, in terms of morphometrics, between *A. superbum* subsp. *superbum* (SS) and *A. superbum* subsp. *brentberlinii* (SB) showing the existence of two defined morphogroups. The PCA plot placed individuals from SS on the right side of the plot, while it grouped SB individuals towards the left side (Figure 2). It is also possible to see that the types for both subspecies, noted SS1T and SB1T, are located close to the center of each group, which supports the idea of these types are good representatives of their respective subspecies and can be clearly differentiated from each other.

Furthermore, the results from the K-means clustering algorithm also fully support a difference between *Anthurium superbum* subsp. *superbum* (SS) and *A. superbum* subsp. *brentberlinii* (SB) (Figure 3). The algorithm correctly placed all SS individuals in class 1 (blue circle, left side of graph) and all SB individuals in class 2 (red circle, right side of graph). While this graph does not depict the magnitude of the difference between classes, it endorses the idea that the individuals from one class are more similar between them than they are to any other individual from the other class. The small overlap zone between classes 1 and 2 is to be expected as there are similarities between the subspecies regarding certain variables (i.e., blade shape and size). As before, the type specimens of each subspecies, noted SS1T and SB1T, are correctly assigned to their respective classes and well-separated from each other (Figure 3).

Based on the results of both these morphometric analyses, it was concluded that *Anthurium superbum* subsp. *superbum* and *A. superbum* subsp. *brentberlinii* are indeed two distinguishable entities according to differences based on size, shape and distribution, and therefore would remain as separate subspecies for the taxonomic treatment below.

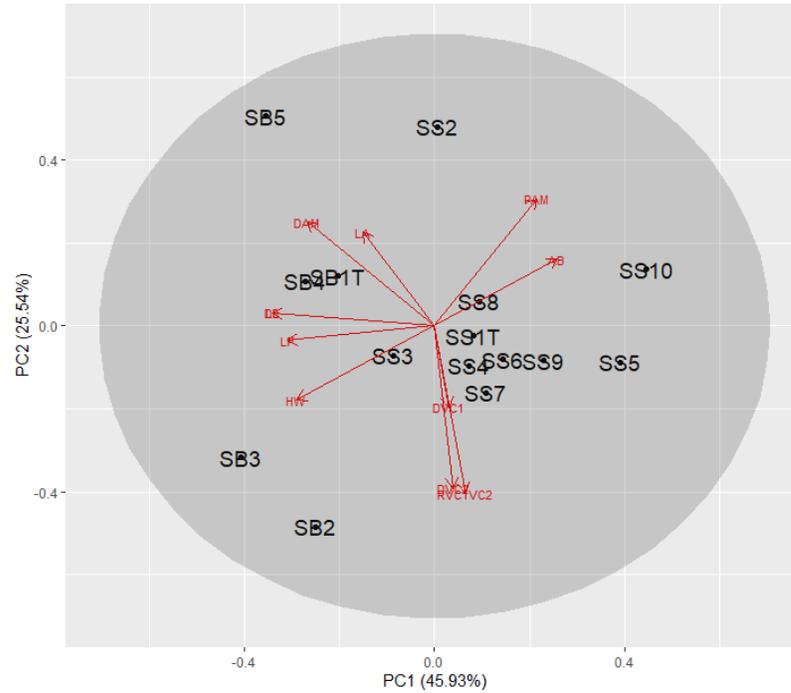


Figure 2. PCA visualization for morphometric analysis of *Anthurium superbum* subsp. *superbum* (SS) and *Anthurium superbum* subsp. *brentberlinii* (SB). Red vectors indicate variables and their tendencies, and the axes correspond to the principal component 1 (PC1 - x axis) and the principal component 2 (PC2 - y axis), including the percentage of variance explained by each principal component in parenthesis. Type specimens are noted as SS1T and SB1T for each subspecies, respectively.

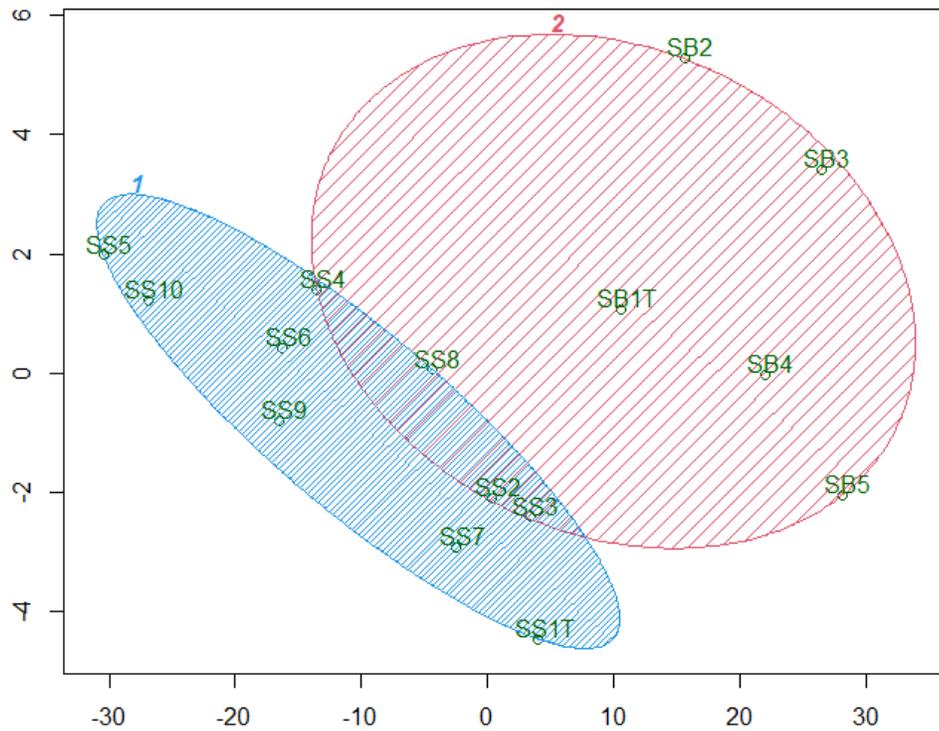


Figure 3. Visualization of K-means analysis (k=2; 500 seeds) of *Anthurium superbum* subsp. *superbum* (SS) and *Anthurium superbum* subsp. *brentberlinii* (SB). Axes correspond to the principal component 1 (x axis) and principal component 2 (y axis). Blue circle indicates class 1 and red circle indicates class 2. Type specimens are noted as SS1T and SB1T for each subspecies, respectively.

Case 2: Taxon delimitation at the species level - *Anthurium coripatense* N.E. Br. ex Engl. versus *Anthurium yungasense* Croat & Acebey

Anthurium coripatense and *A. yungasense* are two very similar species. Regarding leaf and reproductive characters, the specimens observed from this pair of taxa did not display notable differences other than variation in sizes and lengths. Additionally, these two species share the same geographic distribution, which ranges from central Ecuador to central Bolivia along the eastern flank of the Andes without venturing into the Amazonian lowlands (> 400 m in elevation). *A. coripatense* is a very old species name that was described in the year 1905. Its description is not detailed and quite incomplete which are factors that could play a role in the confusion between these two species. It is also important to mention that the specimen chosen as the holotype for *A. yungasense* when the species was described in 2005 (Thomas B. Croat 84783) was

previously identified as being a specimen of *A. coripatense*. Therefore, due to the lack of visible qualitative differences between these two taxa, their shared geographic distribution, and the taxonomic history of *A. yungasense*, this pair of species was selected to be analyzed with linear morphometrics using 13 morphometric variables to try to better delimit them (see appendix 3).

The graph visualizing the results of the PCA of *Anthurium coripatense* (C) and *A. yungasense* (Y) (Figure 4) indicates that the first principal component (PC1) accounts for the majority of variation among the data set (37.91%) while PC2 accounts for 14.77%. In combination, both PCs account for just about half of the variation in the dataset, thus hinting at the lack of variability among the specimens analyzed. Furthermore, it is noticeable that the red vectors representing the morphometric variables included in this analysis all point towards the same direction, with the exception of two of them. This indicates that most of the variables, while not directly correlating to one another, do share some harmony when increasing or decreasing, thus, the specimens analyzed seem to be different in just incremental dimensions. This PCA plot of the analysis of specimens of *A. coripatense* and *A. yungasense* did not show well-defined groups in the morphospace, instead it showed a lack of consistent morphometric differences in vegetative traits between these two species. The group as a whole, including specimens of both C and Y, presents a continuum of size variation with no easy way to define two well-delimited groups without a lot of overlapping in the morphospace. It is important to mention the type specimens for both species, noted C11T and Y25H, respectively, were placed very close to each other in the morphospace (Figure 4), therefore confirming the great similarity between them.

The K-means clustering algorithm analysis of specimens of *Anthurium coripatense* and *A. yungasense* found two classes, each one including a mix of specimens from both species, when forced to look for these two classes (Figure 5). However, it is possible to see in the K-means graph that the algorithm was not capable of correctly placing individuals from each species in the same group. Moreover, the type specimens for these species, noted C11T and Y25H, respectively, were both placed within class 1 (blue circle), meaning that they are both more similar to one another than they are to other individuals of their respective species placed within class 2 (red circle).

Based on the results of both morphometric analyses, it was determined that *Anthurium coripatense* and *A. yungasense* are not unique entities with enough differences to consider them separate species, as the specimens studied for both these taxa belong to a single, variable, and widely distributed population. Therefore, *A. yungasense* would be treated as a synonym of *A. coripatense* in the taxonomic treatment below.

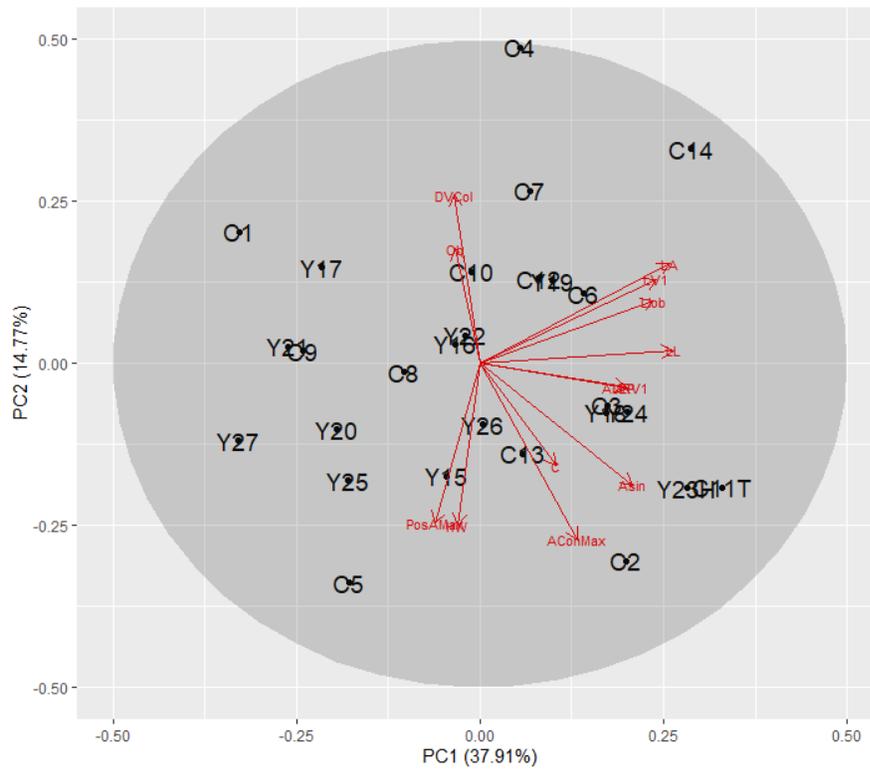


Figure 4. PCA visualization of morphometric analysis of *Anthurium coripatense* (C) and *Anthurium yungasense* (Y). Red vectors indicate variables and their tendencies, and the axes correspond to the principal component 1 (PC1 - x axis) and the principal component 2 (PC2 - y axis), including the percentage of variance explained by each principal component in parenthesis. Type specimens are noted as C11T and Y25H for each species, respectively.

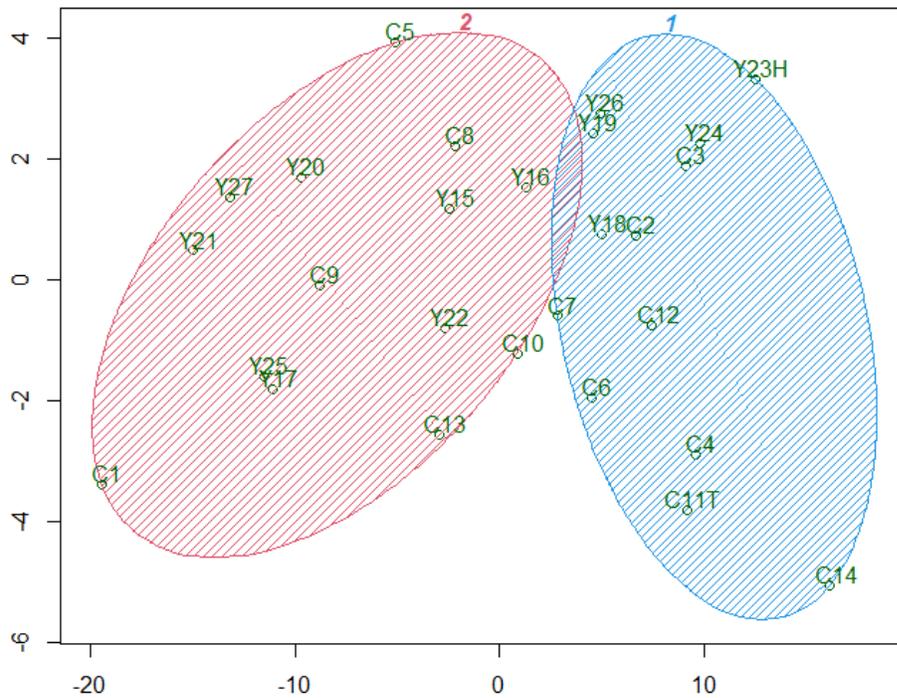


Figure 5. Visualization of K-means analysis (k=2; 500 seeds) of *Anthurium coripatense* (C) and *Anthurium yungasense* (Y). Axes correspond to the principal component 1 (x axis) and principal component 2 (y axis). Blue circle indicates class 1 and red circle indicates class 2. Type specimens are noted as C11T and Y25H for each species, respectively.

Taxonomic treatment

In this section the taxonomic treatment for the group is given. This treatment derives from literature revision as well as from direct observations of dried specimens.

Anthurium Schott, *Wiener Z. Kunst* 828, 1829. LECTOTYPE: *Anthurium acaule* (Jacq.) Schott. *Pothos acaulis* Jacq., Enum. Syst. Pl. 31. 1760.

Herbs, usually epiphytic, less often terrestrial or lithophyte, the growth habit monophyllous or rarely polyphyllous sympodial; petioles variously shaped, usually conspicuously geniculate at apex; leaf blades simple to palmately divided or compound with the lesser veins reticulate; inflorescence terminal (but appearing axillary), one per leaf; spathe free, persistent; spadix uniformly tapered; flowers perfect, densely arranged in spirals, tepals 4, cucullate at apex and usually overtopping pistils; stamens 4; pollen globose, forate or rarely (sect. *Polyphyllium*) inaperturate, the exine basically reticulate; ovary 2-locular, with 1 or 2 ovules per cell, rarely 3 or more; fruit a berry.

Key to the *Anthurium* sections included in this study

- 1a. Velvety leaves ----- 2
- 2a. Blades cordate with thick white primary veins or elliptic with bullate slightly lobed at the base ----- “Clade 12” Carlsen & Croat
- 2b. Blades cordate with thick yellow or orange primary veins ----- *Cardiolonchium* Schott
- 1b. Leaves not velvety ----- 3
- 3a. Blades cordate or triangular ----- 4
- 4a. Glandular punctuations present, steeply ascending basal veins ----- *Digitinervium* Sodiro
- 4b. Punctuations absent, thick spades usually hooded ----- *Belolonchium* (Schott) Engl.
- 3b. Blades elliptic, oblong, ovate, lanceolate, oblanceolate, or tri-lobed ----- 5
- 5a. Rosulate habit, “bird’s nest” habit, involute vernation ----- 6
- 6a. Thick and pale primary veins, collective vein often absent ----- *Pachyneurium* Schott
- 6b. Numerous and closely spaced primary veins, collective vein conspicuous -----
----- *Multinervia* (Croat) Croat & Carlsen
- 5b. Not rosulate habit, no “bird’s nest” habit ----- 7
- 7a. Blades elongated and elliptical ----- 8
- 8a. Punctuations present ----- *Porphyrochitonium* Schott

- 8b. Punctuations absent ----- *Decurrentia* Croat
 7b. Blades strongly tri-lobed ----- *Semaephyllium* Schott

Diagnostic morphological characteristics of the *Anthurium* sections included in this study

***Anthurium* sect. "Clade 12"** Carlsen & Croat, Syst. Bot. 38(3): 584. 2013.

This relatively new monophyletic group is characterized by having velvety bullate leaves with red venation underneath and purple stubby spadices. Leaf blades may present lobes and tertiary veins are usually visible only on the abaxial surface. Inflorescences are commonly purplish, while stipes are inconspicuous or not present at all. In its original description (Carlsen & Croat 2013), this clade included only two species: *A. bessae* Croat and *A. willifordii* Croat; however, in this study two more species and one subspecies were added to this clade. *A. regale* Linden, *A. superbum* Madison, *A. superbum* subsp. *brentberlinii* Croat are included in this section.

Anthurium* sect. *Belolonchium (Schott) Engl., Monogr. Phan. 2: 151. 1879. *Pothos subsagittatum* Kunth, Nov. Gen. Sp. (quarto ed.) 1: 77–78. 1815[1816]. TYPE: *Anthurium subsagittatum* (Kunth) Kunth, Enum. Pl. 3: 79. 1841.

This is one of the biggest sections within the genus, and it contains at least two different groups of species. It is characterized by having cordate blades, thick and usually hooded spathes, pendent spadices, and densely fibrous cataphylls. Most of the species included here occur at high elevations and possess leaves either with thick blades which dry brown or thin blades which dry green. This section includes a total of 308 species, of which 2 are present in the EAG region and thus included in this study. *A. acebeyae* Croat and *A. monzonense* Engl. are included in this section.

Anthurium* sect. *Cardiolonchium Schott, Prodr. Syst. Aroid. 526. 1860. *Pothos sagittate* Sims Bot. Mag. 38: t.1584. 1813. TYPE: *Anthurium sagittatum* (Sims) G. Don, Hort. Brit. (ed. 3) 633. 1839.

The species in this section have short stems and short internodes. Additionally, the peduncles and petioles are often striate or ribbed, the blades are velvety on the adaxial surface, dry green and often possess pale venation, and the tertiary veins are inconspicuous on the abaxial surface. This section includes a total of 316 species, of which 2 are present in the EAG region and thus included in this study. *A. coripatense* N. E. Br. ex Engl. and *A. incurvatum* Engl. are included in this section.

Anthurium* sect. *Decurrentia Croat, Rodriguésia 56(88): 16. 2005. TYPE: *Anthurium decurrens* Poepp., Nov. Gen. Sp. Pl. 3: 83, pl. 293. 1845.

This recently described section is characterized by its elongated and granular blades which are usually acute at the base. In addition to this, short internodes, elongated petioles and ribbed and ridged peduncles are typical among its species. This section includes a total of 57 species, of which 1 is present in the EAG region and thus included in this study. *A. huanucense* Engl. is included in this section.

Anthurium* sect. *Digitinervium Sodiro, Anturios Ecuador. 54. 1903. TYPE: *Anthurium subellipticum* Sodiro, Revista Chilena Hist. Nat. 4(6): 76–78. 1900.

This section is a natural one and easy to identify. The most important features are its thick blades with glandular punctuations and steeply ascending basal veins which end up at the apex. Another characteristic is the presence of parallel tertiary veins between the basal veins. Species from this group usually have 2 or more pairs of collective veins. This section includes a total of 52 species, of which 2 are present in the EAG region and thus included in this study. *A. lechlearianum* Schott and *A. weberbaueri* Engl. are included in this section.

Anthurium* sect. *Multinervia (Croat) Croat & Carlsen, Ann. Missouri Bot. Gard. 78:573. 1991. TYPE: *Anthurium napaeum* Engl., Bot. Jahrb. Syst. 25:407. 1898.

This section is known for having an involute leaf vernation and a “bird’s nest” habit. Blades are usually elliptic-oblong or elliptic, rarely oblanceolate. The leaves of species from this section dry green or yellow-green and possess numerous and widely spaced lateral veins. The fruits are mostly orange, sometimes purple. This section includes a total of 21 species, of which 1 is present in the EAG region and thus included in this study. *A. soukupii* Croat is included in this section.

Anthurium* sect. *Pachyneurium Schott, Prodr. Syst. Aroid. 466. 1860. TYPE: *Anthurium crenatum* (L.) Kunth, Enum. Pl. 3: 75. 1841. *Pothos crenata* L. Sp. Pl. Ed. 2: 1373.

This section is also known for having an involute leaf vernation and a “bird’s nest” habit. Primary lateral veins are thick and often extend free to the margin which means a short (or absent) collective vein. This section includes a total of 137 species, of which 9 are present in the EAG region and thus included in this study. *A. basirotundum* Croat, *A. dombeyanum* Brongn. ex Schott, *A. galactospadix* Croat, *A. knappiae* Croat, *A. latissimum* Engl., *A. llewelynii* Croat, *A. manuanum* Croat, *A. oxycarpum* Poepp., and *A. reflexinervium* Croat are included in this section.

Anthurium* sect. *Porphyrochitonium Schott, Prodr. Syst. Aroid. 439. 1860. TYPE: *Anthurium scherzerianum* Schott, Oesterr. Bot. Wochenbl. 7(7): 54. 1857.

This section is characterized by having dense roots, persistent fibrous cataphylls, slender stems with short internodes and glandular punctuated elongated blades. This section includes a

total of 283 species, of which 1 is present in the EAG region and thus included in this study. *A. beckii* Croat & Acebey is included in this section.

Anthurium sect. ***Semaephyllum*** Schott, Prodr. Syst. Aroid. 534. 1860. LECTOTYPE: *Anthurium sagittaria* Linden ex Schott, Prodr. Syst. Aroid. 537. 1860.

This last section is easy to identify due to its deeply 3-lobed leaf blades with short stems and short internodes. This section includes a total of 27 species, of which 1 is present in the EAG region and thus included in this study. *A. huallagense* Engl. is included in this section.

Key to *Anthurium* species included in this study

- 1a. Blades deeply 3-lobed and drying black; plants with short internodes ---- *A. huallagense* Engl.
- 1b. Blades cordate, 2-lobed, or entire; plants not drying black ----- 2
- 2a. Abaxial surface of leaves with black or reddish punctuations ----- 3
- 3a. Leaves entire, elongated with short internodes, slender stems, small spadix ---- *A. beckii* Engl.
- 3b. Leaves cordate-like or triangular-like with steeply ascending basal veins ----- 4
- 4a. Leaves green, cordate-like, and lobed; the lobes oblong with a sinus between them parabolic to spatulate ----- *A. lechlerianum* Schott
- 4b. Leaves brown, triangular-like, and lobed; the lobes short to almost with a sinus between them arched ----- *A. weberbaueri* Engl.
- 2b. Abaxial surface of leaves without punctuations ----- 5
- 5a. Blades cordate, with lobes ----- 6
- 6a. Spathe hooded ----- 7
- 7a. Stipe longer than 10 mm, lobes oblong ----- *A. acebeyae* Croat
- 7b. Stipe shorter than 10 mm, lobes auriculate to reniform ----- *A. monzonense* Engl.
- 6b. Spathe free ----- 8
- 8a. Primary veins white, curved ----- 9
- 9a. Blade cordiform; basal ribs absent ----- *A. besseae* Croat
- 9b. Blade ovate; basal ribs present ----- *A. regale* Linden
- 8b. Primary veins yellowish-mustard, straight ----- 10
- 10a. Petiole terete; collective vein starting from the first pair of basal veins -- *A. incurvatum* Engl.
- 10b. Petiole triangular or "D"-shaped; collective vein absent ----- *A. coripatense* N. E. Br. ex Engl.
- 5b. Blades entire, without lobes ----- 11
- 11a. Blade elliptic, elongated; primary veins straight, numerous ----- 12

12a. Prominent and thick margin visible on the abaxial surface; stipe absent ----	<i>A. soukupii</i> Croat
12b. Non-prominent margin; stipe present -----	<i>A. huanucense</i> Engl.
11b. Blade elliptic, oblanceolate, or ovate, not elongated -----	13
13a. Stipe present -----	14
14a. Hooded spathe; primary veins prominent and alternate -----	<i>A. galactospadix</i> Croat
14b. Free spathe; risen midrib -----	15
15a. Leaves drying brown -----	16
16a. Blade base cuneate; petiole cross section terete; primary spiral right-handed ----- -----	<i>A. latissimum</i> Engl.
16b. Blade base acute -----	17
17a. Petiole cross section “D”-shaped; primary spiral right-handed ----- -----	<i>A. dombeyanum</i> Brongn. ex Schott
17b. Petiole cross section terete; primary spiral left-handed -----	<i>A. manuanum</i> Croat
15b. Leaves drying green -----	18
18a. Tertiary veins visible; spadix green to yellowish green -----	<i>A. oxycarpum</i> Poepp.
18b. Tertiary veins not visible; spadix cream -----	<i>A. knappiae</i> Croat
13b. Stipe absent -----	19
19a. Oblanceolate blades; tertiary veins not visible -----	20
20a. One pair of collective veins -----	21
21a. Petiole terete -----	<i>A. llewelynii</i> Croat
21b. Petiole hexagonal and acutely ribbed -----	<i>A. willifordii</i> Croat
20b. Two pairs of collective veins -----	22
22a. Petioles 5 – 10 cm long; base of the blade with an 82° angle on average; collected in Ecuador -----	<i>A. superbum superbum</i> Madison
22b. Petioles 9 – 12.5 cm long; base of the blade with a 35° angle on average; collected in Peru -- -----	<i>A. superbum brentberlinii</i> Croat
19b. Elliptic blades; tertiary veins visible -----	23
23a. Base round, primary veins curved towards the base but quickly moving towards the apex --- -----	<i>A. basirotundum</i> Croat
23b. Base slightly cuneate; primary veins curved towards the base and joining the margin at a lower point beneath their starting position -----	<i>A. reflexinervium</i> Croat

Description of species

In this section, complete species descriptions are provided. These descriptions are based on known literature and direct observations from dried samples. Also included are representative images and distribution maps generated using geographic coordinates from the Missouri Botanical Garden Tropicos online database (Missouri Botanical Garden, 2022).

1. *Anthurium acebeyae* Croat, sect. Belolonchium. TYPE: Bolivia. La Paz department, Nor Yungas province: 14.3 km NE of Chuspipata, 16°14'S, 67°47 W, 2000 m, 23 Mar. 1984, *James C. Solomon* 12090 (holotype, MO-3213306; isotypes, K, LPB, US).

Terrestrial herb or epiphytic vine; stem long, 1.3 – 1.4 cm in diameter; cataphylls dark brown, 11 – 15 cm long, apex acute, persistent. *Leaves* glabrous, petioles 33 – 55 cm long, 3 – 6 mm in diameter, cross section circular, olive green to dark green; geniculum dark green to blackish, 1 – 1.5 cm long, 2.7 – 4 mm in diameter; blade coriaceous, obpyriform, apex acuminate, base lobate, 33 – 44 cm long, 16 – 29 cm in width, broadest at the lobes, margins entire; lobes oblong, 8 – 11 cm long, sinus shape parabolic to spatulate; adaxial surface dark green; abaxial surface olive green to light glaucous green, blade drying green; midrib concolorous and risen in an upside down “V” shape; basal ribs curved, naked at the sinus, 2 – 4 cm long; basal veins 4 – 5 pairs, 2 (1) pairs radiating, 3 pairs coalescing; primary lateral veins 12 – 17 per side, alternate to subopposite, concolorous, straight to straight turning acutely curve towards the apex; 1 – 8 interprimary veins; secondary veins reticulate ; tertiary veins reticulate; collective vein beginning at 5th basal vein to 2nd – 4th primary veins, distance from margin 0.3 – 0.6 cm. *Inflorescence* erect, peduncle 13 - 30 cm long, 1.7 – 3.1 mm in diameter, 0.39 – 0.53 times the length of the petiole, dark green to olive green; spathe surrounding to free at 90° from spadix, coriaceous, green, reflexed, elliptic, 6.2 – 8.8 cm long, 5 – 10 mm in width, broadest part at the middle section, apex acute, base acute; spadix brownish green to cream, tapered to cylindrical, erect, 7.6 – 10.2 cm long, 3.2 – 5.7 mm in diameter; stipe darkish brown, 9 – 21 mm long, 0.9 – 2.5 mm in width; flowers squared or rhombic, 1.5 – 2 mm long, 1.3 – 1.7 mm in width; primary spiral mostly right-handed, 5-7 visible flowers in primary spiral, 5 – 6 visible flowers in secondary spiral; tepals matte, lateral tepals interior margins straight or convex; pistil quadrangular, 0.6 – 0.9 mm long; stigma elliptic, 0.2 – 0.4 mm long, 0.2 mm in width; stamens 1.1 – 1.4 mm long; filaments flat; anthers 0.3 – 0.4 mm long, 0.4 – 0.5 mm in width; pollen white.

Distribution: *Anthurium acebeyae* is found in Northern Bolivia (La Paz, Nor Yungas) all the way to southern Peru (Cusco, La Convención) in altitudes ranging from 1800 to 2300 m on the eastern flank of the Andes (Figure 6).

This species can be recognized by its long stipe and the obpyriform-shaped blade. The surrounding spadix is also frequent among individuals. *Anthurium acebeyae* could be confused with *A. incurvatum* but the latter has a longer geniculum and an ovate blade in contrast to *A. acebeyae* obpyriform leaf blade. *Anthurium acebeyae* could also be confused with *A. monzonense*, but this species has shorter stipes (< 10 mm) and smaller leaf lobes (auricular to reniform in shape).

Specimens examined: *James Clinton Solomon 12090, Thomas B. Croat 51459, James Clinton Solomon 12166, Gloria Calatayud Hermoza 4652.*

2. *Anthurium basirotundum* Croat, sect. Pachyneurium. TYPE: Peru. San Martín department, Tarapoto province: Above Hotel de Turistas, 400 m, cultivated at SEL (# 86-1976-2). *Timothy Plowman 5980A* (holotype, MO-2727371; isotype, SEL).

Rosette herb; stem short, 2 – 3 cm in diameter; roots numerous, descending to spreading, green, slender, cross section with 3 – 5 cm in diameter; cataphylls subcoriaceous, lanceolate, 3 – 7 cm long, apex round, green tinged reddish, brown when dry, persistent. *Leaves* glabrous, petioles 2 – 5.3 cm long, 3.5 – 4.1 mm in diameter, cross section triangular to D-shaped, olive green to reddish brown; geniculum brownish, 0.5 – 0.8 cm long, 3.3 – 5 mm in diameter; blade coriaceous, ovate, apex acute, base obtuse to round, 23 – 37 cm long, 10 – 16 cm in width, broadest at the inferior half, margins entire; adaxial surface green when dry; abaxial surface glaucous green when dry, small whitish pustules present, blade drying reddish brown to greenish brown; midrib concolorous and shortly risen in an upside down “C” to “V” shape; primary lateral veins 10 – 12 per side, alternate, concolorous, greatly curved and ascending in a positive parabolic fashion; 4 – 17 interprimary veins; secondary veins reticulate; tertiary veins reticulate; collective vein beginning at 4th to 9th primary veins, distance from margin 0.66 – 0.75 cm, collective vein is formed from a brochidodromous arrangement and gets closer to margin on its way to the apex. *Inflorescence* erect, peduncle 29 – 35 cm long, 3.5 – 4.7 mm in diameter, 5.5 – 7.1 times the length of the petiole, light green, cross section circular; spathe free at 90° to 135° from spadix, coriaceous, green tinged with purple to purple, reflexed, oblong, 6 – 7.7 cm long, 9 - 17 mm in width, broadest at the central two quarters, apex acuminate, base acute; spadix olive green to

brown, tapered, erect, 8.2 – 10.6 cm long, 5 – 5.5 mm in diameter, stipe inconspicuous; flowers tetra-lobed, 2 – 2.5 mm long, 1.8 – 2.2 mm in width; primary spiral right-handed, 4 – 5 visible flowers in primary spiral, 4 – 5 visible flowers in secondary spiral; tepals matte, lateral tepals interior straight to convex; pistil quadrangular, 1.3 – 1.8 mm long; stigma elliptic, 0.3 – 0.5 mm long, 0.3 – 0.4 mm in width; stamens 1.1 – 1.8 mm long; filaments flat; anthers 0.4 mm long, 0.5 – 0.7 mm in width; pollen cream-yellow. *Infructescence* with spathe persisting; berries ovoid, deep wine-red.

Distribution: *Anthurium basirotundum* seems to be endemic to the San Martín department in Peru at around 400 m of altitude (Figure 7).

This species can be identified by its obtuse or round leaf bases, its short petiole, and its rosette habit. Additionally, the collective veins are born at the middle or upper third of the blade and it follows a strong brochidodromous pattern decreasing the distance to the margin while approaching the apex. *Anthurium basirotundum* does not develop a conspicuous stipe and has an oblong spathe.

Specimens examined: *Timothy Plowman 5980A, Eric A. Christenson 1139, Thomas B. Croat 49741.*

3. *Anthurium beckii* Croat & Acebey, sect. *Porphyrochitonium*. TYPE: Bolivia. La Paz department, Abel Iturralde province: NW of Tumupasa along slope leading up to Madidi National Park, 830 – 850 m, 15° 45' S, 67° 50' W. *Thomas B. Croat 84387* (holotype, MO-5187101; isotypes, K, LPB, NY, US).

Epiphyte; stem short, 0.7 – 0.9 cm in diameter; cataphylls coriaceous, lanceolate, 3 – 3.5 cm long, apex acute, color, beige when dry, persistent. *Leaves* glabrous, petioles 6.5 – 17.5 cm long, 1.8 – 4 mm in diameter, cross section terete, light beige when dry; geniculum dark brown, 0.8 – 1.4 cm long, 2.3 – 3.5 mm in diameter; blade coriaceous, elliptic to falcate, apex acute, base attenuate, 24.7 – 42.3 cm long, 2.8 – 4.1 cm in width, broadest at the division of the halves, margins entire; adaxial surface green to light green when dry; abaxial surface brownish green to light brown when dry, black to dark reddish punctuations present; midrib light greenish beige and acutely risen; primary lateral veins 8 – 11 per side, opposite, concolorous, trajectory straight, slightly risen on adaxial surface; 1 -2 interprimary veins or not visible at all; secondary veins not visible; tertiary veins not visible; collective beginning at the base of the leaf, distance from margin 0.35 – 0.5 cm, slightly risen. *Inflorescence* erect, peduncle 36.5 – 42 cm long, 1.8 – 3.2 mm in

diameter, 2.1 – 5.6 times the length of the petiole, light brown, cross section terete; spathe almost surrounding to free at 90° from spadix, coriaceous, tingled with purple, lanceolate, 3.5 – 4.5 cm long, 4.5 – 5.2 mm in width, broadest part at the inferior third, apex acuminate, base acute; spadix greenish dun to dark purple violet, tapered, erect or slightly inclined, 7.1 – 10 cm long, 2.5 – 3 mm in diameter, stipe absent; flowers rhombic to quadrangular, 2.1 – 3 mm long, 1.1 – 2.1 mm in width; primary spiral mostly right-handed, 3 visible flowers in primary spiral, 2 – 4 visible flowers in secondary spiral; tepals matte, lateral tepals interior margins straight to concave; pistil ellipsoid, 1 – 1.6 mm long; stigma circular, 0.2 mm long, 0.2 – 0.3 mm in width; stamens 1 – 1.3 mm long; filaments flat; anthers 0.2 – 0.3 mm long, 0.3 – 0.4 mm in width; pollen orange. *Infructescence* erect; berries subglobose, orange.

Distribution: *Anthurium beckii* is found only in Bolivia, La Paz department, particularly among the Abel Iturralde, Sud Yungas, Caranavi and Bautista Saavedra provinces between 830 and 1250 m (Figure 6).

It has very consistent collective veins which are born at the base of the leaf. Additionally, this species is easily recognized by its dark punctuations on the abaxial surface of the blade, its straight primary veins, and its inconspicuous secondary and tertiary veins.

Specimens examined: *Thomas B. Croat 84387, Thorsten Krömer 711, Michael Kessler 11664, Michael Kessler 11664, Alfredo Fernando Fuentes Claros 6199.*

4. *Anthurium besseae* Croat, sect. “Clade 12”. TYPE: Bolivia. Cochabamba department, Chapare province: along the road from Cochabamba to Villa Tunari, 240 m, cultivated at Selby Botanical Gardens (originally collected by Libby Besse, 25 Jan. 1986), 29. Sept. 1996, *Thomas B. Croat 79380* (holotype, MO-3301223; isotypes, B, K, LPB. NY, SEL. US).

Terrestrial; stem short, 1 – 2.5 cm in diameter; cataphylls coriaceous, lanceolate, up to 5.5 cm long, apex acute, dark when dry, persistent. *Leaves* glabrous, petioles 13 – 27 cm long, 2.2 – 5.4 mm in diameter, cross section terete, greenish light brown when dry; geniculum dark brown, 1.3 – 1.7 cm long, 1.2 – 2.6 mm in diameter; blade coriaceous, cordiform to ovate, apex acuminate (acute), base lobate to cordate, 10.5 – 25.3 cm long, 8 – 18 cm in width, broadest part at the inferior half, margins entire; lobes round, 1 – 4.6 cm long, sinus between lobes spatulate (triangular); adaxial surface dark green when dry, velvety; abaxial surface glaucous green to light beige when dry; midrib white and risen in an upside down “V” shape; basal veins (2) 3 (4) pairs, radiating; primary lateral veins 2 – 6 per side, alternate, concolorous, trajectory turning curved

towards the apex; 2 – 6 interprimary veins, yellowish; secondary veins yellowish, reticulate, with a parallel pattern; tertiary veins inconspicuous; collective vein beginning at the 1st primary vein (2nd basal vein), distance from margin 0.9 – 1.2 cm, slightly risen. *Inflorescence* erect, peduncle 9 – 25 cm long, 0.9 – 2.6 mm in diameter, 0.7 – 1.5 times the length of the petiole, light brown, cross section terete; spathe free at 100° to 150° from spadix, coriaceous, green tinged with purple to purple and garnet, lanceolate, 2.2 – 3.7 cm long, 2 – 6.2 mm in width, broadest part at the inferior third, apex acuminate, base cordate; spadix dark purple to purple-maroon, tapered to cylindric, erect or slightly inclined, 1.5 – 6.8 cm long, 2.5 – 4.9 mm in diameter, stipe brown, inconspicuous, 1.3 – 1.8 mm in width; flowers tetra-lobed (quadrangular or rhombic), 2 – 3.5 mm long, 1.4 – 3.1 mm in width; primary spiral right-handed, 3 visible flowers in primary spiral, 4 visible flowers in secondary spiral; tepals matte, lateral tepals interior margins straight or convex; pistil quadrangular, 1.1 – 1.6 mm long; stigma ellipsoid, 0.2 mm long on average, 0.2 – 0.3 mm in width; stamens 1 – 1.1 mm long; filaments flat; anthers 0.3 mm long on average, 0.3 – 0.7 mm in width; pollen orange. *Infructescence* not seen.

Distribution: *Anthurium besseae* is endemic to Bolivia, in the province of Chapare, Cochabamba department (Figure 7).

This species is characterized by its white midrib, basal and primary veins, and the absence of basal ribs. The lobes are round, and the sinus (i.e., space between the lobes) is cordate. Overall, this species has small-sized leaf blades, 10 – 25 cm long and 8 – 18 cm in width, in which the length is about 1.5 – 1.7 times the width. *Anthurium besseae* could be confused with *A. regale*, but the latter has larger leaf blades, (26.5) 56 – 76 cm long and (16.5) 41 – 55 cm in width, and basal ribs which *A. besseae* lacks.

Specimens examined: *Thomas B. Croat 79380, Thomas B. Croat 71836 (1/2), Thomas B. Croat 71836 (2/2), Eric A. Christenson 1134 (1/2), Eric A. Christenson 1134 (2/2), Stephen W. Ingram 1029.*

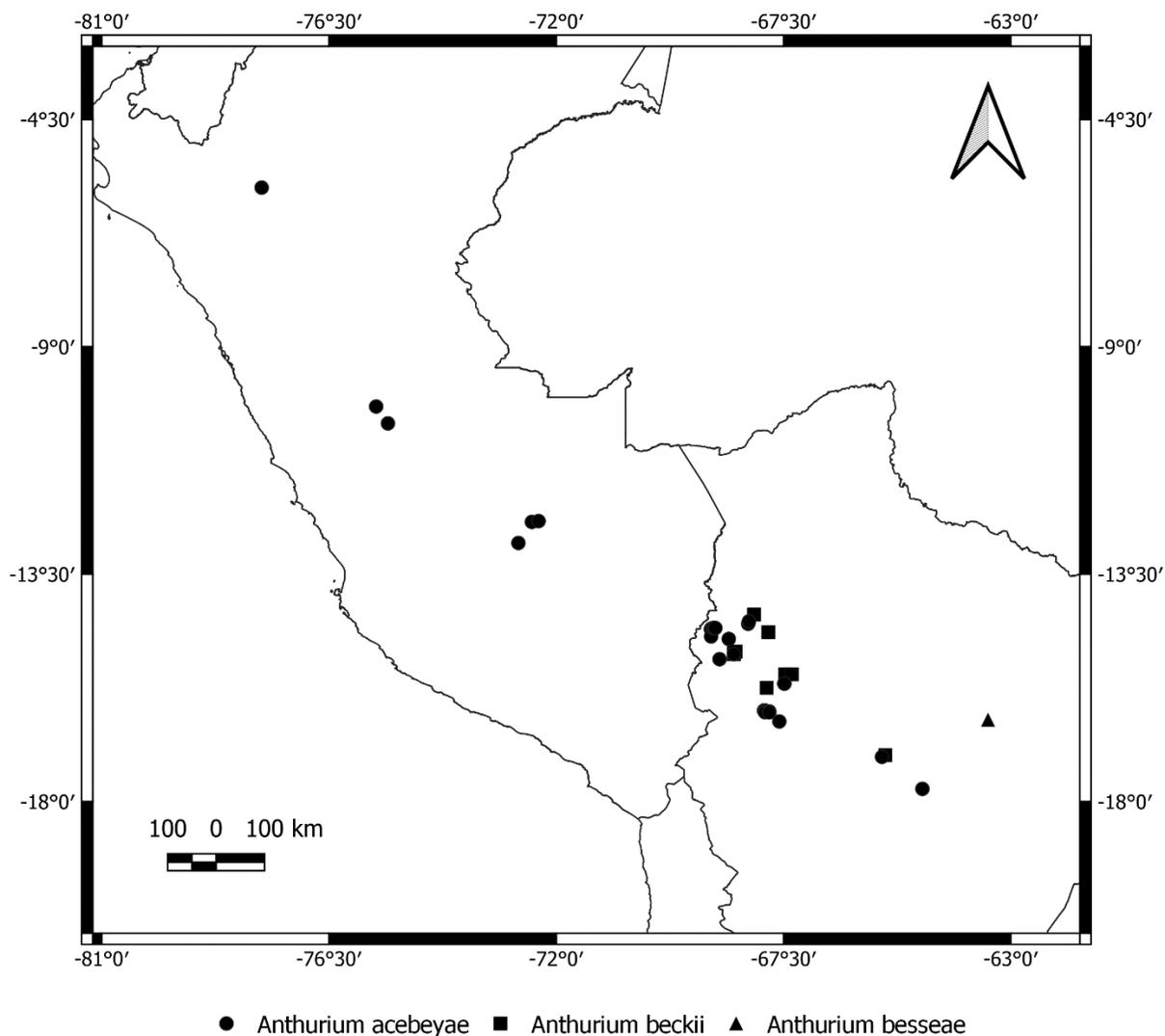


Figure 6. Distribution map of *Anthurium acebeyae*, *A. beckii* and *A. besseae*.

5. *Anthurium coripatense* N.E. Br. ex Engl., sect. *Cardiolonchium*. TYPE: Bolivia. La Paz Department. Nor Yungas Province: Coripata. *Miguel Bang* 2311 (holotype, B; isotypes, K).

Anthurium yungasense Croat & Acebey, sect. *Cardiolonchium*. TYPE: Bolivia, La Paz: Nor Yungas, Anmi Cotapata National Park, Estación Biológica Tunquini, NW of Coroico, NNE of La Paz, 23 km W of Yolosa 16°12'S, 67°50'W, 1300 – 1500 m, 23 Aug. 2000, *Thomas B. Croat* 84782 (holotype, MO-5185105; isotypes, B, COL, GOET, K, LPB, NY, QCNE, UB, US, USM, VEN)

Epiphyte or vine; stem long, 3 cm in diameter on average; cataphylls coriaceous, triangular, 12 – 16 cm long, apex acute, dark mustard when dry, persistent. *Leaves* glabrous,

petioles 34 – 60 cm long, 5 – 8.5 mm in diameter, cross section terete to triangular, 3-ribbed, green to brownish beige; geniculum dark yellow to brown, 1.6 – 2.5 cm long, 3.8 – 6 mm in diameter; blade coriaceous to chartaceous, obpyriform to ovate, apex acute (acuminate), base lobate, 35 – 50 cm long, 19 – 30 cm in width, broadest part at the inferior half, margins entire; lobes round to auriculate or reniform, 8.5 – 13 cm long, sinus between lobes spatulate to rhombic (obovate); adaxial surface brownish beige to greenish beige when dry, raphides present in young specimens; abaxial surface greenish or brownish beige to aquamarine green when dry; midrib yellowish and risen in an upside down “C” shape; basal ribs curved, naked at the sinus, 2.8 – 5 cm long; basal veins 4 – 8 pairs, coalescing; primary lateral veins 5 – 7 per side, subopposite, yellowish, straight; 1 – 5 interprimary veins; secondary veins visible, reticulate, concolorous; tertiary veins visible, reticulate, concolorous; collective vein absent strictly speaking, primary veins arch themselves acutely near the margin and fuse with it in a craspedodromous fashion, 0.2 – 0.25 cm before they merge with margin. *Inflorescence* erect, peduncle 24 – 53 cm long, 3.4 – 4.9 mm in diameter, 0.7 – 1 times the length of the petiole, greenish brown to aquamarine, cross section terete; spathe surrounding or free at 60° – 90° from spadix, coriaceous, green, lanceolate, 6.6 – 16.3 cm long, 1.6 – 18 mm in width, broadest part at the inferior third, apex acuminate, base acute or amplexicaul; spadix green to dark purple, tapered to cylindrical, erect to slightly inclined, 14.5 – 24 cm long, 7 – 9 mm in diameter; stipe brown, 4.9 – 12 mm long, 3.8 – 7 mm in width; flowers tetra-lobed or rhombic, 2.1 – 3.9 mm long, 2.1 – 2.6 mm in width; primary spiral left-handed (right handed), 5 – 9 visible flowers in primary spiral, 5 – 7 visible flowers in secondary spiral; tepals matte, lateral tepals interior margins convex; pistil rhomboid to ellipsoid, 1 – 1.7 mm long; stigma ellipsoid, 0.2 – 0.3 mm long, 0.2 – 0.3 mm in width; stamens 1.2 – 2 mm long; filaments flat; anthers 0.3 – 0.7 mm long, 0.5 – 0.7 mm in width; pollen pale yellow. *Infructescence* 16 – 36 cm long; berries purple and white.

Distribution: *Anthurium coripatense* is widely distributed along the eastern flank of the Andes from La Paz department in Bolivia to the north in Pichincha and Napo in Ecuador (Figure 8).

This species is distinguished by its big leaves, 35 – 50 cm long and 19 – 30 cm in width, with basal ribs and round to auriculate or reniform big leaf lobes. The leaf has an overall ovate shape and there is no collective vein present except for some individuals in which it only appears near the apex.

Specimens examined: Miguel Bang 2311, N. Salinas 2364, Marko Lewis 39124 (2/2), Marko Lewis 39124 (1/2), Thomas B. Croat 51548 (1/2), Thomas B. Croat 51548 (2/2), Michael Kessler 6917, Juan Perea 989, Jorge Lingán 337, Juan Perea 688, Abel Monteagudo Mendoza 3692, Bruce Alan Stein 2078, René Chávez Alfaro 3106, Percy Núñez Vargas 13147, Thomas B. Croat 51548 (1/2), Luis Valenzuela Gamarra 3490, Miguel Bang 2311, Thomas B. Croat 51548 (2/2), Isaú Huamantupa Chuquimaco 10179, Philip J. Barbour 2867, Thomas B. Croat 84782, Stephan G. Beck 3056, Alfredo Fernando Fuentes Claros 10263 (1/2), Alfredo Fernando Fuentes Claros 10263 (2/2), Fabricio Miranda Avilés 711 (2/2), James Clinton Solomon 9308, Stephan G. Beck 3123, Kerstin Bach 1174, Thomas B. Croat 51572 (2/2), Thomas B. Croat 84782, Michael Kessler 13107, Thomas B. Croat 51444 (1/4), Michael Kessler 11580, Luis Valenzuela Gamarra 5682 (2/2).

6. *Anthurium dombeyanum* Brongn. ex Schott, sect. *Pachyneurium*. TYPE: Peru. *Dombey* s.n. (holotype, P).

Terrestrial; stem long; cataphylls coriaceous, triangular, 1.5 cm long on average, apex acute, brown when dry. *Leaves* glabrous, petioles 9 – 25 cm long, 3.5 – 7 mm in diameter, cross section D-shaped, olive green; geniculum brown, 0.5 – 1 cm long, 5 – 8 mm in diameter; blade coriaceous, oblanceolate to elliptic, apex acute to acuminate, base acute or cuneate, 37.5 – 63.5 cm long, 15.5 – 28 cm in width, broadest part at the superior half or third, margins entire; adaxial surface brownish olive when dry; abaxial surface concolorous when dry; midrib dark olive green and risen in an upside down “V” shape; primary lateral veins 10 – 17 per side, subopposite, concolorous, curved ascending; 3 – 12 interprimary veins, concolorous; secondary veins visible, reticulate, concolorous; tertiary veins visible, reticulate; collective vein beginning at the 8th or 7th primary vein, distance from margin 0.4 – 0.5 cm. *Inflorescence* erect, peduncle 42.5 – 47 cm long, 3.7 – 4 mm in diameter, green, cross section terete; spathe free at 45° – 90° from spadix, coriaceous, green or purple-green, lanceolate to elliptic, 7.5 – 10 cm long, 7- 11 mm in width, broadest part at the inferior third of in the middle, apex acuminate, base acute; spadix green to yellowish brown, tapered, erect, 13.5 – 16.7 cm long, 6.2 – 7 mm in diameter; stipe dark green to dark olive green, 2.5 – 19 mm long, 3 – 3.5 mm in width; flowers rhombic or quadrangular, 1.7 – 2 mm long, 1.5 – 1.7 mm in width; primary spiral right-handed, 7 – 11 visible flowers in primary spiral, 8 – 9 visible flowers in secondary spiral; tepals matte, lateral tepals interior margins straight to concave; pistil rhomboid, 1.2 – 1.8 mm long; stigma rhomboid to ellipsoid, 0.2 – 0.3 mm long,

0.2 – 0.3 mm in width; stamens 1.5 – 2.1 mm long; filaments flat; anthers 0.6 mm long on average, 0.6 – 0.7 mm in width. *Infructescence* erect; berries subglobose.

Distribution: *Anthurium dombeyanum* has a wide distribution ranging from Beni in Bolivia up to Loja in Ecuador in the eastern flank of the Andes, varying from ca. 1300 to 2800 m in altitude (Figure 8).

This species can be recognized by its oblanceolate or elliptic leaves and its petiole with a D-shaped cross section. Additionally, this species has unusually long stamens, 1.5 – 2.1 mm long, in comparison with the rest of the flower.

Specimens examined: *Thomas B. Croat 84699 (1/2), Thomas B. Croat 84699 (2/2), Thomas B. Croat 50919 (1/2), Thomas B. Croat 50919 (2/2), James Clinton Solomon 3111.*

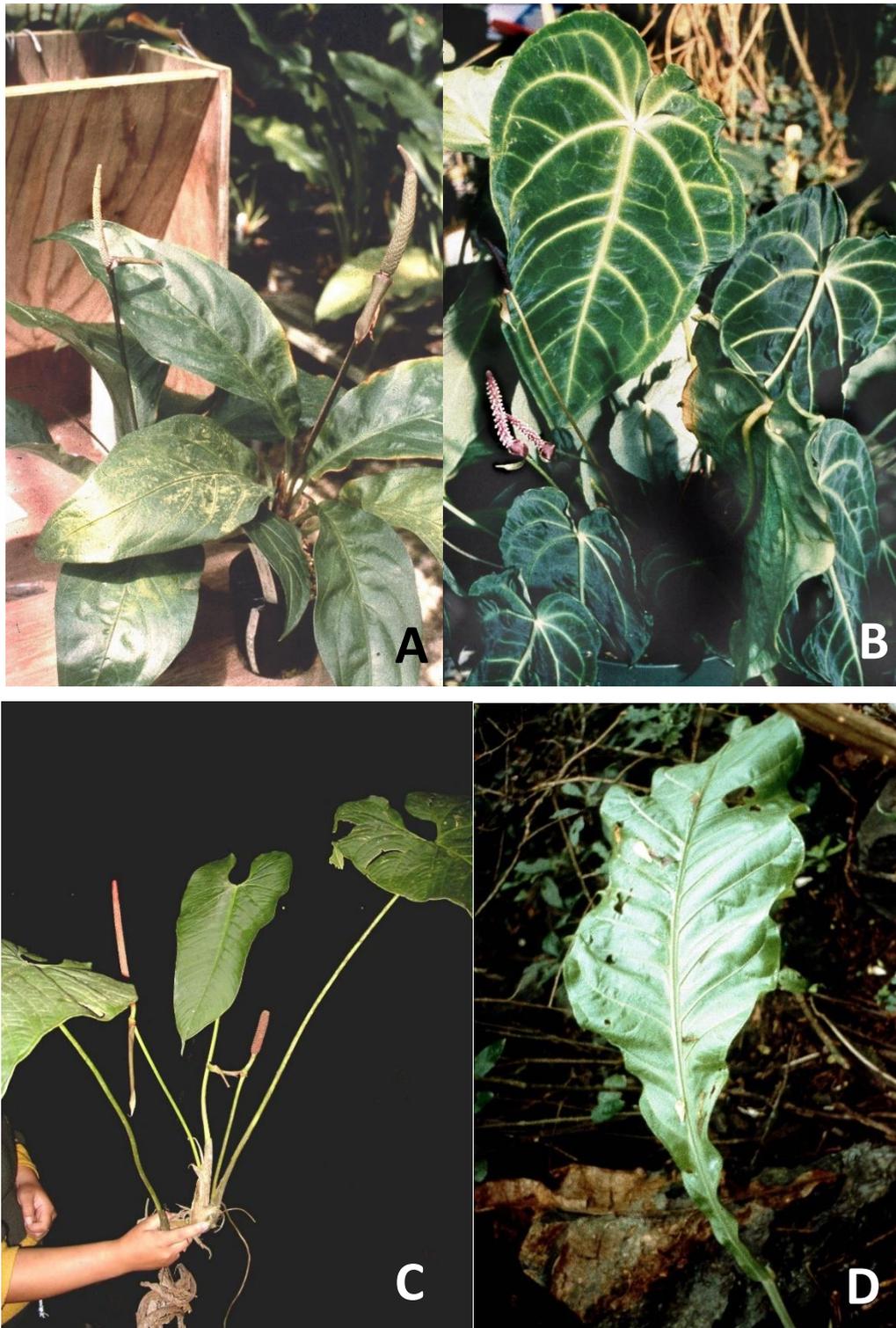


Figure 7. Representative specimens of (A) *A. basirotundum*, (B) *A. besseae*, (C) *A. coripatense*, and (D) *A. dombeyanum* (pictures taken from Tropicos.org)

7. *Anthurium galactospadix* Croat, sect. Pachyneurium. TYPE: Brazil. Acre state: N bank of Rio Juruá, opposite Cruzeiro do Sul, 7°37'52''S, 40°12'00''W, 27 Oct. 1966, *Ghilleen T. Prance* 2924 (holotype, INPA; isotypes, NY, US).

Epiphyte; stem long, 1.8 cm in diameter on average; roots dense, short, cross section with 0.3 – 0.5 cm in diameter; cataphylls coriaceous, triangular, 12.5 cm long on average, apex acute, light reddish brown when dry, persistent. *Leaves* glabrous, petioles 10.5 – 26.5 cm long, 4.3 – 12 mm in diameter, cross section terete, green to greenish brown; geniculum terete, 0.5 – 1.3 cm long, 6.2 – 8 mm in diameter; blade coriaceous, elliptic (oblanceolate), apex acuminate to acute, base acute to attenuate, 61 – 85 cm long, 18 – 38 cm in width, broadest part at the upper half, margins entire; adaxial surface green to brown when dry, very shiny; abaxial surface opaque green to brown when dry; midrib concolorous and greatly risen and prominent; primary lateral veins 11 – 16 per side, alternate, straight becoming curved towards the end; 5 – 15 interprimary veins, concolorous; secondary veins visible, concolorous, reticulate; tertiary veins visible, concolorous, reticulate; collective vein absent, veins quickly merge towards the margin. *Inflorescence* erect, peduncle 13 cm long on average, 2.1 mm in diameter on average, 0.6 times the length of the petiole on average, dark brown, cross section terete; spathe surrounding at 0° – 10° from spadix, coriaceous, green to whitish green, elliptic, 15 cm long on average, 50 mm in width, broadest part at the center, apex acute, base acute; spadix yellowish green to white, cylindrical, erect, 8.2 – 12 cm long, 8.3 – 11 mm in diameter; stipe dark brown, 5 mm long on average, 9 mm in width on average; flowers rhombic, 1.5 – 2.1 mm long, 1.1 – 1.7 mm in width; primary spiral left-handed, 14 visible flowers in primary spiral on average, 16 – 20 visible flowers in secondary spiral; tepals matte, lateral tepals interior margins straight to convex; pistil quadrangular, 0.4 – 1 mm long; stigma circular to ellipsoid, 0.3 mm long on average, 0.2 mm in width on average; stamens 1.1 mm long on average; filaments flat; anthers 0.4 mm long on average, 0.3 mm in width on average. *Infructescence* erect; berries reddish dun.

Distribution: This species occurs in the mostly flat region comprising southern Colombia, northeast and eastern Peru, western Brazil, and northwest Bolivia at less than 300 m of altitude (Figure 8).

Anthurium galactospadix is easily distinguishable by its white spadix, its spathe which closely surrounds the spadix and by its prominent and thick primary veins.

Specimens examined: *José Schunke Vigo* 16126, *Efraín Suclli Montañés* 1880 (1/2), *Efraín Suclli Montañés* 1880 (2/2).

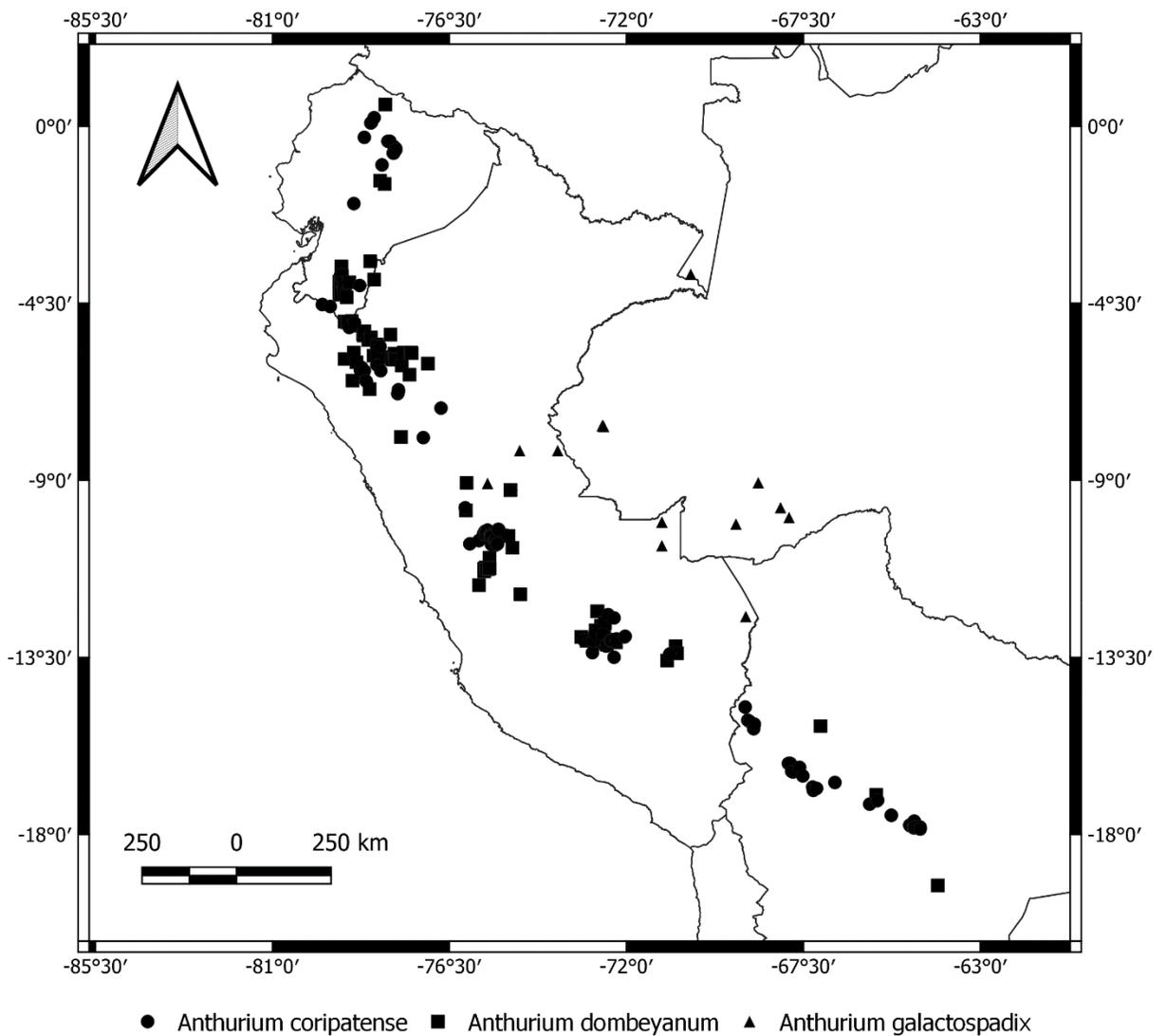


Figure 8. Distribution map of *Anthurium coripatense*, *A. dombeyanum*, and *A. galactospadix*.

8. *Anthurium huallagense* Engl., sect. *Semaephyllium*. TYPE: Peru. Huánuco department, Huamalíes province: between Monzón and Huallaga rivers in a flat terrain near Monzón, 600 – 700 m, Sept. 1903, *August Weberbauer* 3660 (holotype, B).

Epiphyte; stem long, 0.5 – 1.3 cm in diameter; cataphylls, 10 – 14 cm long, persistent. *Leaves* glabrous, petioles 28.5 – 34 cm long, 3.7 – 4.1 mm in diameter, cross section D-shaped, 2-ribbed acutely edged near the base, greenish gray to green, semi glossy; geniculum blackish, 1.6 – 1.7 cm long, 3.2 – 3.6 mm in diameter; blade coriaceous to sub coriaceous, tri-lobed, apex acuminate, base straight, 24 – 26.5 cm long, 28 – 30.5 cm in width, broadest part at the inferior

half, margins entire; anterior lobe elliptic to oblanceolate, 18 – 21 cm long, 6.6 – 6.8 cm in width at the most constricted part, 9 – 10.5 cm in width at the broadest part; posterior lobes samariform, 1.6 – 2.1 cm long below the petiole insertion point; adaxial surface black when dry; abaxial surface concolorous dry, semi glossy; basal ribs 3.9 – 5.3 cm long, winged starting at the insertion of the petiole at a 14° angle; basal veins 4 – 5 pairs, 2 – 4 radiating and the rest coalescing; midrib concolorous and acutely risen; primary lateral veins 8 – 11 per side, concolorous, straight to curved and ascending towards the margin; 2 – 5 interprimary veins, concolorous; secondary veins visible, reticulate, concolorous; tertiary veins visible only on the abaxial surface, concolorous, reticulate; collective vein beginning at 1st pair of basal veins for the anterior lobe and at the 2nd – 5th pair of primary veins, distance from margin 0.4 – 0.45 cm. *Inflorescence* erect, peduncle 19 – 28.5 cm long, 2.2 – 4.2 mm in diameter, 0.8 – 1.4 times the length of the petiole, cross section terete to quadrangular; spathe free at 90° from spadix, coriaceous, strongly yellow, elliptic, 9 cm long on average, 5.6 mm in width average, broadest part at the center, apex acuminate, base acute; spadix greenish yellow to green, cylindric, straight, 9 – 19 cm long, 3.6 – 4 mm in diameter; flowers rhombic to quadrangular, 2 – 2.1 mm long, 1.6 – 1.8 mm in width; primary spiral right-handed, 4 – 5 visible flowers in primary spiral, 5 – 7 visible flowers in secondary spiral; tepals matte, lateral tepals interior margins convex; pistil circular, 0.8 – 1.2 mm long; stigma ellipsoid, 0.3 mm long on average, 0.1 mm in width on average; stamens 0.9 mm long on average; filaments flat; anthers 0.5 mm long on average, 0.6 mm in width on average. *Infructescence* green; berries oblong, greenish vivid yellow.

Distribution: This species is endemic to the Huánuco department in Peru, particularly in the Leoncio Prado, Pachitea and Huamalíes provinces ranging from 600 to 1650 m in altitude, but it can also be found in the Ucayali department, in the Coronel Portillo province (Figure 9).

Anthurium huallagense can be easily distinguished from all other species in this revision by its tri-lobed leaf shape. Additionally, the leaf blades in this species dry with a dark black color.

Specimens examined: *Thomas B. Croat 81707, José Schunke Vigo 9281 (1/2), José Schunke Vigo 9281 (2/2)*.

9. *Anthurium huanucense* Engl., sect. *Decurrentia*. TYPE: Peru. Huánuco department, Huamalíes province: Near Monzón, 900 – 1000 m, *August Weberbauer 3449* (holotype, B).

Vine, climber, or lithophyte; stem short, 0.6 – 0.8 cm in diameter; roots spreading, white, shape, cross section with 0.1 – 0.5 cm in diameter; cataphylls coriaceous, triangular, 2.5 – 8 cm

long, apex acute, light brown when dry, persistent. *Leaves* glabrous, petioles 10.2 – 14 cm long, 2.5 – 3.3 mm in diameter, cross section terete, aquamarine green; geniculum light yellow to light brown, 0.3 – 1.1 cm long, 3 – 4.2 mm in diameter; blade coriaceous to coriaceous, shape elliptic, apex slightly acuminate, base acute to attenuate, 28.8 – 40 cm long, 4.3 – 8 cm in width, broadest part at the middle, margins entire; adaxial surface aquamarine green when dry, semi glossy; abaxial surface concolorous when dry; midrib light green to greenish yellow and risen in an upside down “C” shape; primary lateral veins 18 – 29 per side, concolorous, straight; 1 – 4 interprimary veins, concolorous; secondary veins not visible or hardly visible, curved or diagonal; tertiary veins not visible; collective vein beginning at the base of the blade or up to the 3rd primary vein pair, distance from margin 0.38 – 0.45 cm. *Inflorescence* erect, peduncle 26.6 – 27.7 cm long, 2.1 – 3.1 mm in diameter, 2.2 – 2.6 times the length of the petiole, light brown, cross section terete; spathe free at 90° – 150° from spadix, coriaceous, green tingled with purple, lanceolate to oblanceolate, 6.7 – 8 cm long, 5.1 – 8.2 mm in width, broadest part at the inferior third to the superior third, apex acute, base amplexicaul and cordate; spadix pale purple, cylindric to tapered, erect, 8 – 19 cm long, 2.8 – 3 mm in diameter; flowers tetra-lobed, 4 mm long on average, 2 mm in width on average; primary spiral right-handed, 2 visible flowers in primary spiral, 3 visible flowers in secondary spiral; tepals weakly glossy, lateral tepals interior margins convex; pistil quadrangular, 1.1 mm long on average; stigma quadrangular, 0.2 mm long on average, 0.1 mm in width on average; stamens 1 mm long on average; filaments flat; anthers 0.4 mm long on average, 0.6 mm in width on average. *Infructescence* spreading or curved; berries globose to obovoid, reddish orange to dark orange, 1.5 mm long on average, 2.6 mm in width on average.

Distribution: This species was thought to be endemic to a small region in Peru between Monzón and Tingo María (Huánuco department) at 800 to 1000 m of elevation, but newer specimens have been collected in other parts of the country such as Chanchamayo (Junín department), Tocache (San Martín department), and Bagua (Amazonas department) meaning that its range could be larger than originally reported and its elevation could range up to 2150 m (Figure 9).

Anthurium huanucense can be identified by the high density of primary lateral veins along the leaf blade. Additionally, this species has very consistent elliptical elongated leaves which dry green.

Specimens examined: *Thomas B. Croat 58361 (1/2), Thomas B. Croat 58361 (2/2), José Schunke Vigo 8590 (1/2).*

10. *Anthurium incurvatum* Engl., *Belonchium*. TYPE: Ecuador. Pichincha Province, Mejía district: Selva Monte Corazón, 2000 m. *Luigi Aloysius Sodiro* 20262 (holotype, QPLS; isotypes, MO, B, F; syntypes USM, US).

Climbing epiphyte; stem 1.8 cm in diameter on average; roots 2 – 3 per fascicle, vine-like, brown; cataphylls coriaceous, triangular, 21 cm long on average, apex acute, light brown when dry, persistent. *Leaves* glabrous, petioles 48 – 66.5 cm long, 5.5 – 8 mm in diameter, cross section terete, mustard yellow; geniculum dark brown, 2.4 – 2.5 cm long, 4.6 – 6 mm in diameter; blade coriaceous, ovate, apex acute to acuminate, base lobed, 49.5 – 52.5 cm long, 30 – 35 cm in width, broadest part at the inferior third, margins entire; lobes oblong, 11.5 – 13.5 cm long, sinus shape obovate to hippocrepiform (parabolic); adaxial surface dark glaucous green when dry; abaxial surface light brown to opaque green; midrib green and slightly risen; basal ribs curved, naked at the sinus, 3.6 – 4.5 cm long; basal veins 6 (4) radiating and 6 coalescing; primary lateral veins 9 – 13 per side, slightly yellow, straight (curved towards the apex); 1 – 4 interprimary veins, concolorous; secondary veins visible, straight curving towards the interprimary veins, concolorous; tertiary veins visible, concolorous, reticulate; collective vein beginning at 2nd pair (most outer pair) of basal veins, distance from margin 0.35 – 0.55 cm. *Inflorescence* erect or inclined, peduncle 34 cm long on average, 2.6 – 4.1 mm in diameter, 0.5 times the length of the petiole on average, olive green to brown, cross section terete; spathe free at 45° – 90° from spadix, coriaceous, green, lanceolate, 7 – 12 cm long, 8.9 mm in width on average, broadest part at the inferior third, apex acuminate, base acute; spadix green turning yellow, cylindrical (tapered), straight, 8.5 – 15.5 cm long, 5.2 – 12 mm in diameter; stipe brown, 5.5 – 17 mm long, 2.5 – 4.3 mm in width; flowers rhombic to tetra-lobed, 1.9 – 2.3 mm long, 1.5 – 1.8 mm in width; primary spiral right-handed (left-handed), 6 – 8 visible flowers in primary spiral, 5 – 7 visible flowers in secondary spiral; tepals matte, lateral tepals interior margins straight to convex; pistil quadrangular, 0.8 – 1.5 mm long; stigma circular to ellipsoid, 0.1 – 0.5 mm long, 0.2 – 0.3 mm in width; stamens 1.5 – 1.6 mm long; filaments flat; anthers 0.4 – 0.6 mm long, 0.3 – 0.5 mm in width. *Infructescence* erect to reflexed.

Distribution: *Anthurium incurvatum* can be found across the eastern flank of the Andes in high elevation montane forests from Santa Cruz (Bolivia) to Carchi (Ecuador) in altitudes ranging from 1600 to 3000 m (Figure 9).

This species can be recognized by its long stipe, long geniculum and ovate-shaped leaf blade. A surrounding spadix is also frequent among individuals. *Anthurium incurvatum* could be confused with *A. acebeyae* but the latter has a shorter geniculum, 1 – 1.5 cm long, and an obpyriform blade in contrast to *A. acebeyae* ovate leaf blade.

Specimens examined: *Luigi Aloysius Sodiro 20262 (1), Luigi Aloysius Sodiro 20262 (2), Luigi Aloysius Sodiro 20262 (3), Luigi Aloysius Sodiro 20262 (4), Luigi Aloysius Sodiro 20270, James Leonard Luteyn 8950.*

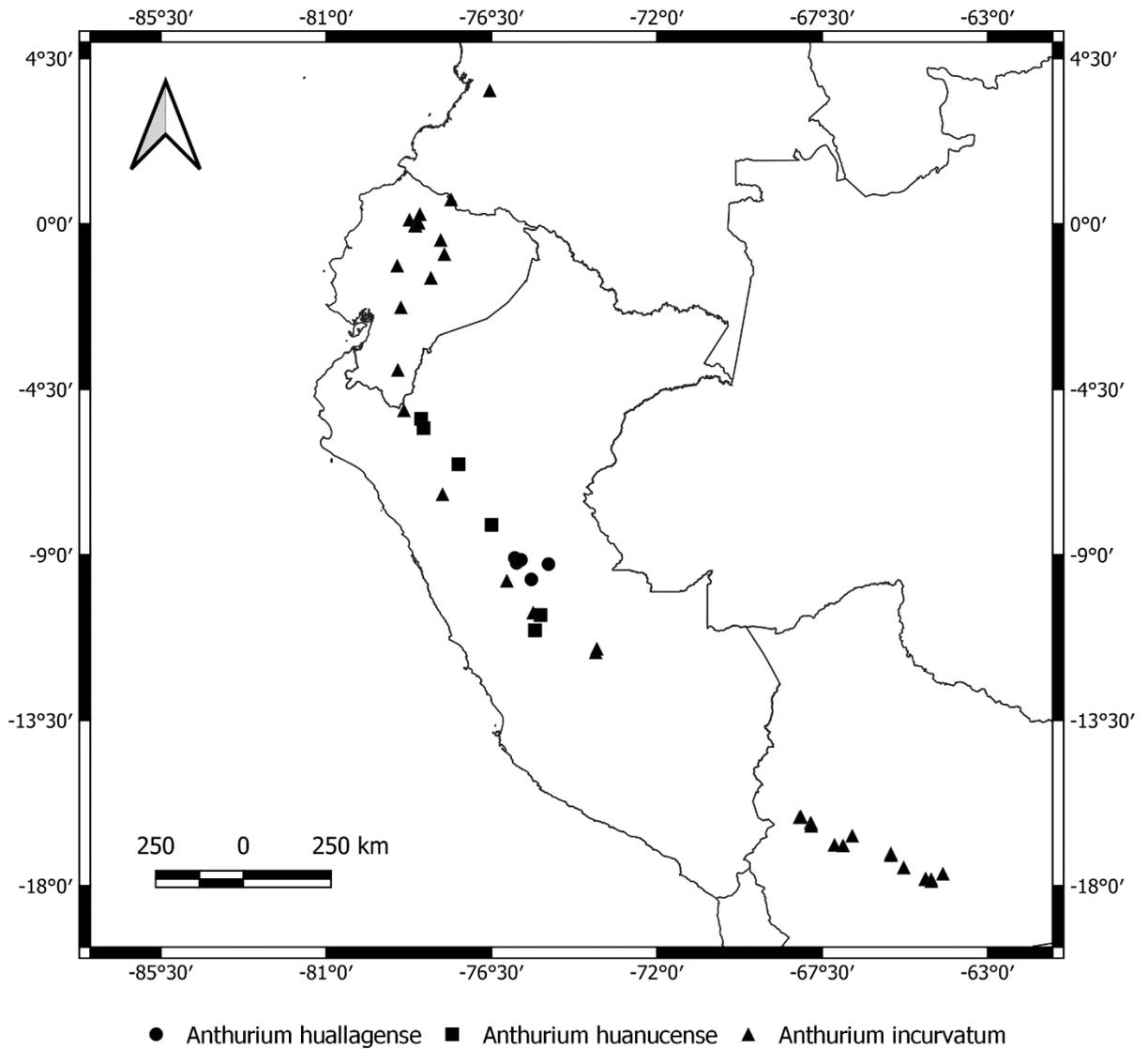


Figure 9. Distribution map of *Anthurium huallagense*, *A. huanucense* and *A. incurvatum*.

11. *Anthurium knappiae* Croat, sect. Pachyneurium. TYPE: Peru. San Martín department, Lamas province: On old trail from Yumbatos to San Antonio de Cumbasa, S of Shapajilla, lower slopes of Cerro Isco, 5 Oct. 1986, 400 – 500 m. *Sandra Knapp* 8544 (holotype, MO-3483655; isotypes, B, US, USM).

Epiphyte; cataphylls ca. 7 cm long, persistent. *Leaves* glabrous, petioles 37.5 cm long on average, 6.1 mm in diameter on average, cross section terete, aquamarine green; geniculum light yellow, 1 cm long on average, 5.5 mm in diameter on average; blade coriaceous, elliptic, apex acute, base attenuate, 57.5 cm long on average, 17.5 cm in width on average, broadest part at the first top or middle, margins entire; adaxial surface yellowish green when dry; abaxial surface dark green when dry; midrib dark yellowish and risen in an upside down “C” shape; primary lateral veins 18 per side on average, dark yellow, straight ascending; 4 – 9 interprimary veins, concolorous; secondary veins visible, reticulate, dark yellow; tertiary veins inconspicuous; collective vein beginning at the base of the blade or at the 3rd primary vein, distance from margin 1.6 cm on average. *Inflorescence* erect, peduncle 91 cm long on average, 3.4 mm in diameter on average, 2.4 times the length of the petiole on average, dark green, cross section terete; spathe free at 90° on average from spadix, coriaceous, green, lanceolate, 9 cm long on average, 12 mm in width on average, broadest part at the inferior third, apex acuminate, base decurrent ; spadix cream, tapered, straight, 10.5 cm long on average, 5.5 mm in diameter on average; stipe yellowish green, 3 mm long on average, 3.6 mm in width on average; flowers tetra-lobed, 2.6 mm long on average, 2.4 mm in width on average; primary spiral left-handed, 4 visible flowers in primary spiral on average, 4 visible flowers in secondary spiral on average; tepals matte with white spots, lateral tepals interior margins straight; pistil quadrangular, 1.5 mm long on average; stigma circular, 0.2 mm long on average, 0.6 mm in width on average; stamens 1 mm long on average; filaments flat; anthers 0.3 mm long on average, 0.5 mm in width on average. *Infructescence* erect-spreading; berries ellipsoid, green.

Distribution: *Anthurium knappiae* is only known from the type which was collected in Tarapoto, Peru (Figure 11).

It can be distinguished by its long and attenuate leaf base in conjunction with its long collective vein-margin distance and its green-drying leaves. This species can be confused by *Anthurium oxycarpum*, but the latter does not have attenuate leaf bases and its petioles are much

shorter. It can also be confused with *Anthurium latissimum*, but the latter dries brown and has wider leaf blades.

Specimen examined: *Sandra Knapp 8544*.

12. *Anthurium latissimum* Engl., sect. Pachyneurium. TYPE: Peru. Junín department, Tarma province: La Merced, Chanchamayo valley, ca. 1000 m, Dec. 1902, *August Weberbauer* 1939 (holotype, B).

Epiphyte or hemi epiphyte; stem short. *Leaves* glabrous, petioles 17.5 – 33 cm long, 3 – 5.7 mm in diameter, cross section terete, olive green to beige; geniculum dark brown to reddish beige, 0.55 – 1.3 cm long, 4.9 – 6.6 mm in diameter; blade subcoriaceous, oblanceolate (elliptic), apex acute to acuminate, base cuneate, 36.5 – 58.6 cm long, 17 – 27 cm in width, broadest part at the upper third, margins entire; abaxial surface reddish light brown when dry; abaxial surface concolorous when dry; midrib concolorous and slightly risen in an upside down “V” shape; primary lateral veins 13 – 17 per side, concolorous, ascending curved; 2 – 12 interprimary veins, concolorous; secondary veins visible, reticulate, concolorous; tertiary veins visible, reticulate, concolorous; collective vein beginning at 7th – 9th primary vein, distance from margin 0.38 – 0.56 cm. *Inflorescence* erect, peduncle (12) 27.5 – 99.5 cm long, (1.6) 2.7 – 10 mm in diameter, 0.5 – 1.5 times the length of the petiole, reddish brown, cross section terete to triangular; spathe free at 45° – 135° from spadix, coriaceous, green, lanceolate, 5.4 – 17.5 cm long, (7.5) 13 – 21 mm in width, broadest part at the inferior third, apex acuminate, base acute; spadix reddish green to yellowish green, tapered, straight, 6.5 – 16.7 cm long, 4.8 – 9.7 mm in diameter; stipe brown to light brown, 2.3 – 2.8 mm long, 3.1 – 7.6 mm in width; flowers tetra-lobed to rhombic, 2.1 – 2.4 mm long, 1.3 – 2 mm in width; primary spiral right-handed, 6 – 9 visible flowers in primary spiral, 4 – 7 visible flowers in secondary spiral; tepals matte, lateral tepals interior margins convex (straight); pistil quadrangular to circular, 0.9 – 1.3 mm long; stigma ellipsoid to lineal, 0.2 – 0.3 mm long, 0.1 – 0.3 mm in width; stamens 0.5 – 1.3 mm long; filaments flat; anthers 0.5 – 0.6 mm long, 0.5 mm in width on average. *Infructescence* erect; berries ovoid to subtruncate.

Distribution: *Anthurium latissimum* is found in the Peruvian central rainforests, particularly among the Junín and Pasco departments ranging from 700 to 1200 m in altitude. Newer collections have been made in the Huánuco and San Martín departments in Peru and in the Cochabamba department in Bolivia extending the range of this species (Figure 11).

Anthurium latissimum can be recognized by its long cuneate leaf base and obovate or oblanceolate blade shape. This species dries brown which differentiates it from *A. knappiae* which dries green and has a slender leaf blade.

Specimens examined: *Rocío Rojas 8662, Abel Monteagudo Mendoza 3913, José Schunke Vigo 10498, Thomas B. Croat 57727 (1/5), Thomas B. Croat 57727 (4/5), Thomas B. Croat 57727 (5/5).*

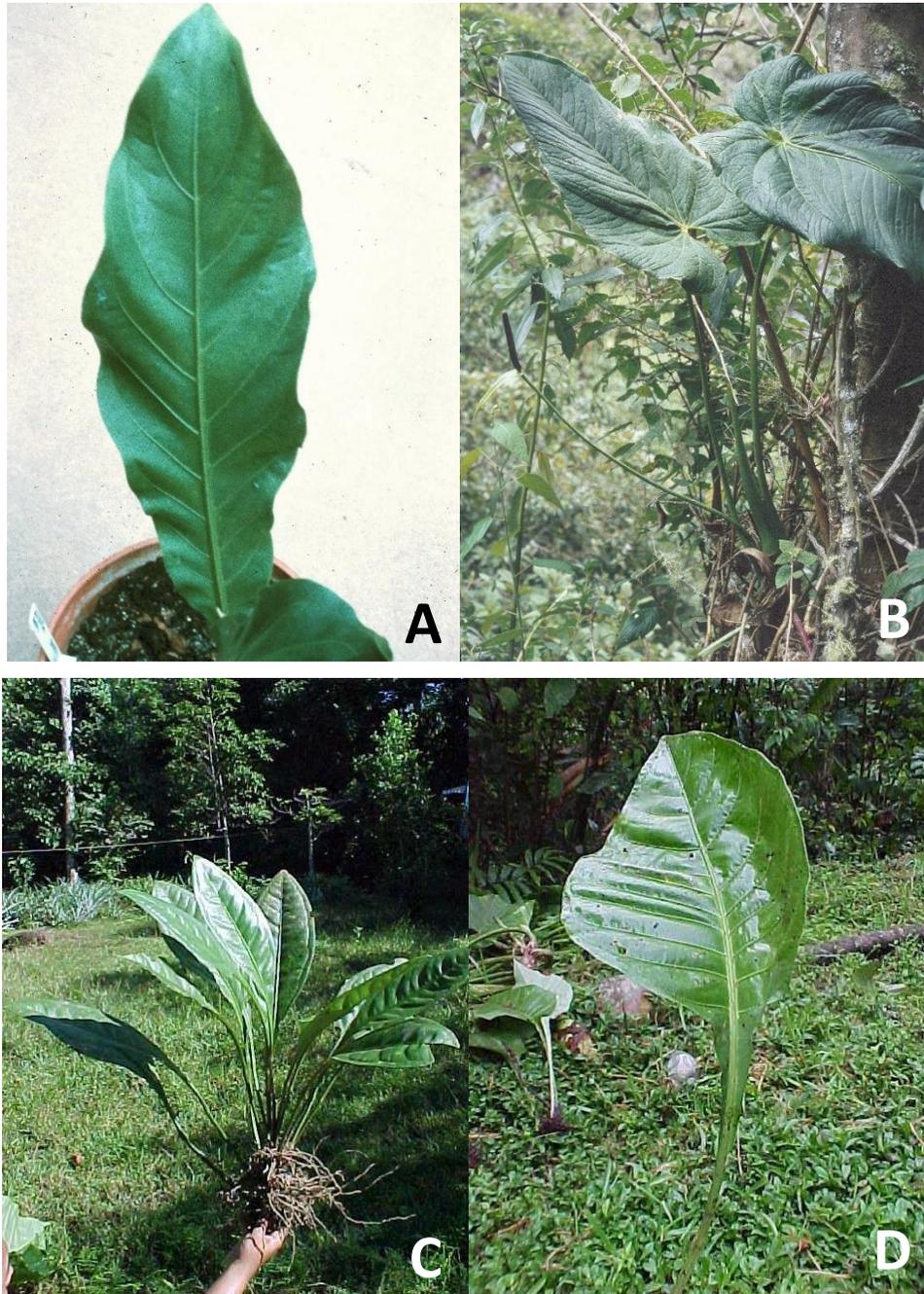


Figure 10. Representative specimens of (A) *A. galactospadix*, (B) *A. incurvatum*, (C) *A. knappiae*, and (D) *A. latissimum* (pictures taken from Tropicos.org)

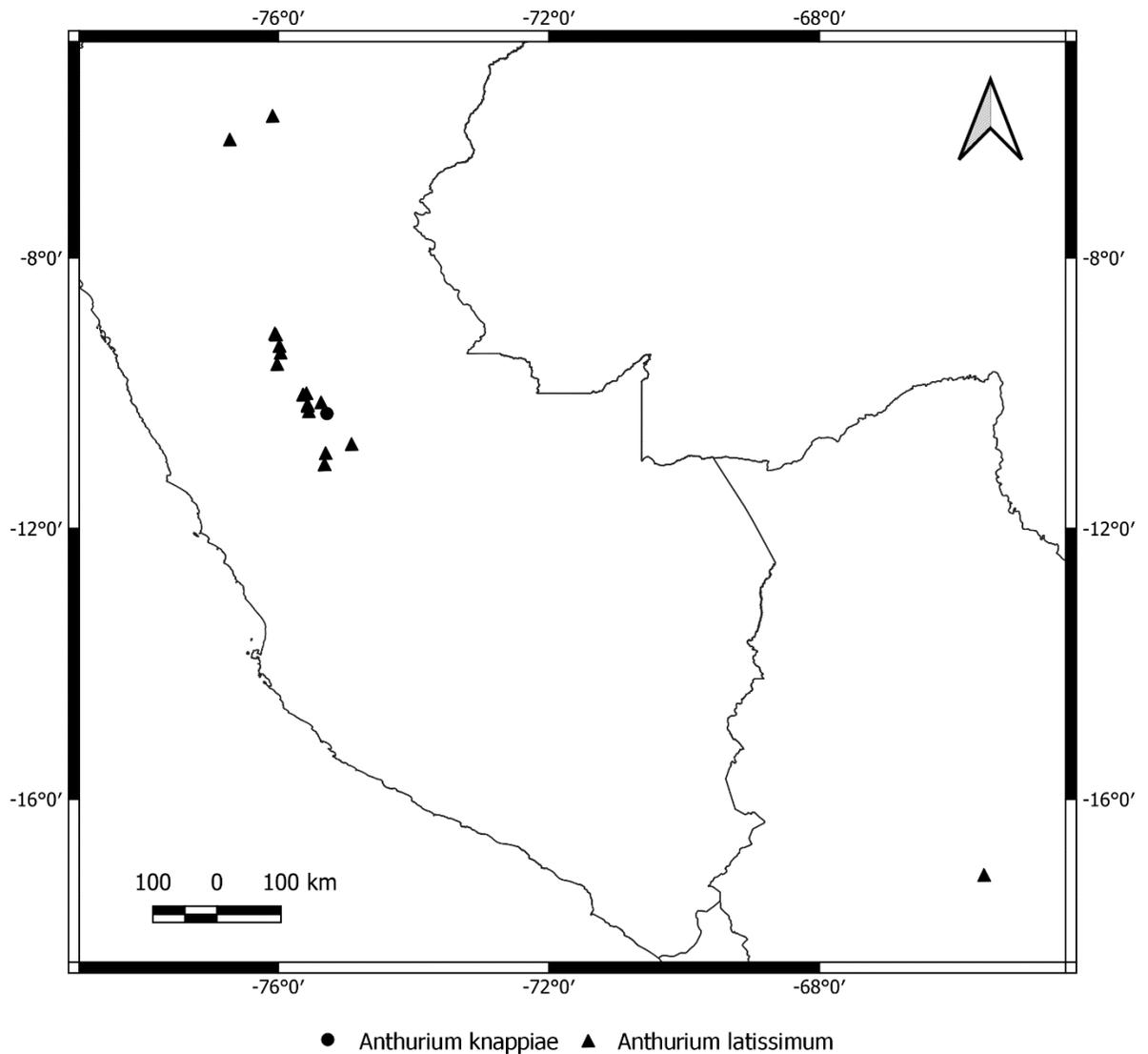


Figure 11. Distribution map of *Anthurium knappiae* and *A. latissimum*.

13. *Anthurium lechlerianum* Schott, sect. *Digitinervium*. TYPE: Peru. Huánuco department, Huamalíes province: Monzón, 1600 – 1900 m, *August Weberbauer* 3513 (holotype, B; isotypes, E, GH, LPB).

Terrestrial; stem long, 0.7 – 1.4 cm in diameter on average; cataphylls coriaceous, triangular, 8 – 13.5 cm long on average, apex acute, light brown when dry, persistent. *Leaves* glabrous, petioles 65.5 – 98 cm long, 3 – 6 mm in diameter, cross section quadrangular, light

reddish brown to yellowish green; geniculum dark reddish brown, 0.9 – 2.5 cm long, 3.2 – 6.9 mm in diameter; blade coriaceous, triangular, apex emarginate (round), base lobed, 21.5 – 43.5 cm long, 22 – 27.5 cm in width, broadest part at the inferior fourth, margins entire; lobes oblong, 7.1 – 13.5 cm long, sinus shape parabolic to spatulate (triangular); adaxial surface light greenish yellow when dry; abaxial surface light glaucous green when dry, black punctuations present; midrib concolorous and weakly risen; basal ribs curved, naked at the sinus, 4.5 – 6.5 cm long; basal veins 4 (3) pairs, 2 radiating and 2 coalescing; primary lateral veins (12) 16 - 18 per side, straight ascending, concolorous; 1 – 4 interprimary veins, concolorous; secondary veins visible, reticulate, concolorous; tertiary veins visible, concolorous, reticulate; collective vein beginning at the 1th basal vein, distance from margin non-constant. *Inflorescence* erect, peduncle 74.5 – 89 cm long, 4.1 – 5.1 mm in diameter, 0.9 – 1.1 times the length of the petiole, light green to light green brownish, cross section quadrangular; spathe free at 90° from spadix, coriaceous, green, oblong, 10.3 cm long on average, 14 mm in width on average, broadest part at the middle two fourths, apex acuminate, base acute; spadix green, tapered, straight, 8.5 – 11 cm long, 5.3 – 7.2 mm in diameter; stipe absent; flowers rhombic, 2.5 – 3 mm long, 2.1 – 2.5 mm in width; primary spiral mostly right-handed, 6 – 7 visible flowers in primary spiral, 5 – 8 visible flowers in secondary spiral; tepals matte, lateral tepals interior margins concave or straight, bent towards the exterior; pistil quadrangular to circular, 1.3 – 1.5 mm long; stigma linear to circular, 0.3 – 0.5 mm long, 0.1 – 0.5 mm in width; stamens 1 mm long on average; filaments flat; anthers 0.4 – 0.6 mm long, 0.6 – 0.7 mm in width. *Infructescence* spreading; berries ovoid.

Distribution: This species occurs in the region consisting of the Cochabamba and La Paz departments in Bolivia and the Cusco, Huánuco, and Pasco regions in Peru from ca. 1000 to 2800 m of altitude (Figure 12).

Anthurium lechlerianum most relevant morphological characteristics are its triangular leaves and its emarginate apex. Additionally, this species can be identified by its quadrangular petiole and the presence of black punctuations on the abaxial leaf surface. Perhaps its most notable trait is that the first pair of basal veins make up the collective vein and end up in the apex of the blade. Some confusion could occur with *A. weberbaueri*, but this species differs in having shorter lobes, 1 – 2.1 (3.2) cm long, an arched sinus, and an overall more brownish leaf color when dry.

Specimens examined: René Chávez Alfaro 852, Luis Valenzuela Gamarra 4042 (1/2), Luis Valenzuela Gamarra 4042 (2/2), Isaú Huamantupa Chuquimaco 9554, Michael Kessler 11548.

14. *Anthurium llewelynii* Croat, set. Pachyneurium. TYPE: Peru. San Martín department, Tarapoto province: Río Mayo, near Cumumbigue, 6 km S of Tarapoto-Moyobamba road at km 15, 350 m, 6°23'S, 76°39'W, *Thomas B. Croat* 51092 (holotype, MO-2819899; isotypes, B, K, M, NY, RSA, SEL, US, USM).

Epiphyte or terrestrial; stem short, 0.9 – 2.5 cm in diameter; roots [range] per fascicle, vine-like, white; cataphylls coriaceous, triangular, 5.2 – 9 cm long, apex acute, brown reddish when dry, persistent. *Leaves* glabrous, petioles (5.1) 10.7 – 34.4 cm long, 3.3 – 4.5 mm in diameter, cross section “D” shaped, light brown to aquamarine green; geniculum light reddish brown to dark brown, 0.5 – 0.9 cm long, 4.8 – 5.8 mm in diameter; blade coriaceous, oblanceolate (elliptic), apex strongly acute, base round to cuneate, 62.8 – 80.5 cm long, 5 – 15 cm in width, broadest part at the first third, margins entire; adaxial surface opaque green when dry, semi glossy; abaxial surface opaque dark green when dry; midrib dark green to brownish green and risen in an upside down “V” shape; primary lateral veins 13 – 24 per side, concolorous, curved ascending; 2 – 15 interprimary veins, concolorous; secondary veins visible, reticulate, concolorous; tertiary veins not visible; collective vein beginning absent, primary veins curve towards the apex at the margin in a craspedodromous fashion. *Inflorescence* erect to semi erect, peduncle 18 – 63 cm long, 1.1 – 3.2 mm in diameter, 1.4 – 5.5 times the length of the petiole, brownish to pink, cross section terete; spathe free at 90° from spadix, coriaceous, green to green tingled with purple, lanceolate to oblanceolate, 8.5 – 11 cm long, 11 – 22 mm in width, broadest part at the lower half or middle two fourths, apex acuminate, base acute to almost fusing and decurrent; spadix green, tapered, straight, 6.1 – 10.9 cm long, 3 – 9 mm in diameter; stipe absent; flowers quadrangular, 1.5 – 2.2 mm long, 1.1 – 2.2 mm in width; primary spiral mostly right-handed, 5 – 7 visible flowers in primary spiral, 4 – 6 visible flowers in secondary spiral; tepals surface matte, lateral tepals interior margins concave to straight (convex); pistil quadrangular, 0.5 – 1.7 mm long; stigma ellipsoid (linear), 0.2 – 0.4 mm long, 0.1 – 0.3 mm in width; stamens 0.8 – 1.4 mm long; filaments flat; anthers 0.3 – 0.5 mm long, 0.5 – 0.6 mm in width; pollen pale yellow. *Infructescence* erect to spreading (pendent); berries globose and truncate, green to purple or purple dark violet.

Distribution: *Anthurium llewelynii* is found in Peru, in the San Martín department, province of Tarapoto, and in the Huánuco department, ranges ca. 250 to 850 m in elevation (Figure 12).

This species can be easily recognized by the absence of a proper and continuous collective vein, and its oblanceolate-shaped blade, in addition to a green spadix and pink peduncle, 18 – 63 cm long, which is longer than the petiole, (5.1) 10.7 – 34.4 cm long.

Specimens examined: *Thomas B. Croat 51092 (1/2), Thomas B. Croat 82889, Thomas B. Croat 21086, Sandra Knapp 7336, Thomas B. Croat 50981 (1/2), Thomas B. Croat 50981 (2/2).*

15. *Anthurium manuanum* Croat, sect. *Pachyneurium*. TYPE: Peru. Madre de Dios department, Manu province: Salvación a Gloria, 710 m, *Julio César Vargas Calderón 17747* (holotype, CUZ; isotypes, MO).

Epiphyte; stem short, 1.5 cm in diameter on average; roots densely woolly-pubescent, vine-like, brown to white; cataphylls coriaceous, triangular, 5 – 7.1 cm long on average, apex acute, reddish brown when dry, persistent. *Leaves* glabrous, petioles 8 – 9.7 cm long, 3.2 – 4.5 mm in diameter, cross section terete, light reddish brown; geniculum dark brown, 0.4 – 0.5 cm long, 3.5 – 4.4 mm in diameter; blade coriaceous, oblanceolate to elliptic, apex acute to slightly acuminate, base cuneate, 34.2 – 40 cm long, 12 – 13 cm in width, broadest part at the first half, margins entire; adaxial surface light brown when dry; abaxial surface concolorous when dry; midrib concolorous and acutely risen in an upside down “V” shape; primary lateral veins 6 – 10 per side, curved ascending, concolorous; 4 – 15 interprimary veins, concolorous; secondary veins visible, reticulate and parallel, concolorous; tertiary veins not visible; collective vein not present strictly speaking, primary veins curve at the margin towards the apex in a craspedodromous fashion. *Inflorescence* erect or slightly inclined, peduncle (4.5) 8.5 (12.7) cm long on average, 1.2 – 1.6 mm in diameter, 0.5 – 1.3 times the length of the petiole, light brown, cross section terete; spathe free at 120° – 150° from spadix, coriaceous, green, lanceolate, 3.2 – 4.3 cm long, 8 – 10.1 mm in width, broadest part at the inferior third, apex acuminate, base cuneate; spadix grayish brown, cylindric, straight, 4.7 – 4.8 cm long, 5.1 mm in diameter on average; stipe brown, 1.5 mm long on average, 2 mm in width on average; flowers tetra-lobed, 1.2 – 1.9 mm long, 1.1 – 1.6 mm in width; primary spiral right-handed, 7 – 9 visible flowers in primary spiral, 5 – 6 visible flowers in secondary spiral; tepals surface matte, lateral tepals interior margins straight; pistil quadrangular, 1 – 1.1 mm long; stigma ellipsoid, 0.3 – 0.4 mm long, 0.3 – 0.5 mm in width; stamens 0.7 – 0.9 mm long; filaments flat; anthers 0.3 – 0.4 mm long, 0.3 – 0.5 mm in width; pollen yellow. *Infructescence* not seen.

Distribution: This species is only known from the Manu province, Madre de Dios department, in Peru ranging from 250 to 850 m of altitude (Figure 12).

Anthurium manuanum can be recognized by its relatively short stipe, 1.5 mm long on average, and its similar petiole and peduncle lengths (8 – 9.7 cm and (4.5) 8.5 (12.7) cm, respectively).

Specimens examined: *Julio César Vargas Calderón 17747, Percy Núñez Vargas 5769, Michel Alexiades 972.*

16. *Anthurium monzonense* Engl., sect. *Belolonchium*. TYPE: Peru. Huánuco department, Huamalíes province: In the montane forest Southwest of Monzón, 1600 – 1800 m, *August Weberbauer 3562* (holotype, B).

Climber or terrestrial; stem short. *Leaves* glabrous, petioles 39 – 50 cm long, 2.5 – 4.6 mm in diameter, cross section terete, light brown; geniculum dark brown, 1.4 cm long on average, 2.8 mm in diameter on average; blade coriaceous, ovate, apex acuminate, base lobed, 30.5 – 33 cm long, 20 – 21 cm in width, broadest part at the inferior third, margins entire; lobes auriculate or reniform, 6.5 – 8.5 cm long, sinus between lobes spatulate; adaxial surface brown when dry; abaxial surface concolorous when dry; midrib concolorous and slightly risen; basal ribs 1.1 cm long on average, curved and naked at the sinus; basal veins 2 radiating, 2 coalescing or all pairs 4 – 5 pairs coalescing; primary lateral veins 9 – 10 per side, subopposite to alternate, curved ascending, concolorous; 3 – 8 interprimary veins, concolorous; secondary veins visible, reticulate, concolorous; tertiary veins visible, reticulate, concolorous; collective vein beginning at 3rd pair of basal veins or 2nd pair of primary veins, distance from margin 0.22 – 0.33 cm. *Inflorescence* erect, peduncle 36 – 47 cm long, 4.3 – 5.6 mm in diameter, light brown, cross section terete; spathe surrounding at 10° – 20° from spadix, coriaceous, white, elliptic, 7 – 10.5 cm long, 18 – 47 mm in width, broadest part at the middle, apex acuminate, base acute; spadix green, tapered, straight, 8.2 – 9.5 cm long, 8.5 – 9.8 mm in diameter; stipe brown, 2.1 mm long on average, 5 mm in width on average; flowers tetra-lobed, 1.7 mm long on average, 1.7 mm in width on average; primary spiral right-handed, 7 – 11 visible flowers in primary spiral, 7 – 9 visible flowers in secondary spiral; tepals surface matte, lateral tepals interior margins convex taking the shape of a circular sector ; pistil quadrangular, 1.3 – 1.5 mm long; stigma linear, 0.4 mm long on average, 0.1 mm in width on average; stamens 1.1 – 1.2 mm long; filaments flat; anthers 0.4 mm long on average, 0.6 mm in width on average. *Infructescence* not seen.

Distribution: *Anthurium monzonense* is found in the Monzón region in the Huánuco department of Peru, and in La Convención region in the Cusco department. The total altitudinal range for this species is ca. 1400 to 2300 m (Figure 12).

This species is easily recognizable by its white spathe which surrounds the spadix and its lateral tepals with interior margins convex resembling the shape of a circular sector. This species could be confused with *A. acebeyae*, but the latter has a longer stipe (> 10 mm) and bigger, 33 – 44 cm long and 16.5 – 28.5 cm in width, oblong lobes.

Specimens examined: *Julio César Vargas Calderón 2570, Julio César Vargas Calderón 3475.*

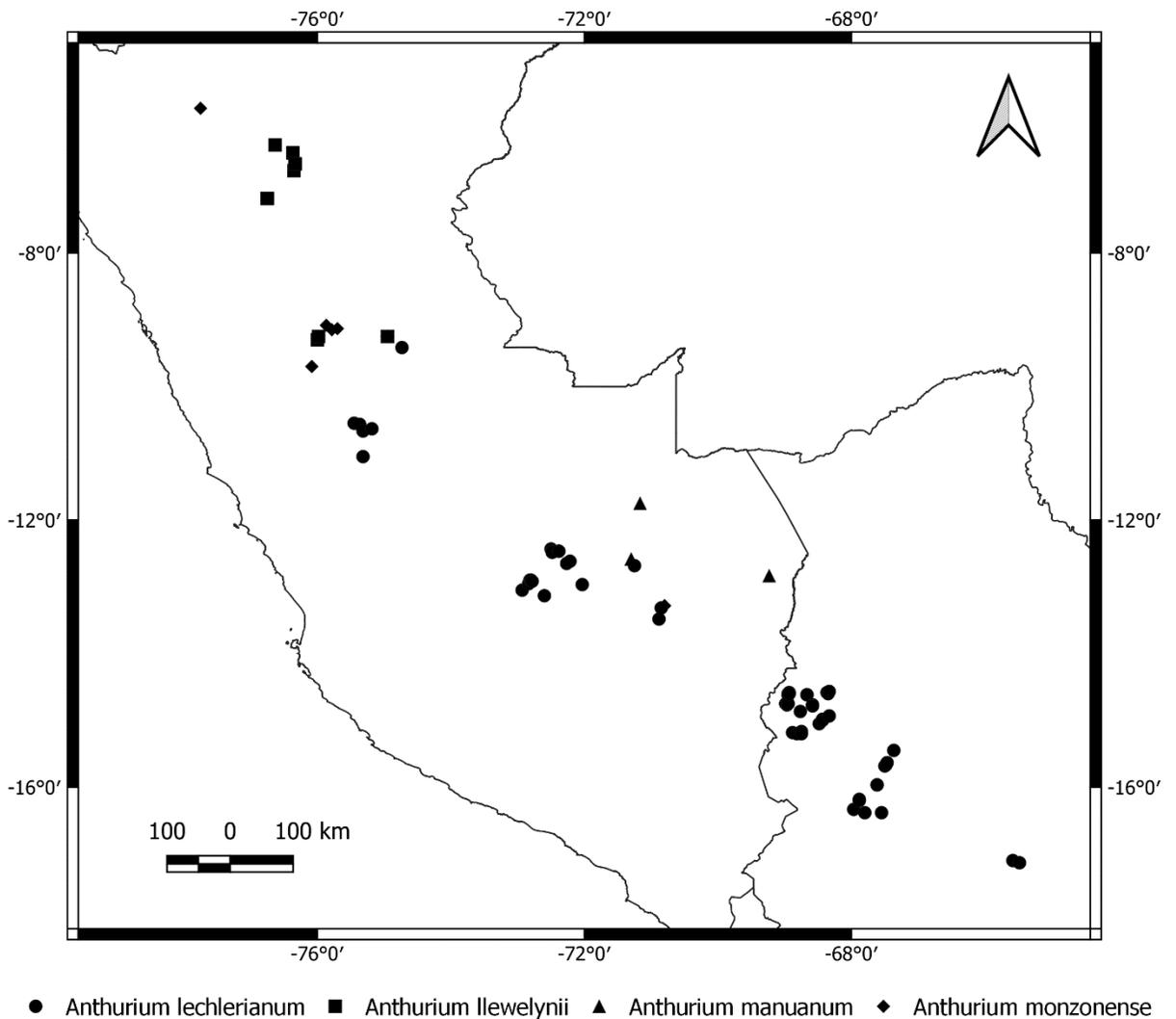


Figure 12. Distribution map of *Anthurium lechlerianum*, *A. llewelynii*, *A. manuanum*, and *A. monzonense*.

17. *Anthurium oxycarpum* Poepp., sect. *Pachyneurium*. TYPE: Peru. Loreto department, Yurimaguas province, *Eduard Friedrich Poeppig* s.n. (lectotype, G; paratypes, MO, HOXA, USM).

Epiphyte or lithophyte, rosette; stem short, 1 – 3 cm in diameter on average; roots numerous, greenish to whitish; cataphylls membranous to subcoriaceous, 9.5 cm long on average, apex acute, pale yellow when dry, persistent. *Leaves* glabrous, petioles 4 – 14.5 cm long, (1.9) 3.1 – 7.9 mm in diameter, cross section terete, light green to greenish light brown; geniculum dark green, 0.6 – 0.8 cm long, 2.1 – 7 mm in diameter; blade coriaceous, oblanceolate (elliptic), apex acuminate, base acute, 32 – 54.5 cm long, 13 – 18.6 cm in width, broadest part at the middle two fourths, margins entire; adaxial surface dark opaque green when dry; abaxial surface concolorous or slightly more glaucous when dry; midrib yellowish and flat; primary lateral veins 15 – 34 per side, straight and curved at the margins towards the apex, concolorous; 2 – 9 interprimary veins, concolorous; secondary veins visible, reticulate, orangish green; tertiary veins visible, reticulate, yellowish green; collective vein beginning at the base or at the 1st pair of primary veins, distance from margin 0.65 – 0.85 cm. *Inflorescence* erect, peduncle 26.5 – 65 cm long, 2 – 5.3 mm in diameter, 3 – 10 (15) times the length of the petiole, dark opaque green, cross section terete; spathe free at 45° – 150° from spadix, coriaceous, green to yellowish green, lanceolate, 6 – 12 cm long, 9.3 – 17 mm in width, broadest part at the inferior third, apex acuminate, base acute; spadix green to yellowish green, tapered, straight, 5.3 – 12.5 cm long, 4.8 – 5.6 mm in diameter; stipe dark yellow, 4 mm long on average, 2.1 mm in width on average; flowers tetra-lobed to rhombic, 2 – 2.4 mm long, 2 mm in width on average; primary spiral right-handed or left handed, 4 – 5 visible flowers in primary spiral, 5 – 5 visible flowers in secondary spiral; tepals surface matte with white punctuations, lateral tepals interior margins straight or convex; pistil circular to quadrangular, 0.9 – 2.3 mm long; stigma linear, 0.2 mm long on average, 0.1 mm in width on average; stamens 1 mm long on average; filaments flat; anthers 0.4 – 0.6 mm long, 0.6 – 0.7 mm in width; pollen white. *Infructescence* with berries scattered; berries obovoid to oblong, red to purple.

Distribution: *Anthurium oxycarpum* ranges from southeastern Colombia to Amazonian Ecuador, Peru, Bolivia, and Brazil at 100 to 870 (1300) m (Figure 13).

It can be recognized by its well-defined collective vein, high density of primary lateral veins, flat yellowish midrib, and overall rosette shape. Additionally, the leaves in this species dry green. This species can be confused with *Anthurium knappiae* and *A. latissimum*, but it differs

from them in the petiole length, 4 – 14.5 cm long, and leaf base (longer petiole, 37.5 cm long on average, and attenuate leaf base for *A. knappiae*) and drying color of the blade (brown for *A. latissimum*).

Specimens examined: *Rodolfo Vásquez 8262, Rodolfo Vásquez 22486, Rodolfo Vásquez 7830, José Schunke Vigo 9465.*

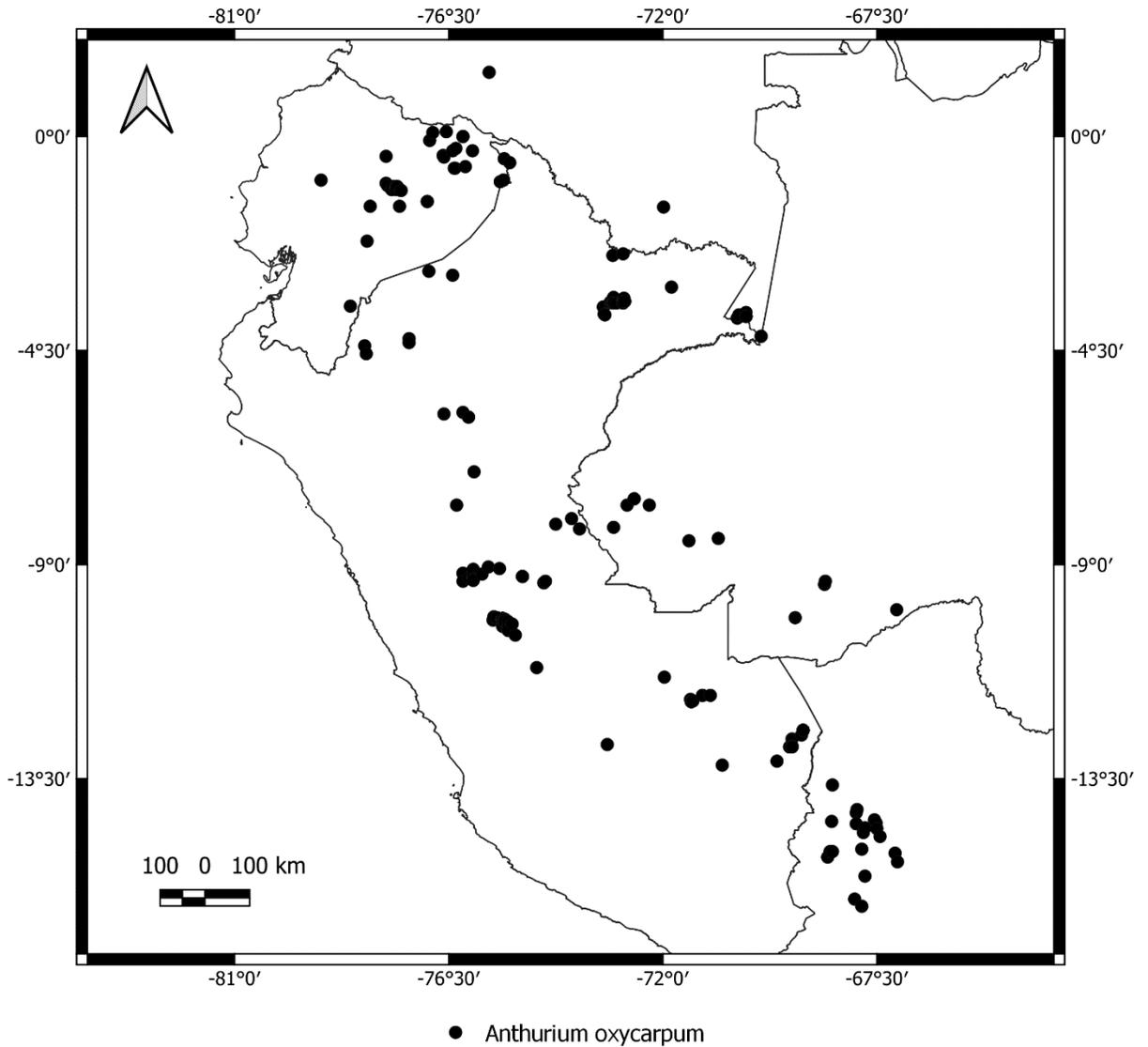


Figure 13. Distribution map of *Anthurium oxycarpum*.

18. *Anthurium reflexinervium* Croat, sect. Pachyneurium. TYPE: Peru. Huánuco department, Leoncio Prado province: Rupa Rupa, Tingo María, vicinity of airport, 750 – 800 m. *Timothy Plowman* 7585 (holotype, MO-2743714; isotypes, F, K, NY, SEL).

Terrestrial or epiphyte (lithophyte); stem short, 1 – 3 cm in diameter on average; roots dense, brown; cataphylls subcoriaceous, triangular to lanceolate, 3 – 4 cm long on average, apex acute, dull brown when dry, persistent. *Leaves* glabrous, petioles 4.2 – 8.5 cm long, 4.5 – 6.7 mm in diameter, cross section triangular to “D”-shaped with acute edges, light mustard; geniculum dark brown, 0.3 – 0.55 cm long, 7 – 8.6 mm in diameter; blade coriaceous to sub coriaceous, elliptic, apex acute, base cuneate to slightly lobed, 63.5 – 69 cm long, 17.5 – 20 cm in width, broadest part at the middle, margins entire; adaxial surface light green to light mustard when dry, shiny to semi glossy; abaxial surface concolorous when dry, shiny to semi glossy; midrib concolorous and risen in an upside down “Y” shape; primary lateral veins 28 – 30 per side, opposite, curved towards the base but then returning to the same horizontal level, yellowish to whitish; 2 – 5 interprimary veins, concolorous; secondary veins visible, reticulate and parallel, dark yellowish; tertiary veins visible, reticulate, dark green; collective vein beginning at the base, distance from margin (0.2) 0.32 – 0.5 cm, strongly printed. *Inflorescence* erect, peduncle 18.8 – 38.8 cm long, 2.6 – 3.5 mm in diameter, 4 – 4.5 times the length of the petiole, dark green to dark brownish green, cross section terete; spathe free at 50° – 150° from spadix, coriaceous, green to olive green, lanceolate, 5 – 8.6 cm long, 5.2 – 13.6 mm in width, broadest part at the inferior third, apex acuminate, base attenuate; spadix reddish dark purple, cylindric or tapered, straight, 3.6 – 5.9 cm long, 4.9 – 6.2 mm in diameter; stipe absent; flowers rhombic to tetra-lobed, 1.5 – 1.9 mm long, 1.4 – 1.5 mm in width; primary spiral right-handed, 6 – 7 visible flowers in primary spiral, 5 – 7 visible flowers in secondary spiral; tepals surface matte, lateral tepals interior margins straight; pistil quadrangular, 1.1 – 1.2 mm long; stigma ellipsoid, 0.4 – 0.5 mm long, 0.1 – 0.2 mm in width; stamens 0.8 – 1.2 mm long; filaments flat; anthers 0.4 – 0.5 mm long, 0.5 – 0.7 mm in width. *Infructescence* with green spathe persisting; berries reddish violet.

Distribution: The specimens of *Anthurium reflexinervium* all come from the vicinity of Tingo María (Huánuco department, Peru) ranging ca. 650 to 800 m in altitude (Figure 15).

This species is distinguished by its arched primary veins which maintain a curved yet horizontal configuration resembling an open ribcage and a spine. The leaf blade in this species dries green.

Specimens examined: *Timothy Plowman 7585, Thomas B. Croat 57949 (2/2), Thomas B. Croat 21080.*

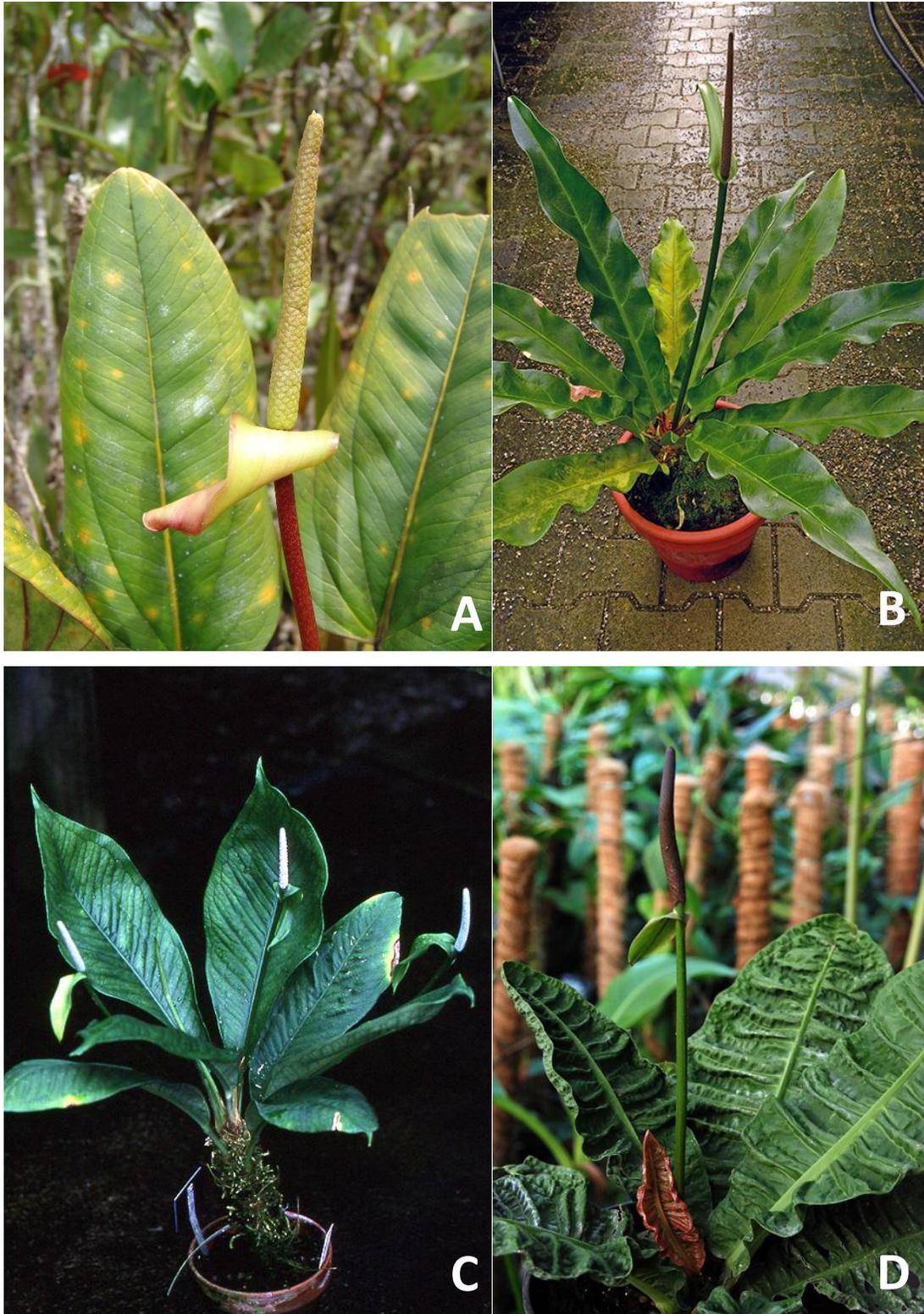


Figure 14. Representative specimens of (A) *Anthurium lechlearianum* (picture taken from Tropicos.org), (B) *A. llewelynii*, (C) *A. oxycarpum*, and (D) *A. reflexinervium* (pictures taken from www.aroidpictures.fr)

19. *Anthurium regale* Linden, sect. "Clade 12". TYPE: Peru. *Gustav Wallis* s.n. (holotype, K).

Terrestrial herb; stem long, 1.6 – 2.7 cm in diameter; cataphylls coriaceous, triangular, 6 – 14 cm long, apex acute, light green, persistent. *Leaves* glabrous, petioles 61 – 120 cm long, 4 – 13 mm in diameter, cross section terete, light brown to beige; geniculum reddish, 1.8 – 2.5 cm long, 4.4 – 6 mm in diameter; blade coriaceous, ovate, apex acute to acuminate, base lobed, (26.5) 56.2 – 67 cm long, (16.5) 41 – 55 cm in width, broadest part at the inferior third, margins entire; lobes auriculate to reniform, (6) 14.5 – 17 cm long, sinus between lobes spatulate to parabolic (hippocrepiform); adaxial surface dark green or brown greenish when dry; abaxial surface concolorous when dry; midrib white and risen in an upside down "C" shape; basal ribs (0.5) 4.4 – 7.5 cm long, curved and naked at the sinus; basal veins 4 – 6 pairs, half coalescing and half radiating; primary lateral veins 8 – 10 per side, alternate, white, curved ascending; 3 – 9 interprimary veins, light green; secondary veins visible, reticulate, white; tertiary veins visible only on abaxial surface, concolorous with abaxial surface, reticulate; collective vein absent, primary veins curve towards the apex at the margins in a craspedodromous fashion. *Inflorescence* erect, peduncle 41 – 57 cm long, 2.9 – 3.9 mm in diameter, brown, cross section terete; spathe free at 90° – 150° from spadix, coriaceous, pale green turning yellowish pink, elliptic (lanceolate), 12 – 14 cm long, 17 – 19 mm in width, broadest part at the middle third, apex acute, base cuneate; spadix pink to yellowish pink, tapered, straight, 8 – 12 cm long, 5.8 – 6.6 mm in diameter; stipe green, 0.4 – 1 mm long, 3.2 – 4.5 mm in width; flowers rhombic (tetra-lobed), 1.9 – 2.7 mm long, 1.5 – 1.7 mm in width; primary spiral right-handed (left-handed), 7 – 12 visible flowers in primary spiral, 6 – 9 visible flowers in secondary spiral; tepals surface matte, lateral tepals interior margins concave; pistil quadrangular, 1.1 – 1.3 mm long; stigma ellipsoid, 0.1 – 0.3 mm long, 0.1 – 0.2 mm in width; stamens 1 – 1.2 mm long; filaments flat; anthers 0.3 – 0.6 mm long, 0.4 – 0.6 mm in width. *Infructescence* arched; berries subglosobe, reddish purple.

Distribution: *Anthurium regale* appears to occur only in the eastern flank of the Andes of Peru, from the northern department of Amazonas up until the center of the country at the department of Pasco ranging from 300 to 1000 m (Figure 15).

It can be distinguished by its big, (26.5) 56.2 – 67 cm long and (16.5) 41 – 55 cm in width, ovate and heart-shaped leaves with prominent white veins. This species is easily distinguishable from *Anthurium besseae* because of the presence of basal ribs which create a well-defined sinus between the posterior lobes, while basal ribs are absent in *A. besseae*. *Anthurium regale* was

previously placed in section *Cardiolonchium*, but it is now recognized as a member of Clade 12 (from Carlsen & Croat 2013, 2019).

Specimens examined: *Timothy Plowman 11637 (1/2), Timothy Plowman 11637 (2/2), Rodolfo Vásquez 22227 (2/2), Rodolfo Vásquez 22652 (2/2), Rodolfo Vásquez 18930, Rodolfo Vásquez 22227 (1/2), Rodolfo Vásquez 22652 (1/2).*

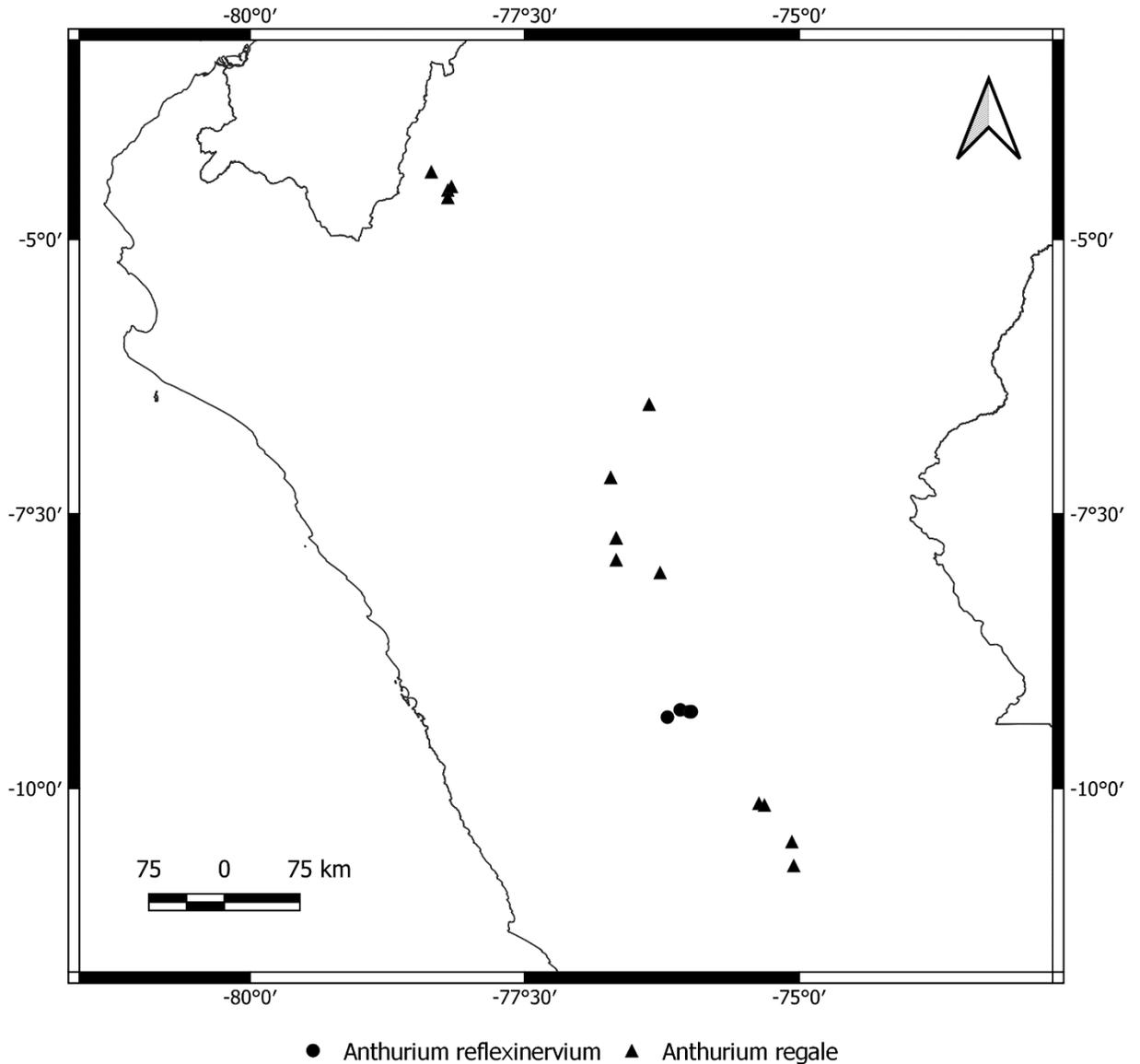


Figure 15. Distribution map of *Anthurium reflexinervium* and *A. regale*.

20. *Anthurium soukupii* Croat, sect. *Multinervia*. TYPE: Peru. Cusco department, Urubamba province: Machu Picchu, 0.5 km N of the union of the Sayacmarca and Aobamba rivers, 2370 m, *Bernie Peyton* 1486 (holotype, MO-3024625).

Climbing epiphyte; stem long, 1.5 – 1.6 cm in diameter; roots 2 – 4 per fascicle, vine-like, white; cataphylls coriaceous, triangular, 9 – 13 cm long, apex acute, opaque yellow when dry, persistent. *Leaves* glabrous, petioles 6 – 14 cm long, 4.2 – 6.9 mm in diameter, cross section “D”-shaped, light green to opaque light yellow; geniculum slightly darker than petiole, 0.5 – 1.3 cm long, 4. – 7 mm in diameter; blade coriaceous, oblanceolate, apex acute, base cuneate, 42 – 62.5 cm long, 7.1 – 11.4 cm in width, broadest part at the upper third, margins entire and prominent on the abaxial surface; adaxial surface dark green when dry; abaxial surface concolorous when dry, pustules present; midrib yellowish green and flat or slightly risen in an upside down “C” shape; primary lateral veins 44 – 65 per side, straight ascending, concolorous; 1 – 3 interprimary veins, concolorous; secondary veins visible, reticulate, concolorous; tertiary veins visible, reticulate, concolorous; collective vein beginning at the base, distance from margin 0.7 – 0.85 cm. *Inflorescence* erect, peduncle 19 – 29 cm long, 1.9 – 3.8 mm in diameter, 1.5 – 3.5 times the length of the petiole, green to brown-yellowish green, cross section terete; spathe free at 45° – 150°, coriaceous, green, lanceolate, 3.9 – 6.9 cm long, 7 – 15 mm in width, broadest part at the inferior third, apex acuminate, base acute; spadix green turning brown or vinous, tapered, straight, 3.8 – 6.1 cm long, 5.5 – 8 mm in diameter; stipe dark brown to dark green, 4.3 – 8 mm long, 1.3 – 4.3 mm in width; flowers rhombic, 2.2 – 3.6 mm long, 2.1 – 2.9 mm in width; primary spiral right-handed, 4 – 5 visible flowers in primary spiral, 4 – 5 visible flowers in secondary spiral; tepals surface matte, lateral tepals interior margins straight to convex; pistil ellipsoid to quadrangular, 1.5 – 1.8 mm long; stigma ellipsoid, 0.2 mm long on average, 0.1 – 0.3 mm in width; stamens 1.4 mm long on average; filaments flat; anthers 0.3 – 0.4 mm long, 0.2 – 0.5 mm in width; pollen dark. *Infructescence* erect, globose, green turning black with white spots.

Distribution: *Anthurium soukupii* has a large range of distribution from the Zamora province in Ecuador all the way to the Cochabamba department in Bolivia following the montane forests of the eastern flank of the Andes from (650) 1000 to 2500 (2800) m (Figure 16).

This species is easily identifiable by its blades with high density of primary lateral veins. These veins are straight, ascending in a 65° angle and distanced between one another by 0.8 – 1.2 cm. Additionally, this species has a prominent and risen margin visible on the abaxial surface of the blades.

Specimens examined: *Noel Altamirano 550a*, *Rodolfo Vásquez 31156*, *Rodolfo Vásquez 31093*, *Stephan G. Beck 8756*, *Diego de la Quintana 44*, *Percy Núñez Vargas 8928*, *Camilo Díaz Santibáñez 3361*, *Alwyn Howard Gentry 74704*, *Michael Owen Dillon 4385a*, *Bernie Peyton 1486 (1/2)*.

21a. *Anthurium superbum* Madison subsp. ***superbum***, sect. "Clade 12". TYPE: Ecuador. Napo province: La Primavera, Napo River, *Michael Timothy Madison 5516* (holotype, SEL 2727370; isotypes, F, K, MO, QCA, U, US).

Epiphyte or liana; stem short, 1 cm in diameter on average; roots 4 – 8 per fascicle, vine-like, white; cataphylls coriaceous, triangular, 3.5 – 10 cm long, apex acute, dark brown when dry, persistent. *Leaves* glabrous, petioles (2) 5 – 10 cm long, 4 – 5.8 mm in diameter, cross section terete to quadrangular, dark opaque green to grayish green; geniculum brownish mustard, 0.4 – 0.8 cm long, 4.8 – 6.5 mm in diameter; blade coriaceous to chartaceous, oblanceolate (elliptic), apex acute, base cuneate, 22 – 52 cm long, 9 – 15 cm in width, broadest part at the upper third, margins entire; adaxial surface dark green when dry, small white areolas present; abaxial surface concolorous when dry, small white areolas present; midrib olive green and risen in an upside down "V" shape; primary lateral veins 12 – 16 per side, curved ascending, slightly lighter than blade; 5 – 15 interprimary veins, concolorous; secondary veins visible, reticulate, concolorous; tertiary veins not visible; first collective vein beginning at the base or up to the 10th pair of primary veins, distance from margin 0.1 – 0.3 cm; second collective vein beginning two primary vein pairs after the first collective vein, distance from margin 0.8 – 1.9 cm. *Inflorescence* erect, peduncle 16 – 21 cm long, 1.3 – 3 mm in diameter, 1.5 – 2.1 times the length of the petiole, brown, cross section terete; spathe free at 45° – 150° from spadix, coriaceous, light green, lanceolate, 3.7 – 6 cm long, 9.5 – 15 mm in width, broadest part at the inferior third, apex acute (acuminate), base acute (decurrent); spadix white, cylindrical or tapered, straight, 5 – 9 cm long, 4 – 14 mm in diameter; stipe absent; flowers tetra-lobed, 0.8 – 1 mm long, 0.8 – 1 mm in width; primary spiral right-handed, 12 visible flowers in primary spiral on average, 8 visible flowers in secondary spiral on average; tepals surface yellowish matte, lateral tepals interior margins straight; pistil circular, 0.8 mm long on average; stigma circular, 0.2 mm long on average, 0.2 mm in width on average; stamens 0.6 mm long on average; filaments flat; anthers 0.2 mm long on average, 0.2 mm in width on average. *Infructescence* with spathe persisting; berries obovoid, sharply apiculate, lavender, and white at the apex.

Distribution: *Anthurium superbum* subsp. *superbum* occurs in the Napo province in Ecuador at ca. 200 m (Figure 16).

It can be distinguished by its long blades, short petioles, and the presence of two collective veins. Naturally, this subspecies can be confused with *Anthurium superbum* subsp. *brentberlinii*, there are key differences in dimensions and distributions that support the existence of these two species. *A. superbum* subsp. *superbum* has smaller leaf blades, 39 cm long on average and 12.5 cm in width on average, in contrast to *A. superbum* subsp. *brentberlinii*, 70 cm long on average and 13.2 cm in width on average. Additionally, *A. superbum* subsp. *superbum* has a larger blade base angle, 82° on average, while *A. superbum* subsp. *brentberlinii* has a drastically smaller one, 35° on average. *Anthurium superbum* was previously recognized as a member of section Pachyneurium, but given its morphological affinity with *A. willifordii*, it is now placed in Clade 12 (fide Carlsen & Croat, 2013; 2019).

Specimens examined: *Michael Timothy Madison 5516 (1), Michael Timothy Madison 5516 (2), Michael Timothy Madison 5516 (3), Elizabeth L. Besse 1960, Thomas B. Croat 71831a, Joe Wright 7, Thomas B. Croat 71831b, Calaway H. Dodson s.n., Eric A. Christenson 1529, Thomas B. Croat 69680.*

21b. *Anthurium superbum* subsp. *brentberlinii* Croat, sect. "Clade 12". TYPE: Peru. Amazonas department: Cenepa River, E of community of Huampaní, 300 – 330 m, *Brent Berlin 644* (holotype, MO-2251387; isotypes, NY).

Epiphyte or liana; stem short, 1 cm in diameter on average; roots 4 – 8 per fascicle, vine-like, white; cataphylls coriaceous, triangular, 3.5 – 10 cm long, apex acute, dark brown when dry, persistent. *Leaves* glabrous, petioles 9 – 12.5 (17) cm long, 4 – 5.8 mm in diameter, cross section terete to quadrangular, dark opaque green to grayish green; geniculum brownish mustard, 0.4 – 0.8 cm long, 4.8 – 6.5 mm in diameter; blade coriaceous to chartaceous, oblanceolate (elliptic), apex acute, base cuneate, 60 – 77 cm long, 9 – 17.5 cm in width, broadest part at the upper third, margins entire; adaxial surface dark green when dry, small white areolas present; abaxial surface concolorous when dry, small white areolas present; midrib olive green and risen in an upside down "V" shape; primary lateral veins 12 – 16 per side, curved ascending, slightly lighter than blade; 5 – 15 interprimary veins, concolorous; secondary veins visible, reticulate, concolorous; tertiary veins not visible; first collective vein beginning at the base or up to the 10th pair of primary veins, distance from margin 0.2 – 0.4 cm; second collective vein beginning two primary vein pairs

after the first collective vein, distance from margin 0.8 – 1.4 cm. *Inflorescence* erect, peduncle 16 – 21 cm long, 1.3 – 3 mm in diameter, 1.5 – 2.1 times the length of the petiole, brown, cross section terete; spathe free at 45° – 150° from spadix, coriaceous, light green, lanceolate, 3.7 – 6 cm long, 9.5 – 15 mm in width, broadest part at the inferior third, apex acute (acuminate), base acute (decurent); spadix white, cylindrical or tapered, straight, 5 – 9 cm long, 4 – 14 mm in diameter; stipe absent; flowers tetra-lobed, 0.8 – 1 mm long, 0.8 – 1 mm in width; primary spiral right-handed, 12 visible flowers in primary spiral on average, 8 visible flowers in secondary spiral on average; tepals surface yellowish matte, lateral tepals interior margins straight; pistil circular, 0.8 mm long on average; stigma circular, 0.2 mm long on average, 0.2 mm in width on average; stamens 0.6 mm long on average; filaments flat; anthers 0.2 mm long on average, 0.2 mm in width on average; pollen color. *Infructescence* spreading-pendent; berries obovoid-ellipsoid, purple at the body and white at the tip.

Distribution: *Anthurium superbum* subsp. *brentberlinii* is endemic to the Amazonas department in Peru, close to the border with Ecuador and it ranges from 200 to 350 m in altitude (Figure 16).

This species can be distinguished by its long blades and short petioles and the presence of two collective veins. The confusion may rise when trying to compare it with the typical variety, *Anthurium superbum* subsp. *superbum*, but there are differences in size and shape. *Anthurium superbum* subsp. *brentberlinii* has longer petioles, 12.3 cm on average, longer, 70 cm on average, and more oblanceolate blades while *Anthurium superbum* subsp. *superbum* has more ovate or elliptic blades and a wider angle, 82° on average, at the base of the blade. These differences may not be practical to identify in the field. In addition, both subspecies are geographically isolated, with the typical variety occurring in Ecuador and *Anthurium superbum* subsp. *brentberlinii* occurring in Peru. Similarly, to the typical variety, *Anthurium superbum* subsp. *brentberlinii* is now considered to be a member of Clade 12 (fide Carlsen & Croat 2013, 2019).

Specimens examined: *Brent Berlin 644*, *Brent Berlin 513*, *A. Kujikat 162*, *Rubio Kayap 1252*, *Rubio Kayap 2007 (1/2)*, *Brent Berlin 886 (2/2)*, *Brent Berlin 886 (1/2)*.

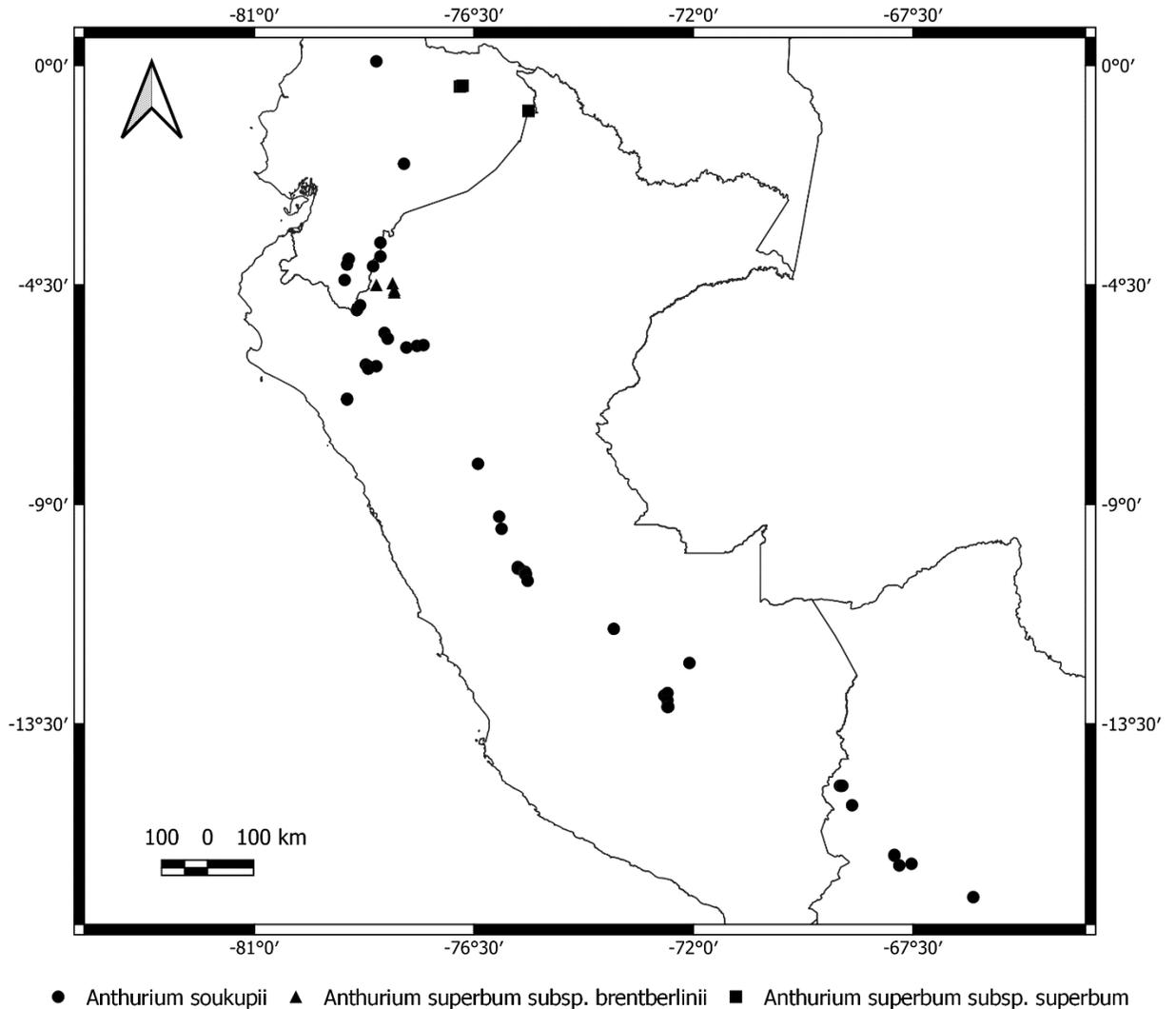


Figure 16. Distribution map of *Anthurium soukupii*, *A. superbum* subsp. *brentberlinii*, and *A. superbum* subsp. *superbum*.

22. *Anthurium weberbaueri* Engl., sect. *Digitinervium*. TYPE: Peru. Puno department, Sandia province: 2100 – 2300 m, Mar. 1902, *August Weberbauer* 543 (lectotype, G).

Climbing epiphyte; stem long, 0.9 – 1.4 cm in diameter on average; cataphylls coriaceous, triangular, 9 cm long on average, apex acute, light brown when dry, persistent. *Leaves* glabrous, petioles 35.5 – 54.5 cm long, 4.8 – 7 mm in diameter, cross section quadrangular to “D”-shaped, light brownish; geniculum dark brown, 1.2 – 2.4 cm long, 5.1 – 8.1 mm in diameter; blade coriaceous, triangular, apex emarginate, base obtuse, 19.5 – 46.5 cm long, 12 – 30 cm in width, broadest part at the inferior third at the lobes, margins entire; lobes small, 1 – 2 (3.2) cm long,

sinus between lobes arched; adaxial surface greenish brown when dry, black punctuations present; abaxial surface concolorous when dry, black punctuations present; midrib concolorous and flat; basal veins 3 (4) pairs, radiating; primary lateral veins 21 – 30 per side, straight ascending, concolorous; 1 – 3 interprimary veins, concolorous; secondary veins visible, concolorous, reticulate; tertiary veins visible, concolorous, reticulate; collective vein beginning at the 3rd pair of basal veins, distance from margin largely variable. *Inflorescence* erect, peduncle 45.5 – 74 cm long, 3.2 – 9 mm in diameter, 1.3 – 2.6 times the length of the petiole, reddish brown, cross section terete; spathe free at 90° from spadix, coriaceous, reddish green, lanceolate, 8.2 – 8.5 cm long, 1.6 – 3.9 mm in width, broadest part at the inferior third, apex acute, base acute; spadix red, cylindric, straight, (3.1) 9 – 14.5 cm long, (5.8) 8 – 11 mm in diameter; stipe reddish brown, 5.5 mm long on average, 3.1 – 3.2 mm in width on average; flowers rhombic or quadrangular, 2.8 – 3.6 mm long, 2.6 – 3.5 mm in width; primary spiral left-handed (right-handed), 4 – 6 visible flowers in primary spiral, 4 – 9 visible flowers in secondary spiral; tepals surface matte, lateral tepals interior margins straight (convex); pistil quadrangular; stigma linear, 0.2 mm long on average, 0.1 mm in width; stamens not seen; filaments flat; anthers 0.5 mm long on average, 0.9 mm in width on average. *Infructescence* erect or spreading; berries ellipsoid to cylindrical, greenish white and rose at the tip.

Distribution: *Anthurium weberbaueri* can be found across the Amazonian rainforests in the eastern flank of the Andes from the Zamora province in Ecuador to the La Paz department in Bolivia ranging from 1000 to ca. 3000 m in elevation (Figure 18).

This species is recognized by its leaves with an emarginate apex and black punctuations on the blade. It might be confused with *A. lechlerianum*, but the latter has longer lobes, 7.5 – 13.5 cm long, a parabolic to spatulate sinus and a more greenish leaf color when dry.

Specimens examined: *Jorge Lingán 663 (2/2)*, *Jorge Lingán 663 (1/2)*, *David Nelson Smith 2685*, *Roy Zehnder Torres 51*, *Abel Monteagudo Mendoza 15380*.



Figure 17. Representative specimens of (A) *Anthurium regale* (picture taken from Tropicos.org), (B) *A. superbum* (picture taken by Daniel Tarazona at MBG Climatron), and (C) *A. soukupii* (picture taken from Tropicos.org).

23. *Anthurium willifordii* Croat, sect. "Clade 12". TYPE: Peru. Loreto department: Napo River, Explorama Camp, on Sucusari River, below 200 m (originally collected by Jack Williford), *Thomas B. Croat* 61087 (holotype, MO-3244489; isotypes, B, K, NY, USM).

Epiphyte; stem short, 1 – 2 cm in diameter; roots numerous, dense, pale to medium green; cataphylls subcoriaceous, triangular, 1.5 – 5 cm long, apex acute, brown when dry, persistent. *Leaves* glabrous, petioles 5 cm long on average, 10 mm in diameter, cross section hexagonal, green; geniculum reddish green, 1 cm long on average, 10 mm in diameter on average; blade coriaceous and quilted, elliptic, apex acute, base cordate, 24 cm long on average, 10 cm in width on average, broadest part at the half, margins entire; adaxial surface dark green, brown when dry; abaxial surface reddish green, brown when dry when dry, quilted; midrib green and acutely risen in an upside down "V" shape; primary lateral veins 14 per side on average, curved ascending, lighter than the blade; 3 – 7 interprimary veins, concolorous; secondary veins visible, reticulate, concolorous; tertiary veins not visible; collective vein beginning at the middle of the blade, distance from margin 0.6 cm. *Inflorescence* spreading, peduncle 2.5 cm long on average, 1.4 mm in diameter on average, 0.5 times the length of the petiole, brown, terete; spathe free at 10° from spadix, coriaceous, purplish, lanceolate, 2.1 cm long on average, 7.7 mm in width on average, broadest part at the inferior third, apex acuminate, base acute; spadix reddish, tapered, straight, 2.4 cm long on average, 2.3 mm in diameter; stipe absent; flowers rhombic, 0.8 mm long on average, 0.6 mm in width on average; primary spiral left-handed, 6 visible flowers in primary spiral on average, 5 visible flowers in secondary spiral on average; tepals surface matte, lateral tepals interior margins convex; pistil flattened-oval, 0.6 mm long on average; stigma linear, 0.3 mm long on average, 0.1 mm in width on average; stamens 0.6 mm long on average; filaments flat; anthers 0.4 mm long on average, 0.4 mm in width on average; pollen yellow. *Infructescence* with scattered berries; berries obovoid, magenta.

Distribution: *Anthurium willifordii* was collected only in the vicinity of the Explorama Camp in the Loreto department in Peru at ca. 200 m (Figure 18).

This species can be recognized by its quilted velvety leaves and its short petioles with a hexagonal cross-section. Additionally, the leaves have small ear-like lobes at the base.

Specimen studied: *Mónica Carlsen* 3873.

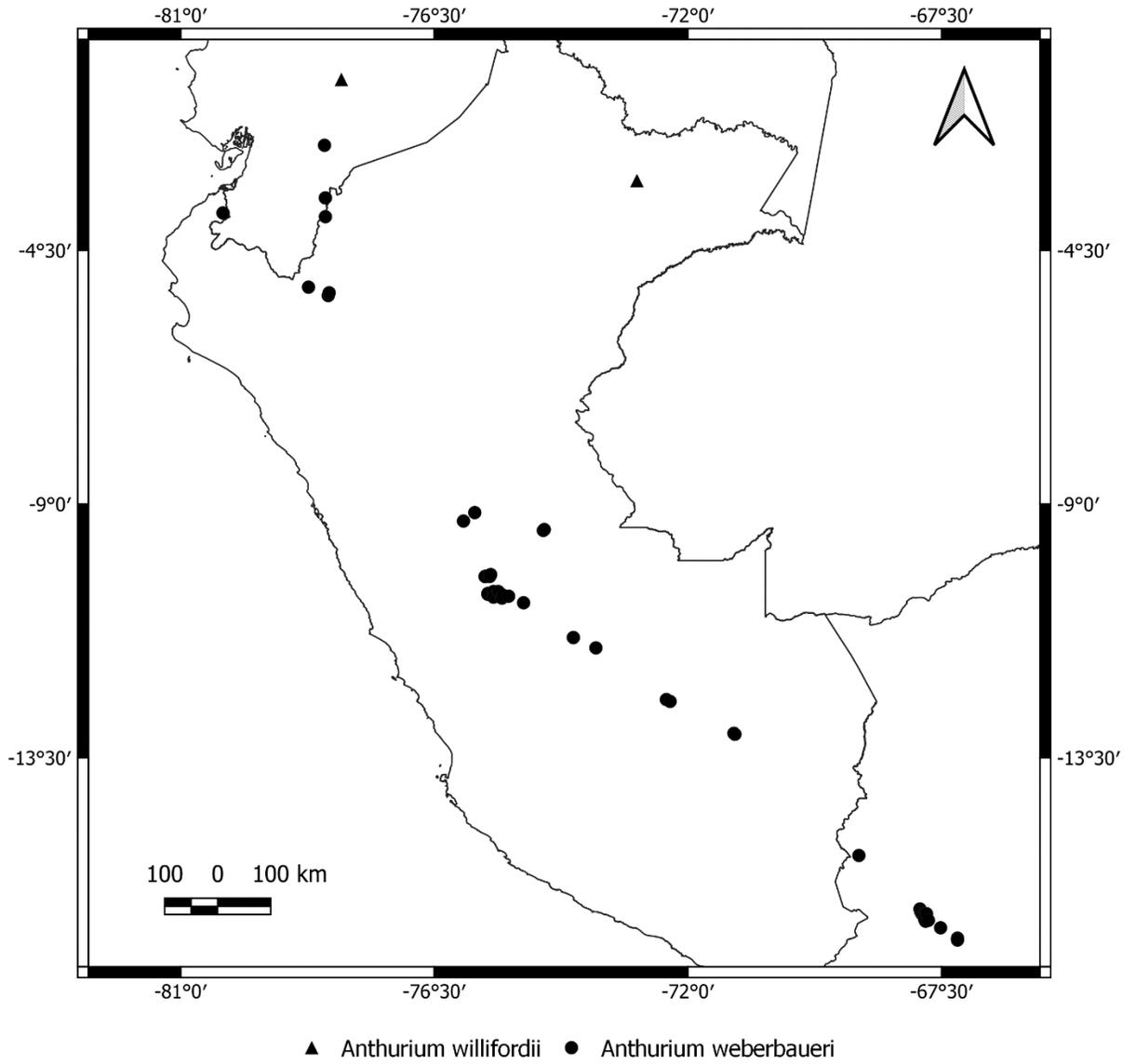


Figure 18. Distribution map of *Anthurium willifordii* and *A. weberbaueri*.

CONCLUSIONS

After reviewing the species that occur endemically or almost exclusively in the EAG region, 24 updated and detailed descriptions for 23 species and one subspecies were provided. These descriptions include a combination of characters taken from previous descriptions as well as new observations taken from the herbarium specimens studied here. As a result, it was possible to identify the most relevant characters for identifying *Anthurium* species in this study. These important characters include the blade shape, the presence of punctuations, the trajectory of the primary lateral veins, the distance between the collective vein and margin of the leaf blade, the cross section of the petiole, the presence of basal ribs, the color of the spathe, the presence/absence of a hooded spathe, the color of the spadix, the direction of the primary spiral of flowers in the spadix, the number of flowers in the spadix primary spiral, and the stipe length.

Additionally, linear morphometrics proved to be a helpful technique to discriminate between groups of subspecies and to consolidate the taxonomy for two species. This is an easy to use, not expensive, and powerful tool to support taxonomic changes within a revision. The use of linear morphometrics is to be encouraged for plant taxonomy studies.

In the near future, as herbaria around the world restart their standard procedures for loans of specimens, it would be plausible to include the remaining 10 species from the EAG region that had to be discarded at the beginning of this study due to lack of sample availability. It should be noted that while current digital images from types and specimens of the genus *Anthurium* are available online from several herbaria and are of the highest quality, they provide little to no information regarding flower morphology as it is necessary to dissect single flowers to record certain measurements and traits. Therefore, the use of physical herbarium specimens is imperative to continue the taxonomic revision of *Anthurium* species in the EAG region.

This study constitutes the first step towards a revision of the genus *Anthurium* for Peru and Bolivia, and as such, it is of extreme importance given the lack of complete taxonomic treatments for *Anthurium* in these countries, which currently have only outdated checklists of species names. In order to continue this work, it would be necessary to also study the species that only occur in the Pacific tropical rainforests in the Northern coast of Peru, the 10 species in the EAG region that were not studied here due to lack of specimens, and those species of wide distribution not considered in this study (which mostly occur in the Amazonian lowlands). With enough resources and time, this work can be done if physical samples are available.

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APPENDIX 1. List of morphological characters used in this study.

Characters are indicated in the first column, reproductive and qualitative nature are indicated in the second and third column, respectively.

Habit	Non-reproductive	Qualitative
Roots kind	Non-reproductive	Qualitative
Roots quantity	Non-reproductive	Quantitative
Roots color	Non-reproductive	Qualitative
Roots texture	Non-reproductive	Qualitative
Stem length	Non-reproductive	Quantitative
Stem cross section	Non-reproductive	Qualitative
Stem color	Non-reproductive	Qualitative
Stem texture	Non-reproductive	Qualitative
Internodes diameter	Non-reproductive	Quantitative
Internodes length	Non-reproductive	Quantitative
Scars shape	Non-reproductive	Qualitative
Scars dimension	Non-reproductive	Quantitative
Cataphylls length	Non-reproductive	Quantitative
Cataphylls ribbing	Non-reproductive	Qualitative
Cataphylls apex	Non-reproductive	Qualitative
Cataphylls color when live	Non-reproductive	Qualitative
Cataphylls color when dry	Non-reproductive	Qualitative
Cataphylls persistence	Non-reproductive	Qualitative
Cataphylls decomposition	Non-reproductive	Qualitative
Cataphylls consistency	Non-reproductive	Qualitative
Leaves availability	Non-reproductive	Qualitative
Leaves phyllotaxy	Non-reproductive	Qualitative
Leaves position	Non-reproductive	Qualitative
Petiole length	Non-reproductive	Quantitative
Petiole diameter base	Non-reproductive	Quantitative
Petiole diameter mid	Non-reproductive	Quantitative
Petiole diameter apex	Non-reproductive	Quantitative
Petiole cross section	Non-reproductive	Qualitative
Petiole color	Non-reproductive	Qualitative
Petiole notes	Non-reproductive	Qualitative
Geniculum length	Non-reproductive	Quantitative
Geniculum diameter	Non-reproductive	Quantitative
Geniculum cross section	Non-reproductive	Qualitative
Geniculum color when dry	Non-reproductive	Qualitative
Blade texture	Non-reproductive	Qualitative
Blade length	Non-reproductive	Quantitative
Blade width	Non-reproductive	Quantitative
Blade width position	Non-reproductive	Qualitative
Blade shape	Non-reproductive	Qualitative
Blade margin	Non-reproductive	Qualitative
Blade apex	Non-reproductive	Qualitative
Blade base	Non-reproductive	Qualitative

Lobe (mid) shape	Non-reproductive	Qualitative
Lobe (mid) length	Non-reproductive	Quantitative
Lobe (mid) constriction length	Non-reproductive	Quantitative
Lobe (mid) width	Non-reproductive	Quantitative
Lobes (lateral) shape	Non-reproductive	Qualitative
Lobes (lateral) length	Non-reproductive	Quantitative
Lobes (lateral) sinus	Non-reproductive	Qualitative
Adaxial surface additional	Non-reproductive	Qualitative
Adaxial surface color	Non-reproductive	Qualitative
Abaxial surface additional	Non-reproductive	Qualitative
Abaxial surface color	Non-reproductive	Qualitative
Midrib shape	Non-reproductive	Qualitative
Midrib color	Non-reproductive	Qualitative
Midrib position	Non-reproductive	Qualitative
Basal ribs length	Non-reproductive	Quantitative
Basal ribs nature	Non-reproductive	Qualitative
Basal veins coalescence	Non-reproductive	Qualitative
Basal veins number	Non-reproductive	Quantitative
Veins (primary) number	Non-reproductive	Quantitative
Veins (primary) color	Non-reproductive	Qualitative
Veins (primary) trajectory	Non-reproductive	Qualitative
Veins (primary) number of pairs	Non-reproductive	Quantitative
Veins (primary) distancing	Non-reproductive	Quantitative
Veins (interprimary) number	Non-reproductive	Quantitative
Veins (secondary) number	Non-reproductive	Quantitative
Veins (secondary) color	Non-reproductive	Qualitative
Veins (secondary) trajectory	Non-reproductive	Qualitative
Veins (tertiary) position	Non-reproductive	Qualitative
Veins (tertiary) color	Non-reproductive	Qualitative
Veins (tertiary) trajectory	Non-reproductive	Qualitative
Veins (lesser reticulate) areoles	Non-reproductive	Qualitative
Veins (collective) source	Non-reproductive	Qualitative
Veins (collective) distance to margin	Non-reproductive	Quantitative
Leaves additional	Non-reproductive	Qualitative
Inflorescence disposition	Reproductive	Qualitative
Peduncle length	Reproductive	Quantitative
Peduncle diameter	Reproductive	Quantitative
Peduncle cross section	Reproductive	Qualitative
Peduncle color	Reproductive	Qualitative
Peduncle length: petiole length ratio	Reproductive	Quantitative
Peduncle position	Reproductive	Qualitative
Spathe texture	Reproductive	Qualitative
Spathe color	Reproductive	Qualitative

Spathe longevity	Reproductive	Qualitative
Spathe angle	Reproductive	Quantitative
Spathe length	Reproductive	Quantitative
Spathe width	Reproductive	Quantitative
Spathe shape	Reproductive	Qualitative
Spathe apex	Reproductive	Qualitative
Spathe base	Reproductive	Qualitative
Spathe margin angle	Reproductive	Quantitative
Spadix shape	Reproductive	Qualitative
Spadix length	Reproductive	Quantitative
Spadix diameter	Reproductive	Quantitative
Spadix inclination	Reproductive	Quantitative
Spadix color when live	Reproductive	Qualitative
Spadix color when dry	Reproductive	Qualitative
Stipe color	Reproductive	Qualitative
Stipe length	Reproductive	Quantitative
Stipe diameter	Reproductive	Quantitative
Flower functionality	Reproductive	Qualitative
Flower anther development	Reproductive	Qualitative
Flower contour	Reproductive	Qualitative
Flower vertical diameter	Reproductive	Quantitative
Flower horizontal diameter	Reproductive	Quantitative
Spiral (primary) direction	Reproductive	Qualitative
Spiral (secondary) direction	Reproductive	Qualitative
Spiral (primary) number of flowers	Reproductive	Quantitative
Spiral (secondary) number of flowers	Reproductive	Quantitative
Tepals color	Reproductive	Qualitative
Tepals color changes	Reproductive	Qualitative
Tepals surface	Reproductive	Qualitative
Tepals interior margins	Reproductive	Qualitative
Pistil length	Reproductive	Quantitative
Pistil shape	Reproductive	Qualitative
Stigma shape	Reproductive	Qualitative
Stigma length	Reproductive	Quantitative
Stigma diameter	Reproductive	Quantitative
Stamens length	Reproductive	Quantitative
Stamens emergence	Reproductive	Qualitative
Filament type	Reproductive	Qualitative
Anther length	Reproductive	Quantitative
Anther width	Reproductive	Quantitative
Anther disposition	Reproductive	Qualitative
Anther spacing	Reproductive	Qualitative
Anther distancing	Reproductive	Qualitative

Pollen color	Reproductive	Qualitative
Infructescence position	Reproductive	Qualitative
Fruit shape	Reproductive	Qualitative
Fruit length	Reproductive	Quantitative
Fruit width	Reproductive	Quantitative
Fruit color	Reproductive	Qualitative

APPENDIX 2. List of variables used in the morphometric analysis of *Anthurium superbum* subsp. *superbum* versus *Anthurium superbum* subsp. *brentberlinii*.

Abbreviations are followed by the description of the variable and the units used are in parentheses.

- LL: Blade length (cm)
- LA: Blade width (cm)
- HW: Blade length: blade width ratio. $HW = LL/LA$
- DAM: Distance from apex to maximum width (cm)
- PAM: Position of maximum width
- AB: Angle at the blade of the blade ($^{\circ}$)
- LP: Petiole length (cm)
- DVC1: Distance from margin to farthest collective vein (cm)
- DVC2: Distance from margin to closest collective vein (cm)
- RVC1VC2: Distance from margin to farthest collective vein: distance from margin to closest collective vein ratio. $RVC1VC2 = DVC1/DVC2$
- D3: Distance from apex to first third of the blade from the apex (cm)

APPENDIX 3. List of variables used in the morphometric analysis of *Anthurium coripatense* versus *Anthurium yungasense*.

Abbreviations are followed by the description of the variable and the units used are in parentheses.

- LL: Blade length (cm)
- LA: Blade width (cm)
- HW: Blade length: blade width ratio. $HW = LL/LA$
- Llob: Perpendicular distance from most bottom point of a lob to petiole insertion on the blade (cm)
- AConsMax: Length of the shortest distance between the lateral sides of lobes that make the sinus (cm)
- Asin: Length of the longest distance between the lateral sides of the lobes that make the sinus (cm)
- PosAMax: Position of maximum width
- LP: Petiole length (cm)
- DVCol: Distance from margin to collective vein (cm)
- Ob: Oblongivity (see Figure 1)
- AMRV1: Angle between midrib and most bottom primary vein (°)
- LV1: Length of most bottom primary vein (cm)
- C: Vein curvature (see Figure 1)