ISSN 1409-3871

LANKESTERIANA

VOL. 17, No. 1

APRIL, 2017

UNIVERSIDAD DE COSTA RICA

LUCEM ASPICIO

INTERNATIONAL JOURNAL ON ORCHIDOLOGY

LANKESTERIANA

INTERNATIONAL JOURNAL ON ORCHIDOLOGY

Editor-in-Chief (Director)

Franco Pupulin
Universidad de Costa Rica, Costa Rica
franco.pupulin@ucr.ac.cr

Managing Editors

Adam P. Karremans
Universidad de Costa Rica, Costa Rica
adam.karremans@ucr.ac.cr

Melissa Díaz-Morales
Universidad de Costa Rica, Costa Rica
melissa.diaz_m@ucr.ac.cr

Editorial Assistant

Noelia Belfort Oconitrillo
Universidad de Costa Rica, Costa Rica
noelia.belfort@ucr.ac.cr

Consejo Editorial / Editorial Committee

Mario A. Blanco
Universidad de Costa Rica, Costa Rica
Víctor Jiménez García
Universidad de Costa Rica, Costa Rica
Gabriela Jones Román
Universidad Estatal a Distancia, Costa Rica

Adam P. Karremans
Universidad de Costa Rica, Costa Rica
Franco Pupulin
Universidad de Costa Rica, Costa Rica
Jorge Warner
Universidad de Costa Rica, Costa Rica

Comité Científico / Scientific Committee

James D. Ackerman
University of Puerto Rico, U.S.A.
Germán Carnevali
Centro de Investigación Cientifica de Yucatán, Mexico
Phillip Cribb
Royal Botanic Gardens, Kew, U.K.
Carlos F. Fighetti
The American Orchid Society, U.S.A.
Günter Gerlach
Botanischer Garten München-Nymphenburg, German
Heiko Hentrich
University of Basel, Switzerland
Julián Monge-Nájera
Universidad de Costa Rica, Costa Rica
David L. Roberts
University of Kent, U.K.
André Schuiteman
Royal Botanic Gardens, Kew, U.K.
Jorge Warner
Universidad de Costa Rica, Costa Rica

Franco Bruno
Universitá La Sapienza, Roma, Italia
Mark W. Chase
Royal Botanic Gardens, Kew. U.K.
Robert L. Dressler
Universidad de Costa Rica, Costa Rica
Lauren Gardiner
Royal Botanic Gardens, Kew, U.K.
Eric Hágsater
Herbario AMO, Mexico
Wesley E. Higgins
Florida Museum of Natural History, U.S.A.
Alec M. Pridgeon
Royal Botanic Gardens, Kew, U.K.
Gustavo A. Romero
Harvard University Herbaria, U.S.A.
Philip Seaton
IUCN/SSC Orchid Specialist Group, U.K.
W. Mark Whitten
Florida Museum of Natural History, U.S.A.

Norris H. Williams
Florida Museum of Natural History, U.S.A

ISSN 1409-3871

LANKESTERIANA

VOL. 17, No. 1 APRIL 2017

UNIVERSIDAD DE COSTA RICA
LUCEM ASPICIO

INTERNATIONAL JOURNAL ON ORCHIDOLOGY

LANKESTERIANA
INTERNATIONAL JOURNAL ON ORCHIDOLOGY

Effective publication dates ISSN 2215-2067 (electronic): February 8 - April 25, 2017 (specific dates recorded on the title page of each individual paper)
Effective publication date ISSN 1409-3871 (printed): April 30, 2017

Layout: Jardín Botánico Lankester.
Cover: *Platystele baqueroi*. Ecuador, *L. Baquero 3103*. Photograph by L. Jost.
Printer: MasterLitho.
Printed copies: 500

Printed in Costa Rica / Impreso en Costa Rica

R Lankesteriana / International Journal on Orchidology
No. 1 (2001)-- . -- San José, Costa Rica: Editorial Universidad de Costa Rica, 2001--
v.
ISSN-1409-3871

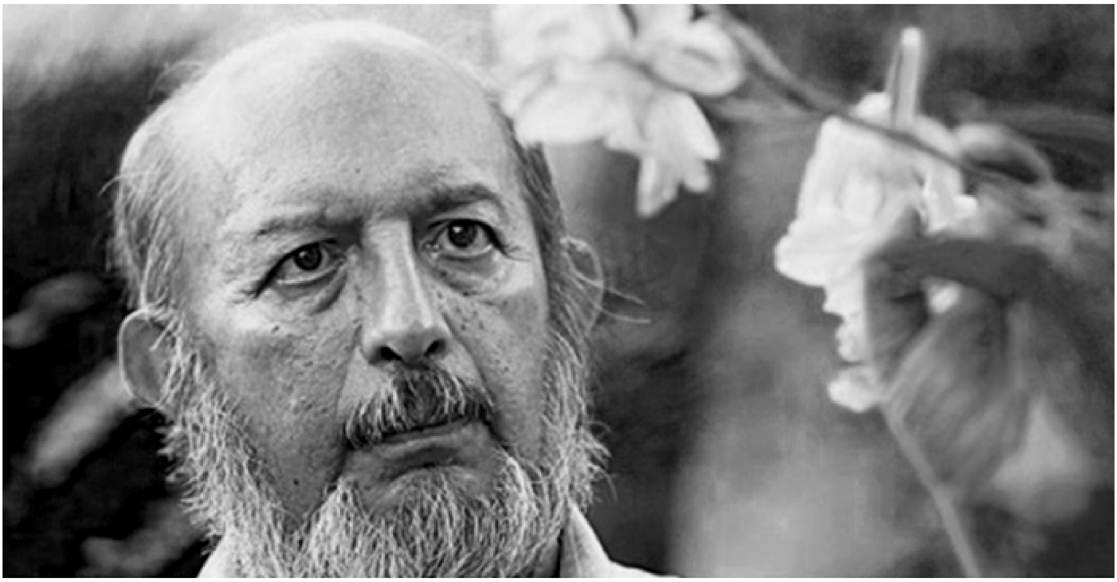
1. Botánica - Publicaciones periódicas, 2. Publicaciones periódicas costarricenses

LANKESTERIANA 17(1): i—iv. 2017.

TRIBUTE TO ROBERTO VÁSQUEZ CHÁVEZ, BOLIVIAN ORCHIDOLOGIST

Adolfo Moreno

World Wildlife Foundation, Bolivia • riopalo1962@yahoo.com



A little more than a year after his death, the Senate of the Plurinational State of Bolivia paid a tribute to Roberto Vásquez Chávez, the main scholar of the orchids of that country.

The recognition was given to Don Roberto's family in a beautiful ceremony held in the library of the French Alliance of Santa Cruz de la Sierra, Bolivia, where presentations were made about his work, both in orchids and bromeliads and Amaryllidaceae, concluding with the give of the recognition from the Senate by Senator Juan José Ric Riera.

Born in Cochabamba on December 7, 1941, with a bachelor degree and studies in business administration in that city and in the United States, respectively, Roberto Vásquez was essentially a self-taught in botany. His interest in the biological sciences began in Santa Cruz under the influence of the great Bolivian botanist Martín Cárdenas, and was complemented by the opportunity of frequent field trips to visit and take care of some pineapple plantations that his family had in the tropical region of Cochabamba, where the high precipitation, broad altitudinal variation, and the presence of cloud forests have led to the development of a very diverse epiphytic flora. This richness is now seriously threatened by the progress of deforestation, which makes even more relevant the appropriate studies of orchids, bromeliads, cacti and passifloras made by him.

His fundamental work in the study of Bolivian orchids was emphasized by all speakers, recognizing him as an active explorer, a great botanical illustrator, and a dedicated scholar who managed to establish contact with the main international specialists. Several of them nurtured him in scientific information, and at the same time they were nurtured with native material from Bolivia, both in the form of herbarium specimens and exquisite photographs, establishing an affectionate and at the same time professional relationship of exchange that resulted in the discovery of hundreds of species new to science.

With 225 genera recorded to date, the orchid flora

Received 1 October 2016; accepted for publication 30 January 2017. First published online: 8 February 2017.

of Bolivia is one of the least explored and known in the continent. Although there are estimated to be at least two thousand native species in the country, currently only 1,271 species are recorded, of which 35% (440 species) are endemic. Many of them have been identified in the last 40 years, and Roberto Vásquez' contribution has been fundamental to this aim, having contributed to the record of 185 species. It is safe to say that almost 15% of the orchid species of Bolivia have been known thanks to his work. Of these, 25 species have been dedicated to him with the epithet *vasquezii*, and a new genus, *Vasqueziella*, was created in his honor, recognizing its discovery of *Vasqueziella boliviana*.

Roberto Vásquez was remembered with much affection by his friends, and precisely his cultivation of friendship was highlighted by everyone, including Dr. Carlyle Luer, who sent a message read at the event, which in its most outstanding part reads: "*Roberto Vásquez was one of our closest friends. He was the one who introduced us to Bolivia and made our many visits to his country successful, the first having happened in 1978. The Lepanthes and the Stelis of Bolivia could not have been produced without his support.*"

Dedicated to dairy farming in the last years of his life, Don Roberto was confined to his hacienda Colpa Mesa where he continued his research work, which did not cease despite the health problems he had to face until his death in August 2015.

As one of his friends and collaborators, I received from him a great support whenever I wanted to publish a journalistic or historical article on the explorations and the orchid and bromelias discoveries in which we were involved. As a grateful knowledger of his great generosity to transmit his knowledge, his unwavering will to organize the Bolivian Society of Botany, and his hospitality to receive us frequently at home, in my own name and of his beloved family I thank Lankesteriana the space dedicated to his memory.

HOMENAJE A ROBERTO VÁSQUEZ CHÁVEZ, ORQUIDEÓLOGO BOLIVIANO

Adolfo Moreno

World Wildlife Foundation, Bolivia • riopalo1962@yahoo.com

Transcurrido poco más de un año de su fallecimiento, el Senado del Estado Plurinacional de Bolivia rindió merecido homenaje a don Roberto Vásquez Chávez, principal estudioso de las orquídeas de ese país.

El reconocimiento fue entregado a la familia de don Roberto en un bonito acto realizado en la biblioteca de la Alianza Francesa de Santa Cruz de la Sierra, Bolivia, donde se hicieron presentaciones sobre su obra, tanto en orquídeas como en bromeliáceas y amarilidáceas, concluyendo con la entrega del reconocimiento del Senado a cargo del Senador Juan José Ric Riera.

Nacido en Cochabamba el 7 de diciembre de 1941, con estudios de bachillerato y en administración de empresas cursados en esa ciudad y en los Estados Unidos, respectivamente, don Roberto Vásquez fue esencialmente un autodidacta en la botánica. Su interés por las ciencias biológicas comenzó en la ciudad del valle bajo el influjo del gran botánico boliviano don Martín Cárdenas, y se complementó gracias a la oportunidad de salir frecuentemente al campo a visitar y hacerse cargo de unas plantaciones de piña que su familia tenía en el trópico cochabambino, donde las altas precipitaciones, la gran variante altitudinal y la presencia de bosques de neblina han propiciado el desarrollo de una flora epifítica muy diversa, misma que se encuentra actualmente muy amenazada por el avance de la deforestación, lo que hace todavía más relevantes los oportunos estudios de orquídeas, bromelias, cactus y pasifloras realizados por él.

Su obra en el estudio de las orquídeas fue fundamentalmente destacada por todos los oradores, reconociéndosele como un activo explorador, un gran ilustrador botánico, y un dedicado estudioso que logró establecer contacto con los principales especialistas internacionales, de quienes se nutrió en información científica y a quienes alimentó con material nativo de Bolivia, tanto de herbario como fotográfico, estableciendo una afectuosa y a la vez profesional relación de intercambio de la que resultaron centenas de especies nuevas para la ciencia.

Con 225 géneros registrados a la fecha, la flora orquideológica de Bolivia es una de las menos exploradas y conocidas del continente. Aunque se estima que debe haber al menos unas dos mil especies nativas del país, actualmente se tienen registradas solamente 1.271 especies, de las cuales un 35 % (440 especies) son endémicas. Gran parte de ellas han sido identificadas en los últimos 40 años y, para ello, la intervención de don Roberto Vásquez ha sido fundamental, habiendo contribuido al registro de 185 especies, es decir que casi el 15 % de las especies del país han sido conocidas gracias a su trabajo. De estas, 25 especies le han sido dedicadas nombrándolas con el epíteto *vasquezii*, y un género nuevo, *Vasqueziella*, fue creado en su honor, reconociendo su descubrimiento de *Vasqueziella boliviana*.

Don Roberto Vásquez fue recordado con mucho cariño por sus amigos, y precisamente su cultivo de la amistad fue destacado por todos, entre ellos el Dr. Carlyle Luer, que mandó un mensaje que fue leído en el evento y que en su parte más sobresaliente dice (traducción): *"Roberto Vásquez fue uno de nuestros amigos más cercanos. Él fue quien nos introdujo a Bolivia e hizo que nuestras muchas visitas a su país fuesen exitosas, la primera habiendo ocurrido en 1978. Los Lepanthes y los Stelis de Bolivia no podrían haber sido producidos sin su apoyo".*

Dedicado a la ganadería lechera en los últimos años de su vida, don Roberto se recluyó en su hacienda Colpa Mesa donde continuó con sus trabajos de investigación, que no cesaron a pesar de los problemas de salud que tuvo que enfrentar hasta su fallecimiento, ocurrido en agosto del año 2015.

Como amigo y colaborador suyo recibí de su parte un gran apoyo cada vez que quise publicar algún artículo periodístico o crónica de las exploraciones y descubrimientos de orquídeas o bromelias en las que estuvimos involucrados. Como agradecido conocedor de su gran generosidad para transmitir sus conocimientos, de su inquebrantable voluntad para organizar la Sociedad Boliviana de Botánica, y de su hospitalidad para recibirnos frecuentemente en su casa, en nombre propio y de su querida familia agradezco a Lankesteriana el espacio que dedica a su memoria.

ROBERTO VÁSQUEZ CHÁVEZ (1900-2016). BIBLIOGRAPHY ON THE ORCHIDACEAE

(arranged chronologically)

Vásquez, R. & Dodson, C. H. 1982. Orchids of Bolivia, part 1. *Icones Plantarum Tropicarum*, 6: pl. 501-600. Marie Selby Botanical Gardens, Sarasota, Florida, USA.

Vásquez, R. 1985. Bolivian orchids. Pp. 372-375 in: K. W.Tan (ed.). *Proceedings of the Eleventh World Orchid Conference*, International Press, Singapore.

Vásquez, R. 1994. El género *Coryanthes* en Bolivia. *Revista de la Sociedad de Estudios Botánicos*, 1(1): 33-39.

Vásquez, R. 1994. Un viaje de observación botánica a la región de Ivitiapi (Provincia Cordillera, Departamento Santo Cruz). *Revista de la Sociedad de Estudios Botánicos*, 1(1): 61-69.

Vásquez, R. & Dodson, C. H. 1997. Dos nuevas especies de *Catasetum* del Parque Nacional Noel Kempff M. (Santa Cruz, Bolivia). *Revista de la Sociedad de Estudios Botánicos*, 1(2): 1-8.

Vásquez, R. 1998. A new *Stellilabium* from Bolivia. *Lindleyana*, 13: 61-63.

Vásquez, R. & Dodson, C. H. 1998. Nuevas especies de orquídeas de Bolivia. *Revista de la Sociedad de Estudios Botánicos*, 2(1): 1-18.

Vásquez, R. & Ibisch, P. L. 1998. Ecología y estado de conservación de las especies bolivianas del genero *Phragmipedium* y el registro de *Phragmipedium boisserianum* (Rchb.f.) Rolfe come especie nueva para Bolivia. *Revista de la Sociedad de Estudios Botánicos*, 2(1): 60-69.

Vásquez, R. 1999. *Crossoglossa*: un registro nuevo para la fora de Bolivia, *C. dodsonii* una especie nueva del Departamento de Cochabamba. *Revista de la Sociedad de Estudios Botánicos,* 2(2): 153-156.

Vásquez, R. & Dodson, C. H. 1999. Nuevas especies de orquídeas de Bolivia (2). *Revista de la Sociedad de Estudios Botánicos*, 2(2): 143-152.

Gerlach, G. & **Vásquez, R.** 1999. Notas sobre *Sanderella discolor* (Orchidaceae) en Bolivia. *Revista de la Sociedad de Estudios Botánicos*, 2(2): 261-264.

Moreno, L.A. & **Vásquez, R.** 1999. El género *Laelia* (Orchidaceae) en Bolivia. *Revista de la Sociedad de Estudios Botánicos*, 2(2): 255-259.

Neudecker, T., **Vásquez, R.** & Heider, H. 1999. *Sievekingia trolii* (Orchidaceae) – la única *Sievekingia* de Bolivia redescubierta después de 70 años. *Revista de la Sociedad de Estudios Botánicos*, 2(2): 251-254.

Vásquez, R. & Ibisch, P. L. 2000. *Orchids of Bolivia, diversity and conservation status, Subtribu Pleurothallidinae*. Editorial F.A.N., Santa Cruz de la Sierra, Bolivia. 552 pp.

Vásquez, R. & Dodson, C. H. 2001. Nuevas especies de orquídeas de Bolivia (3). *Revista de la Sociedad de Estudios Botánicos*, 3(1/2): 10-36.

Vásquez, R. & Senghas, K. 2001. Michail Gorbatschow und die Orchideenkunde. *Journal für den Orchideenfreund*, 8: 319-322.

Vásquez, R. 2002. The subtribe Oncidiinae in the mountains of Bolivia. P. 420 in: J. Clark, W. M. Elliott, G. Tingley & J. Biro (eds.). *Proceedings of the 16th World Orchid Conference, Vancouver 1999*. Vancouver, Vancouver Orchid Society.

Vásquez, R. 2003. *Zygostates riefenstahliae* - a new species from an isolated dry inter-Andean valley in Bolivia. *Revista de la Sociedad de Estudios Botánicos*, 4(1): 41-44.

Vásquez, R. & Ibisch, P. L. 2003. Nuevas especies de orquídeas de Bolivia (4). *Revista de la Sociedad Boliviana de Botánica*, 4(1): 31-39.

Vásquez, R., Ibisch, P. L. & Gerkmann, B. 2003. Diversity of Bolivian Orchidaceae - a challenge for taxonomic, floristic and conservation research. *Organisms, Diversity & Evolution*, 3: 93-102.

Vásquez, R., Ibisch, P. L. & Gerkmann, B. 2003. Preliminary checklist of Bolivian Orchid species. *Organisms, Diversity & Evolution*, 3 (electronic supplement): 1-14.

Vásquez, R. & Ibisch, P. L. 2004. *Orchids of Bolivia, diversity and conservation status, Subtribu Laeliinae - Polystachyinae - Sobraliinae*. Editorial F.A.N., Santa Cruz de la Sierra, Bolivia. 649 pp.

Vásquez, R. 2005. Orchids of Bolivia: diversity, endemism, and conservation status. P. 43 in: A. Pridgeon (ed.). *Primera Conferencia Científica de Orqúideas de los Andes. Nov.11-13, 2005*. Gualaceo, Ecuador.

Vásquez, R. & Romero, G. A. 2009. Nueva especie del genero *Catasetum* Rich.ex Kunth de Bolivia. A new species of *Catasetum* Rich.ex Kunth from Bolivia. *Revista de la Sociedad de Estudios Botánicos*, 4(2): 217-224.

LANKESTERIANA 17(1): 1—15. 2017. doi: http://dx.doi.org/10.15517/lank.v17i1.27897

RELACIÓN FENOLOGÍA-CLIMA DE CUATRO ESPECIES DE ORQUÍDEAS EN UN BOSQUE ALTOANDINO DE COLOMBIA

Juan Camilo Ordóñez-Blanco[1,2] & Ángela Parrado-Rosselli[1]

[1] Maestría en Manejo Uso y Conservación del Bosque, Universidad Distrital Francisco José de Caldas,
Calle 72 no 88-44 Apto 103, Código Postal 111711, Bogotá, Bogotá D. C., Colombia
[2] Autor para correspondencia: phaleno@gmail.com

Abstract. The objective of this research was to characterize, during an annual cycle, the relationship between weather and the phenology of four common orchid species in a high-Andean forest of the Eastern Cordillera of Colombia. Flowering and fruiting of 30 adult individuals of *Cyrtochilum revolutum, Malaxis excavata, Ponthieva diptera* and *Stelis pulchella* were monitored on a monthly basis. The number of flowering buds, open flowers, unripe and ripe fruits (closed and open capsule, respectively) were correlated to climatic variables (*i.e.* mean monthly precipitation, mean, minimum and maximum monthly temperature and, relative humidity) obtained during the same time period. The results showed that all orchid species exhibited reproductive activity during the studied year. *C. revolutum* only flowered, and was positively correlated with rainfall. The flowering peak of *S. pulchella*, occurred during the coldest months when relative humidity was also low. In contrast, the peak of unripe fruits was recorded when both the relative humidity and mean temperature were the highest, while capsules opened during the driest months. Flowering and fruiting of *M. excavata* were extended, lasting more than four months. The greatest number of open flowers was positively correlated to precipitation, while the number of unripe fruits was correlated with relative humidity and rainfall of two-months prior. Few individuals of *P. diptera* flowered and fruited during the studied year, while reproductive activity was correlated to rainfall and temperature. Although the relationship between climatic variables and phenology is differential between species, our findings consistently showed that three out of four of the studied species (*C. revolutum, M. excavata y P. diptera*) flowered during the rainy season with significant positive correlations, which is discussed in light of literature findings.

Resumen. El objetivo de esta investigación fue caracterizar, durante un ciclo anual, la relación fenología-clima de cuatro especies comunes de orquídeas en un bosque altoandino de la Cordillera Oriental colombiana. Se monitoreó mensualmente la floración y la fructificación de 30 individuos adultos de *Cyrtochilum revolutum, Malaxis excavata, Ponthieva diptera* y *Stelis pulchella*. El número de flores en botón, flores abiertas, frutos inmaduros (cápsula cerrada) y el número de frutos maduros (cápsula abierta) se correlacionaron con las variables climáticas precipitación media mensual, temperatura media, mínima y máxima mensuales y humedad relativa mensual del mismo período de estudio. Los resultados mostraron que las cuatro especies de orquídeas presentaron actividad reproductiva durante el año de seguimiento. *C. revolutum* sólo floreció y se correlacionó de forma positiva con la precipitación. El pico de floración de *S. pulchella*, ocurrió en los meses más fríos y con menor humedad relativa. En contraste, la producción de frutos verdes se presentó en los momentos de mayor humedad y mayor temperatura, mientras que la apertura de las cápsulas ocurrió en los meses más secos. *M. excavata* presentó un patrón de floración y de fructificación extendido y el mayor número de flores abiertas se correlacionó de forma positiva con la precipitación. La producción de frutos verdes se correlacionó con la humedad relativa y la precipitación de dos meses atrás. Aunque *P. diptera* mostró pocos individuos en flor y en fruto, la actividad reproductiva se correlacionó con la precipitación y con la temperatura. A pesar de que la relación entre las variables climáticas y la fenología es diferente entre las especies, para tres de las cuatro especies estudiadas (*C. revolutum, M. excavata* y *P. diptera*) fue consistente la ocurrencia de la mayor floración durante la época de lluvias con correlaciones positivas significativas, aspecto que se discute a la luz de estudios previos.

Key words: Andean forest, climatic variables, flowering, fruiting, Orchidaceae

Received 1 October 2016; accepted for publication 30 January 2017. First published online: 8 February 2017.

Introducción. Las orquídeas son un grupo de plantas de gran importancia en términos ecológicos y económicos. Estas son atractivas en términos del ecoturismo, el biocomercio y la bioprospección (Cozzolino & Widmer 2005, Giraldo & Betancur 2011, Ballantyne & Pickering 2012, Parra 2013); así como también han sido consideradas como indicadores del estado de salud de los ecosistemas (Gentry & Dodson 1987, Pineda 2004). Esto ha generado que hayan sido estudiadas desde diversos campos que involucran inventarios, ecología e incluso tecnologías en métodos de propagación y cultivo *ex situ* (Schweinfurth 1958, Dunsterville & Garay 1979, Ackerman 1992, Escobar 1994, Romero & Carnevali 2000, Dodson 2003, Hágsater & Soto 2008, Otero & Bayman 2009, Giraldo & Betancur 2011).

El cultivo de las orquídeas bajo condiciones *ex situ* se ha intensificado en los últimos años y constituye un renglón promisorio en el sector de la floricultura y la restauración ecológica (Ballantyne & Pickering 2012). Sin embargo, se han identificado limitantes considerables en la adaptación y reproducción, puesto que sólo algunas especies o individuos logran reproducirse bajo condiciones controladas (Singer 2009, Quiroga *et al.* 2010). En el caso de las orquídeas altoandinas, observaciones personales muestran que muchas especies presentan pobre desarrollo, mortalidad y baja reproducción en condiciones *ex situ*, lo que se debe, en gran medida, a que se desconocen las condiciones climáticas que se deben procurar con el fin de lograr su aclimatación y manejo. Por lo tanto, el conocimiento del efecto de las variables ambientales sobre los eventos de floración y fructificación de las especies podría ayudar a entender las condiciones que deben ser manejadas a la hora de aplicar estrategias de manejo reproductivo *ex situ.*

La fenología de floración y fructificación de las especies de plantas tropicales ha mostrado una gran relación con factores tanto bióticos como abióticos (van Schaik *et al.* 1993). Para el caso de las orquídeas, los patrones de floración han sido atribuidos principalmente a la precipitación, en donde el aumento de las lluvias se relaciona con el inicio de la floración (Ibarra *et al.* 1991, Reich 1995, Lemus-Jiménez & Ramírez 2002). Respecto a la fructificación, esta se ha asociado comúnmente a las temporadas secas dado el carácter anemocórico de la mayoría de las especies (Diez 2002, Roldán & Larrea 2003, Vieira-Faria *et al.* 2007).

Así, el objetivo de esta investigación fue caracterizar, durante un ciclo anual, la relación fenología-clima de cuatro especies comunes de orquídeas en un relicto de bosque altoandino de la Cordillera Oriental colombiana. Para tal fin, se caracterizó durante un año la fenología reproductiva (floración y fructificación) de cuatro especies de orquídeas (*Cyrtochilum revolutum*, *Stelis pulchella, Malaxis excavata* y *Ponthieva diptera)* y se correlacionó con las variables climáticas: temperatura media, mínima y máxima, humedad relativa y precipitación media durante el período de estudio. A pesar de que en la actualidad, los estudios fenológicos multianuales proveen información más robusta sobre las dinámicas reproductivas de las especies (Hudson & Keatley 2009), dado el escaso conocimiento sobre la fenología de las orquídeas colombianas, consideramos que este estudio de un año, constituye un importante aporte para el mejor entendimiento de la ecología de las orquídeas tropicales.

Materiales y métodos. Esta investigación se desarrolló en un relicto de bosque altoandino de la Cordillera Oriental, ubicado en el municipio de La Calera, Cundinamarca, Colombia (4°43'6.8''N 73°58'9.26''W). El área de estudio se encuentra en un rango altitudinal entre los 2815-3050 m. La zona presenta una temperatura media anual entre los 14 y 16°C y un régimen bimodal de lluvias, con una precipitación media anual de 970 mm, siendo mayo y noviembre las épocas más húmedas (Caballero *et al.* 1997, Montenegro & Vargas 2005, Guerrero *et al.* 2008). Por estar situada en la zona ecuatorial las horas luz son relativamente constantes a lo largo del año y no difieren más de 30 minutos (Borchert *et al.* 2015).

La vegetación predominante corresponde a relictos de bosque secundario, donde las familias de árboles más abundantes son Melastomataceae y Winteraceae (Vargas 1986, Caballero *et al.* 1997, Montenegro & Vargas 2005). Además, los géneros más comunes son: *Clethra* (Clethraceae), *Clusia* (Clusiaceae), *Drimys* (Winteraceae), *Hesperomeles* (Rosaceae) y *Weinmannia* (Cunoniaceae; Vargas 1986, Caballero *et al.* 1997, Montenegro & Vargas 2005).

Las orquídeas estudiadas corresponden a cuatro especies altoandinas silvestres de amplia distribución y con abundante número de individuos en la zona de estudio. Estas son *Cyrtochilum revolutum* (Lindl.)

Dalström, *Stelis pulchella* Kunth., *Malaxis excavata* (Lindl.) Kuntze y *Ponthieva diptera* Linden & Rchb.f. y (Fig. 1). Estas especies son de variados hábitos y tipos de crecimiento, es así que *C. revolutum* se desarrolla como semiterrestre (Baker & Baker, 2006); *S. pulchella* crece tanto como semiterrestre o litófita, mientras que *M. excavata* y *P. diptera* son terrestres pequeñas e inconspicuas (Tabla 1). Según la literatura de orquídeas emparentadas con las especies de estudio *C. revolutum es* polinizada por abejas y avispas (Torreta *et al.* 2011) y *S. pulchella, M. excavata* y *P. diptera* son polinizadas principalmente por moscas (entomofilia; Borba & Semir 2001, Kite *et al.* 2008, Duque-Buitrago *et al.* 2014).

Toma de datos —. Se monitoreó la floración y fructificación de las cuatro especies de forma mensual durante un ciclo anual entre agosto de 2013 y agosto de 2014. Los registros se tomaron para 30 individuos por especie en estado adulto. Con el fin de minimizar el efecto del microclima en la fenología de las especies la ubicación de los ejemplares se realizó al azar desde el suelo hasta la altura de 2 m sobre los forófitos (Parra 2013). A pesar de lo anterior, no se encontraron individuos por encima de los 50 cm del suelo, por lo que la variabilidad en términos de la distribución horizontal fue mínima. Adicionalmente, para los casos de especies terrestres y semiterrestres se muestrearon individuos agregados teniendo en cuenta que fueran distintos entre sí.

La floración de cada individuo se registró en términos del número de flores en botón, número de flores abiertas (Talora & Morellato 2000, Roldán & Larrea 2003, Tremblay *et al.* 2006, Ely-Bali *et al.* 2010, Torretta *et al*. 2011, Sánchez-Landaverde 2014). La fructificación se registró en términos del número de frutos inmaduros (cápsula cerrada) y del número de frutos maduros (cápsula abierta) con base en Talora & Morellato (2000) y Roldán & Larrea (2003).

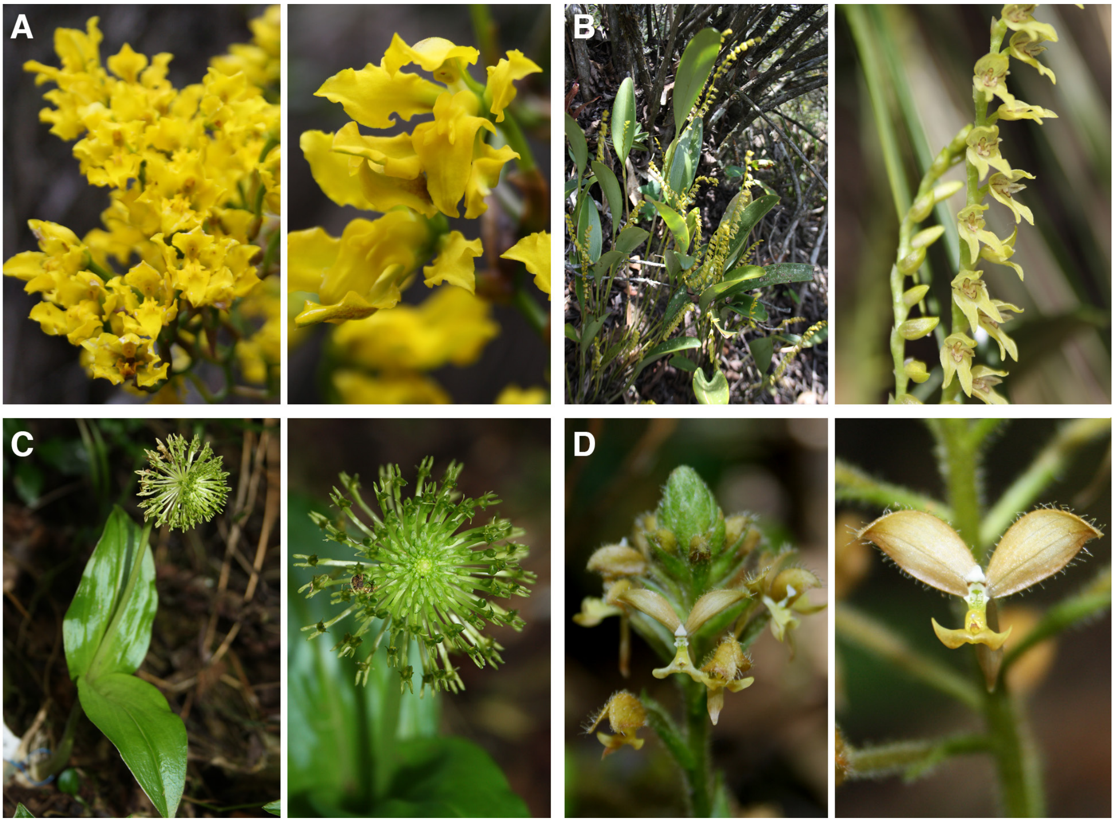


Figura 1. Especies estudiadas en un bosque altoandino de la Cordillera Oriental de Colombia. A. *Cyrtochilum revolutum* (Lindl.) Dalström, B. *Stelis pulchella* Kunth, C. *Malaxis excavata* (Lindl.) Kuntze y D. *Ponthieva diptera* Linden & Rchb.f.

Tabla 1. Características generales de las especies de estudio.

Especie	**Subfamilia**	**Tribu**	**Subtribu**	**Hábito**
Cyrtochilum revolutum (Lindl.) Dalström	Epidendroideae	Cymbidieae	Oncidiinae	Semiterrestre
Stelis pulchella Kunth	Epidendroideae	Epidendreae	Pleurothallidinae	Semiterrestre-Litófita
Malaxis excavata (Lindl.) Kuntze	Epidendroideae	Malaxideae	Malaxidinae	Terrestre
Ponthieva diptera Linden & Rchb.f.	Orchidoideae	Cranichideae	Cranichidinae	Terrestre

Especie	**Tipo de crecimiento**	**Estructuras vegetativas**	**Sindrome de polinización**	**Taxa**	**Referencia**
Cyrtochilum revolutum (Lindl.) Dalström	Simpodial	Pseudobulbos	Entomofilia	Hymenoptera	Torreta *et al.* 2011
Stelis pulchella Kunth	Simpodial	Ramicaules y hojas coriáceas	Entomofilia	Díptera	Duque-Buitrago *et al.* 2014
Malaxis excavata (Lindl.) Kuntze	Simpodial	Cormos	Entomofilia	Díptera	Kite *et al.* 2008
Ponthieva diptera Linden & Rchb.f.	Monopodial	Hojas arrosetadas y con tricomas	Entomofilia	Díptera	Borba & Semir 2001, Kite *et al.* 2008, Duque-Buitrago *et al.* 2014

Todos los individuos se marcaron y enumeraron utilizando etiquetas plásticas según su aparición en el campo. Se recolectaron ejemplares testigo, los cuales fueron procesados de acuerdo a las técnicas estándar de herborización y depositados en el Herbario UDBC. La identificación de estas especies se hizo a partir de la revisión de fuentes bibliográficas especializadas y consulta de los ejemplares que hacen parte de la colección en los herbarios JBB (Jardín Botánico de Bogotá José Celestino Mutis), UDBC (Universidad Distrital Francisco José de Caldas), HUA (Universidad de Antioquia) y COL (Nacional Colombiano). Adicionalmente y con el objeto de identificar patrones fenológicos de las especies a partir de muestras de herbario, se registró la fecha de la floración y la fructificación de los ejemplares fértiles. Sin embargo, debido al bajo número de ejemplares no fue posible obtener un patrón fenológico para cada una de las especies.

Los datos de precipitación se obtuvieron de la Empresa de Acueducto de Bogotá de la estación climatológica del Embalse San Rafael, localizada a 1.7 km del sitio de muestreo y a 2809 m de altura. Los datos de temperatura media, máxima y mínima, y humedad relativa media se obtuvieron de la estación de Guasca del IDEAM ubicada a 12.2 km del sitio y 2750 m de altura. Aunque esta estación se encuentra relativamente distante de la zona de estudio, corresponde al mismo flanco de la cordillera e igual rango altitudinal, por lo que se consideró que los valores de temperatura y humedad relativa son similares a los del área de estudio.

Análisis de datos —. La duración de la floración/fructificación se estableció de acuerdo con lo sugerido por Newstrom *et al.* (1994) y Stevenson *et al.* (2008) como breve (<1 mes), intermedia (1-5 meses) y extendida (>5 meses). Si la especie no presentó patrones de duración detectables se consideró como irregular (Parada *et al.* 2012). También se clasificó como continua (floración/fructificación a lo largo del año por un período mayor a seis meses), episódica (producción de flores/frutos más de una vez por año en eventos discontinuos de menos de seis meses) y anual (únicamente un ciclo por año) de acuerdo con Newstrom *et al.* (1994) y Stevenson *et al.* (2008).

Para cada especie se analizaron las variaciones de los eventos fenológicos entre cada mes por medio de una ANOVA de medidas repetidas. Con el fin de establecer la relación entre la ocurrencia de las fenofases con las variables climáticas mensuales, se realizó un análisis

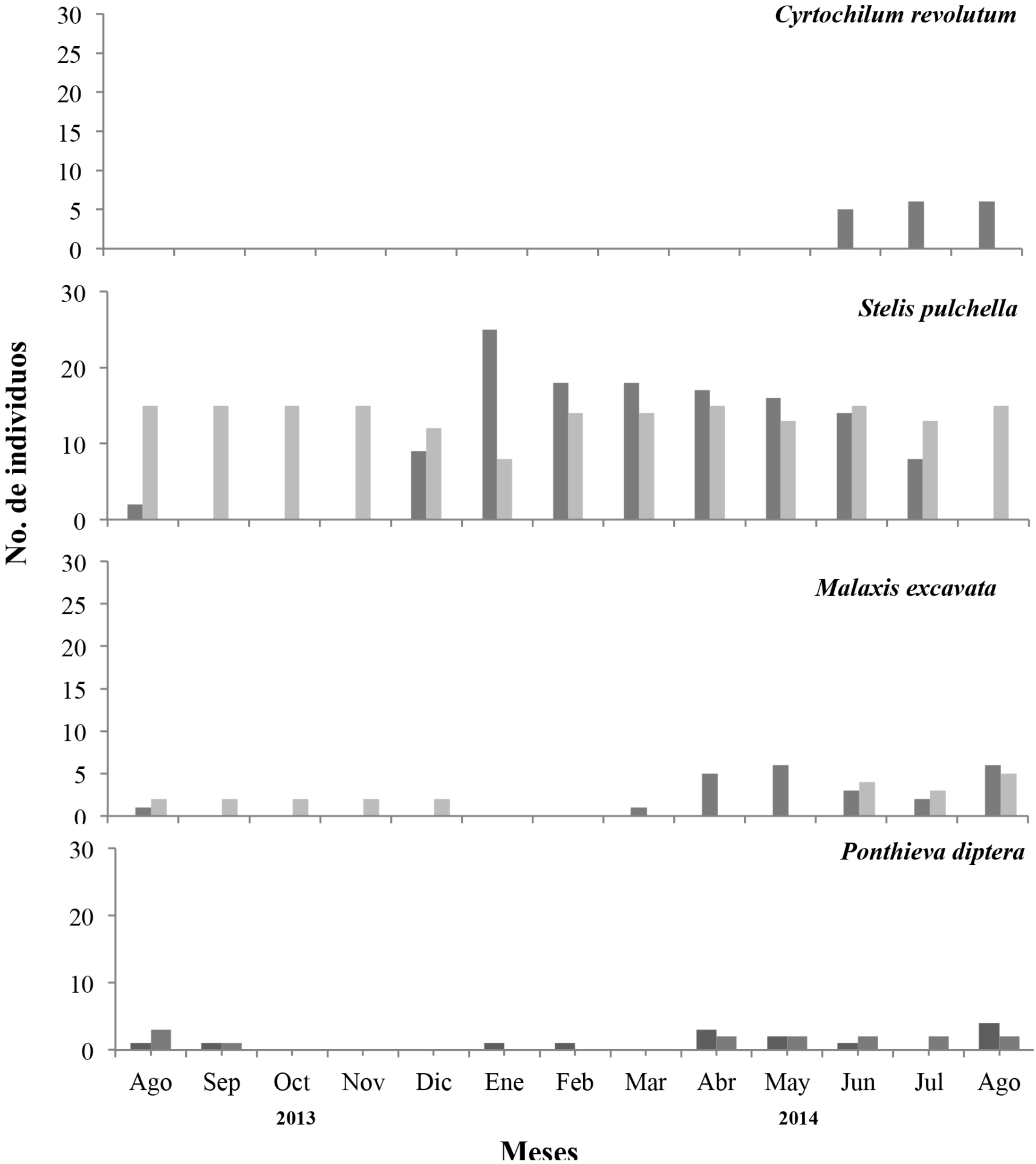


Figura 2. Número de individuos en estadio fenológico por especie. Barras grises oscuras corresponden a la floración (flores en botón y abiertas), barras grises claras fructificación (frutos maduros e inmaduros).

de correlación por rangos de Spearman (r_s) para cada especie ≤ 0.05 (Talora & Morellato 2000) entre cada variable fenológica monitoreada y los valores mensuales de las variables climáticas del mes inmediato, de uno y de dos meses previos (Sáenz *et al.* 2003). Las pruebas estadísticas se realizaron con el programa IBM SPSS Statistics 22 (Field 2013).

Resultados. Los resultados en este estudio muestran que las cuatro especies de orquídeas estudiadas presentaron actividad reproductiva entre agosto 2013 y agosto 2014. Respecto a *C. revolutum* sólo presentó actividad de floración intermedia, mientras que no se encontraron individuos en fruto (Fig. 2; flores en botón, F=26.6 P=0.00; flores abiertas F=26.06 P=0.00). El

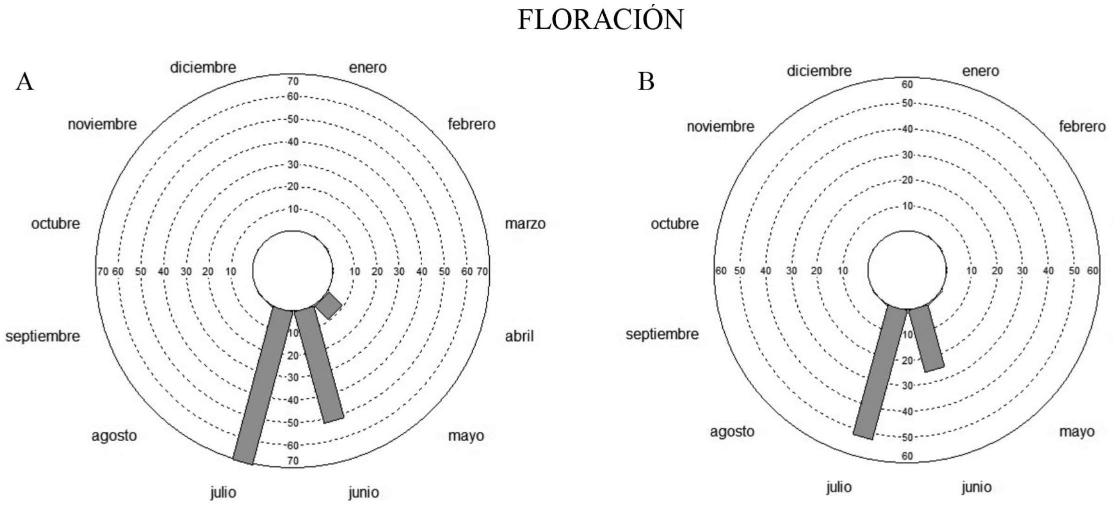


Figura 3. Histogramas circulares de la fenología reproductiva (floración-fructificación) de *Cyrtochilum revolutum.* A, número de flores en botón. B, número de flores abiertas.

pico de floración ocurrió en julio (Fig. 3). Teniendo en cuenta que no se registró fructificación en ninguno de los individuos estudiados.

Para *S. pulchella,* la mayoría de los individuos florecieron entre diciembre y julio por lo que se consideró que la floración es extendida (Fig. 2). El pico de floración ocurrió en enero tanto para flores en botón (F=159.23 P=0.00) como para flores abiertas (F=123.16 P=0.00; Fig. 4). Presentó individuos en fruto durante todo el año, por lo que se consideró como continua. Sin embargo, el pico de producción de frutos verdes ocurrió en agosto (F=51.74 P=0.00), mientras que el pico de maduración en diciembre (F=72.08 P=0.00).

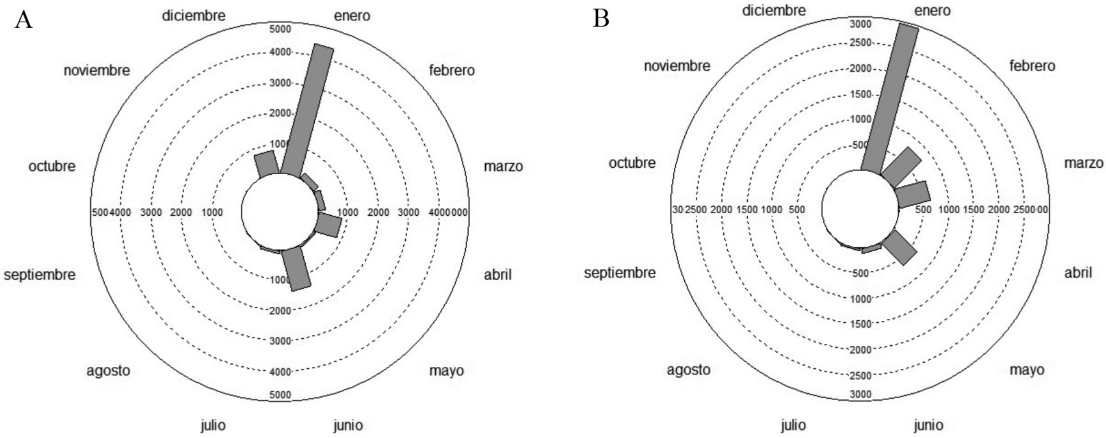
Se encontró que *M. excavata* aunque tuvo pocos individuos en flor o en fruto durante el año de estudio (Fig. 2) presentó un patrón de floración y de fructificación extendida (ANOVA de medidas repetidas, floración F=45.64 P=0.000; fructificación F=35.27 P=0.000; Fig. 2). Así, la mayor actividad floral ocurrió entre marzo y julio con el mayor número de flores abiertas en abril-mayo (Fig. 5). La fructificación sucedió entre junio y diciembre (Fig. 2) presentándose la mayor producción de frutos verdes en junio-julio mientras que la maduración y liberación de semillas se registró en noviembre-diciembre (Fig. 5).

La especie *P. diptera* también mostró pocos individuos en flor y en fruto durante el año y por ende, no se presentaron picos marcados de actividad fenológica (frutos inmaduros F= 23,85 P: 0,02 y frutos maduros F=22,18 P: 0,04; Fig. 2). Por tal razón, no se sugiere ningún patrón de duración de la floración y fructificación. De todas formas el mayor número de flores abiertas se registró para el mes de mayo (Fig. 6), mientras que la liberación de semillas (maduración) se presentó entre julio-septiembre (Fig. 6).

Relación de la fenología con las variables climáticas —. Durante el período de estudio, la temperatura media fue de 16.5°C, con un máximo de 26.2°C en el mes de septiembre (Fig. 7). La humedad relativa osciló entre 78 y 65% y la precipitación total fue de 943.4 mm, donde enero de 2014 fue el mes más seco con 14.8 mm, y noviembre de 2013 el mes más lluvioso con 201.8 mm. Aunque las temperaturas de septiembre de 2013 y la precipitación de noviembre del mismo año fueron muy altas, el periodo de estudio no coindice con un evento de El Niño ni La Niña. El patrón general se ajusta con los promedios multianuales registrados por el IDEAM para el periodo (1981-2010; IDEAM 2017).

La floración de *C. revolutum* se correlacionó de forma positiva con la precipitación. Así, para el periodo de estudio, la formación de botones florales y flores abiertas ocurrió uno y dos meses después de las mayores precipitaciones. De igual forma, la floración coincide con las menores temperaturas mínimas registradas, por lo cual se presentó una correlación negativa significativa (Tabla 2).

FLORACIÓN



FRUCTIFICACIÓN

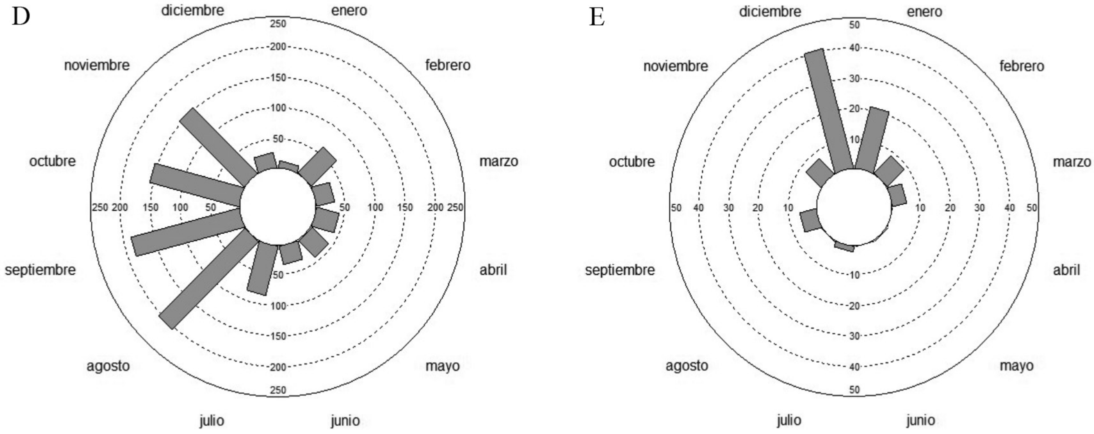


Figura 4. Histogramas circulares de la fenología reproductiva (floración-fructificación) de *Stelis pulchella*. A, número de flores en botón. B, número de flores abiertas. C, número de frutos inmaduros. D, número de frutos maduros.

Para el caso de *S. pulchella*, se encontró que la floración se presentó en los meses más fríos (de menor temperatura) y con menor humedad relativa del año (Tabla 2). En contraste en los momentos de mayor humedad y mayor temperatura se presentó la producción de frutos verdes. La apertura de las cápsulas ocurrió en los meses más secos del año estudiado (Tabla 2).

La relación entre la fenología de *M. excavata* y las variables climáticas fue significativamente positiva para la floración y la precipitación (Tabla 2). Así, esta especie floreció durante la primera estación de lluvias entre marzo y mayo. La producción de frutos (inmaduros) ocurrió inmediatamente después de la floración, y se correlacionó con la precipitación de dos meses antes. La cantidad de frutos verdes aumentaron a medida que la humedad relativa aumentó. En contraste, teniendo en cuenta que la dispersión de los frutos es por viento, la maduración y apertura de las cápsulas ocurrió en los meses más secos, con base en la correlación negativa encontrada entre la cantidad de frutos maduros y la precipitación (Tabla 2).

Ponthieva diptera se vio influenciada tanto por la precipitación como por la temperatura. Las lluvias

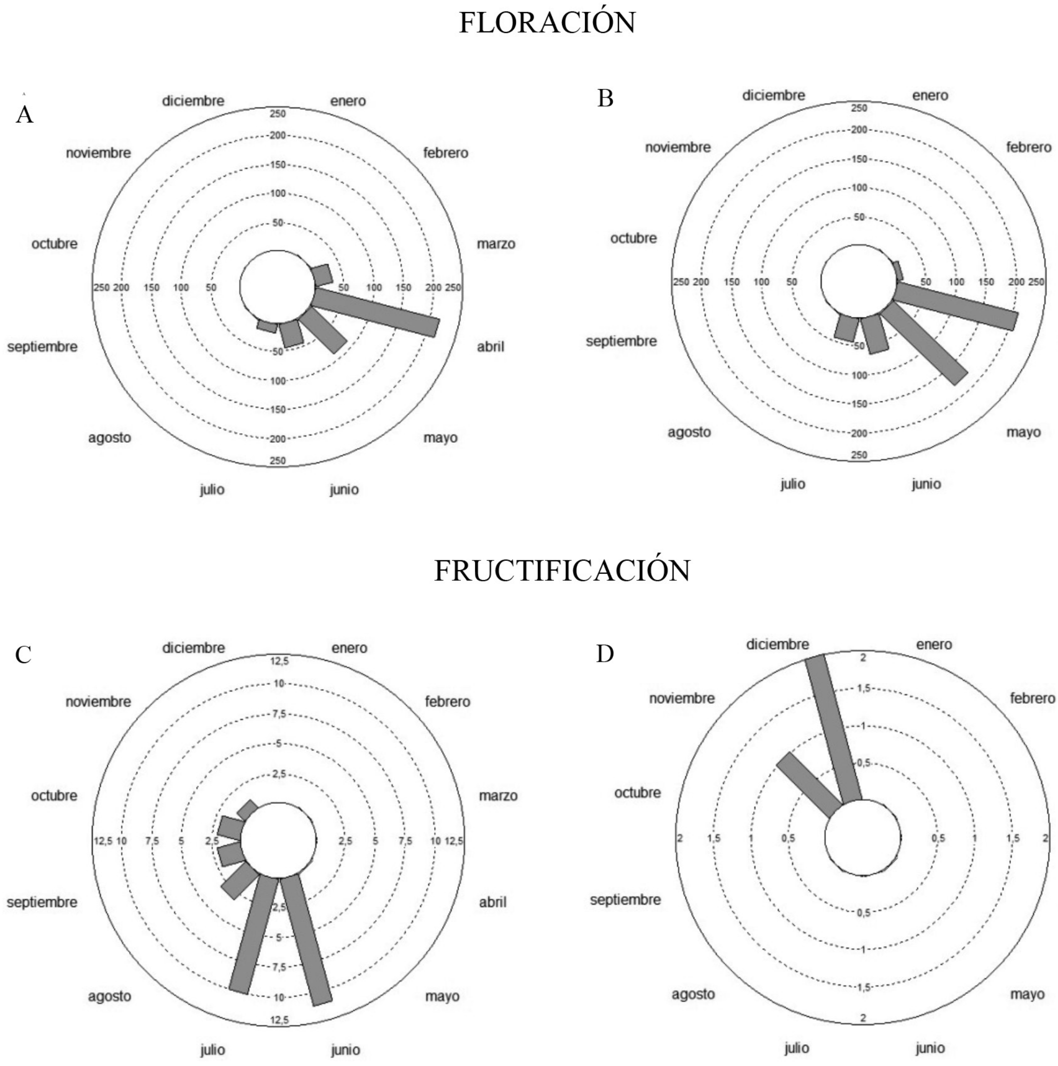


Figura 5. Histogramas circulares de la fenología reproductiva (floración-fructificación) de *Malaxis excavata*. A, número de flores en botón. B, número de flores abiertas. C, número de frutos inmaduros. D, número de frutos maduros.

ocurridas durante el mes inmediato se relacionaron con la apertura de las flores en mayo (0.68) así como la producción de frutos verdes ocurrió entre abril y junio (Tabla 2). Se encontró una correlación positiva entre la floración y la temperatura media. La maduración de los frutos ocurrió en los meses de agosto y septiembre meses con la mayor humedad relativa (rs=0.76, $p<0.05$; rs=0.64) al evento (Tabla 2).

Discusión. Los principales estudios en fenología se han realizado para arbustos, árboles, palmas y lianas en regiones templadas y tropicales (*e.g.* Kotchmer & Handel 1986, Ibarra *et al.* 1991, Roldán & Larrea 2003, Parada *et al.* 2012, Sánchez-Landaverde 2014), pero en menor frecuencia para herbáceas o epífitas (pero ver Ely-Bali *et al.* 2010). Los estudios realizados para estos grupos se basan en plantas cultivadas y registros de herbario (*e.g.* Ospina-Calderón *et al.* 2007, Sánchez-Landaverde 2014). Así, aunque los registros corresponden sólo a un ciclo anual, este trabajo constituye un aporte al conocimiento *in situ* de la fenología reproductiva de algunas especies de orquídeas, generando información base para su manejo y futuros planes de conservación.

En términos generales, los resultados de este estudio

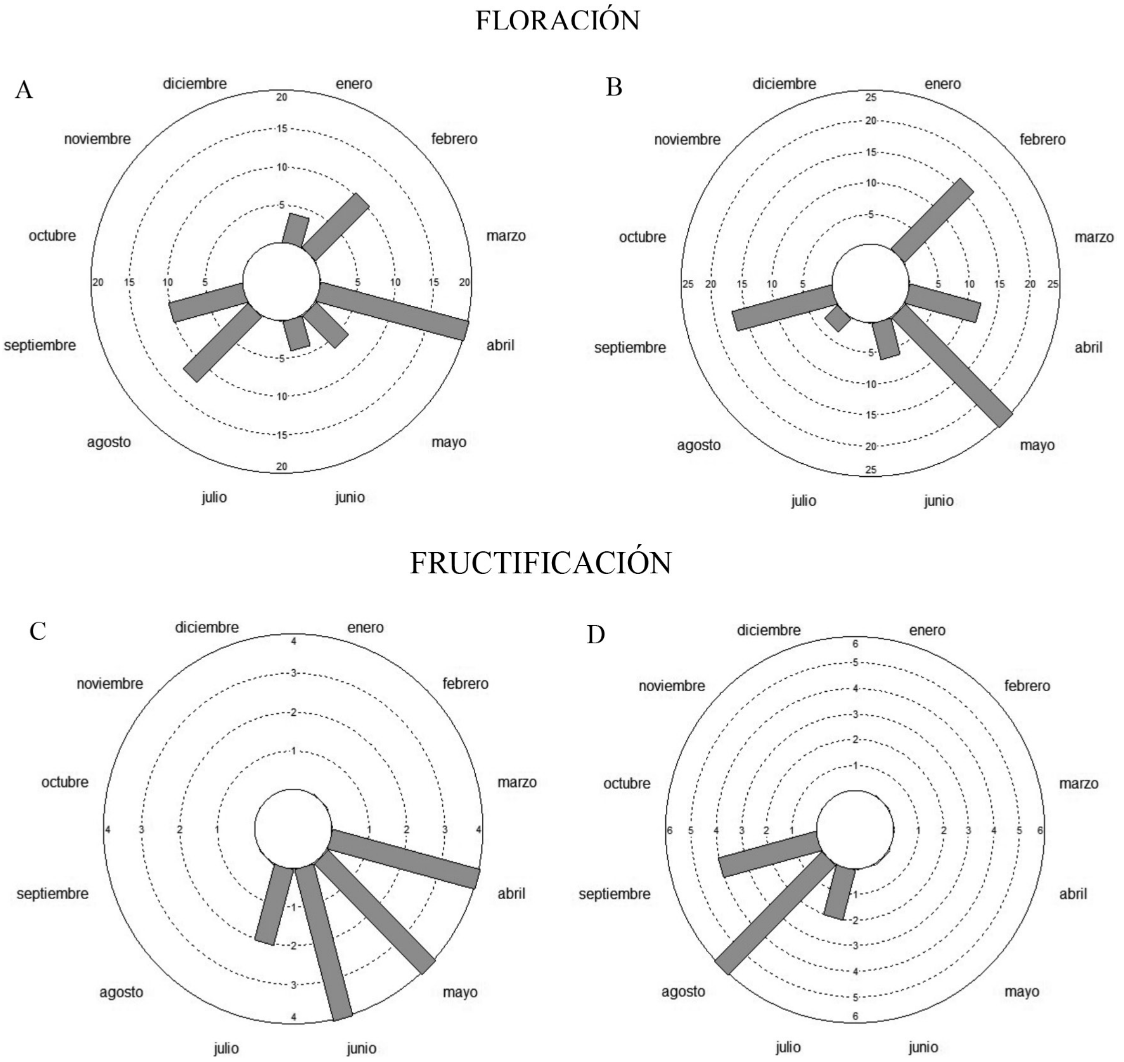


Figura 6. Histogramas circulares de la fenología reproductiva (floración-fructificación) de *Ponthieva diptera*. A, número de flores en botón. B, número de flores abiertas. C, número de frutos inmaduros. D, número de frutos maduros.

muestran que tres de las cuatro especies estudiadas (*C. revolutum, M. excavata* y *P. diptera*) presentan una estacionalidad marcada en sus eventos fenológicos, mientras *S. pulchella* presentó estacionalidad en la floración más no en la fructificación. La relación entre las variables climáticas y la fenología de las especies estudiadas fue diferencial, pues cada especie mostró correspondencia con por lo menos una variable climática. Sin embargo, fue mucho más clara la relación de la floración con las variables climáticas que con la fructificación. Esto coincide con la literatura previa que ha reportado que la florogénesis en orquídeas epífitas, aunque es sensible a factores genéticos propios de cada especie, los cambios ambientales (estacionalidad), cambios en la temperatura (descensos) y disponibilidad de agua son altamente influyentes (Kochmer & Handel 1986, Steinfort *et al.* 2012, Sánchez-Landaverde 2014).

Un hallazgo de gran importancia radica en que para las especies *C. revolutum, M. excavata* y *P. diptera* florecieron en la época de lluvias con correlaciones positivas significativas (Tabla 2). Esto contrasta con la floración de *S. pulchella* y con Bonilla *et al.* (2005) quienes encontraron que la floración en otras especies de orquídeas está más relacionada con la época seca.

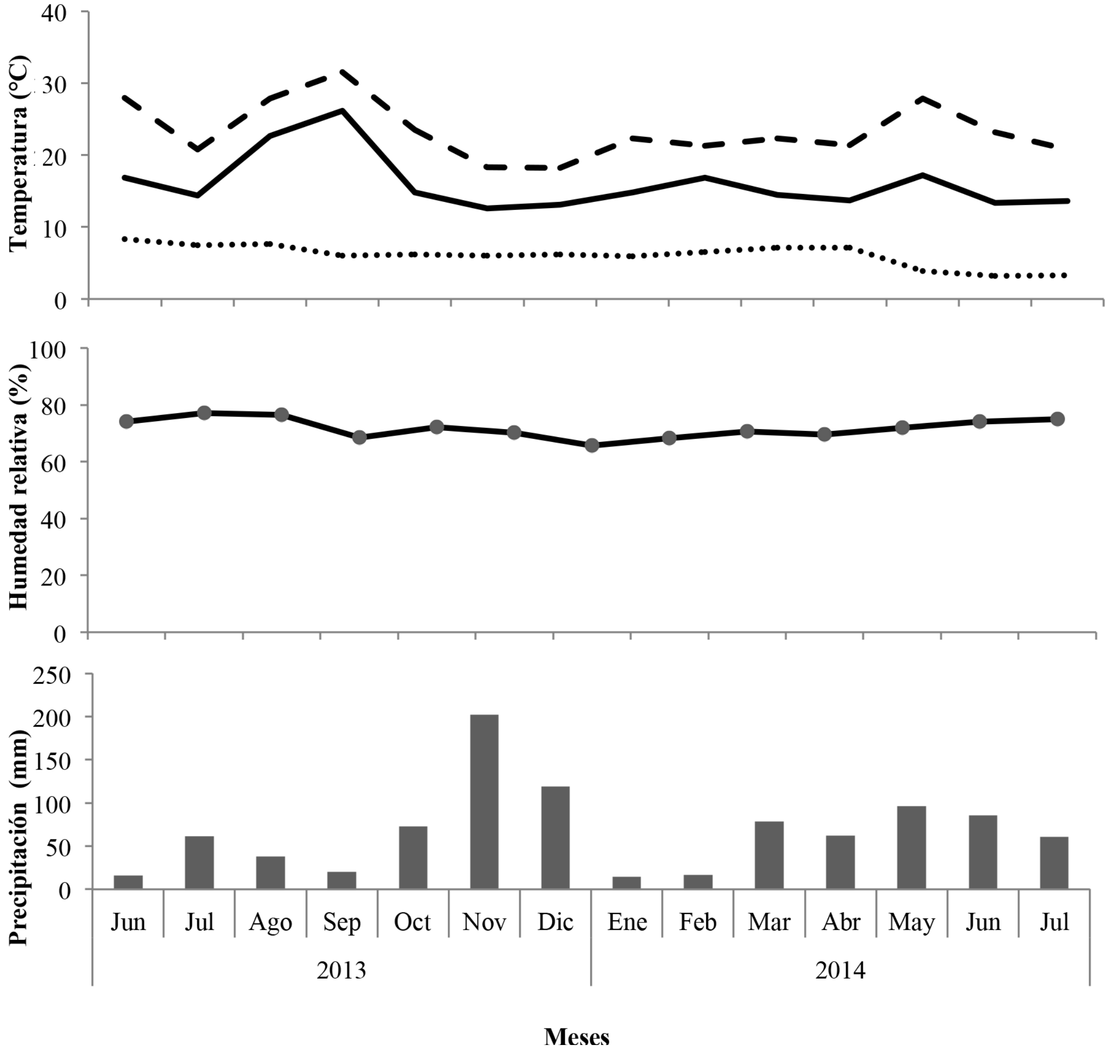


Figura 7. Variables climáticas registradas en el área de estudio para el periodo agosto de 2013- julio de 2014. Temperatura máxima (línea punteada), media (línea continua) y mínima (punto redondo); Humedad Relativa media mensual y Precipitación total mensual tomadas en las estaciones Santa Cruz de Siecha por la Corporación Autónoma Regional de Cundinamarca y Francisco Wiesner por el Acueducto de Bogotá.

Posiblemente, esta diferencia se debe a que estas tres especies se desarrollan en un medio con una limitada disponibilidad de recursos (suelo con bajo nivel de material orgánica, elevada pendiente y baja humedad en el suelo), que resultan disponibles al aumentar las lluvias, generando condiciones propicias para la floración (van Schaik 1993).

Adicionalmente, en este estudio la fructificación se relacionó de forma significativa con factores ambientales, lo que contrasta con otros estudios en donde esta relación es más débil y se tiende a asociar a otros factores como la fisiología, la disponibilidad de polinizadores y la fecundidad (Roldán & Larrea 2003, Cuartas-Domínguez & Medel 2010, Sánchez-Landaverde 2014, Zárate *et al.* 2006).

Con relación a *C. revolutum* la variable principal asociada a la floración fue la precipitación, para la que el incremento de las lluvias se asoció con una mayor floración. La ausencia de frutos de esta especie, durante el año de estudio, posiblemente se debe a que

Tabla 2. Coeficiente de correlación por rangos de Spearman (*rs*) entre las variables fenológicas y las variables climáticas del mes inmediato (0), un mes antes (1) y dos meses antes del suceso (2). B: flores en botón; FA: flores abiertas; FrI: frutos inmaduros y FrM: frutos maduros. En negrita las correlaciones significativas (P≤0.05).

Variables climáticas		***Cyrtochilum revolutum***				***Stelis pulchella***				***Malaxis excavata***				***Ponthieva diptera***			
	Meses antes	**B**	**FA**	**FrI**	**FrM**	**B**	**FA**	**FrI**	**FrM**	**B**	**FA**	**FrI**	**FrM**	**B**	**FA**	**FrI**	**FrM**
Temperatura mínima (°C)																	
	0	**0,8**	**-1**	.	.	-0,2	-0,3	0,24	0,17	-0,5	-0,5	-0,2	-0,2	0,26	-0,1	**-1**	0,32
	1	**-1**	**-1**	.	.	**-1**	-0,4	**0,6**	-0,1	-0,4	-0,5	-0,1	-0,1	0,29	0,09	-0,5	0,04
	2	-0,4	-0,4	.	.	**-1**	**-1**	0,49	-0,1	-0,4	-0,5	0,23	0,5	-0	-0,1	-0,3	0,06
Temperatura media (°C)																	
	0	-0,3	-0,4	.	.	-0,4	0,04	0,43	-0,2	-0,2	-0,2	-0,1	**-1**	**0,6**	0,5	-0,2	0,48
	1	-0,2	-0	.	.	-0,4	-0,3	0,45	-0,4	-0	-0,1	0,35	-0,3	0,02	-0,1	-0,1	-0
	2	-0	0,04	.	.	**-1**	**-1**	0,51	-0,3	-0	0,02	0,29	0,33	-0,4	-0,4	-0	0,15
Temperatura máxima (°C)																	
	0	0,08	-0,9	.	.	-0,6	-0,3	**0,6**	**-1**	0,07	0,06	0,38	0,38	0,47	0,43	0,1	0,48
	1	0,26	0,31	.	.	-0,5	**-1**	0,46	-0,5	0,16	0,18	**0,6**	-0,1	-0,2	-0,3	0,25	0,16
	2	0,24	0,21	.	.	-0,4	-0,4	0,11	-0,2	0,09	0,1	0,22	0,5	**-1**	**-1**	0,08	-0,2
Humedad Relativa (%)																	
	0	0,34	0,39	.	.	-0,5	-0,2	**0,6**	-0,2	-0,1	-0	**0,6**	-0,2	0,28	0,18	0,05	**0,8**
	1	0,07	0,2	.	.	-0,4	**-1**	0,48	-0,3	-0,2	-0,2	**0,6**	-0,1	0,05	-0,1	-0	**0,6**
	2	-0,1	-0,1	.	.	**-1**	-0,4	**0,7**	-0	**-1**	**-1**	0,44	0,02	-0,1	-0,2	-0,4	0,37
Precipitación (mm)																	
	0	**0,7**	0,4	.	.	0,37	0,36	-0,3	-0,5	**0,8**	**0,8**	-0,1	-0,1	0,39	**0,7**	**0,7**	-0,1
	1	**0,7**	**0,6**	.	.	0,19	0,01	0,04	**-1**	**0,7**	**0,8**	0,45	**-1**	0,38	0,47	**0,8**	0,32
	2	**0,8**	**0,6**	.	.	-0,3	-0,2	0,41	**-1**	0,49	0,55	**0,6**	-0,5	0,09	0,24	**0,7**	0,34

es una planta que desarrolla pseudobulbos grandes y requiere períodos prolongados desde su germinación hasta su madurez. Por lo tanto, se requiere mucho más de un año de seguimiento para poder registrar este fenómeno (Roldán & Larrea 2003, Cuartas-Domínguez & Medel 2010). Adicionalmente, teniendo en cuenta que florece en la época húmeda en la que la cantidad de polinizadores, principalmente de la familia Apidae (Torreta *et al.* 2011) es menor, podría estar afectando la fecundidad de la especie.

En el caso de *S. pulchella,* anteriormente clasificada como *Pleurothallis pulchella* (Kunth) Lindl., la floración ocurrió al final de la temporada seca y comienzo de las lluvias, períodos donde hay una mayor humedad relativa y temperatura. Esto coincide con lo reportado por Borba & Semir (2001) en una especie similar, *Pleurothallis ochreata,* que tiene el pico de floración para la época de mayores precipitaciones. Posiblemente, lo observado en *S. pulchella* puede deberse a que requiere períodos de estrés hídrico para iniciar la floración (Roldán & Larrea 2003). Adicionalmente, la relación con la temperatura puede deberse a la intensidad en la fragancia necesaria para atraer polinizadores tal y como ocurre en otras especies de Pleurothallidineas (Borba & Semir 2001).

La relación entre fructificación y la disminución de la precipitación durante la segunda temporada de lluvias puede explicarse desde la fisiología de la planta y por la disponibilidad de recursos en esta época. Así, similar a lo reportado por Borba y Semir (2001), la lluvia previa se convierte en un importante recurso para la formación de frutos antes de la maduración, que tarda entre tres y cinco meses. Posiblemente, experimentos relacionados con factores limitantes en la producción de frutos pueden aclarar esta tesis.

Por otro lado, la floración de *M. excavata* está altamente relacionada con la cantidad de lluvia, en donde además genera muchas flores de forma secuencial (Aragón & Ackerman 2001) que se mantienen abiertas por períodos cortos. La presencia de estructuras de almacenamiento como cormos le permite permanecer en estado latente (Sahagún-Godínez 1996) que se rompe con el cambio de estación (Steinfort *et al.* 2012). De esta forma, se observó que al iniciar las lluvias emergieron tanto los brotes foliares como los florales. En contraste, en la fructificación de *M. excavata,* la apertura de las cápsulas se relacionó con la época seca, lo cual es congruente con la dispersión por viento de las semillas, que ocurre en las épocas más secas del año.

La floración de *P. diptera* se caracterizó por ofrecer un bajo número de flores de apertura suscesiva durante un largo periodo de tiempo (cuatro meses). Además, esta se relacionó con la temperatura media y con bajas temperaturas máximas durante el periodo de estudio. En el caso de la fructificación la apertura de la única cápsula se relacionó con la mayor humedad relativa; sin embargo, dado a que es un único fruto, es probable que este no sea el real patrón de la especie. Dado el bajo éxito reproductivo (poca cantidad de frutos) habría que hacer más seguimientos en el tiempo para comprender mejor la fenología de esta especie y entender el efecto de los factores endógenos (fisiológicos), nutricionales (disponibilidad de recursos como agua y nutrientes) y disponibilidad de polinizadores (Roldán & Larrea 2003, Cuartas-Domínguez & Medel 2010, Sánchez-Landaverde 2014).

Finalmente, con el fin de aportar al manejo de las orquídeas en estrategias *ex situ*, se sugiere realizar registros fenológicos continuos por períodos prolongados de más de un año para el mejor entendimiento de su dinámica reproductiva (Ochoa-Gaona *et al.* 2008), teniendo en cuenta la variabilidad climática entre un año y otro (Kotchmer & Handel 1986, Ely-Bali *et al.* 2010). Adicionalmente, aunque el periodo de estudio no correspondió a un evento de El Niño o de La Niña, estos fenómenos pueden afectar de forma considerable la fenología de las especies. A pesar de lo anterior, con base en los resultados encontrados se recomienda, para las especies aquí estudiadas, el empleo del riego y la variación en las temperaturas, si se pretenden reproducir o mantener en condiciones de invernadero (Blanchard *et al.* 2006).

Agradecimientos. Los autores agradecen al Jardín Botánico de Bogotá José Celestino Mutis por el apoyo financiero a través del programa de estímulos a la investigación Thomas van der Hammen. Al señor Libardo Almeciga por poner a nuestra disposición su predio. A la Universidad Distrital Francisco José de Caldas por su apoyo con las instalaciones y equipos. A las personas que estuvieron apoyando el trabajo de campo. A los Herbarios UDBC, JBB y HUA. Al Biólogo F. Guardiola por su apoyo en los análisis estadísticos. A M. Cuartas, N. Ospina y R. Cortés por sus valiosos comentarios a versiones previas del manuscrito. Dedicamos este trabajo a la memoria del Padre Pedro Ortiz Valdivieso, S.J. †

Literatura Citada

Ackerman, J. (1992). The Orchids of Puerto Rico and the Virgin Islands. First Edition. University of Puerto Rico Press. 147 p.

Alvim, P. T. & Alvim, R. (1978). Relation of climate to growth periodicity in tropical trees. Cambridge: Cambridge University Press. 464 p.

Aragon, S. & Ackerman, J. D. (2001). Density effects on the reproductive success and herbivory of *Malaxis massonii*. *Lindleyana*, West Palm Beach, 16(1), 3–12.

Ashton, P. S. E. (1988). Dipterocarp biology as a window to the understanding of tropical forest structure. *Annual Review of Ecology, Evolution and Systematics*, 19, 293–304.

Baker, L. M. & Baker, O. C. (2006). Orchid species culture, *Oncidium/Odontoglossum* Alliance. Portland: Timber press. 992 p.

Ballantyne, M. & Pickering, C. (2012). Ecotourism as a threatening process for wild orchids. *Journal of Ecotourism*, 11(1), 34–47. Doi: http://dx.doi.org/10.1080/14724049.2011.628398

Blanchard, M. G. & Runkle, E. S. (2006). Temperature during the day, but not during the night, controls flowering of *Phalaenopsis* orchids. *Journal of Experimental Botany*, 57(15), 4043–4049. Doi: https://doi.org/10.1093/jxb/erl176

Bonilla, G. M., Chaparro, H. A., Martínez, E. & Cuervo, M. (2005). Rasgos de historia de vida de las orquídeas clonales terrestres *Epidendrum chioneum* y *Elleanthus ensatus* del páramo el granizo. Estrategias adaptativas de plantas del páramo y del bosque altoandino en la Cordillera Oriental de Colombia. Parte V. Universidad Nacional de Colombia. 307–322.

Borba, E. L. & Semir, J. (2001). Pollinator specificity and convergence in fly-pollinated *Pleurothallis* (Orchidaceae) species: a multiple population approach. *Annals of Botany*, 88(1), 75–88. Doi: https://doi.org/10.1006/anbo.2001.1434

Borchert, R., Calle, Z., Strahler, A. H., Baertschi, A., Magill, R. E., Broadhead, J. S., Kamau, J., Njoroge, J. & Muthuri, C. (2015). Insolation and photoperiodic control of tree development near the equator. *New Phytologist,* 205(1), 7–13. Doi: 10.1111/nph.12981

Caballero, R. L., Rodríguez, N., Martin, C. (1997). Dinámica de elementos epífitos de un bosque altoandino de la Cordillera Oriental de Colombia. *Caldasia,* 19(1-2), 311–322.

Chaves, O. M. & Avalos, G. (2008). Do seasonal changes in light availability influence the inverse leafing phenology of the neotropical dry forest understory shrub *Bonellia nervosa* (Theophrastaceae). *Revista de Biología Tropical*, 56(1), 257–268.

Cozzolino, S. & Widmer, A. (2005). Orchid diversity: An evolutionary consequence of deception? *Trends in Ecology & Evolution*, 20(9), 487–494.

Cuartas-Domínguez, M. & Medel, R. (2010). Pollinator-mediated selection and experimental manipulation of the flower phenotype in *Chloraea bletioides*. *Functional Ecology,* 24(6), 1219–1227.

Diez, G. M. C. (2002). Biología reproductiva de las plantas de los bosques tropicales. (Trabajo de pregrado, Ingeniería forestal). Medellín: Universidad Nacional de Colombia. 73 p.

Dodson, C. H. (2003). Native Ecuadorian Orchids. Volume I-IV. Dodson Trust, Sarasota, Florida. USA.

Dunsterville G. C. K. & Garay, L. A. (1979). Orchids of Venezuela. Printed for the Botanical Museum of Harvard University. Vol I-III. 1055 p.

Duque-Buitrago, C. A. D., Álzate-Quintero, N. F. & Otero, J. T. (2014). Nocturnal pollination by Fungus gnats of the Colombian endemic species, *Pleurothallis marthae* (Orchidaceae: Pleurothallidinae). *Lankesteriana*, 13(3), 407–417. Doi: http://dx.doi.org/10.15517/lank.v13i3.14429

Ely-Bali, F., Schwarzkopf Kratzer, T., Rada, R., Fermín, J., León Vargas, Y., & Gaviria Rincón, J. C. (2010). Respuesta hídrica y fenológica de epífitas y plantas de sotobosque de una selva nublada andina introducidas en un bosque secundario. *Ecotrópicos*, 23(1), 1–17.

Escobar, R. R. (1994). Native Colombian Orchids: Volume 1-6. Medellín: Editorial Colina.

Field, A. (2013). Discovering statistics using IBM SPSS statistics. Sage. 957 p.

Gentry, A. H. & Dodson, C. H. (1987). Diversity and biogeography of Neotropical vascular epiphytes. *Annals of the Missouri Botanical Garden*, 74(2), 205–233. Doi: 10.2307/2399395

Giraldo, G. & Betancur, J. (2011). Guía de campo de las orquídeas de Santa María (Boyacá, Colombia). Serie guías de campo del Instituto de Ciencias Naturales, Universidad Nacional de Colombia No. 9. Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá. 188 p.

Guerrero, D. E., Zambrano, W. R., Salazar, A., Lamprea, D. A., Vásquez, B. J., Sandoval, T. J., Posada, A. (2008). Formulación de una cooperativa de servicios turísticos en los municipios de Sopó y La Calera, Cundinamarca (Colombia). *Actualidad & Divulgación Científica*, 11(1), 175–184.

Hágsater, E. & Soto, M. (2008). *Icones Orchidacearum* Fascicle 10, Orchids of México, Part 4. México. 240 p.

Hudson, I. L. & Keatley, M. R. (Eds.). (2009). Phenological research: methods for environmental and climate change analysis. Springer Science & Business Media. 521 p.

Ibarra, M. G., Sánchez, G. B. & González, G. L. (1991). Fenología de lianas y arboles anemócoros en una selva cálido-húmeda de México. *Biotropica*, 23(3), 242–254.

IDEAM. (2017). Catálogo nacional de estaciones IDEAM Instituto de Hidrología, Meteorología y Estudios Ambientales. Disponible en: http://www.ideam.gov.co/documents/21021/553571/Promedios+Climatol%C3%B3gicos++1981+-+2010.xlsx/f28d0b07-1208-4a46-8ccf-bddd70fb4128

Kite, G. C. & Salazar, G. A. (2008). Composición química del olor de la inflorescencia de *Malaxis rzedowskiana* (Orchidaceae). *Revista Mexicana de Biodiversidad*, 79(1), 153–157.

Kochmer, J. P. & Handel, S. N. (1986). Constraints and competition in the evolution of flowering phenology. *Ecological Monographs*, 303–325.

Lemus-Jiménez, L. J. & Ramírez, N. (2002). Fenología reproductiva en tres tipos de vegetación de la planicie costera de la península de Paraguaná, Venezuela. *Acta Científica Venezuelana,* 53(4), 266–278.

Montenegro, A. & Vargas, O. (2005). Estrategias de regeneración del banco de semillas en una comunidad de bosque altoandino secundario. En: M. A. Bonilla (Ed.), *Estrategias adaptativas de plantas de páramo y del bosque alto andino en la Cordillera Oriental de Colombia* (pp. 227-246). Bogotá: Editorial Universidad Nacional de Colombia.

Newstrom, L. E., Frankie, G. W. & Baker, H. G. (1994). A new classification for plant phenology based on flowering patterns in lowland tropical rain forest trees at La Selva, Costa Rica. *Biotropica*, 26, 141–159.

Ochoa-Gaona, S., Pérez-Hernández, I. & De Jong, B. H. (2008). Fenología reproductiva de las especies arbóreas del bosque tropical de Tenosique, Tabasco, México. *Revista de Biología Tropical*, 56(2), 657–673.

Ospina-Calderón, N., Díaz-Granados, M. & Viveros-Bedoya, P. (2007). Observaciones de la polinización de *Brassia cf. antherotes* Rchb.f. (Orchidaceae) en un relicto de selva sub-Andina en la reserva natural la montaña del ocaso. *Universitas Scientiarum*, 12(1), 83–95.

Otero, J. T. & Bayman, P. (2009). Germinación simbiótica y asimbiótica en semillas de orquídeas epífitas. *Acta Agronómica*, 58(4), 270–276.

Parada, Q. M., Alarcón, J. D. & Rosero, L. L. (2012). Fenología de la floración de especies ornitófilas de estratos bajos en dos hábitats altoandinos del Parque Natural Municipal Ranchería (Paipa-Boyacá-Colombia). *Caldasia*, 34(1), 139–154.

Parra, S. E. (2013). Efecto de los patrones del paisaje sobre la diversidad de orquídeas de bosques nublados del Valle del Cauca (Tesis de maestría: Ciencias Naturales, Biología, Línea Biodiversidad y Conservación). Bogotá: Universidad Nacional de Colombia. 92 p.

Pineda, M. J. (2004). Estructura y composición de las comunidades de orquídeas epífitas (Orchidaceae) en un bosque de niebla con diferentes grados de tala selectiva, en Valle del Sibundoy, Alto Putumayo (Trabajo de pregrado, Biología). Cali: Universidad del Valle. 46 p.

Quiroga, D., Martínez, M. & Larrea, D. (2010). Pollination systems of five species of orchids growing under greenhouse conditions. *Ecología en Bolivia*, 45(2), 131–137.

Ramírez, N. (2009). Correlaciones entre la fenología reproductiva de la vegetación y variables climáticas en los altos llanos centrales venezolanos. *Acta Botánica Venezuelica*, 32(2), 333–362.

Reich, P.B. (1995). Phenology of tropical forests: Patterns, causes and consequences. *Canadian Journal of Botany,* 72, 164–174.

Roldán, A. I. & Larrea, D. M. (2003). Fenología de 14 especies arbóreas y zoócoras de un bosque yungueño en Bolivia. *Ecología en Bolivia,* 38(2), 125–140.

Romero, G. & Carnevali, G. (2000). Orchids of Venezuela, An illustrated Field Guide. Second Edition. Armitano Editores.

Sáenz, L. C., Gutiérrez, B. & Alcolado, S. M. (2003). Fenología, agrobiología y producción del Olivar en Almodóvar del campo (Castilla-La Mancha). *Anales del Jardín Botánico de Madrid,* 60(1), 73–81.

Sahagún-Godínez, E. (1996). Trends in the phenology of flowering in the Orchidaceae of western México. *Biotropica,* 28(1), 130–136. Doi: 10.2307/2388778

Sánchez-Landaverde, E. (2014). Patrones fenológicos reproductivos y análisis climático de un encinar en Amealco de Bonfil, Querétaro. Santiago de Querétaro: Universidad Autónoma de Queretaro. 64 p.

Sarmiento, J. (2007). La familia Orchidaceae en Colombia. Actualidades Biológicas. IV Congreso Colombiano de Botánica. Medellin-Colombia: Universidad de Antioquia.

Schweinfurth, C. (1958). Orchids of Perú, Part 1-4 Fieldiana, Bot. 30: 1026p. Printed in the USA by Chicago Natural History Museum Press.

Singer, R. (2009). Morfología floral y polinización de orquídeas: el segundo libro de Charles Darwin. *Acta biológica Colombiana*, 14(1), 337–348.

Steinfort, U., Cisternas, M., García, R., Vogel, H. & Verdugo, G. (2012). Phenologycal cycle and floral development of *Chloraea crispa* (Orchidaceae). *Ciencia e Investigación Agraria*, 39(2), 377–385.

Stevenson, P. R., Castellanos, M. C., Cortés A. I. & Link, A. (2008). Flowering patterns in a seasonal tropical lowland forest in western Amazonia. *Biotropica*, 40(5), 559–567.

Talora, D. C., & Morellato, P. C. (2000). Fenología de espécies arbóreas em floresta de planície litorânea do sudeste do Brasil. *Revista brasileira de Botânica*, 23(1), 13–26.

Torretta, J. P., Gomiz, N. E., Aliscioni, S. S. & Bello, M. E. (2011). Biología reproductiva de *Gomesa bifolia* (Orchidaceae, Cymbidieae, Oncidiinae). *Darwiniana*, 49(1), 16–24.

Tremblay, R. L., Pomales-Hernández, G. & Mendez-Cintron, M. (2006). Flower phenology and sexual maturation: Partial protandrous behavior in three species of orchids. *Caribbean Journal of Science*, 42(1), 75–80.

van Schaik, C. P., Terborgh, J. W., & Wright, S. J. (1993). The phenology of tropical forests: adaptive significance and consequences for primary consumers. *Annual Review of Ecology and Systematics*, 24, 353-377.

Vargas, J.O. 1986. Estudios ecológicos en un relicto de bosque de *Weinmannia tomentosa* y *Drimys granadensis* en la región de Monserrate. *Perez-Arbelaezia*, 1(3), 338–356.

Vieira-Faria, M., Andrade, M., Bittencourt, N. & Carvalho, O. R. (2007). Flowering phenology, nectary structure and breeding system in *Corymborkis flava* (Spiranthoideae: Tropidieae), a terrestrial orchid from a Neotropical forest. *Australian Journal of Botany*, 55, 635–642.

Wright, S. J. & van Schaik, C.P. (1994). Light and the phenology of tropical trees. *The American Naturalist*, 143, 192–199.

Wright, S. J. (1996). Phenological responses to seasonality in tropical forest plants. In: S.S. Mulkey, R. L. Chazdon & A. P. Smith (Eds.), *Tropical Forest Plant Ecophysiology* (pp. 440–460). Springer US.

Zárate, R., Amasifuen, C. & Flores, M. (2006). Floración y Fructificación de plantas leñosas en bosques de arena blanca y de suelo arcilloso en la Amazonía Peruana. *Revista Peruana de Biología,* 13(1), 95–102.

LANKESTERIANA 17(1): 17-47. 2017. doi: http://dx.doi.org/10.15517/lank.v17i1.27999

ORCHID DISTRIBUTION AND BIOCLIMATIC NICHES AS A STRATEGY TO CLIMATE CHANGE IN AREAS OF TROPICAL DRY FOREST IN COLOMBIA

Guillermo A. Reina-Rodríguez[1,3], Jorge E. Rubiano Mejía[2], Fabio A. Castro Llanos[2] & Ignasi Soriano[1]

[1] Department of Evolutionary Biology, Ecology and Environmental Sciences., University of Barcelona, Section of Botany and Mycology. Av. Diagonal 643. E-08028 Barcelona, Spain. C.P. 08028

[2] Department of Geography, Valle University, Cali, Colombia. Av. Pasoancho 100-00, Cali, Colombia.

[3] Author for correspondence: guireina@hotmail.com

Abstract. Climate change projections in Colombia predict an average increase in temperature of 2.6°C and in precipitation of 20% by the end of the century. These changes would directly affect the tropical dry forest (TDF) and its biodiversity. Epiphytic orchids, more exposed to the atmosphere than the terrestrial biota, remain dependent on climatic variables, making them particularly susceptible to climate change. We studied the spatial and temporal changes of a focal group of 12 orchid species typical of the TDF in Colombia, and the future conservation areas to this ecosystem. The algorithm used by MaxEnt was employed for modelling. A total of 439 records: direct observations (276); herbaria collections (159) and bibliographical sources (4) collected since September 2009 to April 2015 were considered for use in training the model. The actual potential niche was compared to the SRES 8.5 climate change emissions scenario for two periods: 2020–2049 (2030) and 2040–2069 (2050). The results indicate an altitudinal displacement compared to the present, conditioned by variables such as temperature, accessibility and precipitation. Mid-mountain areas (1300–1700 m) increased their idoneity in future potential niche models (2030 and 2050) to the detriment of the lowlands (0–1000 m). Other variables analysed, such as distance thresholds of pollinators (Euglossini), availability of phorophytes, and distances to TDF cover and protected areas, all suggest an improving connectivity between the lowland and mid-mountain areas. Consequently, bioclimatic niches (BN) are proposed as a new landscape management unit. Throughout the country, 69 of these BN were located as an adaptation-conservation strategy against climate change in the TDF in Colombia.

Resumen. Las proyecciones del cambio climático en Colombia, indican en promedio un incremento en 2.6°C de temperatura y 20% de la precipitación para el fin del siglo. Estos cambios afectarán directamente al bosque seco tropical (Bs-T) y su biodiversidad. Las orquídeas epífitas, más expuestas a la atmósfera que la biota terrestre mantienen dependencia de variables ligadas al clima. Esta condición las hace particularmente susceptibles al cambio climático. Nosotros estudiamos los cambios espacio-temporales de un grupo focal de 12 especies de orquídeas típicas del Bs-T en Colombia y las futuras áreas de conservación de este ecosistema. El algoritmo usado por MaxEnt fue empleado para el modelamiento. Un total de 439 registros: observaciones directas (276); registros de herbario (159) y fuentes bibliográficas (4), colectadas desde septiembre de 2009 hasta abril 2015 fueron consideradas para entrenar el modelo. El nicho potencial actual fue comparado con el escenario de emisiones de cambio climático SRES 8.5 para dos periodos: 2020–2049 (2030) y 2040–2069 (2050). Los resultados indican un desplazamiento altitudinal respecto al presente, condicionado por variables como: temperatura, accesibilidad, y precipitación. Las áreas de montaña media (1300–1700 m) incrementarán su idoneidad en los modelos de nicho potencial futuro (2030 y 2050) en detrimento de las tierras bajas (0–1000 m). Otras variables analizadas como umbrales de distancia en polinizadores (Euglossini), disponibilidad de forófitos, distancias a coberturas de Bs-T y áreas protegidas, sugieren mejorar la conectividad entre tierras bajas y áreas de montaña media. En consecuencia, los *nichos bioclimáticos* (BN) son propuestos como nueva unidad

Received 3 October 2016; accepted for publication 31 January 2017. First published online: 2 March 2017.

de manejo del paisaje. En todo el país, 69 de ellos fueron localizados como estrategia de adaptación-conservación frente al cambio climático en áreas de Bs-T en Colombia.

Key words: bioclimatic niches, climate change, Euglossini, orchids

Palabras clave: Bosque seco tropical, cambio climático, Euglossini, nichos bioclimáticos, orquídeas

Introduction. It is a challenging problem to understand and predict how organisms and plant communities respond to climate change and what is that response. A first research line focus on Bioclimatic Envelope Models (BEMs) still lack an ecological sense. Some authors use BEM to project the rank / abundance of current distribution of the species(s) including climate change (Bellard *et al.* 2012, Pearson & Dawson 2003, Thomas *et al.* 2004, Thuiller *et al.* 2004, Thuiller *et al.* 2008) and a second research line focus on controlled experiments (Bilton *et al.* 2016, Lloret *et al.* 2009, Peñuelas *et al.* 2007) but the models do not yet have ecologically meaningful processes representing orchids life cycle, *e.g.* dispersal, pollinating insects, phorophytes, mycorrhizae. We had included some of these as *a posteriori* analysis.

In this paper we define a "bioclimatic niches" from the evaluation of biotic and abiotic variables complementary to the model *per se* and we provided an ecological, dynamic and pragmatic sense to face the climatic change from the modelling of 12 orchids species in five areas of Tropical Dry Forest (TDF) in Colombia. The bioclimatic niches are areas where government and environmental agencies must focus conservation efforts.

Climate change and land-cover changes by anthropogenic activities are usually the main responsible factors altering the structure and function of ecosystems today (IPCC 2013). The climate change is direct threat of extinction of 4% of the vegetal species whereas the use of the land for livestock and crop farming is of 31%, the selective logging is 21.3% and the housing and commercial/industrial areas on the 12.3% (RBG Kew 2016). These stressors have caused devastating effects on the ecosystem and wiped out important chorological evidence for the management, reintroduction and conservation of orchids.

The lack of spatiotemporal scientific evidence from specific areas in basins and municipalities, where organisms will move into ecosystems, delays national and local conservation strategies facing the threat of climate change. Displacements of up to 500 meters in the plant zone are predicted in Colombia, affecting 23% of the country (Gutiérrez-Rey 2002). In addition, the national deforestation rate is approximately 200,000 ha/year, including of TDF, of which only 3.7% remains of what existed 150 years ago. These changes will significantly affect the five main TDF areas of the country, as well as the biodiversity they contain. With the aim of designing conservation strategies to address environmental change, the objective of this study consisted of identifying potential changes in the geographic distribution of a focal group of 12 orchid species typical of the Columbian TDF (Fig. 1).

Tropical Dry Forest (TDF)

This biome of lowlands and deciduous trees has three months or more of drought annually, with ecological processes marked by their seasonality (Pennington *et al.* 2006). Our data show no more than 32 orchids species/km^2 in Colombian TDF. During the Pleistocene, the TDF would have covered the inter-Andean valleys from northern to southern Colombia, providing refuge for flora and fauna (Hernández-Camacho & Sánchez 1992, Van der Hammen *et al.* 1973). Palynological evidence of areas of TDF in the Patía Valley, Cauca River Valley and savannah areas in the Eastern Plains (not included in this study) reveals the existence of these Pleistocene refuges in the last ten thousand years (Berrío *et al.* 2002a, 2002b, González-Carranza *et al.* 2008, Marchant *et al.* 2006, Vélez *et al.* 2005).

At present, according to Etter *et al.* (2008), 8.9 million hectares in Colombia may potentially contain TDF areas that are restricted to the Caribbean region, the Santander region, south of the Magdalena Valley, the Cauca River Valley, and the Patía Valley. However, deforestation processes and the land use transformation for cattle ranching and agriculture have caused devastating effects on the ecosystem. Currently, the extent of the remnant TDF is 720,000 ha, and moreover it is poorly and insufficiently represented in the National System of Protected Areas (NSPA,

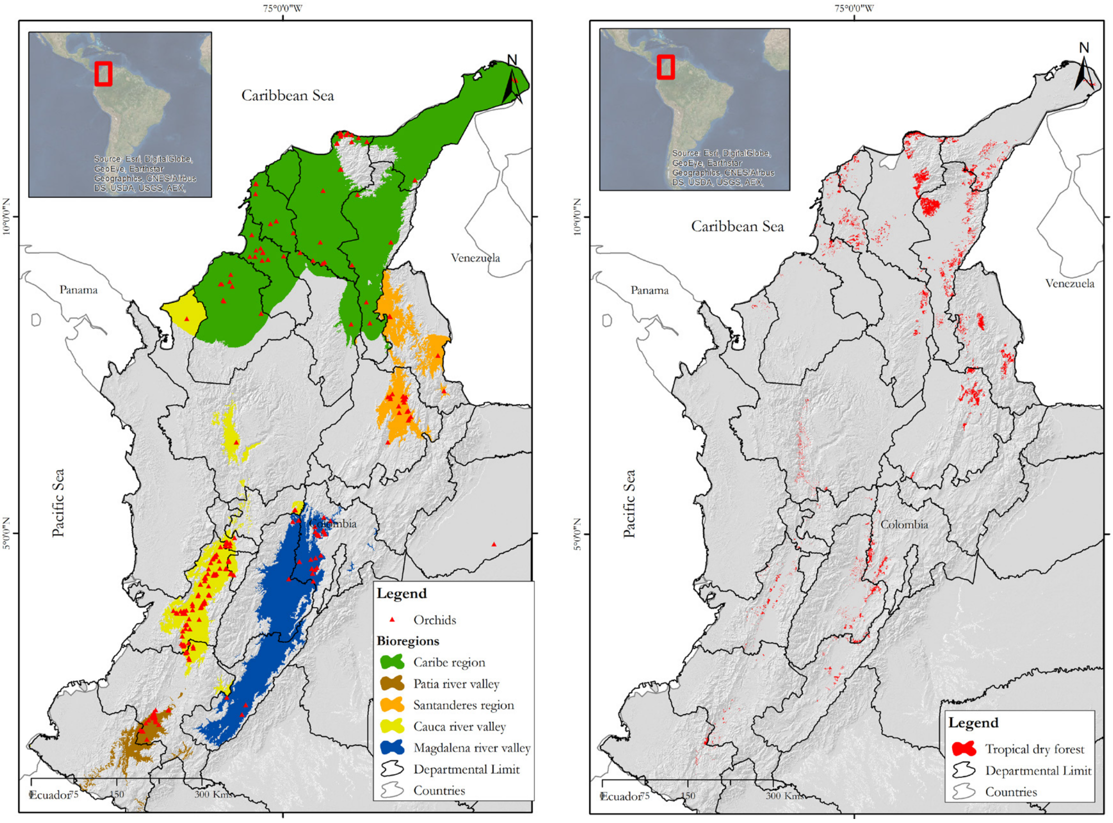


Figure 1. Left: Five main areas of potential TDF distribution in Colombia. Magdalena River Valley, Cauca River Valley, Caribbean region, Patía River Valley, Santander region. The red triangles indicate georeferenced records of TDF orchids in Colombia from field collections, herbarium sheets and bibliographic sources. Right: Actual distribution of TDF in Colombia. Source: Ariza *et al.* 2014.

in Spanish SINAP), because it accounts for only 5% (Pizano & García 2014).

By the 2071-2100, Colombian areas of TDF) are expected to have an increase in temperature of 2.4–2.8°C and will receive between 10 and 20% less rain (IDEAM *et al*. 2015). Climate change can also affect biota of the TDF through erratic or extreme rains, changes in evaporation, acceleration of erosive processes, modification of the microclimate and alteration of the composition of forest-grassland flora, as well as through an increase of the frequency of fires in the affected areas (Bates *et al.* 2008).

Orchids of the Tropical Dry Forest

Colombia with 4270 species of Orchidaceae reported, has the highest diversity of these plants in the world (Betancur *et al.* 2015). Their distribution, however, was defined by political-administrative areas, but not to bioregions of TDF associated with this taxonomic group, which remains a pending task. Plant inventories of the TDF reported only 81 species and 48 genera of orchids in Colombia (Pizano & García 2014), which is quite similar in number and composition to the 70 species and 41 genera reported for the TDF of the Cauca River Valley (Reina-Rodríguez *et al.* 2010). This fact can be attributed to scarce efforts and the difficulties of sampling of the epiphytic biotype (mostly between 10 and 40 meters above the ground). We estimated 350 orchid species present in these five areas of TDF in Colombia. However we believe that this number can increase because there are still many unexplored areas.

The marked seasonality of the TDF is manifested in the morphological and anatomical adaptations of these plants to conditions of prolonged drought (Oliveira & Sajo 2001) such as roots with velamen, idioblasts, trichomes and a thickened epidermis (Torres *et al.* 2007), all of which prevent water loss. Orchids and other epiphytes share light, temperature, moisture and nutrients in the forest canopy. The health of these plants is important to life cycles in the canopy, as well as to the ecosystem, not only for their contribution to trophic chains and microhabitats for invertebrates and amphibians but also because they serve as sinks of water (Richardson *et al.* 2000, Benzing 1998).

Orchids can respond to climate change challenges by shifting their climatic niche along three non-exclusive axes: time (e.g., phenology), space (e.g., range) and self (e.g., physiology) (Bellard *et al* 2012). The increase in temperature that will be induced by climate change will catalyse the migration of plants to higher latitudes and altitudes in search of suitable habitat (Chen *et al.* 2011). These natural migrations will maintain equilibrium with the climate and thus avoid potential extinctions (Feeley *et al.* 2010, Still *et al.* 1999). Such changes, however, modify the vegetation zone because migrations are closely linked to temperature increases (Primack & Corlett 2005). We identifying 69 high priority areas ("bioclimatic niches*"*) in Colombia where conservation efforts by land management agencies should be focused.

Materials and methods

Study area —. The TDF in Colombia includes localized areas between 12°24'33" and 1°39'35.31" latitude N and 77°21'31" and 70°27'43" longitude W, with an average annual temperature greater than 17°C. It corresponds to the lowlands and mountains with altitudes below 1500 m; the precipitation does not exceed 2000 mm, the rains are distinctly seasonal, and drought occurs for 3 months or longer (Mooney *et al.* 1995, Sánchez-Azofeifa *et al.* 2005). A population of 30.6 million people is settled in these areas (DANE 2015), which is equivalent to 63% of the Colombian population. The potential TDF cover in Colombia is 8.9 million ha, of which only 3.8% is conserved in its natural condition (Pizano & García 2014). Considering the possibility that climate change may alter the delimitation of the TDF, for this study, the territory was expanded to include areas with a total annual precipitation between 0 and 2100 mm and located at a maximum elevation of 1800 m (Fig. 1). TDF areas of the Eastern Plains (Casanare and Arauca) and insular Caribbean (San Andrés and Providencia) were not considered for this study due primarily to the presence of soils with laterite shields, which limit the potential vegetation (Pizano & García 2014) and secondly to the absence of primary information.

Collection of primary and secondary information —. During the 2009-2015 period, 1200 hours were spent gathering primary information, with 60 persons being directly or indirectly involved during 57 field trips. The areas explored included the TDF of the Cauca River Valley, the dry enclave of the Dagua River, the Patía River Valley, south of the Magdalena Valley, the Caribbean region and the department of Santander. More than 200 linear km were covered *ad libitum* with two or more expert observers, who used 8 x 40 binoculars to locate canopy orchids. The final expeditions were defined using the map of TDF in Colombia (Ariza *et al*. 2014) (Fig. 1).

In addition, geographic information was gathered from specialized scientific literature and botanical specimens deposited in the following 15 national and international herbaria: CUVC: Valley University, Cali; VALLE: National University, Palmira; TULV: Botanical Garden Juan María Céspedes Herbaria, Tuluá; CAUP: Cauca University, Popayán; CDMB: Eloy Valenzuela Botanical Garden, Floridablanca; COL: National Colombian Herbaria, Bogotá; FMB: Alexander von Humboldt Institute, Villa de Leyva; HUC: Córdoba University, Montería; Guillermo Piñeres Botanical Garden, Cartagena de Indias; UIS: Industrial University of Santander, Bucaramanga; UTMC: Magdalena University, Santa Marta; HPUJ: Pontifical Xavieriana University, Bogotá; Quindío University, Armenia; BC: Botanical Institute of Barcelona, Barcelona; and AMO: Mexican Association of Orchidology, México D.F. The data collected were sufficient for niche modeling and also improved the knowledge of the distribution range of these plants in areas of TDF in Colombia.

Orchid selection —. In total, 12 "*core*" species typical of TDF orchids in Colombia were selected; their classification and distribution ranges are shown in Appendix 1. Information from collections and/ or field observations, as well as from the herbarium sheets, was compiled in a Darwin core format database (Wieczorek *et al.* 2012) available at http://rs.tdwg.org/dwc. This database consists of the 439 records were used to generate the model. The database also contains 314 aditional records of TDF orchid species different from the "*core*" species, as well as additional information, yielding a total of 753 records. Parts of these records are currently published as biological data sets in the form of three data sets; orchid associated flora-phorophytes, orchids observed in the field and orchids identified in herbaria which can be consulted in: http://i2d.humboldt.org.co/ceiba/resource.do?r=rrbb_bst_orquideas_2015; http://i2d.humboldt.org.co/ceiba/resource.do?r=rrbb_bst_orquideas_observaciones_2015 http://i2d.humboldt.org.co/ceiba/resource.do?r=rbb_bst_orquideas_identificaciones_2015

The selection criteria for these species were as follows: a) more than 18 records per species are required for greater reliability with MaxEnt; b) records were within the five areas of potential TDF delimited for Colombia; c) georeferenced records that occupy the same 1 × 1 km pixel were excluded to prevent over-estimation (over-fitting) in the model and to permit good discrimination between presences and pseudo-absences (Isaac *et al.* 2009, Van der Wal *et al.* 2009); d) species were geographically representative and complementary in TDF areas in Colombia such that they were present in most of the five areas studied. These characteristics are associated with the TDF species. Among the selected species, *Trizeuxis falcata* Lindl. has flattened and streamlined shapes to reduce the effects of the wind; *Cyrtopodium paniculatum* (Ruiz & Pav.) Garay and *Catasetum tabulare* Lindl. have large pseudobulbs and lose their leaves when the dry season is prolonged; *Epidendrum rigidum* Jacq., *Trichocentrum carthagenense* (Jacq.) M.W. Chase & N.H. Williams and *Polystachya foliosa* (Hook.) Rchb. have leathery leaves with thick cuticles to prevent water loss; *Vanilla calyculata* Schltr. has swollen stems to store a greater volume of water; and *Scaphyglottis prolifera* (Sw.) Cogn. has multiple elongated pseudobulbs as a strategy for water storage.

Modelling algorithm —. For modelling, the maximum entropy algorithm was used in the application MaxEnt (Elith *et al.* 2006, 2011, Phillips *et al.* 2006, Phillips & Dudík 2008). This algorithm uses maximum entropy and Bayesian methods to estimate the probability distribution of each species based on their presence or absence and pseudo-absences, which are defined as areas where presence or absence of the species is uncertain. The algorithm used by MaxEnt is one of the most robust models of species distribution (MSD) in terms of successfully estimating the area from only a few records of presence (Hernández *et al.* 2006), as occurs with most tropical epiphytes. MaxEnt has been widely tested for species idoneity in both present and future conditions (Merow *et al.* 2013, Phillips 2008, Reina-Rodríguez *et al.* 2016) and has been used with actual species from more than ten locations (Ramírez-Villegas *et al.* 2014, Wiz *et al.* 2008). In this study, to avoid *over-fitting* (Barbet-Massin *et al.* 2012), 2120 pseudo-absences were included, with ten for each presence obtained from our database (herbaria data and fieldwork) in TDF-delimited areas.

Given that a species can migrate and occupy new locations under future climatic conditions, we consider that by limiting the study area up to 1800 m and precipitation to 2100 mm/year, the thresholds of commission (too far from the niche of the taxon) and omission (lack of observations) are assumed implicit in the areas and periods proposed in this study.

Selection and preparation of modelling variables

For modelling, the potential niche or *habitat idoneity* is understood as the *n*-dimensional area where the species encounters the conditions that allow its survival and reproduction (Wiens *et al.* 2009). A total, 19 variables correspond to bioclimatic parameters associated with the baseline annual temperature and precipitation characteristics (1950-2000) (Hijmans *et al.* 2005) were selected. The other three variables were altitude, taken from the Digital Elevation Model (DEM) at 1 km (Jarvis *et al.* 2004); forest cover (Hansen *et al.* 2013); and accessibility, measured as time in minutes to get to a town of over 50,000 inhabitants, which was taken from the Joint Research Centre, available at http://ec.europa.eu/jrc/. Additional factors considered were the availability of free-access climatic data, a spatial resolution of 1 km and spatial cover. Large number of predictors in MaxEnt may cause excess in the

TABLE 1. Variables selected for the modelling of present and future scenarios. Bold indicates the seven variables selected by means of the Variance Inflation Factor (VIF) < 10. The (*) indicates variables excluded by low percentage contribution in the first iteration according to the model.

Variable	Brief Description	Unit of Measure	Source	VIF
Bio 2*	Average daytime temperature range	Degrees centigrade	Hijmans 2005	1.6
Bio 3	Isothermality. Index of temperature variability	Reason for average diurnal range with respect to annual range		3.5
Bio 4	Temperature seasonality	Standard deviation * 100		2.2
Bio 8	Average temperature of the wettest trimester	Degrees centigrade		2.2
Bio 13	Precipitation of the wettest month	Millimetres		2.3
Bio 14	Precipitation of the driest month	Millimetres		3.7
Bio 18*	Precipitation of the warmest trimester	Millimetres		1.5
Bio 19*	Precipitation of the coldest trimester	Millimetres		0.7
Tree cover	Forest cover	Percentage of area	Hansen 2013	2.1
Acc	Accessibility to population centres of more than 50,000 inhabitants	Time in minutes	Joint Research Centre	3.5

fit (*over-fitting)*, thereby skewing the responses (Warren & Seifert 2011). To reduce the number of variables, the Variance Inflation Factor statistical technique (VIF) was applied, which consists of a multiple regression analysis to identify the least co-linear variables among them, or, in other words, to determine which variables do not depend on others. The value VIF<10 (Montgomery *et al.* 2006) was used as a maximum threshold to reduce the number of variables for discarding in subsequent modelling routines (Austin & Van Niel 2011, Montgomery *et al.* 2006). This preliminary analysis reduced the number of variables to be used from 22 to 10. The Table 1 shows these variables used for performing the final routines for the climate of the present, near future (2030) and distant future (2050).

For modelling potential niches under climate change conditions, altitude and accessibility variables remained fixed. Forest cover was adjusted to an annual deforestation rate of 2% for 2030 and 4% for 2050, which was based on the current value reported in Colombia of 200,000 hectares per year (Reymondin *et al.* 2010). Climatic variables were taken from the projections conducted by the IPCC (2013), and the RCP 8.5 emission scenario of the fifth assessment report (AR5) was chosen for this study, specifically the projections for the 2020-2049 and 2040-2069 periods, referred to in this study as 2030 and 2050, respectively. This scenario was chosen because it represents the most likely path of events related to the production of greenhouse gases (GHG) emitted by the energy, industry, agriculture and forestry sectors, and it also combines interdisciplinary models that operate at different spatial resolutions and are interrelated and integrated into an overall evaluation framework (Riahi *et al.* 2007). The RCP 8.5 scenario predicts an increase of 2.7°C in average temperature and a change of 20% annual precipitation by the year 2069 and resembles the projections for Colombia conducted by IDEAM (2015) for the period 2041–2070.

Evaluation of model performance, behaviour and results

Three statistical methods were used to evaluate the quality and performance of the models obtained. Testing values for the area under the curve (AUC) indicate the ability of the model to discriminate presences from absences. AUC values oscillate between 0, which indicates randomness, to 1.0, which indicates greater discrimination (Engler *et al.* 2004); values of AUC<0.7 indicate poor models; values 0.7>*x*<0.9 indicate moderately useful models; and *x*>0.9 indicate excellent models (Pearce & Ferrier 2000). The Cohen's *Kappa* index was also calculated, which assesses the effect of randomness in associating observed objects to a specific classification category (Viera & Garret 2005). Concordance was thus identified from the results of the 25 iterations performed through *cross-validation* (Hijmans *et al.* 2012), using the sensitivity threshold *Maximum test sensitivity logistic threshold* as a reference (Liu *et al.* 2013). The model fit from the *Kappa* value was estimated by following the ranges proposed by Monserud & Leemans (1992) (See Appendix 2).

The spatial distribution patterns of orchids obtained for present and future conditions were quantified and compared to each other by identifying, for the entire study area, the potential gain or loss of the areas in which these species occur. To explore conservation strategies, this quantification also considered regional conglomerates of TDF, administrative units (Departments) and the Protected Areas listed in the Only National Register of Protected Areas (Registro Único Nacional de Áreas Protegidas – RUNAP) and in the Private Reserves of Civil Society (Reservas Privadas de la Sociedad Civil –NRCS), all of which have influence on the TDF areas throughout Colombia.

Idoneity indices —. Indices have been frequently used to estimate spatiotemporal changes (Armenteras *et al.* 2006, Mcgarigal & Marks 1995, Reina-Rodríguez & Soriano 2008, Rudas *et al.* 2002). In this study, three indices of idoneity were calculated for the 2030 and 2050 periods to assess the magnitude of future changes that can promote understanding of the spatiotemporal dynamics.

Index of tropical dry forest orchids IoBsT

This index represents the national magnitude of future idoneity, *IoBsT*_30 and *IoBsT*_50, compared to the present total idoneity.

$$IoBsT = \frac{Suitability_{t30,t50}}{Total\ Suitability_{tPresent}} * 100$$

Bioregional index of Tropical Dry Forest orchids IoBioreg

This index expresses the bioregional magnitude of future change, *IoBioreg*_30 and *IoBioreg*_50, with respect to the value of present idoneity in the bioregion in question.

$$IoBioreg = \frac{Suitability_{t30,t50}}{Suitability\ Bioregion_{tPresent}} * 10$$

Severity index of tropical dry forest orchids IoShp

The severity index expresses the strength or intensity of change. It is the ratio of the present idoneity with respect to the value of future idoneity, *IoShp*_30 and *IoShp*_50, in the bioregion in question.

$$IoShp = \frac{Suitability\ Bioregion_{tPresent}}{Suitability_{t30,t50}}$$

Proposal of bioclimatic niches —. Factors such as the persistence of certain species under climate change, migration speed, ecotones, immigration potential, and spatiotemporal plant-pollinator relations are excluded from predictive studies (Ibáñez 2006). Given that the current model generation does not consider factors that may increase biological realism and therefore approximation in future predictions (Urban 2015), *a posteriori* evaluations were proposed for the models obtained to identify where refuge areas for these plants would be in the Colombian TDF. A previous selection criteria filtered areas by river basins, with *p*>0.61 for the model obtained for the 2050 period. Subsequently, a Geographic Information System (GIS) and expert judgment were used to evaluate biotic and abiotic conditions complementary to the model. The biotic conditions were a) composition of the flora, b) presence of pollinators and c) presence of mycorrhizae. The abiotic conditions were a) altitudinal gradient, b) relief and c) distance to Protected Areas (PA and NRCS) and TDF fragments.

It was verified in 25% of the points, the presence of flora associated with at least three of the phorophytes reported in Table 2, were present within a radius of 23 km. From the biotic approach, wasps and bees are responsible for the transport and pollination of 60% of *Orchidaceae* (Ackerman 1983, Camargo *et al.* 2006, Whitten *et al.* 1993, Williams 1982). Large pollinators,

Table 2. Biotic and abiotic conditions evaluated for locating climatic niches proposed as a refuge for orchids of the Tropical Dry Forest (TDF) in Colombia.

Biotic conditios	**Requirements**
a) Composition of flora	Presence of at least three of these phorophytes: *Pseudobombax septenatum, Anacardium excelsum, Luehea seemannii* Planch. & Triana, *Guarea guidonia, Guazuma ulmifolia, Brosimum alicastrum, Calliandra pittieri, C. magdalenae, Samanea saman, Tetrorchidium rubrivenium* Poepp., *Guapira cf. costaricana* (Standl.) Woodson, *Ficus insipida, Erythroxylum ulei* O.E. Schulz, *Maclura tinctoria* (L.) D. Don ex Steud., *Crescentia cujete, Machaerium capote, Caesalpinia punctata* Willd., *Psidium guajava, Erythrina poeppigiana, Poulsenia armata* (Miq.) Standl., *Astronium graveolens* Jacq., *Sterculia apetala* (Jacq.) H.Karst and *Daphnopsis americana* (Mill.) J.R. Johnst.
b) Presence of pollinators	Presence of Euglossini bees (Hymenoptera: Apidae) such as *Eulaema*, *Euglossa, Eufriesea* and *Exaerete*. Thresholds less than 23 linear km are reached by these bees (Dressler 1982, Janzen 1971). Therefore, orchids and other TDF plants are also reached.
c) Mycorrhizae	Molecular studies of orchid-fungal associations, which indicate geographic range of mycorrhizal fungi are much larger than the range of the orchids themselves (Phillips *et al* 2014). Therefore we consider that forests of more than 10 ha and physiognomically well structured, harbor the mycorrhiza necessary for the development of seedlings.
Abiotic conditions	**Requirements**
a) Altitudinal gradient	Availability of 175 to 350 metres of altitudinal gradient in the next 25 to 50 years to compensate for an increase in temperature and possible extinctions (Feeley 2011, Lutz *et al.* 2013)
b) Relief	Moderate to very steep slopes. Presence of deep channels (canyons) with vegetated bottoms and slopes. Presence of rocky formations with cavities. Establishment of agriculture or population centres is not possible.
c) Distance to protected areas and/or fragments of TDF forest. Size of fragmented forest patches.	According to the TDF map (IAvH 2014) and the only national record of protected areas (RUNAP). Dense forest cover or sub-xerophytic shrubland greater than 10 ha (Harris 1984).

such as Euglossini bees (Hymenoptera: Apidae), have foraging routes up to 23 km long (Janzen 1971). Orchids pollinated by genera *Eulaema* Lepeletier, *Eufriesea* Cockerell, *Exaerete* Hoffmannsegg and *Euglossa* Latreille, can thermoregulate allowing them to fly under conditions of low humidity and high temperature, which are typical of open spaces (Janzen 1974, May & Casey 1983, Roubik 1993). They are present from Mexico to Argentina in several types of dry and semi-deciduous ecosystems (Rebêlo & Garófalo 1997), humid forests (Roubik & Ackerman 1987, Sandino 2004) and Amazonian forests (Becker *et al.* 1991). These pollinators ensure genetic variability through cross-pollination increasing the chance of surviving environmental changes and also migrate along altitudinal gradients from the lowlands to highlands in response to temperature increases and resource availability (Uehara-Prado & Garófalo 2006). This evolutionary adaptation gives this group of insects a key role under climate change conditions because in a short-term climate change effects are not expected for this group of organisms (Roberts 2003).

Emerging evidence from other molecular studies of orchid-fungal associations, indicate that geographic range of mycorrhizal fungi appears to be typically much larger than the range of the orchids themselves. (Phillips *et al.* 2014). For the analysis, we consider that forests of more than 10 ha and physiognomically well structured, harbour the orchid mycorrhiza necessary for the development of seedlings.

Results

Current knowledge of the orchids of TDF in Colombia —. Preliminary data of Orchidaceae in the TDF of Colombia indicate that 53 species exist in the Caribbean bioregion at altitudes <1000 m (Betancur *et al.* 2015); 127 species in the Santander bioregion (Martínez *et al.* 2015); 73 species in the Magdalena Valley (Bernal *et al.* 2015), with data mainly from the north (Antioquia) with gaps towards the south (Huila, Tolima); and 70 species in the Cauca River Valley (Reina-Rodríguez *et al.* 2010). According to our data on the Patía Valley,

Table 3. Representativeness of the selected species in the Colombian Tropical Dry Forest (TDF) . In *each cell,* the number of *records* of the species from the database generated for all Colombia is shown. Numbers in bold are higher than the average. PV= Patia river valley, CV= Cauca river valley, MV= Magdalena river valley, SR= Santander region, CR= Caribbean region.

	Regions of tropical dry forest (Bs-T) in Colombia					
Species	**PV**	**CV**	**MV**	**SR**	**CR**	**Total species records**
Brassavola nodosa (L.) Lindl	0	0	3	4	20	27
Catasetum tabulare Lindl	14	11	2	0	1	28
Cyrtopodium paniculatum (Ruiz & Pav.) Garay	7	13	2	5	28	**55**
Dimerandra emarginata (G. Mey.) Hoehne	1	25	2	9	13	**50**
Epidendrum rigidum Jacq.	3	19	6	2	2	32
Jacquiniella globosa (Jacq.) Schltr	0	23	4	2	2	31
Oeceoclades maculata (Lindl.) Lindl	7	6	5	11	19	**48**
Polystachya foliosa (Hook.) Rchb.f.	0	14	6	2	4	26
Scaphyglottis prolifera (Sw.) Cogn.	0	21	5	6	2	34
Trichocentrum carthagenense (Jacq.) M.W. Chase & N.H. Williams	1	19	3	5	12	**40**
Trizeuxis falcata Lindl.	7	22	8	12	1	**50**
Vanilla calyculata Schltr.	4	12	1	0	1	18
Total regional records	45	**185**	48	56	**105**	439

orchids species would not exceed 30 species. This group would be the most vulnerable to the effects of Climate Change due to the total absence of conservation areas.

The database compiled in the Darwin core contains 439 records of orchids from the Colombian TDF, of which, 276 correspond to herbarium collections, 159 to direct observations and four to bibliographic sources. Data indicate the presence of these taxa in five TDF areas in Colombian territory. The TDF map for Colombia, which was elaborated by the Alexander von Humboldt Institute (Ariza *et al.* 2014) and discussed by Pizano & García (2014), places the TDF ecosystem in Colombia in 22 departments and 314 municipalities. Concerning our 12 focal orchids support the presence of these plants in 19 departments and 118 municipalities. In other words, slightly more than half of the municipalities (196) lack records for these species, suggesting important geographical information gaps. By bioregion, the Cauca River Valley and the Caribbean region have higher than average values. The Patía River Valley and Magdalena River Valley have the poorest values. The representativeness of each 'core' species of the TDF is shown in Table 3.

Evaluation of the model and influencing variables —. From the filtering of the 439 records of our database, 212 points (one record per pixel of 1 km^2) were selected for these training tests. The AUC values for training tests of the twelve species ranged between 0.8562 and 0.8641, with x'=0.8598, whereas the test data ranged between 0.6702 and 0.9721, with 0.8126. AUC data for future periods yielded a value of 0.8825, and those from the test yielded 0.7570. Because the values have an AUC>0.7, the model is considered *'very good'* (Pearce & Ferrier 2000) and is consistent for species discrimination. The Kappa index demonstrates model performance and compares model prediction to random prediction (Naoki *et al.* 2006). In other words, it is a measure to assess the random effect and its concordance with what is observed. For our analysis, the degree of agreement is 0.85, which is within the $0.85 \leq K < 0.99$ range and qualifies it as *excellent* according to (Monserud & Leemans 1992), which indicates a high degree of agreement; therefore, the data used in the modelling can be regarded as reliable.

The most important variables in the model were the seasonality of temperature **Bio 4**, which explained

Table 4: *Bioclimatic niches* for the 2050 period and proximity to tropical dry forest (TDF) areas (Ariza *et al.* 2014), public protectec areas (PA) and private protected areas (NRCS) in the five bioregions of TDF in Colombia.

Bioregion	**(a) Number of basins with suitability areas $p > 0.61$**	**Suitability areas $p > 0.61$ (ha)**	**(b) No. Polygons of TDF < 23 km (ha)**	**Areas of TDF < 23 km (ha)**	**(c) No. PA < 23 km**	**Area of PA < 23 km (ha)**	**(d) No. NRCS < 23 km**	**Areas of NRCS < 23 km (ha)**	**Altitudinal range: (a-b); (a-c); (a-d) (meters)**
Cauca River Valley	13	115,256	239	28,111	25	62,571	23	946	629-1796
Caribbean Region	8	4756	91	76,436	0	-	2	446	0-1485
Magdalena Valley	15	49,061	157	63,848	16	33,320	4	13	237-1790
Patía Valley	1	9299	10	1.186	0	-	0	-	612-1443
Santander Region	8	9235	112	76,205	11	57,236	0	-	154-1798
Total	**45**	**187,607**	**609**	**245,786**	**52**	**153,127**	**30**	**1405**	**0-1798**

26.9%; the average temperature of the wettest trimester **Bio 8**, which explained 22.9%; and isothermality **Bio 3**, which explained 3.5%. These variables account for a total of 53% of the thermal influence and, consequently, the altitudinal influence in the model explanation. Accessibility to population centres of more than 50,000 inhabitants contributed 35.1%, which suggests a negative anthropogenic influence from proximity to urban and populated areas to locations where populations of orchids are found. Precipitation of the wettest month **Bio 13** explained 2.3%, and precipitation of the driest month **Bio 14** explained 3.7%, together add up to 6% of the explanation being influenced by the contribution of water seasonality to the model, is obviously indispensable for epiphytic and terrestrial orchids in terms of their physiological requirements, with the orchids depending on water reserves held in their specialized morphological structures. Finally, the forest cover explained 2.1%, which demonstrates the importance of a defined forested structure and, more specifically, the need for suitable phorophytes for the establishment of orchids.

Altitudinal migration of tropical dry forest orchids —. Data points obtained from the modelling totalled n=16,547, with idoneity $p>0.61$ and a pixel size of 1 km^2. The ANOVA results indicated statistically significant differences among the different combinations of the periods analysed (present–2030, present–2050 and 2030–2050) with $p<0.05$, showing drastic changes between the periods and also bioregion in the altitudes required by these plants, which are attributed to the effect of climatic change, reflecting the areas suitable for orchids in TDF for the next 50 years (see Appendix 3). The Caribbean region would be at approximately 954.3±141.1 SD m during the 2050 period, while the bioregion of the Cauca River Valley for the same period would be at 1393.6±183.4 SD m, identified as a suitable altitude under future climate scenarios according to the model. In the Caribbean bioregion, the availability of area will be concentrated at the Sierra Nevada of Santa Marta where net idoneity and forest cover still exists in 6 basin (see Appendix 5). At the other extreme, the suitability for orchids in the Cauca River Valley there is availability of areas and altitude gradients found below 15 km distance of the current populations in both the Dagua Canyon and Cauca River Valley; however, anthropogenic factors limit the coverage required for the establishment of these plants (Reina-Rodríguez *et al.* 2016).

On the other hand, the Patía and Santander bioregions show similarities in the 2030 period (1121.3±174.3 SD m and 1140.9±166.7 SD m, respectively) and the 2050 period (1269.7±147.1 SD and 1275.5±150.6 SD, respectively) in the altitudinal suitability requirements for both periods and also

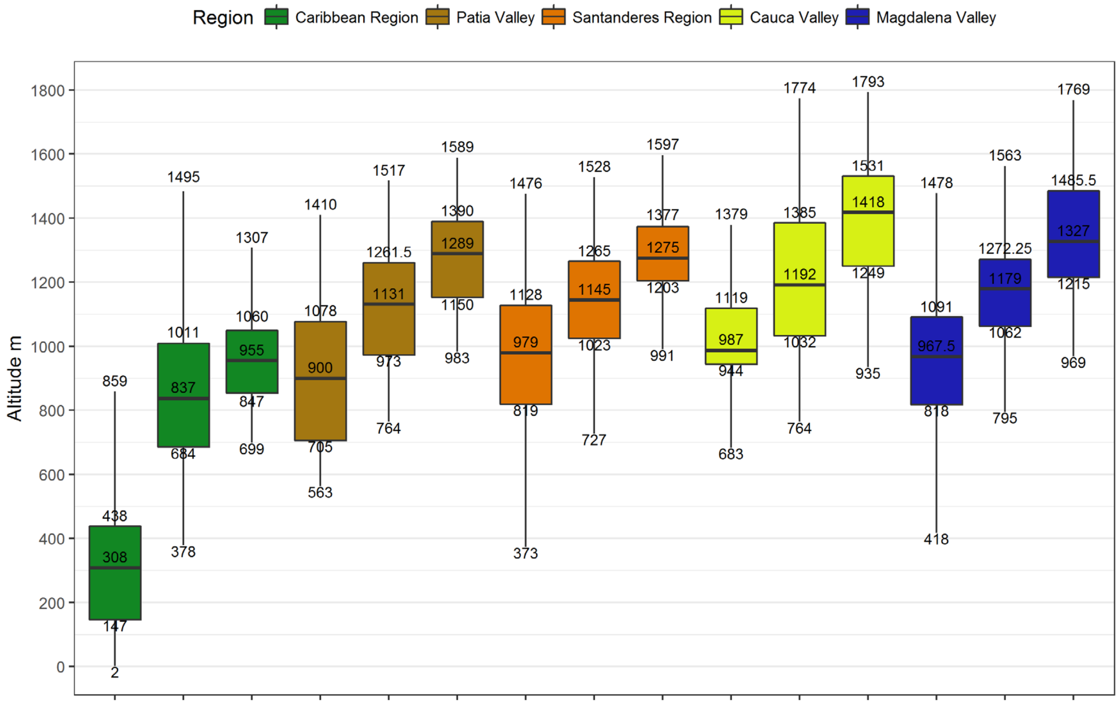


FIGURE 2. Altitudinal and temporal spectrum of suitability by bioregions for 12 species of orchids of Tropical Dry Forest (TDF) in Colombia. 1st position of the series=Present, 2nd=2030 and 3rd=2050. *Caribbean Region:* Present (*n* = 460), 2030 (*n* = 286) and 2050 (*n* = 60). *Patía River Valley:* Present (*n* = 380), 2030 (*n* = 173) and 2050 (*n* = 115). *Santander Region:* Present (*n* = 1510), 2030 (*n* = 471) and 2050 (*n* = 110). *Magdalena river Valley:* Present (*n* = 1644), 2030 (*n* = 544) and 2050 (*n* = 585). *Cauca river Valley:* Present (*n* = 6599), 2030 (*n* = 2128) and 2050 (*n* = 1482).

coincide in terms of the minimum size of suitable area (9299 ha and 9235 ha areas p>0.61 respectively see Table 4), suggesting similar dispersal patterns and possible convergent management strategies.

In a comparison of the SRES-A2 emission scenario of climate change obtained for the Cauca Valley for the 2100 period by Reina-Rodríguez *et al.* (2016) with the RCP 8.5 emission scenario used in this manuscript, the altitudinal suitability in the last quartile (25% of the data) of the SRES-A2 is between 1210 and 1470 m and is more similar to the second and third quartile (50% of the data) of the RCP 8.5, with a suitability range of 1220–1500 m for the 2050 period. Some overlap was found between the suitability of areas of the Western Cordillera and north of the Cauca River Valley; however, most of the suitability for the RCP 8.5 scenario changes from the eastern slope of the Western Cordillera to the western slope. This change is mainly attributed to the scenario used and a greater humidity on the Pacific slope than on the Cauca slope.

Figure 2 shows altitudinal suitability as a probability of occurrence for present and future conditions for orchids in the five bioregions. Fifty percent of the areas under present conditions are concentrated in the altitudinal range of 900–1100 m; however, for the 2030 climate change period, 50% of the data are concentrated between 1000 and 1300 m, with 25% between 1300 and 1700 m. For the 2050 climate change period, 50% of the data is concentrated between 1200 and 1500 m, with 25% between 1500 and 1800 m. Evidence of a shift towards higher areas of elevation in all the bioregions is evident when comparing periods.

Changes in spatial and temporal distribution —. The results of the model generated with p>0.61 project a drastic decline in suitability for orchids in all TDF areas in Colombia. The nearly 1,000,000 ha that are TDF orchids currently potential suitable area would be reduced to less than 240,000 ha during the 2050 period (see Table 5 and Figure 3).).

Table 5: Extent (ha) based on suitability ($p>0.61$) for orchids of the Tropical Dry Forest (TDF) in Colombia. The values are discriminated by bioregions and departments for three periods (Present, 2030 and 2050). *minimum extent.

Bioregion	**Hectares**			**Net gain/loss (Hectares)**	
	Present	**2030**	**2050**	**2030**	**2050**
Cauca River Valley					
Antioquia	13,038	19,773	18,909	6735	5871
Caldas	173	0	0	-173	-173
Quindío	28,666	5353	2245	-23,313	-26,421
Risaralda	20,032	0	0	-20,032	-20,032
Cauca Valley	493,280	166,038	106,979	-327,242	-386,301
Subtotal	**555,189**	**191,164**	**128,133**	**-364,025**	**-427,056**
Caribbean Region					
Atlantic	259	0	0	-259	259
Bolívar	2159	0	0	-2159	2159
Cesar	6476	18,737	6735	12,261	-259
Córdoba	2849	0	0	-2849	2849
La Guajira	1813	2936	86	1123	-1727
Magdalena	18,391	4576	86	-13,815	-18,305
Sucre	14,074	173	0	-13,901	-14,074
Subtotal	**46,021**	**26,422***	**6,907***	**-19,599**	**-39,114**
Magdalena Valley					
Cundinamarca	70,543	29,184	45,762	-41,359	-24,781
Huila	68,816	20,204	11,570	-48,612	-57,246
Tolima	17,700	9152*	7080*	-8548	-10,620
Subtotal	**157,059**	**58,540**	**64,412**	**-98,519**	**-92,647**
Patía Valley				0	0
Cauca	57,246	23,399	21,759	-33,847	-35,487
Nariño	7253	950*	0*	-6303	-7253
Subtotal	**64,499**	**24,349***	**21,759***	**-40,150**	**-42,740**
Santander					
North of Santander	8548	21,500	6907	12,952	-1641
Santander	130,033	28,148	6303	-101,885	-123,730
Subtotal	**138,581**	**49,648**	**13,210***	**-88,933**	**-125,371**
				0	0
Total	**961,349**	**350,123**	**234,421**	**-611,485**	**-727,187**

A reduction of 63.3% (-609,196 ha) suitability is expected for the 2030 period compared to the present, and a reduction of 75.6% (-724,878 ha) for 2050. The minimum suitability area in the Caribbean Region is 26,422 ha, and in the Patía Valley, 24,349 ha for the 2030 period. For the 2050 period, the minimum suitability for the Caribbean Region is 6907 ha; for the Santander region, 13,210 ha; and for the Patía Valley,

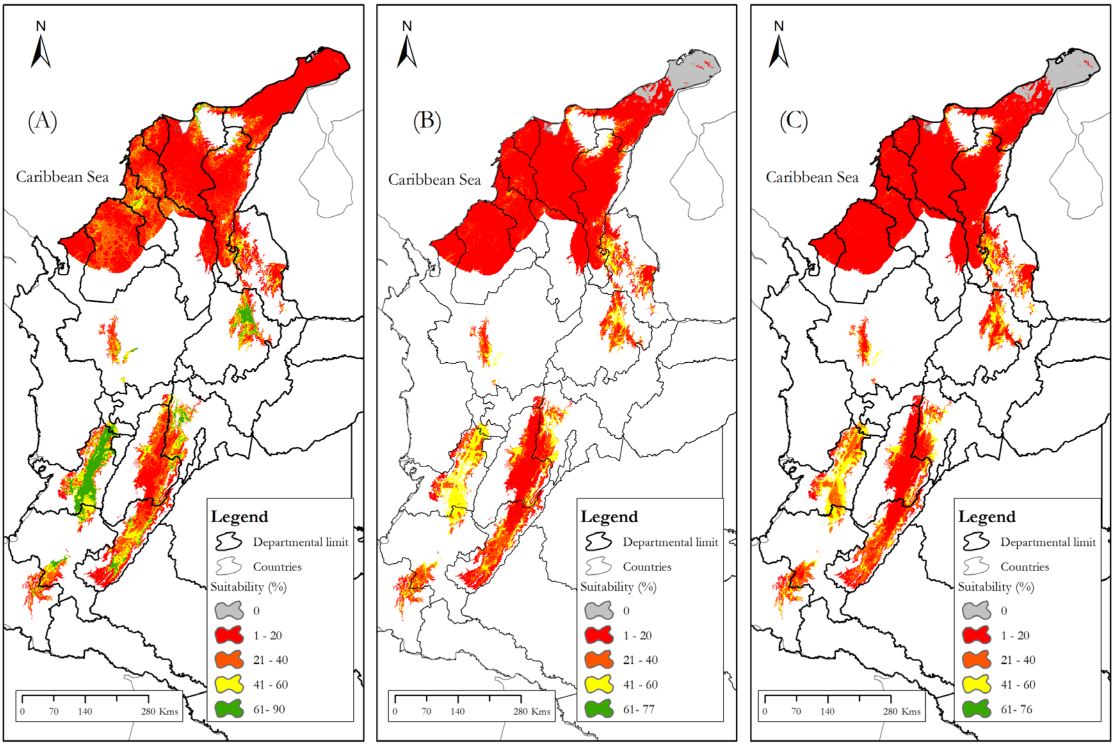


FIGURE 3. Suitability of Tropical Dry Forest (TDF) in Colombia for 12 studied orchid species. A) Present, B) 2030 and C) 2050. Red indicates areas of lower suitability and green areas of greater suitability.

21,759 ha. The values for each bioregion and the departments they comprise are shown in Table 5**.** The particularities and highlight events of every bioregion are discussed in Appendix 4.

Bioclimatic niches a bet for the future —. The bioclimatic niches proposed here are areas that include: a) suitable areas (p>0.61) for the future according to our model; b) areas that maintain patches of TDF within or nearby (less than 23 km); c) public or private currently protected areas (PA and NRCS) within or nearby (less than 23 km). The climatic niches would be suitable as a thermal refuges and for the altitudinal migration of flora and fauna of an area or bioregion under climate change conditions. The set of present and suitable areas, as well as the spatiotemporal ecological dynamics that occur there, would constitute this new landscape management unit. Since their inception, they are integrated into altitudinal migration corridors (AMC; see Reina-Rodríguez *et al.* 2016) and are susceptible to monitoring and management by the environmental authorities.

In Colombia, 45 basins with bioclimatic niches for the TDF ecosystem were detected at p>0.61, as shown in Table 4 and figure 4, which include 609 TDF polygons, with 52 public protected areas (PA) and 30 private protected areas (NRCS), located between 0 and 1798 m and spreading on 187,604 ha. Due to the lack of protected areas with the traits above mentioned in the Caribbean and Patía Valley bioregions, eight more areas are proposed. These areas share abiotic characteristics such as steep slopes, rock formations or relief forms that are unsuitable for agriculture and livestock, forming natural barriers for the permanent establishment of TDF cover. A total of 69 bioclimatic niches (45 net areas, 16 complementary and 8 below the threshold p=0.61) (see figure 4), based on the concept are listed in Appendix 5, and more information of interest for its management.

For the **Cauca River Valley**, 13 basins with p>0.61 for the occurrence of bioclimatic niches are proposed, which showed proximity to 239 TDF polygons, 25 PA and 23 NRCS less than 23 km away, lying within the altitudinal ranges of 629–1796 m (see Table 4 and

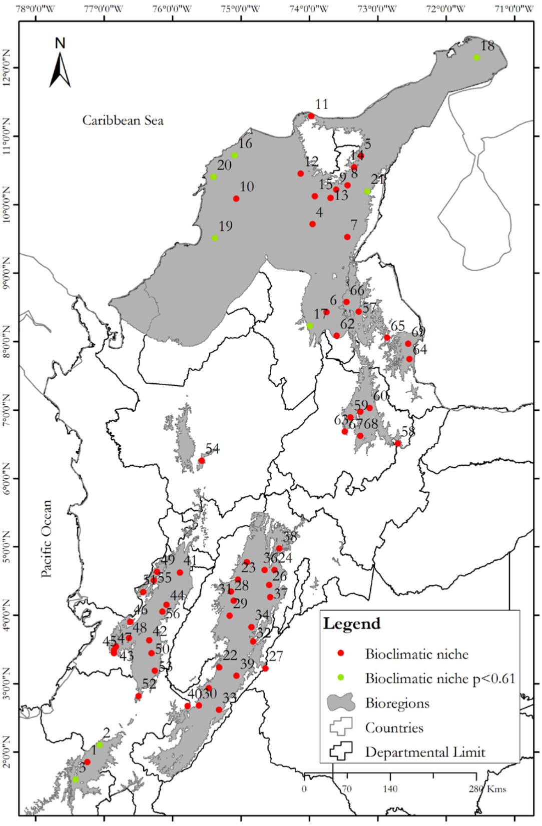


FIGURE 4. Locations of basins with the presence of bioclimatic niches and complementary areas with $p<0.61$ based on modelling of Tropical Dry Forest (TDF) orchids for the period 2050.

Appendix 3). These data target areas for management and conservation under climate change conditions. TDF orchids with narrow altitudinal distribution such as *Encyclia betancourtiana* Carnevali & I. Ramírez, *E. chloroleuca* (Hook) Neumann and *Pleurothallis aryter* Luer, as well as endemics or those at the maximum of their altitudinal distribution such as *Cattleya quadricolor* Lindl., *Catasetum tabulare* and *Vanilla calyculata,* would require special monitoring under climate change.

Important areas for the future conservation of these plants will be on both slopes of the Western Cordillera and on the eastern slope of the Central Cordillera of the Cauca and Risaralda Valley, as well as on the northern flank of the Western Cordillera in the department of Antioquia (see Appendix 3). Maintaining connectivity is essential between the orchid flora of the Chocó biogeographic region and the Andes through the relict, sub-xerophytic, sub-Andean forest-dry shrubland forest existing on both slopes of the Western Cordillera, especially to conserve the richness of these plants, the existing endemics and the gene flow occurring there. New species recently described and others under study (García-Ramírez & García-Revelo 2013, Leopardi *et al.* 2014) justify management strategies and investment in conservation.

For the **Caribbean** bioregion, 8 basins are proposed with $p>0.61$ for the occurrence of bioclimatic niches, mainly along the three slopes of the Sierra Nevada de Santa Marta, with close to 91 polygons of TDF, but these polygons include no PA and only two NRCS (private areas) at less than 23 km; the altitude ranges from 0–1485 m (see Table 4 and Appendix 3). Because of the low suitability of the Caribbean bioregion, the consideration of the six areas below the established threshold of $p=0.61$ is reasonable. This would include the rolling hills and limestone cliffs up to 800 m such as the Montes de María between the Sucre and Córdoba departments, which have suitability values of $p=0.26$; the precoastal hills of the Cartagena de Indias at 170 m with $p=0.07$; the Serranía de Piojó (Atlantic) with elevations up to 350 m and $p=0.13$; the Serranía de San Lucas (Bolívar) with altitude ranging from 60–1617 m and $p=0.02$; the Serranía de Macuira with altitude up to 1000 m (Guajira) and $p=0.0$; the Serranía de Perijá (Cesar) with $p=0.03$; and the northern part of the Western Cordillera (*ex.* PNN Paramillo, Córdoba), which has a wide altitudinal range of 350–3960 m, as well as the presence of important phorophytes for orchids of the bioregion such as *Anacardium excelsum* (Bertero ex Kunth) Skeels, *Brosimum alicastrum* Sw., *Pseudobombax septenatum* (Jacq.) Dugand, *Guazuma ulmifolia*, *Samanea saman* and *Attalea butyracea* (Mutis ex L.f.) Wess.Boer (Patiño-Uribe *et al.* 2002, Sugden 1981). The presence of threatened fauna such as the cotton-top tamarin *Saguinus oedipus* L., endemic to Colombia and categorized as critically endangered (CR) (Savage & Causado 2008), demonstrates the enormous value of these areas for conservation purposes and that they have sufficient weight for being proposed as sites for bioclimatic niches in the Caribbean region. Orchids of importance in the area include *Encyclia cordigera* (Kunth) Dressler, *Cyrtopodium paniculatum* and *Trichocentrum nudum* (Bateman ex Lindl.) M.W. Chase & N.H. Williams, as well as others with a more restricted distribution such as *Mormodes cartonii* Hook., which would require special monitoring under climate change conditions.

For the **Magdalena Valley** bioregion, 15 basins with p>0.61 for the occurrence of bioclimatic niches are proposed. This is the highest value in Colombia and has 157 TDF polygons, 16 PA and four NRCS less than 23 km away and within the altitudinal range of 237–1790 m (see Table 4 and Appendix 3). Magdalena Valley has the following preferred phorophytes for orchids: *Anacardium excelsum, Attalea butyracea, Guazuma ulmifolia, Albizia guachapele* (Kunth) Dugand*, Samanea saman, Calliandra pittieri, Guarea guidonia* (L.) Sleumer*, Machaerium capote* Dugand and *Trichilia pallida* Sw. (Pizano & García 2014). The valley also has a significant number of basins with areas suitable for bioclimatic niches along both the western slope of the Eastern Cordillera and the eastern slope of the Central Cordillera. All of these basins hold the possibility of a migration event. Representative orchids in the area are *Dimerandra emarginata* (G. Mey.) Hoehne and other endemics such as *Mormodes theiochlora* (Rchb.f.) Salazar, *Trichocentrum aguirrei* (Königer) M.W. Chase & N.H. Williams*, Epidendrum mutisii* Hágsater and *E. rodrigoi* Hágsater*,* which would require special monitoring under climate change.

For the **Patía Valley**, only one basin was detected with p>0.61 for the occurrence of bioclimatic niches. This is the lowest value for all Colombia. The basin consists of ten polygons of TDF, and not a single PA nor NRCS are located within 23 km distance, with altitude ranging from 612–1443 m (see Table 4 and Appendix 3). Public and private protected areas are lacking, few plant inventories are available, and the State has an incipient presence at all levels.

For now, prospects for orchid conservation indicate that only natural geographic barriers exist in this territory, and these are present in specific locations with rocky massifs, which are found at the centre, north and south of the Patía Valley, showing suitability values of p=0.31; the dry canyons of Guáitara-Juanambú (p=0.32) are lower than our threshold but have steep slopes and altitudinal gradients that favour the conservation of these plants. The presence of the phorophytes preferred by orchids was recorded by our field team in these places between 500 and 1500 m; these include *Erythrina poeppigiana* (Walp.) O.F. Cook*, Ficus obtusifolia* Kunth*, Samanea saman* (Jacq.) Merr., *Guapira costaricana* (Standl.) Woodson, *Inga spectabilis* (Vahl) Willd., *Psidium sartorianum* (O. Berg) Nied., *P. guajava* L., *Calliandra pittieri* Standl., *Crescentia cujete* L., *Guazuma ulmifolia* Lam. and *Eugenia* sp. The *2013 Patía Expedition* recorded the southernmost populations of *Catasetum tabulare* Lindl., which is endemic to Colombia, and the Cauca guan *Penelope perspicax* Bangs (Class Aves, Phylum Chordata), which had not been recorded for more than 25 years in the bioregion. This demonstrates the value of these areas for conservation purposes and lends sufficient weight for these sites to be proposed as bioclimatic niches of flora and fauna in the Patía bioregion.

For the **Santander** bioregion, 8 basins with p>0.61 for the occurrence of bioclimatic niches were found. These niches showed proximity to 112 TDF polygons, 11 PA, no NRCS less than 23 km away and altitudinal ranges of 154–1798 m (see Table 4 and Appendix 3). The field team recorded phorophytes in the range of 730–1200 m, including *Anacardium excelsum, Machaerium capote, Guarea guidonia, Psidium guajava* L.*, Calliandra magdalenae* (DC.) Benth.*, Clusia alata* Planch. & Triana*, Hura crepitans* L., *Crescentia cujete, Guazuma ulmifolia, Ficus insipida* Willd. and *Eugenia* sp.; endemic orchid species of TDF such as *Catasetum lucis* P. Ortiz & G. Arango*, Catasetum tricorne* P. Ortiz and *Phragmipedium manzurii* W.E. Higgins & Viveros*,* (Martínez *et al.* 2015); and birds in the IUCN threatened category such as the Blue-billed Curassow *Crax alberti* Fraser (CR), Niceforo's Wren *Thryothorus nicefori* Meyer de Schauensee (EN), and Chestnut-bellied Hummingbird *Amazilia castaneiventris* Gould (EN), among others (Donegan *et al.* 2010). The prospects for conservation of this bioregion are greater due to the existence of public protected areas, contiguity with more humid life zones (*ex*. Yariguíes National Park with continuous canopy at altitudes >1500 m) and TDF at intermediate altitudes, which increase the probability of their occurrence.

Discussion

Geographic gaps —. Large gaps of geographic information of these orchids are present in all areas of TDF in Colombia. The overlap in genera and species richness between the national listings (Pizano & García 2014) and the Cauca River Valley bioregion

TABLE 6: Suitability indices for the 2030 and 2050 periods in five areas of Tropical Dry Forest (TDF) in Colombia. Relative to the size of the TDF in Colombia: *IoBsT*_30 and $IoBsT_{30}$; size in the bioregion: $IoBioreg_{30}$ and $IoBioreg_{50}$; and severity: $IoShp_{30}$ and $IoShp_{50}$. Values in **bold** are higher than the average for that index.

Bioregion	$IoBsT_{30}$	$IoBsT_{50}$	$IoBioreg_{30}$	$IoBioreg_{50}$	$IoShp_{30}$	$IoShp_{50}$
Cauca River Valley	**19.9**	**13.3**	**3.4**	2.3	2.9	**4.3**
Caribbean Region	2.7	0.7	**5.7**	1.5	1.7	**6.7**
Magdalena Valley	**6.1**	**6.7**	**3.7**	**4.1**	2.7	2.4
Patía Valley	2.5	2.3	**3.8**	**3.4**	2.6	3.0
Santander Region	5.2	1.4	**3.6**	1.0	2.8	**10.5**

(Reina-Rodríguez *et al.* 2010) demonstrates that current knowledge is far from reality. The difficult logistics of collecting orchids, as well as omission by collectors who are not specialists in this group, have hindered their presence being recorded. While it is true that our data do not represent 100% of the orchids in the ecosystem, they do provide an estimate of the geographical gaps of these plants in TDF areas. There are 314 municipalities with influence in the TDF areas in Colombia. Our data for the 12 "core" species support the presence of these orchids in 118 municipalities (see Appendix 6). In other words, slightly more than half of the municipalities 196 (62,4%), do not have records, mainly the departments of Cesar, Bolívar, Atlántico, Nariño, Cauca, Caldas, Córdoba, Sucre, Huila and Cundinamarca, suggesting important geographical information gaps. Greater effort in rethinking national and regional strategies is needed to fill in these geographical gaps.

Lowland-highland altitudinal migration —. Altitudinal and latitudinal migrations have occurred during the glacial and interglacial periods; however, current extinction rates are 1000 times the background rate (Pimm *et al.* 2015). A progressively warmer climate would induce these plants to migrate, probably vertically from low-lying areas to higher areas (Foster 2001). Recent studies support this hypothesis in Peru (Feeley *et al.* 2011, Lutz *et al.* 2013), Venezuela (Safont *et al.* 2012) and Colombia (Reina-Rodríguez *et al.* 2016). The data herein supported estimates of altitudinal changes of 177.5 m (present–2030) and 379.8 m (present–2050) for the 12 focal species. In the case of TDF orchids, the greatest impediment to ascending the mountains is the availability of suitable habitat due to habitat fragmentation, land use and the extraction of phorophytes in mid-mountain areas. Undoubtedly, this condition limits the dispersal of orchids from lowland areas. The possibilities of success and responses to thermal (low altitude) and water stress may vary according to the degree of specialization that varies between species (Laurance *et al.* 2011, Stevens 1992, Hsu *et al.* 2014, Reina-Rodríguez *et al.* 2016) and the intrinsic resistance capabilities linked to their evolutionary history (Darwin 1872). Further studies focused on genotypic and physiological responses of these plants would be desirable in the short term. Preventive measures are urgently required due to the limited availability of habitat and land use in the mountainous areas north of the Andes (Young & Lipton 2006). The assemblage between bioclimatic niches (BN) proposed here and Altitudinal Migrations Corridors AMC, planned dispersal routes that connect forest relics through a gradient of thermal, edaphic, and moisture and will play an important role in the adaptation and altitudinal displacement of orchids caused by Climate Change (Reina-Rodríguez *et al.* 2016). The establishment of AMC, included the enrichment and management of phorophytes and the use of protective riverine forest of 30 m or more (Law 1449/1977). It also covered public protected areas (PA), such a Natural Parks, and private protected areas such as Natural Reserves of Civil Society (NRCS) stipulated in Colombian legislation (Law 2372/2010); all of these are included in the National System of Protected Areas (NSPA, in Spanish SINAP). These areas would function as nodes of altitudinal connectivity and are fundamental units of the landscape to facilitate orchid dispersal. The spatiotemporal dynamic and interspecific relationships of biodiversity have recurrently been ignored. However, we in section 4.4 have analyzed some complementary factors not included in the current models.

Where will the orchids be found in the future? —. The areas and associated maps show a drastic reduction in areas of suitability due to climate change in the two periods and the five bioregions examined. The loss of suitable areas is especially evident in the Caribbean, the Santander and the Patía River Valley regions as shown in Figure 1. However, in terms of extent, the IoBsT index (see Table 6, available only electronically as supplemnetal material at: http://www.lankesteriana.org/Lankesteria-naJournal/17(1)/reina%20rodriguez%20et%20al%202017%20appendix6.pdf), identifies the Cauca River Valley as the bioregion with the greatest loss of suitability for both future periods, showing reduction to one-quarter (1/4) of its present size, while the IoBioreg index shows that the most significant regional losses will occur inside the Caribbean region, which will be reduced to one-sixth (1/6) of its present extent. However, the IoShp index shows that change will occur with the greatest severity in the Santander region, where the area will be reduced to one-tenth (1/10) of the present area. The minimum suitability values suggest that the Caribbean and Patía Valley bioregions are the most critical in the country.

Suitability for the 2050 period will disappear from the following departments: the Atlantic, Bolívar, Sucre and Córdoba departments in the Caribbean bioregion; the department of Nariño in the Patía Valley bioregion; and the department of Risaralda in the Cauca River Valley bioregion. Meanwhile, the Cauca Valley department of the Cauca River Valley bioregion, the Cundinamarca department of the Magdalena Valley bioregion and the Cauca department of the Patía Valley bioregion will maintain the highest suitability for this period.

Results from the model suggest that many areas, especially from the Caribbean Plains and the Patía Valley, will not be suitable following the changes that lie ahead (see Appendix 3). Flat areas below 600 m without elevation gain within 50 km of populated centres of more than 50,000 inhabitants are characteristics that may lead to the eventual loss of suitability in the next 50 years. Temperature increases, decreased water availability, and the long distances required for migration to higher altitudes are all risk factors for the survival of these plants. Greater efforts and national conservation strategies of TDF should focus on these areas, specifically in the basins and complementary areas shown in Appendix 3.

Bioclimatic niches, pollinators and mycorrhizae —. The spatiotemporal dynamic and interspecific relationships of biodiversity have recurrently been omitted in previous studies. Biotic and abiotic factors exist at the margins of the current tools being used and are worth considering when preparing the new generation of models with greater biological realism, which will include interactions, types of dispersion and evolutionary patterns that will improve the accuracy of predictions (Urban 2015). This study evaluated several factors for assigning bioclimatic niches *a posteriori* as a landscape management unit and as a new spatiotemporal management strategy.

According to the database of Insect Collection of the Museum of Entomology of the Valley University (2013), available at http://ipt.sibcolombia.net/valle/resource.do?r=insectos-universidad-del-valle, insect pollinators are present in TDF areas of Colombia across wide altitudinal gradients from 0–2800 m, favouring cross-pollination and dispersal processes. These pollinators can travel up to 23 km in the five bioregions, which include 609 TDF polygons, 52 public protected areas (PA) and 30 private protected areas (NRCS) that are located between 0 and 1798 m on 187,604 ha distributed in 45 basins throughout the country; thus, the potential exists for this proposal to be feasible throughout the country. Nonetheless, some areas at altitudes below the threshold generated by the model had abrupt relief-forming natural barriers that prevent the establishment of urban areas, mechanized agriculture or other types of exploitation. This condition allows the establishment of plant cover that creates a microclimate suitable for the establishment of the phorophytes, mycorrhizae, pollinators and dispersers necessary for the occurrence of Orchidaceae. Populations of *Catasetum tabulare* with fruits were observed in the pyroclastic massifs in the north-east and centre of the Patía Valley, confirming the presence of these pollinators and the quality of the ecosystem. In the Caribbean bioregion, areas with these characteristics are also present in the precoastal hills close to Cartagena de Indias (100 m), Serranía del Piojo, Serranía de Macuira (735 m), Serranía de San Lucas (1617 m) and Montes de María (570 m), making their inclusion as bioclimatic niches acceptable, given the absence of protected areas in these bioregions.

Little is known about the survival of mycorrhizal fungi and their spatiotemporal variations when faced with an increase in average temperature in Colombia of 2.6°C. However, physiognomically well-structured and conserved forests greater than 10 ha can be assumed to have a microclimate suitable for containing the mycorrhizae necessary for orchid germination. The presence of at least three of the major phorophytes of these plants (see Table 2) was corroborated in the field in 25% of the bioclimatic niches presented here.

Conclusions and recommendations

In this paper we provide a complementary vision based on the presence of living organisms that are intrinsic parts of the ecosystem. The results suggest a significant loss of areas of suitability due to climate change by bioregions and periods (present–2030, present–2050 and 2030–2050). The Santander region, the Caribbean region and the Cauca River Valley will lose much of their present extent of suitability. An altitudinal displacement, which was not uniform, was also detected in the five studied bioregions. Foothills with altitudes of 1165.4 SD±222.6 will have greater suitability for the 2030 period, and the areas of foothills with altitudes of 1364.1 SD±195.1 will have greater suitability for the 2050 period.

In this sense, the model results reinforce the hypothesis of migration of TDF orchids in the northern part of South America, where there has been an increase in altitudinal suitability of the orchids of TDF lowlands towards the mid-mountain areas in the Colombian Andes.

Euglossini bees, vectors of cross-pollination in orchids, are present in both TDF areas and in moist forests at a wide range of altitudes. Their ability to thermoregulate and fly long distances even in dry environments is one of the key biotic elements that enable this altitudinal migration.

The results highlight the importance of articulating complementary spatiotemporal dynamic conservation strategies compared to current and static protected areas. Herein, a new landscape management unit *bioclimatic niche* was defined, which combines the current ecologically valuable coverages of ecosystems and their future areas of suitability. Several biotic and abiotic variables not collected for the actual generation of models have been included in the analysis. In total, 69 areas were proposed as bioclimatic niches, becoming the first national approximation to use living organisms to complement technical criteria in decision-making for land-use planning under climate change conditions. The identification of these bioclimatic niches serves as an early warning for focusing resources and efforts on these areas and altitudinal ranges. In the short term and at a detailed scale, design, implementation and articulation are required between the bioclimatic niches proposed here and supported by the model with AMC and the public and private protected areas in TDF in Colombia. The inclusion of some areas with $p<0.61$ and abrupt relief are the only guarantee of conservation of orchids in the Caribbean region, and the Patía Valley is equally important, where the absence and low representation of orchids are evident. In terms of land-use management, bioclimatic niches should be included within restoration-reforestation plans, land-use plans (LUP), watershed management plans (WSMP) and approaches such as ecosystem-based adaptation (EbA) referred to in the national climate change policy. This task should be specifically undertaken in the short term by the regional autonomous corporations throughout Colombia as an adaptation measure to safeguard biodiversity.

The regional environmental authorities and agencies for the conservation of nature of the national and international order, as well as NGO's and local communities, are key actors in considering, implementing and adjusting the implementation of the conclusions supported herein and currently underway. Finally, evidence shows large geographical gaps of orchids in this ecosystem, especially in the Patía Valley, Caribbean region, and south of the Magdalena Valley, as well as in the inaccessible dry enclaves. However, new knowledge of their geographical distributions is becoming available through infrastructure projects established by the Colombian legislature.

ACKNOWLEDGMENTS. The funds for this project were sponsored by Agreement 14-12/117—14/0025-280CE of 2014 between the Alexander von Humboldt Biological Resources Research Institute and the Fundacion Universidad del Valle and the CI 4326 project of the Vice-Rectory of Research of the Universidad del Valle. Special thanks to UMATA (Anapoima, Cundinamarca), the University of Barcelona, and the Anonymous Society Colinas de San Simeón (Cartagena de Indias, Bolívar). Thanks also to the people with whom we directly or indirectly collaborated: Diego Alejandro Castro; Francisco López-Machado; Isabel Nichols (Cali, Valle del Cauca); Jorge Meza (Bucaramanga, Santander); Alicia Rojas (Floridablanca, Santander); Hedy Saab Ramos (Montería, Córdoba); Jorge Contreras (Montería, Córdoba); Rosalba Ruiz Vega (Montería, Córdoba); Hernando Gómez (Sincelejo, Sucre); Pedro José Álvarez (Sincelejo, Sucre); Felipe Ballesteros (Coello, Tolima); Álvaro Cogollo (Medellín, Antioquia); Eduino Carbonó (Santa Marta, Magdalena); Diego Yepes (Santa Marta, Magdalena); Humberto Mendoza (Villa de Leyva, Boyacá); Hernando García (Bogotá, Cundinamarca); Carolina Castellanos Castro (Bogotá, Cundinamarca); Bernardo Ramírez (Popayán, Cauca); Carlos Parra (Bogotá, Cundinamarca); Philip Silverstone-Sopkin (Cali, Valle del Cauca); Mayra Erazo (Cali, Valle del Cauca); Eric Hágsater (México, D.F.); Elizabeth Santiago Ayala (México D.F.); José Luis Alanís (Tuxpan, México); Ana Milena Silva (Cali, Valle del Cauca); Marcelo di Bonito (Nottingham, United Kingdom); Cristina Bustos Roldán (Esplugas de Llobregat Barcelona, España); Ethan Reina-Rodríguez (Barcelona, Spain); Carmen Lozano (Anapoima, Cundinamarca); Javier Ocampo (Bogotá, Cundinamarca); Gonzalo González (Cartagena de Indias, Bolívar); Geovanny L. Rodríguez (El Bordo, Cauca); Jerry Rubio (El Bordo, Cauca) Gilberto Rivas (Puerto Nuevo, Nariño); Philip Silverstone-Sopkin (Cali, Valle del Cauca); Jana Rubiano; Mayo Rubiano (Dapa, Cauca Valley); and Julián A. Reyna Rodríguez (Cali, Valle del Cauca).

LITERATURE CITED

Ackerman, J.D. (1983). Specifiity and mutual dependency of the orchid-euglossine bee interaction. *Biological Journal of the Linnean Society,* 20, 301–314.

Ariza, A., Isaacs, P. & González-M., R. (2014). Mapa de coberturas de bosque seco tropical en Colombia (escala 1:100.000, 2.0v). Instituto de Investigaciones de Recursos Biológicos “Alexander von Humboldt” – Ministerio de Ambiente y Desarrollo. 1 hoja cartográfica.

Armenteras, D., Rudas, G., Rodríguez, N., Sua, S. & Romero, M. (2006). Patterns and causes of deforestation in the Colombian Amazon. *Ecological indicators,* 6, 353–368.

Austin, M. V. & van Niel K. (2011). Improving species distribution models for climate change studies: Variable selection and scale. *Journal of Biogeography,* 38, 1–8.

Barbet-Massin, M., Jiguet, F., Albert, C. & Thuiller, W. (2012). Selecting pseudo-absences for species distribution models: How, Where and How Many? *Methods in ecology and evolution*, 3(2), 327–338. Doi: 10.1111/j.2041-210X.2011.00172.x

Bates, B.C., Kundzewicz, Z.W., Wu, S. & Palutikof, J.P. (2008). *Climate Change and Water*. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp.

Becker, P., Moure, J.S. & Peralta, F.J.A. (1991). More about euglossine bees in Amazonian forest fragments. *Biotropica,* 23, 586–591.

Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller W. & Courchamp, F. (2012). Impacts of climate change on the future of biodiversity. *Ecological Letters,* 15(4), 365–377. Doi:10.1111/j.1461-0248.2011.01736.x.

Benzing, D. (1998). Vulnerabilities of tropical forests to climate change: The significance of resident epiphytes. In: A. Markham (Ed.), *Potential impacts of Climate Change on Tropical Forest Ecosystems* (pp. 379–400). The Netherlands: Springer Netherlands.

Bernal, R., Gradstein, R. & Celis, M. (2015). Catálogo de Plantas y Líquenes de Colombia. Bogotá D.C., Cundinamarca, Colombia: Universidad Nacional de Colombia. (Accessed 04/20/2015 from http://catalogoplantasdecolombia.unal.edu.co/catalog).

Berrío, J., Hooghiemstra, H., Marchant, R., & Rangel-Chacón, O. (2002). Late-glacial and Holocene history of the Dry forest area in the south Colombian Cauca valley. *Journal of Quaternary science,* 17(7), 667–682.

Berrío, J. C., Hooghiemstra, H., Behling, H., Botero, P. & Van der Borg, K. (2002). Late-Quaternary savanna history of the Colombian Llanos Orientales from Lagunas Chenevo and Mozambique: a transect synthesis. *The Holocene,* 12, 35–48.

Betancur, J., H. Sarmiento-L., Toro-González, L. & J. Valencia. (2015). *Plan para el estudio y la conservación de las orquídeas en Colombia*. Ministerio de Ambiente y Desarrollo Sostenible; Universidad Nacional de Colombia, Bogotá D.C. 336 pp.

Bilton, M. C., Metz, J. & Tielbörger, K. (2016). Climatic niche groups: A novel application of a common assumption predicting plant community response to climate change. *Perspectives in Plant Ecology, Evolution and Systematics,* 19, 61–69.

Camargo, E., Silva, V. & Leit, E. (2006). Reproductive biology of two *Cattleya* (Orchidaceae) species endemic to north-eastern Brazil. *Plant Species Biology,* 21, 85–91.

Chen, I. C., Hill, J. K., Ohlemueller, R., Roy, D. B. & Thomas, C. D. (2011). Rapid range shifts of speices associated with high levels of climate warming. *Science*, 333, 1024–1026.

DANE. Departamento Administrativo Nacional de Estadística (2005). Censo 2005. Bogotá D.C., Cundinamarca, Colombia. (Accessed on 05/04/2015, from http://www.dane.gov.co/).

Darwin, Ch. (1872). *The origen of species*. 6a Edition. John Murray, London.

Donegan T. M., Avendaño, J. E., Briceño, E. R., Luna, J. C., Roa, C., Parra, R., Turner, C., Sharp, M. & Huertas B. (2010). Aves de la Serranía de los Yariguíes y tierras bajas circundantes, Santander, Colombia. *Cotinga,* 32, 72–89.

Dressler, R. L. (1982). Biology of the orchid bees (Euglossini). *Annual Review of Ecology, Evolution, and Systematics*, 13, 373–394.

Elith, J., Graham, C., Anderson, R., Dudik, M., Ferrier, S., Guisan, A., Hijmans, R. J., Huettmann, F., Leathwick, J. R., Lehmann, A., Li, J., Lohmann, L. G., Loiselle, B. A., Manion, G., Moritz, C., Nakamura, M., Nakazawa, Y., Overton, J. McC. M., Peterson, A. T., Phillips, S. J., Richardson, K., Scachetti-Pereira, R., Schapire, R. E., Soberón, J., Williams, S., Wisz, M. S. & Zimmermann, N. E. (2006). Novel methods improve prediction of species distributions from occurence data. *Ecography,* 29(2), 129–151. Doi: 10.1111/j.2006.0906-7590.04596.x

Elith, J., Phillips, S., Hastie, T., Dudik, M., Chee, Y. & Yates, C. (2011). A stadistical explanation of MaxEnt for ecologist. *Diversity and Distributions,* 17, 14–57.

Engler, R., Guisan, A. & Rechteiner, L. (2004). An improved approach for predicting the distribution of rare and endangered species from occurrence and pseudo-absence data. *Journal of Applied Ecology,* 41, 263–274.

Etter, A., McAlpine, C. & Possingham, H. (2008). A historical analysis of the spatial and temporal drivers of landscape change in Colombia since 1500. *Annals of the American Association of Geographers,* 98, 2–23.

Feeley, K., Silman, M., Bush, M., Farfan, W., Garcia-Cabrera, K., Malhi, Y., Meir, P., Revilla, N. S., Raurau Quisiyupanqui, M. N. & Saatchi, S. (2011). Upslope migration of andean trees. *Journal of Biogeography,* 38, 783–791. Doi: 10.1111/j.1365-2699.2010.02444.x

Feeley, K. & Silman, M. (2010). Land-use ande climate change effects on population size and extinction risk of Andean plants. *Global change biology,* 16, 3215–3222.

Foster, P. (2001). The potential negative impacts of global climate change on tropical montane cloud forests. *Earth-Science Reviews,* 55, 73–106.

García-Ramírez, D. A. & García-Revelo, J. S. (2013). Diversidad de orquídeas de los bosques altos de la Serranía de los Parguas, Chocó biogeográfico, Colombia. *Lankesteriana,* 13 (1-2), 132.

González-Carranza, Z., Berrío, J., Hooghiemstra, H., Duivenvoorden, J. & Behling, H. (2008). Changes of seasonally dry forest in the Colombia Patía Valley duringe the early and middle Holocene and development of a dry climatic record for the northernmost Andes. *Review of paleobotany and palynology,* 152, 1–10.

Gutiérrez-Rey, H. J. (2002). Aproximación a un modelo para la evaluación de la vulnerabilidad de las coberturas vegetales de Colombia ante un posible cambio climático utilizando SIG. *Meteorología Colombiana,* 6, 55–63.

Hansen, M., Popatov, P., Moore, R., Hancher, M., Tarubanova, S., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., Loveland, T. R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O. & Townshend, J. R. G. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science,* 342(6160), 850–853. Doi: 10.1126/science.1244693

Harris, L. (1984). *The Fragmented Forest: Island Biogeography Theory and the Preservation of Biotic Diversity*. University of Chicago Press, Chicago, IL.

Hernández, P., Graham, C., Lawrence, L. & Albert, D. (2006). The effect of sample size and species characteristics on performance of different species distribution modeling methods. *Ecography,* 29, 773–785.

Hernández-Camacho, J. & Sánchez, P. (1992). Biomas Terrestres de Colombia. En: G. Halffter (Ed.), *La diversidad Biológica de iberoamérica I* (pp. 153–190). México D.F.: CYTED-D. Programa iberoamericano de ciencia y tecnología para el desarrollo. Instituto de Ecología.

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones P. G. & Jarvis, A. (2005). Very High resolution interpolated climate surfaces for global land areas. *International Journal of climatology*, 25, 1965–1978.

Hijmans, R., Van Etten, J., Cheng, J., Mattiuzzi, M., Summer, M., Greenberg, J., Perpina, O., Bevan, A., Racine, E. B. & Shortridge, A. (2012). CRAN R. (Downloaded on 08/10/2015 from http://cran.rproject.org/web/packages/raster/raster.pdf)

Hsu, R., Wolf, J. & Tamis, W. L. (2014). Regional and elevational patterns in vascular epiphyte richness on an east Asian island. *Biotropica,* 46(5), 549–555.

Ibáñez, I., Clark, J. S., Dietze, M. C., Feeley, K., Hersh, M., Ladeau, S., Mcbride, A., Welch, N. E. & Wolosin, M. S. (2006). Predicting biodiversity change: outside the climate envelope, beyond the species–area curve. *Ecology,* 87(8), 1896–1906.

IDEAM, PNUD, MADS, DNP, CANCILLERÍA. (2015). *Nuevos Escenarios de Cambio Climático para Colombia 2011-2100.* Herramientas Científicas para la Toma de Decisiones– Enfoque Nacional – Departamental: Tercera Comunicación Nacional de Cambio Climático.

Isaac, J. L., Van der wal, J., Jhonson, C. N. & Williams, S. E. (2009). Resistance and resilience: Quantifying relative extinction risk ina diverse assemblage of Australian tropical rainforest vertebrates. *Diversity and Distributions*, 15, 280–288.

IPCC. Panel Intergubernamental de Cambio Climático. (2013). *Cambio climático*. Base de ciencia física. Suiza: IPCC. 222 pp.

Janzen, D.H. (1971). Euglossine Bees as long-distance pollinators of tropical plants. *Science*, 171(3967), 203–205.

Janzen, D.H. (1974). The deflowering of Central America. *Journal of Natural History,* 83, 48–53.

Jarvis, A., Rubiano, J. & Cuero, A. (2004). *Comparison of SRTM derived DEM vs. topographic map derived DEM in the region of Dapa*. International Center for Tropical Agriculture CIAT.

Laurance, W. F., Useche, C., Shoo, L. P., Herzog, S. K., Kessler, M., Escobar, F., Brehm, G., Axmacher, J. C., Chen, I-C., Arellano Gámez, L., Hietz, P., Fiedler, K., Pyrcz, T., Wolf, J., Merkord, C. L., Cardelus, C., Marshall, A. R., Ah-Peng, C., Aplet, G. H., Arizmendi, M. d. C., Baker, W. J., Barone, J., Brühl, C. A., Bussmann, R. W., Cicuzza, D., Eilu, G., Favila, M. E., Hemp, A., Hemp, C., Homeier, J., Hurtado, J., Jankowski, J., Kattán, G., Kluge, J., Krömer, T., Lees, D. C., Lehnert, M., Longino, J. T., Lovett, J., Martin, P. H., Patterson, B. D., Pearson, R. G., Peh, K. S.-H., Richardson, B., Richardson, M., Samways, M. J., Senbeta, F., Smith, T. B., Utteridge, T.M.A., Watkins, J. E., Wilson, R., Williams, S. E. & Thomas, C. D. (2011). Global warming, elevational ranges and the vulnerability of tropical biota. *Biological Conservation,* 144, 548–557. Doi: http://dx.doi.org/10.1016/j.biocon.2010.10.010

Leopardi-Verde, C., Reina-Rodríguez, G.A., Carnevali, G. & Romero-González, G. (2014). Two new greenish *Encyclia*: *E. parkeri* and *E. silverarum* (Laeliinae, Orchidaceae). *Phytotaxa*, 183(3), 159–170.

Liu, C., White, M. & Newell, G. (2013). Selecting thresholds for the prediction of species ocurrence with presence-only data. *Biogeography,* 40, 778–789.

Lloret, F., Peñuelas, J., Prieto, P., Llorens, L. & Estiarte, M. (2009). Plant community changes induced by experimental climate change:seedling and adult species composition. *Perspectives in Plant Ecology, Evolution and Systematics*, 11, 53–63. Doi: http://dx.doi.org/10.1016/j.ppees.2008.09.001

Lutz, D. A., Powell, R. L. & Silman, M. R. (2013). Four decades of Andean timberline migration and implications for biodiversity loss with climate change. *Plos One,* 8(9), e74496. Doi: 10.1371/journal.pone.0074496

Marchant, R., Berrío, J. C., Behling, H., Boom, A. & Hooghiemstra, H. (2006). Colombian dry moist forest transitions in the Llanos Orientales—a comparison of model and pollen-based biome reconstructions. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 234(1), 28–44.

Martínez, S., Bonilla, M. & López, H. (2015). Listado de la flora orchidaceae de Santander y comentarios sobre sus especies endémicas. *Revista facultad de ciencias básicas Universidad militar nueva granada*, 11(2), 54–111.

May, M.L. & Casey, T.M. (1983). Thermorregulation and heat exchange in euglossine bees. *Physiological Zoology,* 56, 541–551.

Mcgarigal, K. & Marks, B.J. (1995). *Fragstats: spatial pattern analysis program for quantifying landscape structure*. Gen. Tech.REP. PNW-GTR-351. Portland, Oregon: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 122p.

Merow, C., Smith, M. & Silander, J. (2013). A practical guide to MaxEnt for modeling species distributions: what it does, and why inputs and settings matter. *Ecography*, 36, 1058–1070.

Montgomery, D., Peck, E. A. & Vining, G. (2006). *Introducción al análisis de regresión lineal* (pp.106-108). México D.F.: Editorial Continental.

Monserud, R.A. & Leemans, R. (1992). Comparing global vegetation maps with the Kappa statistics. *Ecological Modelling,* 62, 275–293.

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

Naoki, K., Gómez, I., López, R., Meneses, R. & Vargas, J. (2006). Comparación de Modelos de Distribución de Especies para predecir la distribución potencial de vida silvestre en Bolivia. *Ecología en Bolivia*, 41(1), 65–78.

Oliveira, V.C. & Sajo, M.G. (2001). Morfo-anatomía caulinar de nove espécies de Orchidaceae. *Acta Botanica Brasilica,* 15, 177–188.

Pearson, R.G. & Dawson, T.P. (2003). Predicting the impacts of climate change on the distribution of species: ¿are bioclimate envelope models useful? *Global Ecology and Biogeography,* 12, 361–371. Doi: 10.1046/j.1466-822X.2003.00042.x

Pennington, R. T., Lewis, G. P. & Ratter, J. A. (2006). An overview of the plant diversity, biogeography and conservation of Neotropical savannas and seasonally dry forests. En: Pennington, R. T., Lewis, G. P. & Ratter, J. A. (Eds.), *Neotropical Savannas and Seasonally Dry Forests* (pp.1–30). CRC.

Peñuelas, J., Prieto, P., Beier, C., Cesaraccio, C., de Angelis, P., de Dato, G., Emmett, B. A., Estiarte, M., Garadnai, J., Gorissen, A., Kovács Láng, E., Kröel-Dulay, G., Llorens, L., Pellizzari, G., Riis-Nielsen, T., Schmidt, I.K., Sirca, C., Sowerby, A.,Spano, D. & Tietema, A. (2007). Response of plant species richness and primary productivity in shrublands along a north–south gradient in Europe to seven years of experimental warming and drought: reductions in primary productivity in the heat and drought year of 2003. *Global Change Biology*, 13, 2563–2581. Doi: 10.1111/j.1365-2486.2007.01464.x

Pimm, S. L., Jenkins, C. N., Abell, R., Brooks, T. M., Gittleman, J. L., Joppa, L. N., Raven, P. H., Roberts, C. M. & Sexton, J. O. (2014). The biodiversity of species and their rates of extinction, distribution, and protection. *Science*, 344(6187). Doi: 10.1126/science.1246752Phillips, S.J. & Dudík, M. (2008). Modeling of species distributions with MaxEnt: new extensions and a comprehensive evaluation. *Ecography,* 31, 161–175.

Phillips, S.J., Anderson, R. & Schapire, R. (2006). Maximum entropy modeling of species geographic distribution. *Ecological Modelling,* 190, 231–259.

Phillips, R. D., Peakall, R., Hutchinson, M. F., Linde, C. C., Xu, T., Dixon, K. W. & Hopper, S. D. (2014). Specialized ecological interactions and plant species rarity: the role of pollinators and mycorrhizal fungi across multiple spatial scales. *Biological Conservation*, 169, 285–295.

Patiño-Uribe, R.D., Rangel-Chacón, O. & Fernandez-Alonso, J. L. (2002). *Estudio de la vegetación y flora en los montes de María (Colosó, Sucre, Colombia)*. Libro resúmenes octavo congreso latinoamericano y segundo congreso colombiano de Botánica. Instituto de ciencias naturales, Universidad Nacional de Colombia. 460 p.

Pearce J. & Ferrier, S. (2000). Evaluating the predictive performance of habitat models developed using logistic regression. *Ecological modelling*, 133, 225–245.

Pizano, C. & García, H. (Eds.) (2014). *El Bosque seco tropical en Colombia.* Bogotá, D.C.: Instituto de investigacion de recursos biológicos Alexander von Humboldt (IAvH). Bogotá, D.C., Colombia. 349 pp.

Primack, R. & Corlett, R. (2005). *Tropical Rain Forest: An Ecological and biogeographical comparison*. Blackwell. United Kingdom 336 p.

Ramirez-Villegas, J., Cuesta, F., Devenish, C., Peralvo, M., Jarvis, A. & Arnillas, C. (2014). Using species distributions models for designing conservation strategies of Tropical Andean biodiversity under climate change. *Journal for Nature Conservation,* 22(5), 391–404.

Reina-Rodriguez, G.A. & Soriano, I. (2008). Diachronic cartography and spatial pattern assessment in coastal habitats: The case of Torredembarra (northeast Spain). *Journal of Coastal Research,* 24(1A), 87–98.

Reina-Rodríguez, G.A., Ospina-Calderón, N., Castaño, A., Soriano, I. & Otero, J. T. (2010). Listado de las orquídeas del Valle del río Cauca y su piedemonte andino (930-1200 m.s.n.m) Sur-occidente colombiano. *Cespedesia*, 32(90-91), 7–22.

Reina-Rodríguez, G. A., Rubiano, J. E., Castro-Llanos F. A & Otero, J. T. (2016). Spatial distribution of dry forest orchids in the Cauca river valley and Dagua Canyon: Towards a conservation stategy to climate change. *Journal for nature conservation,* 30, 32–43.

Reymondin, L., Jarvis, A., Perez-Uribe, A., Touval, J., Argote, K., Rebetez, J., Guevara, E. & Mulligan, Mark. (2010). A methodology for near real-time monitoring of habitat change at continental scales using MODIS-NDVI and TRMM. *Remote Sensing of Environment,* 21, 983–1008.

Rebêlo, J.M.M. & Garófalo, C.A. (1997). Comunidades de machos de Euglossini (Hymenoptera: Apidae) em matas semidecíduas do Nordeste do estado de São Paulo. *Anais da Sociedade Entomológica do Brasil,* 26, 243–255

Riahi, K., Rao, S., Krey, V., Cho, C., Chirkow, V., Fischer, G., Kindermann, G., Nakicenovic, N. & Rafaj, P. (2011). RCP 8.5 - A Scenario of Comparatively High Greenhouse Gas Emissions. *Climatic Change*, 109, 33–57.

Richardson, B.A., Richardson, M.J., Scatena, F.N. & McDowell, W.H., (2000). Effects of nutrient availability and other eleva-tional changes on bromeliad populations and their invertebratecommunities in a humid tropical forest in Puerto Rico. *Journal of Tropical Ecology,* 16, 167–188.

Roberts, D. L. (2003). Pollination Biology: The role of sexual reproduction in orchid conservation. In: K.W. Dixon, S.P. Kell, R, L, Barrett, P.J. Cribb (Eds.), *Orchid Conservation* (pp. 113–136). Natural History Publications, Kota Kinabalu.

Roubik, D.W. (1993). Tropical pollinators in the canopy and understory: field data and theory for stratum "preferences". *Journal of Insect Behavior*, 6, 659–674.

Roubik, D.W. & Ackerman J.D. (1987). Long-term ecology of euglossine orchid-bees (Apidae: Euglossini) in Panamá. *Oecología*, 73, 321–333.

RBG Kew (2016). The State of the World's Plants Report – 2016. Royal Botanic Gardens, Kew.

Rudas, G.D., Armenteras, S.M. & Sua-Rodríguez, N. (2002). *Indicadores de Seguimiento de la Política de Biodiversidad en la Amazonia Colombiana 2001*. Informe Final de Resultados. Proyecto Diseño e Implementación del Sistema de Indicadores de Seguimiento de la Política de Biodiversidad en la Amazonia Colombiana. Instituto Humboldt, CDA, Corpoamazonia, Cormacarena, Instituto Sinchi, Unidad de Parques, Ministerio del Medio Ambiente (Crédito BID 774 OC/CO), Bogotá, Colombia, 105p.

Safont, E., Vegas-Vilarrúbia, T. & Rull, V. (2012). Use of Environmental Impact Assessment (EIA) tools to set priorities and optimize strategies in biodiversity conservation. *Biological conservation*, 149, 113–121.

Savage, A. & Causado, J. (2008). *Saguinus oedipus*. IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>.

Sánchez-Azofeifa, G., Quesada, M., Rodríguez, J., Nassar, J., Stoner, K., Castillo, A. & Garvin, T., Zent, E. L., Calvo-Alvarado, J. C., Kalacska, M.E.R., Fajardo, L., Gamon, J. A. & Cuevas-Reyes, P. (2005). Research priorities for neotropical dry forest. *Biotropica,* 37, 477–485.

Stevens, G. C. (1992). The elevational gradient in altitudinal range: an extensión of Rapoport's latitudinal rule to altitude. *American Naturalist,* 140, 893–911.

Still, C., Foster, P. N. & Schneider, S. H. (1999). Simulating the effects of climate change on tropical montane cloud forests. *Nature,* 398, 608–610.

Sandino, J.C. (2004). Are there any agricultural effects on the capture rates of male euglossine bees (Apidae: Euglossini). *Revista de Biología Tropical*, 52(1), 115–118.

Thomas, C. D., Cameron, A., Green, R. E., Bakkenes, M., Beaumont, L. J., Collingham, Y. C., Erasmus, B.F.N., de Sequeria, M. F., Grainger, A., Hannah, L., Hughes, L.,Huntley, B., van Jaarsveld, A. S., Midgley, G. F., Miles, L., Ortega-Huerta, M. A., Peterson, A. T., Phillips, O. L. & Williams, S.E. (2004). Extinction risk from climate change. *Nature,* 427, 145–148.

Thuiller, W. (2004). Patterns and uncertainties of species' range shifts under climate change. *Global Change Biology*, 10, 2020–2027.

Thuiller, W., Albert, C., Araujo, M.B., Berry, P.M., Cabeza, M., Guisan, A., Hickler, T., Midgley, G.F., Paterson, J., Schurr, F.M., Sykes, M.T. & Zimmermann, N.E. (2008). Predicting global change impacts on plant species' distributions: future challenges. *Perspectives in Plant Ecology, Evolution and Systematics,* 9, 137–152.

Torres, E. F., Fermín, F.R. & Yelitza, L. (2007). Estudio morfo-anatómico de dos orquídeas de una selva nublada tropical. *Interciencia,* 32(6), 410–418.

Uehara-Prado, M. & Garófalo, C.A. (2006). Small-scale elevational variation in the abundance of *Eufriesea violacea* (Blanchard) (Hymenoptera: Apidae). *Neotropical Entomology,* 35(4), 446–451.

Urban, M.C. (2015). Acelerating extinction risk from climate change. *Science*, 348(6234), 571–573.

Van der Hamen, T., Werner, J. & van Dommelen, H. (1973). Palynological record of the upheaval of the northern Andes: a study of the pliocene and lower Quaternary of the Colombia eastern cordillera and the early evolution of its high-andean biota. *Review of paleobotany and palynology,* 16, 1–122.

Van der Wal, J., Shoo, L. P., Graham, C. & Williams, S.E. (2009). Selecting pseudo-absence data for presence-only distribution modeling: How far should you stray from what you know? *Ecological Modelling*, 220, 589–594.

Vélez, M. I., Berrío, J. C., Hooghiemstra, H. & Metcalfe, S. (2005). Palaeoenvironmental changes during the last ca. 8529 cal yr in the dry forest ecosystem of the Patía Valley. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 216, 279–302.

Viera, A.J. & Garrett, J.M. (2005). Understanding interobserver agreement: The *kappa* statistic. *Family medicine*, 37(5), 360–363.Warren, D. & Seifert, S. (2011). Ecological niche modelling in MaxEnt: The importance of model complexity and the performance of model selection criteria. *Ecological applications*, 21 (2), 335–342.

Whitten, W.M., Young, A.M. & Stern, D.L. (1993). Non-floral sources of chemicals that attract male euglossine bees. *Journal of Chemical Ecology*, 19, 3017–3027.

Wiens, J. A., Stralberg, D., Jongsomjita, D., Howell, C. A. & Snyder, M. A. (2009). Niches, models, and climate change: Assessing the assumptions and uncertainties. *Proceedings of the National Academy of Sciences,* 106, 19729–19736.

Williams, N.H. (1982). The biology of orchids and euglossine bees. In: J. Arditti (Ed.), *Orchid biology II* (pp.121-169). Cornell University Press, Ithaca, New York.

Wiz, M.S., Hijmans, R.J., Li, J., Peterson, A.T., Graham, C.H., Guisan, A. & NCEAS Predicting Species Distributions Working Group. (2008). Efects of samples size on the performance of species distribution models. *Diversity and distributions*, 14, 763–773.

Wieczorek, J., Bloom, D., Guralnick, R., Blum, S., Döring, M., Giovanni, R., Robertson, T. & Vieglais, D. (2012). Darwin Core: An Evolving Community-Developed Biodiversity Data Standard. *Plos one* 7(1). doi: 10.1371/journal.pone.0029715

Young, K.R. & Lipton, J. (2006). Adaptive governance and climate change in the tropical highlands of western south america. *Climatic change,* 78, 63–102.

Web sites for data used in this research

Biological Information Catalogue CEIBA-IAvH. I2D-Institutional data infrastructure. Retrieved at: http://i2d.humboldt.org.co/ceiba/; http://i2d.humboldt.org.co/ceiba/resource.do?r=rrbb_bst_orquideas_2015; http://i2d.humboldt.org.co/ceiba/resource.do?r=rrbb_bst_orquideas_observaciones_2015; http://i2d.humboldt.org.co/ceiba/resource.do?r=rbb_bst_orquideas_identificaciones_2015

Geodata Portal of King´s College London. Retrieved at: http://www.policysupport.org/waterworld

Insect collection of the Entomological Museum of the Universidad del Valle MUSENUV (2013). Retrieved at: http://ipt.sibcolombia.net/valle/resource.do?r=insectos-universidad-del-valle. I-Terra. Retrieved at:http://www.terra-i.org/terra-i.html

Joint Research Centre. Retrieved at: http://bioval.jrc.ec.europa.eu/products/gam/index.html

Worldclim Graham & Hijmans, 2006. Retrieved at: http://www.worldclim.org

APPENDICES

Appendix 1. Species of orchids selected for modelling, their distribution in departments in Colombia, altitudes and notes on their ecology.

Species	Distribution	Supplemental notes
Brassavola nodosa (L.) Lindl.	Neotropical; (Bol, Col, CR, Ecu, Guy, Mex, Per) Col: (Ant, San, Bol, Cal, Ces, Cor, Cho, Cun, Gua, Mag, San, Suc, Tol) 5-950 m.	Rounded and succulent leaves to store water and prevent dessication. Grows in open areas exposed to light. Grows in dry forests and sub-xerophytic shrubland. Phorophytes: *Caesalpinia punctata, Caesalpinia tortuosa, Pereskia guamacho, Samanea saman, Crescentia cujete* and *Anacardium excelsum.*
Catasetum tabulare Lindl.	Endemic; (Col) 200-1350 m. Col: (Ant, Ris, VdC, Tol, Suc)	Equipped with pseudobulbs up to 25 cm in length to store water. Prefers perimeter areas of dry forest and riverine forests with medium brightness. It has been observed in living fences and at the perimeters of abandoned coffee plantations, as well as in groups of trees outside the forest but sheltered from the wind. It grows on *Gliricidia sepium, Senna spectabilis, Anacardium excelsum, Machaerium capote* and *Brosimum alicastrum.*
Cyrtopodium paniculatum (Ruiz & Pav.) Garay	Neotropical; (Bol, Col, CR, Ecu, Guy, Mex, Per) Col: (Ant, Cor, Bol, Cau, Ces, Cun, Mag, Hui, San, Suc Vch, VdC) 5-1200 m.	Equipped with pseudobulbs up to 60 cm in length to store water. Grows in dry forest and sub-xerophytic dry shrubland and as a terrestrial plant in outcrops of sedimentary rocks in foothill areas with frequent wildfire, despite which this species persists. As an epiphyte, it has been observed on *Anacardium excelsum*, *Sterculia apetala* and *Elaeis guineensis*.
Dimerandra emarginata (G. Mey.) Hoehne	Neotropical; (Bel, Bra, CR, Ecu, Sal, GFr, Gua, Guy, Hnd, Mex, Nic, Pan, Per, Sur, Ven) Col: (Ant, Ara, Bol, Cal, Cas, Cau, Ces, Cun, Gua, Mag, Met Qui, Ris, San, VdC) 100-1400 m.	Possesses elongated pseudobulbs up to 40 cm in length. It grows in lowlands and Andean foothills and is present in dry forests, sub-xerophytic shrubland and seasonally flooded forests, including wooded pasture. Populations present in the Cauca River Valley occupy the altitudinal ceiling of the continent. It has been observed on *Anacardium excelsum, Erythroxylum ulei, Ficus insipida, Xylopia ligustrifolia, Laetia americana* and *Oreopanax cecropifolius*.
Epidendrum rigidum Jacq.	Neotropical; (Arg, Bel, Bol, Bra, Bhm, Cub, Rdm, Jam, PR, Tri, Col, CR, Ecu, Gua, Guy, Hnd, Mex, Nic, Pan, Per, Sur, Ven) Col: (Ant, Boy, Cal, Cau, Cun, Hui, Nsa, Mag, Ris, San, Qui, VdC) 600 -1355 m.	Has waxy cuticle as an adaptation to the conditions of water stress. Grows in dry forest, seasonally flooded forests, riverine forests and forest-pasture perimeters in areas of high and medium brightness. It has been observed on *Anacardium excelsum, Laetia americana, Luehea seemannii, Guarea guidonia, Erythroxylum ulei, Guarea kunthiana, Chlorophora tinctoria* and *Ficus obtusifolia.*
Jacquiniella globosa (Jacq.) Schltr.	Neotropical; (Bel, Bol, Bra, Col, CR, Cub, Ecu, GFr, Gua, Guy, Hnd, Jam, Mar, Mex, Nic, Pan, Per, PR, RD, Sal, Sur, T&T, Ven) Col: (Ant, Cho, Cau, Cun, Gua, Hui, Mag, Met, Qui, Ris, San, VdC) 700-1600 m.	Small epiphyte with rounded leaves and thick cuticle. Grows in riparian forests, sub-xerophytic shrubland and seasonally flooded forests. Establishes both on the exterior branches of shrubs a few metres from the ground and in treetops more than 30 metres high. It has been observed on Ficus insipida, *Lonchocarpus* sp., *Anacardium excelsum*, *Neea divaricata*, *Clusia minor, Zanthoxylum fagara* and *Clusia fructiangusta.*
Oeceoclades maculata (Lindl.) Lindl.	Subcosmopolitan; (Arg, Bol, Bra, R. Dom, Jam, PR, Col, Com, CR, Ecu, El Salv, Gua, Guy, Hnd, Mex, Pan, Par, Per, Sur, Tan, Ven) Col: (Ant, Bol, Cal, Cas, Cau, Ces, Cor, Cun, Mag, Nsa, VdC, Ris, San, Suc, Tol.) 20-1150 m.	Only terrestrial species, occasional epiphyte. Possesses underground succulent pseudobulbs for water storage. Extensive global distribution occurring in both the Paleotropics and Neotropics. Grows in dry forests dominated by *Anacardium excelsum, Sabal mauritiiformis, Syagrus sancona* and *Attalea butyracea* in transition areas between pasture and riparian forest. This adaptation to different ombro climates has enabled its colonization to different environments around the world.
Polystachya foliosa (Hook.) Rchb. f.	Neotropical; (Arg, Bel, Bol, Bra, Cub, Rdm, Jam, PR, Col, CR, Ecu, Sal, Gua, Guy, Hnd, Mex, Nic, Pan, Par, Per, Sur, Ven) Col: (Ant, Ara, Boy, Cal, Cas, Cau, Cun, Guaj, Mag, Met, Nsa, Qui, Ris, San, VdC, Vich) 50 -1400 m.	Possesses small oval pseudobulbs to store water. Grows at perimeters of riverine forests and seasonally flooded forests. More abundant below 500 m. It has been observed on *Laetia americana, Guarea guidonia, Vitex orinocensis, Inga spectabilis* and *Miconia* sp.

Appendix 1 (*continues*).

Species	**Distribution**	**Supplemental notes**
Scaphyglottis prolifera (R. Br.) Cogn.	Neotropical; (Bel, Bol, Col, CR, Ecu, Gua, Guy, Hnd, Jam, Mex, Nic, Pan, Per, Tri, Ven). Col: (Ant, Cau, Cho, Cun, Gua, Hui, Mag, Met, Ris, San, VdC) 500-1600 m.	Possesses multiple elongated and plump pseudobulbs to prevent dessication. Grows in riparian forests, sub-xerophytic shrubland and forest perimeters or at the interior of forests with neighbouring areas of pasture. In localities with semi-arid climate, this plant finds refuge in the depressions of water channels where the microclimate is more humid. It has been observed on *Brosimum alicastrum, Matisia* sp., *Guarea guidonia, Anacardium excelsum, Guazuma ulmifolia, Amyris pinnata, Daphnopsis americana, Aegiphila grandis, Machaerium capote, Guarea guidonia, Hura crepitans, Erythroxylum ulei, Luehea seemannii, Laetia americana and Dendropanax colombianum.*
Trichocentrum carthagenense (Jacq.) M.W. Chase & N.H. Williams	Neotropical; (Bel, Col, CR., Gua, Hnd, Mex, Nic, Pan, Sal, Ven.) Col: (Ant, Ara, Bol, Boy, Cas, Cau, Cor, Cun, Gua, Hui, Mag, Met, Boy, Tol, Mag, San, Suc, VdC, Vic) 50-1200 m.	Waxy cuticle for adaptation to conditions of water stress. Grows in dry forest and in flooded and non-flooded habitats, sub-xerophytic shrubland, and riverine forests. Frequently epiphytic on trunks and stems a few metres from the ground and less often in matts of leaf litter and decaying trunks. It has been observed on *Eugenia bicolor, Anacardium excelsum, Citharexylum kunthianum, Eugenia monticola, Neea divaricata, Ardisia guianensis, Guazuma ulmifolia, Calliandra* sp., *Jacaranda obtusifolia, Maclura tinctoria* and *Machaerium capote.*
Trizeuxis falcata Lindl.	Neotropical; (Bol, Bra, Col, CR, Ecu, Pan, Per, Ven). Col (Ant, Ara, Boy, Caq, Cas, Cau, Cun, Met, Mag, VdC, Qui, Ris, San) 100-1500 m.	Small pseudobulbs and flattened leaves reduce the effect of the wind to minimise dessication. Frequent on fences, trunks, roadsides, and citrus trees and always found in environments of bright light and with a high level of recruitment. Rarely found at the interior of the forest. It has been observed on *Psidium guajava, Citrus* spp., *Crescentia cujete, Parathesis reticulata, Coffea arabica, Guapira costaricana* and *Eugenia* sp.
Vanilla calyculata Schltr.	Neotropical; (Col, Hnd, Mex, Sal) Col: (Hui, Mag, Nar, Tol, VdC) 570 -1200 m.	Possesses creeping habit and swollen stalks with greater capacity to store water and prevent desiccation. Grows in foothills of the Central Cordillera and Western Cordillera in dry and sub-xerophytic habitats, as well as in alluvial deposits of the inter-Andean valleys. It has been observed on *Cupania americana, Eugenia monticola* and *Psidium sartorianum.*

Country abbreviations: **Arg**: Argentina; **Bel**: Belize; **Bhm**: Bahamas; **Bol**: Bolivia; **Bra**: Brasil; **CR**: Costa Rica; **Col**: Colombia; **Cub**: Cuba; **Ecu**: Ecuador; **Gua**: Guatemala; **Guy**: Guyana; **GFr**: French Guyana; **Hat:** Haiti; **Hnd:** Honduras; **Jam**: Jamaica; **Mex**: Mexico; **Nic**: Nicaragua; **Pan**: Panama; **Per**: Peru; **RD**: Dominican Republic; **Sal**: El Salvador; **Sur**: Surinam; **T&T**: Trinidad& Tobago; **Urg**: Uruguay; **PR**: Puerto Rico; **Par**: Paraguay; **Ven:** Venezuela. Abbreviations of departments of Colombia: **Ama**: Amazonas; **Ant**: Antioquia; **Ara**: Arauca; **Atl**: Atlantic; **Bol:** Bolívar; **Boy:** Boyacá **Cal:** Caldas; **Caq**: Caquetá; **Cau**: Cauca; **Cas:** Casanare; **Ces**: Cesar; **Cho**: Chocó; **Cor**: Córdoba; **Cun**: Cundinamarca; **Guai**: Guainía; **Guav**: Guaviare; **Guaj**: La Guajira; **Hui**: Huila; **Mag**: Magdalena; **Met**: Meta; **Nar**: Nariño; **Nsa**: North of Santander; **Put**: Putumayo; **Qui**: Quindío; **Ris**: Risaralda; **San**: Santander; **Sap**: Sán Andrés and Providencia; **Suc**: Sucre; **Tol**: Tolima; **VdC**: Valle del Cauca; **Vau**: Vaupés; **Vich:** Vichada.

Appendix 2. Kappa value according to Monserud and Leemans (1992).

Kappa Value	Estimation
K <0.05	No agreement
0.05 ≤ K <0.20	Very poor
0.20 ≤ K <0.40	Poor
0.40 ≤ K <0.55	Medium
0.55 ≤ K <0.70	Good
0.70 ≤ K <0.85	Very good
0.85 ≤ K <0.99	Excellent
0.99 ≤ K ≤100	Perfect

Appendix 3. Variance Analysis of one factor.

Summary

Groups	*Count*	*Sum*	*Mean*	*Variance*
Presente	10213	10041305	983,1885832	54291,62268
2030a	3429	3996036	1165,364829	49544,98559
2050b	2237	3051427	1364,071077	38030,01239

Variance Analysis

Origin of variations	*Sum of squares*	*Degrees of freedom*	*Average of squares*	*F*	*P* Value *Probability*	Critical value for F
Between groups	300995377,6	2	150497688,8	2952,301082	0,0000	2,996297626
Within groups	809301369,1	15876	50976,40269			
Total	1110296747	15878				

Appendix 4. Highlights for adaptation to climate change in five Tropical Dry Forest (TDF) bioregions in Colombia.

Bioregion	Number of orchids	Spatiotemporal changes according to the model	IDEAM Prediction	Highlights
Cauca River Valley	70 species (Reina-Rodríguez *et al.* 2010)	Loss of suitability areas, especially north of the Department of Cauca, Cauca Valley, to Risaralda along the floodplain of the Cauca River; see Table 4. Compared to other bioregions, it loses the largest area of suitability and does so consistently in the two periods and = 13.3). These changes will be more pronounced in the short term = 3.4) than in the medium term = 2.3). The severity will be more pronounced in this last period with above average values (4.3); see Table 5. Suitability increased only in Antioquia for both the 2030 and 2050 periods, attributed to an increase of 9.3% in precipitation.	Temperature will increase by 2.4 degrees, and precipitation will only increase at the limits of the department of the Valle del Cauca and the department of Risaralda.	The northern area of this bioregion hosts the largest relicts of TDF and is where most of the orchid richness is maintained. The implementation of conservation action in the short and medium term is vital. The loss of suitability in areas of connectivity of the Dagua and Cauca basin, which is consistent in the two periods with $p \leq 20$, is of great concern, as seen in Figure 3. Attention-investment should be in design actions and implementation of AMC. AMC are high priority.
Caribbean Region	53 species at altitudes < 1000 m. (Betancur *et al.* 2015)	More than any other bioregion, suitability areas in the Caribbean region are especially low ($p \leq 20$) and marked on maps; see Figure 3. Suitability areas will be lost in both the 2030 and 2050 periods. Changes in this bioregion will be more pronounced in the short-term = 5.7) than medium-term = 1.5). Severity will be greater in the second period, with values greater than average > see Table 5.	10-30% less precipitation and an average annual temperature of 30°C are predicted.	The minimum values detected by the model for both periods (26,422 ha and 6907 ha) are critical values compared to other TDF areas in Colombia. For the 2050 period, suitable areas disappear in departments such as Córdoba, Sucre, Bolívar and Atlantic. Orchids present here will be more exposed to hydric and thermal stress, especially in the large flat areas without altitudinal gradients. Areas with strong slopes, cliffs and areas unsuitable for mechanized agriculture and urbanization become important (Macuira, Snia. Piojó, Montes de María, precoastal hills to Cartagena). Attention-investment in knowledge of orchid biodiversity and conservation activities is high priority.
Magdalena Valley	73 species in the Magdalena Valley (Bernal *et al.* 2015)	At the national level, this bioregion loses the second-most area of suitability after the Cauca River Valley; see Table 4. It is consistent in both periods and = 6.7), especially the departments of Huila and Cundinamarca in both periods. The department of Tolima will have minimum areas of regional suitability in both periods; see Table 1. Bioregional indices are above average = 3.7 and =4.1), but particularly notable is the medium-term value, which exceeds that of the other bioregions in Colombia, for which it is expected that the effect on biodiversity will be greater during this period; see Table 5.	Increases of 2.7°C in temperature, and between 20% and 30% in precipitation are expected, especially towards the southern part.	The Magdalena Valley has extensive flat areas, but unlike the Caribbean region, it has thermic/altitudinal gradients less than 50 km away. In this regard, the prospects for orchid conservation in the mid-basin of the Magdalena river are greater. The basins of the inner slopes of the Central and Eastern cordillera acquire great relevance for conservation. Attention-investment in knowledge of orchid biodiversity activities in the central and southern area of this bioregion is high priority. The design and implementation of AMC is a priority.
Patía Valley	< 30 species (Reina-Rodríguez *com pers.*)	Losses of suitable areas are expected in both periods. The indices calculated show values above average in both periods =3.8 and =3.4), also suggesting significant changes in size, with the greatest intensity in the short-term. The severity will be more pronounced than other areas of the country	Precipitation will increase 10-30%, and temperature will increase by up to 2.4°C.	The model detected minimum values in suitability areas for the two periods (26,422 has and 6907 has). The department of Cauca will lose the largest suitable area, and suitable areas would disappear from Nariño; see Table 4. The Patía Valley has thermic/altitudinal gradients at less than 50 km, which facilitate the design and establishment of AMC. During the field phase, areas with cliffs and concave rock formations up to 760 m. were observed, which contain TDF vegetation and where the flora and fauna found refuge against a warmer and more exposed environment. Other territories to the south have relief with steep slopes that form natural barriers on the inner slopes of the Central-Western Cordillera. Some of these areas have been proposed as climatic niches.

Appendix 4 (*continues*).

Bioregion	Number of orchids	Spatiotemporal changes according to the model	IDEAM Prediction	Highlights
Santander Region	127 species (Martínez *et al.* 2015)	Loss of areas of suitability is expected for both periods. The severity index for the 2050 period has the highest value of the country =10.5). Therefore, stronger and higher changes than any other TDF area are expected (see Figure 4). The minimum value of 13,210 ha for the 2050 period along with the Patía Valley and the Caribbean region is one of the lowest for this period	Thermic increases of 2.7°C and hydric decreases of 10% to 40% are predicted for the end of the century, which could affect the ecosystem simultaneously.	The Santander territory, as well as other areas, has large steep areas on the western slope of the Eastern Cordillera that connect the Andes with altitudinal gradients from the Magdalena River to areas of páramo (100-3400 m.a.s.l.). It is the only bioregion with large TDF areas located in mid-mountain areas, a factor that could facilitate migration routes more quickly in this bioregion than in other areas. Attention-investment in in the design and implementation of AMC is high-priority.

Appendix 5. Location of bioclimatic niches in Colombia for adaptation-conservation. Based on the modelling of Tropical Dry Forest (TDF) orchids for 2050 under Climate change scenario. In **bold** are complementary areas with p<0.61. Abbreviations: PA = Public proctected areas; NRCS = Natural Reserves of Civil Society (private protected areas); S.N.S.M= Sierra Nevada de Santa Marta

Id.	Bioregion	Basin (s) and/or Areas with	Mountainous System/ Cordillera	Slope	Municipalities	(a) Areas with net suitability $p > 0.61$ (ha)	(b) Areas of TDF < 23 km (ha)	(c) Areas of PA < 23 km (ha)	(d) Areas of NRCS < 23 km (ha)	Altitudinal range (a-b); (a-c); (a-d)	% of suitable area in the basin	Environmental authority
1	Cauca River Valley	Direct to Cauca	Western C.	East-West	Medellin, Ebéjico, San Jerónimo, Heliconia	50074	22988	10308	82	460-1791	2.04	CVC-CRC
2		Amaime	Central C.	West	El Cerrito, Palmira	4398				1026-1775	5.53	CVC
3		Anchicayá	Western C.	East	Buenaventura, Dagua			23765		629-1789		CVC
4		Bugalagrande	Central C.	West	Bugalagrande, Andalucía, Tuluá	3386	370			1017-1128	4.93	CVC
5		Cajambre	Western C.	East	Buenaventura			2201		1131-1692	5.62	CVC
6		Calima	Western C.	East	Calima, Restrepo, Yotoco	8864	119		141	1544-1619	12.60	CVC
7		Cuenca	Western C.	East	Buenaventura			20164		697-1771	0.17	CVC
8		Dagua	Western C.	East	Dagua, Restrepo, Yotoco, Vijes, Calima	16234	2179	15015	343	649-1796	6.36	CVC
9		De Las Vueltas	Western C.	East	El Cairo, Versalles, El Dovio, Bolívar	7284	417		298	1096-1466	2.29	CVC-CODECHOCO
10		Fraile	Central C.	West	Palmira, Florida, Pradera	1537	41	608		948-1752	1.76	CVC
11		Garrapatas	Western C.	East	Bolívar, Trujillo	1249	395			920-1254	2.73	CVC

12		Ovejas	Central C.	West	Caldono, Piendamó	1284				1521-1570	1.10	CVC-CRC
13		Paila	Central C.	West	Miranda, Corinto, Florida	1341				1248-1576	4.66	CVC
14		Porce	Western C.	North	Itaguí, Medellín, Sabaneta	13480		507		1472-1791	0.07	CORANTIOQUIA
15		Sipi (Garrapatas)	Western C.	East	El Dovio	81	656		11	804-1140	5.34	CVC
16		Tuluá	Central C.	West	Andalucía, Tuluá, San Pedro	6044	946		70	958-1374	0.05	CVC
17	Caribbean Region	Ariguaní	S.N.S.M.	West	Pueblo bello	880	1808			249-846	0.22	CORPOMAG
18		Badillo	S.N.S.M.	East	Valledupar	168	8138			147-992	0.27	CORPOCESAR
19		Catatumbo	Eastern C.	East	Río de Oro	169	1717			1214-1485	0.48	CORPONOR
20		Cesar	S.N.S.M.	East	Manaure balcón del Cesar, Valledupar	502	33048		373	118-1337	0.07	CORPOCESAR
21		Cesarito	S.N.S.M.	East	Pueblo bello, Valledupar	314				782-1095	0.26	CORPOCESAR
22		Dilubio	S.N.S.M.	East	Valledupar		82			507-736		CORPOCESAR
23		Direct to Magdalena	Central C.	North	Río de Oro	169	5475			83-829	0.17	RACDIQUE
24		Direct to Caribe	S.N.S.M.	North	Santa Marta	62	12156		72	0-535	0.06	CORPOCARIBE
25		Fundación	S.N.S.M.	West	Aracataca		28			867-962		CORPOMAG
26		Garupal	S.N.S.M.	East	Valledupar, El Copey		10146			308-1194		CORPOCESAR
27		Guatapurí	S.N.S.M.	East	Valledupar	2492	1053			196-730	3.19	CORPOCESAR
28		Mallorquin	S.N.S.M.	West	El Copey		2785			322-1083		CORPOCESAR
29		**Snia. Piojó**	Isolated hills	All	Luruaco, Piojó							CRA
30		**Snia. San Lucas**	Isolated hills	All	San Jacinto del Cauca, Simití, Sta Rosa							CARDIQUE
31		**Snia de Macuira**	Isolated hills	All	Uribia							CORPOGUAJIRA
32		**Snia. Montes De María**	Isolated hills	All	S. J. de Nepomuceno, S. Jacinto, El carmen de Bolivar, Ovejas, Los Palmitos, Morroa, S. Onofre, Chalán, Toluviejo, Colosó							CARSUCRE
33		**Colinas prelitorales Cartagena de indias**	Isolated hills	All	Cartagena de Indias, Turbaco, S.ta Rosa, S.ta Catalina							CARDIQUE
34		**Snia. Perijá**	Eastern C.	West	Urumita, Manaure, Agustin Codazzi, Becerril, La Jagua de Ibirico, San Diego							CORPOCESAR

Appendix 5 (*continues*).

Id.	Bioregion	Basin (s) and/or Areas with	Mountainous System/ Cordillera	Slope	Municipalities	(a) Areas with net suitability $p > 0.61$ (ha)	(b) Areas of TDF < 23 km (ha)	(c) Areas of PA < 23 km (ha)	(d) Areas of NRCS < 23 km (ha)	Altitudinal range (a-b); (a-c); (a-d)	% of suitable area in the basin	Environmental authority
35	Magdalena River Valley	Aipe	Central C.	East	Neiva	173	52			702-776	0.16	CAM
36		Alvarado	Central C.	East	Ibagué		23			724-757		CORPOTOLIMA
37		Apulo	Eastern C.	West	Cachipay, La Mesa, Tena, Anolaima, Zipacón	6675	4935			518-1548	12.36	CAR
38		Bache	Central C.	East	Neiva, Palermo, Santa María	5544	1102			554-814	3.76	CAM
39		Bogotá	Eastern C.	West	El Colegio, Tequendama, La Mesa, Tena	2973	8233	323		335-1751	0.61	CAR
40		Cabrera	Eastern C.	West	Alpujarra	1172	9533	5800		368-1621	0.48	CAM
41		Coello	Central C.	East	Ibague	85	180	134		693-1108	0.05	CORPOTOLIMA
42		Direct to Magdalena	Central C.-Oriental	East-West	Tello, Neiva, Rivera, Dolores, Prado, Guaduas, S.J. Rioseco, Chaguaní	7445	26814	20864		200-1797	0.17	CORMAGDALENA
43		Iquira	Central C.	East	Íquira	249				1077-1132	0.56	CAM
44		Luisa	Central C.	East	Valle del San Juan		5			638-660		CORPOTOLIMA
45		Negro	Eastern C.	West	Caparrapí, Villeta, Guaduas, Pacho, Chaguaní, Dolores	3570	750	163	10	418-1207	11.22	CORPOTOLIMA
46		Neiva	Eastern C.	West	Riverar, Algeciras, Campoalegre	536	4508			495-1530	0.48	CAM
47		Prado	Eastern C.	West	Pardo, Icononzo, Melgar		2913	87		307-1324		CORPOTOLIMA
48		Recio	Central C.	East	Ambalema		96			237-737		CORPOTOLIMA
49		Seco	Eastern C.	West	S.J. Rioseco, Anolaima	1025	1460			378-1298	1.69	CAR
50		Sumapaz	Eastern C.	West	Tibacuy, Fusagasugá, Arbelaez, Silvania	7842	3242	2339	1	305-1744	2.37	CAR
51		Tobia	Eastern C.	West	Villeta, Quipile, Sasaima, La Vega, San Francisco, Nocaima, Vianí, Bituima, Anolaima, Albán, Guayabales de Síquima	11512			2	966-1790	13.48	CAR
52		Villa Vieja	Eastern C.	West	Tello	165		3606		428-775	0.18	CAM
53		Yaguará	Central C.	East	Iquira	93				955-1078	0.05	CAM

54	Patía Valley	Patia-Guachicono	Central C.	West	Patía, La Vega, La Sierra, Rosas	9299	1186			612-1443	3.5	CRC
55		**Rocky massifs**	Isolated hills	Central & North	Patía, Timbío, Mercaderes							CRC
56		**Juanambu-Guaitara**	Deep canyons	South	Leyva, Policarpa, El Rosario, Taminango							CORPONARIÑO
57	Santander Region	Catatumbo	Eastern C.	East	Ocaña, Río de Oro, Ábrego	1583	13528	2231		481-1778	0.48	CORPONOR
58		Chicamocha	Eastern C.	West	Girón		448			1159-1364		CAS
59		Chucurí	Eastern C.	West	S. V. de Chucurí, Betulia, Zapatoca			23181		178-1776		CAS
60		De Oro	Eastern C.	West	Bucaramanga, Floridablanca, Pidecuesta	2638	8363	16		650-1798	4.82	CDMB
61		Direct to Magdalena	Eastern C.	West	Ocaña, río de Oro	617		41		1453-1553	0.17	CAS
62		Lebrija	Eastern C.	West	Ocaña, Charta, Tona, Lebrija	2537	22139	196		280-1776	0.54	CDMB
63		Oponcito	Eastern C.	East	S. V. de Chucurí			597		1011-1221		CAS
64		Pamplonita	Eastern C.	East	Cúcuta, Bochalema	186	15973			304-1756	0.15	CORPONOR
65		Sardinata	Eastern C.	East	Lourdes	147				1325-1429	0.09	CORPONOR
66		Simana	Eastern C.	West	Ocaña		24			1511-1563		CORPOCESAR
67		Sogamoso	Eastern C.	West	Girón	339	5172	30518		177-1785	0.17	CAS
68		Suarez	Eastern C.	West	Los Santos			1		678-678		CAS
69		Zulia	Eastern C.	East	Cúcuta, Gramalote, Santiago, San Cayetano, Cucutilla, Salazar, Durania	1187	10559	542		154-1696	0.37	CORPONOR

Abbreviations for the Jurisdictions of Environmental Authority. **COROPOCESAR**: Regional Autonomous Corporation of Cesar. **CORPAMAG**: Regional Autonomous Corporation of Magdalena; **CAR**: Regional Autonomous Corporation of Cundinamarca; **CORPOTOLIMA**: Regional Autonomous Corporation of Tolima; **CAM**: Regional Autonomous Corporation of Alto Magdalena; **CORANTIOQUIA:** Regional Autonomous Corporation of Central Antioquia; **CVC**: Regional Autonomous Corporation of Cauca Valley; **CRC**: Regional Autonomous Corporation of Cauca; **CAS**: Regional Autonomous Corporation of Santander; **CDMB**: Regional Autonomous Corporation for the Defence of the Bucaramanga Plateau; **CORPONOR**: Regional Autonomous Corporation of the Northeastern Border; **CARDIQUE**: Regional Autonomous Corporation of the Dique Canal; **CORPOCARIBE:** Regional Autonomous Corporation of the Caribbean.

Appendix 6. List of Tropical Dry Forest (TDF) orchid "core" recorded in five tropical dry forest regions in Colombia. Available only elctronically as supplemnetal material at: http://www.lankesteriana.org/LankesterianaJournal/17(1)/Reina_rodriguez%20et%20al%202017%20Appendix6.pdf

LANKESTERIANA 17(1): 49—54. 2017. doi: http://dx.doi.org/10.15517/lank.v17i1.28269

PORROGLOSSUM RAOI, A NEW SPECIES OF PLEUROTHALLIDINAE (ORCHIDACEAE) FROM ECUADOR

LUIS E. BAQUERO R.[1–4] & GABRIEL A. ITURRALDE[1]

[1] Carrera de Ingeniería Agroindustrial y Alimentos. Facultad de Ingeniería y Ciencias Agropecuarias.
Universidad de Las Américas, Calle José Queri, Quito 170137, Pichincha, Ecuador

[2] Jardín Botánico de Quito, Pasaje #34, Rumipampa E6-264 y Av Shyris, Interior Parque La Carolina,
Quito, 170135, Pichincha, Ecuador.

[3] Instituto Nacional de Biodiversidad, Pasaje Rumipamba 341 y Av. de los Shyris, 170135, Quito,
Pichincha, Ecuador

[4] Correspondent author: lbaquero@hotmail.com

ABSTRACT. A new species of *Porroglossum* (Pleurothallidinae), *Porroglossum raoi* Baquero & Iturralde, apparently endemic to a cloud forest close to Chical, is described here. *Porroglossum raoi* is compared to known species within the genus growing close to the area where it was discovered. The big white flower, the thick, subclavate and brown-purple lateral sepal tails, a single subacute angle on the lower margin of the petals and a strong cinnamon and clove smell, immediately separates this from other species in *Porroglossum*. Taxonomical and ecological notes are given.

KEY WORDS: Pleurothallidinae, *Porroglossum hoijerii*, *Porroglossum* section *Porroglossum*

Introduction. The genus *Porroglossum* Schltr. was proposed by Schlechter in 1920 when some of the species previously placed in *Masdevallia* Ruiz & Pav. did not seem to fit among the rest of species in this genus. 55 species of *Porroglossum* are known at the moment (Luer 1987, Dodson 2003, Merino, Doucette & Pupulin 2010, Chase *et al.* 2015, Karremans 2016), and new taxa continue to be added to the list (Luer 2010, 2011, Luer & Thoerle 2012, 2013, Doucette, McDaniel, Merino, Portilla & Cameron 2015). The most remarkable feature of the flowers of *Porroglossum* is the trigger-sensible lip, something that is otherwise only in *Masdevallia teaguei* Luer, and some species belonging to *Specklinia* Lindl. (ex *Acostaea* Schltr.) and *Stelis* (ex *Condylago* Luer). *Porroglossum* is one of the three genera in the Pleurothallidinae with a lip capable of moving when affected by an external stimulus (Luer 1987). A change in turgor in a layer of cells from a tiny structure of the lip called the claw, causes it to move into a "closed" position on where the callus of the lip presses against the frontal surface of the column-foot (Sweet 1970, Luer 1987). Some species of *Porroglossum*, section *Porroglossum* (Luer 1987), have glabrous peduncles and big, expanded, dorsal sepals, wider than the synsepal formed by the fused lateral sepals, the apex of the dorsal sepal, with a longer or shorter tail, reflected towards the ovary. Species exhibiting such characteristics include *Porroglossum actrix* Luer & Escobar, *P. amethystinum* (Rchb. f.) Garay, *P. aureum* Luer, *P. hoeijeri* Luer, *P. josei* Luer, *P. marniae* Luer, *P. nutibara* Luer & Escobar, *P. olivaceum* Sweet, *P. rodrigoi* Sweet, *P. sergioi* P. Ortiz and *P. teaguei* Luer. Except for *P. actrix*, from Putumayo department in Colombia, the rest of the species grow on the western slopes of the Andes from Colombia and Ecuador (Luer 1980, 1987, 1988, 1989, 1991, 1994, 1995, 1998, 2006).

The north-western cloud forests of Carchi and Esmeraldas provinces in Ecuador are an area in which some species such as *Porroglossum aureum*, *P. hoeijeri* and *P. josei* have been discovered (Luer 1987, 1995). Before 2008, the only way to reach Maldonado and Chical, in Carchi province, was through Tulcán, the biggest city near the Ecuador-Colombia border. This meant a long trip, first, going north to Tulcán and, from there, driving west until getting to Maldonado and Chical. *Porroglossum aureum* and *P. hoeijeri* were discovered along the Tulcán-Maldonado road. In 2008, the road that connects Chical to el Carmen (E187) was officially opened; this allowed the access to previously unexplored zones. Through the E187 road, not only the possibility to reach certain unexplored areas was

Received 29 December 2016; accepted for publication 6 March 2017. First published online: 20 March 2017.

possible, but also, a faster way from Quito and most of Ecuador. *Porroglossum eduardii* (Rchb. f.) Sweet is one of the species which can be found growing along the new road at about 2300 m very close to where populations of *P. hoeijeri* thrive. Both species grow within a private protected area called Dracula Reserve, managed by the Ecominga foundation. A new species of *Porroglossum* has been discovered in this area, near the 14th km in the Chical-El Carmen road; *Porroglossum raoi* Baquero & Iturralde is described below.

Porroglossum raoi Baquero & Iturralde, ***sp. nov.*** (Figs. 1–2).

TYPE: Ecuador. Carchi, El Carmen-Chical road, 0°52'54.5"N 78°13'20.7"W, 1972 m, *Luis Baquero 3045* (holotype, QCNE).

Diagnosis. Species similar to *Porroglossum aureum* from which it differs in the proportionally longer inflorescence, the white flowers with brown-purple, sub-clavate tails, a shortly elevated keel in the broadly thickened callus of the lip, the lower margin of the petals with a subacute angle near the middle and a characteristic cinnamon and clove fragrance, not detected in any other species of *Porroglossum*.

Plant caespitose, epiphytic, medium in size 6–13 cm tall. *Roots* slender, flexuous, 1 mm in diameter. *Ramicauls* abbreviated, terete, erect, slender, 10–40 mm long, enclosed by two or three tubular sheaths. *Leaf* erect, coriaceous, minutely verrucose, long petiolate, 5–9 cm long including the petiole; the blade 3–5 × 0.8–1.2 mm, narrowly obovate; the apex subacute, mucronate; the base narrowed into a slender, conduplicate petiole 2.0–4.5 cm long. *Inflorescence* congested, successively few-flowered (three to five flowers) raceme; peduncle 20 cm long, slender, glabrous, erect to suberect, with a few widely spaced, thin, translucent bracts, floral bracts tubular, imbricating, 8–9 mm long; pedicel 10–13 mm long; ovary smooth, sparsely pocked, 4–5 mm long. *Flowers* resupinate, with a detectable cinnamon and clove fragrance. *Sepals* translucent white; the dorsal sepal depressed obovate, bilobed, 3-veined, 5 × 10 mm expanded, spotted with purple subulated short hairs and more densely covered throughout the veins, gradually increasing in density towards the apex and the tail, connate to the lateral sepals for 3 mm to form a gaping cup; the apex acutely reflexed, obtuse, minutely apiculate, abruptly contracted into a conduplicate tail 3 mm long that does not reach the ovary; the lateral sepals oblong, oblique, glabrous, 3-veined, 6–7 × 4 mm, connate 5 mm to form an acute mentum below the column-foot; the apices oblique, acute, contracted into slender, brownish-purple tails, thickened along the middle, 11 mm long. *Petals* translucent yellow, the color intensity gradually increasing towards the apex, with a red-purple, translucent midvein, ovate-lanceolate, glabrous, 5 × 2 mm narrowed to the slightly dilated, rounded, sub falcate apex; the lower margin with a subacute angle near the middle; the upper margin obtusely angled near the middle. *Lip* white, suffused with dispersed purple dots, sensitive and actively motile; the blade widely obtrullate, 5 × 4 mm; the broadly thickened callus with a shortly elevated keel running longitudinally towards the base; the apex minutely pubescent, acute, with a sulcus running 2 mm from the apex to the center of the blade; the base deflexed and hinged to the free apex of the column-foot by a strap-like claw. *Column* white, stout, semiterete, 3.5 mm long, with two tooth-like processes near the stigma; the column-foot slender, curved, 4 mm long. *Pollinia* 2, droplet shaped, each with a glandular caudicle. *Fruits and seeds* not seen.

EPONYMY**:** Named in memory of the late Velliyur "Malli" Rao and his wife (from Wilmington, Maryland), important donors and promoters of Ecominga Foundation who made possible the purchase and protection of an extensive area of primary forest close to where *Porroglossum raoi* was discovered and other native forests around Ecuador.

DISTRIBUTION**:** *Porroglossum raoi* is known for several plants found growing in primary cloud forest, at an elevation of ~1900 m, around km 14 of the Chical-El Carmen road in the Province of Carchi, Ecuador.

HABITAT AND ECOLOGY**:** Several plants of *Porroglossum raoi*, including the type specimen, have been found growing as epiphytic in extremely humid cloud forest between the 1890 m and 1970 m above sea level. Individuals of this species were growing sparsely, between direct sunlight and heavy shade in the understory of the cloud forest. No other *Porroglossum* species were found growing sympatrically with *P. raoi* while

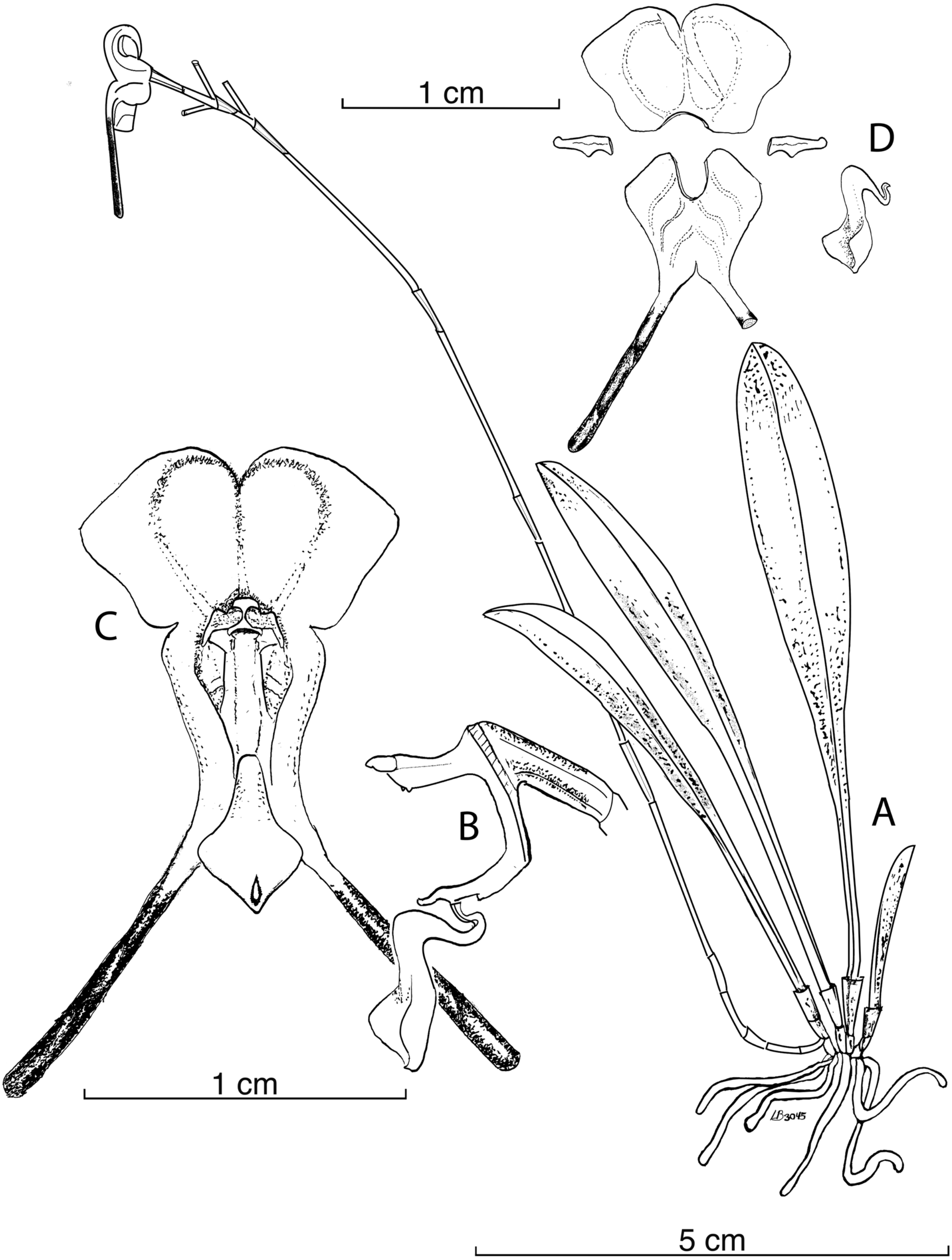


Figure 1. *Porroglossum raoi*. A. Habit. B. Column and lip, lateral view. C. Flower, front view. D. Dissected perianth. Drawn by Luis Baquero from the holotype.

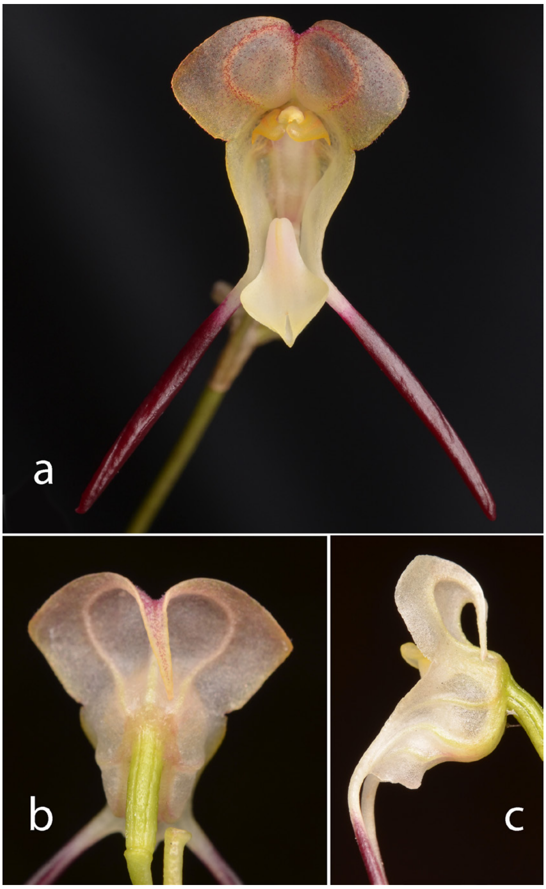


FIGURE 2. Flower of *Porroglossum raoi*. A. Frontal view. B. View from behind. C. Lateral view.

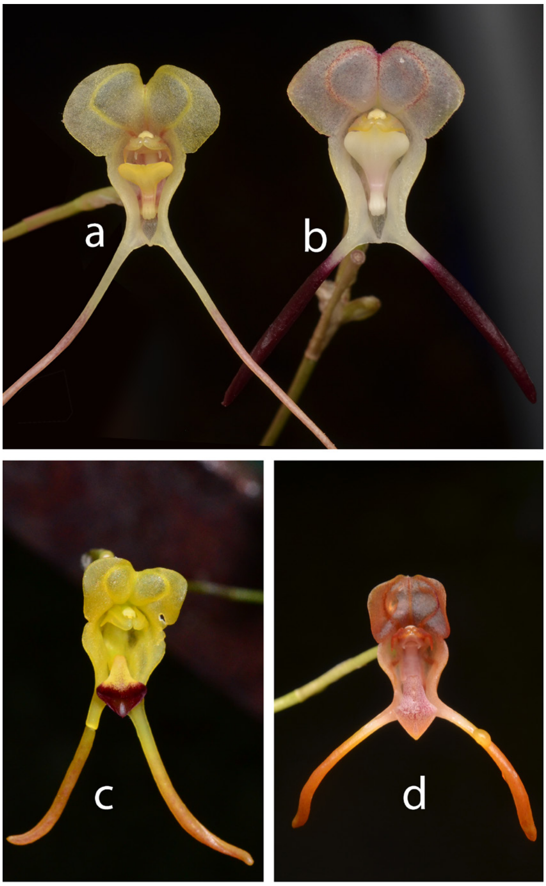


FIGURE 3. Flowers of four species of *Porroglossum*. A. *P. aureum*. B. *P. raoi*. C. *P. marniae.* D. *P. olivaceum*.

other Pleurothalliidinae grow sympatrically: *Dracula trigonopetala* Gary Mey. & Baquero ex A.Doucette, *Scaphosepalum swertiifolium* (Rchb. f.) Rolfe, *Brachionidium imperiale* Luer & R. Escobar, *Lepanthes hexapus* Luer & R. Escobar. *Porroglossum raoi* has not been reported outside its type locality, further field research could result on finding these species in other localities including the neighbor Colombia.

CONSERVATION STATUS*:* Because of its limited range of distribution and the risk of deforestation in the type locality, *Porroglossum raoi* should be considered as endangered or critically endangered by the IUCN criteria. Although it has not been found elsewhere, hopefully a healthy population of *P. raoi* thrives inside Dracula Reserve of the Ecominga Foundation, which exists close to where this species has been discovered.

Porroglossum raoi is considered as a different species by a unique combinations of features, being the strong cinnamon and clove smell the most notorious characteristic. The most similar and, probably, most closely related species is *P. aureum* which was discovered not too far from where *P. raoi* grows; it also shares similar features with *P. marniae* (Fig. 3). Nonetheless*,* the white flowers with a short channeled tail of the dorsal sepal, the brownish-purple, thickened along the middle tails of the lateral sepals, the lower margin of the petals with a subacute angle near the middle and the detectable cinnamon and clove fragrance immediately separate it from similar species (Table 1; sources Luer 1980, 1987, 1988, 1989, 1991, 1994, 1995, 1998, 2006, Merino, Doucette & Pupulin 2010, Kolanowska & Szlachetko 2013).

TABLE 1. Comparison between *Porroglossum raoi* and other related species.

Species	**Dorsal sepal tail length**	**Lateral sepals tails**	**Lip**	**Lip callus**	**Petals**	**Fragrance**
P. raoi	3 mm	Thickened, subclavate, brownish-purple	White, obtrullate, suffused with dispersed purple dots	Broadly, thickened, with a shortly elevated keel	Translucent yellow with red-purple midvein, the lower margin with a subacute angle near the middle	Strong cinnamon and clove
P. aureum	2 mm	Slender, thickened along the middle, yellow	Yellow, cuneate, glabrous	Tall, thick	Translucent yellow with a dark yellow midvein, margins obtusely angled near the middle	Not detected
P. hoeijeri	4 mm	Slender, purplish	Rose, cuneate, broadly rounded, shortly pubescent	Tall, rounded	Translucent orange, the margins with acute angles below the middle	Not detected
P. amethystinum	2 mm	Slender, slightly thickened apically, orange	White, subfused and dotted with dark purple, apex purple black, cuneate	Low, smooth	Translucent with brown midvein, margins obtusely angled near the middle	Not detected
P. marniae	2 mm	Thickened, subclavate, white	Dark purple, white at the base, obovate, microscopically pubescent	Low, longitudinal, brown	Translucent white, obtuse angles below the middle	Not detected
P. nutibara	absent	Thickened, subclavate, yellow	White and red minutely pubescent above the middle, obovate	Tall, rounded, longitudinal, glabrous	Translucent white, margins with obtuse angles below the middle	Not detected
P. olivaceum	2–3 mm	Slender, orange–red	Yellow, dark purple and densely short-pubescent on the distal half, cuneate	Tall, rounded, longitudinal	Translucent yellow or light brown, with a darker midvein, lower margins with an acute angle near the middle	Not detected

ACKNOWLEDGEMENTS. We acknowledge Universidad de Las Americas (UDLA) for funding research on orchids in Ecuador. The Ministerio del Ambiente del Ecuador is acknowledged for issuing the Environmental Research Permit No. 008-2016-IC-FLO-DNB/MA. We also want to thank Mr. Velliyur "Malli" Rao and his wife for being vital supporters and donors which made possible the Dracula Reserve as well as other reserves managed by Ecominga Foundation. Also Ecominga Foundation for working in conservation of orchids *in situ* by preserving forests before being cut down. Finally, we are grateful to the Editor and the anonymous reviewers for suggestions on the manuscript.

LITERATURE CITED

Chase, M. W., Cameron, K. M., Freudenstein, J.V., Pridgeon, A. M., Salazar, G., van den Berg, C. & Schuiteman, A. (2015). An updated classification of Orchidaceae. *Botanical Journal of the Linnean Society,* 177, 151–174.

Dodson, C. H. (2003). *Native Ecuadorian orchids*. Vol. 4: *Oncidium-Restrepiopsis*. Sarasota, Florida: Dodson Trust.

Doucette, A., McDaniel, J., Merino, G., Portilla, J. & Cameron, K. (2015). Two new *Masdevallia* species and a new *Porroglossum* (Orchidaceae: Pleurothallidinae) from Zamora-Chinchipe, Ecuador. *AOS-Orchids (Lindleyana),* 84(8), 504–511.

Karremans, A. P. (2016). *Genera Pleurothallidinarum*: an updated phylogenetic overview of Pleurothallidinae. *Lankesteriana*, 16(2), 219–241.

Kolanowska, M. & Szlachetko, D. L. (2013). A new species of *Porroglossum* (Orchidaceae, Pleurothallidinae) from

Colombia. *Polish Botanical Journal*, 58(2), 629–632.

Luer, C. A. (1980). Miscellaneous new species in the Pleurothallidinae (Orchidaceae). *Phytologia*, 46(6), 374–381.

Luer, C. A. (1987). Icones Pleurothallidinarum IV. Systematics of the genus *Porroglossum*. *Monographs in Systematic Botany from the Missouri Botanical Garden*, 24, 25–90.

Luer, C. A. (1988). Icones Pleurothallidinarum V. Systematics of *Dresslerella* and *Scaphosepalum*. Addenda to *Porroglossum*. *Monographs in Systematic Botany from the Missouri Botanical Garden,* 26, 108–109.

Luer, C.A. (1989). Icones Pleurothallidinarum VI. Systematics of *Pleurothallis* subgenus *Ancipitia*, subgenus *Scopula* and *Trisetella*. Addendum to *Porroglossum*. *Monographs in Systematic Botany from the Missouri Botanical Garden,* 31, 124–125.

Luer, C. A. (1991). Icones Pleurothallidinarum VIII. Systematics of *Lepanthopsis*, *Octomeria* subgenus *Pleurothallopsis*, *Restrepiella*, *Restrepiopsis*, *Salpistele*, and *Teagueia*: addenda to *Platystele*, *Porroglossum* and *Scaphosepalum* (Orchidaceae). *Monographs in Systematic Botany from the Missouri Botanical Garden*, 39, 152–156.

Luer, C. A. (1994). Icones Pleurothallidinarum XII. Systematics of the genus *Lepanthes* subgenus *Brachycladium* and *Pleurothallis* subgenus *Aenigma* subgenus *Elongatia* subgenus *Kraenzlinella*. Addenda to *Dracula*, *Lepanthopsis*, *Myoxanthus*, *Platystele*, *Porroglossum* and *Trisetella*. *Monographs in Systematic Botany from the Missouri Botanical Garden*, 52, 134.

Luer, C. A. (1995). Icones Pleurothallidinarum XII. Systematics of the genus *Brachionidium*. Addenda to *Dresslerella*, *Platystele* and *Porroglossum*. *Monographs in Systematic Botany from the Missouri Botanical Garden*, 24, 144–145.

Luer, C. A. (1998). Icones Pleurothallidinarum XVII: *Pleurothallis* Subgenus *Pleurothallis* Sections *Pleurothallis* and *Acroniae*, *Pleurothallis* Subgenera. Addenda to *Dracula*, *Lepanthes*, *Masdevallia*, *Porroglossum* and *Scaphosepalum*. *Monographs in Systematic Botany from the Missouri Botanical Garden,* 72, 114–115.

Luer, C. A. (2006). Icones Pleurothallidinarum XXVIII: A reconsideration of *Masdevallia*, and the systematics of *Specklinia* and Vegetatively similar taxa (Orchidaceae). Addendum to *Porroglossum*. *Monographs in Systematic Botany from the Missouri Botanical Garden*, 105, 253–254.

Luer, C. A. (2010). Icones Pleurothallidinarum XXXI: *Lepanthes* of Bolivia. Systematics of *Octomeria* species north and west of Brazil. *Monographs in Systematic Botany from the Missouri Botanical Garden*, 120, 147–153.

Luer, C. A. (2011). Miscellaneous New Species in the Pleurothallidinae (Orchidaceae) Excluding Species from Brazil. *Harvard Papers in Botany*, 16(2), 341–345.

Luer, C. A. & Thoerle, L. (2012). Miscellaneous New Species in the Pleurothallidinae (Orchidaceae). *Harvard Papers in Botany*, 17(2), 333–368.

Luer, C. A. & Thoerle, L. (2013). Miscellaneous New Species in the Pleurothallidinae (Orchidaceae). *Harvard Papers in Botany*, 18(2), 183–185.

Merino, G., Doucette, A. & Pupulin, F. (2010). New species of *Porroglossum* (Orchidaceae: Pleurothallidinae) from Ecuador. *Lankesteriana,* 9(3), 459–466.

Schlechter, R. (1920). Beschreibungen neuer Arten: *Porroglossum colombianum. Repertorium specierum novarum regni vegetabilis, Beihefte,* 7, 83.

Sweet, H. R. (1970). Orquídeas andinas poco conocidas. IV. *Porroglossum* Schltr.. *Orquideologia,* 5, 155–170.

LANKESTERIANA 17(1): 55—60. 2017. doi: http://dx.doi.org/10.15517/lank.v17i1.28479

A SHOWY NEW *PLATYSTELE* (PLEUROTHALLIDINAE: ORCHIDACEAE) FROM NORTHWEST ECUADOR

Lou Jost[1,2,4] & Gabriel Iturralde[3]

[1] Fundacion EcoMinga, 270 12 de noviembre and Luis A Martinez, Banos, Tungurahua, Ecuador
[2] Jardín Botánico de Quito, Parque Carolina, Quito, Pichincha, Ecuador
[3] Universidad de Las Américas, Calle José Queri, Quito 170137, Pichincha, Ecuador
[4] Author for correspondence: loujost@gmail.com

Abstract. A new species of *Platystele* (Pleurothallidinae: Orchidaceae) is described from foothill forest in the province of Carchi in northwestern Ecuador. The species has relatively large flowers for the genus, with long slender sepaline tails. It resembles *Platystele caudatisepala,* but is distinguished from that species by the partially connate lateral sepals, the convex lip with reflexed tip and margins, the deflexed petals, sometimes with their tips touching behind the flower, the sepals with recurved margins, and the leaves long-petiolate.

Resumen. Se describe una nueva especie de *Platystele* (Pleurothallidinae: Orchidaceae) de los bosques piemontanos de la provincia de Carchi en el noroccidente de Ecuador. Esta especie presenta flores relativamente grandes en relación a la mayoría de las especies del género, cuyas caudas de los sépalos son largas y delgadas. Es similar a *Platystele caudatisepala* pero se distingue de esa especie por sus sépalos laterales parcialmente connados, el labio convexo con la punta y márgenes reflexos, los pétalos deflexos, a veces tocando sus puntas hacia atrás de la flor, los sépalos con márgenes recurvados y las hojas largamente pecioladas.

Key words: Carchi, Ecuador, Orchidaceae, *Platystele*, Pleurothallidinae

Introduction. The genus *Platystele* Schltr. (Pleurothallidinae: Orchidaceae) is a large Neotropical genus of mostly tiny orchids, with leaves not exceeding 15cm, and some with flowers less than 3 mm across (Luer 1990). They are usually found in very wet forests, where they are inconspicuous and seldom noticed by non-specialist collectors. At the time of its most recent monograph (Luer 1990), the genus *Platystele* contained 73 species. Since then, four species have been removed to be placed in the recently-established genus *Teagueia* (Luer) Luer (1991) and at least 41 new species have been added (Karremans 2016). Genetic analysis shows that *Platystele* is most closely related to *Scaphosepalum* Pfitz. (Pridgeon *et al.* 2001).

Though most *Platystele* species have flowers only a few millimeters across, a few have relatively larger flowers (though still on small plants), and a very few may even be considered "showy". The species described here is one of the larger and showier members of the genus, with flowers exceeding 30 mm because of their long sepaline tails.

Taxonomic treatment

Platystele baqueroi Jost & Iturralde, ***sp. nov.*** (Figs. 1-4).

TYPE: Ecuador. Carchi: epiphyte on cliff-side vegetation, 1.003° N, 78.214° W, elevation 1080 m, May 10, 2016, *L. Baquero 3100* (Holotype, QCNE!). Figs. 1–2.

Diagnosis. Similar to the widely distributed *P. caudatisepala* (C. Schweinf.) Garay, but differs in its more long-petiolate leaves, lateral sepals connate for 2 mm and not divergent, petals usually strongly deflexed, with tips that often meet or cross behind the flower, and adaxial surface of lip strongly convex rather than planar.

Herb, epiphytic, densely caespitose; roots slender, 0.3–0.4 mm thick. *Ramicauls* slender, 2–3 mm long, enclosed by 2–3 thin, ribbed, imbricating, apiculate, persistent sheaths. *Leaf* erect, coriaceous, obovate, 12–14 mm in length including petiole, 4 mm wide, gradually narrowing into a slender

Received 13 March 2017; accepted for publication 5 April 2017. First published online: 7 April 2017.

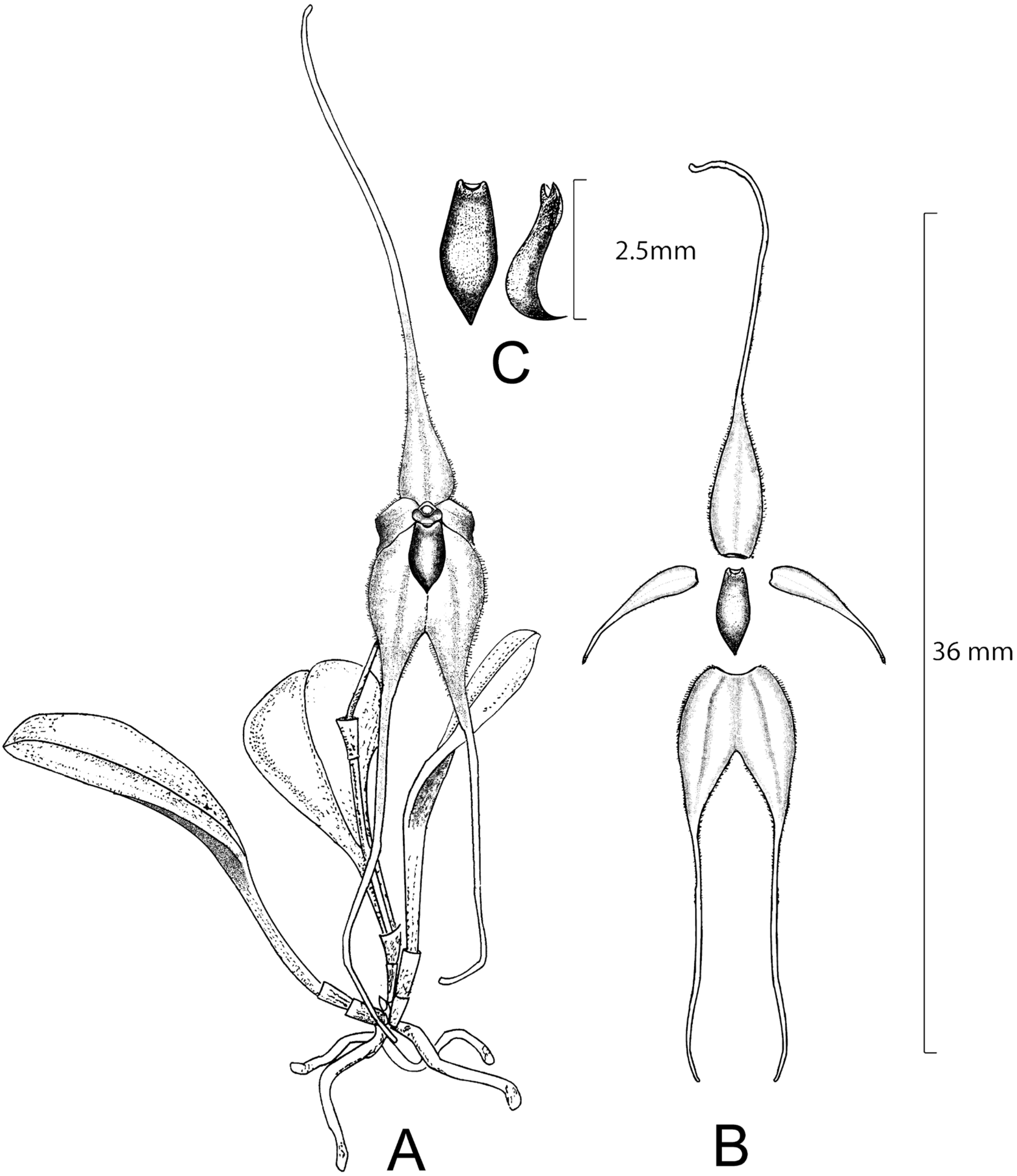


FIGURE 1. *Platystele baqueroi*. A, plant. B, dissection. C, lip, frontal and lateral views. Drawing by Luis Baquero from the holotype.

petiole about 4 mm long. *Inflorescence* a congested, successively many-flowered raceme up to 10 mm long, with an imbricating apiculate sheath, born on an erect, filiform peduncle 5 mm long arising laterally from the ramicaul; floral bracts thin, imbricating, apiculate, 1 mm long; 0.2–0.5 mm between flowers; pedicels straight, 1–3 mm long; ovary 0.5 mm long; *sepals* translucent, single-veined, with clavate cilia on margins and inner surfaces, very narrowly ovate, acute, long-attenuated; dorsal sepal yellowish, 15.0 mm × 1.4 mm wide; lateral sepals yellowish with purple wash, each 15 mm × 2 mm, connate for 2 mm; *petals* translucent yellowish washed with purple, with clavate cilia on margins, narrowly

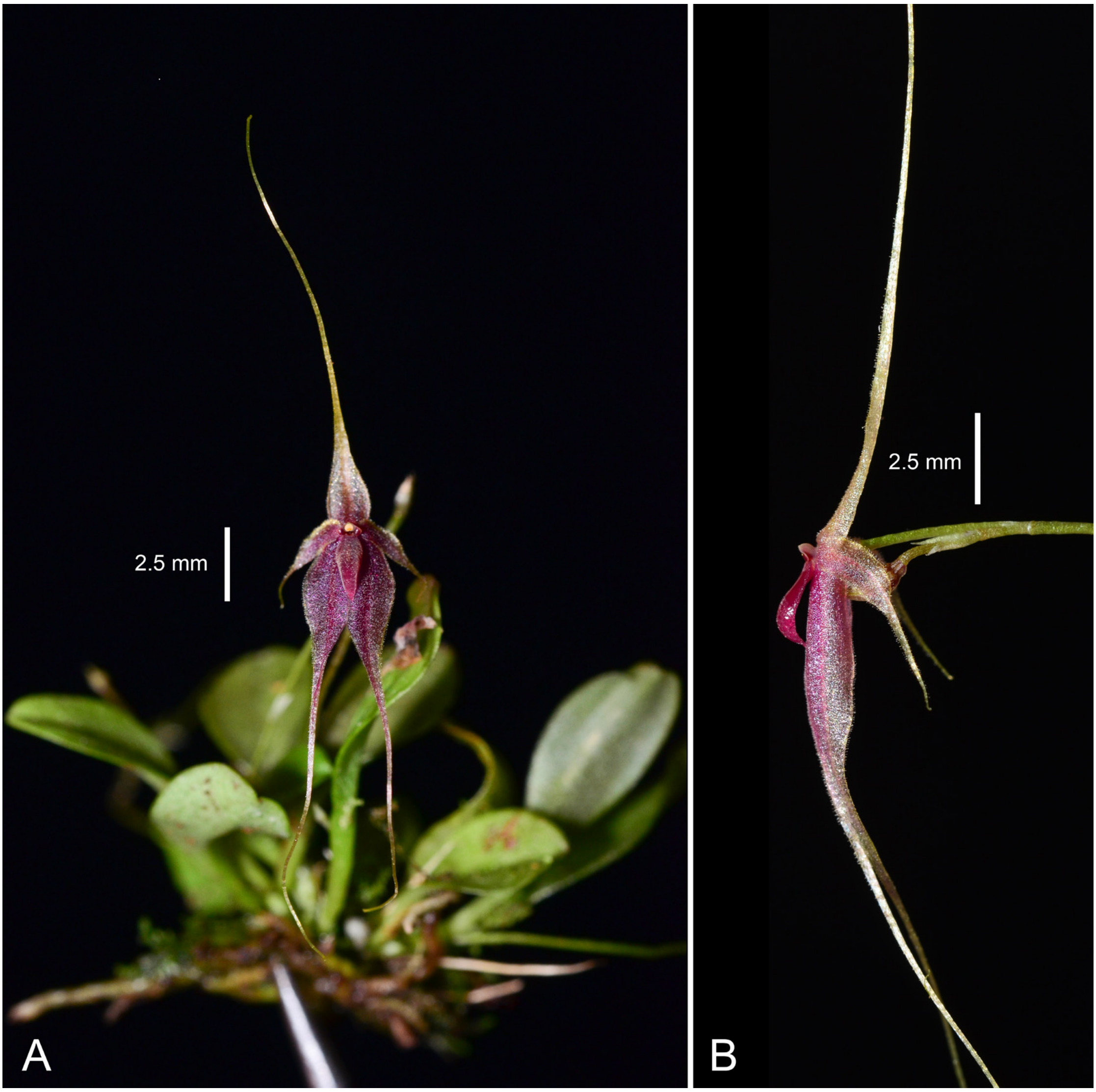


Figure 2. *Platystele baqueroi.* A, frontal view. B, lateral view. Scale bars = 2.5 mm. Photographs of the specimen that served as the holotype by Luis Baquero.

ovate, oblique, acute, 4.0 mm × 0.7 mm; *lip* purple, three-veined, cellular-glandular, ovate, acute, convex, edges reflexed, 2.2 mm long, including 0.5 mm acuminate tip, 0.8 mm wide, the base truncate with small glenion; attached to column foot; *column* cucullate, 0.5 mm × 0.7 mm, the stigma bilobed.

Paratype: Ecuador. Carchi: epiphyte on cliff-side vegetation, 1.003° N, 78.214° W, elevation 1080 m. May 26, 2016, *L. Baquero 3103*, (QCNE!)

Eponymy: Named after Luis Baquero, Quito, Ecuador, enthusiastic orchidologist and conservationist who discovered this species.

This species is similar to *P. caudatisepala*, which occurs from Mexico to Ecuador at similar elevations; the discoverer Luis Baquero reports that *P. caudatisepala* are present in the same area as *P. baqueroi*. As in *P. caudatisepala*, the dorsal sepal varies greatly in length from flower to flower, and the margins of the floral parts have conspicuous clavate cilia (Fig. 3). The most obvious difference between

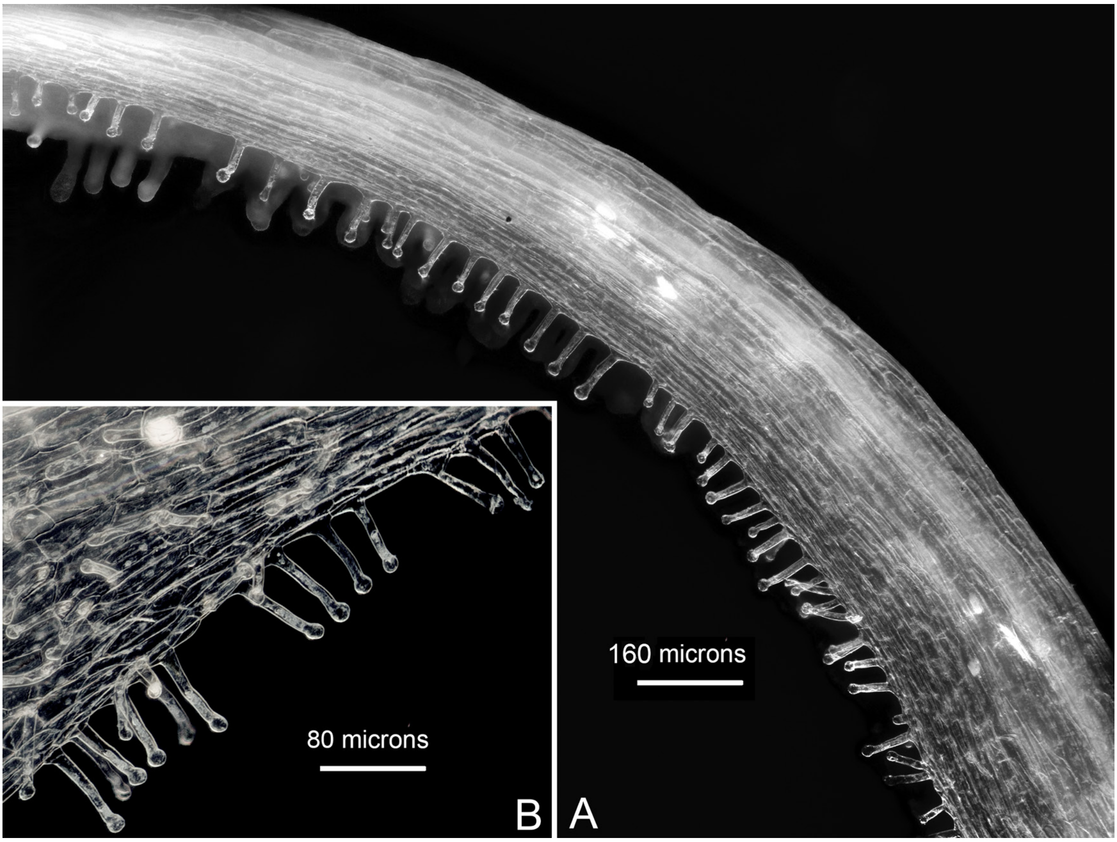


Figure 3. *Platystele baqueroi*. A, dorsal sepal margin. B, detail of clavate cilia. Alcohol-preserved specimen (*L. Baquero 3103*). Photographs by Lou Jost.

P. baqueroi and *P. caudatisepala* is that the former's lateral sepals are connate for 2 mm while the latter's sepals are free to the base. The petals of *P. baqueroi* are usually strongly reflexed, as are the outer margins of the sepals. The lip is thick in the middle, thin at the edges, and the upper (adaxial) surface is strongly convex (Fig. 4), unlike the planar lip of *P. caudatisepala*. The leaves of *P. baqueroi* are petiolate versus subpetiolate in *P. caudatisepala*.

Another similar *Platystele* with long sepaline tails is *P. posadarum* Luer & Escobar from Colombia (Luer 1990). *Platystele baqueroi* differ from *P. posadarum* in having lateral sepals connate for 2 mm versus free to near the base in *P. posadarum*, smaller more narrow petals than *P. posadarum* (4 mm × 0.7 mm *versus* 6 mm × 2.3 mm), front surface of the lip featureless versus sulcate in *P. posadarum*, and tip of lip apiculate and deflexed versus obtuse in *P. posadarum*.

Platystele speckmaieri Luer & Sijm (Luer 2010) is also superficially similar with its long-attenuate sepals. However, its sepals are free and spreading, its petals are also spreading, the lip is sulcate, contracted above the middle, narrowly obtuse at apex , and the peduncle of the inflorescence is up to 60 mm long versus 5mm in *P. baqueroi*.

Conservation status: *Platystele baqueroi* is as yet only known from the province of Carchi, but nearby Colombia is poorly explored, and it probably occurs there as well. It should be classified as Data Deficient.

Acknowledgements. Luis Baquero and Gabriel Iturralde thank the Ministry of the Environment for Permit 008-2016-IC-FLO-DNB/MA/MODIFICACION under which this specimen was collected. The authors thank Universidad de Las Americas, Quito, for supporting biodiversity research in Ecuador.

Figure 4. *Platystele baqueroi*. Column and lip. A, column. B, lip. Alcohol-preserved specimen (*L. Baquero 3103*). Scale bar = 1 mm. Photograph by Lou Jost.

LITERATURE CITED

Karremans, A. P. (2016). *Genera Pleurothallidinarum*: An updated phylogenetic overview of Pleurothallidinae. *Lankesteriana,* 16 (2), 21–241.

Luer, C. A. (1990). Icones Pleurothallidinarum VII. Systematics of *Platystele* (Orchidaceae). *Monographs in Systematic Botany from the Missouri Botanical Garden,* 38, 1–184.

Luer, C. A. (1991). Icones Pleurothallidinarum VIII. Systematics of *Lepanthopsis*, *Octomeria* subgenus *Pleurothallopsis*, *Restrepiella*, *Restrepiopsis*, *Salpistele,* and *Teagueia* (Orchidaceae). *Monographs in Systematic Botany from the Missouri Botanical Garden,* 39, 139–146.

Luer, C. A. (2010). Icones Pleurothallidinarum XXXI. Addenda: Miscellaneous new species, new name, and new combinations. *Monographs in Systematic Botany from the Missouri Botanical Garden,* 120, 137–154.

Pridgeon, A. M., Solano, R. & Chase, M. W. (2001). Phylogenetic relationships in Pleurothallidinae (Orchidaceae): combined evidence from nuclear and plastid DNA sequences. *American Journal of Botany,* 88(12), 2286–2308.

LANKESTERIANA 17(1): 61—71. 2017. doi: http://dx.doi.org/10.15517/lank.v17i1.28527

PRECURSORS OF THE BOTANICAL EXPLORATION OF SOUTH AMERICA. WILLEM PISO (1611–1678) AND GEORG MARCGRAVE (1610–1644)

Carlos Ossenbach

Orquideario 25 de Mayo, San José, Costa Rica • caossenb@racsa.co.cr

Abstract. The Dutch colonization of northeastern Brazil from 1630 to 1654 is described, with emphasis on the years 1636–1644, when the colony was under the administration of Johan-Maurits Prince of Nassau-Siegen (1604–1679). During his rule, the Company sent the geographer and astronomer Georg Marcgrave (1610–1644) and the physician Willem Piso (1611–1678) to Recife. Both explored northern Brazil and made rich botanical and zoological collections, which were published in Amsterdam in 1648, after Pisos's return, under the title *Historia naturalis Brasiliae*; a second edition followed in 1658. In this work Piso mentions for the first time the orchid *Vanilla* in its current spelling. Both Piso and Marcgrave collected and illustrated *Catasetum maculatum*, whilst a third orchid species, *Trigonidium acuminatum*, can be found in Marcgrave's herbarium.

Key words: Brazil, *Catasetum*, Herbaria, Marcgrave, Nassau-Siegen, Piso, *Vanilla*

The Dutch colonization of Brazil 1630–1654. The Netherlands had long been part of the Spanish Empire until, during the Eighty Years' War (1568–1648), the Dutch established the Republic of the Seven United Netherlands (The Dutch Republic). The Dutch involvement in Brazil began in 1594, when Phillip II of Spain granted a special permit for a fleet of twenty Dutch ships to sail to the Portuguese colony once a year — Portugal being in a dynastic union with Spain from 1580 to 1640. In 1609 Spain and the Dutch Republic signed a Twelve Years' Truce, in which the Dutch were allowed to trade with Portuguese settlements in Brazil, Portugal's small size and small population meant that it needed foreign participation in the colonization and the commerce of its overseas empire; the Dutch provided such mutually beneficial collaboration. As part of the truce the Dutch also agreed to delay the creation of a West India Company — a counterpart to the already existing Dutch East India Company — thus explicitly renouncing trade with the Spanish colonies in America.

By the end of the truce in 1621, the Dutch Republic had vastly expanded its trade networks, gaining over half of the cargo trade between Brazil and Europe. As a result, from three sugar refineries in the Northern Netherlands in 1595 the industry had grown to 29 by 1622. When the peace treaty expired, the Dutch West India Company was immediately created. Through the new company the Dutch now started to interfere in the Spanish and Portuguese possessions in America.

In December 1623, as part of the *Groot Desseyn* (grand design), Admiral Jacob Willekens led an expedition comprising 26 ships and 3,300 men of the Dutch West India Company (WIC) to Salvador, then the capital of Brazil and the center of Brazil's sugarcane production. They arrived there on May 8th 1624 and soon forced the surrender of the Portuguese Governor, Diogo Tristão de Mendonça Furtado. However, by April 30th 1625 and with help from Spain, the Portuguese recaptured the city. During the next three decades the city was to play a critical role as a base of the Portuguese struggle against the Dutch for the control of Brazil.

Part of the plan was also to conquer the main Portuguese fort and slave station on the coast of Angola, São Paulo de Loanda (Luanda). In this way the company would control both the lucrative sugar plantations in Brazil and the Atlantic slave trade. Control of the trade itself was necessary because of the high mortality rate in the plantations' harsh conditions and from tropical diseases such as malaria.

In 1628 the seizure of a Spanish silver convoy by Piet Heyn in Matanzas Bay (Cuba) provided the Dutch WIC with the funds for another attempt to conquer Brazil. this time through Pernambuco. In the summer of 1629 the Dutch finally landed, gaining control of Olinda and Recife (the capital of Pernambuco) by February 16th 1630. By 1634 the Dutch controlled the coastline from the Rio Grande do Norte to

Received 17 February 2017; accepted for publication 18 April 2017.

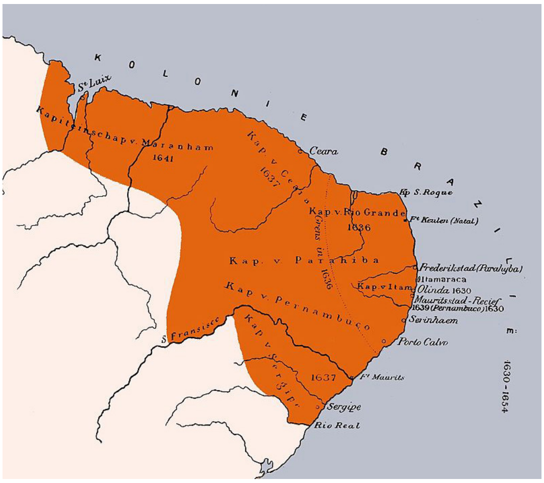


Figure 1. Map of Nieuw Holland (New Holland = Dutch Brazil), around 1641.

Pernambuco's Cabo de Santo Agostinho (Fig.1). They still maintained control of the seas as well. By 1635 many Portuguese settlers were choosing Dutch-occupied land over Portuguese-controlled land as the Dutch offered freedom of worship and security of property. In the same year the Dutch conquered three Portuguese towns: Porto Calvo, Arraial do Bom Jesus, and Fort Nazaré on Cabo de Santo Agostinho. These strongholds expanded the Dutch sugar lands which led to an increase in profitability.

Dutch Brazil under Johan Maurits van Nassau-Siegen. In 1636 the Dutch West Indian Company gave control of its Brazilian possessions, now called "Nieuw Holland," to Count, later Prince, Johan Maurits van Nassau-Siegen (1604-1679) (Fig. 2), the great-nephew of William the Silent (William I, Prince of Orange, 1533–1584, leader of the Dutch revolt against the Spaniards). He landed at Recife in January of 1637.

Within the year, he had conquered the Brazilian province of Ceara and sent a fleet to capture the West African trading post of Elmina Castle, which became the capital of the Dutch Gold Coast. In 1641 the Dutch captured the province of Maranhão, meaning that Dutch control now extended across the entire north and the coastline between the Amazon and Sao Francisco Rivers (Fig. 3). His exploits meant that in later years Maurits was often called *the Brazilian.*

Under Maurits' rule, the colony thrived. He commissioned Golden Age painters, such as Albert Eckhout (1610–1655) and Frans Post (1612–1680), to depict Brazil's richness, resulting in works showing different races, landscapes, and still lifes (Fig. 4). On the island of António Vaz, he founded the town of Mauritsstad (also known as Mauricia), named after himself, where he created an astronomical observatory and a meteorological station, the first such created by Europeans in the Americas. In 1643 he equipped the expedition of Hendrik Brouwer, which unsuccessfully attempted to establish an outpost in southern Chile. In 1644, following the cession of hostilities, the WIC recalled him to Europe in an attempt to curb military expenditure.

Figure 2. Johan-Maurits of Nassau-Siegen (1604-1679). Unknown artist.

Maurits also sought to explore the country's natural history and geography. To this end he sent for the physician Willem Piso (1611–1678) (Fig.5), the geographer and astronomer Georg Marcgrave (1610–1644) and a student of medicine and mathematics, H. Cralitz (who unfortunately succumbed to tropical disease, dying within 12 months of his arrival).

Willem Piso had finished his studies in Caen in 1633 and settled in Amsterdam as a doctor before leaving for Brazil. Georg Marcgrave was born in Liebstadt near

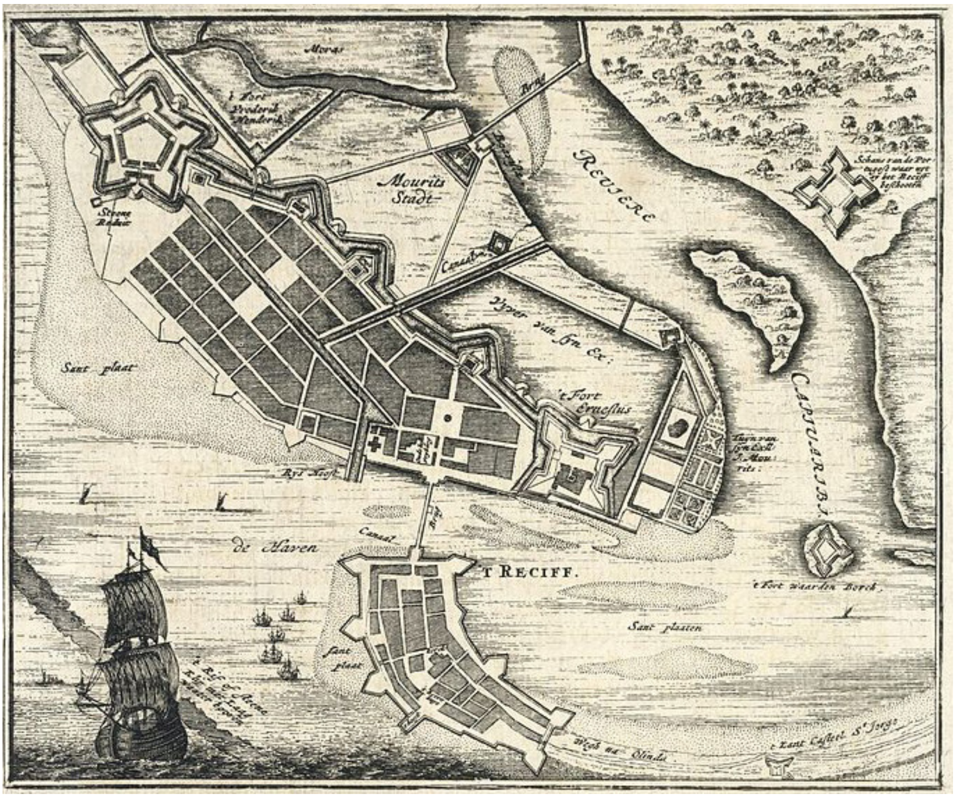


Figure 3. Map of Recife and Mauritsstad. By Georg Marcgrave.

Figure 4. Brazilian landscape with oxcart by Frans Post (1838).

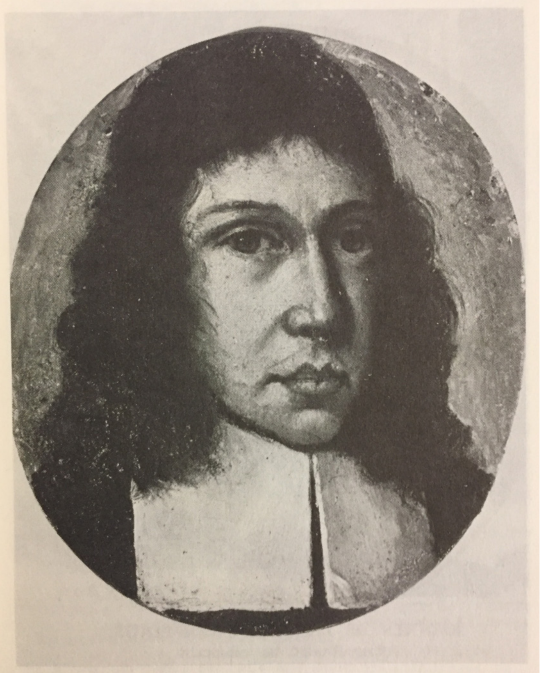


Figure 5. Willem Piso (1611-1678).

Dresden and studied astronomy, botany, mathematics and medicine at German and Swiss universities before moving to Leiden, Holland, in 1636. Once in Recife Marcgrave won favour with the Count, who let him work at his observatory. Both scientists worked as physicians to the Dutch forces in the region, Piso recommending the consumption of fresh fish, vegetables, and fruits after discovering that soldiers and seamen suffered from physical problems resulting from malnutrition. Marcgrave travelled extensively with Piso, collecting animals and plants over a wide area. However, he was eventually stricken with a lethal fever. While preparing to sail for home in 1644, Marcgrave was unexpectedly called upon to travel to Angola, where, on arrival, he died from the illness.

The Count and Willem Piso thus returned to Holland without Marcgrave or Cralitz, but laden with considerable collections of specimens and the very confusing notes of Marcgrave, who had written his natural history findings in a cipher, purportedly to prevent Piso for claiming credit for the work. Marcgrave, with great foresight, was indeed attempting to foil any act of plagiarism on the part of the physician. Willem Piso's contributions to the first edition of *Historia Naturalis Brasiliae* (1648) (Fig. 6), in twelve volumes, were published under the heading *De medicine Brasiliense*. The eight volumes on botany and zoology were compiled from the material authored by Marcgrave, decoded and edited by Johannes de Laet (1593–1649), one of the directors of the Dutch West India Company.

Ten years later, a second edition of this work appeared under the title *De Indiae Utrusque re naturali et medica* (Fig. 7), in which Piso carelessly made his own treatment of Marcgrave's work, omitting most of Marcgrave's botanical descriptions and without mentioning Johannes de Laet. For this he was severely criticized by, among others, Carolus Linnaeus. This second edition was complemented with a chapter written by the Dutch physician Jakobus Bontii (Jacob Bontius) (1592–1631) on medicinal plants from Batavia (Dutch East Indies).

This work must be considered as the earliest ethnobotanical study of the Brazilian flora and one of the first treatises on tropical plants and human diseases. It is complemented by a herbarium with 177 specimens collected by Marcgrave, and has been kept in the Botanical Museum of Copenhagen since 1653.

In the spring of 1646 the Dutch sent a relief expedition to Recife, temporarily forestalling the fall of the city. Back in Europe, the collapse of Dutch Brazil accelerated Dutch efforts to end the Eighty Years' War, its longstanding conflict with Spain. In August 1647 Dutch representatives acquiesced to the Peace of Munster ending the war with Spain. A second, larger relief expedition then set out to reconquer Brazil.

In Brazil the Dutch had already abandoned Itamaracá on December 13th 1647. The new expeditionary force arrived late at Recife, with many of its soldiers either dead or mutinous from lack of pay. On April 1648 the Portuguese routed this expeditionary force at the First Battle of Guararapes, fought outside Recife. On February 1649 the Portuguese defeated the Dutch again at the Second Battle of Guararapes. The Dutch finally lost control of Recife on January 28th 1654, leaving to the Portuguese their colony of Brazil and putting an end to Nieuw Holland (Fig. 8).

Meanwhile, the British, French, and Dutch Caribbean colonies had become major competitors to Brazilian sugar due to rising sugar prices in the 1630s and 1640s. After the Dutch evacuated Pernambuco, they brought their expertise and capital to the

Figure 6. Frontispiece of Piso's first edition (1648).

Figure 7. Frontispiece of Piso's second edition (1658).

Caribbean. In the 1630s, Brazil provided 80% of the sugar sold in London, while by 1690 it only provided 10%. The Portuguese colony of Brazil did not recover economically until the discovery of gold in southern Brazil during the 18th century.

Orchids in the works of Piso and Marcgrave. Willem Piso has gained a name among orchidologists for having been the first to use the term *Vanilla* in its present spelling. In the 1658 edition of his *De Indiae Utriusque re naturali et medica* (Piso, 1658: *Mantissa Aromatica*) he writes: […] *est herba Mexicanis 'Tlilxochitl' dicta, quam Francisc. Hernandez 'Araco Aromatico' comparat.* […] *quas vulgus Hispanorum a vaginarum similitudine 'Vaynillas' appellat.* (it is a herb which the Mexicans call 'Tlilxochitl', that compares to that called 'Araco Aromatico' by Francisco Hernandez […] which common Spaniards because of its similitude with the vagina call 'Vaynillas') (Fig. 9).

The fact that Piso did not name *Vaynilla* in the first edition of his work ten years earlier was probably due to the fact that he only had access to the work of Francisco Hernández through the second edition of his *Rerum Medicarum Novae Hispaniae Thesaurus, seu Plantarum, Animalium, Mineralium Mexicanarum Historia*, published in 1651 by the Italian Accademia dei Lincei under the guidance of Francesco Stelluti. A first, very incomplete, edition had been published in 1615 by Francisco Ximenez, and is cited once by Marcgrave in the edition of *Historia Naturalis Brasiliae* of 1648; a further reduced edition was brought out in 1628 by the same Accademia dei Lincei. (Ossenbach 2009).

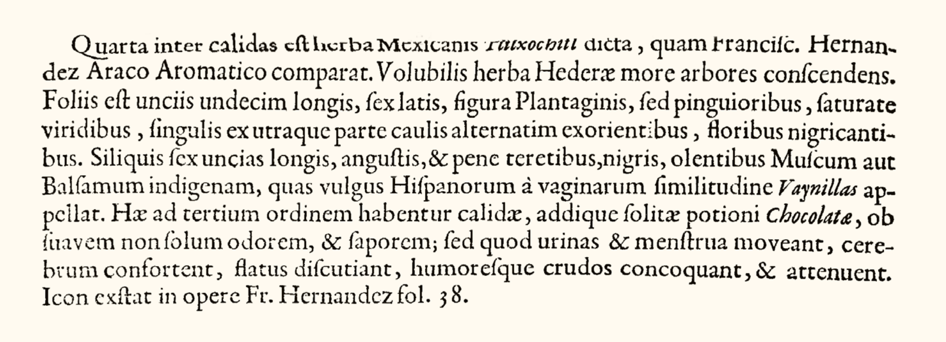
Another orchid is mentioned and illustrated in Piso's first edition of 1648 (Piso 1648) and named *Tupaipi, aliis Urucatu*, which Pickel (2008) has identified as *Catasetum macrocarpum* L.C.Rich. ex Kunth (Pickel 2008) (Fig. 10). The same plant, with an identical illustration but a different description can be found in

FIGURE 8. Map of the coast Pernambuco by Post and Marcgrave.

the same edition of 1648, but in the volumes written by Marcgrave (Marcgrave 1648) (Fig. 11) where it was described by him as *Urucatú Brasiliensum*. Both names used by Piso and Marcgrave, *Tupaipi* and *Urucatú*, belong to the language of the Tupinambá tribe of the Amazonas region (Alcántara Rodríguez 2015: Appendix 1). According to Hoehne (1949) *tupaipí* or *tupaypy* means ‘of divine origin’.

A third orchid specimen described and illustrated by Marcgrave in the 1648 edition has been identified as *Trigonidium acuminatum* Bateman ex Lindl. (Fig. 12).

Georg Marcgrave’s herbarium can be found today



Quarta inter calidas eſt herba Mexicanis *Tlilxochitl* dicta, quam Franciſc. Hernandez Araco Aromatico comparat. Volubilis herba Hederæ more arbores conſcendens. Foliis eſt unciis undecim longis, ſex latis, figura Plantaginis, ſed pinguioribus, ſaturate viridibus, ſingulis ex utraque parte caulis alternatim exorientibus, floribus nigricantibus. Siliquis ſex uncias longis, anguſtis, & pene teretibus, nigris, olentibus Muſcum aut Balſamum indigenam, quas vulgus Hiſpanorum à vaginarum ſimilitudine *Vaynillas* appellat. Hæ ad tertium ordinem habentur calidæ, addique ſolitæ potioni *Chocolatæ*, ob ſuavem non ſolum odorem, & ſaporem; ſed quod urinas & menſtrua moveant, cerebrum confortent, flatus diſcutiant, humoreſque crudos concoquant, & attenuent. Icon exſtat in opere Fr. Hernandez fol. 38.

FIGURE 9. Piso’s description of *Vaynilla*. Page 200 (Appendix: *Mantisssa Aromatica*) of his 1658 edition of *De Indiae Utrusque re naturali et medica.*

DE FACVLTATIBVS SIMPLICIVM LIB. IV. 117

CAP. XCIV.

De Albara, aliis Pacivira, ejuſque facultatibus.

IIſdem locis ſilveſtribus atque triviis umbroſis luxuriat alia quædam planta aſpectu pulchra, ſtolonis & radicis firmitate atque pondere *Cannam* quoq; Indicam; ſed ſummitate ſua *Lilium* Americanum ſilveſtre æmulans: foliis quoque licet prælongis, anguſtioribus tamen eſt & ex imo caulis erumpentibus. Flore denique (licet æque flavo & inodoro ſicut *Canna* Indica) majore & cochleariformi, nunc incurvato, nunc in poſtica parte inſtar cuſpidis extenſo. Semine eſt nigro, & radice bulboſa, ſicut *Meeru*, prædita.

Folia vulneribus & ulceribus utiliter adhibentur, unde *Herba dos feridos* vulgus Luſitanicum nominat. Tuberoſa & ſucculenta ejus radix à Nigritis comeditur & ab omnibus pariter Incolis intenſæ habetur caliditatis, ac proinde Hiſpanis æque ac noſtris Chirurgis Batavis in quotidiano habetur uſu; maxime in Apoſtematis & ulceribus maturandis.

CAP. XCV.

De Tupaipi, aliis Urucatu.

PLanta eſt nobilis, quæ nunc humi, nunc ſuper arbore (ſicut aliæ multæ plantæ) ſine radice luxuriat, interque bulboſas, quod bulbum habeat prægrandem & utilem, facile primum locum meretur. Cujus ſi formam externam, ſi vires ſpectes, ſquillam Europæam diceres, quod illam per omnia referat; ac proinde Braſilienſes Indigenæ à potiori videntur nomen *Tupaipi*, quod bulbum ſignificat, Luſitani *Cebola*, impoſuiſſe. Folia habet numero quinque vel ſex, tribus nervis ſecundum longitudinem prædita, nec florem nec fructum ferentia; ſunt autem cubitum longa, gladiata, inferius deſinentia in bulbum illum prægrandem, qui medullam vireſcentem pinguem & inodorum, ſed ſatis efficacem ſuppeditat. Dolores enim ſedare ex calore natos, perhibent Barbari: Luſitani vero mecum ipſum bulbum in uſum quotidianum ſicut ſquillam Europæam feliciter applicabant.

CAP. XCVI.

De Iuquiri, aliis Caaeo, ſpeciebus, ejuſque facultatibus.

DUas Herbæ caſtæ vel mimoſæ, (ut quidam nuncupant) differentias notavi.

Prior quæ fruticeſcens eſt, in mediocrem altitudinem attollitur, caulibus ſtriatis, quadratis,

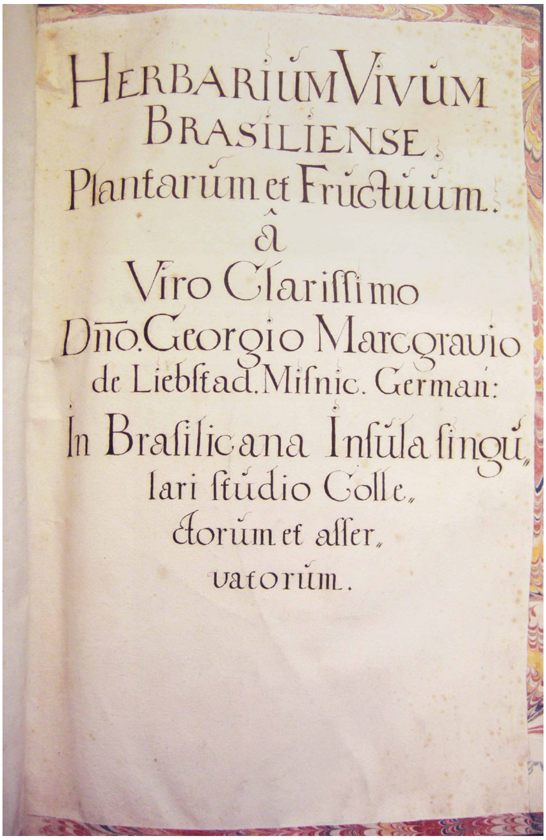
P 3 viri-

Figure 10. Piso’s description and illustration of *Tupaipi, aliis urucatú* in page (P)117 of his 1648 edition of *Historia Naturalis Brasiliae.*

at the Natural History Museum of the University of Copenhagen, Denmark. A clue to its history is given in the letters of Ole Worm (1588–1644), a professor of medicine at the University of Copenhagen, who had made the acquaintance of Jan de Laet, the editor of the *Historia Naturalis Brasiliae* of Piso and Marcgrave. From this correspondence it appears that Worm received duplicates of minerals, wood samples and fruits from Marcgrave’s collections. After de Laet’s death in 1649, Worm’s eldest son, Willum, went to study to Leiden in 1653. Soon after his arrival he bought, on behalf of his father, Marcgrave’s herbarium, which was sent to Copenhagen, where it arrived in October of the same year. Ole Worm died in 1654 and in 1655 his collections, including Marcgrave’s herbarium, were

Figure 11. Marcgrave’s description and illustration of *Urucatú brasiliensibus* in page (M) 35 of his 1648 edition of *Historia Naturalis Brasiliae.*

Figure 12. Marcgrave’s illustration of *Trigonidium acuminatum* in page (M)107 of his 1648 edition of *Historia Naturalis Brasiliae.*



HERBARIÚM VIVÚM
BRASILIENSE,
Plantarúm et Frúctuúm:
â
Viro Clariſſimo
Dño. Georgio Marcgravio
de Liebſtad. Miſnic. German:
In Braſilicana Inſúla ſingú,,
lari ſtúdio Colle,,
ctorúm et aſſer,,
vatorúm.

FIGURE 13. Title page of Marcgrave's herbarium, courtesy and reproduced with permission of the Natural History Museum of Denmark.

sold by the family to King Frederik III, after whose death in 1670 the collections were passed on to the Botanical Museum (Andrade-Lima *et al.* 1977).

The bound herbarium (Fig. 13) comprises 173 sheets with 177 plant collections. Four of these sheets contain mixed collections; for example, page number 18 (Fig. 14) which presents a specimen of *Zollernia latifolia* together with the epiphytic orchid *Trigonidium acuminatum*. The latter specimen can be recognized as the one illustrated in Marcgrave (1648). It is in all probability historically the first specimen of Orchidaceae ever prepared from tropical America.

Marcgrave's herbarium in a historical perspective. That Marcgrave's herbarium holds in all probability the first dried specimens of plants from tropical America is based on strong evidence. Let us remember that the end of the 16th and the beginning of the 17th centuries, the time which saw the rise of the Scientific Revolution, *was the time when, slowly, the pages of the herbaria, the 'hortus siccus'* (Latin = 'the dry garden')*, even more than those of the herbal, began to displace the garden as the principal instrument of botanical research. Herbaria could easily contain many thousand plants and could quickly be formed by those who travelled in distant lands. At the same time, those without land or talent for the cultivation of exotics might hoard them in their cabinets of curiosities. Like the 'pulvilli'* (Italian for flower beds) *of the botanic gardens, the drawers of the 'hortus siccus' offered a space for philosophical accumulation* (Ossenbach 2017).

In the 16th century botanical gardens were already helping to add to the knowledge of plants; the first were formed in Italy at Padua in 1545, Pisa in 1547, and Bologna in 1567. Soon similar collections of living plants were made in northern Europe: in 1577 at Leiden and in 1593 at Heidelberg and Montpellier. The 16th century Italian botanist Luca Ghini (1490?–1556), a Professor at the University of Bologna, is credited as the first person to press and preserve plants under sheets of paper and then to bind the specimens within a book. His two pupils, Aldrovandi and Cesalpino, are said to have formed the first herbaria in our sense of the word. One of the first collections of the kind, perhaps made as early as 1556, was the herbarium formed by Carl Ratzenberger in Wittenberg. (Sachs 1890). Other herbaria followed, such as those of Jehan Girault in 1558 in Paris, and Felix Platter in Basel, who lived from 1536 to 1614. In various cities in Europe, more than twenty herbaria are preserved, which were formed, or at least begun, in the sixteenth century (Arber 1912).

In 1606 Adriaan van de Spiegel (1578–1625) published instructions on producing dried herbarium specimens in his *Isagoges in Rem Herbarium*. The oldest herbarium known from the 17th century (the oldest in Britain, today part of the Oxford University Herbarium), is the herbarium volume of Gregorio a Reggio. He was an industrious Capuchin monk who studied and collected plants in the region of Emilia, near Bologna (Marner 2006). This herbarium is labelled "*Herbarium Diversarum Naturalium Gregorio a Reggio*" (Fig. 15), and the collection is dated 1606, approximately 35 years before Marcgrave's herbarium.

Figure 14. Page 18 of Marcgrave's herbarium. Courtesy and reproduced with permission of the Natural History Museum of Denmark.

FIGURE 15. Book herbarium of Gregorio a Reggio.

If we additionally consider the difficulties of travelling in these years, and the fact that the Spanish and Portuguese posessions in America were jealously closed against all foreigners, then the chance of a tropical plant finding a way into a European herbarium in the late 16th or early 17th centuries was indeed very small, if not nil. Only the combination of a strong Dutch military force, able to break into those possessions, and a learned and enlightened Governor, willing to bring scientists and men of art across the Atlantic, made this botanical exploration and thus Marcgrave's herbarium possible.

It is surely no coincidence that the famous *Accademia dei Lincei*, from whose publications of the works by Francisco Hernández Piso and Marcgrave had drawn so much of their knowledge of American plants, was founded by Federico Cesi during the same period, in 1603.

AKNOWLEDGEMENTS. Special thanks must be expressed to Professor Nina Rønsted and Dr. Olof Ryding from the Natural History Museum of Denmark, University of Copenhagen, for providing the images of Marcgrave's Herbarium. Also to Diego Bogarín, presently at the University of Leiden, the Netherlands, for information and reproductions of Piso's and Marcgrave's works. Thanks also to both reviewers, especially to one of the reviewers for his careful revision of the English text.

LITERATURE CITED

Alcántara Rodríguez, M. (2015). *Medicinal and other useful plants from Historia Naturalis Brasiliae (1648): Are they currently used in Brazil?* Major Research Project. Utrecht University.

Andrade-Lima, D. de, Fox-Maule, A., Pedersen, T. M. & Rahn, K. (1977). Marcgrave's Brazilian Herbarium Collected 1638–1644. *Botanisk Tidsskrift,* 71, 121–160.

Arber, A. (1912). *Herbals: their origin and evolution. A chapter in the history of Botany, 1470–1670.* Cambridge and London, Cambridge University Press.

Hoehne, F. C. (1949). *Iconografia de Orchidaceaes do Brasil.* Secretaria de Agricultura. São Paulo, Brazil.

Marner, S. (2006). 400 years old! [A book herbarium from Italy]. *Oxford Plant Systematics*, 8, 8–10.

Ossenbach, C. (2009). Orchids and orchidology in Central America: 500 years of history. *Lankesteriana*, 9(1–2), 1–268.

Ossenbach, C. (2017). *An Encyclopaedic History of Orchids and Orchidology in the Antilles.* Oberreifenberg (Germany), Koeltz Botanical Books.

Pickel, B. J. (2008). *Flora do Nordeste do Brasil segundo Piso e Marcgrave no século XVII*. Editora da Universidade Federal Rural de Pernambuco, Recife.

Piso, W. (1658). *Indiae utriusque re naturali et medica.* Amsterdam, L. & D. Elzevirios.

Piso, W. & Marcgrave, G. (1648). *Historia naturalis Brasiliae*. Amsterdam, Hackium & Elizevirium.

Sachs, J. von. (1890). *History of Botany (1530–1860)*. Oxford, Clarendon Press.

LANKESTERIANA 17(1): 73–104. 2017. **doi**: http://dx.doi.org/10.15517/lank.v17i1.28526

NOVELTIES IN THE ORCHID FLORA OF THE MUNICIPALITY OF BENEDITO NOVO, SANTA CATARINA, BRAZIL, AND AN UPDATED CHECKLIST

Jader Oslim Caetano[1], Randi Raddatz[2], Juliane L. Schmitt[3], Carlos R. Schlemper[4] & Leonardo R. S. Guimarães[5–6]

[1] Rua Holanda, 395, Alto Benedito, Benedito Novo, SC, 89124-000, Brazil
[2] Rua Leopoldo Koprowski, s.n., Alto Benedito, Benedito Novo, SC, 89124-000, Brazil
[3] Rua Manoel Barreto, 54, apto 804, Victor Konder, Blumenau, SC, 89012-134, Brazil
[4] Rua Rio Negrinho, 555, Progresso, Rio do Sul, SC, 89163-640, Brazil
[5] Núcleo de Pesquisa Orquidário do Estado, Instituto de Botânica, Av. Miguel Stéfano, 3687, São Paulo, SP, Caixa Postal 68041, 04045-972, Brazil
[6] Correspondence author: leo.rsguimaraes@hotmail.com

Abstract. In 2013, Caetano and colleagues published two lists of the Orchidaceae of the Municipality of Benedito Novo, Santa Catarina, totalling 99 species. Between January 2014 and September 2016, additional field trips were made and new species were found in the region. Thus, in this paper an updated checklist of the Orchidaceae of Benedito Novo is presented based on herbarium collections and field surveys. A total of 184 species distributed in 66 genera are registered, comprising about 35% of the species and 60% of the genera cited for Santa Catarina. The richest genera are *Acianthera* Scheidw. (18 species), *Pabstiella* Brieger & Senghas (14), *Epidendrum* L., *Gomesa* R.Br., and *Maxillaria* Ruiz & Pav. (13 each). A new combination and a lectotypification in the genus *Pabstiella* are proposed.

Key words: Brazilian Atlantic Forest, flora, Itajaí Valley, monocots, orchids

Introduction. There are few studies with Orchidaceae for the state of Santa Catarina (Favretto & Geuster 2011, Reis *et al.* 2011, Siqueira, Zanin & Menini Neto 2014), and the most important research, conducted between 40 and 60 years ago, focused on the capital Florianopolis and its surroundings (Rohr 1951, Pabst 1951, 1952, 1953, 1954, 1956, 1957, 1959, Klein, Bresolin & Reis 1977/1978). A vegetation inventory of the Itajaí Valley, including 200 orchid species, was published by Klein (1979). Two lists of 99 species of Orchidaceae were previously prepared as a result of fieldwork carried out between November 2009 and October 2013 in the Municipality of Benedito Novo (Caetano & Guimarães 2013; Caetano *et al.* 2013). Expeditions between January 2014 and September 2016 revealed additional new records for the region, which are included in the present, The updated checklist presented here includes those species, as well as numerous nomenclatural emends.

The Brazilian Atlantic Forest is one of the largest tropical forests in the Americas, and its high levels of species richness and endemic taxa renders it one of the 34 global biodiversity hotspots (Myers *et al.* 2000, Mittermeier *et al.* 2004). Nevertheless, these forests and species are under intense pressure due to the deforestation suffered in the past.(Myers *et al.* 2000, Mittermeier *et al.* 2004). Currently, only about 11% of the total forest cover is considered to be the original native vegetation (Ribeiro *et al.* 2009), distributed in small forest fragments. The state of Santa Catarina is fully inserted in the Atlantic Forest biome and currently 23.04% (about 22,100 km²) remain as total forest remnants of Brazilian Atlantic Forest in Santa Catarina (Fundação SOS Mata Atlântica & INPE 2011).

Over 20,000 species of vascular plants were estimated for the Brazilian Atlantic Forest (Myers *et al.* 2000), of which 8,000 (40%) are endemic to this phytogeographical domain. According to Stehmann *et al.* (2009), Orchidaceae is one of the most diverse families in the Brazilian Atlantic Forest, represented by more than 1,500 species (BFG 2015).

Received 31 October 2016; accepted for publication 23 April 2017. First published online: 25 April 2017.

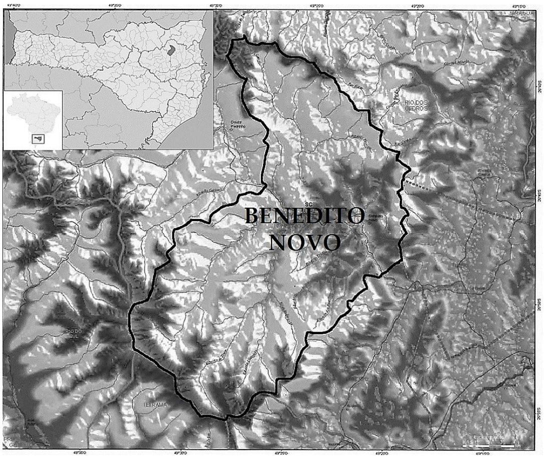


FIGURE 1. Location of the Municipality of Benedito Novo, Santa Catarina, Brazil.

This study aims to present a current inventory of the species of Orchidaceae that occur in the Municipality of Benedito Novo, by including all the most recent findings and the most current taxonomic information. This inventory hopes to contribute to the knowledge of the flora of the Itajaí Valley, and the state of Santa Catarina.

Material and methods. The Municipality of Benedito Novo, with an area of 385,402 km², is situated in the Itajaí Valley, region of Blumenau, in Eastern state of Santa Catarina (26º46'58" S, 49º21'50" W) (Fig. 1). It has 66.13% of natural forest, 23.39% of rural areas, 8.96% of reforested vegetation, and the urban setting occupies an area of only 1.28% of the total municipal territory (Fig. 2A). A region well preserved of native forest is the "Campo do Zinco" Farm, where is located the Zinco

FIGURE 2. Landscape of the Municipality of Benedito Novo. A. View of the city center of Benedito Novo, showing the Benedito River and areas of Atlantic Forest. B. "Salto do Zinco" Waterfall. C. Riparian forest along an artificial lake in "Campo do Zinco" Farm. D. Zinco River. Photos by Jardel F. de Araujo (A) and Egon Koprowski (B–D).

River, the "Salto do Zinco" Waterfall (76 m) and many riparian forests (Figs. 2B–D). The climate is oceanic with temperate summer and no dry season (Alvares *et al.* 2013; type Cfb according to Köppen 1936). The average annual precipitation is 1,561 mm and the average annual temperature is 20.3°C (Climate-Data.org 2016).

The present study is an updated checklist, based on several field surveys made between November 2009 and October 2013 (whose species list were published in Caetano & Guimarães 2013 and Caetano *et al.* 2013), plus the excursions carried between January 2014 and September 2016. As in the previous list of 2013, field trips were made mainly at strategic points of the municipality (e.g. riparian forests and top of hills), following the method of active search (for details see Filgueiras *et al.* 1994). The samples were submitted to the usual taxonomic procedures (Mori *et al.* 1985) and then deposited in the herbarium of the Universidade Regional de Blumenau (FURB). To update this checklist, we have also reviewed the specimens from the following herbaria: CGMS, FLOR, FUEL, HB, HUCS, ICN, R, RB and UPCB (acronyms according to Thiers 2016).

The circumscription of the genera and species followed BFG (2015) and Flora do Brasil 2020 (2016), except for the subtribes Goodyerinae and Maxillariinae, which are according to Chase *et al.* (2015). For the subtribe Pleurothallidinae, we followed Flora do Brasil 2020 (2016), but we updated some nomenclatural novelties according to the most recent works, which are indicated in brackets in the Checklist below. Each accepted taxon name is presented in bold with author(s) followed by full citation. If there is a basionym, it is mentioned just after the correct name followed by most popular used homotypic and heterotypic synonym(s) and respective authors (Govaerts *et al.* 2015). Endemic species to Brazil are indicated with an asterisk (*) and endangered species in category "Vulnerable" are indicated with [VU].

Results. In the Municipality of Benedito Novo, there are 184 species belonging to 66 genera of Orchidaceae. Of these, 160 (86.9%) are epiphytes, 20 (10.9%) terrestrial, and 4 (2.2%) rupicolous, occurring in several phytophysiognomies. The genus with the highest number of taxa is *Acianthera* Scheidw. (18 species), followed by *Pabstiella* Brieger & Senghas (14), *Epidendrum* L., *Gomesa* R.Br., and *Maxillaria* Ruiz & Pav. (13 each). In contrast, 37 genera were represented by a single species. Aside from this, we collected three species not previously referred to the state of Santa Catarina. These species were treated in more detail in Guimarães *et al.* (2016).

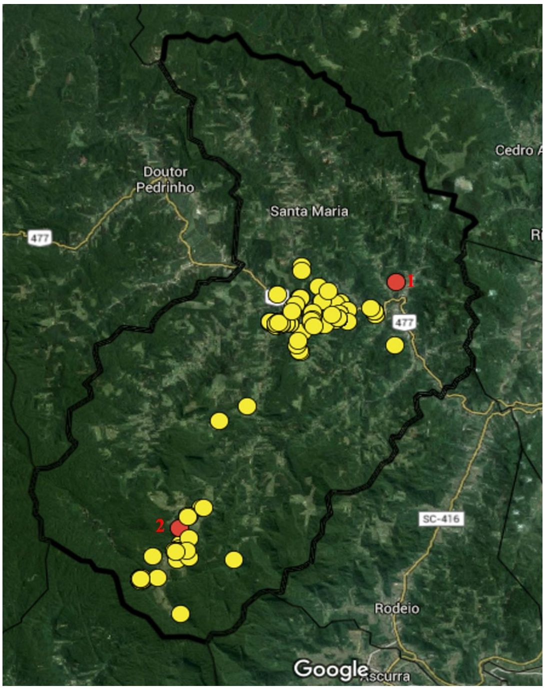


FIGURE 3. Map showing all collection points of Orchidaceae in the Municipality of Benedito Novo. The red dots are: 1: city center of Benedito Novo; 2: "Campo do Zinco" Inn. Mapping: Google Maps.

The species were collected mainly in two areas of the municipality. The first along the Benedito River, near the center of the city, the second on the "Campo de Zinco" Farm (Fig. 3).

Eighty-six species recorded for the Municipality of Benedito Novo are endemic to Brazil, and also considered endemic to the Brazilian Atlantic Forest, according to BFG (2015). Among the species found in the area, two are found only in the South Region of Brazil (includes states of Paraná, Santa Catarina and Rio Grande do Sul), *viz.*, *Acianthera alborosea* (Kraenzl.) Luer and *Pabstiella matinhensis* (Hoehne) Luer.

Seven species recorded in the Municipality of Benedito Novo are cited as endangered in category "Vulnerable" (VU) by Menini Neto *et al.* (2013), mainly caused by habitat loss or destruction. They are: *Cattleya guttata* Lindl., *Cattleya intermedia* Graham, *Dryadella lilliputiana* (Cogn.) Luer, *Grandiphyllum divaricatum*

(Lindl.) Docha Neto, *Grandiphyllum hians* (Lindl.) Docha Neto, *Grobya fascifera* Rchb.f. and *Pabstiella carinifera* (Barb.Rodr.) Luer.

Discussion. A total of 59 new records of Orchidaceae were added to a previous checklist for the Itajaí Valley elaborated by Klein (1979), which cited a total of 274 species. However, 50 species of Orchidaceae listed in that work are synonyms according to the current nomenclature of Flora do Brasil 2020 (2016); therefore, the number of species of orchids cited for Itajaí Valley is 224, 40 more than was found in Benedito Novo.

This study comprises about 35% of species and 60% of the genera cited by Flora do Brasil 2020 (2016) for the state of Santa Catarina. With about 11% of its original area, the Brazilian Atlantic Forest is currently distributed in scanty fragments that hardly exceed 100 ha (Ranta *et al.* 1998, Ribeiro *et al.* 2009). In the state of Santa Catarina, more than 80% of the remnants of this domain have less than 50 ha (Vibrans *et al.* 2012). We registered almost 200 species of orchids in ca. 38,540 ha, showing the importance of the conservation of this area.

The main areas of species collected are concentrated along the Benedito River and at the "Campo de Zinco" Farm (Fig. 3). The most probable explanation for this high number of species is that they are preserved areas of the municipality, i.e. the riparian forest of the river and the private property of the farm, which contains a fragment of Atlantic Forest and the collection of specimens is only carried out with prior authorization of the owner. This hypothesis justifies the conservation of the Orchidaceae in the Municipality of Benedito Novo.

Seven species found in Benedito Novo are threatened, mainly due to the loss or destruction of the habitat. Moreover, all of them are included in official red list of threatened species of Brazilian states. *Cattleya guttata* and *C. intermedia* are classified as "Vulnerable" (VU) in Espírito Santo (Kollmann *et al.* 2007) and Rio Grande do Sul (Rio Grande do Sul 2002), respectively; and *Pabstiella carinifera* is treated as "Endangered" (EN) in Paraná (Hatschbach & Ziller 1995). *Dryadella lilliputiana*, *Grandiphyllum divaricatum*, *Grobya hians* and *G. fascifera* were considered probably extinct (EX) in São Paulo by Mamede *et al.* (2007); fortunately, we found specimens of these species in Benedito Novo and thus apply conservation actions. In the state of Santa Catarina, no list of threatened plant species was published until now. These facts reinforce the great value of the Municipality of Benedito Novo for the conservation of Orchidaceae.

A comparison of the number of species of Orchidaceae occurring in Benedito Novo with 13 other areas of the Brazilian Atlantic Forest (Table 1), shows that the Municipality of Benedito Novo, Cantareira State Park and Ilha do Cardoso State Park have the highest number of species (184, 159 and 147, respectively), followed by the Fontes do Ipiranga State Park and Serra do Japi (125 each). Among the areas analysed,

TABLE 1. Comparison of the number of genera and species of Orchidaceae among several surveys in areas of Atlantic Forest in Brazil. Locals: BR = Biological Reserve, ES = Ecological Station, MNP = Municipal Nature Park, NP = National Park, SP = State Park. States: ES = Espírito Santo, MG = Minas Gerais, PE = Pernambuco, SC = Santa Catarina, SP = São Paulo.

Local (State)	Nº genera/species	Area (ha)	Reference
Fontes do Ipiranga SP (SP)	52/125	345	Barros 1983
Serra do Brigadeiro SP (MG)	37/55	32,500	Leoni 1992
Caparaó NP (MG)	31/86	31,853	Leoni 1997
"Restingas" (ES)	41/71	48,600	Fraga & Peixoto 2004
Represa do Grama BR (MG)	23/28	264	Menini Neto, Almeida & Forzza 2004
Juréia-Itatins ES (SP)	40/77	84,379	Catharino & Barros 2004
Ilha do Cardoso SP (SP)	66/147	22,500	Romanini & Barros 2007
Serra do Japi (SP)	61/125	3.54	Pansarin & Pansarin 2008
Serras Negra e do Funil (MG)	50/109	ca. 10,000	Abreu, Menini Neto & Kuono 2011
Francisco Afonso de Melo MNP (SP)	47/67	352.3	Rodrigues & Barros 2012
Cantareira SP (SP)	64/159	7,916	Zandoná & Catharino 2015
Serra do Urubu (PE)	50/81	982,76	Pessoa & Alves 2015
Serra do Tabuleiro SP (SC)	51/92	87,405	Lenzi *et al.* 2015
Municipality of Benedito Novo (SC)	66/184	38,540	This work

the Cantareira State Park presents the largest number of species in common with the Municipality of Benedito Novo (76), followed by the Ilha do Cardoso State Park (60). Thus, the Municipality of Benedito Novo is one of the richest areas studied so far, and this high richness of Orchidaceae in the municipality is an important factor to make efforts for its conservation and expansion of biological research and other studies for the area.

The great concentration of species registered here, in the total area of the Municipality of Benedito Novo, is compatible with the number of taxa found in other regions of the Atlantic Forest (Stehmann *et al.* 2009, BFG 2015). Although Orchidaceae is one of the largest and most important families of flowering plants, the field inventory of this family in the state of Santa Catarina has not been published (Nascimento *et al.*, in prep.). This study contributes to the knowledge of the floristic diversity in the state and highlights the richness of the family, which has great appeal for conservation. Furthermore, it encourages researchers to carry out similar studies in the Municipality of Benedito Novo with other families of embryophytes (bryophytes and vascular plants).

CHECKLIST

ACIANTHERA Schweid.

Acianthera alborosea (Kraenzl.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 253. 2004 (Fig. 4).*

Octomeria alborosea Kraenzl., Ark. Bot. 16(8): 16. 1921.

Pleurothallis alborosea (Kraenzl.) Brade, Rodriguésia 1(2): 47. 1935.

HABIT AND HABITAT: Epiphyte; forest interior.

VOUCHER: *Schmitt et al. 1801* (FURB).

Acianthera aphthosa (Lindl.) Pridgeon & M.W.Chase, Lindleyana 16(4): 242. 2001 (Fig. 4)

Pleurothallis aphthosa Lindl., Edwards's Bot. Reg. 24(Misc.): 42. 1838.

Specklinia aphthosa (Lindl.) F.Barros, Hoehnea 10: 109. 1984.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 190* (spirit, FURB).

Acianthera auriculata (Lindl.) Pridgeon & M.W.Chase, Lindleyana 16(4): 242. 2001.

Pleurothallis auriculata Lindl., Companion Bot. Mag. 2: 356. 1837.

Humboltia auriculata (Lindl.) Kuntze, Revis. Gen. Pl. 2: 667. 1891.

Specklinia auriculata (Lindl.) F.Barros, Hoehnea 10: 109. 1984.

Arthrosia auriculata (Lindl.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 105: 248. 2006.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 12* (FURB).

Acianthera bragae (Ruschi) F.Barros, Hoehnea 30(3): 183. 2003 (Fig. 4).*

Physosiphon bragae Ruschi, Bol. Mus. Biol. Prof. Mello-Leitão, Sér. Bot. 27: 1. 1970.

Physosiphon pubescens Barb.Rodr., Gen. Spec. Orchid. 1: 27. 1877.

Phloeophila pubescens (Barb.Rodr.) Garay, Orquideología 9(2): 118. 1974.

Sarracenella pubescens (Barb.Rodr.) Luer, Selbyana 5(3–4): 388. 1981.

Pleurothallis sarracenia Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 20: 73. 1986.

Acianthera sarracenia (Luer) Pridgeon & M.W.Chase, Lindleyana 16(4): 246. 2001.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano s.n.* (FURB 36259).

Acianthera calopedilon Toscano & Luer, Lankesteriana 15(1): 79. 2015 (Fig. 4).

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 31* (FURB).

Acianthera crepiniana (Cogn.) Chiron & Van den Berg, Richardiana 12(2): 73. 2012.*

Pleurothallis crepiniana Cogn. in Mart., Fl. Bras. 3(4): 542. 1896.

Pleurobotryum crepinianum (Cogn.) Hoehne, Bol. Mus. Nac. Rio de Janeiro 12(2): 28. 1936.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano s.n.* (FURB 37348).

Acianthera exarticulata (Barb.Rodr.) Pridgeon & M.W.Chase, Lindleyana 16(4): 243. 2001.*

Pleurothallis exarticulata Barb.Rodr., Gen. Spec. Orchid. 2: 27. 1881.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 185* (spirit, FURB).

Acianthera glanduligera (Lindl.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 253. 2004.*

Pleurothallis glanduligera Lindl., Companion Bot. Mag. 2: 355. 1837.

Humboltia glanduligera (Lindl.) Kuntze, Revis. Gen. Pl. 2: 667. 1891.

Pleurothallis cryptoceras Rchb.f., Flora 69: 554. 1886.

Acianthera cryptoceras (Rchb.f.) F.Barros, Hoehnea 30(3): 185. 2003.

Pleurothallis cearensis Schltr., Repert. Spec. Nov. Regni Veg. 17: 271. 1921.

Acianthera cearensis (Schltr.) Pridgeon & M.W.Chase, Lindleyana 16(4): 242. 2001.

Pleurothallis iguapensis Schltr., Anexos Mem. Inst. Butantan, Secç. Bot. 1(4): 48. 1922.

Anathallis iguapensis (Schltr.) Pridgeon & M.W.Chase, Lindleyana 16(4): 249. 2001.

Acianthera iguapensis (Schltr.) F.Barros, Orchid Memories: 10. 2004.

HABIT AND HABITAT: Epiphyte; anthropic area (pasture).

VOUCHER: *Caetano s.n.* (FURB 36290).

Acianthera hygrophila (Barb.Rodr.) Pridgeon & M.W.Chase, Lindleyana 16(4): 244. 2001.

Pleurothallis hygrophila Barb.Rodr., Gen. Spec. Orchid. 1: 7. 1877.

Specklinia hygrophila (Barb.Rodr.) F.Barros, Hoehnea 10: 110. 1984.

Stelis hygrophila (Barb.Rodr.) Pridgeon & M.W.Chase, Lindleyana 16(4): 263. 2001.

Arthrosia hygrophila (Barb.Rodr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 105: 249. 2006.

Pleurothallis barbacenensis Barb.Rodr., Gen. Spec. Orchid. 2: 11. 1881.

Acianthera barbacenensis (Barb.Rodr.) Pridgeon & M.W.Chase, Lindleyana 16(4): 242. 2001.

Specklinia barbacenensis (Barb.Rodr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 259. 2004.

Arthrosia barbacenensis (Barb.Rodr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 105: 248. 2006.

Pleurothallis platysemos Rchb.f., Flora 69: 555. 1886.

HABIT AND HABITAT: Epiphyte; forest interior.

VOUCHERS: *Caetano s.n.* (FURB 36286); *Schmitt et al. 499* (FURB).

Acianthera luteola (Lindl.) Pridgeon & M.W.Chase, Lindleyana 16(4): 244. 2001 (Fig. 4).*

Pleurothallis luteola Lindl., Edwards's Bot. Reg. 27(Misc.): 1. 1841.

Specklinia luteola (Lindl.) F.Barros, Hoehnea 10: 110. 1984.

HABIT AND HABITAT: Epiphyte; forest interior.

VOUCHERS: *Klein & Bresolin 10891* (FLOR); *Caetano s.n.* (FURB 37779).

Acianthera macropoda (Barb.Rodr.) Pridgeon & M.W.Chase, Lindleyana 16(4): 244. 2001.*

Pleurothallis macropoda Barb.Rodr., Gen. Spec. Orchid. 2: 25. 1881.

HABIT AND HABITAT: Epiphyte; anthropic area (pasture).

VOUCHER: *Caetano 192* (spirit, FURB).

Acianthera nemorosa (Barb.Rodr.) F.Barros, Hoehnea 30(3): 186. 2003.*

Pleurothallis nemorosa Barb.Rodr., Gen. Spec. Orchid. 1: 11. 1877.

Pleurothallis farinosa Pabst, Arch. Jard. Bot. Rio de Janeiro 14: 10. 1956.

Acianthera farinosa (Pabst) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 253. 2004.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 59* (FURB).

Acianthera oligantha (Barb.Rodr.) F.Barros, Hoehnea 30(3): 186. 2003.*

Pleurothallis oligantha Barb.Rodr., Gen. Spec. Orchid. 2: 33. 1881.

HABIT AND HABITAT: Epiphyte; forest interior.

VOUCHER: *Caetano s.n.* (FURB 36260).

Acianthera pubescens (Lindl.) Pridgeon & M.W.Chase, Lindleyana 16(4): 245. 2001 (Fig. 4).

Pleurothallis pubescens Lindl., Companion Bot. Mag. 2(24): 355. 1837.

Humboltia pubescens (Lindl.) Kuntze, Revis. Gen. Pl. 2: 668. 1891.

Pleurothallis smithiana Lindl., Edwards's Bot. Reg. 29(Misc.): 57. 1843.

Humboltia smithiana (Lindl.) Kuntze, Revis. Gen. Pl. 2: 668. 1891.

Pleurothallis riograndensis Barb.Rodr., Gen. Spec. Orchid. 2: 28. 1881.

HABIT AND HABITAT: Epiphyte; forest interior, riparian forest.

VOUCHERS: *Caetano 188* (spirit, FURB); *Caetano 218* (spirit, FURB).

Acianthera punctatiflora (Luer) Pridgeon & M.W.Chase, Lindleyana 16(4): 246. 2001 (Fig. 4).*

Pleurothallis punctatiflora Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 20: 16. 1986.

Cryptophoranthus punctatus Barb.Rodr., Rev. Engenh. 3: 9. 1881; Gen. Spec. Orchid. 2: 80. 1881.
HABIT AND HABITAT: Epiphyte; forest interior (riparian forest).
VOUCHER: *Caetano s.n.* (FURB 38093).

Acianthera saundersiana (Rchb.f.) Pridgeon & M.W.Chase, Lindleyana 16(4): 246. 2001 (Fig. 4).
Pleurothallis saundersiana Rchb.f., Gard. Chron. 1866: 74. 1866.
Specklinia saundersiana (Rchb.f.) F.Barros, Hoehnea 10: 110. 1984.
Pleurothallis butantanensis Hoehne & Schltr., Arch. Bot. São Paulo 1: 209. 1926.
HABIT AND HABITAT: Epiphyte; forest interior.
VOUCHER: *Caetano & Raddatz 69* (FURB).

Acianthera saurocephala (G.Lodd.) Pridgeon & M.W.Chase, Lindleyana 16(4): 246. 2001 (Fig. 4).*
Pleurothallis saurocephala G.Lodd., Bot. Cab. 16: t. 1571. 1830.
Humboltia saurocephala (G.Lodd.) Kuntze, Revis. Gen. Pl. 2: 668. 1891.
HABIT AND HABITAT: Epiphyte; anthropic area (pasture).
VOUCHER: *Caetano 56* (FURB).

Acianthera sonderiana (Rchb.f.) Pridgeon & M.W.Chase, Lindleyana 16(4): 246. 2001.
Pleurothallis sonderiana Rchb.f., Linnaea 22: 830. 1850.
Humboltia sonderiana (Rchb.f.) Kuntze, Revis. Gen. Pl. 2: 668. 1891.
Specklinia sonderiana (Rchb.f.) F.Barros, Hoehnea 10: 110. 1984.
HABIT AND HABITAT: Epiphyte; forest interior.
VOUCHERS: *Caetano s.n.* (FURB 40577); *Schmitt et al. 1738* (FURB); *Korte & Kniess 2079* (FURB).

ANATHALLIS Barb.Rodr.

Anathallis heterophylla Barb.Rodr., Gen. Spec. Orchid. 2: 74. 1881. [Toscano de Brito & Luer 2015] (Fig. 4).*
Pleurothallis heterophylla (Barb.Rodr.) Cogn. in Mart., Fl. Bras. 3(4): 556. 1896.
Specklinia heterophylla (Barb.Rodr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 261. 2004.
Pleurothallis liparanges Rchb.f., Gard. Chron. n.s. 23: 532. 1885.
Specklinia liparanges (Rchb.f.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 261. 2004.
Anathallis liparanges (Rchb.f.) Luer, Novon 18(1): 78. 2008.
HABIT AND HABITAT: Epiphyte; anthropic area (urban area), forest interior.
VOUCHER: *Caetano & Almeida 199* (spirit, FURB); *Caetano 211* (spirit, FURB).

Anathallis linearifolia (Cogn.) Pridgeon & M.W.Chase, Lindleyana 16(4): 249. 2001 (Fig. 4).
Pleurothallis linearifolia Cogn. in Mart., Fl. Bras. 3(4): 573. 1896.
Specklinia linearifolia (Cogn.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 261. 2004.
Pleurothallis depauperata Cogn. in Mart., Fl. Bras. 3(4): 574. 1896.
Specklinia depauperata (Cogn.) F.Barros, Hoehnea 10: 109. 1984.
Pleurothallis glossochila Kraenzl., Ark. Bot. 16(8): 14. 1921.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHERS: *Bresolin 664* (FLOR); *Caetano 51* (FURB).

Anathallis obovata (Lindl.) Pridgeon & M.W.Chase, Lindleyana 16(4): 250. 2001 (Fig. 4).
Specklinia obovata Lindl., Edwards's Bot. Reg. 25(Misc.): 86. 1839.
Pleurothallis obovata (Lindl.) Lindl., Edwards's Bot. Reg. 28(Misc.): 75. 1842.
Pleurothallis minutiflora Cogn. in Mart., Fl. Bras. 3(4): 564. 1896, *nom. illeg.*
Pleurothallis modestiflora Schltr., Repert. Spec. Nov. Regni Veg. Beih. 35: 56. 1925.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano 77* (FURB).

ASPIDOGYNE Garay

Aspidogyne rosea (Lindl.) Meneguzzo, Orquidário 26(3): 90. 2012.
Physurus roseus Lindl., Gen. Sp. Orchid. Pl.: 501. 1840.
Microchilus roseus (Lindl.) D.Dietr., Syn. Pl. 5: 166. 1852.
Erythrodes rosea (Lindl.) Ames, Orchidaceae 7: 75. 1922.
Ligeophila rosea (Lindl.) Garay, Bradea 2(28): 195. 1977.

Habit and habitat: Terrestrial; forest edge.

Voucher: *Caetano 76* (FURB).

Aspidogyne schlechteriana (Hoehne) Meneguzzo, Orquidário 26(3): 90. 2012.*

Physurus schlechterianus Hoehne, Fl. Brasilica 12(2): 354. 1945.

Erythrodes schlechteriana (Hoehne) Pabst, Sellowia 7: 176. 1956.

Platythelys schlechteriana (Hoehne) Garay, Bradea 2(28): 198. 1977.

Habit and habitat: Terrestrial; forest interior.

Voucher: *Caetano et al. 47* (FURB).

Barbosella Schltr.

Barbosella cogniauxiana (Speg. & Kraenzl.) Schltr., Repert. Spec. Nov. Regni Veg. 15: 260. 1918.

Restrepia cogniauxiana Speg. & Kraenzl., Orchis 2: 127. 1908 (Fig. 4).

Barbosella porschii (Kraenzl.) Schltr., Repert. Spec. Nov. Regni Veg. 15: 263. 1918.

Restrepia porschii Kraenzl., Kongl. Svenska Vetensk. Acad. Handl., n.s. 46(10): 51. 1911.

Barbosella handroi Hoehne, Bol. Agric. (São Paulo) 34: 613. 1934 (“1933”).

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano s.n.* (FURB 38277).

Barbosella gardneri (Lindl.) Schltr., Repert. Spec. Nov. Regni Veg. 15: 261. 1918 (Fig. 4).*

Pleurothallis gardneri Lindl., Edwards’s Bot. Reg. 28(Misc.): 83. 1842.

Restrepia gardneri (Lindl.) Benth. in Benth. & Hook., Gen. Pl. 3(2): 491. 1883.

Humboltia gardneri (Lindl.) Kuntze, Revis. Gen. Pl. 2: 667. 1891.

Habit and habitat: Epiphyte; forest edge.

Voucher: *Caetano s.n.* (FURB 37329).

Barbosella miersii (Lindl.) Schltr., Repert. Spec. Nov. Regni Veg. 15: 262. 1918.*

Pleurothallis miersii Lindl., Edwards’s Bot. Reg. 28(Misc.): 84. 1842.

Restrepia miersii (Lindl.) Rchb.f. in Wawra, Bot. Ergebn.: 150. 1866.

Humboltia miersii (Lindl.) Kuntze, Revis. Gen. Pl. 2: 668. 1891.

Barbrodria miersii (Lindl.) Luer, Selbyana 5(3–4): 386. 1981.

Habit and habitat: Epiphyte; riparian forest, forest interior.

Vouchers: *Caetano s.n.* (FURB 37334); *Schmitt et al. 1749* (FURB).

Bifrenaria Lindl.

Bifrenaria aureofulva (Hook.) Lindl., Edwards’s Bot. Reg. 29(Misc.): 52. 1843 (Fig. 4).*

Maxillaria aureofulva Hook., Bot. Mag. 65: t. 3629. 1838.

Stenocoryne aureofulva (Hook.) Kraenzl. in Rchb.f.. Xenia Orchid. 3: 142. 1896.

Epidendrum secundum Vell., Fl. Flumin. Icon. 9: t. 9. 1831 (“1827”), *nom. illeg.*

Stenocoryne secunda (Vell.) Hoehne, Arq. Bot. Estado São Paulo n.s. 2(1): 13. 1944.

Bifrenaria secunda (Vell.) Pabst, Orquídea (Rio de Janeiro) 29(4): 165. 1967.

Habit and habitat: Epiphyte; forest edge, forest interior.

Vouchers: *Klein & Bresolin 10890* (FLOR); *Caetano s.n.* (FURB 37346); *Schmitt et al. 1809* (FURB).

Bifrenaria harrisoniae (Hook.) Rchb.f., Bonplandia 3: 217. 1855 (Fig. 4).*

Dendrobium harrisoniae Hook., Exot. Fl. 2(14): t. 120. 1824.

Maxillaria harrisoniae (Hook.) Lindl., Bot. Reg. 11: t. 897. 1825.

Colax harrisoniae (Hook.) Lindl. ex Spreng., Syst. Veg. (ed. 16) 3: 727. 1826.

Stanhopea harrisoniae (Hook.) P.N.Don in Donn, Hortus Cantabrig., ed. 13: 607. 1845.

Lycaste harrisoniae (Hook.) G.Don ex Loudon, Encycl. Pl. (new ed.) 2: 1468. 1855.

Habit and habitat: Epiphyte; forest interior, riparian forest.

Vouchers: *Caetano s.n.* (FURB 39662); *Schmitt et al. 524* (FURB).

Bifrenaria inodora Lindl., Edwards’s Bot. Reg. 29(Misc.): 48. 1843 (Fig. 5).*

Stenocoryne inodora (Lindl.) Kraenzl. in Rchb.f.. Xenia Orchid. 3: 142. 1896.

Habit and habitat: Epiphyte; anthropic area (pasture).

Voucher: *Caetano s.n.* (FURB 36933).

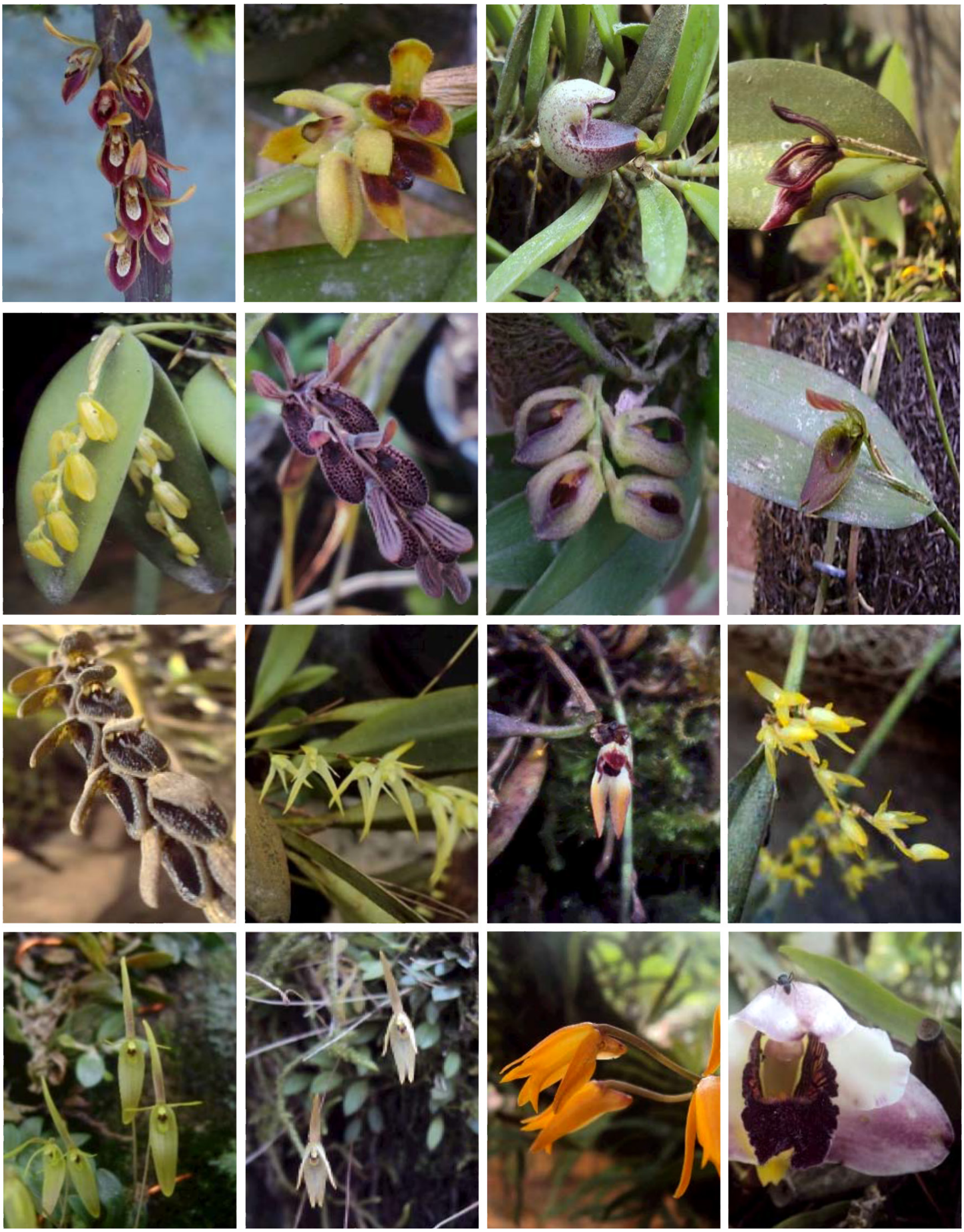


FIGURE 4. From top left to bottom right: *Acianthera alborosea. A. aphtosa. A. bragae. A. calopedilon. A. luteola. A. pubescens. A. punctatiflora. A. saundersiana. A. saurocephala. Anathallis heterophylla. A. linearifolia. A. obovata. Barbosella cogniauxiana. B. gardneri. Bifrenaria aureofulva. B. harrisoniae*. All courtesy of The Field Museum, Chicago.

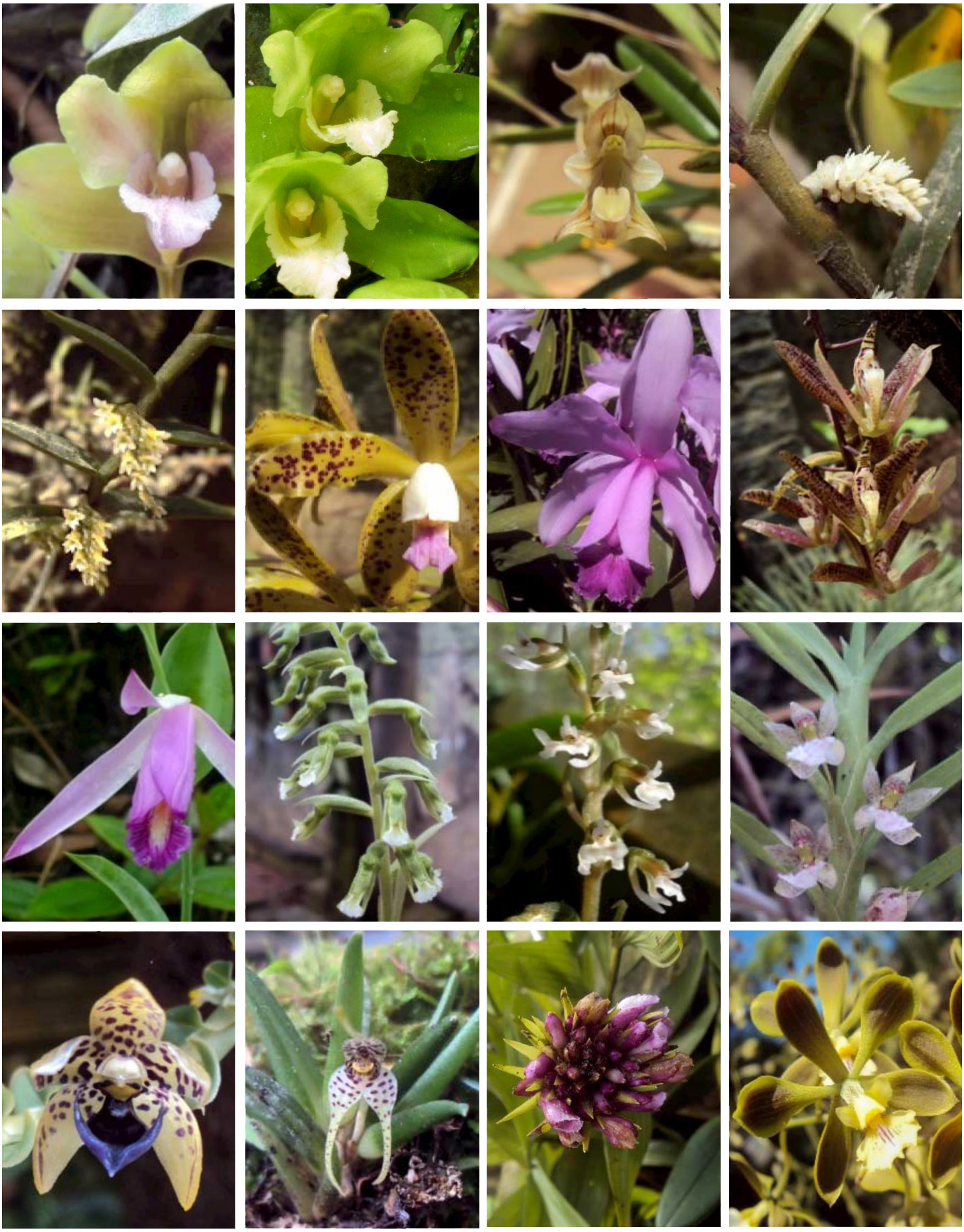


Figure 5. From top left to bottom right: *Bifrenaria inodora*. *B. inodora* var. *alba*. *Bulbophyllum napellii*. *Campylocentrum densiflorum*. *C. pauloense*. *Cattleya guttata*. *C. intermedia*. *Cirrhaea dependens*. *Cleistes libonii*. *Cyclopogon congestus*. *C. subalpestris*. *Dichaea cogniauxiana*. *D. pendula*. *Dryadella lilliputiana*. *Elleanthus brasiliensis*. *Encyclia patens* var. *patens*. All courtesy of The Field Museum, Chicago.

BULBOPHYLLUM Thouars

Bulbophyllum glutinosum (Barb.Rodr.) Cogn. in Mart., Fl. Bras. 3(5): 597. 1902.*

Didactyle glutinosa Barb.Rodr., Gen. Spec. Orchid. 2: 126. 1881.

HABIT AND HABITAT: Epiphyte; forest edge.

VOUCHER: *Caetano s.n.* (FURB 38756).

Bulbophyllum granulosum Barb.Rodr., Gen. Spec. Orchid. 1: 41. 1877.*

Didactyle granulosa (Barb.Rodr.) Barb.Rodr., Gen. Spec. Orchid. 2: 125. 1881.

HABIT AND HABITAT: Epiphyte; anthropic area (pasture).

VOUCHER: *Caetano & Schlemper 204* (spirit, FURB).

Bulbophyllum napellii Lindl., Ann. Mag. Nat. Hist. 10: 185. 1842 (Fig. 5).

Phyllorkis napelli (Lindl.) Kuntze, Revis. Gen. Pl. 2: 677. 1891.

HABIT AND HABITAT: Epiphyte; forest interior.

VOUCHERS: *Bresolin 663* (FLOR, HB); *Schmitt et al. 756* (FURB); *Schmitt et al. 1807* (FURB).

Bulbophyllum regnellii Rchb.f., Linnaea 22: 835. 1850.

Didactyle regnellii (Rchb.f.) Barb.Rodr., Gen. Spec. Orchid. 2: 123. 1881.

HABIT AND HABITAT: Epiphyte; forest edge.

VOUCHER: *Caetano et al. 50* (FURB).

CAMPYLOCENTRUM Benth.

Campylocentrum densiflorum Cogn. in Mart., Fl. Bras. 3(6): 511. 1906 (Fig. 5).

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano et al. 49* (FURB).

Campylocentrum grisebachii Cogn. in Mart., Fl. Bras. 3(6): 522. 1906.

Campylocentrum burchellii Cogn. in Mart., Fl. Bras. 3(6): 522. 1906.

HABIT AND HABITAT: Epiphyte; anthropic area (pasture).

VOUCHER: *Caetano 194* (spirit, FURB).

Campylocentrum ornithorrhynchum (Lindl.) Rolfe, Orchid Rev. 11: 246. 1903.*

Angraecum ornithorrhynchum Lindl., Edwards's Bot. Reg. 26: t. 68. 1840.

Aeranthes ornithorrhyncha (Lindl.) Rchb.f. in Walp., Ann. Bot. Syst. 6(6): 903. 1864.

HABIT AND HABITAT: Epiphyte; anthropic area (reforested).

VOUCHER: *Caetano 221* (spirit, FURB).

Campylocentrum parahybunense (Barb.Rodr.) Rolfe, Orchid Rev. 11: 246. 1903.*

Aeranthes parahybunensis Barb.Rodr., Gen. Spec. Orchid. 2: 245. 1882.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano s.n.* (FURB 40574).

Campylocentrum pauloense Hoehne & Schltr., Arch. Bot. São Paulo 1: 297. 1926 (Fig. 5).

HABIT AND HABITAT: Epiphyte; forest edge.

VOUCHER: *Caetano 48* (FURB).

Campylocentrum ulaei Cogn. in Mart., Fl. Bras. 3(6): 514. 1906.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano et al. 200* (spirit, FURB).

CAPANEMIA Barb.Rodr.

Capanemia gehrtii Hoehne, Arq. Bot. Estado São Paulo, n.s. 1: 43. 1939.*

HABIT AND HABITAT: Epiphyte; anthropic area (urban area).

VOUCHER: *Caetano s.n.* (FURB 36261).

Capanemia thereziae Barb.Rodr., Gen. Spec. Orchid. 2: 244. 1882.*

Quekettia thereziae (Barb.Rodr.) Cogn. in Mart., Fl. Bras. 3(6): 200. 1905.

HABIT AND HABITAT: Epiphyte; anthropic area (urban area).

VOUCHER: *Caetano 213* (spirit, FURB).

CATTLEYA Lindl.

Cattleya guttata Lindl., Edwards's Bot. Reg. 17: t. 1406. 1831 (Fig. 5).* **[VU]**

Cattleya elatior Lindl., Gen. Sp. Orchid. Pl.: 117. 1833.

HABIT AND HABITAT: Rupicolous; riparian forest.

VOUCHER: *Caetano 64* (FURB).

Cattleya intermedia Graham, Bot. Mag. 55: t. 2851. 1828 (Fig. 5). **[VU]**

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 78* (FURB).

CIRRHAEA Lindl.

Cirrhaea dependens (G.Lodd.) Loudon, Hort. Brit.: 370. 1830 (Fig. 5).*

Cymbidium dependens G.Lodd., Bot. Cab. 10(4): t. 936. 1825.
HABIT AND HABITAT: Epiphyte; anthropic (urban) area.
VOUCHER: *Caetano s.n.* (FURB 40573).

CLEISTES Rich. ex Lindl.

Cleistes libonii (Rchb.f.) Schltr., Arch. Bot. São Paulo 1: 179. 1926 (Fig. 5).*
Pogonia libonii Rchb.f., Xenia Orchid. 2: 91. 1865.
Pogonia macrantha Barb.Rodr., Rev. Engenh. 3: 144. 1881.
Cleistes macrantha (Barb.Rodr.) Schltr., Arch. Bot. São Paulo 1: 179. 1926.
Pogonia revoluta Barb.Rodr., Rev. Engenh. 3: 144. 1881.
Cleistes revoluta (Barb.Rodr.) Schltr., Repert. Spec. Nov. Regni Veg. Beih. 35: 26. 1925.
Pogonia magnifica Schltr., Repert. Spec. Nov. Regni Veg. 16: 316. 1920.
Cleistes magnifica (Schltr.) Schltr., Arch. Bot. São Paulo 1: 180. 1926.
HABIT AND HABITAT: Terrestrial; anthropic area (urban area).
VOUCHERS: *Costa s.n.* (R 198377); *Caetano s.n.* (FURB 38279, HUCS 39284).

CORYMBORKIS Thouars

Corymborkis flava (Sw.) Kuntze, Revis. Gen. Pl. 2: 658. 1891.
Serapias flava Sw., Prodr.: 119. 1788.
HABIT AND HABITAT: Terrestrial; forest interior.
VOUCHER: *Caetano 7* (FURB).

CRANICHIS Sw.

Cranichis candida (Barb.Rodr.) Cogn. in Mart., Fl. Bras. 3(4): 248. 1895.
Cystochilum candidum Barb.Rodr., Gen. Spec. Orchid. 1: 198. 1877.
Cranichis similis Rchb.f., Otia Bot. Hamburg. 2: 83. 1881.
HABIT AND HABITAT: Terrestrial; anthropic area (urban area).
VOUCHER: *Caetano 21* (FURB).

CYCLOPOGON C.Presl

Cyclopogon congestus (Vell.) Hoehne, Fl. Brasilica 12(2): 209. 1945 (Fig. 5).
Serapias congesta Vell., Fl. Flumin. Icon. 9: t. 54. 1831.
Beadlea congesta (Vell.) Garay, Bot. Mus. Leafl. 28(4): 300. 1982 (“1980”).
Cyclopogon alpestris var. *bidentatus* Barb.Rodr., Gen. Spec. Orchid. 2: 283. 1882.
Cyclopogon bidentatus (Barb.Rodr.), Szlach., Candollea 48(2): 435. 1993.
Beadlea bidentata (Barb.Rodr.) Garay, Bot. Mus. Leafl. 28(4): 299. 1982 (“1980”).
HABIT AND HABITAT: Epiphyte; forest edge.
VOUCHER: *Caetano 33* (FURB).

Cyclopogon iguapensis Schltr., Anexos Mem. Inst. Butantan, Secç. Bot. 1(4): 25. 1922.*
Beadlea iguapensis (Schltr.) Garay, Bot. Mus. Leafl. 28(4): 300. 1982 (“1980”).
HABIT AND HABITAT: Epiphyte; forest interior.
VOUCHER: *Caetano 27* (FURB).

Cyclopogon longibracteatus (Barb.Rodr.) Schltr., Beih. Bot. Centralbl. 37(2): 390. 1920.
Spiranthes longibracteata Barb.Rodr., Gen. Spec. Orchid. 1: 185. 1877.
Beadlea longibracteata (Barb.Rodr.) Garay, Bot. Mus. Leafl. 28(4): 301. 1982 (“1980”).
HABIT AND HABITAT: Rupicolous; riparian forest.
VOUCHER: *Caetano 26* (FURB).

Cyclopogon multiflorus Schltr., Anexos Mem. Inst. Butantan, Secç. Bot. 1(4): 27. 1922.*
Beadlea multiflora (Schltr.) Garay, Bot. Mus. Leafl. 28(4): 301. 1982 (“1980”).
HABIT AND HABITAT: Epiphyte; forest interior.
VOUCHER: *Caetano & Schlemper 198* (spirit, FURB).

Cyclopogon subalpestris Schltr., Repert. Spec. Nov. Regni Veg. Beih. 35: 32. 1925 (Fig. 5).
Beadlea subalpestris (Schltr.) Garay, Bot. Mus. Leafl. 28(4): 301. 1982 (“1980”).
HABIT AND HABITAT: Rupicolous; forest interior (top of hill).
VOUCHER: *Caetano & Schlemper 25* (FURB).

DICHAEA Lindl.

Dichaea cogniauxiana Schltr., Anexos Mem. Inst. Butantan, Secç. Bot. 1(4): 66. 1922 (Fig. 5).*
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHERS: *Caetano s.n.* (FURB 40575); *Caetano 60* (FURB).

Dichaea pendula (Aubl.) Cogn. in Urb., Symb. Antill.

4(1): 182. 1903 (Fig. 5).
Limodorum pendulum Aubl., Hist. Pl. Guiane 2: 819. 1775.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano 54* (FURB).

DRYADELLA Luer

Dryadella lilliputiana (Cogn.) Luer, Selbyana 2(2–3): 208. 1978 (Fig. 5). **[VU]**
Masdevallia lilliputiana Cogn. in Mart., Fl. Bras. 3(6): 555. 1906.
HABIT AND HABITAT: Epiphyte; forest interior.
VOUCHER: *Schmitt et al. 1799* (FURB).

Dryadella zebrina (Porsch) Luer, Selbyana 2(2–3): 209. 1978.
Masdevallia zebrina Porsch, Oesterr. Bot. Z. 55: 154. 1905.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano s.n.* (FURB 38755).

ELLEANTHUS C.Presl

Elleanthus brasiliensis (Lindl.) Rchb.f. in Walp., Ann. Bot. Syst. 6(3): 475. 1862 (Fig. 5).
Evelyna brasiliensis Lindl., London J. Bot. 2: 661. 1843.
HABIT AND HABITAT: Rupicolous; forest edge.
VOUCHER: *Caetano s.n.* (FURB 36923).

ENCYCLIA Hook.

Encyclia patens Hook., Bot. Mag. 57: t. 3013. 1830 var. ***patens*** (Fig. 5).*
Epidendrum odoratissimum Lindl., Edwards's Bot. Reg. 17: t. 1415. 1831.
Encyclia odoratissima (Lindl.) Schltr., Orchideen: 210. 1914.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano s.n.* (FURB 20595).

EPIDENDRUM L.

Epidendrum avicula Lindl., J. Bot. (Hooker) 3: 85. 1841.
Lanium avicula (Lindl.) Benth., Hooker's Icon. Pl. 14: t. 1335. 1881.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano 71* (FURB).

Epidendrum caldense Barb.Rodr., Gen. Spec. Orchid. 2: 148. 1882.*
HABIT AND HABITAT: Epiphyte; anthropic area (pasture).
VOUCHER: *Caetano & Almeida 201* (spirit, FURB).

Epidendrum campaccii Hágsater & L.Sánchez, Icon. Orchid. 2(1): t. 117. 1993.*
HABIT AND HABITAT: Epiphyte; open field.
VOUCHER: *Caetano s.n.* (FURB 37807).

Epidendrum cristatum Ruiz & Pav., Syst. Veg. Fl. Peruv. Chil. 1: 243. 1798.
Epidendrum raniferum Lindl., Gen. Sp. Orchid. Pl.: 109. 1831.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano s.n.* (FURB 37805).

Epidendrum densiflorum Hook., Bot. Mag. 66: t. 3791. 1840 (Fig. 6).
HABIT AND HABITAT: Epiphyte; forest interior.
VOUCHER: *Caetano s.n.* (FURB 38757).

Epidendrum latilabrum Lindl., Edwards's Bot. Reg. 27(Misc.): 77. 1841.
Amphiglottis latilabra (Lindl.) Acuña, Bol. Estac. Exp. Agron. Santiago de las Vegas 60: 98. 1939.
Neolehmannia latilabris (Lindl.) Pabst, Bradea 2(46): 306. 1978.
HABIT AND HABITAT: Epiphyte; forest interior, riparian forest.
VOUCHERS: *Caetano 18* (FURB); *189* (spirit, FURB).

Epidendrum proligerum Barb.Rodr., Gen. Spec. Orchid. 1: 61. 1877.*
Epidendrum corymbosum Lindl., Fol. Orchid. 3(Epidendrum): 61. 1853, *nom. illeg.*
Epidendrum ochrochlorum Barb.Rodr., Gen. Spec. Orchid. 2: 140. 1882.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano & Schlemper 67* (FURB).

Epidendrum pseudodifforme Hoehne & Schltr., Repert. Spec. Nov. Regni Veg. Beih. 35: 71. 1925.*
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Crestani s.n.* (FURB 8453).

Epidendrum ramosum Jacq., Enum. Syst. Pl.: 29. 1760 (Fig. 6).
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHERS: *Caetano 32* (FURB); *Caetano & Schlemper s.n.* (FURB 40578).

Epidendrum rigidum Jacq., Enum. Syst. Pl.: 29. 1760.
HABIT AND HABITAT: Epiphyte; anthropic area (pasture).
VOUCHER: *Caetano 187* (spirit, FURB).

Epidendrum secundum Jacq., Enum. Syst. Pl.: 29. 1760 (Fig. 6).

Epidendrum elongatum Jacq., Collecteana 3: 260. 1791.

Epidendrum ellipticum Graham in Hook., Exot. Fl. 3: t. 207. 1826.

Epidendrum ansiferum Rchb.f. & Warsz., Bonplandia 2: 111. 1854.

Habit and habitat: Epiphyte; anthropic area (approach road).

Voucher: *Caetano 17* (FURB).

Epidendrum tridactylum Lindl., Edwards's Bot. Reg. 24(Misc.): 46. 1838 (Fig. 6).

Amblostoma tridactylum (Lindl.) Rchb.f. in Walp., Ann. Bot. Syst. 6(4): 485. 1863.

Habit and habitat: Epiphyte; forest interior.

Voucher: *Caetano 20* (FURB).

Epidendrum vesicatum Lindl., Edwards's Bot. Reg. 24(Misc.): 50. 1838 (Fig. 6).*

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano & Schlemper 68* (FURB).

Eulophia R.Br.

Eulophia alta (L.) Fawc. & Rendle, Fl. Jamaica 1: 112. 1910 (Fig. 6).

Limodorum altum L., Syst. Nat. ed. 12. 2: 594. 1767.

Eulophia longifolia (Kunth) Schltr., Orchideen: 347. 1914.

Dendrobium longifolium Kunth, Nov. Gen. Sp. 1(ed. qu.): 360. 1816.

Habit and habitat: Terrestrial; anthropic area (pasture).

Voucher: *Caetano 61* (FURB).

Eurystyles Wawra

Eurystyles cotyledon Wawra, Oesterr. Bot. Z. 13(1): 223. 1863 (Fig. 6).

Habit and habitat: Epiphyte; riparian forest (forest edge), anthropic area (pasture).

Vouchers: *Caetano s.n.* (FURB 40579); *Caetano 220* (spirit, FURB).

Gomesa R.Br.

Gomesa albinoi (Schltr.) M.W.Chase & N.H.Williams, Ann. Bot. (Oxford) 104(3): 395. 2009.*

Oncidium albinoi Schltr., Repert. Spec. Nov. Regni Veg. 23: 63. 1926.

Baptistonia albinoi (Schltr.) Chiron & V.P.Castro, Richardiana 4(3): 117. 2004.

Habit and habitat: Epiphyte; riparian forest, anthropic area (pasture).

Vouchers: *Caetano & Schlemper 203* (spirit, FURB); *Caetano & Schlemper 206* (spirit, FURB).

Gomesa cornigera (Lindl.) M.W.Chase & N.H. Williams, Ann. Bot. (Oxford) 104(3): 396. 2009.

Oncidium cornigerum Lindl., Edwards's Bot. Reg. 18: t. 1542. 1832.

Baptistonia cornigera (Lindl.) Chiron & V.P.Castro, Richardiana 4(3): 117. 2004.

Oncidium hecatanthum Kraenzl., Kungl. Svenska Vetenskapsakad. Handl., n.s. 46(10): 81. 1911.

Habit and habitat: Epiphyte; anthropic area (urban area).

Voucher: *Caetano s.n.* (FURB 37361).

Gomesa eleutherosepala (Barb.Rodr.) M.W.Chase & N.H.Williams, Ann. Bot. (Oxford) 104(3): 396. 2009.*

Rodriguezia eleutherosepala Barb.Rodr., Gen. Spec. Orchid. 2: 240. 1882.

Rodrigueziopsis eleutherosepala (Barb.Rodr.) Schltr., Repert. Spec. Nov. Regni Veg. 16: 427. 1920.

Habit and habitat: Epiphyte; riparian forest, forest interior.

Vouchers: *Schmitt et al. 1740* (FURB); *Caetano s.n.* (FURB 37333).

Gomesa flexuosa (Lodd.) M.W.Chase & N.H.Williams, Phytotaxa 1: 58. 2009 (Fig. 6).

Oncidium flexuosum Lodd., Bot. Cab. 5: t. 424. 1820.

Ampliglossum flexuosum (Lodd.) Campacci, Colet. Orquídeas Brasil. 3: 84. 2006.

Coppensia flexuosa (Lodd.) Campacci, Bol. CAOB 62: 55. 2006.

Habit and habitat: Epiphyte; forest interior (riparian forest).

Voucher: *Caetano s.n.* (FURB 36893).

Gomesa gardneri (Lindl.) M.W.Chase & N.H.Williams, Ann. Bot. (Oxford) 104(3): 397. 2009 (Fig. 6).*

Oncidium gardneri Lindl., London J. Bot. 2: 662. 1843.

Anettea gardneri (Lindl.) Szlach. & Mytnik, Polish Bot. J. 51(1): 50. 2006.

Brasilidium gardneri (Lindl.) Campacci, Colet. Orquídeas Brasil. 3: 79. 2006.

FIGURE 6. From top left to bottom right: *Epidendrum densiflorum. E. ramosum. E. secundum. E. tridactylum. E. vesicatum. Eulophia alta. Eurystyles cotyledon. Gomesa flexuosa. G. gardneri. G. imperatoris-maximiliani. G. recurva. Grandiphyllum divaricatum. Grobya fascifera. Habenaria parviflora. Huntleya meleagris. Lankesterella ceracifolia*. All courtesy of The Field Museum, Chicago.

FIGURE 7. From top left to bottom right: *Leptotes bicolor. L. unicolor. Maxillaria chrysantha. M. marginata. M. ochroleuca. M. picta. M. subulata. Miltonia falvescens. M. regnellii. M. russelliana. Notylia hemitricha. Octomeria crassifolia, O. gracilis. O. micrantha. O. warmingii. Ornithocephalus myrticola*. All courtesy of The Field Museum, Chicago.

HABIT AND HABITAT: Epiphyte; riparian forest, anthropic area (pasture).

VOUCHERS: *Schmitt et al. 506* (FURB); *Schmitt et al. 515* (FURB); *Caetano & Schlemper 202* (spirit, FURB).

Gomesa handroi (Hoehne) Pabst, Orquídea (Rio de Janeiro) 29(4): 165. 1967.*

Theodorea handroi Hoehne, Arq. Bot. Estado São Paulo, n.s. 1(4): 87. 1942.

Hellerorchis handroi (Hoehne) A.D.Hawkes, Orchid J. 3: 275. 1959.

Rodrigueziella handroi (Hoehne) Pabst, Bradea 2(2): 8. 1975.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano s.n.* (FURB 36288).

Gomesa imperatoris-maximiliani (Rchb.f.) M.W.Chase & N.H.Williams, Ann. Bot. (Oxford) 104(3): 397. 2009 (Fig. 6).*

Oncidium imperatoris-maximiliani Rchb.f. in Wawra, Bot. Ergebn.: 154. 1866.

Anettea imperatoris-maximiliani (Rchb.f.) Szlach. & Mytnik, Polish Bot. J. 51(1): 50. 2006.

Oncidium crispum Lodd. ex Lindl., Gen. Sp. Orchid. Pl.: 197. 1833.

Anettea crispa (Lodd. ex Lindl.) Szlach. & Mytnik, Polish Bot. J. 5(1)1: 50. 2006.

Brasilidium crispum (Lodd. ex Lindl.) Campacci, Colet. Orquídeas Brasil. 3: 78. 2006.

Oncidium brunnipetalum Barb.Rodr., Gen. Spec. Orchid. 2: 190. 1882.

Ampliglossum brunnipetalum (Barb.Rodr.) Campacci, Colet. Orquídeas Brasil. 3: 83. 2006.

Coppensia brunnipetala (Barb.Rodr.) Campacci, Bol. CAOB 62: 55. 2006.

Gomesa brunnipetala (Barb.Rodr.) M.W.Chase & N.H.Williams, Ann. Bot. (Oxford) 104(3): 396. 2009.

HABIT AND HABITAT: Epiphyte; anthropic area (pasture).

VOUCHER: *Caetano s.n.* (FURB 37814).

Gomesa loefgrenii (Cogn.) M.W.Chase & N.H.Williams, Ann. Bot. (Oxford) 104(3): 397. 2009.*

Oncidium loefgrenii Cogn. in Mart., Fl. Bras. 3(4): 381. 1896.

Carenidium loefgrenii (Cogn.) Baptista, Colet. Orquídeas Brasil. 3: 91. 2006.

Menezesiella loefgrenii (Cogn.) V.P.Castro & Chiron, Richardiana 6(2): 105. 2006.

Coppensia loefgrenii (Cogn.) F.Barros & V.T.Rodrigues, Bol. CAOB 77-78: 12. 2010.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Klein & Bresolin 10882* (FLOR).

Gomesa radicans (Rchb.f.) M.W.Chase & N.H.Williams, Ann. Bot. (Oxford) 104(3): 398. 2009.*

Sigmatostalix radicans Rchb.f. in Walp., Ann. Bot. Syst. 6(6): 859. 1864.

Ornithophora radicans (Rchb.f.) Garay & Pabst, Orquídea (Rio de Janeiro) 13: 50. 1951.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano s.n.* (FURB 37804).

Gomesa ranifera (Lindl.) M.W.Chase & N.H.Williams, Ann. Bot. (Oxford) 104(3): 398. 2009.*

Oncidium raniferum Lindl., Edwards's Bot. Reg. 23: t. 1920. 1837.

Carenidium raniferum (Lindl.) Baptista, Colet. Orquídeas Brasil. 3: 91. 2006.

Menezesiella ranifera (Lindl.) Chiron & V.P.Castro, Richardiana 6(2): 105. 2006.

Rhinocidium raniferum (Lindl.) Baptista, Orchidstud. 2(2–3): 42. 2007.

Coppensia ranifera (Lindl.) F.Barros & V.T.Rodrigues, Bol. CAOB 77-78: 13. 2010.

HABIT AND HABITAT: Epiphyte; forest interior, anthropic area (pasture).

VOUCHERS: *Schmitt et al. 1798* (FURB); *Caetano & Schlemper 205* (spirit, FURB).

Gomesa recurva R.Br., Bot. Mag. 42: t. 1748. 1815.

Rodriguezia barkeri Hook., Bot. Mag. 54: t. 2746. 1827 (Fig. 6).

Odontoglossum barkeri (Hook.) Rchb.f. in Walp., Ann. Bot. Syst. 6(6): 854. 1864.

Gomesa barkeri (Hook.) Rolfe, Orchid Rev. 9: 166. 1901.

HABIT AND HABITAT: Epiphyte; riparian forest, forest interior.

VOUCHERS: *Bresolin 665* (FLOR, as *Gomesa barkeri*); *Caetano s.n.* (FURB 37353).

Gomesa riograndensis (Cogn.) M.W.Chase & N.H.Williams, Ann. Bot. (Oxford) 104(3): 398. 2009.

Oncidium riograndense Cogn. in Mart., Fl. Bras. 3(6): 446. 1906.

Baptistonia riograndense (Cogn.) Chiron & V.P.Castro, Richardiana 4(3): 118. 2004.

Habit and habitat: Epiphyte; riparian forest.
Voucher: *Crestani s.n.* (FURB 8454).

Gomesa uniflora (Booth ex Lindl.) M.W.Chase & N.H.Williams, Ann. Bot. (Oxford) 104(3): 398. 2009.
Oncidium uniflorum Booth ex Lindl., Edwards's Bot. Reg. 29: t. 43. 1843.
Alatiglossum uniflorum (Booth ex Lindl.) Baptista, Colet. Orquídeas Brasil. 3: 89. 2006.
Kleberiella uniflora (Booth ex Lindl.) V.P.Castro & Cath., Richardiana 6(3): 158. 2006.
Oncidium longipes Lindl., Paxton's Fl. Gard. 1: 46. 1850.
Alatiglossum longipes (Lindl.) Baptista, Colet. Orquídeas Brasil. 3: 88. 2006.
Kleberiella longipes (Lindl.) V.P.Castro & Cath., Richardiana 6(3): 159. 2006.
Gomesa longipes (Lindl.) M.W.Chase & N.H.Williams, Ann. Bot. (Oxford) 104(3): 397. 2009.
Habit and habitat: Epiphyte; forest edge.
Voucher: *Caetano s.n.* (FURB 37350).

Gongora Ruiz & Pav.

Gongora bufonia Lindl., Edwards's Bot. Reg. 27: t. 2. 1841.*
Habit and habitat: Epiphyte; forest interior (top of hill).
Voucher: *Caetano & Henschel 53* (FURB).

Govenia Lindl.

Govenia utriculata (Sw.) Lindl., Edwards's Bot. Reg. 25(Misc.): 47. 1839.
Limodorum utriculatum Sw., Prodr.: 119. 1788.
Habit and habitat: Terrestrial; forest edge.
Voucher: *Caetano 75* (FURB, RB).

Grandiphyllum Docha Neto

Grandiphyllum divaricatum (Lindl.) Docha Neto, Colet. Orquídeas Brasil. 3: 75. 2006 (Fig. 6). **[VU]**
Oncidium divaricatum Lindl., Bot. Reg. 13: t. 1050. 1827.
Aurinocidium divaricatum (Lindl.) Romowicz & Szlach., Polish Bot. J. 51(1): 44. 2006.
Oncidium pulvinatum Lindl., Edwards's Bot. Reg. 24(Misc.): 61. 1838.
Aurinocidium pulvinatum (Lindl.) Romowicz & Szlach., Polish Bot. J. 51(1): 44. 2006.
Grandiphyllum pulvinatum (Lindl.) Docha Neto, Colet. Orquídeas Brasil. 3: 76. 2006.
Oncidium sphegiferum Lindl., Edwards's Bot. Reg. 29(Misc.): 17. 1843.
Aurinocidium sphegiferum (Lindl.) Romowicz & Szlach., Polish Bot. J. 51(1): 44. 2006.
Grandiphyllum sphegiferum (Lindl.) Docha Neto, Colet. Orquídeas Brasil. 3: 76. 2006.
Oncidium robustissimum Rchb.f., Gard. Chron., ser. 3, 4: 352. 1888.
Aurinocidium robustissimum (Rchb.f.) Romowicz & Szlach., Polish Bot. J. 51(1): 44. 2006.
Grandiphyllum robustissimum (Rchb.f.) Docha Neto, Colet. Orquídeas Brasil. 3: 76. 2006.
Habit and habitat: Epiphyte; anthropic area (urban area).
Voucher: *Caetano s.n.* (FURB 39665).

Grandiphyllum hians (Lindl.) Docha Neto, Colet. Orquídeas Brasil. 3: 75. 2006.* **[VU]**
Oncidium hians Lindl., Edwards's Bot. Reg. 24(Misc.): 65. 1838.
Aurinocidium hians (Lindl.) Romowicz & Szlach., Polish Bot. J. 51(1): 44. 2006.
Habit and habitat: Epiphyte; riparian forest.
Voucher: *Caetano 57* (FURB).

Grobya Lindl.

Grobya fascifera Rchb.f., Flora 69: 551. 1886. **[VU]**
Grobya bibrachiata Hoehne, Bol. Agric. (São Paulo) 34: 625. 1934 (Fig. 6).*
Grobya bibrachiata var. *riograndensis* Pabst, Arch. Jard. Bot. Rio de Janeiro 14: 22. 1956.
Habit and habitat: Epiphyte; forest interior.
Voucher: *Caetano 70* (FURB).

Habenaria Willd.

Habenaria josephensis Barb.Rodr., Gen. Spec. Orchid. 2: 257. 1882.*
Habit and habitat: Terrestrial; forest interior.
Voucher: *Caetano 9* (FURB).

Habenaria parviflora Lindl., Gen. Sp. Orchid. Pl.: 314. 1835 (Fig. 6).
Habit and habitat: Terrestrial; anthropic area (pasture).
Vouchers: *Costa s.n.* (R 90253); *Caetano 55* (FURB).

HAPALORCHIS Schltr.

Hapalorchis lineata (Lindl.) Schltr., Beih. Bot. Centralbl. 37(2): 363. 1920.

Spiranthes lineata Lindl., Gen. Sp. Orchid. Pl.: 471. 1840.

Gyrostachys lineata (Lindl.) Kuntze, Revis. Gen. Pl. 2: 664. 1891.

Cyclopogon lineatus (Lindl.) Pabst, Bradea 1(47): 466. 1974.

HABIT AND HABITAT: Terrestrial; forest interior.

VOUCHER: *Caetano 212* (spirit, FURB).

Hapalorchis micranthus (Barb.Rodr.) Hoehne, Fl. Brasilica 12(2): 291. 1945 (“*micrantha*”).

Spiranthes micrantha Barb.Rodr., Gen. Spec. Orchid. 1: 183. 1877.

Cyclopogon micranthus Barb.Rodr., Gen. Spec. Orchid. 1(Index): iii. 1877.

Sauroglossum candidum Kraenzl., Kungl. Svenska Vetenskapsakad. Handl., n.s. 46(10): 38. 1911.

Hapalorchis candida (Kraenzl.) Schltr., Beih. Bot. Centralbl. 37(2): 363. 1920.

Cyclopogon candidus (Kraenzl.) Pabst, Bradea 1(47): 466. 1974.

HABIT AND HABITAT: Terrestrial; riparian forest.

VOUCHER: *Schmitt et al. 504* (FURB).

HUNTLEYA Bateman ex Lindl.

Huntleya meleagris Lindl., Edwards’s Bot. Reg. 23: t. 1991. 1837.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHERS: *Caetano 65* (FUEL, FURB).

ISABELIA Barb.Rodr.

Isabelia pulchella (Kraenzl.) Van den Berg & M.W.Chase, Lindleyana 16(2): 109. 2001.*

Neolauchea pulchella Kraenzl., Bull. Herb. Boissier 5: 110. 1897.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 16* (FURB).

ISOCHILUS R.Br.

Isochilus linearis (Jacq.) R.Br. in W.T.Aiton, Hortus Kew., ed. 2. 5: 209. 1813.

Epidendrum lineare Jacq., Enum. Syst. Pl.: 29. 1760.

Isochilus brasiliensis Schltr., Arch. Bot. São Paulo 1: 235. 1926.

HABIT AND HABITAT: Epiphyte; anthropic area (urban area).

VOUCHER: *Caetano s.n.* (FURB 38753).

LANKESTERELLA Ames

Lankesterella ceracifolia (Barb.Rodr.) Mansf., Notizbl. Bot. Gart. Berlin-Dahlem 15: 217. 1940.

Stenorrhynchos ceracifolium Barb.Rodr., Gen. Spec. Orchid. 2(Index): xv. 1881.

Spiranthes ceracifolia (Barb.Rodr.) Barb.Rodr., Gen. Spec. Orchid. 2: 285. 1882.

HABIT AND HABITAT: Epiphyte; forest edge, forest interior.

VOUCHERS: *Schmitt et al. 1810* (FURB); *Caetano 73* (FURB).

LEPTOTES Lindl.

Leptotes bicolor Lindl., Edwards’s Bot. Reg. 19: t. 1625. 1833 (Fig. 7).

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 37* (FURB).

Leptotes unicolor Barb.Rodr., Gen. Spec. Orchid. 1: 74. 1877 (Fig. 7).

HABIT AND HABITAT: Epiphyte; anthropic area (pasture).

VOUCHER: *Caetano s.n.* (FURB 38094).

LIPARIS Rich.

Liparis nervosa (Thunb.) Lindl., Gen. Sp. Orchid. Pl.: 26. 1830 subsp. ***nervosa***.

Ophrys nervosa Thunb. in Murray, Syst. Veg. ed. 14: 814. 1784.

Liparis elata Lindl., Bot. Reg. 14: t. 1175. 1828.

HABIT AND HABITAT: Terrestrial; forest interior.

VOUCHER: *Caetano 3* (FURB).

MALAXIS Sol. ex Sw.

Malaxis excavata (Lindl.) Kuntze, Revis. Gen. Pl. 2: 673. 1891.

Microstylis excavata Lindl., Edwards’s Bot. Reg. 24(Misc.): 51. 1838.

Cheiropterocephalus sertuliferus Barb.Rodr., Gen. Spec. Orchid. 1: 29. 1877.

Microstylis sertulifera (Barb.Rodr.) Schltr., Repert. Spec. Nov. Regni Veg. Beih. 35: 46. 1925.

Malaxis sertulifera (Barb.Rodr.) Pabst, Orquídea (Rio de Janeiro) 29(3): 112. 1967.

Habit and habitat: Epiphyte; forest edge.
Voucher: *Caetano 35* (FURB).

Malaxis parthonii C.Morren, Bull. Acad. Roy. Sci. Bruxelles 5: 485. 1838.
Microstylis parthonii (C.Morren) Rchb.f., Ann. Bot. Syst. 6: 206. 1861.
Habit and habitat: Terrestrial; riparian forest.
Voucher: *Caetano s.n.* (FURB 40572).

Maxillaria Ruiz & Pav.

Maxillaria brasiliensis Brieger & Illg, Trab. 26 Congr. Nac. Bot., Rio de Janeiro: 240. 1977.*
Heterotaxis brasiliensis (Brieger & Illg) F.Barros, Hoehnea 29(2): 112. 2002.
Habit and habitat: Epiphyte; riparian forest.
Voucher: *Caetano 181* (spirit, FURB).

Maxillaria chrysantha Barb.Rodr., Gen. Spec. Orchid. 1: 115. 1877 (Fig. 7).
Brasiliorchis chrysantha (Barb.Rodr.) R.B.Singer, S.Koehler & Carnevali, Novon 17(1): 96. 2007.
Bolbidium chrysanthum (Barb.Rodr.) J.M.H.Shaw, Orchid Rev. Suppl. 119(1294): 38. 2011.
Maxillaria serotina Regnell & Barb.Rodr., Gen. Spec. Orchid. 2: 203. 1882.
Brasiliorchis serotina (Regnell & Barb.Rodr.) Szlach. & Sitko, Biodivers. Res. Conservation 25: 23. 2012.
Habit and habitat: Epiphyte; anthropic area (pasture).
Voucher: *Caetano 42* (FURB).

Maxillaria cleistogama Brieger & Illg, Trab. 26 Congr. Nac. Bot., Rio de Janeiro: 247. 1977.
Mormolyca cleistogama (Brieger & Illg) M.A.Blanco, Lankesteriana 7(3): 531. 2007.
Habit and habitat: Epiphyte; riparian forest.
Voucher: *Caetano s.n.* (FURB 36888).

Maxillaria crocea Lindl., Edwards's Bot. Reg. 21: t. 1799. 1835.*
Maxillaria lindleyana Schltr., Repert. Spec. Nov. Regni Veg. Beih. 9: 162. 1921, *nom. illeg.*
Habit and habitat: Epiphyte; forest interior.
Voucher: *Caetano et al. 222* (spirit, FURB).

Maxillaria ferdinandiana Barb.Rodr., Gen. Spec. Orchid. 2: 204. 1882.*
Christensonella ferdinandiana (Barb.Rodr.) Szlach. et al., Polish Bot. J. 51(1): 58. 2006.
Habit and habitat: Epiphyte; riparian forest.
Voucher: *Caetano 23* (FURB).

Maxillaria marginata (Lindl.) Fenzl, Fl. Serres Jard. Eur. 10: 112. 1855 (Fig. 7).*
Cymbidium marginatum Lindl., Edwards's Bot. Reg. 18: t. 1530. 1832.
Brasiliorchis marginata (Lindl.) R.B.Singer, S.Koehler & Carnevali, Novon 17(1): 97. 2007.
Bolbidium marginatum (Barb.Rodr.) J.M.H.Shaw, Orchid Rev. Suppl. 119(1294): 38. 2011.
Maxillaria consanguinea Klotzsch, Ann. Sci. Nat., Bot., sér. 3, 19: 375. 1853.
Brasiliorchis consanguinea (Klotzsch) R.B.Singer, S.Koehler & Carnevali, Novon 17(1): 96. 2007.
Habit and habitat: Epiphyte; riparian forest.
Vouchers: *Caetano s.n.* (FURB 36932); *Caetano s.n.* (FURB 37343).

Maxillaria notylioglossa Rchb.f., Bonplandia 2(2): 16. 1854.
Rhetinantha notylioglossa (Rchb.f.) M.A.Blanco, Lankesteriana 7(3): 535. 2007.
Maxillaria cerifera Barb.Rodr., Gen. Spec. Orchid. 1: 118. 1877.
Ornithidium ceriferum (Barb.Rodr.) Barb.Rodr., Gen. Spec. Orchid. 2: 209. 1882.
Rhetinantha cerifera (Barb.Rodr.) M.A.Blanco, Lankesteriana 7(3): 534. 2007.
Habit and habitat: Epiphyte; riparian forest.
Voucher: *Caetano s.n.* (FURB 39736).

Maxillaria ochroleuca G.Lodd. ex Lindl., Gen. Sp. Orchid. Pl.: 143. 1832 (Fig. 7).
Habit and habitat: Epiphyte; riparian forest.
Voucher: *Caetano s.n.* (FURB 37811).

Maxillaria paranaensis Barb.Rodr., Gen. Spec. Orchid. 2: 205. 1882.
Christensonella paranaensis (Barb.Rodr.) Szlach. & Sitko, Biodivers. Res. Conservation 25: 27. 2012.
Maxillaria spegazziniana Kraenzl., Orchis 2: 51. 1908.
Christensonella spegazziniana (Kraenzl.) Szlach. & Sitko, Biodivers. Res. Conservation 25: 27. 2012.
Maxillaria juergensii Schltr., Repert. Spec. Nov. Regni Veg. Beih. 35: 88. 1925.
Christensonella juergensii (Schltr.) Szlach. et al., Polish Bot. J. 51(1): 58. 2006.
Maxillaria cogniauxiana Hoehne, Bol. Agric. (São Paulo) 34: 632. 1934.

Christensonella cogniauxiana (Hoehne) Szlach. et al., Polish Bot. J. 51(1): 58. 2006.

Maxillaria heterophylla Hoehne, Arq. Bot. Estado São Paulo, n.s. 2(6): 132. 1952.

HABIT AND HABITAT: Epiphyte; forest edge.

VOUCHER: *Caetano s.n.* (FURB 37800).

Maxillaria picta Hook., Bot. Mag. 59: t. 3154. 1832 (Fig. 7).

Brasiliorchis picta (Hook.) R.B.Singer, S.Koehler & Carnevali, Novon 17(1): 97. 2007.

Bolbidium pictum (Barb.Rodr.) J.M.H.Shaw, Orchid Rev. Suppl. 119(1294): 38. 2011.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano s.n.* (FURB 38760).

Maxillaria porphyrostele Rchb.f., Gard. Chron. 1: 978. 1873.*

Brasiliorchis porphyrostele (Rchb.f.) R.B.Singer, S.Koehler & Carnevali, Novon 17(1): 97. 2007.

Bolbidium porphyrostele (Rchb.f.) J.M.H.Shaw, Orchid Rev. Suppl. 119(1294): 38. 2011.

HABIT AND HABITAT: Epiphyte; anthropic area (pasture).

VOUCHER: *Caetano 207* (spirit, FURB).

Maxillaria rufescens Lindl., Edwards's Bot. Reg. 22: t. 1848. 1836.

Mormolyca rufescens (Lindl.) M.A.Blanco, Lankesteriana 7(3): 531. 2007.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 72* (FURB).

Maxillaria subulata Lindl., Gen. Sp. Orchid. Pl.: 147. 1832 (Fig. 7).*

Christensonella subulata (Lindl.) Szlach. et al., Polish Bot. J. 51(1): 59. 2006.

Maxillaria acicularis Herb. ex Lindl., Edwards's Bot. Reg. 23: t. 1986. 1837.

Christensonella acicularis (Herb. ex Lindl.) Szlach. et al., Polish Bot. J. 51(1): 58. 2006.

Maxillaria madida Lindl., Edwards's Bot. Reg. 24(Misc.): 44. 1838.

Christensonella madida (Lindl.) Szlach. et al., Polish Bot. J. 51(1): 58. 2006.

Maxillaria cepula Rchb.f., Bonplandia 3(15–16): 216. 1855.

Christensonella cepula (Rchb.f.) S.Koehler, Lankesteriana 7(3): 522. 2007.

Maxillaria mosenii Kraenzl., Kungl. Svenska Vetenskapsakad. Handl. 46(10): 73. 1911.

Maxillaria echinochila Kraenzl., Ark. Bot. 16(8): 22. 1921.

Maxillaria paulistana Hoehne, Arq. Bot. Estado São Paulo, n.s. 2(6): 135. 1952.

Christensonella paulistana (Hoehne) Szlach. et al., Polish Bot. J. 51(1): 58. 2006.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 43* (FURB).

MICROCHILUS C.Presl

Microchilus arietinus (Rchb.f. & Warm.) Ormerod, Lindleyana 17(4): 214. 2002.

Physurus arietinus Rchb.f. & Warm. in Rchb.f., Otia Bot. Hamburg. 2: 82. 1881.

Erythrodes arietina (Rchb.f. & Warm.) Ames, Orchidaceae 7: 66. 1922.

HABIT AND HABITAT: Terrestrial; riparian forest.

VOUCHER: *Caetano 183* (spirit, FURB).

MILTONIA Lindl.

Miltonia flavescens (Lindl.) Lindl., Sert. Orchid.: t. 48. 1841 (Fig. 7).

Cyrtochilum flavescens Lindl., Edwards's Bot. Reg. 19: t. 1627. 1834.

HABIT AND HABITAT: Epiphyte; anthropic area (urban area).

VOUCHER: *Caetano 44* (FURB).

Miltonia regnellii Rchb.f., Linnaea 22: 851. 1850 (Fig. 7).*

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano s.n.* (FURB 37808).

Miltonia russelliana (Lindl.) Lindl., Sert. Orchid.: t. 48. 1841 (Fig. 7).*

Oncidium russellianum Lindl., Edwards's Bot. Reg. 22: t. 1830. 1836.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 19* (FURB).

MYOXANTHUS Poepp. & Endl.

Myoxanthus exasperatus (Lindl.) Luer, Selbyana 7(1): 36. 1982.

Pleurothallis exasperata Lindl., Fol. Orchid. 9(Pleurothallis): 15. 1859.

Humboltia exasperata (Lindl.) Kuntze, Revis. Gen. Pl. 2: 667. 1891.

Pleurothallis peduncularis Lindl., Edwards's Bot. Reg. 29(Misc.): 47. 1843, *nom. illeg.*

Humboltia peduncularis (Lindl.) Kuntze, Revis. Gen. Pl. 2: 668. 1891, *nom. illeg.*

Specklinia peduncularis (Lindl.) F.Barros, Hoehnea 10: 110. 1984, *nom. illeg.*

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano 193* (spirit, FURB).

Notylia Lindl.

Notylia hemitricha Barb.Rodr., Gen. Spec. Orchid. 2: 223. 1882 (Fig. 7).*

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano s.n.* (FURB 37802).

Octomeria R.Br.

Octomeria crassifolia Lindl., Companion Bot. Mag. 2: 354. 1836 (Fig. 7).

Octomeria alpina Barb.Rodr., Gen. Spec. Orchid. 2: 102. 1881.

Octomeria densiflora Barb.Rodr., Gen. Spec. Orchid. 2: 97. 1881.

Octomeria gracilicaulis Schltr., Repert. Spec. Nov. Regni Veg. Beih. 35: 63. 1925.

Habit and habitat: Epiphyte; riparian forest.

Vouchers: *Caetano 28* (FURB); *Caetano 30* (FURB).

Octomeria diaphana Lindl., Edwards's Bot. Reg. 25(Misc.): 91. 1839.*

Octomeria fialhoensis Dutra ex Pabst, Sellowia 10: 133. 1959.

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano s.n.* (FURB 38350).

Octomeria gracilis Lodd. ex Lindl., Edwards's Bot. Reg. 24(Misc.): 36. 1838 (Fig. 7).*

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano s.n.* (FURB 36292).

Octomeria grandiflora Lindl., Edwards's Bot. Reg. 28(Misc.): 64. 1842.

Octomeria robusta Barb.Rodr., Gen. Spec. Orchid. 2: 97. 1881, *nom. illeg.*

Octomeria grandiflora var. *robusta* (Barb.Rodr.) Cogn. in Mart., Fl. Bras. 3(4): 606. 1896.

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano s.n.* (FURB 36925).

Octomeria micrantha Barb.Rodr., Gen. Spec. Orchid. 1: 33. 1877 (Fig. 7).

Habit and habitat: Epiphyte; anthropic area (reforested).

Voucher: *Caetano 29* (FURB).

Octomeria octomeriantha (Hoehne) Pabst, Bradea 1(20): 180. 1972.*

Pleurothallis octomeriantha Hoehne, Bol. Mus. Nac. Rio de Janeiro 12(2): 24. 1936.

Habit and habitat: Epiphyte; anthropic area (reforested).

Voucher: *Caetano 210* (spirit, FURB).

Octomeria palmyrabellae Barb.Rodr., Rodriguésia 8: 38. 1937.*

Habit and habitat: Epiphyte; anthropic area (reforested).

Voucher: *Caetano & Henschel 74* (FURB).

Octomeria pusilla Lindl., Companion Bot. Mag. 2: 354. 1837.*

Octomeria umbonulata Schltr., Repert. Spec. Nov. Regni Veg. Beih. 35: 67. 1925.

Habit and habitat: Epiphyte; anthropic area (pasture).

Voucher: *Caetano & Schlemper 196* (spirit, FURB).

Octomeria warmingii Rchb.f., Otia Bot. Hamburg.: 94. 1881 (Fig. 7).

Octomeria oxychela Barb.Rodr., Gen. Spec. Orchid. 2: 99. 1881.

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano 52* (FURB).

Ornithocephalus Hook.

Ornithocephalus myrticola Lindl., Ann. Nat. Hist. 4(26): 383. 1840 (Fig. 7).

Habit and habitat: Epiphyte; riparian forest.

Vouchers: *Caetano s.n.* (FURB 37875); *Royer 114* (UPCB).

Pabstiella Brieger & Senghas

Pabstiella bicolor (Barb.Rodr.) Luer & Toscano, Harvard Pap. Bot. 16(2): 380. 2011. [Luer & Toscano de Brito 2011].*

Lepanthes bicolor Barb.Rodr., Gen. Spec. Orchid. 2: 49. 1881.

Pleurothallis bicolor (Barb.Rodr.) Cogn. in Mart., Fl. Bras. 3(4): 408. 1896, *nom. illeg.*

Trichosalpinx bicolor (Barb.Rodr.) Luer, Phytologia 54(5): 394. 1983.

Lepanthes quadridentata Barb.Rodr., Gen. Spec. Orchid. 2: 50. 1881.

Pleurothallis quadridentata (Barb.Rodr.) Cogn. in Mart., Fl. Bras. 3(4): 454. 1896.

Trichosalpinx quadridentata (Barb.Rodr.) Luer, Phytologia 54(5): 397. 1983.

Specklinia quadridentata (Barb.Rodr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 263. 2004.

Pabstiella quadridentata (Barb.Rodr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 112: 120. 2007.

Pleurothallis mouraei Cogn. in Mart., Fl. Bras. 3(4): 580. 1896.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano s.n.* (FURB 38759).

Pabstiella bradei (Schltr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 112: 119. 2007.*

Pleurothallis bradei Schltr., Anexos Mem. Inst. Butantan, Secç. Bot. 1(4): 41. 1922.

Trichosalpinx bradei (Schltr.) Luer, Phytologia 54(5): 394. 1983.

Specklinia bradei (Lindl.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 259. 2004.

HABIT AND HABITAT: Epiphyte; forest interior.

VOUCHER: *Klein & Bresolin 10883* (FLOR).

Pabstiella carinifera (Barb.Rodr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 112: 119. 2007.* **[VU]**

Lepanthes carinifera Barb.Rodr., Rev. Engenh. 3(8): 110. 1881.

Pleurothallis carinifera (Barb.Rodr.) Cogn. in Mart., Fl. Bras. 3(4): 584. 1896.

Trichosalpinx carinifera (Barb.Rodr.) Luer, Phytologia 54(5): 394. 1983.

Specklinia carinifera (Barb.Rodr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 259. 2004.

HABIT AND HABITAT: Epiphyte; riparian forest, forest interior.

VOUCHERS: *Schmitt et al. 1747* (FURB); *Caetano s.n.* (FURB 37332).

Pabstiella fusca (Lindl.) Chiron & Xim.Bols., Richardiana 10(2): 56. 2010.*

Pleurothallis fusca Lindl., Companion Bot. Mag. 2: 354. 1837.

Effusiella fusca (Lindl.) Campacci, Colet. Orquídeas Brasil. 9: 337. 2011.

Pleurothallis hypnicola Lindl., Edwards's Bot. Reg. 28(Misc.): 75. 1842.

Humboltia hypnicola (Lindl.) Kuntze, Revis. Gen. Pl. 2: 667. 1891.

Specklinia hypnicola (Lindl.) F.Barros, Hoehnea 10: 110. 1984.

Stelis hypnicola (Lindl.) Pridgeon & M.W.Chase, Lindleyana 16(4): 263. 2001.

Pabstiella hypnicola (Lindl.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 112: 120. 2007.

Effusiella hypnicola (Lindl.) Campacci, Colet. Orquídeas Brasil. 9: 338. 2011.

HABIT AND HABITAT: Epiphyte; riparian forest, forest interior.

VOUCHERS: *Klein & Bresolin 10884* (FLOR); *Schmitt et al. 509* (FURB); *Schmitt et al. 522* (FURB); *Schmitt et al. 1775* (FURB); *Schmitt et al. 1803* (FURB); *Korte & Kniess 988* (FURB); *Caetano 184* (spirit, FURB).

Pabstiella matinhensis (Hoehne) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 112: 120. 2007.

Pleurothallis matinhensis Hoehne, Arq. Bot. Estado São Paulo, n.s. 1(1): 13. 1938.

Trichosalpinx matinhensis (Hoehne) Luer, Phytologia 54(5): 396. 1983.

Specklinia matinhensis (Hoehne) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 262. 2004.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano s.n.* (FURB 38877).

Pabstiella mirabilis (Schltr.) Brieger & Senghas, Orchidee (Hamburg) 27(5): 195. 1976.*

Pleurothallis mirabilis Schltr., Notizbl. Bot. Gart. Berlin-Dahlem 7(66): 274. 1918.

Anthereon mirabilis (Schltr.) Pridgeon & M.W.Chase, Lindleyana 16(4): 252. 2001.

Specklinia mirabilis (Schltr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 262. 2004.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano s.n.* (FURB 36258).

Pabstiella parvifolia (Lindl.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 105: 139. 2006.

Pleurothallis parvifolia Lindl., Companion Bot. Mag. 2: 355. 1837.

Humboltia parvifolia (Lindl.) Kuntze, Revis. Gen. Pl. 2: 668. 1891.

Specklinia parvifolia (Lindl.) Pridgeon & M.W.Chase, Lindleyana 16(4): 258. 2001.

HABIT AND HABITAT: Epiphyte; forest interior.

VOUCHER: *Caetano 215* (spirit, FURB).

Pabstiella punctatifolia (Barb.Rodr.) Chiron, Phytotaxa 46: 55. 2012.*

Lepanthes punctatifolia Barb.Rodr., Gen. Spec. Orchid. 2: 55. 1881.

Pleurothallis punctatifolia (Barb.Rodr.) Pabst, Orquídea (Rio de Janeiro) 28: 227. 1966.

Trichosalpinx punctatifolia (Barb.Rodr.) Luer, Phytologia 54(5): 397. 1983.

Specklinia punctatifolia (Barb.Rodr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 263. 2004.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 58* (FURB).

Pabstiella rubrolineata (Hoehne) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 112: 120. 2007.*

Pleurothallis rubrolineata Hoehne, Bol. Agric. (São Paulo) 34: 609. 1934.

Specklinia rubrolineata (Hoehne) F.Barros, Hoehnea 10: 110. 1984.

HABIT AND HABITAT: Epiphyte; anthropic area (pasture).

VOUCHER: *Caetano & Almeida 208* (spirit, FURB).

Pabstiella seriata (Lindl.) Luer & Toscano, Harvard Pap. Bot. 16(2): 381. 2011.

Pleurothallis seriata Lindl., Edwards's Bot. Reg. 26(Misc.): 75. 1840.

Humboltia seriata (Lindl.) Kuntze, Revis. Gen. Pl. 2: 668. 1891.

Specklinia seriata (Lindl.) Pridgeon & M.W.Chase, Lindleyana 16(4): 259. 2001.

Panmorphia seriata (Lindl.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 105: 174. 2006.

Anathallis seriata (Lindl.) Luer & Toscano, Monogr. Syst. Bot. Missouri Bot. Gard. 115: 259. 2009.

Effusiella seriata (Lindl.) Baptista, Colet. Orquídeas Brasil. 9: 339. 2011.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 219* (spirit, FURB).

Pabstiella stictophylla (Schltr.) J.Caetano & L.R.S.Guim., ***comb. nov.****

Basionym: *Pleurothallis stictophylla* Schltr., Repert. Spec. Nov. Regni Veg. 23: 43. 1926; descr. emend. Hoehne, Bol. Agric. (São Paulo) 34: 608. 1934 ("1933").

Trichosalpinx stictophylla (Schltr.) Luer, Phytologia 54(5): 397. 1983.

Specklinia stictophylla (Schltr.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 264. 2004.

TYPE: Brazil: Paraná, Porto de Cima, *Hatschbach 89* (holotype B†). **Lectotype designated here:** original illustration of the flower analysis sketched by Schlechter and posthumously published by Mansfeld (1930: t. 36, nº. 143!) (Fig. 8).

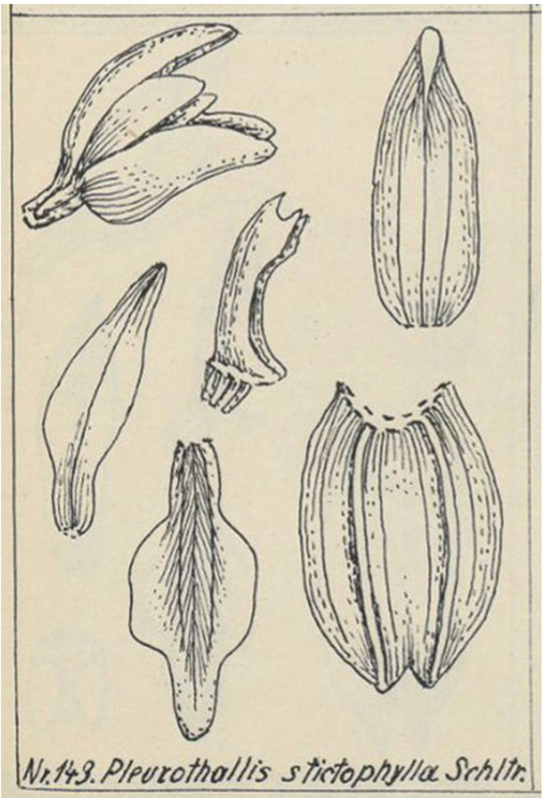


FIGURE 8. *Pabstiella stictophylla*. Lectotype of *Pleurothallis stictophylla*: original illustration in Mansfeld (1930: t. 36, nº. 143).

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Bresolin & Roco 696* (FLOR).

The description of the protologue, the emended description and the examination of the illustration of *Pleurothallis stictophylla* in Hoehne (1933) shows that this plant is clearly a species of *Pabstiella*, and thus this combination is needed. The study of many tropical orchids is severely hampered by the loss of all the holotypes of Schlechter's species due to the bombing of the Berlin Herbarium during the World War II (Merrill 1943, Butzin 1978, 1981, Hiepko 1987). Luckily, an original illustration in Mansfeld's work is available and can be used as taxonomic reference.

Pabstiella trifida (Lindl.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 112: 120. 2007 (Fig. 9).

Pleurothallis trifida Lindl., Edwards's Bot. Reg. 28(Misc.): 82. 1842.

FIGURE 9. From top left to bottom right: *Pabstiella trifida. Platyrhiza quadricolor. Prescottia densiflora. Promenaea rollissonii. Prosthechea glumacea. Sauroglossum elatum. Scaphyglottis modesta. Specklinia grobyi. Stelis megantha. S. montserratii. S. papaquerensis. S. sclerophylla. Warmingia eugenii. Xylobium variegatum. Zootrophion atropurpureum. Zygopetalum maxillare.* All courtesy of The Field Museum, Chicago.

Humboltia trifida (Lindl.) Kuntze, Revis. Gen. Pl. 2: 668. 1891.

Specklinia trifida (Lindl.) F.Barros, Orchid Memories: 19. 2004.

Habit and habitat: Epiphyte; riparian forest, forest interior.

Vouchers: *Schmitt et al. 516* (FURB); *Caetano s.n.* (FURB 38758).

Pabstiella uniflora (Lindl.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 112: 121. 2007.

Pleurothallis uniflora Lindl., Companion Bot. Mag. 2(24): 355. 1837.

Humboltia uniflora (Lindl.) Kuntze, Revis. Gen. Pl. 2: 668. 1891.

Specklinia uniflora (Lindl.) Pridgeon & M.W.Chase, Lindleyana 16(4): 259. 2001.

Pleurothallis leontoglossa Rchb.f., Linnaea 22: 831. 1849.

Humboltia leontoglossa (Rchb.f.) Kuntze, Revis. Gen. Pl. 2: 667. 1891.

Specklinia leontoglossa (Rchb.f.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 261. 2004.

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano 11* (FURB).

Pabstiella versicolor (Porsch) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 112: 121. 2007. [Toscano de Brito & Luer 2016].*

Pleurothallis versicolor Porsch, Oesterr. Bot. Z. 55: 155. 1905.

Pleurothallis podoglossa Hoehne, Arq. Bot. Estado São Paulo, n.s. 1(1): 12. 1938.

Trichosalpinx podoglossa (Hoehne) Luer, Phytologia 54(5): 396. 1983.

Specklinia podoglossa (Hoehne) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 263. 2004.

Pabstiella podoglossa (Hoehne) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 112: 120. 2007.

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano 179* (spirit, FURB).

PELEXIA Poit. ex Lindl.

Pelexia macropoda (Barb.Rodr.) Schltr., Beih. Bot. Centralbl. 37(2): 409. 1920.*

Spiranthes macropoda Barb.Rodr., Gen. Spec. Orchid. 1: 186. 1877.

Stenorrhynchos macropodum Barb.Rodr., Gen. Spec. Orchid. 1(Index): x. 1877.

Habit and habitat: Terrestrial; riparian forest.

Voucher: *Caetano et al. 195* (spirit, FURB).

PHYMATIDIUM Lindl.

Phymatidium aquinoi Schltr., Repert. Spec. Nov. Regni Veg. Beih. 35: 101. 1925.*

Habit and habitat: Epiphyte; anthropic area (pasture).

Voucher: *Caetano 217* (spirit, FURB).

Phymatidium delicatulum Lindl., Gen. Sp. Orchid. Pl.: 210. 1833 var. ***delicatulum***.

Phymatidium myrtophilum Barb.Rodr., Gen. Spec. Orchid. 2: 229. 1882.

Habit and habitat: Epiphyte; riparian forest.

Vouchers: *Caetano s.n.* (FURB 37790); *Caetano & Lenz 62* (FURB).

PLATYRHIZA Barb.Rodr.

Platyrhiza quadricolor Barb.Rodr., Gen. Spec. Orchid. 2: 231. 1882 (Fig. 9).*

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano s.n.* (FURB 39735).

PLATYSTELE Schltr.

Platystele oxyglossa (Schltr.) Garay, Orquideología 9(2): 120. 1974.

Pleurothallis oxyglossa Schltr., Repert. Spec. Nov. Regni Veg. 10: 354. 1912.

Habit and habitat: Epiphyte; riparian forest interior.

Vouchers: *Schmitt et al. 1812* (FURB); *Caetano s.n.* (FURB 38754).

POLYSTACHYA Hook.

Polystachya concreta (Jacq.) Garay & H.R.Sweet, Orquideología 9(3): 206. 1974.

Epidendrum concretum Jacq., Enum. Syst. Pl.: 30. 1760.

Habit and habitat: Epiphyte; anthropic area (pasture).

Voucher: *Caetano s.n.* (FURB 37806).

PRESCOTTIA Lindl.

Prescottia densiflora (Brongn.) Lindl., Ann. Mag. Nat. Hist. 6: 53. 1840 (Fig. 9).*

Decaisnea densiflora Brongn., Voy. Monde, Phan.: 192. 1829.

Habit and habitat: Terrestrial; forest edge.

Voucher: *Caetano s.n.* (FURB 39734).

Prescottia stachyodes (Sw.) Lindl., Edwards's Bot. Reg. 22: t. 1915. 1836.

Cranichis stachyodes Sw., Prodr.: 120. 1788.

Prescottia colorans Lindl., Edwards's Bot. Reg. 22: t. 1915. 1836.

HABIT AND HABITAT: Terrestrial; forest interior, forest edge (top of hill).

VOUCHERS: *Caetano 1* (FURB); *Caetano 38* (FURB).

PROMENAEA Lindl.

Promenaea rollissonii (Lindl.) Lindl., Edwards's Bot. Reg. 29(Misc.): 13. 1843 (Fig. 9).*

Maxillaria rollissonii Lindl., Edwards's Bot. Reg. 23: t. 1986. 1837.

Zygopetalum rollissonii (Lindl.) Rchb.f. in Walp., Ann. Bot. Syst. 6(5): 659. 1863.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 63* (FURB).

PROSTHECHEA Knowles & Westc.

Prosthechea bulbosa (Vell.) W.E.Higgins, Phytologia 82(5): 377. 1998 ("1997").

Epidendrum bulbosum Vell., Fl. Flumin. Icon. 9: t. 11. 1831.

Encyclia bulbosa (Vell.) Pabst, Orquídea (Rio de Janeiro) 29(6): 276. 1972.

Anacheilium bulbosum (Vell.) Withner & P.A.Harding, Cattleyas & Relatives: Debatable Epidendrums: 54. 2004.

HABIT AND HABITAT: Epiphyte; forest interior, anthropic area (pasture).

VOUCHERS: *Korte & Kniess 2110* (FURB); *Caetano & Schlemper 197* (spirit, FURB).

Prosthechea glumacea (Lindl.) W.E.Higgins, Phytologia 82(5): 378. 1998 ("1997") (Fig. 9).

Epidendrum glumaceum Lindl., Edwards's Bot. Reg. 25(Misc.): 38. 1839.

Hormidium glumaceum (Lindl.) Brieger, Publ. Ci. Inst. Genét. Esc. Super. Agric. Luiz de Queiroz 1: 19. 1960.

Encyclia glumacea (Lindl.) Pabst, Orquídea (Rio de Janeiro) 29(6): 276. 1972.

Anacheilium glumaceum (Lindl.) Pabst, Moutinho & A.V.Pinto, Bradea 3(23): 183. 1981.

Epidendrum almasyi Hoehne, Arq. Bot. Estado São Paulo, n.s. 2: 84. 1947.

Hormidium almasyi (Lindl.) Brieger, Publ. Ci. Inst. Genét. Esc. Super. Agric. Luiz de Queiroz 1: 19. 1960.

Encyclia almasii (Lindl.) Pabst, Orquídea (Rio de Janeiro) 29(6): 276. 1972.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHERS: *Klein & Bresolin 10888* (FLOR, ICN); *Caetano s.n.* (FURB 40571).

Prosthechea vespa (Vell.) W.E.Higgins, Phytologia 82(5): 381. 1998 ("1997").*

Epidendrum vespa Vell., Fl. Flumin. Icon. 9: t. 27. 1831.

Encyclia vespa (Vell.) Dressler, Phytologia 21(7): 441. 1971.

Anacheilium vespa (Vell.) Pabst, Moutinho & A.V.Pinto, Bradea 3(23): 184. 1981.

HABIT AND HABITAT: Epiphyte; forest interior.

VOUCHER: *Caetano 216* (spirit, FURB).

PSILOCHILUS Barb.Rodr.

Psilochilus modestus Barb.Rodr., Gen. Spec. Orchid. 2: 273. 1882.

Pogonia modesta (Barb.Rodr.) Cogn. in Mart., Fl. Bras. 3(4): 133. 1893.

HABIT AND HABITAT: Terrestrial; riparian forest.

VOUCHER: *Caetano & Almeida 223* (spirit, FURB).

RODRIGUEZIA Ruiz & Pav.

Rodriguezia bracteata (Vell.) Hoehne, Arq. Bot. Estado São Paulo, n.s. 2: 143. 1952.*

Epidendrum bracteatum Vell., Fl. Flumin. Icon. 9: t. 16. 1831.

HABIT AND HABITAT: Epiphyte; anthropic area (pasture).

VOUCHER: *Caetano 209* (spirit, FURB).

Rodriguezia decora (Lem.) Rchb.f., Bot. Zeitung (Berlin) 10: 771. 1852.

Burlingtonia decora Lem., Jard. Fleur. 2(Misc.): 96. 1852.

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano 15* (FURB).

SACOILA Raf.

Sacoila lanceolata (Aubl.) Garay, Bot. Mus. Leafl. 28(4): 352. 9182 ("1980").

Limodorum lanceolatum Aubl., Hist. Pl. Guiane 2: 821. 1775.

Neottia lanceolata (Aubl.) Willd., Sp. Pl., ed. 4, 4(1): 73. 1805.

Stenorrhynchos lanceolatum (Aubl.) Rich., De Orchid. Eur.: 37. 1817.

Spiranthes lanceolata (Aubl.) León, Contr. Ocas. Mus. Hist. Nat. Colegio "De La Salle" 8: 358. 1946.

Serapias coccinea Vell., Fl. Flumin. 9: t. 48. 1831.

Stenorrhynchos coccineum (Vell.) Hoehne, Arq. Bot. Estado São Paulo, n.s. 2: 146. 1952.

Habit and habitat: Terrestrial; open area (forest regeneration).

Voucher: *Caetano & Schlemper 41* (FURB).

Sauroglossum Lindl.

Sauroglossum elatum Lindl., Edwards's Bot. Reg. 19: t. 1618. 1833 (Fig. 9).

Habit and habitat: Terrestrial; forest interior.

Voucher: *Caetano s.n.* (FURB 38761).

Scaphyglottis Poepp. & Endl.

Scaphyglottis modesta (Rchb.f.) Schltr., Repert. Spec. Nov. Regni Veg. 23: 46. 1926 (Fig. 9).

Tetragamestus modestus Rchb.f., Bonplandia 2(2): 21. 1854.

Ponera modesta (Rchb.f.) Rchb.f., Linnaea 41: 85. 1876.

Habit and habitat: Epiphyte; riparian forest interior.

Voucher: *Caetano s.n.* (FURB 36927).

Specklinia Lindl.

Specklinia grobyi (Bateman ex Lindl.) F.Barros, Hoehnea 10: 110. 1984 (Fig. 9).

Pleurothallis grobyi Bateman ex Lindl., Edwards's Bot. Reg. 21: t. 1797. 1835.

Humboltia grobyi (Bateman ex Lindl.) Kuntze, Revis. Gen. Pl. 2: 667. 1891.

Habit and habitat: Epiphyte; forest interior, riparian forest.

Vouchers: *Bresolin 666* (CGMS, FLOR); *Korte & Kniess 2115* (FURB); *Schmitt et al. 1743* (FURB); *Caetano 178* (spirit, FURB).

Stanhopea J.Frost ex Hook.

Stanhopea lietzei (Regel) Schltr., Arch. Bot. São Paulo 1: 264. 1926.*

Stanhopea graveolens var. *lietzei* Regel, Gartenflora 40(8): 201. 1891.

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano 191* (spirit, FURB).

Stelis Sw.

Stelis argentata Lindl., Edwards's Bot. Reg. 28(Misc.): 64. 1842.

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano 180* (spirit, FURB).

Stelis ciliaris Lindl., Companion Bot. Mag. 2: 353. 1837. [Ignowski *et al.* 2015].

Apatostelis ciliaris (Lindl.) Garay, Bot. Mus. Leafl. 27(7–9): 188. 1979.

Stelis leinigii Pabst, Orquídea (Rio de Janeiro) 29: 7. 1967.

Habit and habitat: Epiphyte; riparian forest.

Vouchers: *Caetano s.n.* (FURB 37339); *Caetano 22* (FURB).

Stelis deregularis Barb.Rodr., Gen. Spec. Orchid. 2: 94. 1882.

Physosiphon deregularis (Barb.Rodr.) Cogn. in Mart., Fl. Bras. 3(4): 341. 1896.

Pseudostelis deregularis (Barb.Rodr.) Schltr., Anexos Mem. Inst. Butantan, Secç. Bot. 1(4): 38. 1922.

Pleurothallis deregularis (Barb.Rodr.) Luer, Selbyana 2(4): 385. 1978.

Physosiphon spiralis Lindl., Edwards's Bot. Reg. 21: t. 1797. 1835.

Pseudostelis spiralis (Lindl.) Schltr., Anexos Mem. Inst. Butantan, Secç. Bot. 1(4): 38. 1922.

Habit and habitat: Epiphyte; anthropic area (urban area).

Voucher: *Caetano 13* (FURB).

Stelis intermedia Poepp. & Endl., Nov. Gen. Sp. Pl. 1: 46. 1836.

Habit and habitat: Epiphyte; forest interior.

Voucher: *Schmitt et al. 1774* (FURB).

Stelis megantha Barb.Rodr., Gen. Spec. Orchid. 2: 83. 1881 (Fig. 9).*

Stelis macrochlamys Hoehne & Schltr., Arch. Bot. São Paulo 1: 204. 1926.

Habit and habitat: Epiphyte; riparian forest.

Voucher: *Caetano & Henschel 40* (FURB).

Stelis montserratii (Porsch) Karremans, Lankesteriana 13(3): 329. 2014. [Karremans 2014] (Fig. 9).

Pleurothallis montserratii Porsch, Oesterr. Bot. Z. 55: 158. 1905.

Pleurothallis rubens Lindl., Edwards's Bot. Reg. 21: t. 1797. 1835.

Humboltia rubens (Lindl.) Kuntze, Revis. Gen. Pl. 2: 668. 1891.

Specklinia rubens (Lindl.) F.Barros, Hoehnea 10: 110. 1984.
Anathallis rubens (Lindl.) Pridgeon & M.W.Chase, Lindleyana 16(4): 250. 2001.
Stelis neorubens Chiron, Phytotaxa 46: 55. 2012.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano 186* (spirit, FURB).

Stelis papaquerensis Rchb.f., Linnaea 22: 822. 1850 (Fig. 9).
Stelis porschiana Schltr., Notizbl. Bot. Gart. Berlin-Dahlem 7: 270. 1917.
Stelis inaequisepala Hoehne & Schltr., Anexos Mem. Inst. Butantan, Secç. Bot. 1(2): 30. 1921.
Stelis juergensii Schltr., Repert. Spec. Nov. Regni Veg. Beih. 35: 49. 1925.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHERS: *Bresolin 662* (FLOR); *Caetano 34* (FURB).

Stelis sclerophylla (Lindl.) Karremans, Lankesteriana 13(3): 330. 2014 (Fig. 9).
Pleurothallis sclerophylla Lindl., Edwards's Bot. Reg. 21: t. 1797. 1835.
Humboltia sclerophylla (Lindl.) Kuntze, Revis. Gen. Pl. 2: 668. 1891.
Anathallis sclerophylla (Lindl.) Pridgeon & M.W.Chase, Lindleyana 16(4): 250. 2001.
Specklinia sclerophylla (Lindl.) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 263. 2004.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano 66* (FURB).

TRICHOCENTRUM Poepp. & Endl.

Trichocentrum pumilum (Lindl.) M.W.Chase & N.H.Williams, Lindleyana 16(2): 138. 2001.
Oncidium pumilum Lindl., Bot. Reg. 11: t. 920. 1825.
Lophiaris pumila (Lindl.) Braem, Schlechteriana 4(1–2): 21. 1993.
Lophiarella pumila (Lindl.) Szlach., Mytnik & Romowicz, Polish Bot. J. 51(1): 54. 2006.
HABIT AND HABITAT: Epiphyte; anthropic area (pasture).
VOUCHER: *Caetano 182* (spirit, FURB).

TRICHOSALPINX Luer

Trichosalpinx montana (Barb.Rodr.) Luer, Phytologia 54(5): 396. 1983.*****
Lepanthes montana Barb.Rodr., Gen. Spec. Orchid. 1: 22. 1877.
Pleurothallis lepanthipoda Hoehne & Schltr., Arch. Bot. São Paulo 1: 218. 1926.
HABIT AND HABITAT: Epiphyte; forest interior.
VOUCHER: *Caetano 214* (spirit, FURB).

TRIZEUXIS Lindl.

Trizeuxis falcata Lindl., Coll. Bot.: t. 2. 1821.
HABIT AND HABITAT: Epiphyte; forest interior, forest edge.
VOUCHERS: *Caetano 4* (FURB); *Caetano s.n.* (FURB 36630).

WARMINGIA Rchb.f.

Warmingia eugenii Rchb.f., Otia Bot. Hamburg.: 87. 1881 (Fig. 9).
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano 14* (FURB).

XYLOBIUM Lindl.

Xylobium variegatum (Ruiz & Pav.) Garay & Dunst., Venez. Orchids Ill. 2: 342. 1961 (Fig. 9).
Maxillaria variegata Ruiz & Pav., Syst. Veg. Fl. Peruv. Chil. 1: 222. 1798.
Dendrobium variegatum (Ruiz & Pav.) Pers., Syn. Pl. 2(2): 524. 1807.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano 79* (FURB).

ZOOTROPHION Luer

Zootrophion atropurpureum (Lindl.) Luer, Selbyana 7(1): 80. 1982 (Fig. 9).
Specklinia atropurpurea Lindl., Edwards's Bot. Reg. 21: t. 1797. 1835.
Pleurothallis atropurpurea (Lindl.) Lindl., Edwards's Bot. Reg. 28(Misc.): 81. 1842.
Cryptophoranthus atropurpureus (Lindl.) Rolfe, Gard. Chron., ser. 3, 2: 693. 1887.
Humboltia atropurpurea (Lindl.) Kuntze, Revis. Gen. Pl. 2: 667. 1891.
HABIT AND HABITAT: Epiphyte; riparian forest.
VOUCHER: *Caetano s.n.* (FURB 37960).

ZYGOPETALUM Hook.

Zygopetalum crinitum G.Lodd., Bot. Cab. 17: t. 1687. 1831.*****
HABIT AND HABITAT: Epiphyte; forest interior.
VOUCHERS: *Schmitt et al. 526* (FURB, UPCB).

Zygopetalum maxillare G.Lodd., Bot. Cab. 18: t. 1776. 1832 (Fig. 9).

HABIT AND HABITAT: Epiphyte; forest interior (riparian forest).

VOUCHER: *Caetano & Schlemper 24* (FURB).

ZYGOSTATES Lindl.

Zygostates pellucida Rchb.f. in Walp., Ann. Bot. Syst. 6(4): 564. 1863.*

HABIT AND HABITAT: Epiphyte; riparian forest.

VOUCHER: *Caetano s.n.* (FURB 37914).

ACKNOWLEDGMENTS. We thank Dr. Fabio de Barros (IBt) for the identification of some species, Dr Eric C. Smidt (UFPR) for taxonomic information on *Stelis*, and Dr Climbiê F. Hall (MPEG) for suggestions and review the English text. LRSG thanks the São Paulo Research Foundation (FAPESP, process 2010/16353-1) for the assistance in the field incursions.

LITERATURE CITED

Abreu, N. L., Menini Neto, L. & Kuono, T. U. P. (2011). Orchidaceae das Serras Negra e do Funil, Rio Preto, Minas Gerais, e similaridade florística entre formações campestres e florestais do Brasil. *Acta Botanica Brasilica*, 25(1), 58–70. doi: http://dx.doi.org/10.1590/S0102-33062011000100009

Alvares, C. A., Stape, J. L., Sentelhas, P. C., Gonçalves, J. L. M. & Sparovek, G. (2013). Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift*, 22(6), 711–728. doi: http://dx.doi.org/10.1127/0941-2948/2013/0507

Barros, F. (1983). Flora fanerogâmica da reserva do Parque Estadual das Fontes do Ipiranga (São Paulo, Brasil.). 198 – Orchidaceae. *Hoehnea*, 10, 74–124.

BFG (The Brazil Flora Group). (2015). Growing knowledge: an overview of Seed Plant diversity in Brazil. *Rodriguésia*, 66(4), 1085–1113. doi: http://dx.doi.org/10.1590/2175-7860201566411

Butzin, F. (1978). In Berlin vorhandene Typen von Schlechters Orchideenarten. *Willdenowia*, 8, 401–407.

Butzin, F. (1981). Typenstudien im Berliner Orchideen-Herbar: Diverse markierte Typen. *Willdenowia*, 11, 119–121.

Caetano, J. O. & Guimarães, L. R. S. (2013). A família Orchidaceae no município de Benedito Novo, Santa Catarina. *Boletim CAOB*, 89, 3–11.

Caetano, J. O., Schlemper, C. R., Henschel, S. & Guimarães, L. R. S. (2013). A família Orchidaceae no município de Benedito Novo, Santa Catarina II: Adições e correções. *Boletim CAOB*, 91, 90–95.

Catharino, E. L. M. & Barros, F. (2004). Orquídeas do Maciço da Juréia e arredores. In: O. A. V. Marques & W. Duleba (Eds.). *Estação Ecológica Juréia-Itatins: ambiente físico, flora e fauna* (pp. 152–161). Ribeirão Preto, SP: Holos.

Chase, M. W., Cameron, K. M., Freudenstein, J. V., Pridgeon, A. M., Salazar, G., van den Berg. C. & Schuiteman, A. (2015). An updated classification of Orchidaceae. *Botanical Journal of the Linnean Society*, 177(2), 151–174. doi: http://dx.doi.org/10.1111/boj.12234

Climate-Data.org (2016). Climate: Benedito Novo. In: Climate-Data.org / AmbiWeb GmbH. Gernsbach. Recovered from http://en.climate-data.org/location/43739/ (accessed 19 August 2016).

Favretto, M. A. & Geuster, C. J. (2011). *Orquídeas e bromélias do Vale do Rio do Peixe, Santa Catarina*. Joaçaba, SC: Clube de Autores Publicações S/A.

Filgueiras, T. S., Nogueira, P. E., Brochado, A. L. & Guala II, G. F. (1994). Caminhamento: um método expedito para levantamentos florísticos qualitativos. *Cadernos de Geociências*, 12, 39–43.

Flora do Brasil 2020 (2016). Rio de Janeiro: Jardim Botânico do Rio de Janeiro. Recovered from http://floradobrasil.jbrj.gov.br/ (accessed 11 October 2016).

Fraga, C. N. & Peixoto, A. L. (2004). Florística e ecologia das Orchidaceae das restingas do estado do Espírito Santo. *Rodriguésia*, 55(84), 5–20.

Fundação SOS Mata Atlântica & INPE. (2011). *Atlas dos remanescentes florestais da Mata Atlântica período 2008–2010*. São Paulo: Fundação SOS Mata Atlântica/Instituto Nacional de Pesquisas Espaciais.

Govaerts, R., Bernet, P., Kratochvil, K., Gerlach, G., Carr, G., Alrich, P., Pridgeon, A. M., Pfahl, J., Campacci, M. A., Baptista, D. H., Tigges, H., Shaw, J., Cribb, P. J., George, A., Kreuz, K. & Wood, J. (2015). *World Checklist of Orchidaceae*. Kew: Royal Botanic Gardens. Recuperado de http://apps.kew.org/wcsp/ (accessed 14 August 2016).

Guimarães, L. R. S., Caetano, J. O., Schlemper, C. R., Couto, C. C. M. & Nascimento, M. V. (2016). Novelties in Orchidaceae from the State of Santa Catarina, Brazil. *Richardiana*, 16, 249–257.

Hatschbach, G. G. & Ziller, S. R. (1995). *Lista vermelha de plantas ameaçadas de extinção no estado do Paraná*. Curitiba: SEMA/GTZ.

Hiepko, P. (1987). The collections of the Botanical Museum Berlin-Dahlem (B) and their history. *Englera*, 7, 219–252.

Hoehne, F. C. (1933). Contribuições para o conhecimento da flora orchidologica brasilica III. *Boletim de Agricultura (São Paulo)*, 34, 600–638.

Ignowski, H., Toscano de Brito, A. L. V., Bona, C. & Smidt, E. C. (2015). Nomenclatural notes on *Stelis ciliaris* (Pleurothallidinae, Orchidaceae). *Phytotaxa*, 218(1), 30–38. doi: http://dx.doi.org/10.11646/phytotaxa.218.1.2

Karremans, A. P. (2014). *Lankesteriana*, a new genus in the Pleurothallidinae (Orchidaceae). *Lankesteriana*, 13(3), 319–332. http://dx.doi.org/10.15517/lank.v13i3.14368

Klein, R. M. (1979). Ecologia da flora e vegetação do Vale do Itajaí. *Sellowia*, 31(1), 1–164.

Klein, R. M., Bresolin, A. & Reis, A. (1977/1978). Distribuição de orquídeas da Ilha de Santa Catarina e arredores. *Insula*, 9(1), 4–29.

Kollmann, L. J. C., Fontana, A. P., Simonelli, M. & Fraga, C. N. (2007). As Angiospermas ameaçadas de extinção no Estado do Espírito Santo. In: M. Simonelli & C. N. Fraga (Orgs). *Espécies da flora ameaçadas de extinção no Estado do Espírito Santo* (pp. 105–137). Vitória: Ipema.

Köppen, W. (1936). Das geographische System der Klimate. In: W. R. Köppen & R. Geiger (Eds.). *Handbuch der Klimatologie. Volume I, Part C* (pp. 1–44). Berlin: Gebrüder Bornträger.

Lenzi, M., Matos, J. Z., Fraga, A. M. & Crespo, M. B. (2015). Orchids of the State Park of Serra do Tabuleiro, Southern Brazil. *Anales del Jardín Botánico de Madrid*, 72(2), e020. doi: http://dx.doi.org/10.3989/ajbm.2345

Leoni, L. S. (1992). Lista das plantas vasculares do Parque Estadual da Serra do Brigadeiro, Minas Gerais. *Pabstia*, 3, 1–13.

Leoni, L. S. (1997). Catálogo preliminar das fanerógamas ocorrentes no Parque Nacional do Caparaó – MG. *Pabstia*, 8(2), 1–28.

Luer, C. A. & Toscano de Brito, A. L. V. (2011). Miscellaneous new species and combinations in the Pleurothallidinae (Orchidaceae) from Brazil and Argentina. *Harvard Papers in Botany*, 16(2), 361–382. doi: http://dx.doi.org/10.3100/0.25.016.0207

Mamede, M. C. H., Souza, V. C., Prado, J., Barros, F., Wanderley, M. G. L. & Rando, J. G. (Orgs.). (2007). *Livro vermelho das espécies vegetais ameaçadas do Estado de São Paulo*. São Paulo: Instituto de Botânica.

Mansfeld, R. (1930). Blütenanalysen neuer Orchideen von R. Schlechter (†). I. Südamerikanische Orchideen. *Repertorium specierum novarum regni vegetabilis; Beihefte*, 58, 1–7, t. 1–60.

Menini Neto, L., Almeida, V. R. & Forzza, R. C. (2004). A família Orchidaceae na Reserva Biológica da Represa do Grama – Descoberto, Minas Gerais, Brasil. *Rodriguésia*, 55(84), 137–156.

Menini Neto, L., Barros, F., Vinhos, F., Furtado, S. G., Judice, D. M., Fernandez, E. P., Sfair, J. C., Barros, F. S. M., Prieto, P. V., Kutschenko, D. C., Moraes, M. A., Zanata, M. R. V. & Santos Filho, L. A. F. (2013). Orchidaceae. In: G. Martinelli & M. A. Moraes (Eds.). *Livro vermelho da flora do Brasil* (pp. 749–818). Rio de Janeiro: Instituto de Pesquisas Jardim Botânico do Rio de Janeiro.

Merrill, E. D. (1943). Destruction of the Berlin Herbarium. *Science*, 3, 490–491. doi: http://dx.doi.org/10.1126/science.98.2553.490

Mittermeier, R. A., Gil, P. G., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C. G., Lamoreux, J. & Fonseca, G. A. B. (2004). *Hotspots Revisited: Earth's biologically richest and most endangered terrestrial ecoregions*. Mexico City: CEMEX.

Mori, S. A., Mattos-Silva, L. A., Lisboa, G. & Coradin, L. (1985). *Manual de Manejo do Herbário Fanerogâmico*. Ilhéus, BA: CEPLAC/CEPEC.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Fonseca, G. A. B. & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, 403, 853–858. doi: http://dx.doi.org/10.1038/35002501

Pabst, G. F. J. (1951). Contribuição para o conhecimento das orquídeas de Santa Catarina e sua dispersão geográfica I. *Anais Botânicos do Herbário "Barbosa Rodrigues"*, 3, 41–53.

Pabst, G. F. J. (1952). Contribuição para o conhecimento das orquídeas de Santa Catarina e sua dispersão geográfica I (continuação). *Anais Botânicos do Herbário "Barbosa Rodrigues"*, 4, 69–86.

Pabst, G. F. J. (1953). Contribuição para o conhecimento das orquídeas de Santa Catarina e sua dispersão geográfica I (conclusão). *Anais Botânicos do Herbário "Barbosa Rodrigues"*, 5, 39–93.

Pabst, G. F. J. (1954). Contribuição para o conhecimento das orquídeas de Santa Catarina e sua dispersão geográfica II. *Sellowia*, 6, 181–197.

Pabst, G. F. J. (1956). Contribuição para o conhecimento das orquídeas de Santa Catarina e sua dispersão geográfica III. *Sellowia*, 7/8, 175–181.

Pabst, G. F. J. (1957). Contribuição para o conhecimento das orquídeas de Santa Catarina e sua dispersão geográfica IV. *Sellowia*, 9, 249–256.

Pabst, G. F. J. (1959). Contribuição para o conhecimento das orquídeas de Santa Catarina e sua dispersão geográfica V. *Sellowia*, 10, 163–166.

Pansarin, E. R. & Pansarin, L. M. (2008). A família Orchidaceae na Serra do Japi, São Paulo, Brasil. *Rodriguésia*, 59(1), 99–111.

Pessoa, E. & Alves, M. (2015). Synopsis of Orchidaceae from Serra do Urubu: an area of montane forest, Pernambuco State, Brazil. *Hoehnea*, 42(1), 109–133.

doi: http://dx.doi.org/10.1590/2236-8906-35/2014

Ranta, P., Blom, T., Niemelä, J., Joensuu, E. & Siitonen, M. (1998). The fragmented Atlantic rain forest of Brazil: size, shape and distribution of forest fragments. *Biodiversity and Conservation*, 7(3), 385–403. doi: http://dx.doi.org/10.1023/A:1008885813543

Reis, A., Boeira, A. F., Dametto, A., Sanches, A. C., Souza, A. C., Neto, A. A. C., Neves, B. T., Longo, B. L., Barcellos, C. S., Perart, D., Freitas, D. M., Zech, D. F., Matos, E. P. M., Pansera, E. G., Marchioretto, L., Bileski, M. K. S., Machado, M. S. C., Heinz, M. K., Cury, R. K., Spuldaro, S. C., Quevedo, T. C., Zanotto, T. L. & Soboleski, V. F. (2011). Listas das espécies vegetais catarinenses da divisão Angiospermas. *Sellowia*, 56(63), 11–256.

Ribeiro, M. C., Metzger, J. P., Martensen, A. C., Ponzoni, F. J. & Hirota, M. M. (2009). The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation*, 142(6), 1144–1153. doi: http://dx.doi.org/10.1016/j.biocon.2009.02.021

Rio Grande do Sul. (2002). *Decreto estadual CONSEMA nº 42.099. Declara as espécies da flora nativa ameaçadas de extinção no estado do Rio Grande do Sul e da outras providências*. Conselho Estadual do Meio Ambiente. Palácio Piratini, Porto Alegre. 31 Dezembro 2002.

Rodrigues, V. T. & Barros, F. (2012). A família Orchidaceae da Serra do Itapeti. In: M. S. C. Morini & V. F. O. Miranda (Orgs.). *Serra do Itapeti: Aspectos históricos, sociais e naturalísticos* (pp. 127–141). Bauru, SP: Canal 6.

Rohr, J. A. (1951). Orquídeas. *Relatório do Colégio Catarinense*, s.n., 5–18.

Romanini, R. P. & Barros, F. (2007). Orchidaceae. In: M. M. R. F. Melo, F. Barros, S. A. C. Chiea, M. Kirizawa, S. L. Jung-Mendaçolli & M. G. L. Wanderley (Eds.). *Flora Fanerogâmica da Ilha do Cardoso, Volume 12* (pp. 29–275). São Paulo: Instituto de Botânica.

Siqueira, C. E., Zanin, A. & Menini Neto, L. (2014). Orchidaceae in Santa Catarina: update, geographic distribution and conservation. *Check List*, 10(6), 1452–1478. doi: http://dx.doi.org/10.15560/10.6.1452

Stehmann, J. R., Forzza, R.C., Sobral, M. & Kamino, L. H. Y. (2009). Gimnospermas e Angiospermas. In: J. R. Stehmann, R. C. Forzza, A. Salino, M. Sobral, D. P. Costa & L. H. Y. Kamino (Eds.). *Plantas da Floresta Atlântica* (pp. 27−37). Rio de Janeiro: Jardim Botânico do Rio de Janeiro.

Thiers, B. (2016). *Index Herbariorum: A global directory of public herbaria and associated staff*. New York Botanical Garden's Virtual Herbarium. Recovered from http://sweetgum.nybg.org/ih/ (accessed 7 July 2016).

Toscano de Brito, A. L. V. & Luer, C. A. (2015). New species and nomenclatural notes in the Pleurothallidinae (Orchidaceae) from Brazil. *Harvard Papers in Botany*, 20(1), 39–68. doi: http://dx.doi.org/10.3100/hpib.v20iss1.2015.n4

Toscano de Brito, A. L. V. & Luer, C. A. (2016). New species and nomenclatural notes in *Pabstiella* (Orchidaceae: Pleurothallidinae) from Brazil. *Lankesteriana*, 16(2), 153–185. doi: http://dx.doi.org/10.15517/lank.v16i2.25997

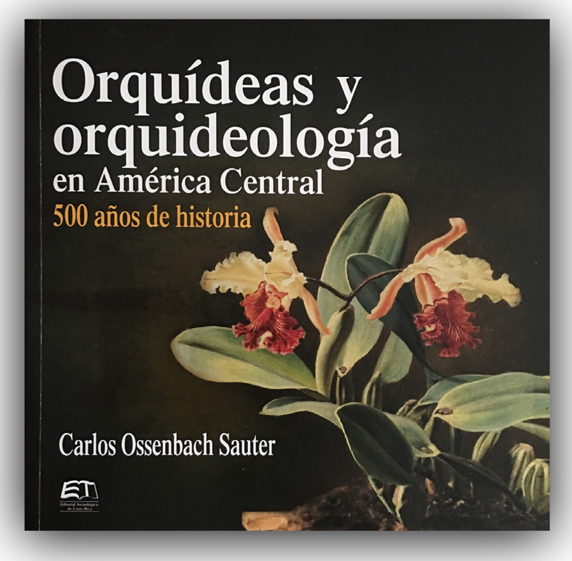
Vibrans, A. C., McRoberts, R. E., Lingner, D. V., Nicoletti, A. L. & Moser, P. (2012). Extensão original e atual da cobertura florestal de Santa Catarina. In: A. C. Vibrans, L. Sevegnani, A. L. Gasper & D. V. Lingner (Eds.). *Inventário Florístico Florestal de Santa Catarina. Volume 1: Diversidade e conservação dos remanescentes florestais* (pp. 65–76). Blumenau, SC: Edifurb.

Zandoná, L. R. & Catharino, E. L. M. (2015). Orchidaceae no Parque Estadual da Cantareira e sua conservação. *Revista do Instituto Florestal*, 27(1), 83–101. doi: http://dx.doi.org/10.4322/rif.2015.007

BOOK REVIEWS

Orquídeas y orquideología en América Central: 500 años de historia

Carlos Ossenbach Sauter. Editorial Teconológica de Costa Rica, Cartago. Primera edición, 2016. ISBN 978-9977-66-364-7, *in octavo* volume (21.5 × 21.5 cm), 624 pp., 273 illustrations in colour and black and white, paperbound. In Spanish. Available through the printer at editorial@itcr.ac.cr.



When, back in 2009, our journal published Carlos Ossenbach's *magnum opus* on the history of orchids in Central America (Ossenbach 2009), a tremendous amount of deeply researched information on virtually any individuals and institutions who collected and studied orchids in the region was revealed for the first time to the readers. Furthermore, Ossenbach framed their stories and activities into a general historical and economic perspective of the concerned region, which made the work of primary interest also for the historian and those scientist and enthusiast readers interested in the historical perspectives of plant exploration and collecting in the American tropics, and the history of biology as well. Made easy to browse by Indexes to "persons and institutions," and to "scientific and common names of plants", and completed by a rich iconographic support, *Orchids and orchidology in Central America: 500 years of history* quickly converted into a classic, and has been since quoted in virtually any scholar work devoted to the orchids of the American isthmus.

Now another public University in Costa Rica, the Tecnológico de Costa Rica, took the initiative through its press to made this fundamental work available also to the Spanish reader. In its elegant square format and substantial paperback binding, which is made up by classical fascicles giving to the book a feeling of solidity, the Spanish edition of the history of orchidology in Central America is further enriched by a great number of large illustrations (some of them full page), mostly in colour and mostly never published before, which far exceed those included in the original *Lankesteriana* edition. Orchid plants sketched by Thaddeus Hanke and plates prepared from the specimens collected by Louis Neé during the Malaspina's expedition to the Paciific (1789–1894), the orchid illustrations prepared in the course of Sessé and Mociño's Mexican expedition (1787–1803), portraits of famous and less famous collectors and travelers, engravings and paintings of early Central American landscapes, are worthy alone the price of this beautiful book.

As its English seebling, the volume stars defining the geographic and historic limits of the treatment, and giving short but useful insights on the political history of Central America, and the biodiversity and phytogeography of the isthmus. Then the body of the work is organized chronologically into four parts and eleven chapters, moving from pre hispanic times and running to seconf half of twentieth century (but excluding living individuals), in a sliding and intruiguing prose which would surely fascinate and absorbe the Spanish reader. In a timeline along which the author tells the story of the orchids in Central America tells us, he selected a series of important events related to the theme (which gives name to the chapters of the book) and subdivided each one in a few related stories. This approach resulted in 74 essays, which cover such different topics as the history of vanilla, the first Spanish scientific expeditions, the born and development of botanical gardens and orchid societies, national and international policies that had an impact on the development of a local botany, and biographic reviews of those individauls who took a part on the orchidology of Central America.

Las orquídeas en las culturas maya y azteca (Orchids in the cultures of Mayas and Aztecs), *El viaje de Thomas Gage por México* (The journey through Mexico of Thomas Gage), *John Lindley y el herbario de Lambert* (John Lindley and the Lambert herbarium), *La fiebre del oro en California y el canal intraoceánico* (The California gold rush and the interoceanic canal) *El Gabinete de Historia Natural de Guatemala* (The Cabinet of Natural History of Guatemala), *La conexión germano-belga* (The German-Belgian connection), *La comisión Científica Española al Pacífico* (The Spanish Scientific Commission to the Pacific), *La Estación Botánica de Belice* (The Botanical Station in Belize), *Costa Rica: los años de Doña Amparo* (Costa Rica: the years of 'doña' Amparo), *Henry Teuscher y el Jardín Botánico de Montreal* (Henry Teuscher and the Montreal Botanical Garden), *Clarence Klaus Horich: el útlimo aventurero* (Clarence Klaus Horich: the last of the adventurers), are just a few of the fascinating narratives, placed in the historical context of Central America and the entire American continent, showing how apparently distant and unrelated events (like the gold rush to California or the Mexican-American war) influenced and gave shape to the history of botanical exploration and the knowledge of orchids in the region.

On the front of workers, virtually no single collector, scientist or enlightened gardener who visited Central America escaped Ossenbach's attention, and the book represents a true encyclopedic work on the botany of the isthmian region.

For both the interested in a general view about the topic and the search of information onspecific details, the book is a "must have" for any avid Spanish reader of history, botany, and orchidology!

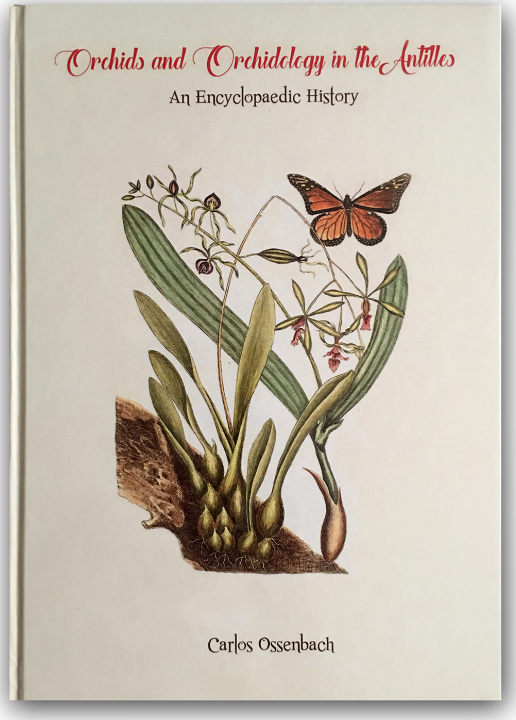
Franco Pupulin

LITERATURE CITED

Ossenbach, C. (2009). Orchids and orchidology in Central America: 500 years of history. Lankesteriana, 9, 1–268.

Orchids and Orchidology in the Antilles. An Encyclopedic History

Carlos Ossenbach. Koeltz Scientific Books, Oberreifenber, Germany, 2017. ISBN 978-3-946583-01-1, *in quarto* volume (30.5 × 22.0 cm), xxi, 723 pp., 352 illustrations in colour and black and white, numerous tables, hardbound. In English. Available through the printer, 228.00 Euro, ca.US$ 250.00.



This great and heavy book (it weights a few grams less than three kilograms!) is the logic continuation of the author's ongoing project, which began in 2009 with the publication of *Orchids and orchidology in Central America: 500 years of history* (Ossenbach 2009; for a review of the recently released Spanish edition, see this issue, pp. 105–106). And, to be true, it is a superb continuation of the work.

As the title itself promises, the book is a real encyclopedic treatment (the "Table of contents" alone occupies 21 pages) of the workers – pioneers, scientists, explorers, gardeners, conservationists, growers and experimenters, as well as their institutions – who revealed the orchid diversity of the Antillean islands and presented it to the world. As the author claims in the introduction to the book, "this work has become a difficult hybrid between a traditional historical narration and an encyclopaedic dictionary of persons and biographies". To which extent this hybrid succeded in its ambitious scope is perhaps best visualized by a synoptical table of 42 pages, enlisting chronologically the main publications on Antillean flora by 622 persons in a temporal arch extending from 1640 to 2015. Another 44 pages of bibliography testify to the amplitude, deepness and completeness of Ossenbach's effort as to the sources consulted and studied to shape the work.

The encyclopaedic character of the work does not detract from the fondness of the author in portraying the historical, cultural, and economic landscape of the West Indies and the Governments and scientific academies interested in their flora, as they changed and evolved through a five-centuries period. As Ossenbach previously did in his account on the orchid hunters in Central America, also in this book he organizes the facts relative to the discovery, use, commerce, study and conservation of orchids within the historical perspective not only of the Antiless, but of the countries that were involved in the "colonization" and exploitment of the West Indies. A useful chronological table (pp. 15–17) on the colonization of the Caribbean by European powers helps framing the narration within the historic events that gave shape to the actual political identity of the archipelago.

The book is chronologically arranged, covering the years from the landing of Columbus at Guanahani to the present days (differently from his work on Central American orchidology, the uthor insludes here also contemporary, living persons), but the narration is preceeded by a short review of the limited information available on the orchids in the life of the indigenous tribes that settled in the Antilles before the Spanish conquest. The main work is then organized in six parts: "From the Spanish Conquest to Carlos Linnaeus", "From the Age of Reason to Spain's 'Ominous Decade'", "The Golden Age of Antillean Orchidology", "The 'Imperial Era'", "From war to war (1914–1945)", "The seconf half of the XX century and the new Millennium". The first chapter also includes a few introductory pages with an overview of the geology, climate and vegetation in the Antillean region, as well as a note on Antillean orchid diversity. Two Appendixes ("Antillean orchidology and related botany: a timeline of travelers, plant collectors, botanists, and persons otherwise of interest to this story" and "The Antilleans islands and regions in the names of their orchids"), the Literature and the Acknowledgmets complete the book. Each one of the six chapters is then subdivided into main headings (I counted 62), under which are presented the narrations of individual and institutional biographies, as well as those prominent historical facts that affected the orchidology in the region.

The personal, free, and pleasant prose of the author immensely helps if following the *file-rouge* of a narration that spans over 475 years and an apparently endless series of actors who lived – and sometimes died – for plants and orchids.

The author has been very successful in showing how the history of orchidology in the Caribbaen profoundly differs from that of Central and South America, mainly due to the character of the respective actors. As the Antillean orchid flora lacks some of the showiest elements – like the species of *Cattleya*, *Odontoglossum*, *Masdevallia* – that the European orchid nurseries were mainly interested in, commercial collectors and true "orchid hunters" were almost absent from the Antillean scene. Botanists, but also horticulturists, who visited and traveled through the Caribbean islands during the last five centuries, rarely had material interests. Instead, the interest in the secrets of nature or in finding new ornaments for the King's gardens and the glory of their scientific societies, by the Plumiers, the Jacquins, the Swartzs, the joy of learning and transmitting their knowledge by people like Humboldt and Bonpland, Woodford and Lockhart, Knowles and Westcott, the love of science by Urban, Cogniaux, Britton, and their modern followers, Carabia, Liogier, Stehlé, right into the contemporary work of Garay, Nir, Zanoni, Ackerman and its school, Bocourt, Mújica: these were the main impulses under which the Antilles were explored and their orchid diversity revealed.

A well-conceived and well-realized book, *Orchids and Orchidology in the Antilles* do not lets much space for criticisms. The iconographic support to the texts is extraordinary, with a lot of previoulsy unpublished material, and it is a pity the graphical decision of writing the captions *inside* the illustrations. For some of the illustrated plants the basionym is sometimes adopted (i.e., *Angraceum funale* for *Dendrophylax funalis, Edpidendrum altissimum* for *Oncidium altissimum, Epidendrum bradfordii* for *Encylia bradfordii*), while in other cases the species are named accordingly to current classification (i.e. *Brassavola nodosa* for *Epidendrum nodosum*, *Broughtonia sanguinea* for *Epidendrum sanguineum*, *Psychilis kraenzlinii* for *Epidendrum kraenzlinii*). Finally, indexes of personal and plants names would have surely helped the reader to find the appropriate reference pages within such a large book, filled with so many characters.

I personally consider this work a monument to the history of orchids in the Caribbean Islands, and an extraordinary tribute to the people that made it possible. To be sure to own a copy of the book, I would buy mine today.

Franco Pupulin

LITERATURE CITED

Ossenbach, C. (2009). Orchids and orchidology in Central America: 500 years of history. *Lankesteriana*, 9, 1–268.

LANKESTERIANA 17(1): 109—113. 2017.

LANKESTERIANA

AUTHOR INSTRUCTIONS

LANKESTERIANA is a peer-reviewed journal. Each manuscript will be critically evaluated by two or more external reviewers.

Please read carefully the following Instructions and check the appropriate items to be sure your manuscript is formatted according to the journal style. Manuscripts that do not conform to the Instructions, both in format and contents, will be sent back to the authors for formatting prior to the reviewing process. This would repre-sent a significant delay in the times required to eventually publish your manuscript

General Instructions

- Type manuscript in Word (or Word compatible word processor) on 8.5" by 11" document with at least 1" (2.5 cm) margin on all sides.
- Use Times New Roman 12- point type, double-space throughout, including tables, figurelegends, and literature cited. Do not justify the right margin. Authors are responsible for diacritical marks.
- Assemble in this order: 1) Title, Author(s) and affiliation(s)page; 2) abstract [+ optional abstract in the second language], key words and running title page; 3) Text, 4) Acknowledgments, 5) Literature cited, 6) Tables, 7) Appendices, 8) Figure legends, 9) Figures.
- Authors not fluentin written English should have their manuscripts checked carefully for correct language use before submission.
- If the paper includes newly described taxa, they must be illustrated, preferably by line drawings.• Include the collect permits and the corresponding institution that granted it in the cases of newly described taxa.

Title, Running title, Addresses, Abstract [+ optional Abstract in second language] & Key Words

- Title is flush left, in upper and lower case letters
- Below Title, author(s) name(s) are on one line, flushleft, in upper and lower case letters. Author(s) name(s) are in the following order: First Name (complete spelling), Second Name (initial), Surname. Indicate by superscript number after author's name any current address. Addresses include Institution, Street, City, State, Postal Code, Country. Indicate with asterisk (*) the name of the correspondent author; indicate with asterisk, after the addresses, the email of the correspondent author, to whom reprints should be sent.
- Abstract begin on new page, is flushleft, in upper and lower case letters. Abstract must be one paragraph and not indented. Do not cite references or use abbreviations in the abstract. Abstract is intended for quick understanding of the article content, and must include short but full reference to paper results. In the case of newly described taxa, diagnostic characters must be shortly stated.• Optional abstract in a second language should follow in separate paragraph in same format. No translation services are provided by the editorial staff.
- Key Words: give up to 6 keywords arranged alphabetically, preceding text as follows: Key Words:...
- Below Key Words, Running title is on one line, flushleft, in upper and lower case letters. The running title includes the author(s) surname(s) and a short title. Total number of characters must not exceed 50.

Text

- Begin on new page.
- Main headings are flushleft in upper and lower case letters and in boldface on a separate line. Secondary headings are flushleft in upper and lower case letters and in italics, followed by a period, dash, and the paragraph text. Tertiary headings are flush leftin upper and lower case letters and underlined, followed by a period, dash, and the paragraph text.
- All figures and tables must be cited in the text and must be cited consecutively in numerical order.
- Each reference cited in the text must be in the Literature Cited section, and vice versa.

- Cite literature in the text as follows:
    1. One author: Nobody (1991) or (Nobody 1991)
    2. Two authors: Nobody and Somebody (1991) or (Nobody & Somebody 1991)
    3. More than two authors:
       The first time you cite it: Nobody, Somebody & Someother (1991) or (Nobody, Somebody & Someother 1991).
       Subsequent citations: Nobody *et al*. (1991) or (Nobody *et al.* 1991).
    4. More than six authors: Nobody *et al.* (1991) or (Nobody *et al.* 1991)
    5. Manuscripts accepted for publication but not yet published: Nobody (in press) or (Nobody in press)
    6. Unpublished materials: S. Nobody (unpubl. data) or (S. Nobody pers. comm. YEAR)
    7. Within parentheses, use a comma to separate different citations (Nobody 1991, Somebody 1991), citations should be listed in the order they appear in the reference list (alphabetically, then chronologically).
    8. Use a, b, c, and so forth, for two or more papers by same author(s) in one year (e.g., Nobody 1990a, b, Boom 1985b).
- Cite authors of all names at rank of genus and below where first used in text. Do not repeat author citations after the first name's use. Refer to Authors of Plant Names (Brummitt & Powell 1992) for correct abbreviations.
- Italicize all scientific names at the generic level or below.
- Spell out genus and species the first time used in a paragraph and abbreviate generic name by first initial thereafter in that paragraph. Do not abbreviate genus name at the beginning of a sentence.
- Use *Index Herbariorum* (*Regnum Veg.* Vol. 120. 1990; http://www.nybg.org/bsci/ih/) abbreviations to designate herbaria. It is not necessary to cite this publication.
- Do not use footnotes.
- Numbers. Write out one through nine, unless a measurement or in a description. Use comma with more than four digits (1000 but 10,000); 0.5 instead of .5; "%" instead of "percent." Use 8.0–8.5 and not 8–8.5.
- Abbreviate units of measurements without a period, e.g., km, mm, ft, mi, and so forth; temperatures are as follows: 20°C.
- Write out other abbreviations the first time used in the text and abbreviate thereafter: "Trichome morphology was examined using scanning electron microscopy (SEM)."
- If keys are included, they should be dichotomous and indented. Couplets should be numbered, not lettered, and the numbers followed by periods. Authors of taxa are not included and species are not numbered in the key.
- Specimen citation should include: locality, latitude and longitude when available, elevation, collection date, collector ("*et al.*" when more than two), collector's number, and herbarium(a) of deposit (using abbreviations in *Index Herbariorum*). Countries are cited from north to south; political subdivisions are in alphabetical order within countries; collectors are in alphabetical order within subdivisions.
- Acknowledgments should be brief and to the point.

Literature Cited

- Use hanging indentation.
- Continue page number sequence.
- "In press" citations must have been accepted for publication; give name of journal (and volume number if known) or publisher.
- Insert a space after each initial of an author's name.
- Insert the year of the publication in parenthesis.
- Do not abbreviate journal names.
- Titles of books are written in lower case except the first word and proper nouns and as required in original language of titles.
- Italicize title of journal and book titles.
- Italicize scientific names in the title of articles.

- Cite literature as follows:
  1. One author: Nobody, A. B. (1991).
  2. Two authors: Nobody, A. B. & Somebody, C. D. (1991).
  3. More than two authors: Nobody, A. B., Somebody, C. D. & Someother, E. F. (1991).
  4. Book chapter: Nobody, A. B. (1991). The effect of light on growth. In: C. D. Somebody (Ed.), *Light and growth* (pp. 209-291). London: Light Press. – or - Nobody, A. B. (1991). The effect of light on growth. In: C. D. Somebody & E. F. Someother (Eds.), *Light and growth* (pp. 209-291). London: Light Press.
  5. Journal article: Nobody, A. B. (1991). The effect of light on growth. *Title of Journal*, 3(1), 15-20. doi: insert DOI when is available.
  6. Manuscripts accepted for publication but not yet published: Nobody, A. B. (In press). The name of the journal where the paper was accepted must be indicated.
- Please refer to the 6th Edition of APA Formatting and Style Guide for more examples of cited literature.

Tables

- Continue page number sequence.
- Each table must start on a separate page and must be double-spaced. Tables can be printed landscape or portrait. Do not reduce type size of tables. If necessary, continue table on additional pages.
- Portrait tables can be prepared to be printed 1- or 2-column width; plan accordingly.
- The title of the table should be flushed left, preceded on the same line by the word "Table" and an arabic numeral.
- Items on each row must be separated by a single tab.
- Superscripts referring to footnotes should be lowercase letters, not numbers.
- Footnotes should be placed as separate paragraphs at end of table.
- References cited in tables must be included in the Literature Cited.

Figure Legends

- Begin a new page; continue page number sequence.
- All figures (maps, photos, line illustrations) should be in a single sequence, consecutively numbered. Tables are in a separate, consecutively numbered sequence.
- Double-space the legends and group them according to figure arrangements. Do not use a separate page for each group.
- Number figures consecutively with arabic numerals.
- Type legends in paragraph format, e.g.: Figure 1. *Pleurothallis inedita*. A. Habitat. B. Flower. C. Flower dissection. D. Outer floral bract. E. Inner floral bract. F. Petal. G. Column, profile view (left) and 3/4 dorsal view (right). H. Pollinarium. (Drawn from the holotype.) Illustration by Who Nobody. Figure 3. *Luisia inedita*. A. Habit. B. Fruit (Somebody 567, CR). Illustration by Who Nobody. Note that labels on figure ("A") should be in upper case and match that on legend. Italicize collector's name and number.
- The specimen(s) on which the illustrations are based must be noted.
- The author(s) of the illustration must be credited in the figure legend.
- Do not include non-alphanumeric symbols (lines, dots, stars, etc.) in legends; label them on the figure itself or refer to them by name in the legend.

Preparation and submission of illustrations

- Illustrations should be submitted digitally as TIF files (or, exceptionally, in any format that is Adobe Photoshop compatible). Do not submit original artworks. Illustrations in "native application" file formats (e.g., PageMaker, Quark, Excel, Word, WordPerfect, etc.) will not be accepted. Photographs should be scanned at a resolution of 600 dpi; line art, 600 to 1200 dpi. All digital illustrations must be complete, with letters, scale bars, and any other labeling; label figures by press-on letters or symbols or by other mechanical lettering process; labels produced on a typewriter, dot matrix, or inkjet are unacceptable. No modifications of incomplete illustrations are provided by the editorial staff; reproduction is virtually identical to what is submitted; illustrations will not be enhanced by the editorial staff.

- Parts of a plate are labeled A, B, C, etc. Letters will be black on a white or light background; white on dark background. They are not placed over a rectangular, contrasting background, but directely on the photograph or the drawing itself, without any frame.
- All original artwork from which digital illustrations are derived MUST be signed; unsigned digital illustrations will not be accepted. The artist must also be cited in the Acknowledgments.
- For all illustrations, halftones/black-and-white photographs, the electronic files print size should be as close as possible to final published size. Print size may be reduced without loss of quality, but small files cannot be altered to fit larger dimensions.
- Length of an illustration or plate as published is 8” (205 mm). Allow space in that 8” for the printed caption to appear below the figure. Two widths are possible as published: 1-column is 2.8” (71 mm); full page is 5.75”(146 mm). Final resolution of all the images can not be less than 300dpi.
- Do not combine photographs and line art.
- When preparing composite illustrations, do not space between the components. Place numbers and/or letters on the illustration itself, not in the margins.
- Magnifications must be indicated by means of scale bars placed directly on the illustrations. Magnifications in the figure legend are not acceptable, and such figures will be returned to the author for scale bars.
- Maps should have a border, an indication of latitude and longitude, and should not have an undue amount of unused area. Distributions of several species with non-overlapping ranges can be placed on one map by using different symbols.
- Illustrations of a new species should show clearly the characteristics that distinguish it.

Conditions for publication

- Authors are not requested to pay page charges.
- In consideration of the publication of the article, authors grant to Jardín Botánico Lankester, Universidad de Costa Rica, all rights in the article.
- Authors warrant that their contribution is an original work not published elsewhere in whole or in part, except in abstract form, and that the article contains no matter which invades the right of privacy or which infringes any proprietary right.
- Authors will receive no royalty or other monetary compensation for the assignment set forth in this agreement.
- Jardín Botánico Lankester, Universidad de Costa Rica, in turn, grants to authors the royalty free right of re-publication in any book of which they are the authors or editors, subject to the express condition that lawful notice of claim of copyright be given.

What to submit

- A working version of the manuscript, including text and low resolution images (210 dpi JPEGs) must be submitted by e-mail to the Editors at: franco.pupulin@ucr.ac.cr, adam.karremans@ucr.ac.cr, melissa.diaz_m@ucr.ac.cr and lankesteriana@ucr.ac.cr, pending the submission of a e-link for high-resolution images downloading (i.e., Dropbox or WeTransfer links). Submissions can also be made through a CD or DVD via regular mail (see address above).
- CD or DVD must be Macinthosh and PC compatible, and must include two copies of manuscript and two copies of illustrations. Priority mail from abroad usually comes to Jardín Botánico Lankester, Universidad de Costa Rica. within 10 days since sent.
- Please double check in your computer the CD or DVD is readable.
- Include in the package a letter with any special instructions, any change of address during the next several months, any phone, fax, e-mail numbers for the corresponding author. Indicate which author of a multiauthored paper (if not the first) should receive the proofs.
- Immediately notify the Editor-in-chief (franco.pupulin@ucr.ac.cr), the Managing editors (adam.karremans@ucr.ac.cr; melissa.diaz_m@ucr.ac.cr) or the Editorial Assitant (noelia.belfort@ucr.ac.cr) by e-mail after sending your package.