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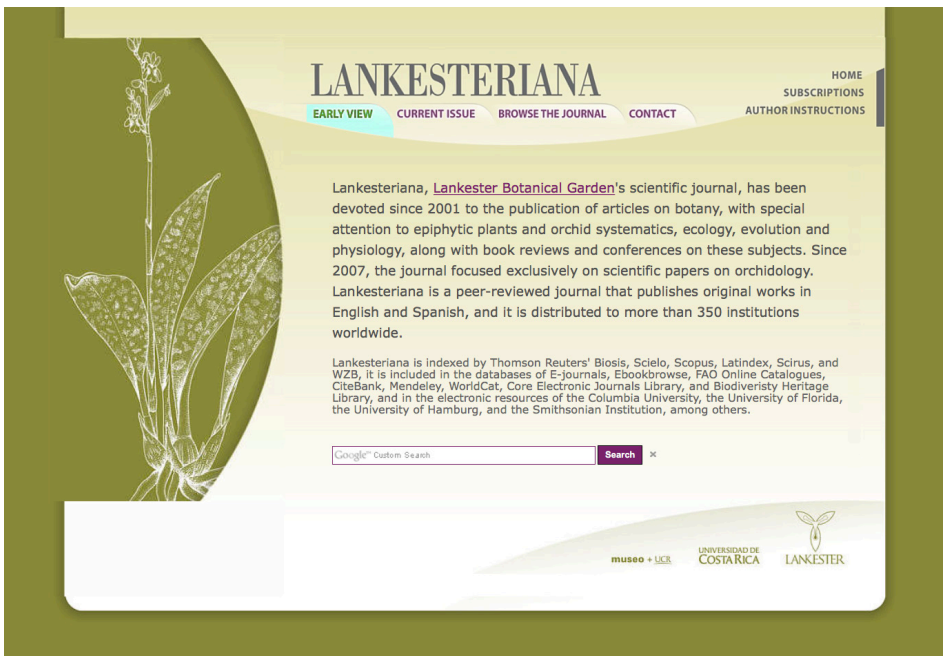

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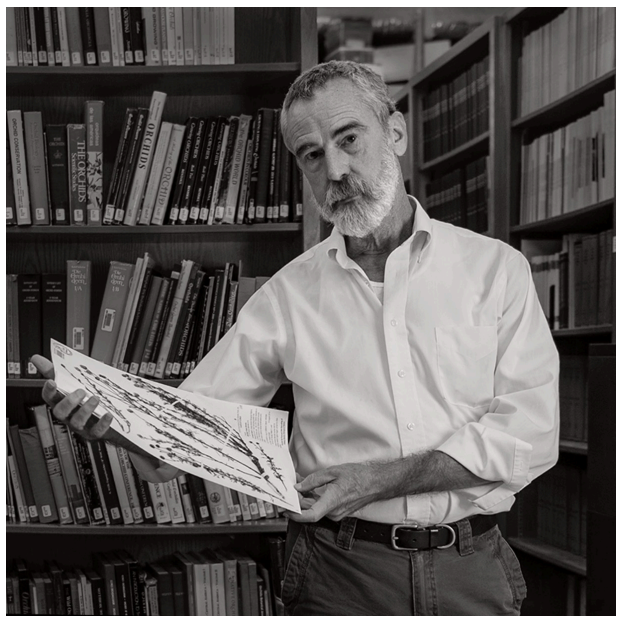
OBITUARY

WILLIAM MARK WHITTEN (1954–2019)



Florida Museum of Natural History. Photo by Kristen Grace.

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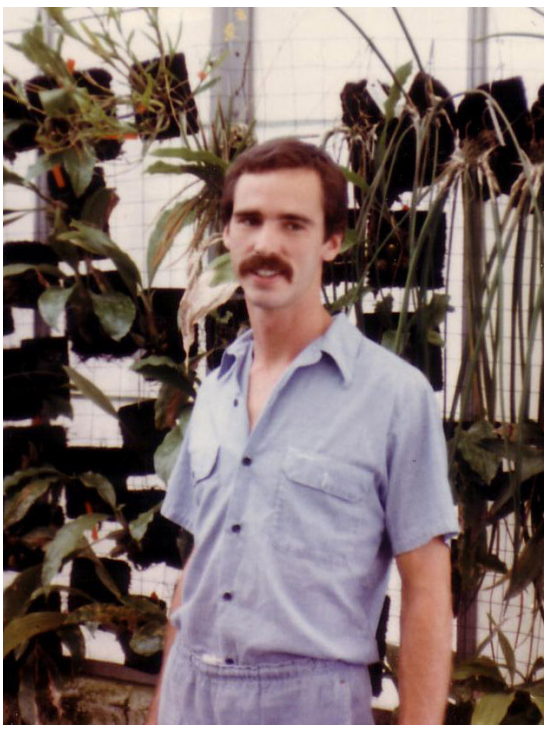
On April 11, 2019, Dr. William Mark Whitten, a prolific neotropical orchid biologist passed away unexpectedly. He leaves an extensive corpus of work focused on (but not limited to) orchid pollination and systematics, and over four thousand beautifully prepared herbarium specimens. Everyone that met Mark can agree that he was a wonderful human being, kind to everyone, incredibly knowledgeable and yet very humble. Always of a calm demeanor, great sense of humor, and willingness to help, Mark was an outstanding and relatable collaborator, and his publications (more than a hundred; see list below) are evidence of a productive and highly collaborative academic career.

Mark was born on October 20, 1954, in Memphis, Tennessee. His early education included Bishop Byrne High School in Memphis, where he graduated in 1972, and the Thomas More College in Crestview Hills, Kentucky, where he obtained a bachelor´s degree in Biology in 1976. During college, he worked for various



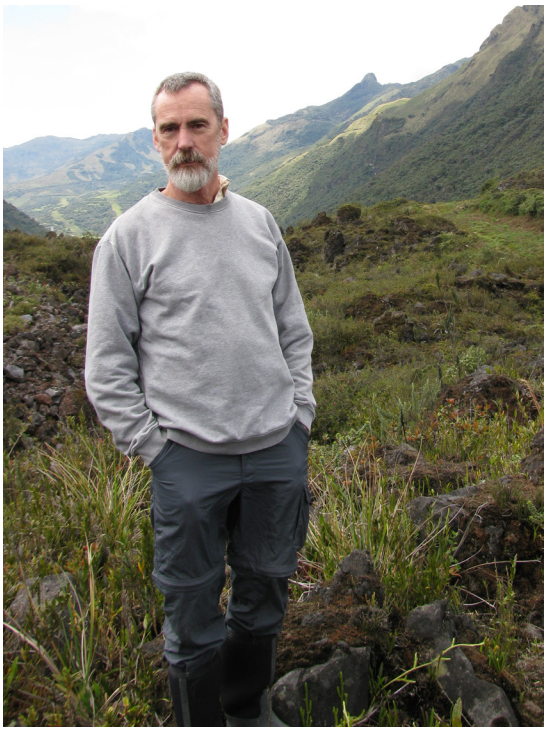
Mark Whitten at Mary Selby Botanical Gardens greenhouse with living orchid research collection, 1982. Photographer unknown.

Mark Whitten in paramo El Angel, Carchi, Ecuador, holding an inflorescence of *Puya hamata* (Bromeliaceae) and *Espeletia pycnophylla* ssp. *angelensis* (Asteraceae) in the background, late 1980´s. Photo: Mark Elliott.

environmental consulting firms on the phytoplankton of the Ohio River. He pursued his graduate education and in 1979, he obtained his Master´s degree in Botany from the University of Tennessee at Knoxville, with a thesis titled "Pollination ecology of *Monarda didyma*, *M. clinopodia* and hybrids (Lamiaceae) in the southern Appalachian Mountains", which, two years later, became his first publication.

In the same year Mark graduated from his Master´s program, he started his doctoral degree at Florida State University in Tallahassee under the direction of Norris H. Williams. His research was centered on the pollination of orchids by euglossine bees. In 1981, Mark moved with the 'Williams Lab' to the Florida Museum of Natural History at the University of Florida in Gainesville. During this period, Mark also received the guidance of Robert L. Dressler (then at the Smithsonian Tropical Research Institute in Panama) and Calaway H. Dodson (then Executive Director of the Marie Selby Botanical Gardens in Sarasota, Florida). He spent the summer of 1981 as an intern at the Orchid Identification Center at the Marie Selby Botanical Gardens. In 1985 he defended his dissertation, titled "Variation in floral fragrances and pollinators in the *Gongora quinquenervis* complex (Orchidaceae) in central Panama".

For his dissertation, Mark learned techniques of gas chromatography and mass spectrometry for the isolation and identification of the chemical compounds produced by flowers of *Gongora* and other orchid genera, responsible for the attraction of their euglossine bee pollinators. He became part of a small group of orchid researchers (including Dressler, Dodson, Williams and James Ackerman) that made substantial contributions to the understanding of the biology of orchid bees. During this period, Mark collected a substantial amount of bee specimens and gathered data and observations that he later shared and published in collaboration with other orchid bee experts. Some interesting anecdotes of Mark´s research during this period are presented in Allen Young´s book "Sarapiquí Chronicle: A Naturalist in Costa Rica" (1991. Smithsonian Institution Press).



Mark Whitten in the lava flows of Paramo de La Virgen, Napo, Ecuador in 2009. Photographer unknown.

Mark Whitten at Ordway-Swisher Biological Station in Florida, 2014, holding *Toxicodendron radicans* (Anacardiaceae). Photo: Kurt Neubig

After obtaining his Ph.D., Mark continued working at the Florida Museum of Natural History, initially as a postdoctoral research associate and later as Senior Biological Scientist. He expanded his professional skills by learning molecular systematic techniques and phylogenetics with Mark W. Chase (first in 1990 at the University of North Carolina in Chapel Hill, and later in 1994 at the Jodrell Laboratory of the Royal Botanic Gardens, Kew). Mark Whitten, Mark Chase and Norris Williams collaborated for many years thereafter, assembling phylogenies for a variety of orchid groups. Mark described or co-described several orchid species in the genera *Basiphyllaea* (1 sp.), *Gongora* (5 spp.), *Ornithidium* (1 sp.), *Solenidium* (1 sp.) and *Stanhopea* (1 sp.), and also one species of *Pitcairnia* (Bromeliaceae). He also co-described two orchid genera (*Brasilocycnis* G. Gerlach & Whitten and *Nohawilliamsia* M.W. Chase & Whitten) and one subgenus (*Houlletia* subgen. *Neohoulletia* G. Gerlach & Whitten). He also authored and co-authored numerous generic transfers. Mark discovered or documented many other new orchid species and genera, but frequently gave them to other specialists or students for their description and publication. Four orchid species are named after him: *Epidendrum whittenii* Hágsater & Dodson, *Lepanthes whittenii* Pupulin & Bogarín, *Maxillaria whittenii* Dodson and *Stanhopea whittenii* Soto-Arenas, Salazar & G. Gerlach.

For most of his time in the Florida Museum of Natural History, Mark was in charge of the Molecular Lab associated with the University of Florida Herbarium (FLAS), a position he held until 2015. In that year, he became a member of the Scientific Committee of *Lankesteriana*, the academic journal of the Lankester Botanical Garden. In 2013, he and collaborators began a floristic inventory and DNA barcoding of the Ordway-Swisher Biological Station in Putnam County, Florida, which he continued until his death. In most recent years, Mark collaborated with Pam and Doug Soltis in a variety of projects, including their US-China Dimensions of Biodiversity project, experimenting with isolation methods for high molecular weight DNA suitable for genome sequencing, gulf coast biodiversity hotspot studies, etc.

Mark was a great mentor for numerous students from the University of Florida, and other institutions alike. He had an encyclopedic knowledge of natural history and he shared it with students and colleagues in a very constructive and encouraging manner. Mark cared deeply for students' academic progress as well as their personal well-being. He was especially generous with international students; he would take time and care in helping them navigate through differences in culture, all while maintaining a sense of humor that made them feel right at home. Mark was fully aware of the challenges faced in academia by students, and he set a high standard of integrity, honesty, and generosity that we all should emulate.

As a group of his former students, we in particular owe Mark a great deal for his help in our academic development and for our career success. He liked to turn a phrase in Latin, and this one meant a lot to him: "*Ubi caritas et amor, Deus ibi est.*"

Other obituaries for W. Mark Whitten

Blanco, M.A., M. Chase, L. Endara, T. Mirenda & K.M. Neubig (2019). Dr. William Mark Whitten (1954–2019). *Orchids (Bulletin of the American Orchid Society)* 88(6): 419–420.

Gerlach, G. (2019). Mark Whitten (1954–2019). *OrchideenJournal* (in press).

Pridgeon, A. (2019). William Mark Whitten (1954–2019). *Orchid Research Newsletter* 74: 7–9.

Publications by W. Mark Whitten

1. **Whitten, W.M.** (1981). Pollination ecology of *Monarda didyma*, *M. clinopodia*, and hybrids (Lamiaceae) in the southern Appalachian Mountains. *American Journal of Botany* 68(3): 435–442.
2. Caponetti, J.D., **W.M. Whitten** & M.J. Beck (1982). Axenic culture and induction of callus and sporophytes of the Applachian *Vittaria* gametophyte. *American Fern Journal* 72: 36–40.
3. Williams, N.H. & **W.M. Whitten** (1982). Identification of floral fragrance components of *Stanhopea embreei* and attraction of its pollinator to synthetic fragrance compounds. *American Orchid Society Bulletin* 51: 1262–1266.
4. Williams, N.H. & **W.M. Whitten** (1983). Orchid floral fragrances and male euglossine bees: methods and advances in the last sesquidecade. *Biological Bulletin* 164: 355–395.
5. Williams, N.H., **W.M. Whitten** & C.H. Dodson (1984). Preliminary analyses of the floral fragrances of species of *Acineta*, *Houlettia*, *Luddemannia*, *Lycomormium*, *Paphinia*, and *Sievekingia* (Orchidaceae). *Selbyana* 7(2/4): 315–317.
6. **Whitten, W.M.** (1985). Floral fragrances and pollinators of the *Gongora quinquenervis* R. &. P. complex (Orchidaceae) in central Panama. (Abstract of talk presented at the Annual Meetings of the Botanical Society of America, Gainesville, Florida, 11–15 August 1985). *American Journal of Botany* 72(6): 916.
7. Williams, N.H., **W.M. Whitten** & L.F. Pedrosa (1985). Crystalline production of fragrance in *Gongora quinquenervis*. *American Orchid Society Bulletin* 54: 598–603.
8. McClure, G.L., N.H. Williams & **W.M. Whitten** (1985). Orchids and Bee's Knees: investigating the euglossine syndrome with Gas Chromatography/Fourier Transform Infrared GC/FT-IR. *Proceedings of the1985 International Conference on Fourier and Computerized Infrared Spectroscopy, Ottawa, Canada*, Volume 0553: 355.
9. **Whitten, W.M.**, N.H. Williams, W.S. Armbruster, M.A. Battiste, L. Strekowski & N. Lindquist (1985). Carvone oxide: an example of convergent evolution in euglossine pollinated plants. *Systematic Botany* 11(1): 222–228.
10. Lindquist, N., M.A. Battiste, **W.M. Whitten**, N.H. Williams & L. Strekowski (1985). Trans-carvone oxide, a monoterpene epoxide from the fragrance of *Catasetum*. *Phytochemistry* 24(4): 863–865.
11. Stern, W.L., K.J. Curry & **W.M. Whitten** (1986). Staining fragrance glands in orchid flowers. *Bullletin of the Torrey Botanical Club* 113(3): 288–297.
12. Hills, H.G., N.H. Williams & **W.M. Whitten** (1986). Cyclic fragrance production in euglossine pollinated orchids. (Conference Abstract). *American Journal of Botany* 73(5): 727.
13. Williams, N.H. & **W.M. Whitten** (1988). *Stanhopea panamensis*, a new species from central Panama. *Lindleyana* 3(1): 9–11.
14. **Whitten, W.M.**, H.G. Hills & N.H. Williams (1988). Occurrence of ipsdienol in floral fragrances. *Phytochemistry* 27(9): 2759–2760.
15. Dodson, C.H., N.H. Williams & **W.M. Whitten** (1989). A new species of *Gongora* (Orchidaceae) from Ecuador. *Lindleyana* 4(1): 30–52.
16. Huck, R.B., W.S. Judd, **W.M. Whitten**, J.D. Skean, R.P. Wunderlin & K.R. Delaney (1989). A new *Dicerandra* (Labiatae) from the Lake Wales Ridge of Florida, with a cladistic analysis and discussion of endemism. *Systematic Botany* 14(2): 197–213.

17. **Whitten, W.M.**, A.M. Young & N.H. Williams (1989). Function of glandular secretions in fragrance collection by male euglossine bees (Apidae: Euglossini). *Journal of Chemical Ecology* 15(4): 1285–1295.
18. **Whitten, W.M.** & N.H. Williams (1991). A new species and nomenclatural changes in *Gongora* Sect. *Acropera* (Orchidaceae: Stanhopeinae). *Lindleyana* 6(2): 109–112.
19. **Whitten, W.M.** & N.H. Williams (1991). *Gongora escobariana* Whitten, a new species from Colombia, and the rediscovery of *G. sanderiana* in Peru. *Orquideología* 18(2): 105–127.
20. Dressler, R.L. & **W.M. Whitten** (1991). *Kegeliella*. *American Orchid Society Bulletin* 60: 684–687.
21. **Whitten, W.M.** & N.H. Williams (1992). Floral fragrances of *Stanhopea* (Orchidaceae). *Lindleyana* 7: 130–153.
22. Luther, H.E. & **W.M. Whitten** (1992). A new *Pitcairnia* from western Ecuador. *Journal of the Bromeliad Society* 42(6): 245–247.
23. **Whitten, W.M.**, A.M. Young & D.L. Stern (1993). Nonfloral sources of chemicals that attract male euglossine bees (Apidae: Euglossini). *Journal of Chemical Ecology* 19(12): 3017–3027. Erratum: (1994) 20(3): 821–822.
24. Christenson, E.A. & **W.M. Whitten** (1995). *Phalaenopsis bellina* (Rchb.f.) Christenson, a segregate from *P. violacea* Witte (Orchidaceae: Aeridinae). *Brittonia* 47(1): 57–60.
25. Eltz, T., D. Roubik, **W.M. Whitten** & K.E. Linsenmair (1999). Fragrance collection: storage and accumulation by individual male orchid bees. *Journal of Chemical Ecology* 25(1):157–176.
26. Cameron, K.M., M.W.Chase, **W.M. Whitten**, P.J. Kores, D. Jarrell, V.A. Albert, T. Yukawa, H.G. Hills & D.H. Goldman (1999). A phylogenetic analysis of the Orchidaceae: evidence from *rbcL* nucleotide sequences. *American Journal of Botany* 86(2): 208–224.
27. **Whitten, W.M.**, N.H. Williams & K.V. Glover (1999). Sulphuryl fluoride fumigation: effect on DNA extraction and amplification from herbarium specimens. *Taxon* 48(3): 507–510.
28. Gerlach, G. & **W.M. Whitten** (1999). *Brasilocycnis*, eine neue Gattung der Subtribus Stanhopeinae. *Journal für den Orchideenfreund* 6: 188–192.
29. Hills, H.G., N.H. Williams & **W.M. Whitten** (1999). Chapter 10: Fragrances of Catasetums. In: A.W. Holst. *The World of Catasetums*. Timber Press, Portland, pp. 263–272.
30. Ryan, A., **W.M. Whitten**, M.A.T. Johnson & M.W. Chase (2000). A phylogenetic assessment of *Lycaste* and *Anguloa* (Orchidaceae: Maxillarieae). *Lindleyana* 15(1): 33–45.
31. Savolainen, V., M.F. Fay, D.C. Albach, A. Backlund, M. van der Bank, K.M. Cameron, S.A. Johnson, M.D. Lledó, J.C. Pintaud, M. Powell, M.C. Sheahan, D.E. Soltis, P.S. Soltis, P. Weston, **W.M. Whitten**, K.J. Wurdack & M.W. Chase (2000). Phylogeny of the eudicots: a nearly complete familial analysis based on rbcL gene sequences. *Kew Bulletin* 55(2): 257–309.
32. van den Berg, C., W. Higgins, R.L. Dressler, **W.M. Whitten**, A. Culham & M.W. Chase (2000). A phylogenetic analysis of Laeliinae (Orchidaceae) based on sequence data from Internal Transcribed Spacers (ITS) of nuclear ribosomal DNA. *Lindleyana* 15(2): 96–114.
33. Wood, T.H., **W.M. Whitten** & N.H. Williams (2000). Phylogeny of *Hedychium* and related genera (Zingiberaceae) based on ITS sequence data. *Edinburgh Journal of Botany* 57(2): 261–270.
34. **Whitten, W.M.**, N.H. Williams & M.W. Chase (2000). Subtribal and generic relationships of Maxillarieae (Orchidaceae) with emphasis on Stanhopeinae: combined molecular evidence. *American Journal of Botany* 87(12): 1842–1856.
35. Ackerman, J.D., R.L. Tremblay & **W.M. Whitten** (2001). Notes on the Caribbean orchid flora. III. New species of *Basiphyllaea* and *Lepanthes*. *Lindleyana* 16(1): 13–16.
36. Sosa, V., M.W. Chase, G. Salazar, **W.M. Whitten** & N.H. Williams (2001). Phylogenetic position of *Dignathe* (Orchidaceae: Oncidiinae): evidence from nuclear ITS ribosomal DNA sequences. *Lindleyana* 16(2): 94–101.
37. Williams, N.H., M.W. Chase, T. Fulcher & **W.M. Whitten** (2001). Molecular systematics of the Oncidiinae based on evidence from four DNA sequence regions: expanded circumscriptions of *Cyrtochilum*, *Erycina*, *Otoglossum*, and *Trichocentrum* and a new genus (Orchidaceae). *Lindleyana* 16(2): 113–139.
38. Williams, N.H. & **W.M. Whitten** (2001). Checking an orchid hybrid´s background: the use of molecular data in determining parentage of hybrids. *Orchids (Bulletin of the American Orchid Society)* 70: 1056–1061.
39. Williams, N.H., M.W. Chase & **W.M. Whitten** (2001). Phylogenetic positions of *Miltoniopsis*, *Caucaea*, a new genus, *Cyrtochiloides*, and *Oncidium phymatochilum* (Orchidaceae: Oncidiinae) based on nuclear and plastid DNA sequence data. *Lindleyana* 16(4): 272–285.
40. Iudica, C.A., **W.M. Whitten** & N.H. Williams (2001). Small bones from dried mammal museum specimens as a reliable source of DNA. *BioTechniques* 30(4): 732–734, 736.
41. Goldman, D.H., J.V. Freudenstein, P.J. Kores, M. Molvray, D.C. Jarrell, **W.M. Whitten**, K.M. Cameron, R.K. Jansen &

M.W. Chase (2001). Phylogenetics of Arethuseae (Orchidaceae) based on plastid matK and rbcL sequences. *Systematic Botany* 26(3): 670–695.

42. Zomlefer, W.B., N.H. Williams, **W.M. Whitten** & W.S. Judd (2001). Generic circumscription and relationships in the Tribe Melanthieae (Liliales, Melanthiaceae), with emphasis on *Zigadenus*: evidence from ITS and trnL-F sequence data. *American Journal of Botany* 88(9): 1657–1669.
43. van den Berg, C., W. Higgins, R.L. Dressler, **W.M. Whitten**, A. Culham & M.W. Chase (2002). Molecular systematics of the Laeliinae. In: J. Clark, W. Elliott, G. Tingley & J. Biro (eds.) *Proceedings of the 16th World Orchid Conference, Vancouver, 1999*, pp. 170–176.
44. Chase, M.W., N.H. Williams & **W.M. Whitten** (2002). DNA phylogenetics and the *Oncidium* alliance: what to do with the Odontoglossums? In: J. Clark, W. Elliott, G. Tingley & J. Biro (eds.) *Proceedings of the 16th World Orchid Conference, Vancouver, 1999*, pp. 419–420.
45. **Whitten, W.M.**, N.H. Williams & M.W. Chase (2002). Molecular phylogenetics of the Maxillarieae. In: J. Clark, W. Elliott, G. Tingley & J. Biro (eds.) *Proceedings of the 16th World Orchid Conference, Vancouver, 1999*, p. 429.
46. Koehler, S., N.H. Williams, **W.M. Whitten** & M.C.E. Amaral (2002). Phylogeny of the *Bifrenaria* (Orchidaceae) complex based on morphology and sequence data from nuclear rDNA Internal Transcribed Spacers (ITS) and chloroplast trnL-trnF region. *International Journal of Plant Sciences* 163(6): 1055–1066.
47. Higgins, W., C. van den Berg, **W.M. Whitten** (2002). A combined molecular phylogeny of *Encyclia* (Orchidaceae) and relationships within Laeliinae. *Selbyana* 24(2): 165–179.
48. Carlsward, B.S., **W.M. Whitten** & N.H. Williams (2003). Molecular phylogenetics of Neotropical leafless Angraecinae (Orchidaceae): reevaluation of generic concepts. *International Journal of Plant Sciences* 164(1): 43–51.
49. Dalström, S. & **W.M. Whitten** (2003). A new species of *Solenidium* (Orchidaceae) from Ecuador. *Lankesteriana* 6(1): 1–4.
50. Carnevali, G., J.L. Tapia, N.H. Williams & **W.M. Whitten** (2003). Sistemática, filogenia y biogeografía de *Myrmecophila* (Orchidaceae). *Lankesteriana* 7(1): 29–32.
51. Ojeda, I., G. Carnevali, N.H. Williams & **W.M. Whitten** (2003). Phylogeny of the *Heterotaxis* Lindley complex (Maxillariinae): evolution of the vegetative architecture and pollination syndromes. *Lankesteriana* 7(1): 45–47.
52. Williams, N.H. & **W.M. Whitten** (2003). Molecular phylogenetics and generic concepts in the Maxillarieae (Orchidaceae). *Lankesteriana* 7(1): 61–62.
53. Zomlefer, W.B., **W.M. Whitten**, N.H. Williams & W.S. Judd (2003). An overview of *Veratrum s.l.* (Liliales: Melanthiaceae) and an infrageneric phylogeny based on ITS sequence data. *Systematic Botany* 28(2): 250–269.
54. Eltz, T., D. Roubik & **W.M. Whitten** (2003). Fragrances, male display and mating behaviour of *Euglossa hemichlora*: a flight cage experiment. *Physiological Entomology* 28(4): 251–260.
55. Dressler, R.L., **W.M. Whitten** & N.H. Williams (2004). Phylogenetic relationships of *Scaphyglottis* and related genera (Laeliinae: Orchidaceae) based on nrDNA ITS sequence data. *Brittonia* 56(1): 58–66.
56. **Whitten, W.M.** (2004). Book review: *Native Ecuadorian Orchids Volume IV* by Calaway H. Dodson [2003. Dodson Trust, 232 pp.]. *Orchids (Bulletin of the American Orchid Society)* 73(2): 142.
57. Chase, M.W., L. Hanson, V.A. Albert, **W.M. Whitten** & N.H. Williams (2005). Life history evolution and genome size in Subtribe Oncidiinae (Orchidaceae). *Annals of Botany* 95(1): 191–199.
58. **Whitten, W.M.**, N.H. Williams, R.L. Dressler, G. Gerlach & F. Pupulin (2005). Generic relationships of Zygopetalinae (Orchidaceae: Cymbidieae): combined molecular evidence. *Lankesteriana* 5(2): 87–107.
59. Loayza, M.D, N.H. Williams & **W.M. Whitten** (2005). *Phragmipedium kovachii*: molecular systematics of a New World orchid. *Orchids (Bulletin of the American Orchid Society)* 74(2): 132–137.
60. Williams, N.H., **W.M. Whitten** & R.L. Dressler (2005). Molecular systematics of *Telipogon* (Orchidaceae: Oncidiinae) and its allies: nuclear and plastid DNA sequence data. *Lankesteriana* 5(3): 163–184.
61. **Whitten, W.M.** & N.H. Williams (2005). Evolutionary relationships within tribe Maxillarieae: lessons from molecules, morphology, and pollination biology. In: A. Raynal-Roques & A. Roguenant (eds.), *Actes du 18e Congrès Mondial et Exposition d'Orchidées, 11–20 mars 2005. France Orchidées*, Naturalia Publications, Turriers, France, p. 604.
62. Zomlefer, W.B., W.S. Judd, **W.M. Whitten** & N.H. Williams (2006). A synopsis of Melanthiaceae (Liliales) with focus on character evolution in Tribe Melanthieae. *Aliso* 22(1): 566–578.
63. Carlsward, B.S., **W.M. Whitten**, N.H, Williams & B. Bytebier (2006). Molecular phylogenetics of Vandeae (Orchidaceae) and the evolution of leaflessness. *American Journal of Botany* 93(5): 770–786.
64. Zomlefer, W.B., **W.M. Whitten**, N.H. Williams & W.S. Judd (2006). Infrageneric phylogeny of *Schoenocaulon* (Liliales: Melanthiaceae) with clarification of cryptic species based on ITS sequence data and geographical distribution. *American Journal of Botany* 93(8): 1178−1192.

65. **Whitten, W.M.**, M.A. Blanco & N.H. Williams (2006). Recircumscription of *Pityphyllum* (Orchidaceae: Maxillariinae). *Orchids (Bulletin of the American Orchid Society)* 75(3): 451−456.
66. Blanco, M.A., **W.M. Whitten**, D.S. Penneys, N.H. Williams, K.M. Neubig & L. Endara (2006). A simple and safe method for rapid drying of plant specimens using forced-air space heaters. *Selbyana* 27(1): 83−87.
67. Blanco, M.A., **W.M. Whitten**, N.H. Williams & S. Koehler (2006). Capillitial extrusion from fruits of *Maxillaria nardoides* (Orchidaceae: Maxillariinae). *Orchids (Bulletin of the American Orchid Society)* 75(9): 677−683.
68. **Whitten, W.M.** & B.S. Carlsward (2006). Ghosts of the Caribbean: *Dendrophylax fawcettii* and an overview of the genus. *Orchids (Bulletin of the American Orchid Society)* 75(10): 742−746.
69. **Whitten, W.M.** & B.S. Carlsward (2006). *Dendrophylax* species. *Orchids (Bulletin of the American Orchid Society)* 75(10): 748−749.
70. **Whitten, W.M.** & B.S. Carlsward (2006). A comparison of *Dendrophylax* and *Campylocentrum*. *Orchids (Bulletin of the American Orchid Society)* 75(10): 748−749.
71. Blanco, M.A., K.M. Neubig & **W.M. Whitten** (2007). A new *Maxillaria* (Orchidaceae) from Panama and Colombia, and a Brazilian species found in Ecuador. *Orchids (Bulletin of the American Orchid Society)* 76(6): 451−456.
72. Ionta, G.M., W.S. Judd, N.H. Williams & **W.M. Whitten** (2007). Phylogenetic relationships in *Rhexia* (Melastomataceae): evidence from DNA sequence data and morphology. *International Journal of Plant Sciences* 168(7): 1055−1066.
73. **Whitten, W.M.**, M.A. Blanco, N.H. Williams, S. Koehler, G. Carnevali, R.B. Singer, L. Endara & K.M. Neubig (2007). Molecular phylogenetics of *Maxillaria* and related genera (Orchidaceae: Cymbidieae) based on combined molecular data sets. *American Journal of Botany* 94(11): 1860−1889 (+ front cover).
74. Blanco, M.A., G. Carnevali, **W.M. Whitten**, R.B. Singer, S. Koehler, N.H. Williams, I. Ojeda, K.M. Neubig & L. Endara (2007). Generic realignments in Maxillariinae (Orchidaceae). *Lankesteriana* 7: 515−537.
75. Blanco, M.A., G. Carnevali, **W.M. Whitten**, R.B. Singer, S. Koehler, N.H. Williams, I. Ojeda, K.M. Neubig & L. Endara (2008). Generic realignments in Maxillariinae (Orchidaceae): corrigenda et addenda. *Lankesteriana* 8: 15.
76. Stern, W.L. & **W.M. Whitten** (2008). Comparative vegetative anatomy of Stanhopeinae (Orchidaceae). *Botanical Journal of the Linnean Society* 129(2): 87−103.
77. Koehler, S., J.S. Cabral, **W.M. Whitten**, N.H. Williams, R.B. Singer, K.M. Neubig, M. Guerra, A.P. de Souza & M.C.E. Amaral (2008). Molecular phylogeny of the Neotropical genus *Christensonella* (Orchidaceae, Maxillariinae): species delimitation and insights into chromosome evolution. *Annals of Botany* 102(4): 491−507.
78. Carlsward, B.S. & **W.M. Whitten** (2008). The correct genus for the jingle bell orchid, *Harrisella porrecta*. *North American Native Orchid Journal* 14: 272−274.
79. N.H. Williams & **W.M. Whitten** (2008). Molecular phylogeny and floral fragrances of male euglossine bee-pollinated orchids: a study of *Stanhopea* (Orchidaceae). *Plant Species Biology* 14(2): 129−136.
80. Chase, M.W., N.H. Williams, K.M. Neubig & **W.M. Whitten** (2008). Taxonomic transfers in Oncidiinae to accord with *Genera Orchidacearum, Vol. 5*. *Orchids (Bulletin of the American Orchid Society)* 77(12): 20−31.
81. **Whitten, W.M.** (2009). Book review: *Huntleyas and Related Orchids*. [P.A. Harding (2008). Timber Press, 260 pp.] *Orchids (Bulletin of the American Orchid Society)* 78(3): 176.
82. Chase, M.W., N.H. Williams & **W.M. Whitten** (2009). Oncidiinae nomenclature: generic changes in *Genera Orchidacearum, Volume 5*. *Orchids (Bulletin of the American Orchid Society)* 78(4): 228−238.
83. **Whitten, W.M.** (2009). *Nohawilliamsia*: a new genus honors Norris H. Williams, Ph.D. *Orchids (Bulletin of the American Orchid Society)* 78(9): 552−555.
84. **Whitten, W.M.** *et al.* (2009). Subtribe Maxillariinae. In: A.M. Pridgeon, P.J. Cribb, M.W. Chase & F.N. Rasmussen (eds.). *Genera Orchidacearum, Volume 5. Epidendroideae (Part two)*. Oxford University Press, Oxford, UK. Pp. 119−211.
85. Neubig, K.M., **W.M. Whitten**, B.S. Carlsward, M.A. Blanco, L. Endara, N.H. Williams & M. Moore (2009). Phylogenetic utility of ycf1 in orchids: a plastid gene more variable than matK. *Plant Systematics and Evolution* 277: 75−84.
86. Chase, M.W., N.H. Williams, A.D. de Faria, K.M. Neubig, M.C.E. Amaral & **W.M. Whitten** (2009). Floral convergence in Oncidiinae (Cymbidieae; Orchidaceae): an expanded concept of *Gomesa* and a new genus *Nohawilliamsia*. *Annals of Botany* 104(3): 387−402.
87. van den Berg, C., W. Higgins, R.L. Dressler, **W.M. Whitten**, M.A. Soto-Arenas & M.W. Chase (2009). A phylogenetic study of Laeliinae (Orchidaceae) based on combined nuclear and plastid DNA sequences. *Annals of Botany* 104(3): 417−430.
88. Neubig, K.M., N.H. Williams, **W.M. Whitten** & F. Pupulin (2009). Molecular phylogenetics and the evolution of fruit and leaf morphology of *Dichaea* (Orchidaceae: Zygopetalinae). *Annals of Botany* 104(3): 457−467.

89. **Whitten, W.M.** (2009). Norris Williams [Biographical sketch]. In: T. Kull, J. Arditti & S.M. Wong (eds.), *Orchid Biology: Reviews and Perspectives, X*, Springer, Pp. xii−xiii.
90. Ackerman, J.D. & **W.M. Whitten** (2010). A new *Ornithidium* (Orchidaceae: Maxillariinae) from the Massif de la Hotte of Haiti. *Lankesteriana* 9(3): 509−512.
91. Gajdeczka, M.T., K.M. Neubig, W.S. Judd, **W.M. Whitten**, N.H. Williams & K.D. Perkins (2010). Phylogenetic analyses of the *Gaylussacia frondosa* complex (Ericaceae: Vaccinieae) based on molecular and morphological characters. *Journal of the Botanical Research Institute of Texas* 4(1): 245−260.
92. Silvera, K., K.M. Neubig, **W.M. Whitten**, N.H. Williams, K. Winter & J.C. Cushman (2010). Evolution along the crassulacean acid metabolism continuum. *Functional Plant Biology* 37: 995–1010.
93. Chase, M.W. & **W.M. Whitten** (2011). Further taxonomic transfers in Oncidiinae (Orchidaceae). *Phytotaxa* 20: 26–32.
94. Endara, L., N.H. Williams & **W.M. Whitten** (2011). Filogenia molecular preliminar de *Scaphosepalum* (Orchidaceae: Pleurothallidinae). *Lankesteriana* 11(3): 245–252.
95. Neubig, K.M., **W.M. Whitten**, M.A. Blanco, L. Endara, N.H. Williams & S. Koehler (2011). Preliminary molecular phylogenetics of *Sobralia* and relatives (Orchidaceae: Sobralieae). *Lankesteriana* 11(3): 307−317.
96. **Whitten, M.W.** & M.A. Blanco (2011). Defining generic limits in *Maxillaria*. *Orchids (Bulletin of the American Orchid Society)* 80(2): 104−113.
97. Carnevali, G., W. Cetzal-Ix & **W.M. Whitten** (2012). *Cryptocentrum beckendorfii* (Orchidaceae: Maxillarinae), an extraordinary new species from Andean Peru. *Phytotaxa* 68: 45−51.
98. Neubig, K.M., **W.M. Whitten**, N.H. Williams, M.A. Blanco, L. Endara, G. Burleigh, K. Silvera, J.C. Cushman & M.W. Chase (2012). Generic recircumscriptions of Oncidiinae (Orchidaceae: Cymbidieae) based on maximum likelihood analysis of combined DNA datasets. *Botanical Journal of the Linnean Society* 168: 117−146.
99. **W.M. Whitten**, C.C. Jacono & N.S. Nagalingum (2012). An expanded plastid phylogeny of *Marsilea* with emphasis on North American species. *American Fern Journal* 102(2): 114−135.
100. Papadopulos, A.S.T., M.P. Powell, F. Pupulin, J. Warner, J.A. Hawkins, N. Salamin, L. Chittka, N.H. Williams, **W.M. Whitten**, D. Loader, L.M. Valente, M.W. Chase & V. Savolainen (2013). Convergent evolution of floral signals underlies the success of Neotropical orchids. *Proceedings of the Royal Society B: Biological Sciences* 280(1765): 20130960.
101. Neubig, K.M., **W.M. Whitten**, J.R. Abbott, S. Elliott, D.E. Soltis & P.S. Soltis (2014). Variables affecting DNA preservation in archival plant specimens. In: W.L. Applequist & L.M. Campbell (eds.), *DNA banking in the 21st Century: Proceedings of the U.S. workshop on DNA banking*. The William L. Brown Center at the Missouri Botanical Garden, St. Louis, pp. 81−136.
102. Neubig, K.M., F. Herrera, S. Manchester, C.C. Germain-Aubrey, R. Abbott & **W.M. Whitten** (2014). Systematics of Ulmaceae and placement of the extinct *Cedrelospermum*. *The Paleontological Society Special Publications* 13: 18−19.
103. **W.M. Whitten**, K.M. Neubig & N.H. Williams (2014). Generic and subtribal relationships in Neotropical Cymbidieae (Orchidaceae) based on matK/ycf1 plastid data. *Lankesteriana* 13(3): 375−392.
104. Neubig, K.M., B.S. Carlsward, **W.M. Whitten** & N.H. Williams (2015). Nectary structure and nectar in *Sobralia* and *Elleanthus* (Sobralieae: Orchidaceae). *Lankesteriana* 15(2): 113−127.
105. Neubig, K.M., O. Blanchard, **W.M. Whitten** & S.F. McDaniel (2015). Molecular phylogenetics of *Kosteletzkya* (Malvaceae, Hibisceae) reveals multiple independent and successive polyploid speciation events. *Botanical Journal of the Linnean Society* 179(3): 421–435.
106. Givnish, T.J., D. Spalink, M. Ames, S.P. Lyon, S.J. Hunter, A. Zuluaga, W.D.J. Iles, M.A. Clements, M.T.K. Arroyo, J. Leebens-Mack, L. Endara, R. Kriebel, K.M. Neubig, **W.M. Whitten**, N.H. Williams & K.M. Cameron (2015). Orchid phylogenomics and multiple drivers of their extraordinary diversification. *Proceedings of the Royal Society B: Biological Sciences* 282(1814): 20151553.
107. Kim, H.T., J.S. Kim, M.J. Moore, K.M. Neubig, N.H. Williams, **W.M. Whitten** & J.H. Kim (2015). Seven new complete plastome sequences reveal rampant independent loss of the ndh gene family across orchids and associated instability of the Inverted Repeat/Small Single-Copy Region boundaries. *PLoSONE* 10(11): e0142215.
108. **Whitten, W.M.** (2015). Orchid pollination 150 years after Darwin. [Book review of R. Edens-Meier & P. Bernhardt (eds.). (2014). *Darwin´s orchids: then and now*. University of Chicago Press, xi + 419 pp.]. *Ecology* 96(7): 2030–2031.
109. Pérez-Escobar, O.A., M. Gottschling, **W.M. Whitten**, G. Salazar & G. Gerlach (2016). Sex and the Catasetinae (Darwin's favourite orchids). *Molecular Phylogenetics and Evolution* 97: 1–10.
110. Molgo, I.E., G. Carnevali Fernández-Concha, **W.M. Whitten** & N.H. Williams (2016). *Dendrophylax megarhizus* (Orchidaceae), a new species from Mexico. *Systematic Botany* 41(2): 263–274.

111. Pastore, J.F.B, J.R. Abbott, K.M. Neubig, **W.M. Whitten**, R.B. Mascarenhas, M.C.A. Mota & C. van den Berg (2017). A molecular phylogeny and taxonomic notes in *Caamembeca* (Polygalaceae). *Systematic Botany* 42(1): 54–62.
112. Pessoa, E.M., J. Viruel, M.V. Alves, D. Bogarín-Chaves, **W.M. Whitten**, M.J.M. Christenhusz & M.W. Chase (2018). Evolutionary history and systematics of *Campylocentrum* (Orchidaceae: Vandeae: Angraecinae): a phylogenetic and biogeographical approach. *Botanical Journal of the Linnean Society* 186(2): 158–178.
113. Salazar, G.A., J.A.N. Batista, L.I. Cabrera, C. van den Berg, **W.M. Whitten**, E.C. Smidt, C.R. Buzatto, R.B. Singer, G. Gerlach, R. Jiménez-Machorro, J.A. Radins, I.S. Insaurralde, L.R.S. Guimarães, F. de Barros, F. Tobar, J.L. Linares, E. Mújica, R.L. Dressler, M.A. Blanco, E. Hágsater & M.W. Chase (2018). Phylogenetic systematics of subtribe Spiranthinae (Orchidaceae: Orchidoideae: Cranichideae) based on nuclear and plastid DNA sequences of a nearly complete generic sample. *Botanical Journal of the Linnean Society* 186(3): 273–303.
114. Smidt, E.C., A.L.V. Toscano de Brito, A.C. Martins, C.A. Royer, **W.M. Whitten** & M.W. Chase (2018). Phylogenetics, biogeography and character evolution in the *Ornithocephalus* clade (Orchidaceae, Oncidiinae). *Botanical Journal of the Linnean Society* 188(4): 339–354.
115. Allen, J.M., C.C. Germain-Aubrey, N. Barve, K.M. Neubig, L.C. Majure, S.W. Laffan, B.D. Mishler, H.L. Owens, S.A. Smith, **W.M. Whitten**, J.R. Abbott, D.E. Soltis, R. Guralnick & P.S. Soltis (2019). Spatial phylogenetics of Florida vascular plants: the effects of calibration and uncertainty on diversity estimates. *iScience* 11: 57–70.

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THREE NEW *LEPANTHES* (ORCHIDACEAE: PLEUROTHALLIDINAE) FROM THE ALTO DE VENTANAS ECOREGION IN ANTIOQUIA, COLOMBIA

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Abstract. Three new species of the genus *Lepanthes* from the Alto de Ventanas ecoregion in the central Andes of Antioquia, Colombia, are described and illustrated. *Lepanthes sabinadaleyana* is similar to *L. lycocephala* but it is distinguished by the narrowly ovate leaves and the lip with oblong-obovate blades with an ovoid, obtuse appendix. *Lepanthes cissyana* is similar to *L. ballatrix*, but it differs by its purple lip with elliptical blades and a semicircular, concave body with two long, pubescent appendices in the sinus. *Lepanthes dougdarlingii* is similar to *L. hortensis* but can be distinguished by the prolific habit and the appendix of the lip lingulate to oblong, pubescent, with a concave depression in the middle, an apical gland-like structure and a tuft of hairs on the abaxial surface near the apex.

Key Words: *Lepanthes cissyana, L. dougdarlingii, L. sabinadaleyana,* orchid conservation, Salvamontes

Introduction. Taxonomy plays an important role in many different disciplines of biology, providing us the universal naming and classification system of biodiversity for centuries (Costello *et al.* 2015). It also allows us to know the number of living species on our planet and their biological characteristics (Dubois 2003). However, our inventory of living organisms is still incomplete, and many times limited by the lack of financial government support because frequently, budgets are assigned for conservation efforts in well-explored areas and also, many conservationists and ecologist think that our current taxonomic survey of biodiversity is largely satisfactory (Dubois 2003). That is why taxonomy and conservation need a stronger bond where they can go hand-in-hand.

In Colombia, Orchidaceae is the most diverse family of plants with more than 4,000 species (Bernal *et al.* 2015), which are found abundantly in virtually every natural ecosystem with its highest richness in the Andes (Luer & Thoerle 2012). Its taxonomy is not always easy due to the high number of species, their wide and localized distribution, the phenotypic variations among species, and the constant changes within phylogenies. Orejuela (2012) stated that orchid conservation has to be multi-faceted, combining the protection of the habitat with the coordination of both *in-situ* and *ex-situ* efforts, the involvement of communities in species and ecosystem conservation projects, outreach activities, and the creation of knowledge networks, increasing education about species and their distribution. This is undoubtedly the only way to route the orchid conservation to its salvation in years to come.

One of the most effective strategies to promote biodiversity conservation is by strengthening systems of national parks and similar reserves at regional (departmental) and local levels, integrating protection of species and ecosystems (Orejuela 2012). In recent years, different efforts have been undergoing in Colombia for the creation of private natural reserves motivated fully or partially by the presence of endangered and rare orchid species. One of these initiatives is the one being developed by Corporación Salvamontes Colombia since early 2016, in the Alto de Ventanas eco-region in the central Andes of Antioquia, with the help of the Orchid Conservation Alliance and the Rainforest Trust. Three natural reserves are now in place, and some of the biggest forest remnants in the region are now preserved inside them, thus protecting the habitat for many rare and endangered orchids.

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The Alto de Ventanas region was explored for orchids during the ’80s by Carl Luer and Rodrigo Escobar where they found several new species in the Pleurothallidinae, most of them in the genus *Lepanthes* Sw. (Luer & Escobar 1984, 1984a, 1984b, 1984c), and so far, known only from that area. While exploring the region for the assessment of orchid species inside the Salvamontes natural reserves we found many *Lepanthes* species, some of them already known, and some that are new to science including the novelties here described.

As part of the mentioned conservation efforts, some of the lands purchased for the expansion of one of the Salvamontes natural reserves were funded by auctioning the names of the three new species described here with the help of the Rainforest Trust. That is a good example and only one of the possible ways where taxonomy and conservation work hand in hand for the protection of orchid habitats.

Taxonomic treatment

Lepanthes sabinadaleyana J.S.Moreno & S.Vieira-Uribe***, sp. nov.*** Fig. 1–4A.

TYPE: Colombia. Antioquia: Municipality of Valdivia, Ventanitas, La Esperanza Natural Reserve, 2150 m, 2 Aug. 2017. *J. S. Moreno 519, A. L. Erazo & S. Vieira* (holotype: JAUM; isotype: CAUP).

Diagnosis: *Lepanthes sabinadaleyana* is most similar to *L. lycocephala* Luer & R.Escobar, both bearing small reddish flowers with longitudinally concave lip blades with everted apices, but the lip in *L. sabinadaleyana* has oblong-obovate blades with an ovoid, obtuse appendix.

Plant epiphytic, sympodial, caespitose herb up to 9 cm tall. *Roots ca*. 0.7 mm in diameter. *Ramicauls* slender, erect to horizontal, elongated, thin, 7–12 cm long, enclosed by 6–11 microscopically scabrous, tightly fitting acuminate lepanthiform sheaths. *Leaf* green, thinly coriaceous, narrowly ovate, acute, attenuate, 3.0–3.5 × 0.7–0.8 cm, the base broadly cuneate, contracted into a petiole *ca*. 2 mm long. *Inflorescence* a congested, distichous, successively flowered raceme up to 7 mm long, borne by a filiform peduncle 11–12 mm long, resting on the adaxial surface of the leaf. *Floral bracts* spiculate, 1 mm long; pedicels 1.5 mm long. *Ovary* costate, 1.5–1.7 mm long. *Flower* with sepals translucent rose, petals, column and lip rose, anther cap white, suffused with rose. *Sepals* similar in shape and size, carinate along the veins on the abaxial surface; *dorsal sepal* ovate, cuspidate, slightly concave, 3-veined, 4.0 × 2.5 mm, connate to the lateral sepals for 0.5 mm; *lateral sepals* connate 1.5 mm into a broadly ovate bifid synsepal, 3.0–3.5 × 3.5 mm, each individual sepal free for *ca*. 1 mm, 2-veined with the apices cuspidate. *Petals* transversely bilobed, pubescent, shallowly retuse at the apex between the two lobes, 0.5 × 2.5 mm, the upper lobe triangular, deflexed, acute, 1.5 mm long, the lower lobe triangular, subacute, 1 mm long. *Lip* bilaminate, the blades diverging, thickened towards the apex, pubescent, oblong-obovate, longitudinally concave, 1.5 mm long with everted, rounded apices; the connectives *ca*. 0.5 mm long, cuneate; the body triangular when expanded, adnate to the base of the column; the appendix ovoid, pubescent, glandular and rounded at the apex. *Column* terete, 1.5 mm long, the anther and stigma apical. *Pollinia* 2, pyriform, attached to a detachable viscidium, 0.5 mm long. *Anther cap* cucullate, 0.5 mm long. *Capsule* 4.2 mm long.

Eponymy: Name after Sabina Daley, a graphic designer, mom, and orchid enthusiast. She lives in New York City, but her dreams often take her to the rainforests where orchids grow. The right to name this species was given to Adam Deaton, who generously donated land purchase funds for the expansion of the natural reserves where the species was found.

Habitat and ecology: Numerous plants of this species have been observed growing at two nearby locations (less than 3 km apart) inside the “Alto de Ventanas” Integrated Management District at 2000–2200 m elevation. Individuals from both populations were growing together with other small pleurothallids on moss-covered low twigs and branches (Fig. 2C) of shrubs and trees growing close to water streams or in swampy, sphagnum covered soil, inside remaining patches of forest or old shrubland. The plants are usually shaded or partially exposed to the sun, and where found, tend to be the most abundant species of *Lepanthes*. It has been found growing near, or together

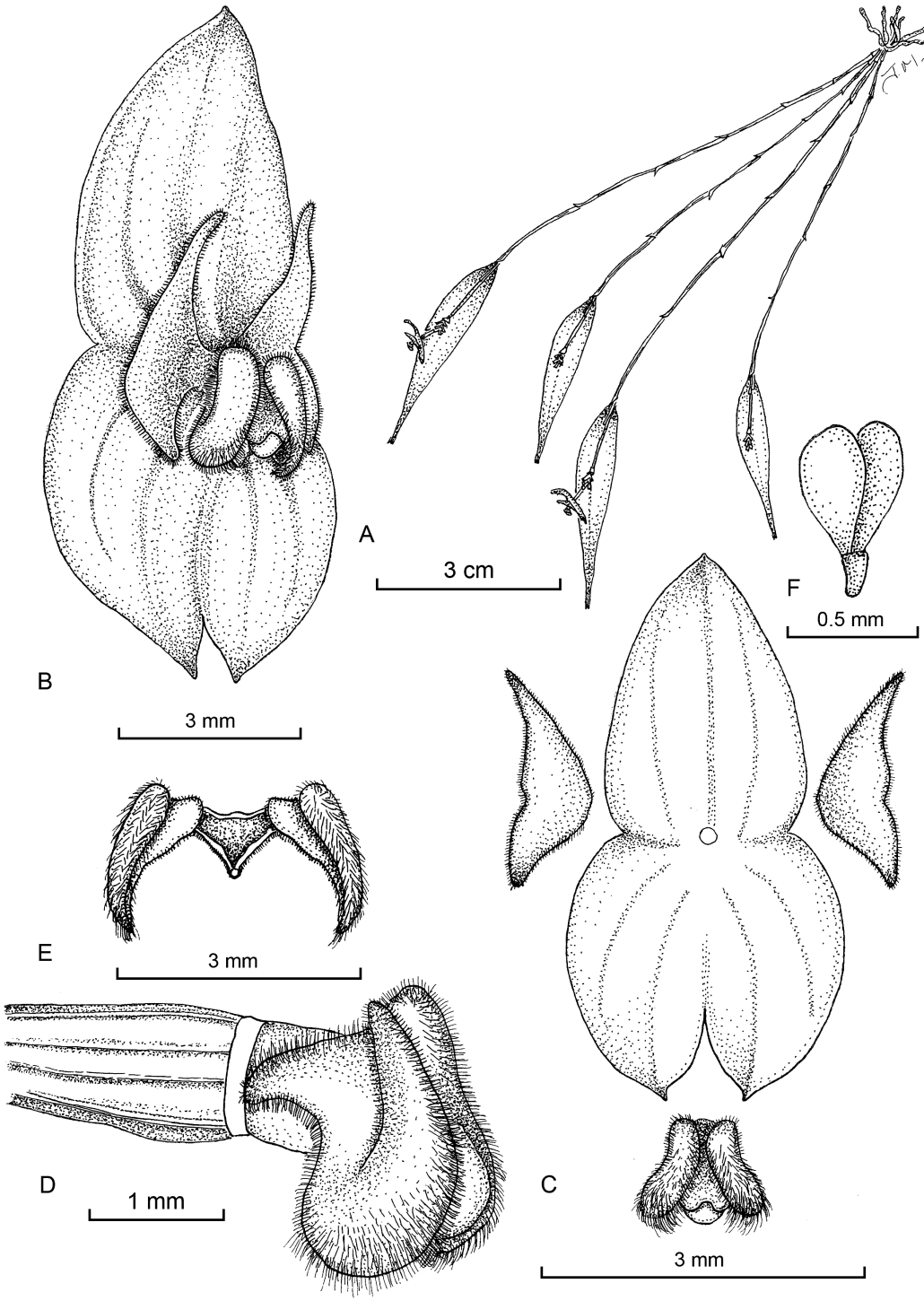

Figure 1. *Lepanthes sabinadaleyana* J.S.Moreno & S.Vieira-Uribe. A. Habit. B. Flower. C. Dissected perianth. D. Ovary, column and lip, side view. E. Lip in expanded position. F. Pollinia. Drawn by Juan Sebastián Moreno from the plant that served as type.

FIGURE 2. *Lepanthes sabinadaleyana* J.S.Moreno & S.Vieira-Uribe. A. Flower, oblique view. B. Flower, side view. C. Plant with flower, *in situ*. Photographed by Sebastián Vieira from unvouchered specimens from the same population of the plant that served as type.

with *Lepanthes culex* Luer & R.Escobar, *L. habenifera* Luer & R.Escobar, *L. skeleton* Luer & R.Escobar, *L. stelidilabia* Luer & R.Escobar, *L. venusta* Luer & R.Escobar, among others.

PHENOLOGY: Under greenhouse conditions on the outskirts of Medellin at 2700 m elevation, this species blooms all the year round. The flowers are frequently pollinated, producing capsules and propagating

naturally on nearby pots. Pseudocopulatory pollination by fungus gnats of the Sciaridae family has been observed several times, with the male fly staying attached to the appendix of the lip of the flower for several minutes (Fig. 3).

Lepanthes sabinadaleyana is distinguished by its medium size plant with elongated, slender ramicauls, and tightly fitting, acuminate lepanthiform sheaths; an inflorescence borne resting on the adaxial surface of the leaf with intense rose flowers; transversely bilobed, pubescent petals, with triangular lobes, acute to subacute; a bilaminate lip with the blades diverging, thick, longitudinally concave, pubescent, and a small, obtuse, ovoid, pubescent appendix. *Lepanthes lycocephala* (Fig. 4B) is the most similar species from the central and western Andes of Colombia, with intense red flowers with pubescent petals and lip, the lip also with thick blades, longitudinally concave but it can be distinguished by having smaller, elliptical, subacute leaves suffused with purple on the abaxial surface and with erose margins (*vs*. narrowly ovate, acute, attenuate leaves with smooth margins in *L. sabinadaleyana*), transversely bilobed petals with the lower lobe narrowly oblong longer than the upper lobe (*vs*. transversely bilobed petals, with both lobes triangular, acute to subacute in *L. sabinadaleyana*) and a bilaminate lip with obovate blades with the

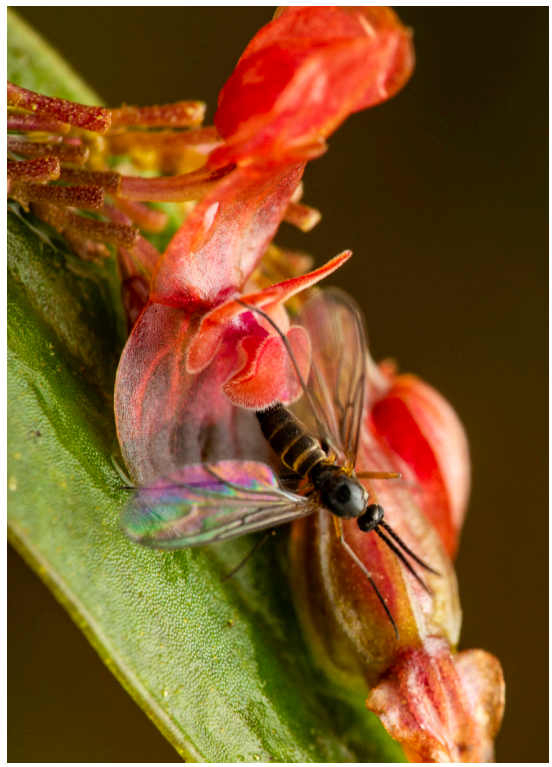

Figure 3. Flower of *Lepanthes sabinadaleyana* J.S.Moreno & S.Vieira-Uribe with Sciaridae fungus gnat pseudocopulating with the flower. Photograph by Sebastián Vieira of an unvouchered specimen from the type locality.

Figure 4. Comparison of the most similar species to *Lepanthes sabinadaleyana* J.S.Moreno & S.Vieira-Uribe. A. *Lepanthes sabinadaleyana.* B. *Lepanthes lycocephala*. C. *Lepanthes wageneri*. Photographed by Sebastián Vieira.

apices broadly subtruncate and without an appendix (*vs*. a bilaminate lip with the blades diverging, oblong-obovate with rounded apices and an obtuse, ovoid pubescent appendix in *L. sabinadaleyana*).

With wide distribution in the Andes from Venezuela to Bolivia, *Lepanthes wageneri* Rchb.f. (Fig. 4C) also has small flowers with a lip with the blades longitudinally concave but it can be easily differentiated from *L. sabinadaleyana* by the thick, elliptical leaves usually suffused with purple (*vs*. green, thinner, narrowly ovate, acute, attenuate leaves in *L. sabinadaleyana*), the inflorescence is shorter and borne on the abaxial surface of the leaf (*vs*. resting on the adaxial surface of the leaf in *L. sabinadaleyana*), its flowers can have various combinations of yellow, orange, red and purple (*vs*. rose in *L. sabinadaleyana*) and a bilaminate lip with more or less oblong, cellular-pubescent blades with truncate apices and a cymbiform appendix (*vs*. bilaminate lip with the blades diverging, oblong-obovate with rounded apices and an obtuse, ovoid pubescent appendix in *L. sabinadaleyana*).

Lepanthes exserta Luer & Hirtz from Ecuador is also superficially similar to *L. sabinadaleyana*, but it can be easily distinguished by the column that protrudes forward and bearing the lip blades horizontally (*vs*. not protruding column with lip blades longitudinally concave), the lip adnate to the column above the middle (*vs*. adnate to the base of the column), and light green sepals (*vs*. translucent rose).

Lepanthes cissyana S.Vieira-Uribe & J.S.Moreno, ***sp. nov.*** Fig. 5–6.

TYPE: Colombia. Antioquia: Municipality of Valdivia, Ventanitas, La Esperanza Natural Reserve, 2150 m, 2 Aug. 2017. *J. S. Moreno 520, A. L. Erazo & S. Vieira* (holotype: JAUM; isotype: CAUP).

Diagnosis: This species is most similar to *Lepanthes ballatrix* Luer, but it is easily distinguished by its petals retuse between the two triangular lobes, and by the lip with the elliptical, oblique blades with truncate apices and with two appendices in the sinus.

Plant epiphytic, sympodial, caespitose herb up to 20 cm tall. *Roots* flexuous, filiform, *ca*. 1 mm in diameter. *Ramicauls* slender, suberect to horizontal, up to 19 cm long, enclosed by 10–13 lepanthiform sheaths. *Leaf* green with veins suffused with purple abaxially, suberect, lanceolate, thinly coriaceous, rugose between veins on the abaxial surface, the apex attenuate and tridentate, 8–9 cm × 2.2–2.4 cm, the rounded base contracted into a petiole *ca*. 6 mm long. *Inflorescence* a congested, successively flowered, distichous raceme shorter than the leaf, borne on the abaxial surface of the leaf, up to 3.8 cm long; peduncle filiform, terete, up to 2.7 cm; floral bracts *ca*. 1.4 mm long. *Ovary* costate, *ca*. 2 mm long. *Flowers* with yellow to saffron sepals, the lateral sepals suffused with red near the interior margin, the petals orange with red margins, the lip and column purple. *Dorsal sepal* triangular, acute, 3-veined, connate at the base to the lateral sepals for *ca*. 1.5 mm, 3 × 6 mm. *Lateral sepals* ovate, oblique, acute, shortly acuminate, 2-veined, abaxially carinate along the mid vein, connate for 3.8 mm, 2.9 × 6.2 mm. *Petals* puberulent, transversely bilobed, retuse between the two lobes, 4.2 × 1.3 mm, 1-veined, the upper lobe ovate to triangular, oblique, obtuse; the lower lobe triangular, with one external basal undulation, subfalcate, oblique, subacute. *Lip* bilaminate, pubescent, blades touching above the column, elliptical, oblique, convex with recurved margins, the apices truncate, 1.4–1.5 × 0.8–0.9 mm, the connectives cuneate, the body semicircular, concave, connate at the base of the column, with two shortly oblong, long pubescent appendices, located at the sinus just below the apex of the column on both sides of the rostellum and viscidium. *Column* adpressed to the body of the lip, terete, *ca*. 1.5 mm long; anther apical, stigma ventral, bilobed, filling the lip body cavity. *Pollinia* 2, pyriform, attached to a detachable viscidium, *ca*. 0.5 mm long. *Anther cap* subquadrate, cucullate, 0.4 mm long. *Capsule* not seen.

Eponymy: Name honoring Cissy Mitchell. The right to name this species was given to John Mitchell, who generously donated land purchase funds for the expansion of the natural reserves where the species was found.

Habitat and ecology: *Lepanthes cissyana* is so far endemic to the "Alto de Ventanas" ecoregion. It was first found in 2010 in Vereda La Candelaria, municipality of Yarumal, at 2200 m elevation growing on the moss-covered trunk of a fallen tree near the

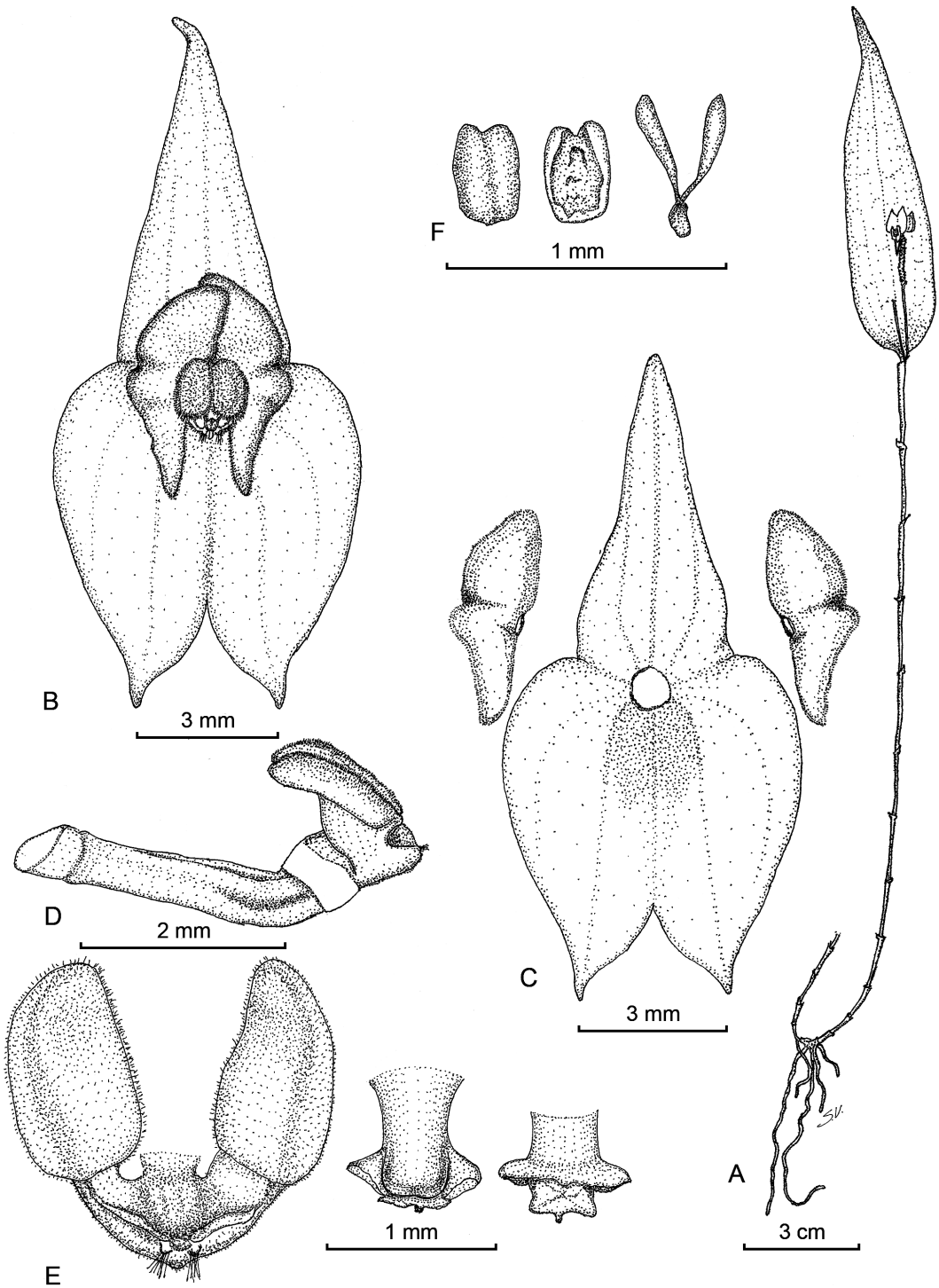

Figure 5. *Lepanthes cissyana* S.Vieira-Uribe & J.S.Moreno. A. Habit. B. Flower. C. Dissected perianth. D. Ovary, column and lip, side view. E. Lip in expanded position, and column in dorsal and ventral view. F. Anther cap and pollinia. Drawn by Sebastián Vieira from the plant that served as type.

FIGURE 6. *Lepanthes cissyana* S.Vieira-Uribe & J.S.Moreno. A. Flower. B. Detail of the flower, showing the two appendices, unique of this species. Photographs by Sebastián Vieira of the plant that served as type.

forest edge. Years later, when exploring the "La Esperanza" natural reserve located just 3 km away from the first locality, several plants were found also growing on moss-covered tree trunks, along the borders of a creek at 2150 m elevation. At this locality, *Lepanthes cissyana* grows close to other species of *Lepanthes,* including *L. agglutinata* Luer*, L. janitor* Luer & R.Escobar*, L. myoxophora* Luer & R.Escobar*, L. sabinadaleyana* J.S.Moreno & S.Vieira-Uribe*, L. skeleton* Luer & R.Escobar and *L. stelidilabia* Luer & R.Escobar, among others, shaded by the forest canopy above the creek and receiving humidity from the nearby flowing water, the frequent fogs and rains.

PHENOLOGY: This species has been observed blooming at its habitat, in different months during consecutive years. It appears to bloom all year round.

This species is worthy of attention because of its purple lip with a concave, semi-circular body having two separate appendices; to date, a characteristic unique to this species. Its flowers are similar to other species having large yellow flowers borne on the abaxial surface of the leaf, with triangular dorsal sepals, ovate lateral sepals, and red-rimmed petals. Among these, *Lepanthes cissyana* is most similar to *L. ballatrix* from Ecuador (Luer & Thoerle 2011), but is easily distinguished from it by its petals with the upper lobe ovate to triangular and the lower lobe triangular, with one external basal undulation (*vs*. lobes suborbicular to broadly elliptical in *L. ballatrix*) and by the characteristic purple lip (*vs*. orange to red, more or less suffused with purple in *L. ballatrix*) with a semi-circular body with two shortly oblong, long pubescent appendices in the sinus (*vs*. body broad with one triangular, concave, ciliate appendix in *L. ballatrix*).

Lepanthes cissyana is also similar to *L. chrysina* Luer & Hirtz, *L. cingens* Luer & R.Escobar, *L. deutera* Luer & Thoerle and *L. membranacea* Luer & Hirtz but

can be easily distinguished by the purple lip having a semi-circular, concave body with two shortly oblong, long pubescent appendices, located in the sinus just below the apex of the column on both sides of the rostellum (Fig. 6B).

Lepanthes dougdarlingii S.Vieira-Uribe & J.S.Moreno, ***sp. nov.*** (Fig. 7, 8, 9A, 10A).

TYPE: Colombia. Antioquia: Municipality of Valdivia, Ventanitas, La Esperanza Natural Reserve, 2150 m, 2 Aug. 2017. *J. S. Moreno 521, A. L. Erazo & S. Vieira* (holotype: JAUM; isotype: CAUP).

Diagnosis: *Lepanthes dougdarlingii* is similar to *L. hortensis* Luer & R.Escobar, but is easily distinguished by its prolific habit; the lip with blades oblong to obovate, rounded, marginally ciliate and the appendix ligulate to oblong, saccate in the middle, with an apical gland-like structure.

Plant terrestrial, sympodial, caespitose, prolific herb up to 35 cm tall, caespitose and prolific. *Roots* slender, flexuous, filiform, *ca*. 1 mm in diameter. *Ramicauls* slender, erect, frequently producing additional ramicauls from the apex, up to 27 cm long, enclosed by 10–21, ribbed lepanthiform sheaths with minutely ciliate, long acuminate ostia. *Leaf* green to olive, horizontal, ovate, attenuate, coriaceous, carinate along the main vein on the abaxial surface, 2.0–4.5 × 1.2–2.3 cm, the rounded base contracted into a petiole *ca*. 2 mm long, the apex emarginate with an apiculus in the middle. *Inflorescence* a congested, successively-flowered, distichous raceme shorter than the leaf, borne from either surface of the leaf, up to 2.6 cm long, with the flowers usually hanging on one side of the leaf; peduncle filiform, up to 2 cm; floral bracts *ca*. 1.6 mm long. *Ovary* costate, 2.3 mm long. *Flowers* with amber sepals suffused with rust along the veins, fulvous petals suffused with rust along the mid vein and along two lines radiating from the base on both sides of the mid vein, the white lip suffused with mauve along the blade margins; *dorsal sepal* triangular-ovate, margins denticulate, attenuate, 3-veined, abaxially carinate along the veins, connate at the base to the lateral sepals for *ca*. 1.9 mm, 6.9 × 4.7 mm; *lateral sepals* ovate, margins denticulate, shortly acuminate, 2-veined, abaxially carinate along the veins, connate for *ca*. 2 mm, 6 × 3 mm. *Petals* transversely bilobed with a small, rounded marginal lobe at the apex, 1.2 × 4.3 mm, the upper lobe oblong, short pubescent, truncate, the apex with a small tooth-like lobe near the interior margin, 2 mm long; the lower lobe triangular, sigmoid, pubescent, acute, 2.3 mm long. *Lip* bilaminate, the blades adherent medially above the column, oblong to obovate, membranous, the margins ciliate, rounded, 2.2 × 0.8

Figure 7. *Lepanthes dougdarlingii* S.Vieira-Uribe & J.S.Moreno. A. Leaf with flowers. B. Habitat and Plant. Photographs by Sebastián Vieira from the plant that served as type.

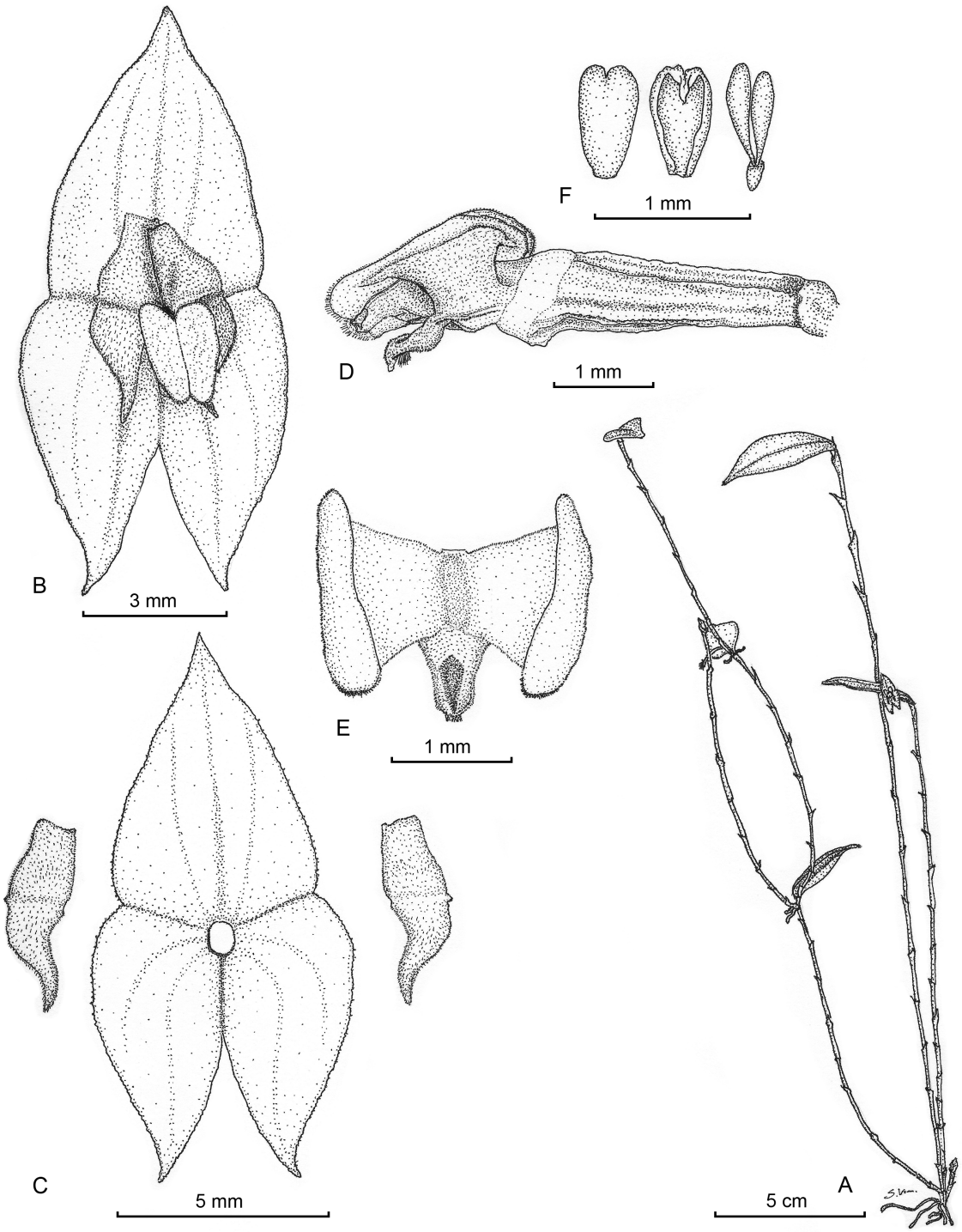

FIGURE 8. *Lepanthes dougdarlingii* S.Vieira-Uribe & J.S.Moreno. A. Habit. B. Flower. C. Dissected perianth. D. Ovary, column and lip, lateral view. E. Lip in expanded position. F. Anther cap and pollinia. Drawn by Sebastián Vieira from the plant that served as type.

Figure 9. Comparison of *Lepanthes dougdarlingii* with some of the most similar species. A. *Lepanthes dougdarlingii*. B. *Lepanthes hortensis*. C–D. *Lepanthes ophelma*. E. *Lepanthes cactoura*. F. *Lepanthes habenifera*. Photographs by Sebastián Vieira.

mm, the connectives cuneate, the body subquadrate, adnate to the base of the column; appendix ligulate to oblong, pubescent, saccate in the middle, with an apical gland-like structure and a tuft of hairs on the abaxial surface near the apex, *ca*. 0.7 mm long. *Column* terete, capitate, *ca*. 1.9 mm long; anther apical, stigma ventral. *Pollinia* 2, pyriform, attached to a detachable viscidium, *ca*. 0.7 mm long. *Anther cap* cordate, cucullate, *ca*. 0.7 mm long. *Capsule* not seen.

Eponymy: Name in remembrance of Doug Schwartz, a dear American friend who had a passion for life, beauty, nature, and the brilliance and warmth of the color orange. The right to name this species was given to Ann Kaupp, who generously donated land purchase funds for the expansion of the natural reserves where the species was found.

Habitat and ecology: *Lepanthes dougdarlingii* has been found only inside the "La Esperanza" natural

FIGURE 10. Comparison of the flower of *L. dougdarlingii* with the most similar species, *L. hortensis*, with a detailed view of the petals and lip appendix. Photographs by Sebastián Vieira.

reserve, always growing as a terrestrial on moss and leaf litter covered soil near the roots of shrubs and trees, always growing under shaded and very humid conditions (Fig. 7B). It seems to prefer disturbed areas inside the forest, near the trails, where its prolific habit allows it to climb the nearby intermingled twigs and plants. It grows between 2100 and 2200 m elevation.

PHENOLOGY: *L. dougdarlingii* has been observed blooming on almost every month of the year, then, it is presumed to bloom all year round.

This new species is remarkable for its large, colorful flowers which frequently hang over the sides of the leaves, and also for its prolific habit. The flowers are similar to other large, colorful flowered species with the lip blades adherent over the column and a small marginal lobe between the two lobes of the petals. Among these, *Lepanthes dougdarlingii* is most similar to *L. hortensis* (Fig. 9B, 10B) and *L. ophelma* Luer & R.Escobar (Fig. 9C, 9D), but can be easily differentiated from them by the petals with the lower lobe triangular, sigmoid and acute, the small and rounded marginal middle lobe; the white lip, suffused with mauve, with the adherent blades oblong to obovate, with the ciliate margins, and the rounded apex; the appendix lingulate to oblong, pubescent, saccate in the middle, with an apical gland, and a tuft of hairs on the abaxial surface near the apex.

Other similar species include *Lepanthes aristata* Luer & R.Escobar, *L. cactoura* Luer & R.Escobar (Fig. 9E), *L. habenifera* Luer & R.Escobar (Fig. 9F), *L. macrantha* Garay, *L. quandi* Luer & R.Escobar and *L. spelynx* Luer & R.Escobar, also with colorful flowers with adherent lip blades and petals with a marginal mid-lobe (Luer & Thoerle 2012), but from all of them, *L. dougdarlingii* can be easily distinguished by growing as a terrestrial and having a prolific habit.

Conservation status: The three new species were found inside one of the natural reserves of Corporación Salvamontes de Colombia, located in the "Alto de Ventanas" ecoregion, an area recently declared by the local government as an Integrated Management District. Due to the protection of the Natural Reserve, we do not consider any of them to be under risk of extinction and suggest classifying the three species under the IUCN category of "Data Deficient" because we don´t have enough information to make a direct or indirect assessment, based on their distribution and/or population status.

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Literature cited

Bernal, R., Gradstein, S. R. & Celis, M. (2015). *Catálogo de plantas y líquenes de Colombia*. Bogotá, Colombia: Instituto de Ciencias Naturales, Universidad Nacional de Colombia. Accesado en http://catalogoplantasdecolombia.unal.edu.co

Costello, M. J., Vanhoorne, B. & Appeltans, W. (2015). Conservation of biodiversity through taxonomy, data publication, and collaborative infrastructures. *Conservation Biology*, 29(4), 711–719.

Dubois, A. (2003). The relationships between taxonomy and conservation biology in the century of extinctions. *Comptes Rendus Biologies*, 326 (1), 9–21.

Luer, C. A. & Escobar, R. (1984). New *Lepanthes* species from Colombia – 2. *American Orchid Society Bulletin*, 53(1), 30.

Luer, C. A. & Escobar, R. (1984a). New *Lepanthes* species from Colombia – 2. *American Orchid Society Bulletin*, 53(3), 261.

Luer, C. A. & Escobar, R. (1984b). New *Lepanthes* species from Colombia – 2. *American Orchid Society Bulletin*, 53(4), 368.

Luer, C. A. & Escobar, R. (1984c). New *Lepanthes* species from Colombia – 2. *American Orchid Society Bulletin*, 53(6), 604–611.

Luer, C. A. & Thoerle, L. (2011). *Lepanthes* Sw. and affiliates. *In* C. Persson & B. Stahl, *Flora of Ecuador*, 88, 13–405. Goteborg: Botanic Institute, Goteborg University.

Luer, C. A. & Thoerle, L. (2012). *Icones Pleurothallidinarum* XXXII, *Lepanthes* of Colombia (Orchidaceae). *Monographs in Systematic Botany from the Missouri Botanical Garden*, 123, 1–296.

Orejuela, J. E. (2012). Orchids of the cloud forests of southwestern Colombia and opportunities for their conservation. *European Journal of Environmental Sciences*, 2(1), 19–32.

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HIDDEN IN PLAIN SIGHT: A NEW SPECIES OF *PLEUROTHALLIS* (ORCHIDACEAE: PLEUROTHALLIDINAE) FROM COLOMBIA PREVIOUSLY MISIDENTIFIED AS *PLEUROTHALLIS LUCTUOSA*

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Abstract. *Pleurothallis tenuisepala*, a new species in subsection *Acroniae*, is described and compared to *Pleurothallis luctuosa* with which it has previously been confused. While the two species are superficially similar, they can be very easily distinguished by the size of the flowers, which are approximately 60 mm long in *P. tenuisepala versus* approximately 29 mm long in *P. luctuosa*, or the length of the sepals, which are approximately four-times the length of the petals in *P. tenuisepala* versus less than twice the length of the petals in *P. luctuosa*. The two species can also be discriminated by their nuclear internal transcribed spacer (nrITS) sequences. *Pleurothallis tenuisepala* occurs on Isla Gorgona off the Pacific coast of Colombia and on the western slopes of the Cordillera Occidental of the Colombian Andes, while *P. luctuosa* is restricted to the Cordillera de Tilarán of Costa Rica. Labellar micromorphology of both species is discussed in relation to possible pollination mechanisms.

Resumen. Se describe *Pleurothallis tenuisepala*, una nueva especie en la subseccción *Acroniae*, y se compara con *Pleurothallis luctuosa*, con la cual ha sido previamente confundida. Aunque las dos especies sean superficialmente similares, pueden ser fácilmente reconocidas por el tamaño de las flores, que miden aproximadamente 60 mm de longitud en *P. tenuisepala versus* cerca de 29 mm en *P. luctuosa*, así como por la longitud de los sépalos, que son aproximadamente cuatro veces más largos de los pétalos en *P. tenuisepala*, mientras que en *P. luctuosa* miden menos que el doble de los pétalos. Las dos especies pueden discriminarse también por las secuencias de su región espaciadora interna nuclear (nrITS). *Pleurothallis tenuisepala* se encuentra en la Isla Gorgona, frente a la costa pacífica de Colombia y en la vertiente occidental de la Cordillera Occidental de los Andes colombianos, mientras que *P. luctuosa* está restringida a la Cordillera de Tilarán de Costa Rica. Se discute la micromorfología del labelo de ambas especies en relación a posibles mecanismos de polinización.

Key words / Palabras clave: *Acroniae,* cryptic species*,* especies crípticas, labellum, morfología, morphology, taxonomía, taxonomy

Introduction. According to Pupulin *et al*. (2010), *Pleurothallis luctuosa* was described by Reichenbach (1877) from a plant in the collection of the botanical garden at the University of Hamburg, Germany, which was presumed to have been collected by Endrés in Costa Rica. Illustrations by Reichenbach (Fig. 1A) and Endrés (Figs. 1B–C) undoubtedly represent the same species found in the Cordillera de Tilarán in northwest Costa Rica, illustrated (Fig. 1D) in Pupulin *et al*. (2010). The flowers of *P. luctuosa* are pink-purple in coloration, sometimes with yellow at the apices of the sepals and petals; have sepals slightly less than twice the length of the petals; and have a yellow-green, scutate or shield-shaped lip (Fig. 2B).

Collections of plants identified as *Pleurothallis luctuosa* exhibit a suspiciously disjunct distribution, coming from northwest Costa Rica and Nicaragua in Central America and from southwest Colombia and northwest Ecuador in South America (Luer 1998, Viveros & Higgins 2007, Tropicos 2019), but without any records from the intervening country of Panama, or from northwest Colombia. Luer (1998) illustrated one of these collections from Pichincha, Ecuador in his monograph of subsection *Acroniae*. The species illustrated has sepals more than twice the length of

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Table 1. Accessions of *Pleurothallis luctuosa* and *Pleurothallis tenuisepala,*

Accession/voucher	Species	Origin	GenBank Accession Number for nrITS
PL0071	*P. luctuosa*	Tropical Orchid Farm	MN240885
PL0327	*P. luctuosa*	Tropical Orchid Farm	MN240886
PL0426	*P. luctuosa*	JBL11663, Jardín Botánico Lankester	MN240887
PL0427	*P. luctuosa*	JBL10449, Jardín Botánico Lankester	MN240888
PL0428	*P. luctuosa*	JBL10438, Jardín Botánico Lankester	MN240889
PL1010	*P. luctuosa*	Andy's Orchids	MN240890
PL1011	*P. luctuosa*	Andy's Orchids	MN240891
PL0963	*P. tenuisepala*	Orquídeas del Valle	MN240875
PL1038	*P. tenuisepala*	Atlanta Botanic Gardens (Orquídeas del Valle)	MN240876

the petals and a distinctly hastate or triangular lip which is clearly different from the scutate lip of *P. luctuosa*. Pupulin *et al*. (2010) suggested that the species illustrated by Luer (1998) as *P. luctuosa* might instead be an undescribed species.

The disjunct distribution, combined with the morphologic variation in the Ecuadorian form noted by Pupulin *et al*. (2010), suggested to us that all South American collections might have been misidentified as *Pleurothallis luctuosa*. To investigate the possibility that one or more so-called "cryptic" species has been included among South American specimens previously identified as *P. luctuosa*, in this first study, plant material from Colombia was compared to *P. luctuosa* from Costa Rica. Here we report on the results of this comparison; demonstrate that the Colombian material is distinct both morphologically and genetically from *P. luctuosa*; and describe the Colombian collections as a new species of *Pleurothallis* in subsection *Acroniae*.

Materials and Methods

Plant material.– Plants sold as *Pleurothallis luctuosa* were purchased from Orquídeas del Valle, Cali, Colombia (PL0963); from Tropical Orchid Farm, Hawaii, USA (PL0071 and PL0327); and from Andy's Orchids, California, USA (PL1010 and PL1011) (Table 1). All plants were accessioned into the living collection in the greenhouse at Colorado College and those which flowered during the study period were vouchered with flowers preserved in spirits. In addition to the living plant material, tissue for DNA was obtained from three accessions of *P. luctuosa* from Jardín Botánico Lankester, Cartago, Costa Rica (PL0426, PL0427, PL0428); and from a plant labeled as *P. luctuosa* at the Atlanta Botanic Gardens, Atlanta, Georgia, USA, which originated from Orquídeas del Valle, Colombia (PL1038) (Table 1).

Morphological and taxonomic comparisons.– The Colombian species was compared morphologically with the holotype of *Pleurothallis luctuosa* at the herbarium of the Vienna Natural History Museum, Vienna, Austria (W); with the drawings of *P. luctuosa* by Reichenbach (Fig. 1A), Endrés (Fig. 1B–C) and Pupulin (Fig. 1D) (Pupulin *et al*. 2010); and with living material of *P. luctuosa* at Colorado College. To confirm uniqueness, the species was also compared with all *Pleurothallis* species published in subsection *Acroniae* since the Luer (1998) monograph (Luer 1999, Luer 2009, 2011, Pupulin *et al*. 2010, Luer & Thoerle 2012, 2013, Doucette *et al*. 2017).

The Colombian species additionally was compared with collections labeled as *Pleurothallis luctuosa*, but suspected to be misidentified, from the herbaria at the Marie Selby Botanical Gardens, FL, USA (SEL); the Smithsonian National Museum of Natural History, Washington DC, USA (US); the herbarium of Jardín Botánico José Celestino Mutis (JBB); and with unidentified collections of *Pleurothallis* from the herbarium at the Universidad del Valle, Cali, Colombia (CUVC).

Scanning electron microscopy.– Flowers of the Colombian species and of *Pleurothallis luctuosa* from the Colorado College living plant collection were prepared for and examined by scanning

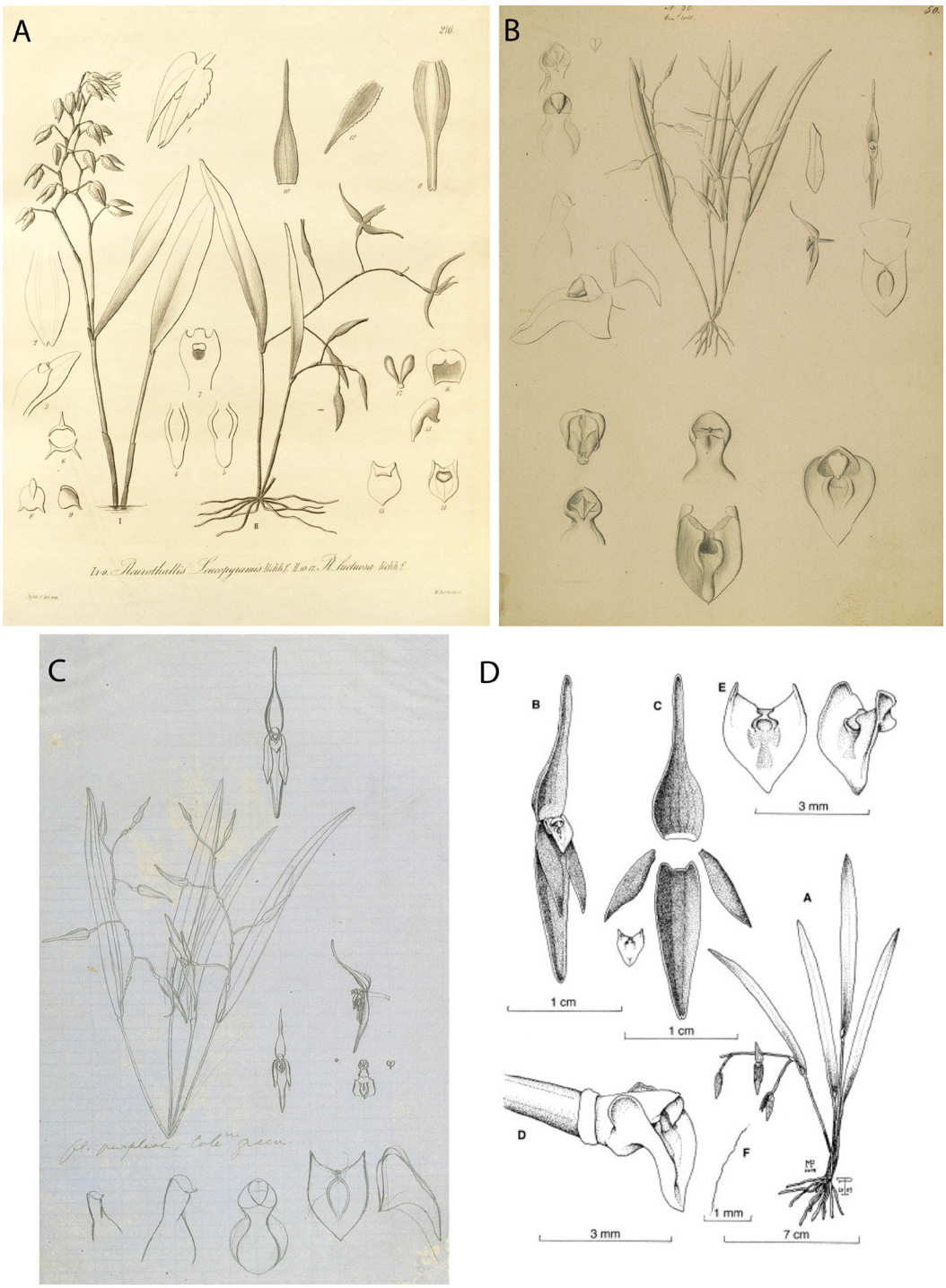


FIGURE 1. A. *Pleurothallis luctuosa* drawing by H. G. Reichenbach (drawings II 10-17). (Plate 210 from Kränzlin 1900.); B. *P. luctuosa* drawing by A. R. Endrés (W 0020308). C. *P. luctuosa* drawing by A. R. Endrés (W 0020306). D. *P. luctuosa* drawing. a. Whole plant. b. Whole flower. c. Dissected flower. d. Column and lip. e. Lip, front view and ¾ view. f. Margin of petal. (From Pupulin *et al.* 2010) (B, C and D courtesy of Vienna Natural History Museum).

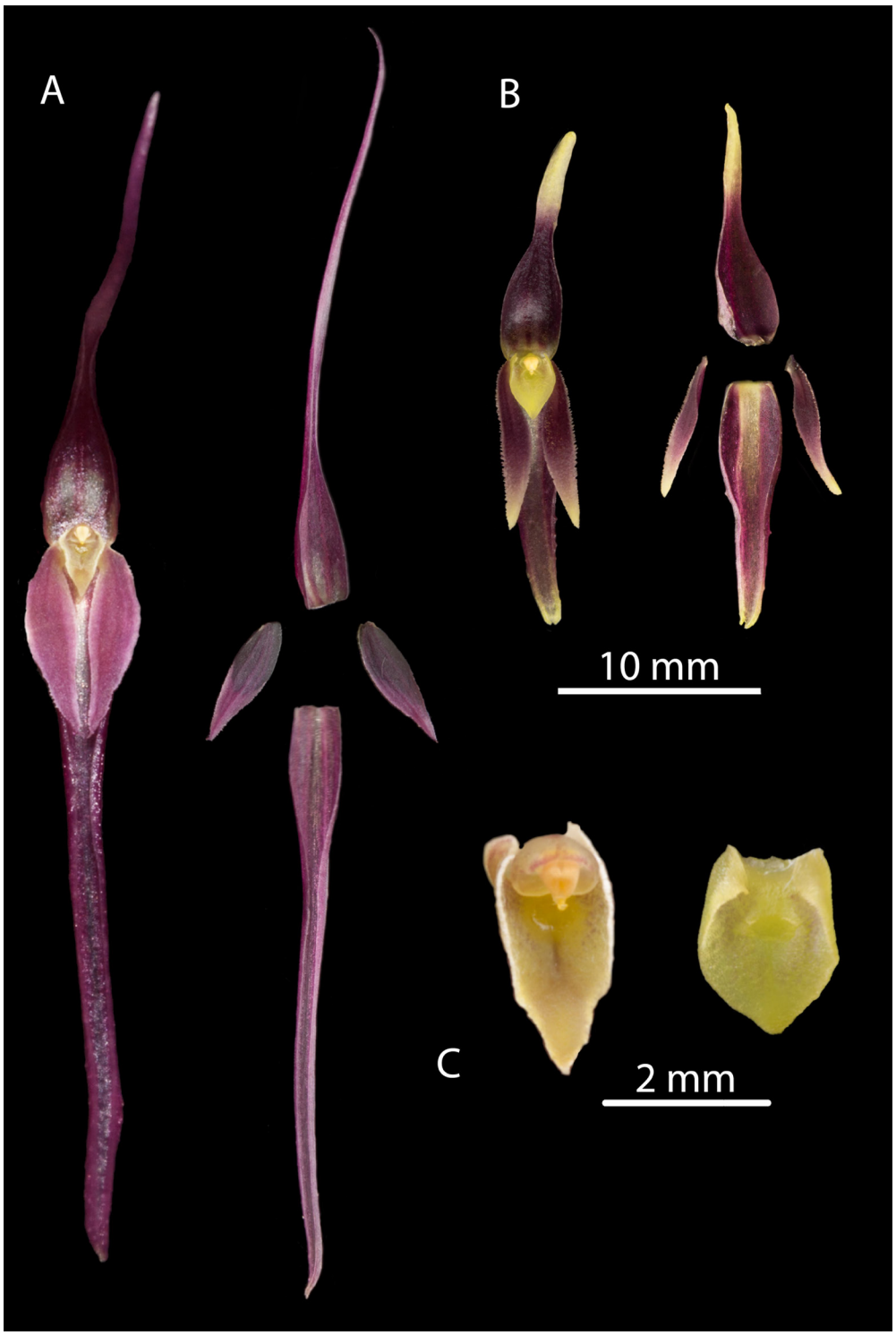


Figure 2. A. *Pleurothallis tenuisepala* whole flower and perianth; B. *Pleurothallis luctuosa* whole flower and perianth; C. Lips of *P. tenuisepala* and *P. luctuosa.* (Prepared by Mark Wilson from *P. tenuisepala* PL0963 and *P. luctuosa* PL0071.)

Table 2. Comparison of dimensions of *Pleurothallis luctuosa* and *Pleurothallis tenuisepala.*

	Pleurothallis luctuosa (from Pupulin *et al.* 2010)	***Pleurothallis tenuisepala***
Whole flower	~29 mm long	~60 mm long
Dorsal sepal	15 × 4 mm 5-veined	29.0 × 2.8 mm 3-veined
Synsepal	14 × 4 mm 3-veined	29.0 × 2.8 mm 4-veined
Petals	8 × 2 mm	7 × 2 mm
Sepal/petal ratio	1.9	4.1
Column	1.0 mm	1.7 mm
Labellum (unexpanded)	3.5 × 1.5 mm	2.8 × 1.2 mm

electron microscopy (SEM). Fresh-harvested flowers were preserved in Kew Mix (5% formalin [37.6% formaldehyde], 53% methanol, 5% glycerol, 37% deionized water). Flowers were dehydrated in successively higher concentrations of ethanol (80%, 95%, 100%, 100%) for 15 min each before being placed in freshly-opened 100% ethanol. Specimens were dried in a critical point dryer (model EMS 850, Electron Microscopy Sciences, Hatfield, PA, USA) prior to mounting on aluminum stubs and sputter coating (model Pelco SC-6, Ted Pella, Redding, CA, USA). Specimens were imaged using a scanning electron microscope (model JSM-6390LV, Jeol, Peabody, MA, USA) with an accelerating voltage of 10-15 kV.

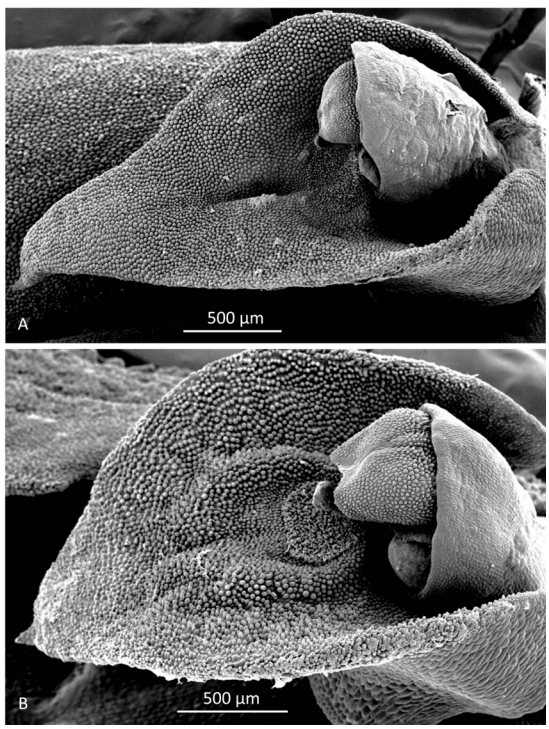
DNA sequence comparisons.– The Colombian species was compared genetically with the samples of *Pleurothallis luctuosa* acquired from Costa Rica and the living plant material at Colorado College. The nuclear internal transcribed spacer (nrITS) region was sequenced for the two accessions of the Colombian species (PL0963 and PL1038); for three samples of *P. luctuosa* from Jardín Botanico Lankester (PL0426, PL0427 and PL0428); and for four accessions of *P. luctuosa* from Colorado College (PL0071, PL0327, PL1010 and PL1011) (Table 1).

Genomic DNA was extracted from fresh material ground under liquid nitrogen using a DNeasy Plant Mini Kit (QIAGEN, USA). The nrITS region was amplified using the primer pair 17SE and 26SE (Sun *et al.* 1994) and the PCR product was purified using a QIAquick Gel Extraction Kit (QIAGEN, USA). The gel-purified PCR products were sequenced at GeneWiz (New Jersey, USA). Forward and reverse sequences were edited and aligned in geneious R11 (geneious.com) and a 765 bp consensus sequence generated. All nrITS sequences were uploaded to GenBank (Table 1). The nrITS sequences of *Pleurothallis luctuosa* and the Colombian species were aligned and compared in geneious.

Results

Morphological comparisons.– The Colombian species (Fig. 2A) differs significantly from *Pleurothallis luctuosa* (Fig. 2B): the flower is much larger, approximately 60 mm long compared to approximately 29 mm long; and the ratio of sepal-to-petal length is much higher, approximately four-times the length versus less than twice the length (Table 2). The lips are also different in shape, being hastate in the Colombian species versus scutate in *P. luctuosa* (Fig. 2C). In scanning electron micrographs, the scutate lip of *P. luctuosa* exhibits a distinct glenion in the mesochile, surrounded by a raised, hippocrepiform or horseshoe-shaped callus with the gap in the horseshoe towards the apex of the lip and a short, shallow sulcus extending towards the apex (Fig. 3–5). In contrast, in the more hastate or triangular lip of the Colombian species the glenion it is set further back under the column in the hypochile region; the prominent callus is absent; and a longer, deeper sulcus extends forward from the glenion into the mesochile of the lip (Fig. 3–5).

DNA sequence comparisons.– The nrITS sequence of *Pleurothallis luctuosa* starting at CGG GCG GTT and ending at CCA CCC G was 765 bp in length. When aligned in geneious R11 the seven *P. luctuosa* sequences



Left, Figure 3. Scanning electron micrographs of lip and column (lateral view). A. *Pleurothallis tenuisepala*. (Micrograph by Kehan Zhao and Mark Wilson from material of *M. Wilson & Andrea Niessen PL0963* used to prepare holotype). B. *Pleurothallis luctuosa* (Micrograph by Kehan Zhao and Mark Wilson from *P. luctuosa* PL0071.)

(PL0071, PL0327, PL0426, PL0427, PL0428, PL1010 and PL1011) exhibited only a single variant nucleotide in one of the sequences. On the other hand, when compared to the *P. luctuosa* sequences, the Colombian species (PL0963 and PL1038) exhibited seven nucleotide differences, a sequence difference of ~0.9%. All sequences are accessible in GenBank (Table 1).

Taxonomy

Pleurothallis tenuisepala Mark Wilson, ***sp. nov.*** (Fig. 6–8)

TYPE: Colombia. Imported from Orquídeas del Valle nursery as *Pleurothallis luctuosa*, without collection data, *M. Wilson & Andrea Niessen PL0963* (holotype: [flowers in spirits] COCO).

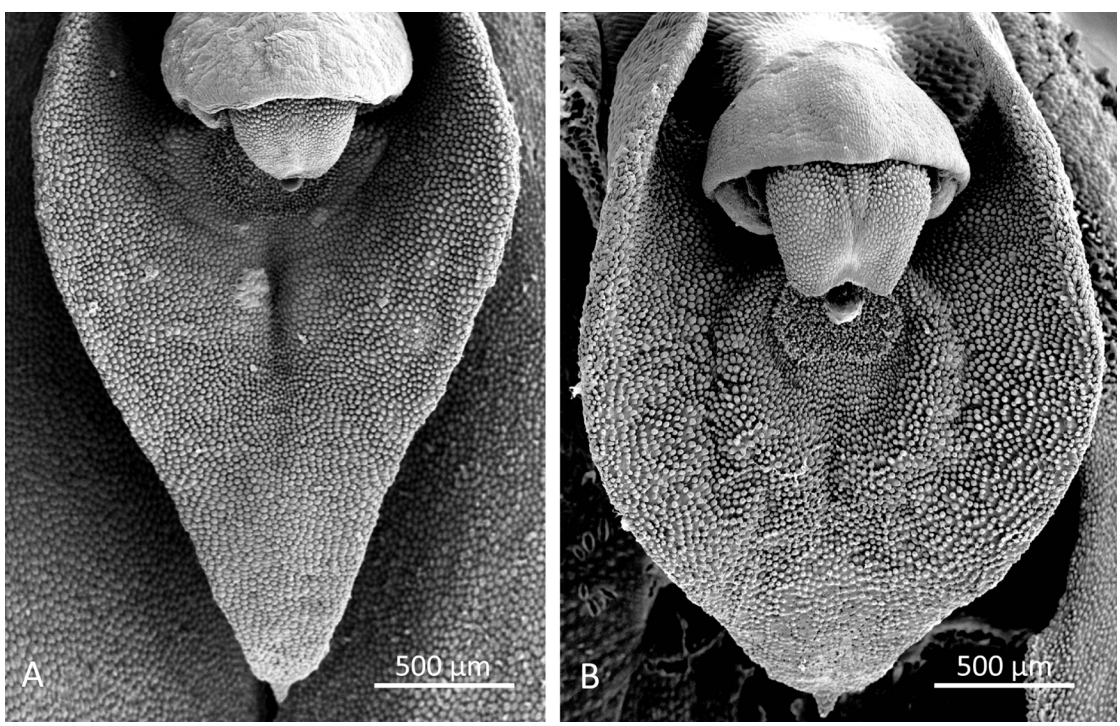


Figure 4. Scanning electron micrographs of lip (dorsal view). A. *Pleurothallis tenuisepala*. (Micrograph by Kehan Zhao, Hailey Hampson and Mark Wilson from material of *M. Wilson & Andrea Niessen PL0963* used to prepare holotype). B. *Pleurothallis luctuosa* (Micrograph by Kehan Zhao and Mark Wilson from *P. luctuosa* PL0071.)

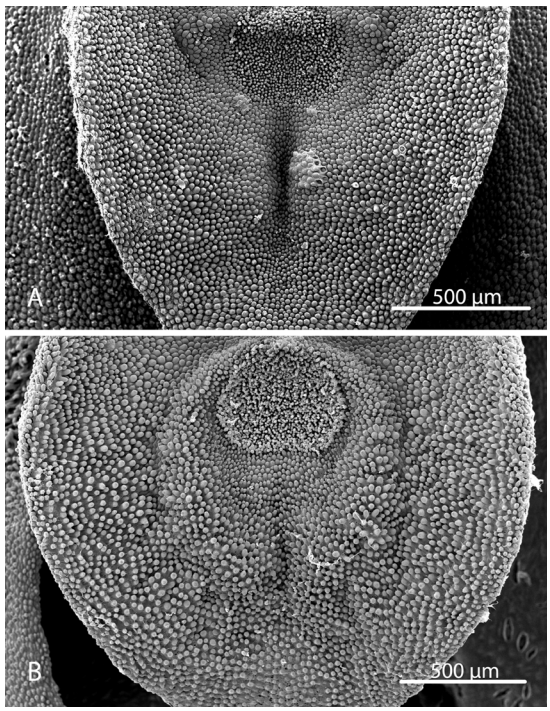


Figure 5. Scanning electron micrographs of lip and glenion (dorsal view). A. *Pleurothallis tenuisepala*. (Micrograph by Kehan Zhao, Hailey Hampson and Mark Wilson from material of *M. Wilson & Andrea Niessen PL0963* used to prepare holotype). B. *Pleurothallis luctuosa* (Micrograph by Kehan Zhao and Mark Wilson from *P. luctuosa* PL0071.)

This species can be distinguished from *Pleurothallis luctuosa* by: the size of the flowers (approximately 60 mm in length in *Pleurothallis tenuisepala* versus approximately 29 mm in *P. luctuosa*); the relative length of the sepals and petals (sepals approximately four-times the length of the petals in *P. tenuisepala* versus less than twice in *P. luctuosa*); and by the shape of the lip (hastate with moderately deep medial sulcus below the glenion in *P. tenuisepala* versus scutate with horseshoe-shaped callus surrounding the glenion in *P. luctuosa*).

Plant small to medium, to ~15 cm tall, epiphytic, caespitose. *Roots* slender, fibrous, densely fasciculate. *Ramicauls* suberect, slender, terete, 2.4–5.5 cm long, enclosed near the base by a papyraceous sheath, 10–19 mm long. *Leaves* suberect to spreading, narrowly ovate-lanceolate, acute, minutely mucronate, base sessile, cuneate, 7.6–10.2 × 1.0–1.4 cm, coriaceous, channeled along midrib. *Inflorescence* arching, distichous, few (4–6)-flowered raceme, ~8 cm long, emerging from a reclining spathaceous bract at leaf base, 4–7 mm long, peduncle 2.7 cm long, rachis internode 1.4 cm long, floral bract tubular, membranous, 4.6 mm long, pedicel 10.8 mm long. *Ovary* pale green, 3.0–3.3 mm long. *Flower* ~60 mm from tip of dorsal sepal to tip of synsepal. *Dorsal sepal* pale purple, lanceolate, concave at base, edges involute toward apex, glabrous, 3-veined, 29 × 2.8 mm. *Synsepal* pale purple, toward apex, lanceolate, concave at base, edges involute toward apex, glabrous, 4-veined, 29 × 2.8 mm. *Petals* pale purple, ovate-subfalcate, acuminate, 3-veined, 7 × 2 mm, glabrous, margin irregularly dentate. *Labellum* pale yellow-green lightly suffused with purple, ~2.8 × 1.2 mm (unexpanded), tri-lobed, central lobe with basal glenion, shallow channel above glenion, tip apiculate, curved, basal lobes clasping the column, margins irregular. *Column* pale yellow-green lightly suffused with purple, stout, 1.5–1.7 × 0.6 mm, subapical anther, bilobed stigma, short column foot. *Pollinarium* two obovate yellow pollinia, 0.50 × 0.18 mm. *Capsule* unknown.

Additional material studied: Colombia. Cauca. Parque Nacional Natural Gorgona. *D. Mora 0009*, 16th December, 2018 (CUVC-spirit!). Colombia. Cauca. Parque Nacional Natural Gorgona. *Killip and Garcia 33162*, 1939 (US!). Colombia. Flowered in cultivation at Marie Selby Botanical Gardens without collection data apart from country, *F.L.Stevenson 61874-14*, 2nd October, 1975 (SEL!). Colombia. Cauca. Popayán from collection of Amalia Lehmann, flowered in cultivation at Colomborquídeas, Medellin, Colombia, *C.Luer 17556*, 23rd May 1995 (SEL!). Colombia. Cauca. Road between Uribe and Quebradito, Km. 81, 2200 m, cultivated by Amalia Lehmann in Popayán, *C.Luer 8180*, 21st October 1982 (SEL!). (Note: The location "Quebradito" does not exist in the area of Popayán and is probably a mistake, the correct location likely being Quebradillas, López de Micay, Cauca.) Confiscated from the farm of JB-JCM. Unknown origin. *Juan Camilo Ordóñez Blanco JACOB 1394*, 20th February 2012 (JBB!). Colombia. Grown in cultivation, but thought to have been collected near Santa Cecilia, Risaralda, *Carlos Uribe Velez*, April 2019 (HPUJ 29767).

Etymology: *Pleurothallis tenuisepala* for the delicate, graceful, narrow sepals.

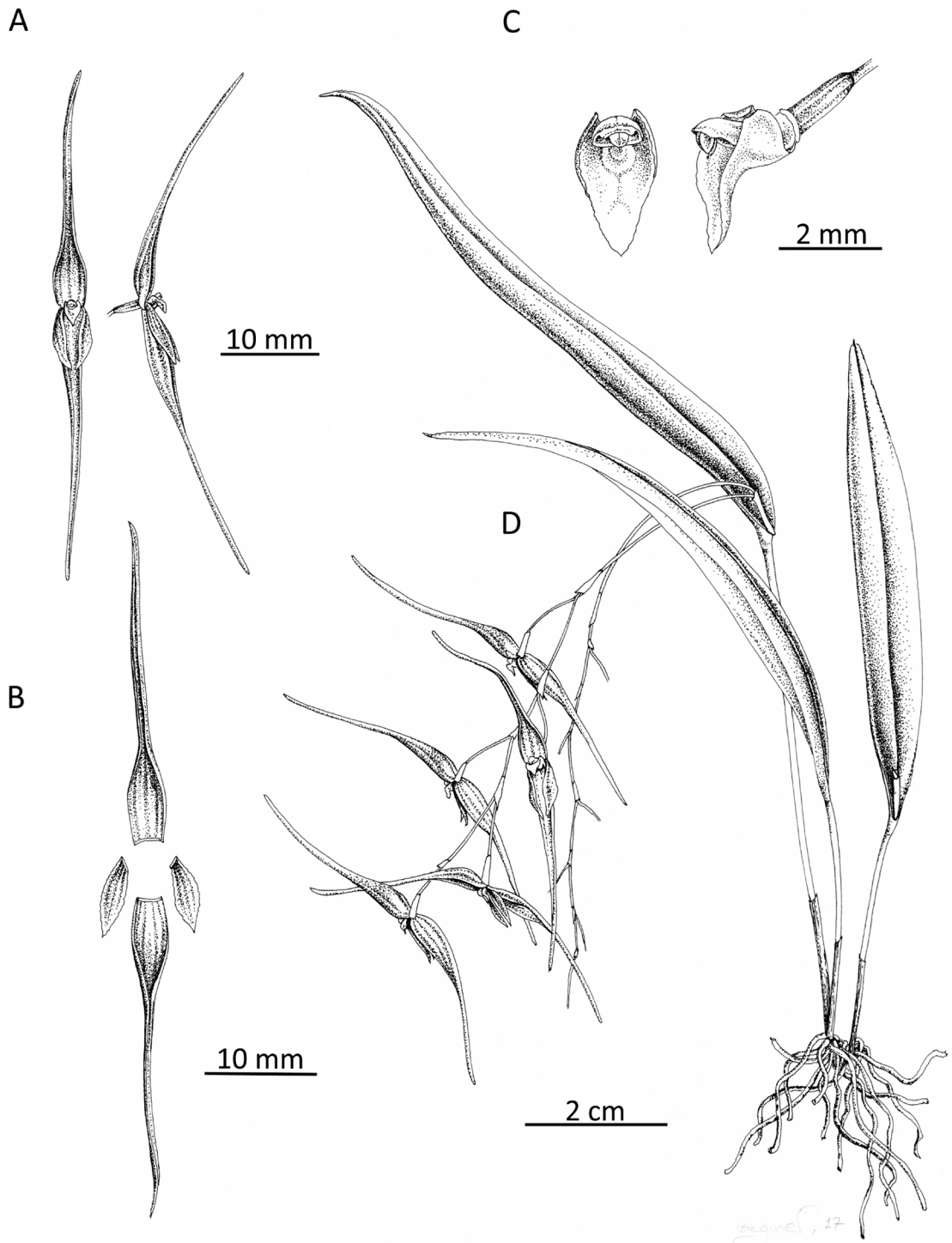


FIGURE 6. *Pleurothallis tenuisepala* drawing. A. Whole flower front and side view. B - Dissected flower. C. Lip and column, front view and ¾ views. D. Whole plant. (Drawing by Işik Güner from material of *M. Wilson & Andrea Niessen PL0963* used to prepare holotype.)

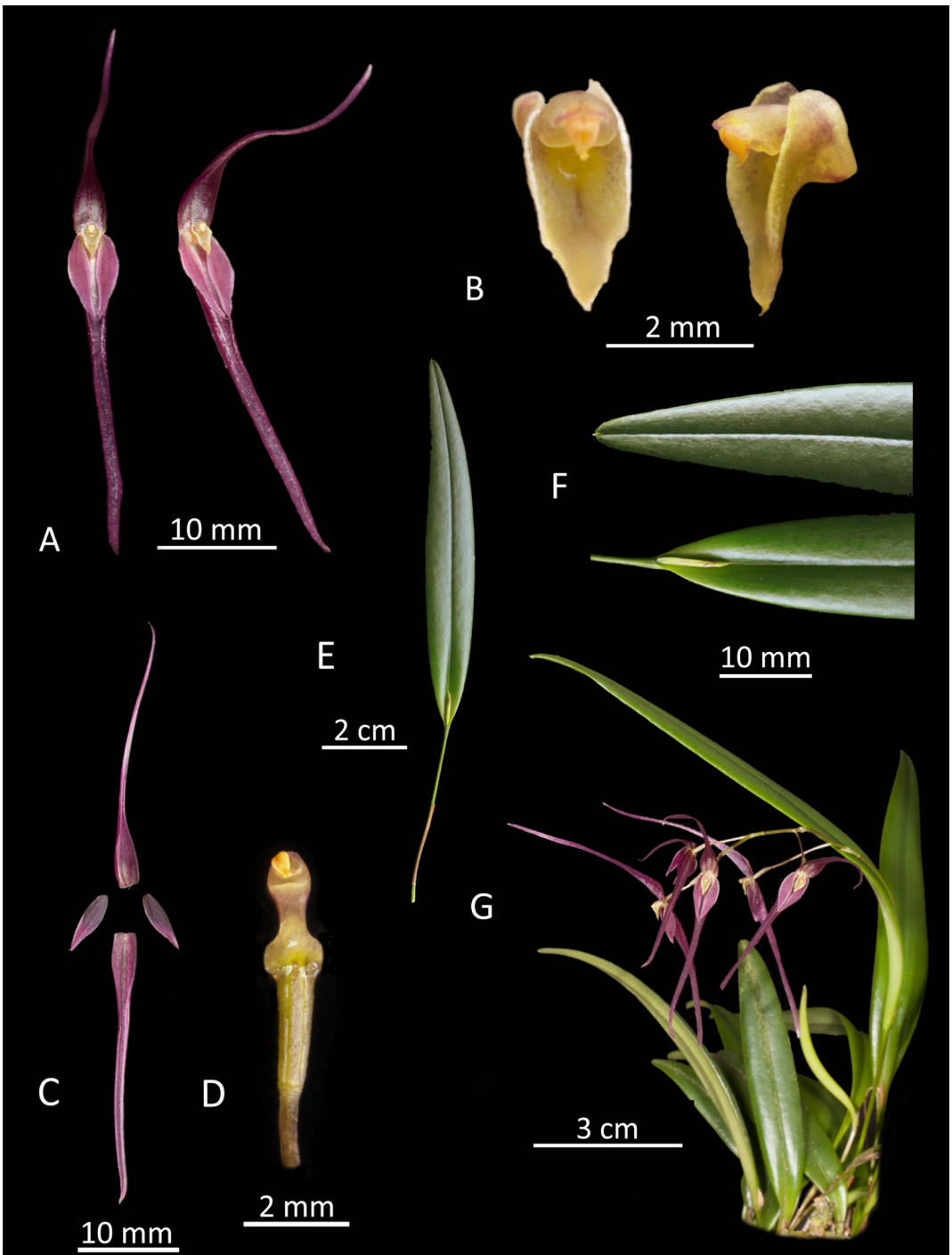


Figure 7. *Pleurothallis tenuisepala* Lankester composite dissection plate (LCDP). A. Whole flower, front and three quarters views. B. Lip and column, front and ¾ views; C. Dissected flower. D. Column and ovary, ventral view. E. Whole leaf; F. Leaf, apex and base. G. Whole plant with inflorescence. (Prepared by Mark Wilson from material of *M. Wilson & Andrea Niessen PL0963* used to prepare holotype.)

FIGURE 8. *Pleurothallis tenuisepala* water color painting. (Painting by Işik Güner from material of *M. Wilson & Andrea Niessen PL0963* used to prepare holotype.)

Distribution and habitat: As far as we know, *Pleurothallis tenuisepala* was first collected from the Parque Nacional Natural (PNN) Gorgona, an island off the Pacific coast of Cauca, Colombia, by Killip and Garcia on February 11th, 1939 (US 1770144; Fig. 9) at an elevation of 50–100 m in dense forest along a stream. It was collected again in PNN Gorgona by Mora in 2018. However, it has also been collected from the road between Quebradillas and Uribe, northwest of Popayán, Cauca, Colombia at an elevation of 2200 m, on the Pacific slope of the Cordillera Occidental. This distribution and elevation range are somewhat surprising and future molecular examination of multiple samples from each location may reveal distinct genotypes corresponding to elevational ecotypes. These two locations may represent relict populations of what was previously a much more widely distributed species at intermediate elevations in forest that has now been destroyed.

Conservation status: While the Pacific lowland forests of the Chocó biogeographic region have experienced high levels of deforestation, the populations of *Pleurothallis tenuisepala* in PNN Gorgona are presumed secure at this time, having been observed recently. It is unknown, however, whether the higher elevation population from northwest of Popayán, which may represent a distinct ecotype of *P. tenuisepala*, still exists. It is possible that the species is extant within the boundaries of the nearby Parque Nacional Natural Munchique. Until further information on distribution and abundance can be obtained *P. tenuisepala* should be considered data deficient (DD) according to IUCN criteria.

Discussion. Although previously misidentified, *Pleurothallis tenuisepala* from Cauca, Colombia is very easily distinguished from the Costa Rican species *Pleurothallis luctuosa* based on floral morphology. How then could such a misidentification occur? Vegetatively the species are indeed very similar and both produce lax racemes of pale purplish flowers. It is likely that Luer had not seen living material of *P. luctuosa* in Costa Rica when, presumably in comparison to the drawings by Reichenbach and Endrés, or to the type material, he concluded that the Ecuadorian species was *P. luctuosa*. A drawing under that name was included in *Icones Plantarum Tropicarum series I* (plate 242 - Dodson *et al*. 1980). Then, in 1991, upon examination of the material from PNN Gorgona collected by Killip and Garcia, presumably due to the similarity with the Ecuadorian material, Luer identified this Colombian specimen to also be *P. luctuosa* (Fig. 9). Subsequently, the use of the *P. luctuosa* drawing from *Icones Plantarum Tropicarum* in the monograph on subsection *Acroniae* (Luer 1998) cemented the belief that the species in Ecuador and Colombia were *P. luctuosa*, that is until the identification was questioned by Pupulin *et al*. (2010).

We agree with Pupulin *et al*. (2010) that the species identified by Luer as *Pleurothallis luctuosa* from Santo Domingo de Las Tsáchilas, Ecuador (Dodson *et al*. 1980, Luer 1998) is not *P. luctuosa*. We cannot yet conclusively say whether the Ecuadorian species is distinct from the Colombian *Pleurothallis tenuisepala*, though preliminary analyses suggest that it is and that the Ecuadorian material represents a distinct species. Studies of herbarium collections and living material of this species are ongoing at this time and will be published in a separate paper.

To date, *Pleurothallis tenuisepala* has been collected from only two confirmed locations in the Department of Cauca, Colombia: in PNN Gorgona, on Isla Gorgona, an island off the Cauca coast; and on the Pacific slope of the Cordillera Occidental near the eastern border of Parque Nacional Natural Munchique, northwest of Popayán, Cauca. The species was also photographed and collected some time ago and has been maintained in cultivation by Uribe Velez and is thought to have come from near Santa Cecilia, Pueblo Rico, Risaralda, Colombia (Ortiz Valdivieso & Uribe Velez 2007, Uribe Velez, pers. comm.). Other than Cauca, and possibly Risaralda, we found no evidence that *P. tenuisepala* has been collected from any other Colombian Departments. While the species may historically have had a wider distribution in the lowland and mid-elevation forests of the Pacific slopes of the Andean Cordillera Occidental of Colombia, part of the Chocó biogeographic region, the only recently confirmed locality is that on Isla Gorgona. To our knowledge, *P. luctuosa* does not occur in Colombia and collections in herbaria identified as *P. luctuosa* from southwest Colombia are in fact all *P. tenuisepala*.

Contemporary disjunct species distributions, like

FIGURE 9. *Pleurothallis tenuisepala* collection Killip and Garcia 33162 (US 1770144) from Isla Gorgona with identification by Luer in 1991 as *Pleurothallis luctuosa*. (Courtesy herbarium of the Smithsonian National Museum of Natural History.)

that exhibited by collections labeled *Pleurothallis luctuosa* from Costa Rica and Colombia, are not necessarily indicative of the presence of undescribed, so-called "cryptic", species. Relatively recent anthropogenic disturbances such as deforestation may have resulted in the extirpation of intervening populations or the intervening areas may have been poorly collected. However, in this instance, the morphological differences combined with the geographic separation indicate that *Pleurothallis tenuisepala* is distinct from *P. luctuosa*. This example further reinforces that *Pleurothallis* species characterized as widely-distributed and morphologically variable, particularly those with disjunct distributions, should be examined closely for the presence of cryptic species. Within *Pleurothallis*, such studies have already revealed new species in the *Pleurothallis crocodiliceps* Rchb.f. complex (Wilson *et al*. 2017a); the *Pleurothallis cardiothallis* Rchb.f. complex (Pupulin *et al*. 2017a); and the *Pleurothallis phyllocardia* Rchb.f. complex (Pupulin *et al*. 2017b). Priorities for future examination of widely-distributed, morphologically variable species include: *Pleurothallis bivalvis* Lindl., *Pleurothallis cordata* Lindl., *Pleurothallis lilijae* Foldats and *Pleurothallis microcardia* Rchb.f., each of which seems to consist of multiple entities (Luer 2005).

In addition to the morphological differences and the disjunct distribution, *Pleurothallis tenuisepala* and *Pleurothallis luctuosa* exhibited an approximately 0.9% difference in nrITS sequences (7 nucleotides out of 765 bp). Several other authors working in the Pleurothallidinae have utilized sequence data to support the description of new species (Meyer *et al*. 2012, Ramos-Castro *et al*. 2012, Karremans *et al*. 2015). However, there is no accepted minimum percentage sequence difference in nrITS between so-called "sister" species in Pleurothallidinae (Karremans *et al*. 2015), nor can there be, since different lineages have evolved at different rates. In a discussion of genetic differences between sister species in Pleurothallidinae, Karremans *et al*. (2015) suggest that nrITS sequences may vary from ~0.25% between the sister species *Specklinia dunstervillei* Karremans, Pupulin and Gravend. and *Specklinia endotrachys* (Rchb.f.) Pridgeon & M.W.Chase up to ~1% between *Specklinia marginata* (Lindl.) Pridgeon & M.W.Chase and *Specklinia* sp. This would place the difference between *P. tenuisepala* and *P. luctuosa* at the upper end of that range, thereby providing additional support for the contention that these are distinct species.

Returning to morphology, Luer (1986) coined the term "glenion", from the Greek *glene*, for "socket or eyeball" (Luer, pers. comm.), for the small, often circular, area of differentiated tissue on the hypochile of the labellum, under the gynostemium or column. Luer (1986) commented that the glenion was often "*shiny or sticky*" and opined that "*undoubtedly it plays a part in attracting pollinators*". Using SEM, Wilson *et al*. (2016) examined the glenion of *Pleurothallis nangaritzae* M.M.Jiménez, Tobar & Mark Wilson and *Pleurothallis rubrifolia* Mark Wilson, Tobar & Salas Guerr. of subsection *Macrophyllae-Fasciculatae*. They hypothesized that the glenion "*acts not just to attract the pollinator but that it serves to position the pollinator in the optimal position for pollinarium acquisition or deposition.*" Wilson *et al*. (2018) further noted that the vast majority of species in subsection *Macrophyllae-Fasciculatae* possess such a glenion. In SEM micrographs of the labellum of *Pleurothallis caucensis* Mark Wilson, from subsection *Macrophyllae-Racemosae*, Wilson *et al*. (2017b) observed a deposit resembling dried liquid partially covering the glenion and the subtending sulcus. Sandoval Mojica (2018) sampled the secretions from the lip of *Pleurothallis coriacardia* Rchb.f. and found these secretions to consist of ~13% sugar. These observations taken together lead us to hypothesize that the glenion, along with other areas of the *Pleurothallis* lip, secrete a liquid, sugar-based pollinator attractant/reward essential to the pollination process.

In SEM micrographs, the labella of both *Pleurothallis tenuisepala* and *Pleurothallis luctuosa* both exhibit a glenion. The glenion of *P. tenuisepala* consists of loosely-packed columnar or papillose cells, surrounded by a region of densely-packed cells forming a slightly raised callus. The glenion is subtended by a sulcus which we hypothesize allows a liquid reward from the glenion to flow by either capillary action or gravity into the mesochile region to act as a pollinator attractant/reward. The glenion of *P. luctuosa* similarly consists of loosely-packed papillose cells, but instead is surrounded by a distinctly raised, hippocrepiform callus. A very shallow sulcus subtends the opening in the callus and, again, we hypothesize that a liquid reward flows from the glenion into the sulcus, providing an attractant/reward to position the pollinator optimally for pollinarium acquisition or deposition. Studies

are ongoing to address the hypothesis that the glenion in *Pleurothallis* acts as a "nectary" producing a sugar-containing, nectar-like pollinator attractant/reward in subsections *Acroniae*, *Macrophyllae-Fasciculatae* and *Macrophyllae-Racemosae*; and, further, that the presence of a glenion and production of a pollinator reward is the ancestral state in subgenus *Pleurothallis*.

In addition to these studies on labellar morphology and secretions, future studies in the *Acroniae* will examine the species from Santo Domingo, Pichincha, Ecuador, to determine whether it is distinct from *Pleurothallis tenuisepala* and will investigate the phylogenetic relationships between *P. tenuisepala*, *Pleurothallis* sp. "Santa Domingo" and the other members of the Central and South American subsection *Acroniae*.

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Literature Cited

Dodson, C. H., Dodson, P. M., Vásquez, R., Hamer, F., Mora, D. E., Atwood, J. & Bennet, D. E. (1980). *Icones Plantarum Tropicarum*, Series I, Fascicle 2. Sarasota, Florida: The Marie Selby Botanical Gardens.

Doucette, A., Portilla, J., Medina, H. & Cameron, K. (2017). A new species of *Pleurothallis* (Orchidaceae: Pleurothallidinae) from Ecuador. *Phytotaxa*, 295(2), 194–198.

Karremans, A. P., Pupulin, F. & Gravendeel, B. (2015). *Specklinia dunstervillei*, a new species long confused with *Specklinia endotrachys* (Orchidaceae: Pleurothallidinae). *PLoS ONE*, 10(7), e0131971.

Luer, C. A. (1986). *Icones Pleurothallidinarum* III: Systematics of *Pleurothallis*. *Monographs in Systematic Botany*, 20, 1–109.

Luer, C. A. (1998). *Icones Pleurothallidinarum* XVII: Systematics of subgen. *Pleurothallis* sect. *Abortivae*, sect. *Truncatae*, sect. *Pleurothallis*, subsect. *Acroniae*, subsect. *Pleurothallis*, subgen. *Dracontia*, subgen. *Unciferia*. *Monographs in Systematic Botany from Missouri Botanical Garden*, 72, 1–121.

Luer, C. A. (1999). Nuevas especies de *Pleurothallis* de Colombia. *Orquideología*, 21(2), 115–134.

Luer, C. A. (2005). *Icones Pleurothallidinarum* XXVII: *Dryadella* and *Acronia* section *Macrophyllae-Fasciculatae*. *Monographs in Systematic Botany from Missouri Botanical Garden*, 103, 1–311.

Luer, C. A. (2009). Miscellaneous new species in the Pleurothallidinae (Orchidaceae). *Selbyana*, 30(1), 1–71.

Luer, C. A. (2011). Miscellaneous new species in the Pleurothallidinae (Orchidaceae) excluding species from Brazil. *Harvard Papers in Botany*, 16(2), 311–360.

Luer, C. A. & Thoerle, L. (2012). Miscellaneous new species in the Pleurothallidinae (Orchidaceae). *Harvard Papers in Botany*, 17(2), 333–369.

Luer, C. A. & Thoerle, L. (2013). Miscellaneous new species in the Pleurothallidinae (Orchidaceae). *Harvard Papers in Botany*, 18(2), 173–196.

Meyer, G., Baquero, L. & Cameron, K. M. (2012). A new Ecuadorian species of *Dracula*: Pleurothallidinae (Orchidaceae). *Orchideen Journal*, 19, 107–113.

Ortiz Valdivieso, P. & Uribe Velez, C. (2007). *Galería de orquídeas de Colombia.* CD. Bogotá, Colombia: Da Vinci Editores.

Pérez-Escobar, O. A., Chomicki, G., Condamine, F. L., Karremans, A. P., Bogarín, D., Matzke, N. J., Silvestro, D. & Antonelli, A. (2017). Recent origin and rapid speciation of Neotropical orchids in the world's richest plant biodiversity hotspot. *New Phytologist*, 215, 891–905.

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, 2286–2308.

Pupulin, F., Bogarín, D. & Fernández, M. (2010). Illustrations and studies in Neotropical orchids. 2. A note on *Pleurothallis luctuosa* (Orchidaceae: Pleurothallidinae), with a new species. *Annalen des Naturhistorischen Museums in Wien*, *B*, 112, 1–14.

Pupulin, F., Díaz-Morales, M., Aguilar, J. & Fernández, M. (2017a). Two new species of *Pleurothallis* (Orchidaceae:

Pleurothallidinae) allied to *P. cardiothallis*, with a note on flower activity. *Lankesteriana*, 17(2), 329–356.

Pupulin, F., Díaz-Morales, M., Fernández, M. & Aguilar, J. (2017b). Two new species of *Pleurothallis* (Orchidaceae: Pleurothallidinae) from Costa Rica in the *P. phyllocardia* group. *Lankesteriana*, 17(2), 153–164.

Ramos-Castro, S. E., Castañeda-Zárate, Solano-Gómez, R. & Salazar, G. A. (2012). *Stelis zootrophionoides* (Orchidaceae: Pleurothallidinae), a new species from Mexico. *PLoS ONE*, 7(11), e48822.

Reichenbach, H. G. (1877). *Pleurothallis luctuosa. Linnaea*, 41, 48.

Sandoval Mojica, A. C. (2018). Aspectos de la biología floral y visitantes florales de *Lepanthes monoptera* Lindl. y *Pleurothallis coriacardia* Rchb.f. (Pleurothallidinae: Orchidaceae) dos especies de orquídeas epífitas en la Reserva Forestal Protectora El Malmo. Tesis, Universidad Pedagógica y Tecnológica de Colombia, Tunja.

Sun, Y., Skinner, D. Z., Liang, G. H. & Hulbert, S. H. (1994). Phylogenetic analysis of *Sorghum* and related taxa using internal transcribed spacers of nuclear ribosomal DNA. *Theoretical and Applied Genetics*, 89, 26–32.

Tropicos. (2019). Tropicos. Missouri Botanical Garden, Missouri, USA. Retrieved on March 2nd 2019 from http://www.tropicos.org/Home.aspx

Viveros, P. & Higgins, W. E. (2007). Checklist of Pleurothallidinae from Colombia. *Selbyana*, 28(1), 13–90.

Wilson, M., Baquero, L., Dupree, K., Jiménez, M. M., LeBlanc, C. M., Merino, G., Portilla, J., Salas Guerrero, M., Tobar Suárez, F. & Werner, J. D. (2016). Three new species of *Pleurothallis* (Pleurothallidinae; Orchidaceae) in subsection *Macrophyllae-Fasciculatae* from northern South America. *Lankesteriana*, 16(3), 349–366.

Wilson, M., Dupree, K., Driessen, W., Larsen, B. T., Löckher, A., Niessen, A., Portilla, J., Salas Guerrero, M., Suarez, M. A. & Tobar Suárez, F. (2017a). A clarification of the taxonomy of *Pleurothallis crocodiliceps* Rchb.f. (Pleurothallidinae, Orchidaceae) and four new species of *Pleurothallis* in subgenus *Ancipitia*. *Lankesteriana*, 17(2), 165–191.

Wilson, M., Dupree, K., Garcia Lopera, D., Haelterman, D., Kay, A., Mesa Londoño, C., Niessen, A., Pinnix, W., Portilla, J. & Werner, J. (2017b). A new species of *Pleurothallis* (Orchidaceae: Pleurothallidinae) from Valle del Cauca, Colombia and a note on the relationship between subsections *Macrophyllae-Racemosae* and *Antenniferae*. *Lankesteriana*, 17(2), 119–131.

Wilson, M., Zhao, K., Hampson, H., Frank, G., Romelroux, K., Jiménez, M. M., Tobar, F., Larsen, B. & Pérez, A. (2018). A new species of *Pleurothallis* (Orchidaceae: Pleurothallidinae) in subsection *Macrophyllae-Fasciculatae* with a unique, highly reduced, morphologically distinct labellum. *Lankesteriana*, 18(3), 217–230.

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HABENARIA AGASTHYAMALAIANA (ORCHIDACEAE), A NEW TERRESTRIAL ORCHID FROM THE SOUTHERN WESTERN GHATS, INDIA

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Abstract. *Habenaria agasthyamalaiana*, a new species of terrestrial orchid is described from Shendurney Wildlife Sanctuary of Agasthyamalai biosphere reserve, a part of the South-western Ghats. This species is morphologically similar to *Habenaria crinifera*. Detailed description and photographs are provided for identification of this new taxon.

Key words: Agasthyamalai, Kerala, Kollam, New species, Shendurney wildlife sanctuary, Western Ghats

Introduction. The mountain chain of the Western Ghats biogeographic zone older than the Himalaya has geomorphic features of immense importance with unique geology, flora and fauna and ecology. The Western Ghats forest ecosystem moderates the tropical climate of the region and has an exceptionally high level of biological diversity and endemism. It is recognized as one of the world's eight 'hottest hotspots' of biological diversity along with Sri Lanka. The Western Ghats is an "Evolutionary Ecotone" and the region demonstrates speciation related to the breakup of the ancient landmass of Gondwanaland and is hence considered as a cradle for biological evolution. More than 7,000 of the plant species have been recorded from the Western Ghats with the number of endemics estimated to be 2,253 (Nayar *et al.* 2014). The historical human presence in the Western Ghats makes it an area of high conservation interest (Joshi *et al*. 2017). The region harbors two Biosphere Reserves, 15 National Parks, 52 Wild Life Sanctuaries, nine Tiger Reserves and 39 UNESCO World heritage sites. During the recent orchid exploration in the Shendurney Wildlife Sanctuary, Kerala, a part of the Agasthyamalai biosphere reserve in the southern Western Ghats, the first author located an interesting *Habenaria* population. This entity was morphologically similar to *Habenaria crinifera* Lindl., however we studied it because of significant morphological differences.

Habenaria Willdenow (1805: 5) (Orchidinae, Orchidoideae, Orchidaceae) is a large genus of approximately 883 terrestrial species (Govaerts *et al*. 2018) distributed throughout the tropical and subtropical regions of the Old and New World (Pridgeon *et al.* 2001), with centers of diversity in Brazil, southern and central Africa and East Asia (Kurzweil & Weber 1992). Most species are perennial, geophytes, with a growth associated with a wet season followed by a dormant period in the form of an underground root tuber during the dry season (Batista *et al*. 2013). There are 69 species reported in India and 39 of them are found in the Western Ghats, with 22 being endemic (Nayar *et al.* 2014, Kumar *et al.* 2016). Kerala is also one of the biodiversity rich state harboring 258 orchid species of which 29 species of *Habenaria* (Nayar *et al.* 2014). Specimens of this entity were collected and measurements were made using fresh material. The flowers were dissected and examined under the Stereozoom microscope SZ61 and description was written. The entity is characteristic by conspicuous flowers, a tripartite lip with a bifurcate midlobe which is shorter than lateral lobes. The specimen was compared with the allied species *Habenaria crinifera* and *Habenaria plantaginea* Lindl. (Table 1). Based on the examination of a fresh specimen and comparison with the known species of the genus, we conclude that our taxon represents new undescribed species which is described here.

Taxonomic treatment

Habenaria agasthyamalaiana Jalal, Jayanthi & Sureshkumar, ***sp. nov.*** Fig. 1–5A.

TYPE: INDIA. Kerala: Kollam District, Shendurney Wildlife Sanctuary, on the way to Rosemala, 550 m elev., 12 October 2018, *J.S.Jalal 197753* (holotype BSI!; isotype BSI!).

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TABLE 1. Comparative morphological characters and distribution range of *Habenaria agasthyamalaiana sp. nov., H. crinifera* and *H. plantaginea.*

Character	*H. agasthyamalaiana*	*H. crinifera* Lindl.	*H. plantaginea* Lindl.
Habit	Terrestrial	Terrestrial or epiphytic	Terrestrial
Height	35–40 cm	15–30 cm	20–40
Flowers in inflorescence	8–11	2–9	up to 16
Floral bracts	lanceolate, entire at margin, 1-veined	ovate, serrulate at margin, 3-veined	ovate-lanceolate, entire at margin, 1-veined
Dorsal sepal	ovate, white	orbicular, greenish	broadly ovate, white
Lateral sepals	obliquely ovate, white	broadly ovate, white	obliquely lanceolate-ovate, white
Petals	oblong-oblanceolate	linear-pandurate	elliptic-oblanceolate
Lip	3-lobed, distinctly clawed (Fig. 5A)	3-lobed, distinctly clawed (Fig. 5B)	3-lobed, obscurely clawed (Fig. 5C)
Side lobes of lip	longer than midlobe, obliquely flabellate, long acuminate at divergent end of the apex	shorter than midlobe, obliquely flabellate-narrow, long caudate at divergent end of the apex	almost equal to midlobe, obliquely flabellate, acute-obtuse at divergent end of the apex
Midlobe of lip	divided into 2 equal to unequal lobules; lobules oblong, obtuse at apex	divided into 2 lobules, obliquely flabellate-narrow, long caudate at divergent end of the apex	not divided, acute-obtuse at apex
Spur	4.5 cm long, without ligule at mouth	2.7–3.5 cm, with a long erect ligule at mouth	3–3.5 cm long, with ligule at mouth
Distribution	southern Western Ghats	throughout Western Ghats & Sri Lanka	throughout India, Bangladesh, Bhutan, Nepal, Sri Lanka

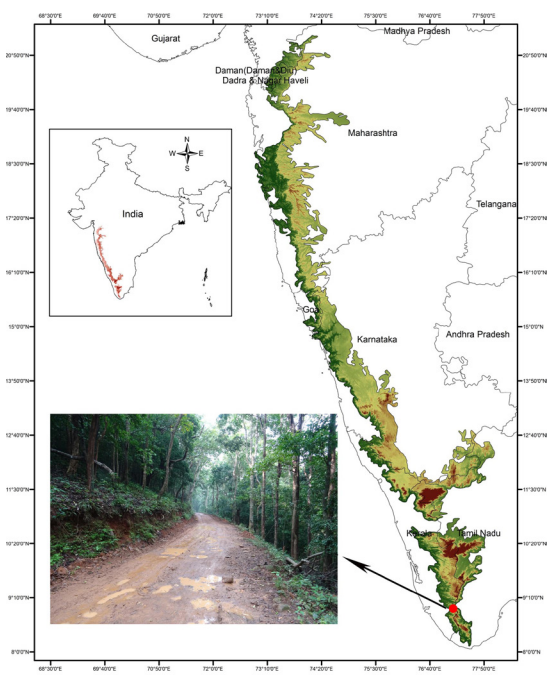

FIGURE 1. Distribution map of *Habenaria agasthyamalaiana sp. nov*. in Western Ghats (DEM data source- Earth Explorer Aster Global, USA; map prepared by J. S. Jalal in ArcGIS 10.5).

FIGURE 2. *Habenaria agasthyamalaiana* in natural habitat showing close up of inflorescence. Photos by J. S. Jalal.

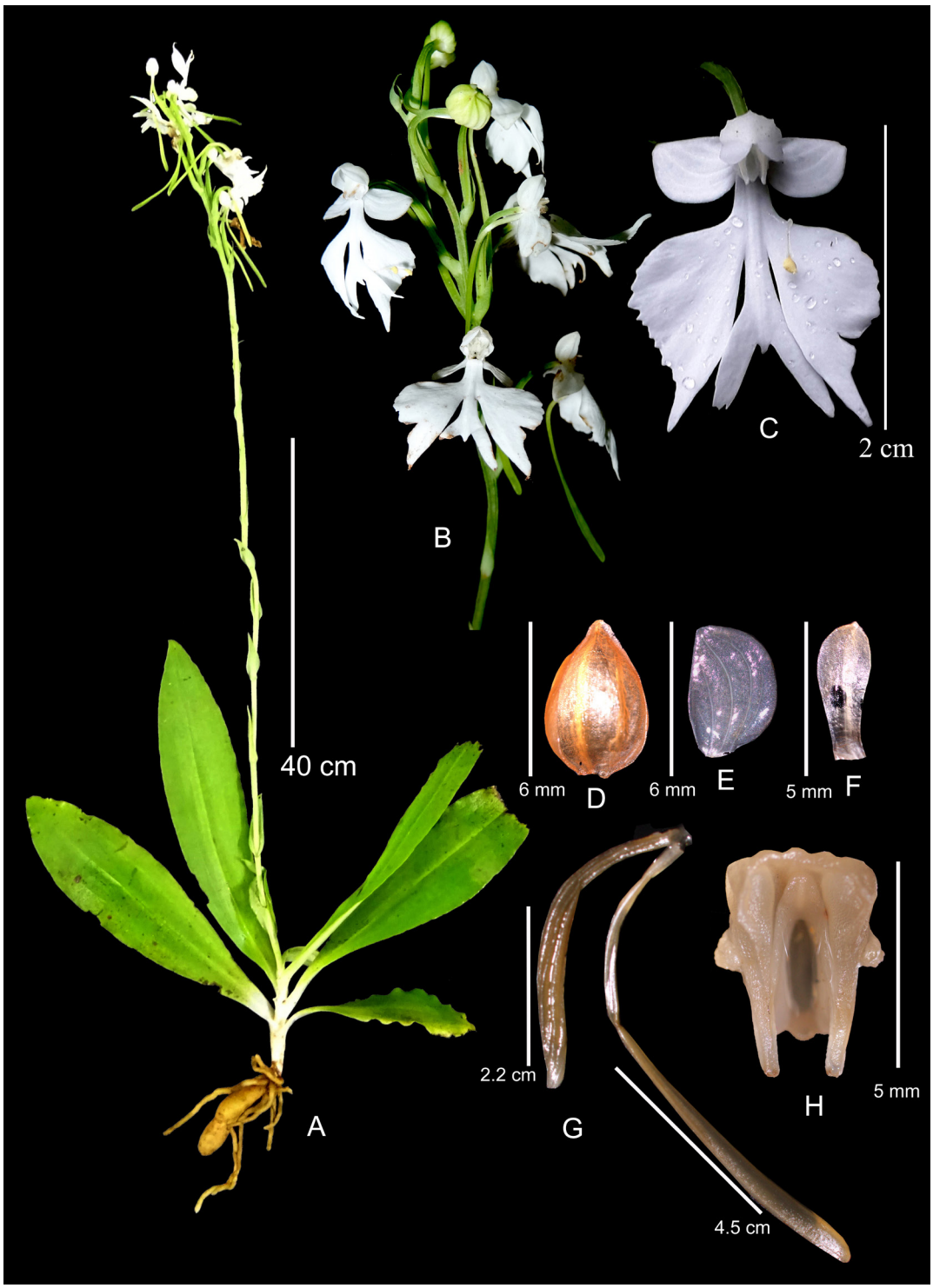

FIGURE 3. *Habenaria agasthyamalaiana* A. Habit. B. Inflorescence showing view of flowers. C. Front view of flower. D. Dorsal sepal. E. Lateral sepal. F. Petal. G. Ovary with pedicel and spur. H. View of column. Photos by J. S. Jalal.

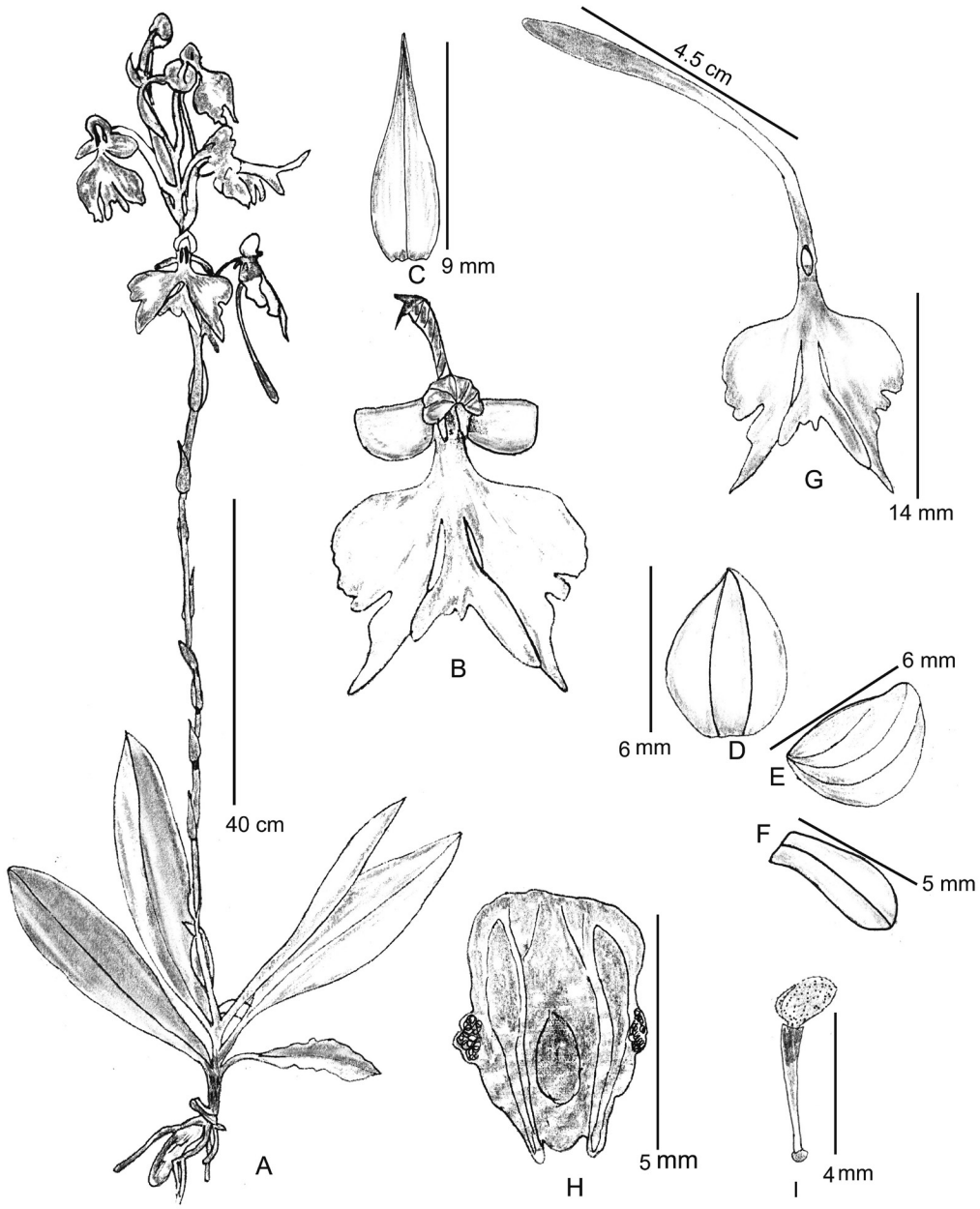

FIGURE 4. *Habenaria agasthyamalaiana* A. Habit. B. View of flower showing lip. C. Floral bract. D. Dorsal sepal. E. Lateral sepal. F. Petal. G. Lip and spur. H. View of column. I. Pollinia. Drawing by J. S. Jalal.

DIAGNOSIS: *Habenaria agasthyamalaiana* is distinguishable by having subradical leaves, with conspicuous flowers, with 3-lobed lip, bifurcate midlobe shorter than lateral lobes. It is closely similar to *H. crinifera* but differs by having up to 11 flowers in inflorescence, floral bracts entire at margin, side lobes of lip longer than midlobe, side lobes acuminate at apex and midlobe bifurcate with obtuse lobes (vs. side lobes and midlobe of lip with long caudate apex).

Terrestrial *herbs*, 35–40 cm high (including

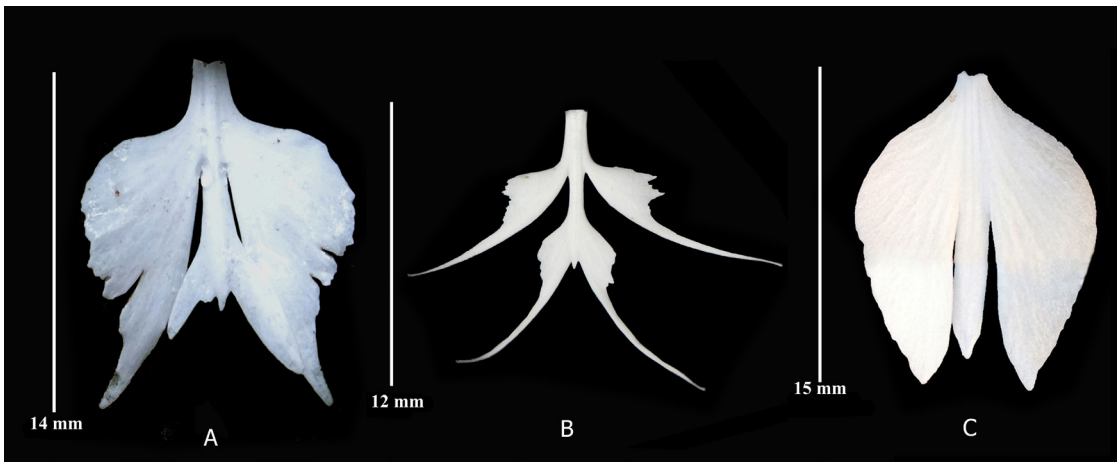

Figure 5. Comparative lip morphology A. *Habenaria agasthyamalaiana* B. *H. crinifera* (*J.S.Jalal 195200* BSI) C. *H. plantaginea* (*J.S.Jalal 200889* BSI). Photos by J. S. Jalal.

inflorescence). *Tuber* solitary, 4.0 × 1.5 cm, oblong in outline, lateral *roots* 9, arising above the tuber, 3 mm in diameter, one of the roots ending in tuberoids. *Leaves* 5–7, subradical, clustered at base, 5–15 × 1–3 cm, oblong–elliptic, entire, wavy margin, tapering and sheathed at base, acute at apex, 3-veined with midrib prominent than lateral veins. *Inflorescence* terminal, racemose, 5–6 cm long, 8–11-flowered. *Peduncle* 23–29 cm, ribbed, with 6–11 bracts. *Peduncular bracts* foliaceous, larger at basal portion, becoming smaller towards apex, 0.7–3.5 × 0.4–1.0 cm, ovate-lanceolate, entire margin, semiamplexicaul at base, acuminate at apex, 1-veined. *Floral bracts* 9 × 4 mm, lanceolate, entire margin, semiamplexicaul at base, acuminate at apex, 1-veined, shorter than ovary, and adnate to it. *Flowers* resupined, white, 2 cm across. *Ovary* with pedicel 2.2 cm long, green, swollen at basal portion, narrowed at upper portion, ribbed, curved, at 90º from the rachis. *Pedicel* 1 mm long. *Dorsal sepal* cucullated, 6 × 4 mm, cymbiform, ovate, entire margin, truncate at base, obtuse at apex, 2-veined. *Lateral sepals* spreading, 6 × 5 mm, obliquely ovate, entire margin, truncate at base, obtuse at apex, 3-veined. *Petals* 5 × 2 mm, oblong-oblanceolate, entire margin, truncate at base, apiculate at apex, 1-veined. *Lip* 3-lobed, clawed, claw 4 mm long; *lateral lobes* longer than midlobe, parallel to midlobe, curved outwards, 10–11 × 8 mm, obliquely flabellate, entire proximal margin, irregularly dentate distal margin, cuneate at base, curved outwards, long acuminate at apex; *midlobe* shorter than lateral lobes, entire margin, divided into 2 equal to unequal lobes, bifurcate-obtuse at apex, with triangular apicule at centre; *spur* much longer than ovary, 4.5 cm long, greenish-white, club-shaped, cylindrical. *Column* 5 × 2 mm, white, narrow at downwards and broad at upper portion. Connective white, shallowly undulate at apex. *Anthers* 2, whitish, straight; white anther canal, 4 mm long white. *Rostellum* slightly shorter than anthers, white, fleshy, adnate to the mouth of the spur. *Auricles* white, small, verrucose. *Pollinia* 2, yellow, 4 mm long, with round viscidium. *Fruits* unknown.

Flowering: October.

Distribution: India: Kerala, Kollam district, Shendurney Wildlife sanctuary, way to Rosemala (Fig. 1).

Habitat and ecology: The new species is found growing along the moist slopes of southern moist mixed deciduous forests on the way to Rosemala at about 550 m of elevation. This habitat is dominated by species as *Oplismenus compositus* (L.) P.Beauv. (Poaceae), *Ophiorrhiza rugosa* Wall. (Rubiaceae), *Selaginella* sp. (Selaginellaceae).

Eponymy: The specific epithet is named after the Agasthyamalai Biosphere Reserve where is the type locality of this new species.

Threats: A small population was found growing in a small area of 1 square meter. A potential threat could be the expansion of the road leading to the Rosemala area.

This new species belongs to section *Plantagineae* and characterized by the presence of subradical leaves, clustered at base, medium flower size, entire petals, 3-lobed lip, side lobes large, slightly to widely crenate-dentate to erose at margin. *Habenaria agasthyamalaiana* is very similar to *H. crinifera* but it differs by having up to 11 flowers in inflorescence, floral bracts entire at margin, side lobes of lip longer than midlobe (Fig. 5B), side lobe acuminate at apex and midlobe of lip bifurcate with obtuse apex. It also seems to *H. plantaginea* Lindl. but it differs by having distinctly clawed lip, divided midlobe of lip, long acuminate lateral lobes whereas in *H. plantaginea* (Fig. 5C) the lip is indistinctly clawed, the midlobe of lip is undivided and lateral lobes of lip acute at apex. A detailed comparison of these species is provided in Table 1.

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Literature Cited

Batista, J. A. N., Borges, K. S., de Faria, M. W. F., Proite, K., Ramalho, A. J., Salazar, G. A. & van den Berg, C. (2013). Molecular phylogenetics of the species-rich genus *Habenaria* (Orchidaceae) in the New World based on nuclear and plastid DNA sequences. *Molecular Phylogenetics and Evolution*, 67, 95–109. http://dx.doi.org/10.1016/j.ympev.2013.01.008.

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., George, A., Kreuz, K. & Wood, J. (2018). *World Checklist of Orchidaceae*. Facilitated by the Royal Botanic Gardens, Kew. Retrieved on 18 December 2018 from http://wcsp.science.kew.org/

Joshi, M., Charles, B., Ravikanth, G. & Arvind, N. A. (2017). Assigning conservation value and identifying hotspots of endemic rattan diversity in the Western Ghats, India. *Plant Diversity*, 39, 263–272. http://dx.doi.org/10.1016/j.pld.2017.08.002.

Kumar, P., Prabhukumar, K. M., Nirmersh, T. K., Sreekumar, V. B., Hareesh, V. S. & Balachandran, I. (2016). *Habenaria sahyadrica* (Orchidaceae, Orchideae) a new species from the Western Ghats (India) with critical notes on allied taxa. *Phytotaxa*, 244 (2), 196–200. https://doi.org/10.11646/phytotaxa.244.2.8

Kurzweil, H. & Weber, A. (1992). Floral morphology of Southern African Orchideae. II. Habenariinae. *Nordic Journal of Botany*, 12, 39–61.

Nayar, T. S., Sibi, M. & Beegam, A. R. (2014). *Flowering plants of the Western Ghats, India*. Palode, India: Jawaharlal Nehru Tropical Botanic Garden and Research Institute.

Pridgeon, A. M., Cribb, P. J., Chase, M. C. & Rasmussen, F. N. (2001). *Genera Orchidacearum, Vol. 2, Orchidoideae (part 1)*. Oxford: Oxford University Press.

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A NEW AND SHOWY SPECIES OF *LEPANTHES* (ORCHIDACEAE: PLEUROTHALLIDINAE) FROM NORTH-WESTERN ECUADOR

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Abstract. A new species of *Lepanthes* from north-western Ecuador is presented here. *Lepanthes mashpica* is similar to *L. satyrica*, with a long, descending, triangular process of the body of the lip but different in the simple and acute appendix versus the vertically bilobed appendix of *L. satyrica.* The species was found growing in several locations of Mashpi Reserve, a low-land cloud forest close to Quito.

Resumen. Se presenta aquí una nueva especie de *Lepanthes* del noroeste de Ecuador. *Lepanthes mashpica* es similar a *L. satyrica*, con el cuerpo del labelo largo, descendente y triangular pero se diferencian en el apéndice simple y agudo del labelo en *L. mashpica* comparado con el apéndice verticalmente bilobado en *L. satyrica.* La especie se encontró creciendo en varias localidades dentro de la Reserva Mashpi, un bosque nublado de tierras bajas cercano a Quito.

Keywords / Palabras clave: Ecuadorean orchids, *Lepanthes mashpica, Lepanthes satyrica*, orquídeas del Ecuador, Mashpi Reserve, Reserva Mashpi

Introduction. New species of *Lepanthes* Sw. are discovered each year at the orchid rich country of Ecuador (Dodson 2004, Baquero *et al.* 2018, Tobar *et al.* 2018, Baquero 2018, Thoerle & Hirtz 2015). The genus, with more than 1,100 species, is one of the largest in the Orchidaceae (Karremans 2016). The species of *Lepanthes* are recognized by the ramicauls enclosed by lepanthiform sheaths, flowers with transversely expanded petals with two or three lobes, a complex lip (with some exceptions) with a body connecting a pair of blades which normally embrace the column, and a very small structure at the base of the lip called the appendix (Luer 1996). The appendix is present in species which are pollinated by small gnats under the pseudo-copulation syndrome where the male insects confuse the structures with the female genitalia and pollinate the orchids under the attempt to copulate (Blanco & Barboza 2005).

Some species have lips with simple structures and without appendixes. Such is the case of species like *Lepanthes calodictyon* Hook., or the recently discovered *L. kayii* Baquero (Luer 1996, Baquero 2018). Other species of *Lepanthes* have complex lips with appendixes but also other unique structures of the lip. *Lepanthes ollaris* Luer & R.Escobar has a body of the lip greatly dilated and saccate into a pot-like structure, *L. menatoi* Luer & R.Vázquez and *L. ricina* Luer & Dalström have lips with the inner surface of the blades with curtains of long pubescence covering the column (Luer & Thoerle 2011). Some species have a body with a long protruding, descending process like *Lepanthes satyrica* Luer & Hirtz from Ecuador. A species discovered in 2016 and described here has also a long descending process from the body of the lip similar to what is seen in *Lepanthes satyrica.*

The new species was found growing in low-land cloud forest of Mashpi Reserve from north-western Ecuador, Pichincha Province. The Mashpi Lodge, built in the heart of the Mashpi Reserve, has no previous research concerning orchids. The new species presented here is an example of how little is known of the orchids from Mashpi Reserve.

Taxonomic treatment

Lepanthes mashpica Baquero & T.S.Jaram, ***sp. nov.*** (Fig. 1–4B)

TYPE: Ecuador. Pichincha: Reserva Mashpi, 1000 m, 0°9’30.6”N, 78°53’7.8”W, 13 September 2017. *L. Baquero, T. Jaramillo. LB 3145* (holotype: QCNE).

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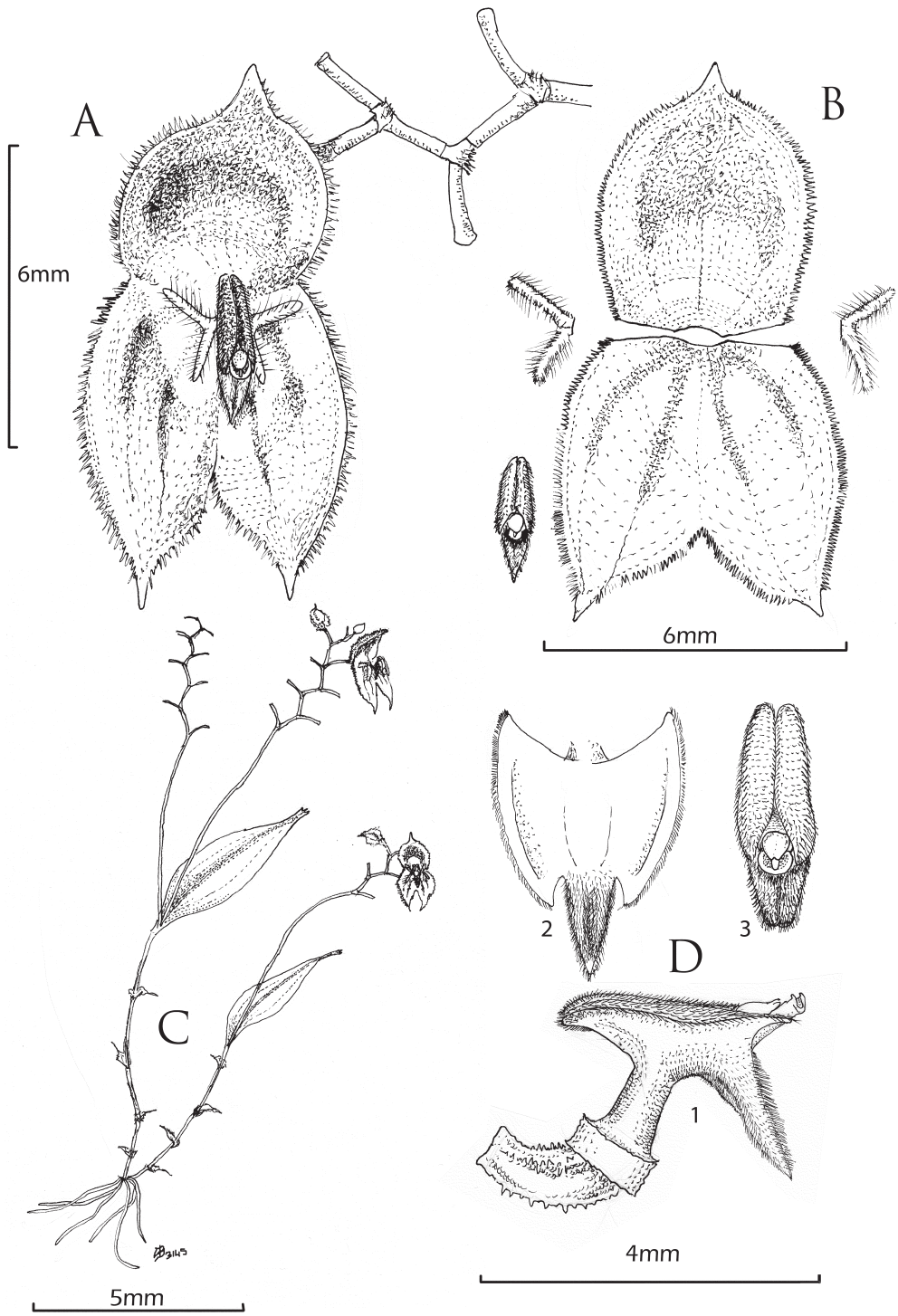

FIGURE 1. Illustration of *Lepanthes mashpica* Baquero & T.S.Jaram. A. Flower. B. Dissected perianth. C. Habit. D. Column and lip. D1. Ovary, column and lip, side view. D2. Lip in expanded position. D3. Lip in normal position. Drawn by Luis E. Baquero from the plant that served as the holotype.

Figure 2. Photographs of the flower of *Lepanthes mashpica* Baquero & T.S.Jaram. A. Frontal view. B. Lateral view. Photographs by Luis E. Baquero.

Diagnosis: *Lepanthes mashpica* is most similar to *L. satyrica* Luer & Hirtz, both bearing a lip with an elongated, descending, triangular process. *Lepanthes mashpica* is distinguished by the spiculate margins of the sepals (vs. minutely cellular-denticulate), the long-pedicellate, inflorescence, successively several-flowered raceme, borne near the apex of the leaf (vs. short inflorescence, successively few-flowered raceme, borne close to the base of the leaf), the petals very small, transversely bilobed, upper and lower lobes similar in size and shape, narrowly oblong, hispid (vs. transversely bilobed petals with a minute apiculum on the margin between the lobes, the upper lobe long-pubescent, the lower lobe, short-pubescent), a lunate and curved apex of the rostellum (vs. truncate, straight apex of the rostellum) and the appendix simple, acute and pubescent (vs. vertically bilobed appendix) (Fig. 1–3).

Plant epiphytic, sympodial, caespitose *herb* up to 10 cm tall. *Roots ca*. 0.7 mm in diameter. *Ramicauls* slender, erect to horizontal, elongated, thin, 1–4 cm long, enclosed by 5–9 apiculated at the apex, acuminated, tightly fitting acuminate lepanthiform sheaths. *Leaf* green, thinly coriaceous, narrowly ovate, acute, the base cuneate, the apex tridentate, lightly-sulcated at adaxial side, 2.8–3.5 × 1.2–1.5 cm. *Inflorescence* a lax, distichous, flexuous, successively flowered raceme up to 50 mm long, including the rachis, borne by a filiform peduncle 25–35 mm long, erect; *floral bracts* spiculate, 0.7 mm long; *pedicels* 3 mm long. *Ovary* costate, spiculate, 1.0–1.3 mm long. *Flower* with sepals translucent yellow suffused with orange, petals yellow, column rose, and lip yellow suffused with red, orange and purple, the apex of the rostellum yellow, anther cap rose. *Sepals* carinate and spiculate along the veins on the abaxial surface. *Dorsal sepal* glabrous at the adaxial side, spiculate at the margin, broadly obovate, acuminate, shallowly concave, 3-veined, broader than the lateral sepals, 7.1 × 4.5 mm, connate to the lateral sepals for 1.4 mm. *Lateral sepals* glabrous, spiculate at the margins, ovate, acuminate, connate 2.3 mm into a synsepal, 7.5 × 4.1 mm, each individual sepal free for

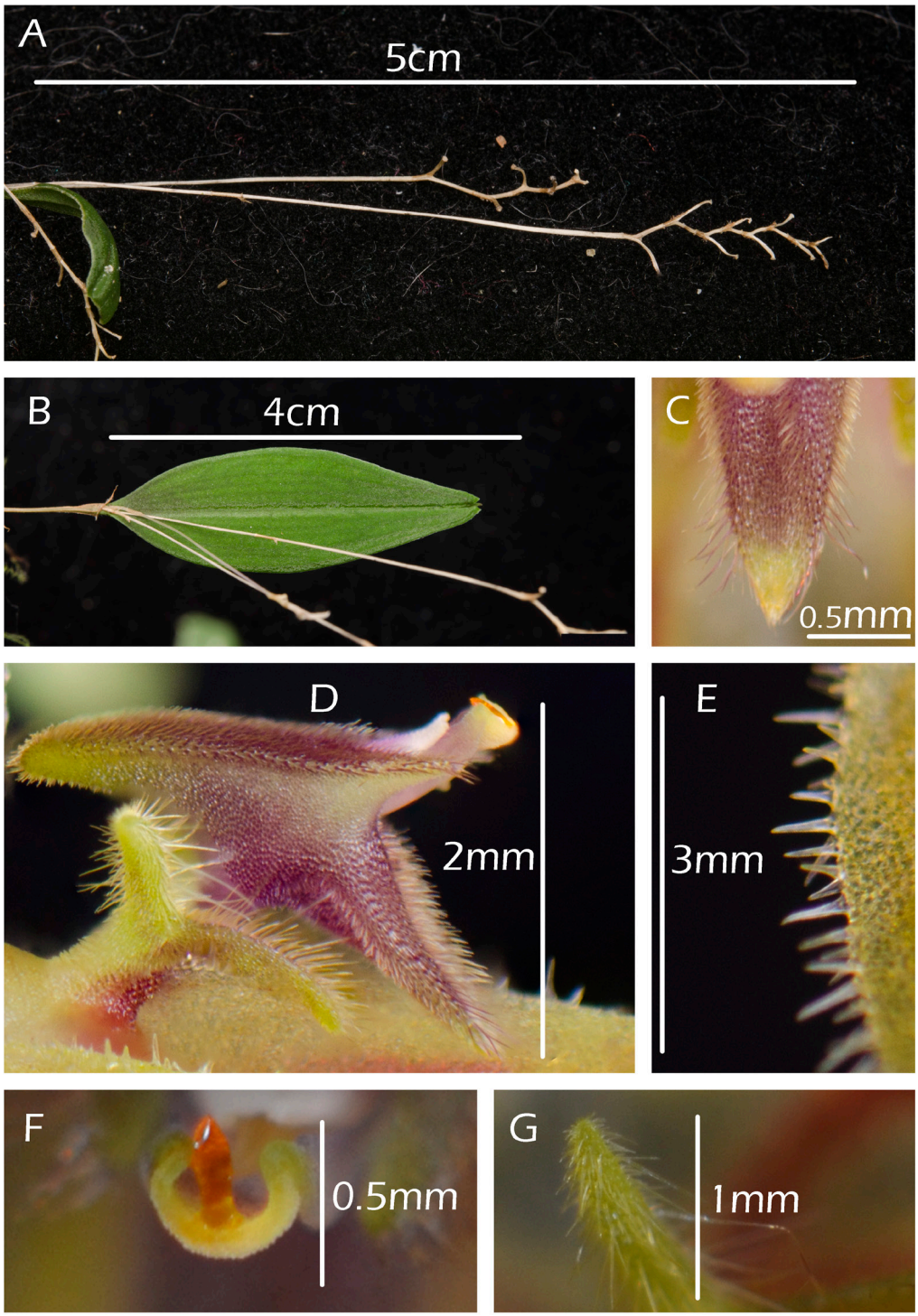

FIGURE 3. Details of *Lepanthes mashpica* Baquero & T.S.Jaram. A. Flexuous inflorescence and peduncle. B. Leaf from dorsal view. C. Apendix. D. Side view of lip and column, E. Spiculated margins of sepals. F. Detail of lunate rostellum. G. Hispid upper lobe of a petal. Photographs by Luis E. Baquero.

Figure 4. Comparison of the most similar species to *Lepanthes mashpica* Baquero & T.S.Jaram. A. *Lepanthes mashpica* (frontal view). B. *Lepanthes mashpica* (¾ *view*). C. *Lepanthes acrogenia,* D. *Lepanthes satyrica,* E. *Lepanthes hirsutula,* F. *Lepanthes thoracica*. Photographs by Luis E. Baquero (A, B and F), Sebastian Moreno (C and E), and Andreas Kay (D).

ca. 3 mm, 2-veined. *Petals* transversely bilobed, hispid (with long, rigid hairs), the lobes linear, 0.12 × 2.60 mm, the upper lobe 1.2 mm long, the lower lobe 1.4 mm long. *Lip* bilaminate, the blades oblong, touching for two thirds of their length, acute, slightly curved, and separated towards the apex of the column, pubescent, 2.8 mm long; the connectives broadly cuneate, oblique, connate above the base of the column, 0.8 mm long, the body with and elongated, descending, triangular, densely pubescent process 1.7 mm long, with an acute, yellow, pubescent appendix. *Column* terete, 1 mm long, the anther dorsal and stigma ventral, the apex of the rostellum conspicuous, lunate, curved. *Anther cap* obovate, 0.3 mm long. *Pollinia* 2, pyriform, attached to a detachable viscidium, 0.3 mm long. *Capsule* not seen.

Toponymy: Named after Mashpi Reserve where it was first found and thrives.

Habitat and ecology: *Lepanthes mashpica* is so far, endemic to the Mashpi Reserve and grows close to Mashpi Lodge. It was first found in 2017 very close to the lodge, at 1000 m in elevation growing on a fallen branch near the "Magnolia trail". After years of research, more plants have been found growing in Mashpi Reserve at different elevations between 800 and 1200 m. This species has been seen growing with other species of pleurothallids like *Lepanthes bituberculata* Luer & Hirtz, *L. pretiosa* Luer & Hirtz and *Pleurothallis ruscifolia* (Jacq.) R.Br. sometimes in the same branch. It has always been found growing in slender branches and adult plants rarely having more than three ramicauls. Although no fruits have been seen it is common to see adult and seedlings growing together which means the species gets pollinated frequently and reproduces easily from seed in its habitat.

Phenology: This species has been observed blooming at its habitat, in different months during consecutive years. It appears to bloom all year round.

This species has relatively big flowers for the genus and pretty color combination. The long inflorescences bear one open flower at a time, successively producing up to 10 flowers on each inflorescence. Due to the long process of the body of the lip, the concave and wide dorsal sepal, and the connate lateral sepals *Lepanthes mashpica* is most similar to *Lepanthes satyrica* from farther north but it is easily distinguished by the comparatively bigger flowers blooming from long inflorescences, longer than the comparatively wider leaves. Other characteristics, less obvious, like the different shape of the appendix (slender and acute in *L. mashpica* vs. vertically bilobed in *L. satyrica*) or the petals (very small in proportion to the rest of the flower, bilobed with two finger-like upper and lower lobes in *L. mashpica* vs. bigger in proportion to the rest of the flower with and apiculum between the lobes in *L. satyrica*) immediately distinguishes both species (Luer 1996, Luer & Thoerle 2011) (Fig. 3–4).

Other species of *Lepanthes* have a long process in the body of the lip like *L. acrogenia* Luer & R.Escobar, *L. ectopa* Luer, *L. hirsutula* Luer & Hirtz, *L. skeleton* Luer & R.Escobar, and *L. thoracica* Luer & Hirtz, but *L. mashpica* can easily be distinguished from them by the bigger and yellow flowers with conspicuously spiculated flowers in the margins and in the adaxial side of the sepals with tiny filiform, bilobed petals (Luer 1996, Luer & Thoerle 2011, 2012) (Fig. 3–4).

Conservation status: Several and healthy populations have been found along the years close to Mashpi Lodge and all grow within the Mashpi Reserve limits. The species is not considered to be under risk of extinction for some time in the future. We suggest to place it under the IUCN "Data Deficient" category since it might grow even outside Mashpi Reserve and there is not enough information to assure it is under threat at the moment.

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Literature Cited

Baquero, L. E. (2018). A new species of *Lepanthes* (Orchidaceae: Pleurothallidinae) from northwestern Ecuador. *Phytotaxa*, 343(1), 75–81.

Baquero, L. E., Moreno, J. S. & Iturralde, G. A. (2018). The Four Footed *Lepanthes* (Pleurothallidinae), a new species from north-western Ecuador. *Lankesteriana*, (18)3, 183–188.

Blanco, M. A. & Barboza, G. (2005). Pseudocopulatory pollination in *Lepanthes* (Orchidaceae: Pleurothallidinae) by fungus gnats. *Annals of Botany*, 95(5), 764–772.

Dodson, C. H. (2004). *Native Ecuadorian Orchids II: Dresslerella-Lepanthes*. Quito, Ecuador: Imprenta Mariscal.

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

Luer, C. A. (1996). *Icones Pleurothallidinarum XIV*. Systematics of *Draconanthes, Lepanthes* subgenus *Marsipanthes* and subgenus *Lepanthes* of Ecuador. *Monographs in Systematic Botany from the Missouri Botanical Garden*, 61, 1–255.

Luer, C. A. & Thoerle, L. (2011). *Lepanthes* Sw. and affiliates. *In* C. Persson & B. Stahl, *Flora of Ecuador*, 88, 13–405. Goteborg: Botanic Institute, Goteborg University.

Luer, C. A. & Thoerle, L. (2012). *Icones Pleurothallidinarum XXXII*. *Lepanthes* of Colombia (Orchidaceae). *Monographs in Systematic Botany from the Missouri Botanical Garden*, 123, 1–296.

Thoerle, L. & Hirtz, A. (2015). Three new *Lepanthes* species (Pleurothallidinae, Orchidaceae) from Ecuador. *Phytotaxa*, 201, 50–62.

Tobar, T., López, M. F., Muñoz-Upegui, D. & Richter, F. (2018). Two new species of *Lepanthes* (Pleurothallidinae; Orchidaceae) from Andean forest remnant in Ibarra, Ecuador. *Phytotaxa*, 375(3), 221–228.

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ORCHID DIVERSITY IN ANTHROPOGENIC-INDUCED DEGRADED TROPICAL RAINFOREST, AN EXTRAPOLATION TOWARDS CONSERVATION

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Abstract. The uncontrolled logging in Peninsular Malaysia and the resulting mudslides in the lowland areas have been perilous, not to just humans, but also to another biodiversity, including the wild orchids. Their survival in these highly depleted areas is being overlooked due to the inaccessible and harsh environment. This paper reports on the rescue of orchids at risk from the disturbed forests for *ex-situ* conservation, the identification of the diversity of orchids and the evaluation of the influence of micro-climatic changes induced by clear-cut logging towards the resilience of orchids in the flood-disturbed secondary forests and logged forests in Terengganu and Kelantan, located at the central region of Peninsular Malaysia, where the forest destruction by logging activities has been extensive. 109 orchid species belonging to 40 genera were collected from the disturbed areas. The diversity and data analyses show that the disturbed secondary forests had a higher orchid density (0.0133 plants/m^2) than the logged sites (0.0040 plants/m^2) as the habitat conditions were more dependable. Nevertheless, the logged forests harboured a higher diversity of orchids (H=4.50 and D=0.99) of which 97.9% were epiphytes. Eleven rare species were found along with six species endemic to Peninsular Malaysia, with two species new to science. The results highlighted the factors that allow the orchids to flourish or suffer in the disturbed forests. The logged forests had a higher ambient temperature and lower moisture level than the mud flood-disturbed and canopy-covered secondary forests. Apart from the extensive ground vegetation due to logs dragging extraction, low soil moisture and absence of leaf litter were believed to be the major attributes causing the low abundance of terrestrial orchids. The high abundance and diversity of epiphytic orchids and the large difference of their densities between the logged sites were influenced by the densities of fallen trees hosting orchid(s), disturbance-induced dryness stresses, durations of exposure to the anthropogenic-induced disturbance, and less favourable soil conditions for the terrestrial orchids.

Key words: conservation, diversity, dryness stress, ecology, epiphyte, logged forest, mudslides, Orchidaceae

Introduction. Kuala Koh, Kelantan and Tasek Kenyir, Terengganu are the largest and commonly visited parts of the Peninsular Malaysia's National Park. Both are located in the northeast states of Peninsular Malaysia. Tasek Kenyir is an artificial lake formed by Kenyir Dam or the Sultan Mahmud Hydro-Electric Power Station, which took 15 years to be constructed and fully operate in 1978. Both areas are gazetted as a protected forest reserve under the Taman Negara (Kelantan) Enactment [En. 14 of 1938] and the Taman Negara (Terengganu) Enactment [En. 6 of 1939]. These Acts are independent from The National Parks Act 1980. These areas have many geological and biological attractions (Hairul *et al.* 2016), apart from being home for the aboriginal tribes of Semaq (Hulu Terengganu) and Bateq (Kuala Koh, Kelantan). The tribal people forage the forest for food and medicines apart from hunting and fishing for their daily necessities (Ramle 1993, Fatanah 2009, Ramle *et al.* 2014, Abdullah *et al.* 2017). Topographically, the Kuala Koh and its adjacent area consist of riverine, largely hill and lowland dipterocarp forests. The shaded and humid environment encourages the growth of mosses on the trees, creating niches suitable for moisture-loving epiphytes. In over logged forest, epiphytic orchids are also found growing in abundance on the ground and on rocks, and a few relying on dead debris living as myco-heterotrophs. However, both terrestrial and epiphytic orchids have experienced population declined mainly because of habitat degradation and timber extraction

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process, which have caused many species to near extinction (Larson 1992, Rauh 1992, Dimmitt 2000, Mondragon & Calvo-Irabien 2006).

The Orchidaceae is a speciose family of considerable significance in horticulture (Hew *et al.* 1997), and traditional medicine, with many species in various genera having been reported to have therapeutic properties (Pant 2013). Unfortunately, many orchids are naturally rare, endangered, or vulnerable, for climate and habitat changes that are often anthropogenic, and from over-collection for horticulture and medicine. Some 972 species of orchids in 159 genera have been recorded in Peninsular Malaysia (Go & Hamzah 2008, Go *et al.* 2010, Kiew *et al.* 2010, Ong *et al.* 2017). About twenty percent of them are endemic to Peninsular Malaysia (Seidenfaden & Wood 1992, Turner 1995, Ong *et al.* 2011). Until recently, a total of 245 orchid species were collected from Terengganu and 223 orchid species from Kelantan as documented in SING Herbarium (2018, January), Swiss Orchid Foundation at the Herbarium Jany Renz (2017, July), National Herbarium of the Netherlands (NHN) (2017, July), Turner (1995), and Jaafar *et al.* (2007).

In recent years, human activities in Kuala Koh and around Tasek Kenyir have directly threatened the survivability of biodiversity including orchids. Kuala Koh and its vicinities are now blatantly known to have the highest rate of deforestation in Peninsular Malaysia. A large tract of forest near the National Park entrance has been cleared for farming, mining and logging (Tuck-Po 2000, Lye 2005, Hairul *et al*. 2016). Forest clearance has spread extensively to Tasek Kenyir area. The clay exposed cleared land caused surface water run-off and land erosion due to lack of retention from grasses, trees, and shrubs had caused the 2014 tragic flash floods and mudslides in the lowland areas of Terengganu and Kelantan. Based on our empirical observations, the uncontrolled and unsustainable timber production might have concurrently shoved the epiphytic orchid flora towards local extinction. The canopy disruptions caused by timber extractions have greatly modified the temperature, humidity, and light conditions, causing unfavourable habitat for the shade-loving species (Gradstein 2008, Benítez *et al*. 2015). Thus, the extremely harsh conditions in the logging sites (logged forests) where full exposure to the sun, water stress, and nutrient-poor soil due to the eroded topsoil and nutrient were detrimental for the orchid survival (Wan Mohd Shukri *et al*. 2007). Coupled with rampant forests destruction in the surrounding areas, the mudslides have also negatively affected the ecosystem balance, especially for the forest floor biodiversity including terrestrial orchids and waterways.

Deforestation and the global climate change have been largely ignored by the authority due to lack of assessing personnel willing to work in dangerous fragile logging sites, thus a stumbling block for conservation efforts to protect forest biodiversity including orchids in Malaysia. Because of their ecological, economical and pharmaceutical importance, an exhaustive evaluation on the diversity and ecology of orchids in the degraded forest areas is crucial for setting its conservation priorities. Hence, this paper focuses on reporting the diversity and distribution of orchids at risk in the degraded forests by uncovering the significance of ecological alterations that are negatively affecting their survival and to provide inference for *ex-situ* conservation plans.

Materials and Methods

Selection of field sampling localities and ecosystems.– The study areas were classified based on the type of disturbance: disturbed secondary forests (DSFs) damaged by mudslides, and logging sites. Observations and botanical collection trips were carried out in the disturbed forests of Terengganu and Kelantan regions from November 2016 until May 2018 (Fig. 1). The areas covered in this study were DSFs in Kuala Koh, Gua Musang, Kelantan (94.4–129.9 m a.s.l.) and Air Canal, Tanah Merah, Kelantan (44 m a.s.l.); and logging sites in Tasek Kenyir, Terengganu (98.8–330.4 m a.s.l.). The disturbed forests were selected based on whether logging was imminent, currently actively logged, and the recent deadly mudslides repercussion. Eight short line-transect plots of 20 m × 5 m with a total area of 800 m^2 were established in Kuala Koh. Meanwhile, two line-transect plots of 25 m × 5 m were created in disturbed lowland secondary forest at Air Canal with the total area of 250 m^2. Three logging sites in the Tasek Kenyir area were selected as study sites. These sites were located using Google Maps and also based on an earlier preliminary empirical study. Site 1 and Site 2 of active logging were located in Gawi, and Site 3 was located in Petuang, with a total area studied

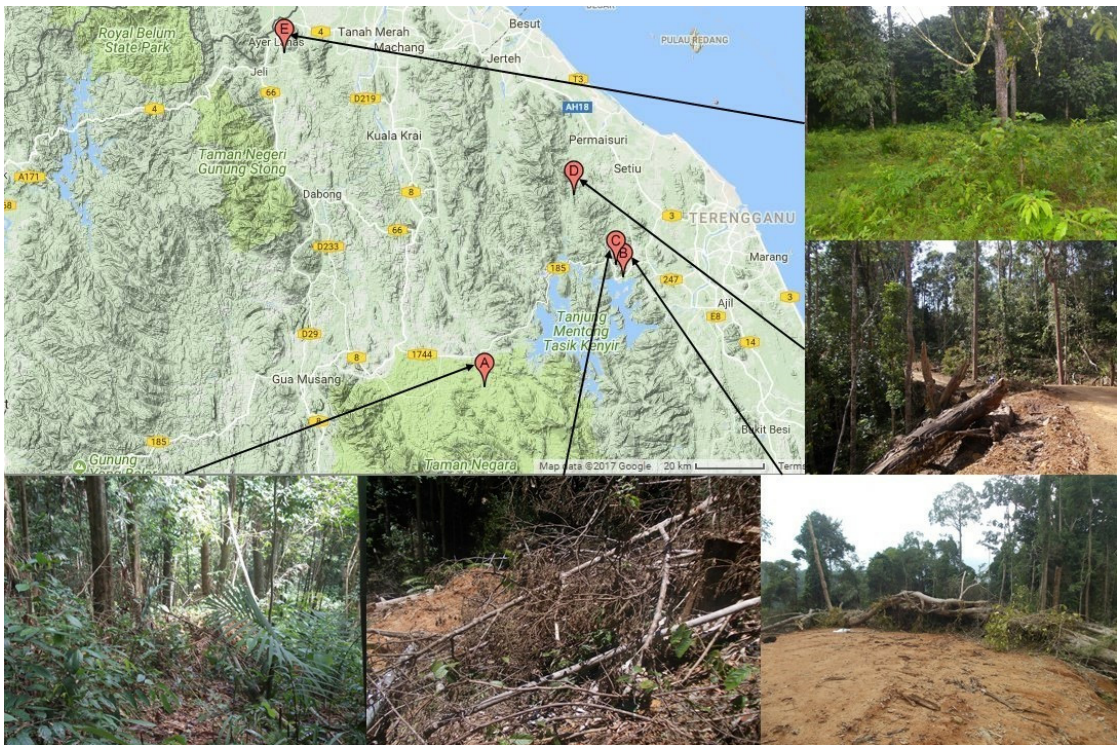

Figure 1. Coordinates of each studied site recorded in disturbed forests of Terengganu and Kelantan regions. **A.** Kuala Koh area (DSFs Site 1). **B.** Gawi area (Logging Site 1). **C.** Gawi area (Logging Site 2). **D.** Petuang area (Logging Site 3). **E.** Tanah Merah area (DSFs Site 2). The map was adapted from http://www.geoplaner.com, a free web-based application that provides several GIS and GPS services.

of approximately 53,000 m^2. The total area studied in the logging sites was calculated based on the distance traveled along the logging road in the logging site times the width of 20 m on each side of the road, and the orchids were mostly found on fallen trees.

Fieldwork and sample collection.– The systematic sampling involved choosing exploration sites based on the existence of disturbed forests in the Terengganu and Kelantan. The date and time of the sample collections were scheduled based on the type of disturbance (DSFs and logging site) and the accessibility (weighed more towards the accessing highly disturbed and risky logging site areas). Non-flowering orchids were transferred to an *ex-situ* facility in Setiu, Terengganu for further flowering monitoring to ascertain the species identity.

Sample processing and identification.– Identifiable samples (with floral structures) were preserved using standard herbarium technique after Bridson and Forman (2000) and the non-flowering ones were transplanted into the *ex-situ* nursery, as living collections, where they were nurtured until flowering usually within five to six months, depending on the species (Go *et al*. 2011). Reliable references and online databases were used in the identification process and evaluation of each species' distribution status: Seidenfaden & Wood (1992), Turner (1995), Comber (2001), Ong *et al*. (2017), the Swiss Orchid Foundation at the Herbarium Jany Renz. (2017, July), the National Herbarium of the Netherlands (NHN) accessed through Browse Dutch Natural History Collections: BioPortal (Naturalis) (2017, July), and the World Checklist of Selected Plant Families (WCSP) (2018, December). Also, expert consultations were sought to make identifications.

Diversity analyses.– Shannon-Wiener Diversity Index (H) and Simpson's Diversity Index (D) were used to determine the species richness and evenness in both

studied areas. The Shannon index in real ecosystems ranges between 1.5 and 3.5 (MacDonald 2003). The H value rarely surpasses 4.5, and if it does increase, the increment is small due to the logarithmic element in the function (Margalef 1972). The greater the value, the higher the diversity. The D value ranges between 0 and 1; 1 represents infinite diversity and 0, no diversity. The closer the value is to 1, the higher the diversity. However, these methods could not tell which factors contributed more to the value, hence, Evenness (E) was used to determine how close in numbers each species in each studied site (Help 1974). The E value is constrained between 0 and 1. The lower E value means the less evenness in the communities between the species with presence of dominant species, and the lower the diversity. The formula is derived according to Pielou's evenness index (Pielou 1966). The frequency of occurrence of each species was determined based on the number of times that particular species occurs or sighted at a specified sample plot.

In-situ measurement of ecological data.– Minimum (min) and maximum (max) values for four ecological parameters were recorded from morning (10:00 a.m.) to afternoon (4:00 p.m.) time in the studied disturbed forests of Terengganu and Kelantan: temperature (ºC), air relative humidity (ARH) (1–100%), soil moisture (SM) (1–10%), and light intensity (Lux or lx).

Data analyses.– All the data were recorded in a spreadsheet, and the following parameters were computed as follows: 1) Density of the orchid species within a plot (plants/m^2): Number of orchid species within the plot (plants) / Total area of the plot (m^2); 2) Density of fallen trees hosting orchid(s) within a plot (plants/m^2): Number of fallen trees in the plot hosting orchids (plants) / Total area of the plot (m^2); and 3) Relative abundance of orchid (%Ao): [Number of clump or population of a particular orchid species within the plot / Total number of all orchid clumps or populations of the plot] × 100.

Statistical analyses.– The ecological data were analysed using IBM SPSS version 19. Non-parametric Kruskal-Wallis one-way analysis of variance (ANOVA) with multiple pairwise comparisons ($p<0.05$) was used to determine the significant relationship of the ecological parameters between the different studied sites with distinctively different disturbance types. The significant difference of mean between groups was determined by comparing directly between the min values recorded for DSFs with min values recorded for logging sites and were also evaluated accordingly for the max values. The Pearson's correlation coefficient was used to measure the linear relationship between the orchid abundance and their host trees; Density of the orchid species within a plot (plants/m^2) and Density of fallen trees hosting orchid(s) within a plot (plants/m^2).

Results

Abundance and distribution pattern.– 132 orchid specimens of 109 orchid species belonging to 40 genera were collected from the disturbed forests (Table 1). Of these, 116 orchid specimens belonging to 96 species were recorded from the Tasek Kenyir logging sites, whereas, 16 specimens of 14 species were recorded from the DSFs. 93.3% of the total number of orchid species collected were epiphytes and 3.7% were terrestrials. Based on Table 1, orchid species collected from the disturbed forests were largely Epidendroideae subfamily with 107 species (98.2%), and only one species was from Orchidoideae (0.9%) and Apostasioideae (0.9%) subfamilies. Species of the genera *Bulbophyllum* Thouars and *Dendrobium* Sw. were found to be the most abundant orchids living in these disturbed forests. The most abundant species found in the logging sites were *Dendrobium crumenatum* Sw. (3.2%) and *Grammatophyllum speciosum* Blume (2.5%), whereas *Corymborkis veratrifolia* (Reinw.) Blume (3.2%) was abundant in the DSFs. A total of 87 species (79.8%) found in the disturbed forests were growing with a sympodial habit. The remaining 22 species (20.2%) were monopodial, of which, 12 species (11%) were climbers.

Rareness and endemism.– Ninety-two orchid species (84.4%) collected were common and widespread. Eleven orchid species (10.1%) were rare (recorded with a very narrow endemic range or less than five locations of occupancy) or uncommon (more abundant than a rare species) which were previously recorded with small distribution area. Six orchid species (5.5%) endemic to Peninsular Malaysia were also discovered; namely, *Bulbophyllum linearifolium*

Table 1. List of orchid species collected from the disturbed forests of Terengganu and Kelantan, and details on their habit, abundance and distribution status. Notes: %Ao: Relative abundance of orchid; EP: Epiphyte; TR: Terrestrial; CM: Common; RR: Rare; NS: New Species; ED(PM): Endemic to Peninsular Malaysia.

Subfamily/Genus	Species	%Ao	Growth Habit	Distribution Status
Epidendroideae				
Acriopsis	1. *Acriopsis liliifolia* (J.Koenig) Seidenf. var. *liliifolia*	1.3	EP	CM
Adenoncos	2. *Adenoncos major* Ridl.	0.6	EP	CM
	3. *Adenoncos vesiculosa* Carr	0.6	EP	CM
Aerides	4. *Aerides odorata* Lour.	1.3	EP	CM
Agrostophyllum	5. *Agrostophyllum glumaceum* Hook.f.	0.6	EP	CM
	6. *Agrostophyllum stipulatum* subsp. *bicuspidatum* (J.J.Sm.) Schuit.	0.6	EP	CM
	7. *Agrostophyllum stipulatum* (Griff.) Schltr. subsp. *stipulatum*	0.6	EP	CM
Appendicula	8. *Appendicula lucida* Ridl.	0.6	EP	CM
	9. *Appendicula uncata* Ridl. subsp. *uncata*	0.6	EP	ED(PM)
Bromheadia	10. *Bromheadia alticola* Ridl.	0.6	EP	CM
	11. *Bromheadia petuangensis* Rusea & Besi *sp. nov.*	0.6	EP	NS
Bulbophyllum	12. *Bulbophyllum armeniacum* J.J.Sm.	0.6	EP	CM
	13. *Bulbophyllum bakhuizenii* Steenis	0.6	EP	CM
	14. *Bulbophyllum biflorum* Teijsm. & Binn.	0.6	EP	CM
	15. *Bulbophyllum biseriale* Carr	0.6	EP	CM
	16. *Bulbophyllum* cf. *caudatisepalum*	0.6	EP	CM
	17. *Bulbophyllum* cf. *corolliferum*	0.6	EP	CM
	18. *Bulbophyllum* cf. *flavescens*	0.6	EP	CM
	19. *Bulbophyllum corolliferum* J.J.Sm.	1.9	EP	CM
	20. *Bulbophyllum ecornutum* (J.J.Sm.) J.J.Sm. subsp. *ecornutum*	0.6	EP	RR
	21. *Bulbophyllum elevatopunctatum* J.J.Sm.	0.6	EP	RR
	22. *Bulbophyllum gracillimum* (Rolfe) Rolfe	0.6	EP	CM
	23. *Bulbophyllum lasiochilum* E.C.Parish & Rchb.f.	0.6	EP	RR
	24. *Bulbophyllum limbatum* Lindl.	1.3	EP	RR
	25. *Bulbophyllum linearifolium* King & Pantl.	0.6	EP	ED(PM)
	26. *Bulbophyllum macranthum* Lindl.	0.6	EP	CM
	27. *Bulbophyllum medusae* (Lindl.) Rchb.f.	0.6	EP	CM
	28. *Bulbophyllum patens* King ex Hook.f.	0.6	EP	CM
	29. *Bulbophyllum setuliferum* J.J.Verm. & Saw	0.6	EP	ED(PM)
	30. *Bulbophyllum* sp. (1)	0.6	EP	CM
	31. *Bulbophyllum vaginatum* (Lindl.) Rchb.f.	1.3	EP	CM
	32. *Bulbophyllum vermiculare* Hook.f.	0.6	EP	CM
Calanthe	33. *Calanthe ceciliae* Rchb.f.	0.6	TR	CM
Callostylis	34. *Callostylis pulchella* (Lindl.) S.C.Chen & Z.H.Tsi	0.6	EP	CM
Campanulorchis	35. *Campanulorchis leiophylla* (Lindl.) Y.P.Ng & P.J.Cribb	0.6	EP	CM
	36. *Campanulorchis pellipes* (Rchb.f. ex Hook.f.) Y.P.Ng & P.J.Cribb	1.3	EP	CM

Ceratostylis	37. *Ceratostylis pendula* Hook.f.	1.3	EP	CM
	38. *Ceratostylis subulata* Blume	0.6	EP	CM
Cleisostoma	39. *Cleisostoma discolor* Lindl.	0.6	EP	CM
	40. *Cleisostoma scortechinii* (Hook.f.) Garay	0.6	EP	CM
	41. *Cleisostoma* sp. (1)	0.6	EP	CM
Coelogyne	42. *Coelogyne cumingii* Lindl.	0.6	EP	CM
	43. *Coelogyne foerstermannii* Rchb.f.	1.3	EP	CM
	44. *Coelogyne tomentosa* Lindl.	0.6	EP	CM
Corymborkis	45. *Corymborkis veratrifolia* (Reinw.) Blume	3.2	TR	CM
Cylindrolobus	46. *Cylindrolobus mucronatus* (Lindl.) Rauschert	0.6	EP	CM
	47. *Cylindrolobus neglectus* (Ridl.) J.J.Wood	0.6	EP	CM
Cymbidium	48. *Cymbidium bicolor* subsp. *pubescens* (Lindl.) Du Puy & P.J.Cribb	0.6	EP	CM
	49. *Cymbidium finlaysonianum* Lindl.	0.6	EP	CM
Dendrobium	50. *Dendrobium acerosum* Lindl.	1.3	EP	CM
	51. *Dendrobium angustifolium* (Blume) Lindl.	0.6	EP	CM
	52. *Dendrobium bancanum* J.J.Sm.	1.9	EP	CM
	53. *Dendrobium* cf. *linguella*	0.6	EP	CM
	54. *Dendrobium connatum* (Blume) Lindl. var. *connatum*	0.6	EP	CM
	55. *Dendrobium convexum* (Blume) Lindl.	1.9	EP	CM
	56. *Dendrobium crumenatum* Sw.	3.2	EP	CM
	57. *Dendrobium farmeri* Paxton	0.6	EP	CM
	58. *Dendrobium indivisum* (Blume) Miq. var. *indivisum*	1.3	EP	CM
	59. *Dendrobium indragiriense* Schltr.	0.6	EP	CM
	60. *Dendrobium kentrophyllum* Hook.f.	0.6	EP	CM
	61. *Dendrobium lamellatum* (Blume) Lindl.	0.6	EP	RR
	62. *Dendrobium leonis* (Lindl.) Rchb.f.	1.3	EP	CM
	63. *Dendrobium pachyphyllum* (Kuntze) Bakh.f.	1.3	EP	CM
	64. *Dendrobium plicatile* Lindl.	0.6	EP	CM
	65. *Dendrobium quadrilobatum* Carr	1.3	EP	RR
	66. *Dendrobium rhodostele* Ridl.	0.6	EP	CM
	67. *Dendrobium singaporense* A.D.Hawkes & A.H.Heller	1.3	EP	CM
	68. *Dendrobium* sp. (1)	0.6	EP	RR
	69. *Dendrobium tortile* Lindl.	0.6	EP	CM
	70. *Dendrobium zebrinum* J.J.Sm.	0.6	EP	CM
Dendrochilum	71. *Dendrochilum pallidiflavens* Blume var. *pallidiflavens*	0.6	EP	CM
Eria	72. *Eria atrovinosa* Carr	1.3	EP	CM
	73. *Eria javanica* (Sw.) Blume	0.6	EP	CM
Grammatophyllum	74. *Grammatophyllum speciosum* Blume	2.5	EP	CM
Grosourdya	75. *Grosourdya* cf. *muscosa*	0.6	EP	RR
Liparis	76. *Liparis elegans* Lindl.	0.6	EP	CM

Micropera	77. *Micropera fuscolutea* (Lindl.) Garay	0.6	EP	RR
	78. *Micropera pallida* (Roxb.) Lindl.	0.6	EP	CM
Mycaranthes	79. *Mycaranthes latifolia* Blume	0.6	EP	CM
	80. *Mycaranthes pannea* (Lindl.) S.C.Chen & J.J.Wood	1.3	EP	CM
Oberonia	81. *Oberonia brachystachys* Lindl.	0.6	EP	CM
	82. *Oberonia ciliolata* Hook.f.	0.6	EP	CM
	83. *Oberonia insectifera* Hook.f.	0.6	EP	CM
Oxystophyllum	84. *Oxystophyllum carnosum* Blume	1.9	EP	CM
Pholidota	85. *Pholidota articulata* Lindl.	0.6	EP	CM
Phreatia	86. *Phreatia plantaginifolia* (J.Koenig) Ormerod	0.6	EP	CM
Pinalia	87. *Pinalia domii* Rusea & Besi *sp. nov.*	0.6	EP	NS
	88. *Pinalia floribunda* (Lindl.) Kuntze	1.9	EP	CM
	89. *Pinalia maingayi* (Hook.f.) Kuntze	0.6	EP	ED(PM)
Pomatocalpa	90. *Pomatocalpa diffusum* Breda	2.5	EP	CM
	91. *Pomatocalpa spicatum* Breda, Kuhl & Hasselt	1.9	EP	CM
Renanthera	92. *Renanthera histrionica* Rchb.f.	0.6	EP	CM
Rhynchostylis	93. *Rhynchostylis retusa* (L.) Blume	1.9	EP	CM
Stichorkis	94. *Stichorkis gibbosa* (Finet) J.J.Wood	1.3	EP	CM
Taeniophyllum	95. *Taeniophyllum pusillum* (Willd.) Seidenf. & Ormerod	0.6	EP	RR
	96. *Taeniophyllum* sp. (1)	0.6	EP	RR
Thecostele	97. *Thecostele alata* (Roxb.) E.C.Parish & Rchb.f.	0.6	EP	CM
Thelasis	98. *Thelasis carinata* Blume	1.3	EP	CM
	99. *Thelasis pygmaea* (Griff.) Lindl.	0.6	EP	CM
Thrixspermum	100. *Thrixspermum acuminatissimum* (Blume) Rchb.f. subsp. *acuminatissimum*	1.3	EP	CM
	101. *Thrixspermum centipeda* Lour.	1.3	EP	CM
	102. *Thrixspermum* cf. *carnosum*	0.6	EP	CM
	103. *Thrixspermum clavatum* (J.Koenig) Garay	0.6	EP	CM
	104. *Thrixspermum* sp. (1)	0.6	EP	CM
	105. *Thrixspermum* sp. (2)	0.6	EP	CM
	106. *Thrixspermum trichoglottis* (Hook.f.) Kuntze	0.6	EP	CM
Trichotosia	107. *Trichotosia gracilis* (Hook.f.) Kraenzl.	0.6	EP	CM
Apostasioideae				
Apostasia	108. *Apostasia nuda* R.Br.	1.9	TR	CM
Orchidoideae				
Hetaeria	109. *Hetaeria oblongifolia* Blume	0.6	TR	CM

King & Pantl., *B. setuliferum* J.J.Verm. & Saw, *Pinalia maingayi* (Hook.f.) Kuntze, *Appendicula uncata* subsp. *uncata* Ridl. and including two species new to science, which have been recently described: *Bromheadia petuangensis* Rusea & Besi (in press in *Pakistan Journal of Botany*) and *Pinalia domii* Rusea & Besi (unpublished). These new, rare, and endemic species were all collected and rescued from the logging sites. The logged forests were expected to have a higher likelihood harbouring rare and endemic

Table 2. Comparison based on diversity and density of orchid species in DSFs of Kuala Koh, Gua Musang, Kelantan and Air Canal, Tanah Merah, Kelantan; and logging sites in Tasek Kenyir, Hulu Terengganu.

Studied sites	Species richness	Shannon Index, H	Simpson Index, D	Evenness, E	Density (plants/m²)
DSFs	14	2.47	0.90	0.94	0.0133
Logging Sites	96	4.50	0.99	0.99	0.0040

Table 3. Diversity of epiphytic orchids found in the logging sites of Tasek Kenyir area.

Studied sites	Species richness	Shannon Index, H	Simpson Index, D	Evenness, E	Density (plants/m²)
Logging Sites	94	4.46	0.99	0.98	0.0013

species than the secondary forests, seeing that the area covered was larger and the fallen trees provided the chance to harvest more epiphytic orchids which are usually unreachable and difficult to see in the non-logged forests.

Diversity analyses and density.– Table 2 shows that the DSFs had a higher orchid density (0.0133 plants/m^2) when compared with the logging sites (0.0040 plants/m^2) although the total of the area covered (1,050 m^2) was very much lower than the latter (73,550 m^2). However, the logged forests had a higher diversity of orchid species (H=4.50 and D=0.99) compared with the secondary forests (H=2.47 and D=0.90) with 94 species (97.9%) of the orchids encountered being epiphytes. The high H and D values are also supported by the high E values (E value of logging sites = 0.99 > E values of DSFs = 0.94) implies that the abundance of clumps or populations of each species in the logging sites was evenly distributed without being dominated by only one species.

The logging sites were dominated by epiphytic orchids which were found attached to the fallen trees within a 73,550 m^2 area with a total density of 0.0013 plants/m^2 (Table 3). The H (H=4.46) and D (D=0.99) values were high indicating a high diversity of epiphytic orchids (Table 3). The high E value (E=0.98), shows that the epiphytic orchid diversity was also influenced by their evenly distributed abundance and absence of dominant species (Table 3). In comparison, according to the data shown in Table 4 the density of epiphytic orchids in Gawi (Site 2) was higher [Gawi (Site 2) = 0.0035 plants/m^2 > Gawi (Site 1) = 0.0026 plants/m^2 > Petuang (Site 3) = 0.0010 plants/m^2] even though the total area studied was lower [Gawi (Site 2) = 9,500 m^2 < Gawi (Site 1) = 10,000 m^2 < Petuang (Site 3) = 53,000 m^2]. The densities of fallen trees hosting orchid(s) also demonstrates a similar pattern; Gawi (Site 2) had a higher density than the other studied sites [Gawi (Site 2) = 0.0031 plants/m^2 > Gawi (Site 1) = 0.0019 plants/m^2 > Petuang (Site 3) = 0.0005 plants/m^2].

Table 4. Comparison on densities of epiphytic orchid species and fallen tree hosting orchid(s) between the three studied logging sites in Tasek Kenyir area.

Parameters	Gawi (Site 1)	Gawi (Site 2)	Petuang (Site 3)
Species Richness	26	33	51
Number of Fallen Trees Hosting Orchid(s) (plants)	19	29	25
Total Area Studied (m^2)	10,000	9,500	53,000
Density of Orchids Species (plants/m^2)	0.0026	0.0035	0.0010
Density of Fallen Trees Hosting Orchid(s) (plants/m^2)	0.0019	0.0031	0.0005

Pearson's correlation was performed to determine the correlation between the density of orchid species and density of fallen trees hosting orchid(s) in the logging sites. Table 5 shows a significant and strong positive correlation between the densities of orchid species and the densities of fallen trees hosting orchid(s), r=0.993, n=3, p=0.037. This implies that a single logging activity in a small area could accumulate and expose a high abundance and diversity of orchids to imminent danger.

Microclimate of the disturbed forests.– Table 6 and Figure 2 show the significant difference of the microclimate between DSFs and logging sites. The max temperature recorded in the clear logged forests (34.9±1.0 ºC) was significantly higher [H(1)=6.621, p=0.010] than in the DSFs with trees canopies (31.1±0.3 ºC) (Figure 2B), with mean rank of 13.2 for logging sites and 5.5 for DSFs. The high temperature recorded in logging sites was also linked to its significantly lower min values [H(1)=5.889, p=0.015] of ARH, with mean rank of 8.93 for logging sites and 16.17 for DSFs (Figure 2C). Moreover, the microclimate values on temperature for both different types of disturbed forests are also much higher than the local climate's; with mean value of Min Temperature = 23.2 ºC and mean value of Max Temperature = 30.9 ºC (Malaysian Meteorology Department 2016, 2017). Simultaneously, both areas would have had lower ARH if compared to the local climate with mean value of ARH is 86.8% (Malaysian Meteorology Department 2016, 2017). This could imply that the microclimate of disturbed forests was much more intense if compared to the local climate of the surrounding areas.

The SM level shows a similar pattern where the min and max values of SM recorded for logging sites were lower than DSFs, although the difference was not statistically significant due to the small sample size studied and limited accessible area in the DSFs (Figure 2G–H).

Optimum range of light intensities on orchid development was referred to Guo *et al.* (2012), a study tested on wild *Phalaenopsis*, where the range of extreme low and high light intensities are 0–1,350 lx and 17,550–24,300 lx, respectively (the values recorded were converted from µmol $m^{-2}s^{-1}$ to Lux unit). The range normally used in a field study is between 15,120–20,520 lx (Chen & Wang 1996). Based on the data collected on light intensities that also defines level of illuminance, it does not inflict any injurious effects as the values were still within the adaptable range. However, the values recorded shown a slight deviation from the specified range values of the used Lux meter, where the standardized specification of the meter signifies the average outdoor sunlight normally ranged between 20,000 lx to 50,000 lx. The values recorded for logging sites only reached up to the max value of 20,000 lx, in which, the light intensity for the opened canopies forest should have been at least 20,000 lx.

Table 5. Correlation between number of epiphytic orchid species and the number of fallen trees hosting orchid(s) found in the logging sites of Tasek Kenyir area. *Correlation is significant at the 0.05 level (1-tailed).

Pearson's Correlation Coefficient		
		Density of Orchid Species
Density of Orchid Species	Pearson Correlation	1
	Sig. (1-tailed)	
	N	3
Density of Fallen Trees Hosting Orchid(s)	Pearson Correlation	0.993*
	Sig. (1-tailed)	0.037
	N	3

Table 6. Summary of topographic and ecological predictors (mean±SE) of DSFs in Kuala Koh, Gua Musang, Kelantan and Air Canal, Tanah Merah, Kelantan; and logging sites in Tasek Kenyir, Hulu Terengganu. Notes: Average rainfall recorded in the current study was between 125.6–414.9 mm (Malaysian Meteorology Department, 2016, 2017); SE: Standard error; Δ: Elevations (m a.s.l.) above sea level; ARH (1–100%): Air Relative Humidity; SM (1–10%): Soil Moisture; LI (lx): Light Intensity in Lux unit; Min: Minimum value; Max: Maximum value; N-value (Logging Sites) = 15; N-value (DSFs) = 6. Different superscripts indicate significant differences ($p<0.05$) in Kruskal-Wallis one-way ANOVA with multiple pairwise comparisons.

Disturbed Forests	Temperature (ºC)	ARH (1–100%)	LI (lx)	SM (1–10%)	Δ
Disturbed Secondary Forests (DSFs)	Min: 28.8±0.5^a	Min: 75.8±1.6^a	Min: 3856.7±1193.0^a	Min: 2.2±0.3^a	44.4-129.9
	Max: 31.1±0.3^b	Max: 88.0±2.4^c	Max: 17833.3±1641.5^c	Max: 3.3±0.5^b	
Logging Sites (logged forests)	Min: 31.2±1.1^a	Min: 67.0±2.3^b	Min: 9180.0±1177.7^b	Min: 2.0±0.4^a	98.8-244.6
	Max: 34.9±1.0^c	Max: 86.7±1.7^c	Max: 17866.7±960.5^c	Max: 3.2±0.9^b	

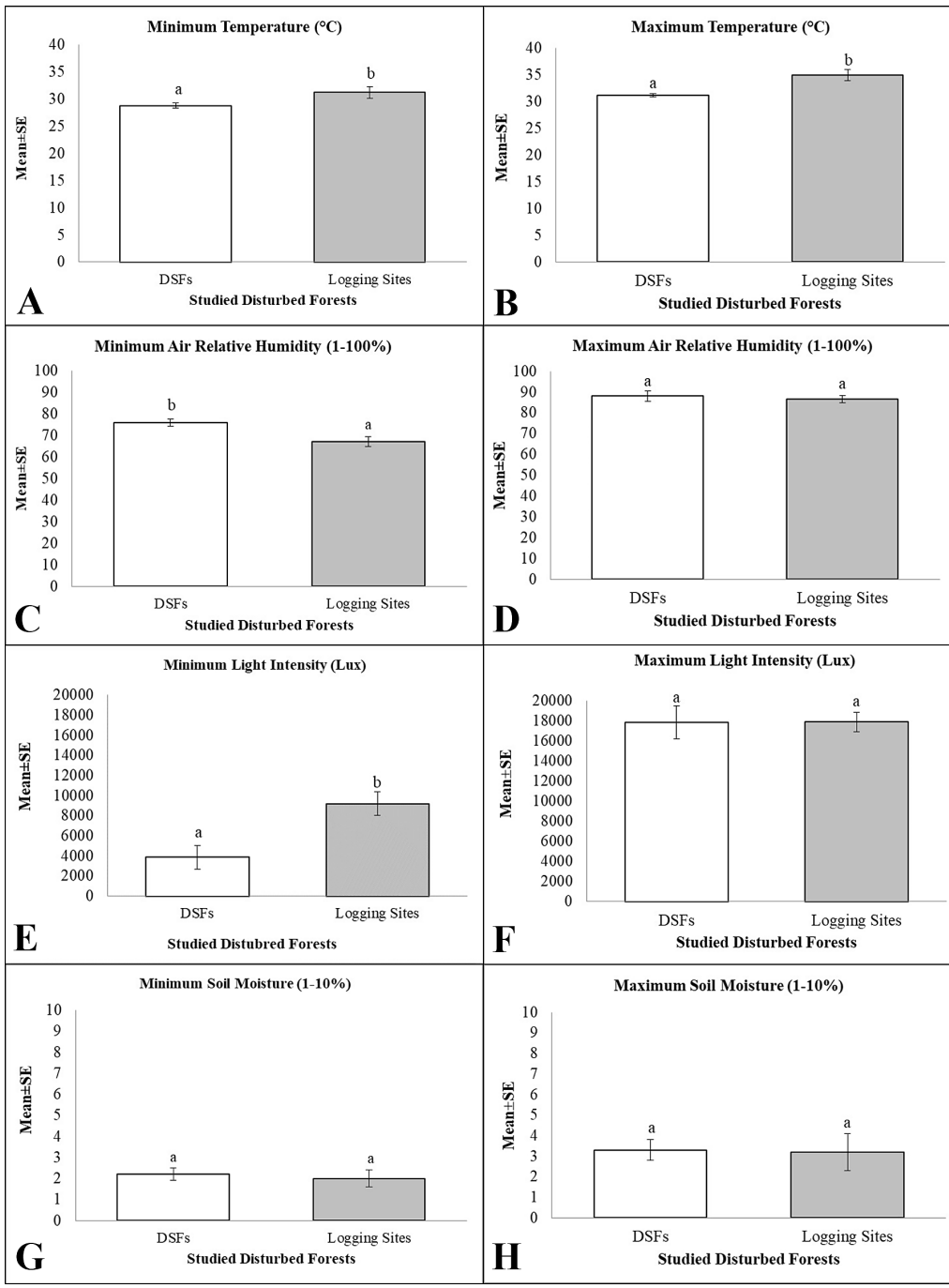

FIGURE 2. *In-situ* ecology parameters recorded in disturbed forests of Terengganu and Kelantan regions. **A.** Mean values of Minimum Temperature. **B.** Mean values of Maximum Temperature. **C.** Mean values of Minimum ARH. **D.** Mean values of Maximum ARH. **E.** Mean values of Minimum Light Intensity. **F.** Mean values of Maximum Light Intensity. **G.** Mean values of Minimum Soil Moisture. **H.** Mean values of Maximum Soil Moisture. Mean±SE is the means with standard error of the each parameter. Different superscripts indicate significant differences ($p<0.05$) in Kruskal-Wallis one-way ANOVA with multiple pairwise comparisons.

Discussion

Relationship between species abundance, species density and the habitat type.– The abundance of orchids and their survival in the disturbed forests were driven by the intensity of disturbance faced by each population in their particular habitat. The results show that the mildly disturbed secondary forests had a higher orchid density than the highly disturbed logging sites. This was certainly due to the ecosystem variations altered by the anthropogenic-driven disturbances. These variations were linked to the weather and microclimatic conditions, especially temperature, humidity, precipitation, and light intensity, and also the presence of supporting trees and organisms such as fungi, mosses, and pollinators.

In comparison, the secondary forests clearly had a healthier environment for orchid survival as the habitat conditions (moisture and nutrient availabilities) were still suitable for the growth of both epiphytic and terrestrial orchids. Furthermore, the presence of standing and healthy trees gave a better support for the epiphytic orchids. The trees were significant in assisting orchid photosynthesis, and also the pollination and reproduction (Cribb *et al.* 2003, Cozzolino & Widmer 2005).

Studies have shown that terrestrial orchids do not survive in secondary habitats or invaded conserved forest (Williams-Linera *et al.* 1995, Bergman *et al.* 2006). However, several small populations of terrestrial *Apostasia nuda* R.Br. and *Corymborkis veratrifolia* were found in the DSFs of Kuala Koh and Tanah Merah. Despite of the heavily damaged by mudslides and heavy flooding since 2014, there are some pockets of the forests that were not affected and terrestrial orchids are still found there. The fragments of the unlogged forests are still very much protected by the forest canopy from the sun, and thus provide a tolerable environment for the orchid growth. This is where small populations of the terrestrials *Calanthe ceciliae* Rchb.f. and *Hetaeria oblongifolia* Blume were found. The low number of terrestrial orchids in the logged forests was greatly attributed to the poor soil condition, where humus-rich soil surface was eroded badly during logging that alters the pH, humidity and the nutrients. The full exposure to sunlight and the radiation heats up the surface in the logged forest without canopy protection had distorted the atmospheric and soil microclimatic stratifications (Werner & Gradstein 2009, Benítez *et al.* 2015), thus killing all the exposed epiphytic and terrestrial plants.

Small changes in ecological conditions may be deleterious to intolerant species. Even slight differences in the humidity may be significant for species near their threshold levels of water supply (Werner & Gradstein 2009), especially epiphytes. Orchids are resistant and adaptive towards distress environmental conditions as long as atmospheric and soil moisture levels and sunlight intensity are tolerable for their survival (Hietz *et al.* 2006). Nevertheless, they would flourish better in less disturbed areas under the forest canopy where they can obtain optimal light, water, and nutrients to reach maturity for reproduction (López & Runkle 2005). Therefore, it is highly recommended that the secondary forest and forest fragments left after logging are identified and protected as these areas were observed to still harbour precious orchid species.

Study based on subfamilies and growth habits.– Subfamily Epidendroideae was found to be the best represented in our study areas. They are predominantly epiphytic and often have aerial roots (Holttum 1964, Seidenfaden & Wood 1992). In the current study, only one species of this subfamily, *Calanthe ceciliae,* was found growing as a terrestrial in the logging sites. Compared to the other lineages, orchids from this subfamily are known to have a wide distribution area along the elevation gradients. They are always found to be abundant in extreme environments, are disturbance-resilient and exhibit more drought-tolerance characteristics when compared with the other subfamilies (Rada & Jaimez 1992, Zhang *et al.* 2015, Yang *et al.* 2016). Previous studies of degraded vegetation indicated the success of vascular epiphytes, including epiphytic orchids entirely belonging to Epidendroideae subfamily (Hietz *et al*. 2006, Werner & Gradstein 2009, Huda & Wilcock 2011). This subfamily is largely characterized as shade-loving species and only a small number are sun-loving. It might be expected that shade-demanding species would find habitat in open forests with direct exposure to the sun's rays, such as logging sites, less favourable. Although, conversely, sun-loving epiphytic orchids, such as *Bromheadia* Lindl. with tough stem and many small or terete leaves, should find the high light

environment in the opened forest equally represented in the upper canopy of the closed forest (Hietz *et al*. 2006).

None species of Cypripedioideae and Vanilloideae subfamilies were recorded from the studied sites. Cypripedioideae is mostly terrestrial, with a few epiphytes and lithophytes; in our area, species belonging to this subfamily are highland species with coriaceous or leathery leaves, without pseudobulbs and only adapted to wet and cool conditions (Seidenfaden & Wood 1992). Meanwhile, Vanilloideae has both warm and cool growing species, yet, have always had been recorded with lower occurrence in Peninsular Malaysia, except for *Vanilla griffithii* Rchb.f., a commonly found species in lowland and swamp forests (Go & Hamzah 2008, Go *et al*. 2011).

Dominance of epiphytic orchids in logging sites.– Epiphyte diversity tends to be reduced markedly following disturbance (Wolf 2005, Nöske *et al*. 2008), with variation due to the severity of disturbance and the types of disturbed habitat studied (Hietz 2005, Holz & Gradstein 2005). Conversely, in the current study, there was a high abundance of epiphytic orchids found in the logging sites (Fig. 3).

However, this does not suggest that orchid diversity and abundance increases with the intensity of anthropogenic-driven disturbance. A high abundance of epiphytic orchids and the significant difference in densities of orchids recorded between the logging sites in Tasek Kenyir area are assumed to be correlated with the abundance or densities of the fallen trees in the logging sites, disturbance-induced dryness stresses, durations of exposure to the anthropogenic-induced disturbance (claim is made based on a survey and empirical evidence), and less favourable soil conditions for the terrestrial orchids to flourish at both sites studied.

A further study on the effect of human-induced environmental disturbance on the survival of orchid community in the degraded forests would help government agencies, conservation biologists and policy makers in formulating better conservation strategies. According to local villagers, the logging activity in Petuang had started some years (unspecified) before the logging activity in Gawi that began in 2014. Thus, time wise, it implies that the orchids in Petuang had been exposed longer to the extreme environment conditions, plus, a high number of them were found degraded with severe sun-damage and dehydration during the field collections, when compared with our collections from Gawi.

The epiphytic orchids have advanced adaptations of one or more organs to allow them to survive the long warm and dry environment conditions. *Bulbophyllum* and *Dendrobium* species for example have storage organs like pseudobulbs and pseudobulbous stems, fleshy or leathery leaves, and aerial roots with velamen as a protective layer against water loss (Zotz & Winkler 2013, Zhang *et al*. 2015) and sun radiation damage (Chomicki *et al*. 2015), including *Thrixspermum* Lour, and the leafless orchids *Taeniophyllum* Blume that have photosynthetic roots. Unfortunately, having adaptations that allow them to survive the long warm and dry conditions do not help them to survive extended periods of desiccation since most of the specimens collected in this study exhibited dormancy and were dying upon collection.

Effects of anthropogenic-driven disturbances towards orchids abundance and survival in the disturbed forests.– The relationship between environmental conditions and orchid abundance has been frequently reported, but little is understood for orchid responses towards micro-climatic challenges and their abundance in the degraded forest with extremely fragmented tree canopies and vegetation. The canopy disruptions caused by clear-cut logging produced openings in the canopy, which had significantly affect ambient temperature and moisture. In the undisturbed-closed forest, the sun irradiation is converted into heat at the interface of the atmosphere and canopy (Werner & Gradstein 2009). The heat intensity was more severe in disturbed-opened canopy forests or clear felling logging sites.

The microclimate of the disturbed forests

Right, Figure 3. Epiphytic orchids on the fallen trees and ground threatened by direct exposure to the sun irradiation and dryness in the logging sites of Tasek Kenyir area. **A.** *Callostylis pulchella*, *Renanthera histrionica, Pinalia maingayi*. **B.** *Cleisostoma scortechinii*. **C.** *Coelogyne cumingii*. **D, E.** *Grammatophyllum speciosum.* **F, G, H.** *Coelogyne foerstermannii*. Photos by DigitalDome.


A
B
C
D
E
F
G
H

showed lower ARH and extremely high surrounding temperature if compared to undisturbed forested area. The direct exposure to sun radiation and heat had imposed desiccation, a state of extreme dryness, and drought-heat physiological stress towards the exposed orchid community in the forest. Deriving from a study tested on an epiphytic orchid leaves, *Phalaenopsis*, the optimal temperature for photosynthetic carbon fixation ranges from 29/25 ºC to 32/28 ºC day/night temperature (Guo & Lee 2006, Guo *et al*. 2012). But, the temperature recorded for the logging sites in the current study was much higher and exceeded the optimal range required for energy production through photosynthesis. The heat irradiation caused burn and browning of the plant parts, which would eventually lead to injuries and death.

Generally, the higher the temperature, the lower the humidity or moisture, and biologically, it means the lower the turgor pressure in plant cells. The changes in turgor pressure in cells and tissues could also trigger the signal transduction pathways (Beauzamy *et al.* 2014) and structural proteins (Yooyongwech *et al*. 2008) involved in flower development: flower opening, anther dehiscence, and pollen tube growth. Thus, the exhibitions of signs of dying such as flowers or buds browning, flowers or buds dropping off (bud or bloom blast) and dormant, and pseudobulbs browning and shriveled in the disturbed forests during the field collections were most caused by high temperature (extreme heat irradiation) and extreme dryness during drought season.

Moreover, the bloom and bud blast are generally orchid's reactions to environmental shock and is the plant's way of protecting itself. This might be brought on by a sudden change in temperature and reduced water potential in plant cells to trigger the flower or bud development. By shedding its buds, the orchid can divert more energy to maintaining its vital systems (Beauzamy *et al*. 2014). A continuous sugar or carbohydrate supply to the apex of a reproductive bud through photosynthetic carbon fixation is essential for continued floral development (Wang 1995, Konow & Wang 2001). Therefore, maximizing sugar production with optimal light intensity is important for orchid growth and flowering (Guo *et al*. 2012).

The browning observed on the leaves of orchids collected from the logging sites could be due to two possibilities: (i) reduction of the chlorophyll content which has reduced the pigment responsible for the green colour of the leaves; (ii) too high light intensity provokes an increase in leaf temperature causing photosynthetic machinery degradation in plant cells (Edmond *et al.* 1978, Sinha & Häder 2002, Stancato *et al.* 2002, Chomicki *et al*. 2015).

The deviations occurred to the data collected in the current study for light intensities could be related to various reasons, including time of the day, season, geographic location, weather, or device systematic error. The light intensity could be also affected by dust particles and atmospheric water vapor, slope and elevation (Edmond *et al*. 1978). The units Lux is simply based on visual sensitivity and do not provide information on the energy or photon content of light, which truly influences the photosynthesis or sugar production in the leaf. Hence, in order to understand better the light intensity for a study relating to plant responses, the suitable unit is the μmol m-2s-1 [number of photons received per unit time (s) on a unit area (m)]. Similarly, the effects of ultraviolet radiation (UV-radiation) on orchids in wide-opened canopy forest are another perspective recommended for future studies of orchids in disturbed forest. UV-radiation is a major hazard for living organisms exposed to sunlight, causing DNA mutation, and plasma membrane lipid peroxidation.

A small number of terrestrial orchids encountered in this study were suspected to be influenced by the soil properties and ground conditions. Inconclusively, aside from the massive clearance of ground vegetation by tractor, the low values of soil moisture (SM) and absence of buffering trees and leaf litter were predicted to reflect and influence the geographical distribution of the individual terrestrial orchids in the logged forests and DSFs. Soil moisture was included as the predictor, because, even though moisture affected by soil-forming factors (mineralization and holding capacity), moisture potentially is a strong factor controls other soil properties, including pH and nutrient (Pulla *et al.* 2016). Although, the min and max values of SM recorded for both sites were not statistically significant different, nonetheless, in comparison, it appears that the min moisture values recorded for logging sites were lower than the moisture values recorded in a previous study on soil properties associated with dry forest

community (see Pulla *et al*. 2016). This suggests that the dryness stress faced by the orchids community in the logging sites was much severe than in the naturally occurred dry forest.

The surface erosion occurred in the logging sites as a result of absence of buffering trees and leaf litter, and direct exposure of mineral soil to the impact of rain might have reduced the soil holding capacity which would have also reduced the soil moisture and nutrient (Raghubanshi 1992, Li *et al.* 2014), and compromising the orchid growth and their mycorrhizal association (Batty *et al.* 2001, Harrington & Schoenholtz 2010, Li *et al*. 2014). Increased frequency of erosions and direct heat exposure would affect the microorganism community, too. In nature, primarily, the terrestrial orchids also require the mycorrhizal association (fungal-roots) for survival and nitrogen fixation (Brundrett 2002). For a better understanding, it is desirable to include soil pH in future studies for a better clarification and to determine the relationship between level of mineralization and nitrification of soil and orchid distribution in the disturbed forest.

Conclusions. Our results show a high diversity of orchids found at Peninsular Malaysia's disturbed forest areas. The diversity indexes reflect a greater orchid diversity in the areas with wide-opened canopies of the logged forests than in the canopy-covered DSFs, with several rare species and six species being endemic to Peninsular Malaysia, including two new species to science, and of these, largely were epiphytes, typically with robust morphological appearance and adaptations. This high species diversity and indexes in wide-opened canopies logged forests is due to accessibility of epiphytic orchids on fallen trees. The current study covered only 5% of the total area of the disturbed forests in Terengganu and Kelantan through 3 years' botanical collections. We anticipate much more orchids at risk could be found in the logged forest following the positive correlation between the density of epiphytic orchids and the density of fallen trees in the logging sites. This orchid community appears to be critically endangered due to ongoing logging activities in the region. The canopy disruptions caused by forest logging and the mudslides had reduced the quality of the orchid habitats. The anthropogenic-driven disturbances had harmfully altered the humidity and temperature in the affected areas. The disturbance-induced drought stress had damaged the orchid morphologically and interfered with their phenology. This study has resulted in new hope for rapid orchid species documentation endeavour in Malaysia, as many epiphytic orchids are accessible resulting in many new discoveries of new records and species to science.

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Literature Cited

Abdullah, R., Ibrahim, A., Simin, M. H. A., Ramle, N. H., & Rasat, M. S. M. (2017). Pemuliharaan hutan dalam kalangan masyarakat Semaq Beri di Negeri Terengganu, Malaysia (Forest conservation and the Semaq Beri community of Terengganu, Malaysia). *Geografia-Malaysian Journal of Society and Space*, 10(3), 113–124. [*Note: Article published in Malay language*]

Batty, A. L., Dixon, K. W., Brundrett, M. & Sivasithamparam, K. (2001). Constraints to symbiotic germination of terrestrial orchid seed in a mediterranean bushland. *New Phytologist*, 152(3), 511–520.

Benítez, Á., Prieto, M. & Aragón, G. (2015). Large trees and dense canopies: key factors for maintaining high epiphytic diversity on trunk bases (bryophytes and lichens) in tropical montane forests. *Forestry: An International Journal of Forest Research*, 88(5), 521–527.

Beauzamy, L., Nakayama, N. & Boudaoud, A. (2014). Flowers under pressure: ins and outs of turgor regulation in development. *Annals of botany*, 114(7), 1517–1533.

Bergman, E., Ackerman, J. D., Thompson, J. & Zimmerman, J. K. (2006). Land-use history affects the distribution of the saprophytic orchid *Wullschlaegelia calcarata* in Puerto Rico's Tabonuco Forest 1. *Biotropica*, 38(4), 492–499.

Besi, E. E., Dome, N., Mustafa, M. & Go, R. (in press). A new species of *Bromheadia* Sect. *Aporodes* (Orchidaceae) rescued from a logging site in Terengganu, Peninsular Malaysia. *Pakistan Journal of Botany*.

Bridson, D. & Forman, L. (2000). *The herbarium handbook, 3rd edition*. London, United Kingdom: Royal Botanic Gardens, Kew. 348 pp.

Brundrett, M. C. (2002). Coevolution of roots and mycorrhizas of land plants. *New phytologist*, 154(2), 275–304.

Chen, W. H. & Wang, Y. T. (1996). *Phalaenopsis* orchid culture. *Taiwan Sugar*, 43, 6–11.

Chomicki, G., Bidel, L. P. R., Ming, F., Coiro, M., Zhang, X., Wang, Y., Baissac, Y., Jay-Allemand, C. & Renner, S. S. (2015). The velamen protects photosynthetic orchid roots against UV-B damage, and a large dated phylogeny implies multiple gains and losses of this function during the Cenozoic. *New Phytologist*, 205(3), 1330–1341.

Comber, J. B. (2001). *Orchids of Sumatra*. Natural History Publications (Borneo) Sdn. Bhd., Kota Kinabalu, Sabah, Malaysia. 1026 pp.

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

Cribb, P. J., Kell, S. P., Dixon, K. W. & Barrett, R. L. (2003). Orchid Conservation: a global perspective. In: K. W. Dixon, S. P. Kell, R. L. Barrett & P. J. Cribb (Eds), *Orchid conservation*. Kota Kinabalu, Sabah, Malaysia: Natural History Publications. 1–24 pp.

Dimmit, M. (2000). Endangered Bromeliaceae. In: D. H. Benzing (ed). *Bromeliaceae: profile of an adaptive radiation* (pp. 609–620). Cambridge, United Kingdom: Cambridge University Press.

Edmond, J. B., Senn, T. L., Andrews, F. S. & Halfacre, R. G. (1978). *Fundamentals of horticulture (4th ed.)*. New York, U.S.A.: McGraw-Hill, Inc. 109–130 pp.

Fatanah, N. (2009). *BatekHep: manifestasi alam dan kebergantungan hidup terhadap rimba*. (Doctoral dissertation). Institut Alam Sekitar dan Pembangunan (LESTARI), Universiti Kebangsaan Malaysia, Bangi, Malaysia. [*Note: Article published in Malay language*]

Go, R. & Hamzah, K. A. (2008). *Orchids of peat swamp forests in Peninsular Malaysia*. Forest Research Institute Malaysia (FRIM), Serdang, Malaysia. Peat Swamp Forest Technical Series No. 13. 136 pp.

Go, R., Eng, K. H., Mustafa, M., Abdullah, J. O., Naruddin, A. A., Lee, N. S., Lee, C. S., Eum, S. M., Park, K. W. & Choi, K. (2011). An assessment of orchids' diversity in Penang Hill, Penang, Malaysia after 115 years. *Biodiversity and Conservation*, 20(10), 2263–2272.

Go, R., Yong, W. S. Y., Joanes, U. & Salleh, R. (2010). *Orchids of Perlis, jewels of the forest*. Revised Edition. Kuala Lumpur, Malaysia: Jabatan Perhutanan Perlis and Universiti Putra Malaysia. 152 pp.

Guo, W. J. & Lee, N. (2006). Effect of leaf and plant age, and day/night temperature on net CO2 uptake in *Phalaenopsis amabilis* var. *formosa*. *Journal of the American Society for Horticultural Science*, 131(3), 320–326.

Guo, W. J., Lin, Y. Z. & Lee, N. (2012). Photosynthetic light requirements and effects of low irradiance and daylength on *Phalaenopsis amabilis*. *Journal of the American Society for Horticultural Science*, 137(6), 465–472.

Gradstein, S. R. (2008). Epiphytes of tropical montane forests-impact of deforestation and climate change. *Göttingen Centre for Biodiversity and Ecology*. *Biodiversity and Ecology Series*, 2, 51–65.

Hairul, N. M. K, Ramle, A., Mohamad, H. A. S. & Asmawi, I. (2016). *Kelestarian alam sekitar taman negara Tasik Kenyir dan impak kesejahteraan kepada masyarakat orang asli sekitar*. International Conference on Education and Regional Development 2016 (ICERD 2016). [*Note: Article published in Malay language*]

Harrington, T. B. & Schoenholtz, S. H. (2010). Effects of logging debris treatments on five-year development of competing vegetation and planted Douglas-fir. *Canadian Journal of Forest Research*, 40(3), 500–510.

Help, C. (1974). A new index measuring evenness. *Journal of the Marine Biological Association of the United Kingdom*, 54(3), 555–557.

Hew, C. S., Arditti, J. & Lin, W. S. (1997). Orchid cut-flower production in ASEAN countries. In: J. Arditti (Ed.). *Orchid Biology: reviews and perspectives*, *Volume 6* (pp. 363–401). New York, U.S.A.: John Wiley & Sons.

Hietz, P. (2005). Conservation of vascular epiphyte diversity in Mexican coffee plantations. *Conservation Biology*, 19(2), 391–399.

Hietz, P., Buchberger, G. & Winkler, M. (2006). Effect of forest disturbance on abundance and distribution of epiphytic bromeliads and orchids. *Ecotropica*, 12(2), 103–112.

Holttum, R. E. (1964). *A revised flora of Malaya, volume 1*. Orchids of Malaya. Singapore: Government Printing Office. 759 pp.

Holz, I. & Gradstein, R. S. (2005). Cryptogamic epiphytes in primary and recovering upper montane oak forests of Costa Rica–species richness, community composition and ecology. *Plant Ecology*, 178(1), 89–109.

Huda, M. K. & Wilcock, C. C. (2011). Colonisation and diversity of epiphytic orchids on trees in disturbed

and undisturbed forests in the Asian tropics. *Gardens' Bulletin Singapore*, 63(1–2), 341–356.

Jaafar, N., Abdul Rasid, J., Zakaria, R., Chu Abdullah, M. R. & Omar, M. (2007). *Wild orchids of Terengganu*. Terengganu, Malaysia: Forestry Department of Terengganu. 120 pp. ISBN: 978-43120-1-5.

Kiew, R., Chung, R. C. K., Saw, L. G. & Soepadmo, E. (2010). Seed Plant Families in Peninsular Malaysia. In: R. Kiew, R. C. K. Chung, L. G. Saw, E. Soepadmo & P. C. Boyce (Eds.), *Flora of Peninsular Malaysia, Series II: Seed Plants, Volume 1* (pp 3–20). Kepong, Kuala Lumpur, Malaysia: Forest Research Institute Malaysia (FRIM).

Konow, E. A. & Wang, Y. T. (2001). Irradiance levels affect in vitro and greenhouse growth, flowering, and photosynthetic behavior of a hybrid *Phalaenopsis* orchid. *Journal of the American Society for Horticultural Science*, 126(5), 531–536.

Larson, R. J. (1992). Population dynamics of *Encyclia tampensis* in Florida. *Selbyana*, 13, 50–56.

Li, X., Niu, J. & Xie, B. (2014). The effect of leaf litter cover on surface runoff and soil erosion in Northern China. *PLoS ONE*, 9(9), e107789.

López, R. G. & Runkle, E. S. (2005). Environmental physiology of growth and flowering of orchids. *HortScience*, 40(7), 1969–1973.

Lye, T. P. (2005). *Changing pathways: forest degradation and the Batek of Pahang*. Strategy Information Research Development, Petaling Jaya, Selangor, Malaysia. 227 pp.

MacDonald, G. M. (2003). *Biogeography: space, time, and life*. New York, U.S.A.: John Wiley and Sons, Inc. 528 pp.

Malaysian Meteorological Department (2016). Data on Monthly Rainfall Amount and Number of Raindays, Monthly Mean Minimum and Maximum Temperature, and Monthly mean relative humidity for Pengkalan Gawi, Terengganu. Received on August 8, 2017.

Malaysian Meteorological Department (2017). Data on Monthly Rainfall Amount and Number of Raindays, Monthly Mean Minimum and Maximum Temperature, and Monthly mean relative humidity for Pengkalan Gawi, Terengganu. Received on August 8, 2017.

Margalef, R. (1972). Homage to Evelyn Hutchinson, or why is there an upper limit to diversity. *Transactions of the Connecticut Academy of Arts and Sciences*, 44, 211–235.

Mondragon, D. & Calvo-Irabien, L. M. (2006). Seed dispersal and germination of the epiphyte *Tillandsia brachycaulos* (Bromeliaceae) in a Tropical Dry Forest, Mexico. *The Southwestern Naturalist*, 51(4), 462–470.

National Herbarium of the Netherlands (NHN) (2017). Accessed on July 11, 2017 through Browse Dutch Natural History Collections: BioPortal (Naturalis) at http://bioportal.naturalis.nl/

Nöske, N. M., Hilt, N., Werner, F. A., Brehm, G., Fiedler, K., Sipman, H. J. & Gradstein, S. R. (2008). Disturbance effects on diversity of epiphytes and moths in a montane forest in Ecuador. *Basic and Applied Ecology*, 9(1), 4–12.

Ong, P. T., O'Bryne, P., Saw, L. G. & Chung, R. C. K. (2017). *Checklist of orchids of Peninsular Malaysia*. Perpustakaan Negara Malaysia, Kuala Lumpur, Malaysia. Research Pamphlet. No. 136. 169 pp.

Ong, P. T., O'Bryne, P., Yong, W. S. Y. & Saw, L. G. (2011). *Wild orchids of Peninsular Malaysia*. Malaysia: Forest Research Institute Malaysia (FRIM) and MPH Group Publishing Sdn. Bhd. 196 pp.

Pant, B. (2013). Medicinal orchids and their uses: Tissue culture a potential alternative for conservation. *African Journal of plant science*, *7*(10), 448–467.

Pielou, E. C. (1966). The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology*, 13, 131–44.

Pulla, S., Riotte, J., Suresh, H. S., Dattaraja, H. S. & Sukumar, R. (2016). Controls of soil spatial variability in a dry tropical forest. *PLoS ONE*, 11(4), e0153212.

Rada, F. & Jaimez, R. (1992). Comparative ecophysiology and anatomy of terrestrial and epiphytic *Anthurium bredemeyeri* Schott in a tropical Andean cloud forest. *Journal of Experimental Botany*, 43(5), 723–727.

Raghubanshi, A. S. (1992). Effect of topography on selected soil properties and nitrogen mineralization in a dry tropical forest. *Soil Biology and Biochemistry*, 24(2), 145–150.

Ramle, A. (1993). *Semaq Beri: komuniti orang asli di Terengganu*. Kolej Agama Sultan Zainal Abidin, Terengganu, Malaysia. [*Note: Article published in Malay language*]

Ramle, A., Asmawi, I., Mohamad Hafis, A. S., Nur Hafizah, R. & Mohd Sukhairi, M. R. (2014). Pemuliharaan hutan dalam kalangan masyarakat Semaq Beri di Negeri Terengganu, Malaysia. *GEOGRAFIA OnlineTM Malaysian Journal of Society and Space*, *10*(3), 113-124. [*Note: Article published in Malay language*]

Rauh, W. (1992). Are Tillandsias endangered plants? *Selbyana*, 13,138–139.

Seidenfaden, G. & Wood, J. J. (1992). *The orchids of Peninsular Malaysia and Singapore*. London, United Kingdom: Royal Botanic Garden, Kew. 779 pp.

Singapore Herbarium Online Database (SING) (2018). Accessed on January 12, 2018 through http://herbaria.plants.ox.ac.uk/bol/sing

Sinha, R. P. & Häder, D. P. (2002). UV-induced DNA damage and repair: a review. *Photochemical and photobiological Sciences*, 1(4), 225–236.

Stancato, G. C, Mazzafera, P. & Buckeridge, M. S. (2002). Effects of light stress on the growth of the epiphytic orchid *Cattleya forbesii* Lindl. x *Laelia tenebrosa* Rolfe.

Brazilian Journal of Botany, 25(2), 229–235.

Swiss Orchid Foundation at the Herbarium Jany Renz. (2017). Accessed on July 7, 2017 through https://orchid.unibas.ch/index.php/en/database-search/advanced-search

Tuck-Po, L. (2000). Forest, Bateks, and degradation. *Japanese Journal of Southeast Asian Studies*, 38(2), 165–184.

Turner, I. M. (1995). A catalogue of the vascular Plants of Malaya: Orchidaceae. *The Garden's Bulletin*, 47(1), 559–620.

Wan Mohd Shukri, W. A., Ismail, H., Nur Hajar, Z. S. & Mohd Rizal, S. (2007). Logged-over forests under the selective management system: a case study in Jengai Forest Reserve, Terengganu (pp 68–77). In: N. M. Nik Zanariah, K. A. Sarifah & H. Nor Azman (Eds), *Highlight of FRIM'S IRPA Projects 2006*. Kepong, Malaysia: Forest Research Institute Malaysia.

Wang, Y. T. (1995). *Phalaenopsis* orchid light requirement during the induction of spiking. *HortScience*, 30, 59–61.

WCSP (2018). World Checklist of Selected Plant Families. Facilitated by the Royal Botanic Gardens, Kew. Accessed on December 28, 2018 through http://apps.kew.org/wcsp/home

Werner, F. A. & Gradstein, S. R. (2009). Diversity of dry forest epiphytes along a gradient of human disturbance in the tropical Andes. *Journal of Vegetation Science*, 20(1), 59–68.

Williams-Linera, G., Sosa, V. & Platas, T. (1995). The fate of epiphytic orchids after fragmentation of a Mexican cloud forest. *Selbyana*, 16(1), 36–40.

Wolf, J. H. (2005). The response of epiphytes to anthropogenic disturbance of pine-oak forests in the highlands of Chiapas, Mexico. *Forest ecology and management*, 212(1–3), 376–393.

Yang, S. J., Sun, M., Yang, Q. Y., Ma, R. Y., Zhang, J. L. & Zhang, S. B. (2016). Two strategies by epiphytic orchids for maintaining water balance: thick cuticles in leaves and water storage in pseudobulbs. *AoB PLANTS*, 8, plw046.

Yooyongwech, S., Horigane, A., Yoshida, M., Yamaguchi, A., Sekozawa, Y., Sugaya, S. & Gemma, H. (2008). Changes in aquaporin gene expression and magnetic resonance imaging of water status in peach tree flower buds during dormancy. *Physiologia Plantarum*, 134, 522–533.

Zhang, S. B., Dai, Y., Hao, G. Y., Li, J. W., Fu, X. W. & Zhang, J. L. (2015). Differentiation of water-related traits in terrestrial and epiphytic *Cymbidium* species. *Frontiers in Plant Science*, 6, 260.

Zotz, G. & Winkler, U. (2013). Aerial roots of epiphytic orchids: the *velamen radicum* and its role in water and nutrient uptake. *Oecologia*, 171, 733–741.

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RUDOLF SCHLECHTER'S SOUTH-AMERICAN ORCHIDS I. HISTORICAL AND BIBLIOGRAPHICAL BACKGROUND

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Abstract. This study represents the first part of a series dedicated to the work of Rudolf Schlechter on the orchid flora of South America. The historical background of Schlechter's botanical activity is outlined, and salient aspects of his biography, as well as his main scientific relationships, in particular with Oakes Ames, and the origins of his interest in tropical America are discussed. We also present a complete bibliography relative to Schlechter's production on the orchid floras of South American countries, with his network of orchid collectors, growers and other purveyors, and checklists of all the new taxa that he described from each individual country.

Key words: bibliography, biography, history of botany, Orchidaceae, South America

Historical background[1]. One will hardly find any scholar who was such an ardent and unconditional defender of Rudolf Schlechter as the late Karlheinz Senghas (1928–2004), who made the study of Schlechter's work one of the goals of his life. Senghas (2002: 1) answers the question about the most important German orchidologists by using the term "the three Popes" when referring to Heinrich Gustav Reichenbach, or Reichenbach *filius* (1824–1899), from Hamburg (Fig. 1A), Ernst Hugo Heinrich Pfitzer (1846-1906) from Heidelberg (Fig. 1B) and Friedrich Richard Rudolf Schlechter (1872–1925), from Berlin (Fig. 2).

Of these three, Rudolf Schlechter must be credited with having described the largest number of new orchid genera and species, monographic revisions of genera and subtribes, and national and regional orchid floras. The publication of *Die Orchideen* (1915) was, years before the end of his scientific work, the crowning moment of his career (Senghas, 2002: 1).

A man of egoistic self-confidence and driving ambition, Schlechter had an enormous capacity for work and a remarkable memory; it is said that at an early age he had set for himself the goal of describing at least one new orchid every day and indeed he proposed in excess of 5,000.

Schlechter was born on October 16, 1872 in Berlin, the third of six children. His father, Hugo Schlechter, was a lithographer. After finishing school at the Friedrich Wilhelm Gymnasium, he started education in horticulture, first at the market garden of Mrs. Bluth and then at the botanical garden of the University of Berlin. There he worked as an assistant until the autumn of 1891, when he left Europe on his first botanical expedition to southern Africa. He was only 19 years of age.

After arriving in Cape Town he worked as a gardener and as an inspector of grape vines for phylloxera. He then was employed as an assistant in the private herbarium of Dr. Harry Bolus, where he must have learned quite a bit about the local flora from his employer[2]. Bolus' herbarium was later acquired by Cape Town University. From 1891–1892 Schlechter collected plants in the surroundings of the city. After leaving Bolus in 1892, he explored other regions in the southern and eastern Cape, Transkei, Natal and Transvaal until 1895, when he returned to Europe and published his first paper on the plant family to which he would devote the rest of his life, the orchids[3].

Schlechter returned to Europe with copious collections of both asclepiads and orchids, on which

[1] Many important facts about Schlechter's life are based on information in the National History Museum, 2013, as well as on K. Senghas (2002: 1-10).

[2] Bolus, together with John M. Wood, Peter Macowan, and Rudolf Marloth, were known as the "Big Four of South-African Botany".

[3] Schlechter, R. 1895. *Beiträge zur Kenntnis neuer und kritischer Orchideen aus Südafrika* (*Contributions to the knowledge of new and critical orchids from South-Africa*). Bot. Jahrb. Syst. 20, Beibl. 50: 1–44.

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Figure 1. A - Heinrich Gustav Reichenbach (1824–1899). Courtesy of the Archives, Naturhistorisches Museums, Wien. B - Ernst Hugo Heinrich Pfitzer (1846–1906). Charcoal by Guido Philipp Schmidt.

he worked at the Botany Department of the British Museum in London. There he established a relationship with Alfred B. Rendle (1865–1938) (Fig. 3A). Together they later researched on the Asclepidaceae of tropical Africa[4].

In 1896 Schlechter returned to southern Africa and was joined by his brother Max, with whom he travelled north to the Vanrhynsdorp district, returning to Cape Town that September. Between November 1896 and April 1897, they collected northwards to the Cedarberg and eastwards to Cape Agulhas. In August 1897 the two brothers set out for Namaqualand and reached the Orange River at Ramansdrift. Schlechter was then in Mozambique from late 1897 to early 1898. Dr. S. Schonland, director of the Albany Museum in Grahamstown (Eastern Cape Province), who received plants from Schlechter, described him as *the most acute and most successful botanical collector who ever visited South Africa* (Schonland, 1897: 5). Schlechter returned to the University of Berlin in April 1898, drained and weakened by dysentery and tropical fevers. This was nevertheles an important period for the young botanist, for he was able to work with such renowned colleagues as Heinrich Gustav Adolf Engler (1844–1930) (who was his tutor while writing his Ph.D. thesis) (Fig. 3B–4), Friedrich Ludwig Emil Diels (1874–1945) (Fig. 4) and Otto Warburg (1859–1938) (Fig. 5A). It was the latter, an economic botanist, who probably saw that Schlechter was hired by the German Colonial Department to lead an expedition to West Africa in search of latex-producing plants (the *Westafrikanische Kautschuk-Expedition*, 1899–1900) (Fig. 5B).

Over the next decades Schlechter was continuously involved in expeditions, visiting Sumatra, Java, Celebes, Borneo, New Guinea and Australia. In 1901–1903, again under contract with the Colonial Department, he explored Malaysia, Indonesia, German New Guinea and the South Sea islands. He proceeded to Sydney and then New Caledonia in 1902,

[4] Schlechter, R. & Rendle, A.B. 1896. New African Asclepiads. Journal of Botany, British and Foreign 34: 97-100.

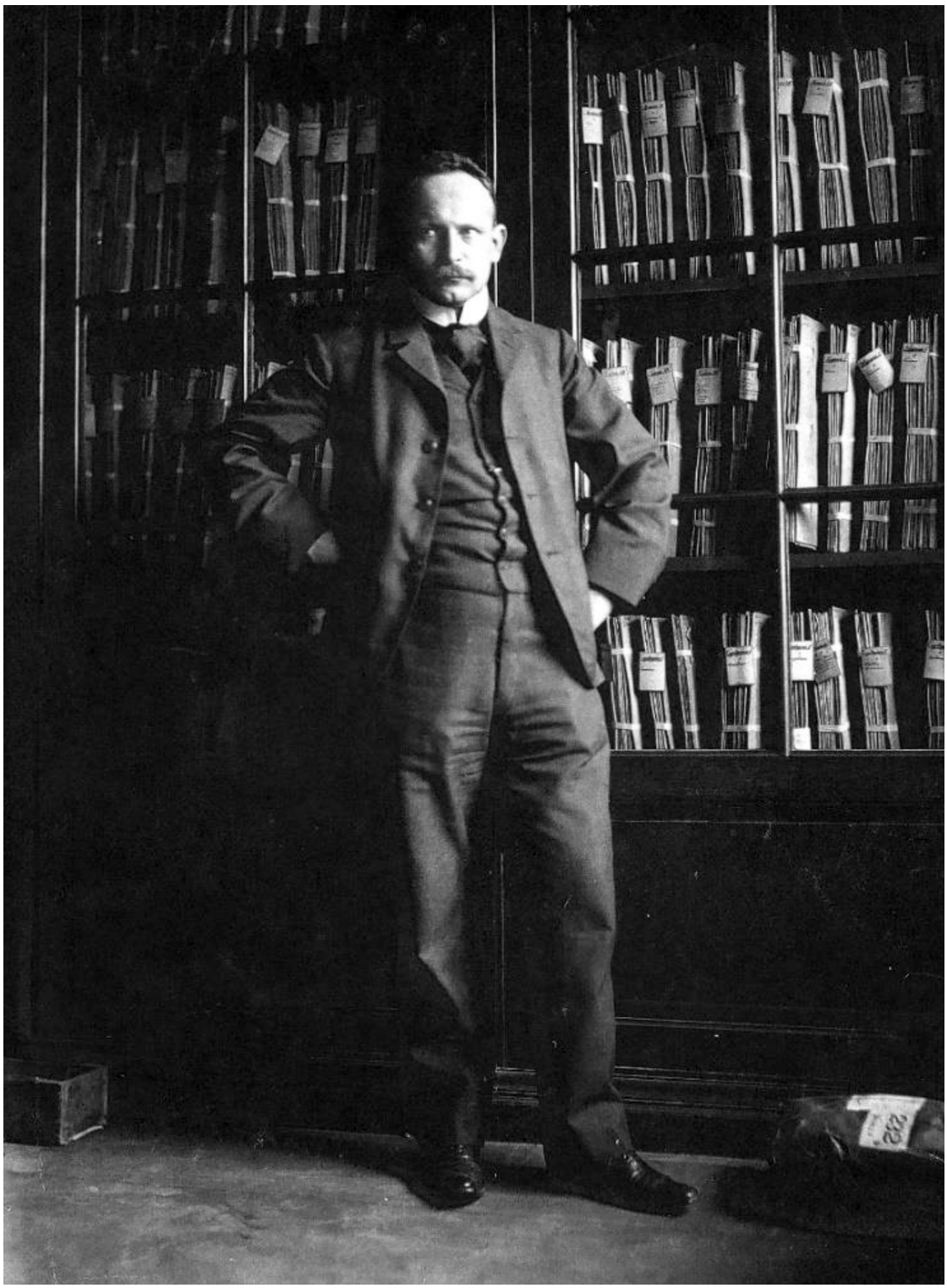


Figure 2. Friedrich Wilhelm Rudolf Schlechter (1872–1925). Archives of Rudolf Jenny.

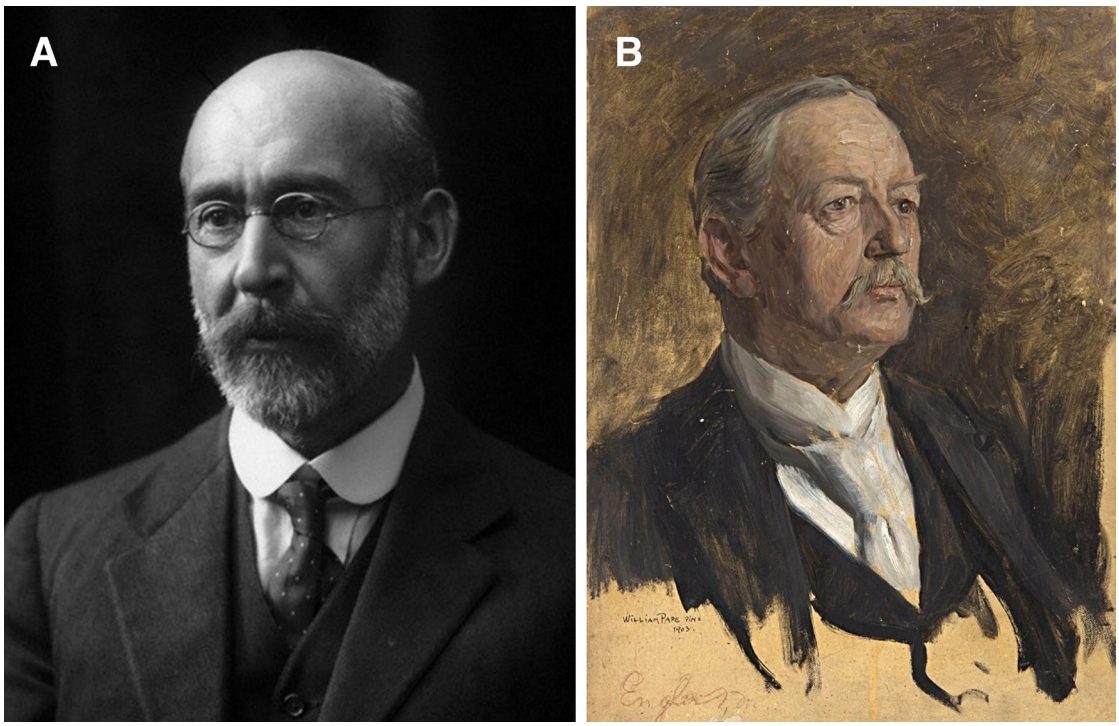


FIGURE 3. A - Alfred Barton Rendle (1865–1938). Photograph by Walter Stoneman. B - Friedrich Gustav Adolf Engler (1844–1930). Study of a portrait by William Page.

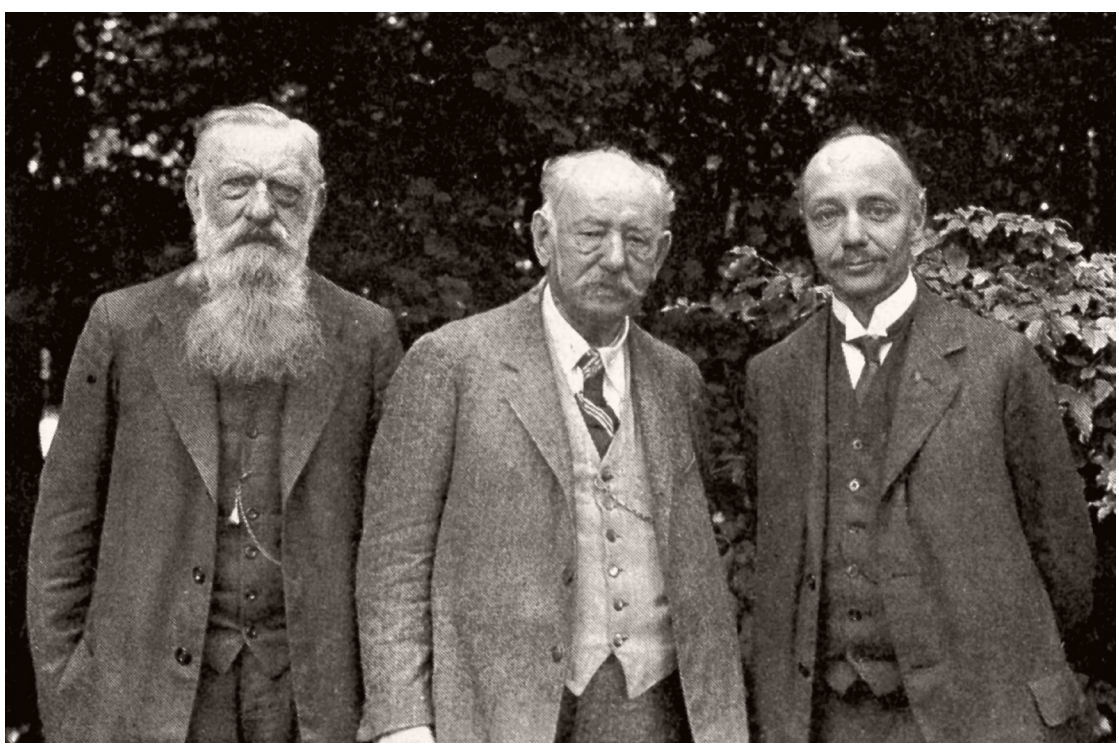


FIGURE 4. Left to right: Ignaz Urban (1858–1931), Adolf Engler, Ludwig Diels (1874–1945). Archives of Rudolf Jenny.

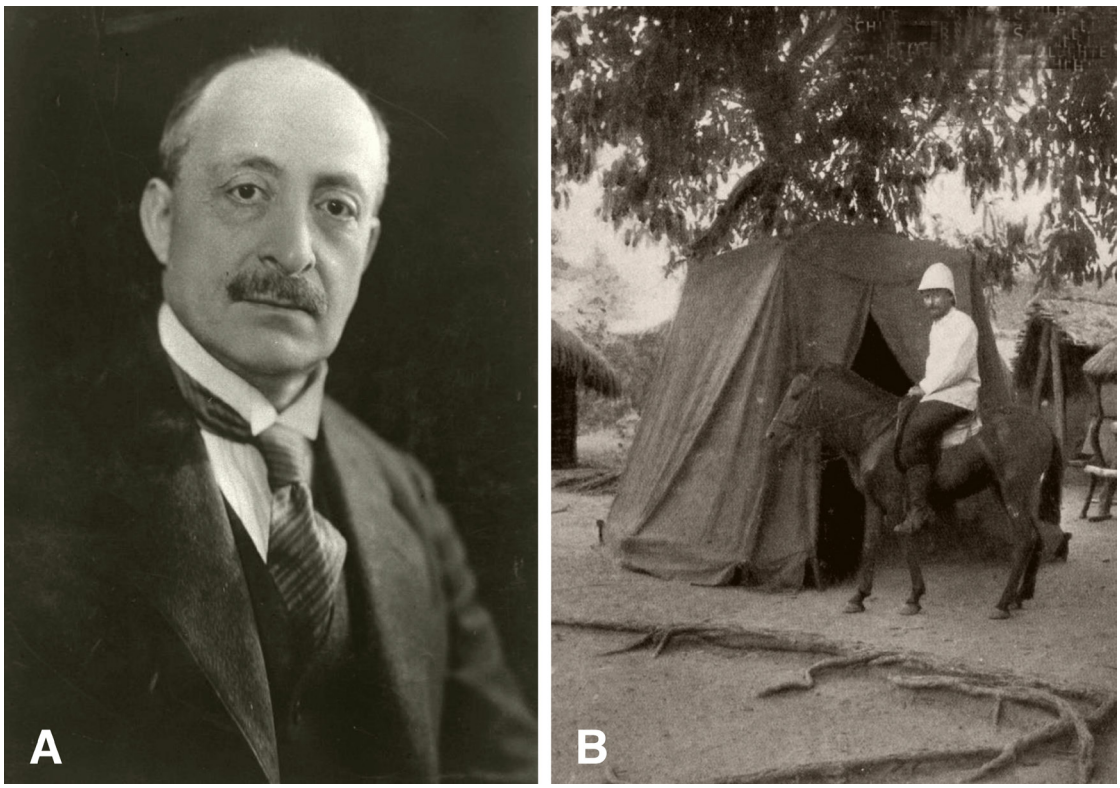


Figure 5. A - Otto Warburg (1859–1938). Archives of Rudolf Jenny. B - Rudolf Schlechter in front of his tent in Kadyebi (Togo), 1900. In Fibeck, 2012, part II: 169. l.

sailing back to Germany in 1903. After completing his doctoral thesis on the phytogeography of New Caledonia, he made another brief trip to West Africa to assess progress with the cultivation of Silkrubber (*Funtumia elastica* Stapf).

In 1906 he embarked on his longest and last expedition, this time back to the Malay archipelago, visiting Hong Kong, the Philippines, Sumatra, Borneo and New Guinea (which served as his base). Although he had been commissioned to establish a rubber research station at the Papuan village of Bulu, it is his botanical collections during this time for which he is best remembered. In 1910 he was back in Berlin, where he began his major work, *Die Orchidaceen von Deutsch-Neu-Guinea*. Published between 1911 and 1914, its 14 volumes numbered over 1,000 pages, in which he described about 1,500 new orchid species.

Schlechter's work had been preceded, after the death of Reichenbach, by Ernst Hugo Heinrich Pfitzer. Pfitzer, who since 1872 was professor and director of the Botanical Garden of Königsberg (Prussia), and dedicated himself to the classification of the Orchidaceae and published his *Beiträge zur Systematik der Orchideen* (*Contributions to the Systematics of Orchids*) in 1895.

Another contemporary of Schlechter was Friedrich Wilhelm Ludwig Kraenzlin (1847–1934) (Fig. 6). studied chemistry and botany at Berlin and Königsberg, receiving his Ph.D. in 1867. He later worked as an assistant to Wilhelm Hofmeister in Heidelberg and under Johannes von Hanstein at the University of Bonn. From 1872 to 1906 he was a professor and director of the botanical garden at Heidelberg. In the first edition of *Die Natürlichen Pflanzenfamilien*[5] (*The natural families of plants*), a work by Adolf Engler and Carl Prantl, Kraenzlin collaborated on the treatment on orchids.

Kraenzlin's work was, however, severely criticized by many of his colleagues. Rudolf Schlechter was no exception. Writing to Oakes Ames on September 12, 1910, he gave his opinion

[5] Engler, A. & Prantl, K. 1897-1915. *Die natürlichen Pflanzenfamilien*. Engelmann, Leipzig.

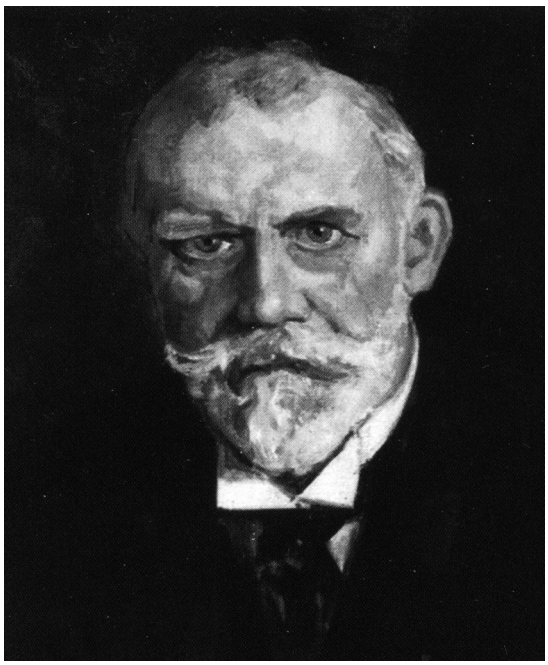


Figure 6. Friedrich Wilhelm Ludwig Kraenzlin (1847–1934). Archives of Rudolf Jenny.

on Kraenzlin's monograph of *Dendrobium*: "*I am very curious to see what Kränzlin's monograph of Dendrobium will be like; from what I see in the Berlin Herbarium in the way of his determinations there will quite a lot of ridiculousness in it and this work will be the crown of foolishness in a man who really has not given a single usuable work to science in spite of his long years of work. Sometimes it almost appears to me as if he is not actually determinating his plants, but raffling them out*." And Ames was equally critical. On December 4, 1910 he replied to Schlechter on the same subject: "*I have just received Dr. Kränzlin's monograph of Dendrobium. I have not yet put it to the test, but in several places I have detected errors which are unpardonable and in every way avoidable*."

Between collecting trips Schlechter continued his visits to London, always stopping in at the herbarium at Kew and the British Museum. He was considered an interesting figure, but being not respectful of persons or things, he was apt to tread on other people's feelings and sensibilities. He was dogmatic in his convictions, a characteristic which did not assist in making him popular; but on the basis of his achievements and experience, he was accorded great respect (Reinikka, 1995: 294). Frequent visits were also made to the herbaria in Paris, Leiden, Brussels, and Vienna.

Shortly after his last expedition, Schlechter married Alexandra Sobennikoff, the daughter of a Russian merchant, with whom he raised two daughters. In 1925 he dedicated the Malagasy orchid genus *Sobennikoffia* to his wife.

Rudolf Schlechter became Secretary of the Orchid Committee of the German Horticultural Society in 1914, and in 1915 editor of the journal *Orchis*. In the same year he finished the publication of the last fascicle of the first edition of his *Die Orchideen*[6], the work that has made him famous to the present day. The First World War interrupted Schlechter's botanical career as he served as officer in the German Army during 1916 and 1917 (Fig. 7). After WWI and until his death in 1925 Schlechter focused on expanding his research collection of orchids.

His production of publications from his orchid research reached its highest point during this period. From a total of 333 publications by Schlechter, 233 were dedicated to Orchidaceae, with the description of some 170 new genera and over 5,500 new orchid species. Among his publications were descriptions of new genera and species, multiple revisions of orchid genera and 20 works about national and regional orchid floras.

Schlechter spent the last 15 years of his career at the Berlin Botanical Museum, where he became a curator in 1921. He died at the relatively young age of 53, in 1925, apparently from the lingering effects of tropical diseases he had contracted during his expeditions. It was, however, fortunate that he did not live to see the destruction of one of his greatest achievements: his collections were destroyed along with the Berlin herbarium by allied bombing on the night of March 1, 1943 (Fig. 8).

Rudolf Schlechter's name lives on in the genera *Schlechteranthus* Schwantes (Aizoaceae), *Schlechteria* Bolus ex Schltr. (Brassicaceae), *Schlechterella* K.Schum (Asclepidaceae), *Schlechterina* Harms (Passifloraceae) and *Rudolfiella* Hoehne (Orchidaceae). Forty-one orchid species carry his name.

[6] Schlechter, R. 1915. *Die Orchideen: ihre Beschreibung, Kultur und Züchtung. Handbuch für Orchideenliebhaber, Züchter und Botaniker*. Berlin, P. Parey.

Figure 7. Rudolf Schlechter as infantry-officer, WWI. In Fibeck, 2014, part V: 59.

FIGURE 8. Berlin Herbarium destroyed during WWII, 1943. Archives of Rudolf Jenny.

Bibliographical background – Schlechter's interest in tropical America. Rudolf Schlechter's first contact with the orchids of South America's vast territory (Fig. 9) was undoubtedly his study of the large collections of orchids by Friedrich Carl Lehmann (1850–1903) held by the British Museum in London. Lehmann began to sell herbarium specimens to the British Museum in 1888, and Robert A. Rolfe was engaged in describing them at Kew. When Schlechter arrived in London in 1898 after his first South-African expedition, the British Museum already had a significant number of Lehmann's Colombian orchid specimens, although Lehmann's early collections were buried in Vienna, together with the rest of Reichenbach's Herbarium. Rudolf Schlechter, in his works of 1920 and 1924 on the Colombian orchid flora, made frequent reference to specimens collected by Lehmann.

Schlechter's publications on orchids that refer to South American orchids can be roughly divided into four periods: the years before WWI, especially those after his return from Papua & New Guinea in 1909 (21 publications); the war years (1914–1918, 30 publications); the postwar years, from 1919 to his death in 1925 (44 publications). There were, additionally, posthumous publications of his works by his wife, Alexandra, Rudolf Mansfeld and others (17 publications).

Schlechter's first publication on tropical orchids from the New World was a product of the return to Germany of Robert Knud Friedrich Pilger (1876–1953), who had travelled as a botanist with an expedition to the Matto Grosso, Brazil, led by Dr. Hermann Meyer (1871–1932), in the years 1899 and 1900. Pilger worked at the Botanical Museum in Berlin on the plants collected during his journey, contacting leading specialists in the different plant families to assist him in the determinations. Schlechter was chosen to work on his favorite family, the *Orchidaceae*, in Pilger's *Beitrag zur Flora von Mattogrosso* (Pilger, 1901: 149–150) describing the relatively small number of 7 orchid species, of which only one (*Habenaria pilgeri*) was new to science.

We find the next two publications by Schlechter, describing a few new orchid species from Brazil and Colombia, five years later, in 1906. We then have to

FIGURE 9. Map of South America by Harlan P. Beach, ca. 1900.

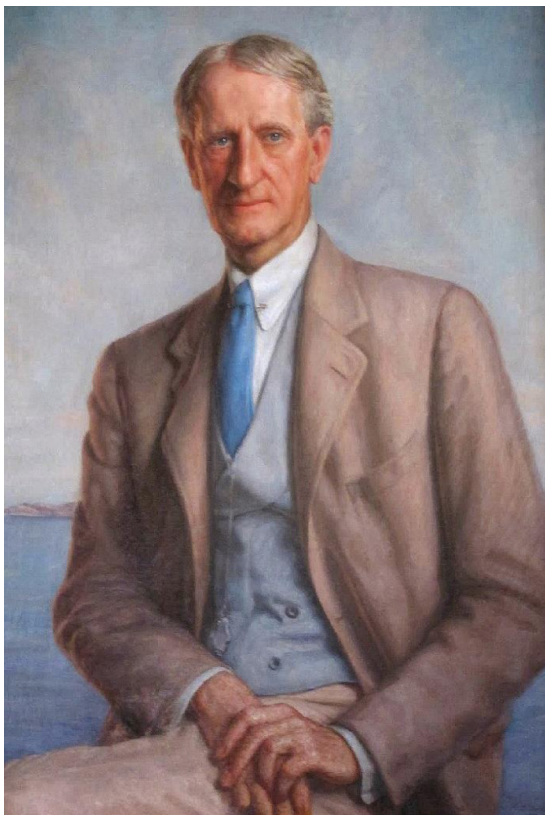


Figure 10. Oakes Ames (1874–1950). Portrait by his wife, Blanche Ames.

wait until 1910 to hear from him again. This unusually unproductive period has naturally to be ascribed to Schlechter's long expeditions to Africa, South-East Asia, Australia, and Papua & New Guinea, which kept him away from Berlin during the best part of the first decade of the 20th century. There was a brief interlude from 1903 to 1906, the time he spent finishing his studies in Berlin and receiving his Ph.D.

Correspondence between individuals has always been one of the primary sources for those writing on history. In our case, we can count ourselves fortunate for being able to read and study the copious correspondence between Rudolf Schlechter and Oakes Ames (1874–1950) (Fig. 10) over a period of some fifteen years. This treasure is today well kept at the Oakes Ames Herbarium of Harvard University. It is not clear how Schlechter established the first contact with the great Harvard botanist, although it was presumably through common acquaintances at Kew. Ames, when writing about the destruction of the herbarium in Berlin (1944) says that "*nearly half a century ago my acquaintance with Schlechter began."* This would have been coincidental with Schlechter's visit to Kew after his first African expedition, so it must have been sometime between 1898 and 1900.

Over 350 pages of letters -mostly typed in the case of Ames; always in his untidy handwriting by Schlechter- give us an impressive insight into each man's particular circumstances and constitute a detailed timeline, especially with regard to Schlechter's publications and his personal, difficult circumstances. Although their relationship grew through the years to one of deep friendship -to a point where the biography of either botanist during this period can only be written with constant mention of the other- the differences in character, as well as in economic and social standing, could hardly be more extreme. Schlechter came from a middle-class family and had to work his way up through untiring personal effort; Ames was born into a family of millionaires, the elite of the high socierty of New England (Fig. 11). Ames' grandfather has been credited by many historians as being the single most important influence in the building of the Union Pacific portion of the transcontinental railroad. While Schlechter spent the first fifteen years of his mature life in extensive and exhausting expeditions through Africa, Southeast Asia, and Australia, developing a deep understanding of orchids in relation to their natural habitats, Ames hardly ever left the sumptuous comfort of his native Boston and his research on orchids was always based on herbarium specimens of plants which he had seldom seen growing in their natural habitats, or on the few living plants growing in the Harvard Botanic Garden.

Schlechter was an incredibly hard worker who produced an average of over 20 publications per year, including such major works as his *Die Orchideen*; Ames, in his own words, was an intermittent worker who wandered from the job, 'a slave of inclination' as he defined himself, for whom there were months at a stretch when he considereed botanical work 'a perfected form of torture'. His literary production -compared with that of Schlechter- was relatively meager. Schlechter was the most important orchidologist of his time, while Ames played a relatively smaller role.

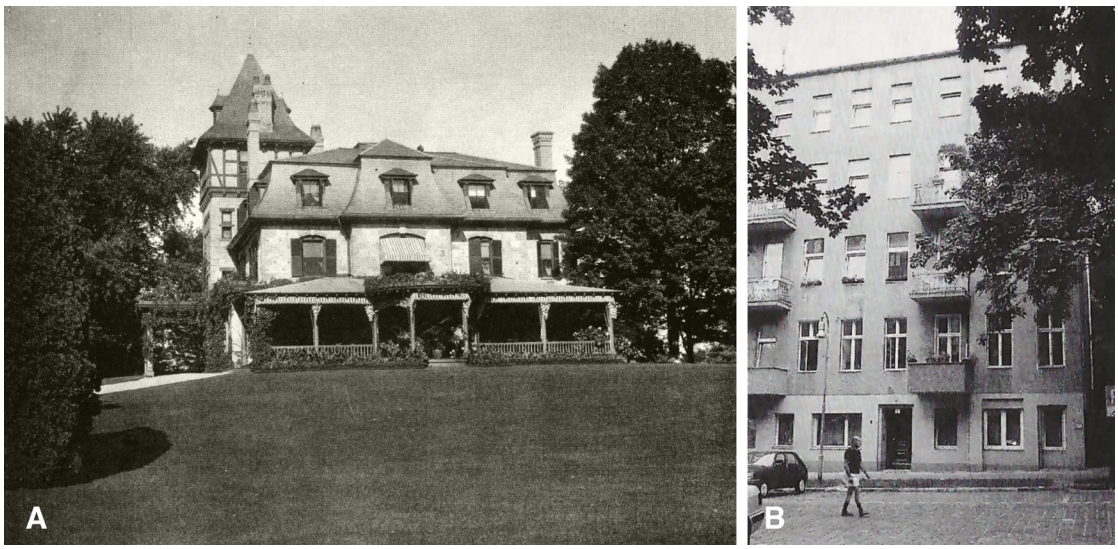
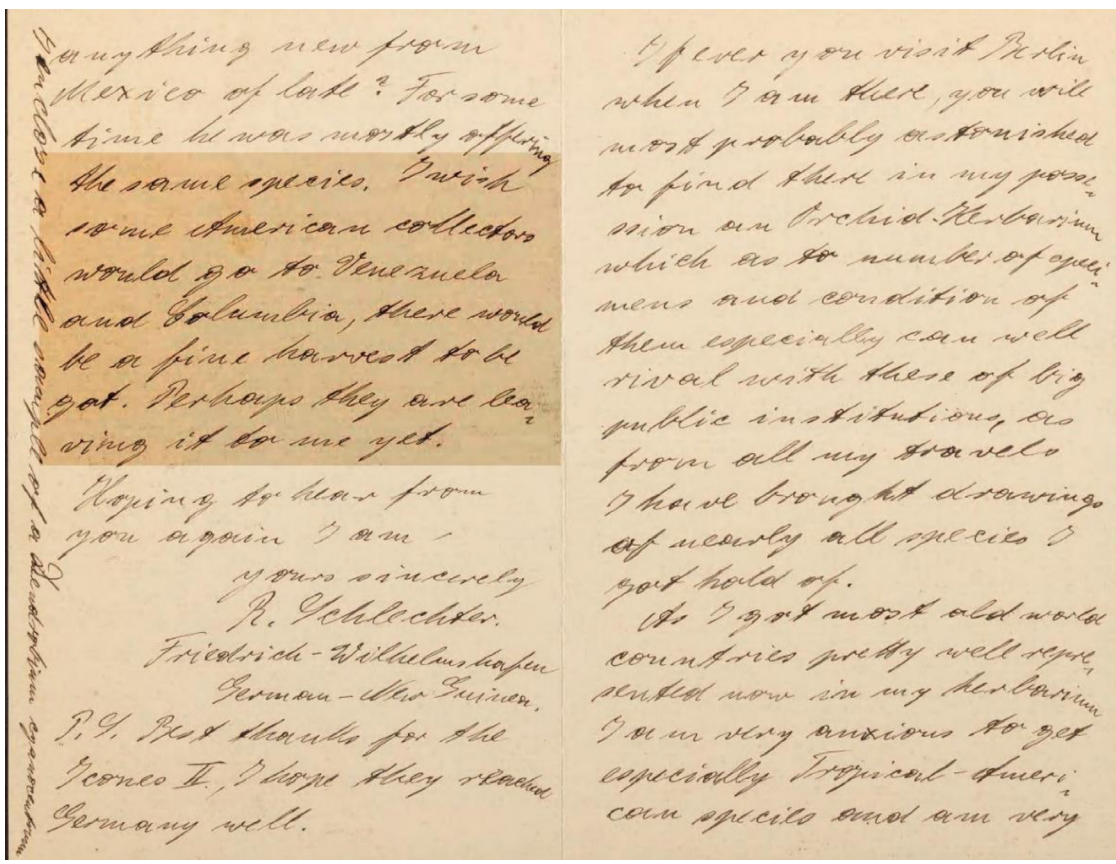


Figure 11. A - Homestead of the Ames family, were Oakes Ames was born and lived in the first years of his marriage (North Easton, Massachusetts). B - Building on Neue Culmstrasse N°5a, where Schlechter lived around 1914 (Berlin-Schöneberg). The building was heavily damaged during the war and rebuilt afterwards.



anything new from Mexico of late? For some time he was mostly offering the same species. I wish some American collectors would go to Venezuela and Columbia, there would be a fine harvest to be got. Perhaps they are leaving it for me yet.

Hoping to hear from you again I am -

yours sincerely

R. Schlechter.

Friedrich-Wilhelmshafen

German-New Guinea.

P.S. Best thanks for the Icones II, I hope they reached Germany well.

Whenever you visit Berlin when I am there, you will most probably astonished to find there in my possession an Orchid-Herbarium which as to number of specimens and condition of them especially can well rival with those of big public institutions, as from all my travels I have brought drawings of nearly all species I got hold of.

As I got most old world countries pretty well represented now in my herbarium I am very anxious to get especially Tropical-American species and am very

Figure 12. Letter from Schlechter to Ames, Feb. 2, 1909: "*I wish some American collectors would go to Venezuela and Columbia, there would be a fine harvest to be got.* […]". In Oakes Ames Orchid Herbarium, Harvard University.

FIGURE 13. Friedrich Karl Gustav Fedde (1873–1942). Archives of Rudolf Jenny.

However, Ames amassed an orchid herbarium which, before being integrated into the larger collection of Harvard University, contained about 131,000 plant specimens, around 3,000 flowers in glycerin, 4,000 specimens in liquid and hundreds of line drawings that supplemented the specimens. Part of this herbarium were hundreds of duplicates and drawings received from Schlechter, and later Mansfeld, before the tragic bombing of the Berlin herbarium in 1943.

With time, Ames became instrumental in providing his German counterpart with information about tropical American orchids: over fifteen years he exchanged duplicates from his Central and South-American herbarium specimens with Schlechter. One could say that during important periods of their work on orchids, Ames and Schlechter became indispensable to each other.

The first record of Schlechter's correspondence with Ames (August 3, 1908, from camp on Mount Komi, in what is now Papua New Guinea) is a letter in which he wrote: "*I dare say I will be able to let you have a rather large number of Orchid specimens from here after my return to Europe and hope that you will have to offer some Orchid-material from Tropical-America in return, or perhaps the West-Indies?*". It is the first mention of Schlechter's growing interest in the orchids of the New World tropics. A few months later, back in Germany, Schlechter wrote again (from Berlin, February 2, 1909) "*I wish some American collectors would go to Venezuela and Columbia, there would be a fine harvest to be got. Perhaps they are leaving it to me yet […] If ever you visit Berlin when I am there you will most probably be astonished to find there in my possession an Orchid-Herbarium which as to number of specimens and condition of them especially can well rival with these of big public institutions, as from all my travels I have brought drawings of nearly all species I got hold of. As I got most old world countries pretty well represented now in my herbarium I am very anxious to get especially Tropical-American and am very pleased to exchange with you any material you can spare from Central- and South America as well as the West-Indies. […] Perhaps after a few years I will make a trip to Tropical America myself to get things better from there. However, this is not quite certain yet*" (Fig. 12).

And then again (from Berlin, December 2, 1910): "*I am very keen on any material from Central- or South America, as these countries are not well represented in my herbarium. […] ...you can perhaps get me New-World-Orchids.*"

Shortly after this letter Schlechter finally started to work on South-American orchids. In yet another letter, this time from Riga (Latvia), on August 27, 1912, he told Ames: "*At present I got some larger collections from South-America, Madagascar and Borneo to go through*."

From 1910 the years immediately preceding WWI were immensely productive: Schlechter published a total of 22 papers in which he described South American orchids. As to Ames, Schlechter's last letter to him before the war was dated May 10, 1914. He would not write again until Aug. 31, 1919.

A fortunate event for Schlechter was the publication by botanist Friedrich Karl Georg Fedde (1873–1942) (Fig. 13) of a long series of booklets under the general title *Repertorium specierum novarum regni vegetabilis* (Fig. 14A).

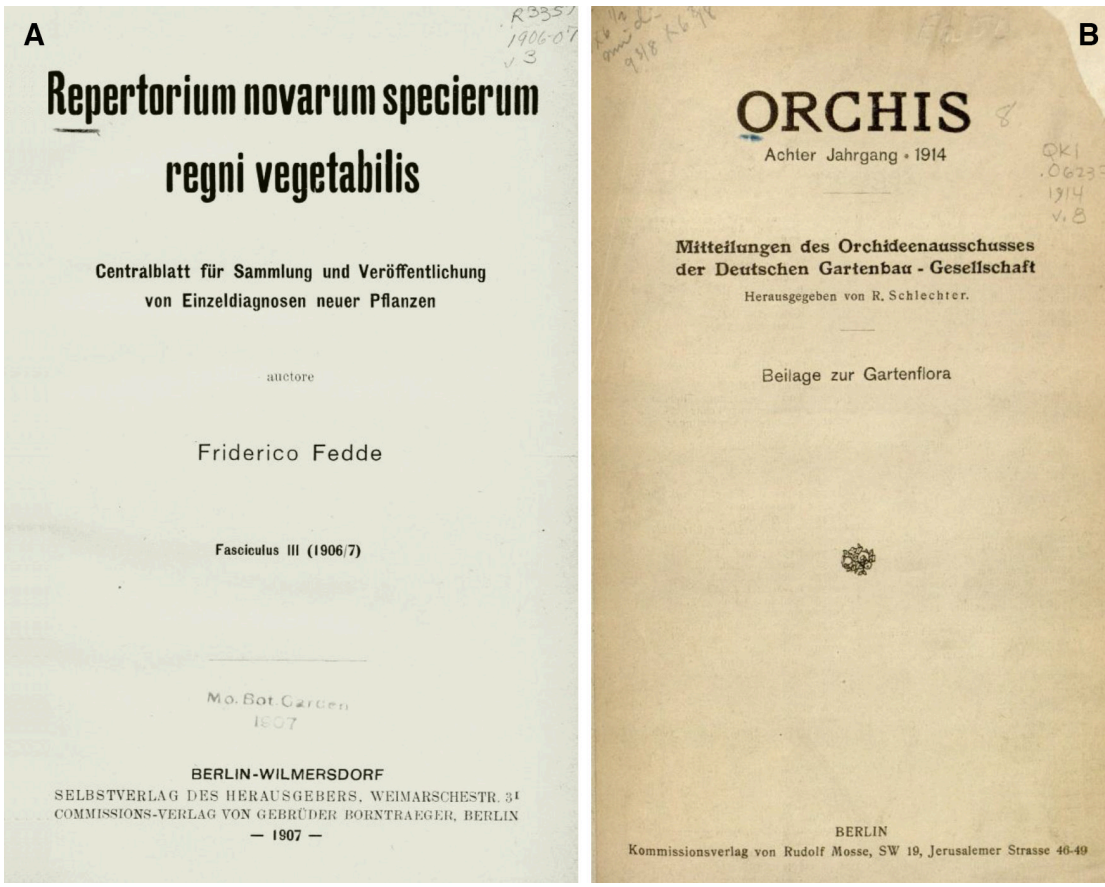


Figure 14. A - Title page of Fedde's *Repertorium Specierum Novarum Regni Vegetabilis*. B - Title page of *Orchis*.

Fedde studied natural sciences, beginning in 1892 and graduating in 1896 in Breslau. After working as a teacher in schools of higher learning in several German cities, he became an associate at the Berlin Botanical Museum in 1901 and a professor there in 1912. Fedde took part in several collecting trips to Southern Europe, Finland, and South Russia. Beginning in 1910, Fedde would publish most of Schlechter's works until the latter's death in 1925. Among the first publications by Fedde were Schlechter's well-known series of articles: *Orchidaceae novae et criticae*. In 21 of these articles Schlechter described, among others, an important number of new South-American orchid species.

The second most important journal that published Schlechter's works was *Orchis* (Fig. 14B) (published from Vol.3, 1909, as part [*Beilage*] of the journal *Gartenflora*), the monthly journal of the German Orchidological Society, from 1906 until its disappearance in 1920, which was edited by Schlechter himself. A total of 31 of his articles were published in this periodical, among them his long series entitled *Neue und seltene Garten-Orchideen* (*New and rare garden orchids*), in which he described dozens of new orchids from Tropical America.

By 1914 Schlechter had already formed a 'network' of collaborators who supplied him with orchid species for determination. At first, his relations were with important orchid growers and collectors in Germany, such as Karl Wilhelm John in Andernach-on-the Rhine, Otto Beyrodt in Marienfelde, the Gardens of Herrenhausen in Hannover, Julius Wrede in Berlin-Dahlem, Wilhelm Hennis in Hildesheim and Baron Max von Fürstenberg, owner of an orchid collection and President of the recently founded German Society of Orchidology. From Ireland, he received plants from Frederic W. Moore, curator of the Botanic Gardens in Glasnevin. The legacy of Friedrich Carl Lehmann, the German plant collector in Colombia who had died

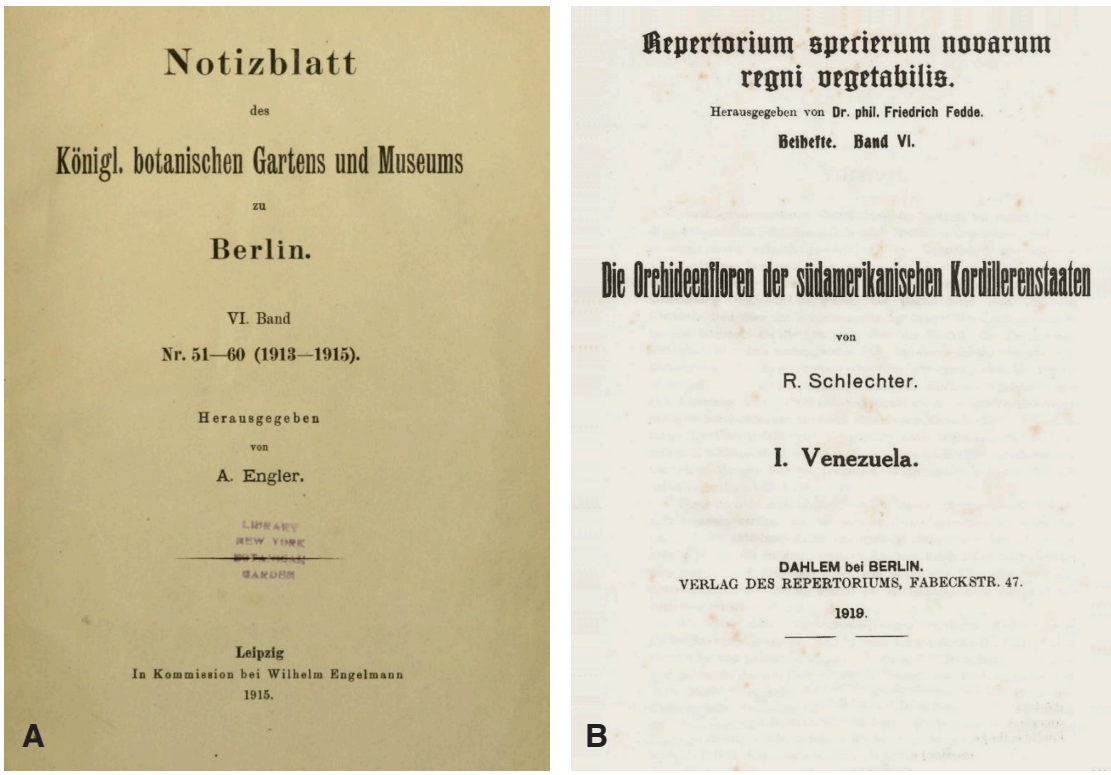


FIGURE 15. A - Title page of *Notizblatt des Königlichen Botanischen Gartens und Museums zu Berlin*. B - Title page of Volume I of Schlechter's *Orchideenfloren der Kordillerenstaaten*, volume I (Venezuela).

in 1903, was another important source of research material. Contact with Oakes Ames at Harvard again gave him the opportunity to receive more South-American material through the exchange of his African and Asian duplicates.

Among the first collectors on American soil from whom he received plants were Ernst Ule, who collected in Brazil, Guayana, Venezuela and Peru, Christian Theodor Koch (Brazil, Colombia, Venezuela), Eugène Langlassé (Colombia), Henrik Franz Alexander von Eggers (Ecuador), Eugene Köhler (Peru), Carl Pflanz (Bolivia), Otto August Buchtien (Bolivia), Robert Statham Williams (Bolivia), Karl August Gustav Fiebrig (Bolivia, Paraguay), Henri François Pittier (Venezuela, Colombia), Theodor Carl Julius Herzog (Bolivia, Argentina), Louis Mille and Luigi Aloysius Sodiro (Ecuador), Per Karl Haljmar Dusen (Brazil, Argentina, Chile, Paraguay), Georg Hans Emmo Hieronymus, and H. Wendt (Argentina, Brazil). Quite an impressive number of collectors and botanists, as one can see.

Despite having to serve in the military, Schlechter published an additional 28 papers in the period between 1914 and 1919, a remarkable number under the conditions in Germany during those years. Noteworthy from that time were Schlechter's monographic treatments on a number of orchid genera, among them *Anguloa*, *Cycnoches*, *Coryanthes*, *Laelia*, *Acineta*, *Aganisia*, *Cochlioda*, *Houletia*, and *Brasssavola.* Of great interest also was his second regional flora (after Mattogrosso in 1901), in which (1919) he determined Per Karl Dusen's orchid collections from the Brazilian province of Paraná. The *Notizblatt des Königlichen*[7] *Botanischen Gartens und Museums zu Berlin*, edited by A. Engler (Fig. 15A) (in its later years, 1918–1924, after the abdication of Emperor Wilhelm II, simply *Notizblatt des Botanischen Gartens und Museums zu Berlin)* was another important means for Schlechter to see his works published.

[7] *Königlich* = Royal.

Schlechter complained in several of his writings that because of the war he received very little new material from collectors in America. This explains the relatively small number of new species described by him during that period. Nevertheless, manynew names of orchid growers, collectors and botanists appeared in this period among Schlechter's orchid suppliers to expand his already important 'network'. Among them, we count orchid growers Paul Wolter in Magdeburg-Wilhelmsburg, R. Blossfeld in Potsdam and Hartmann in Nieder-Höchstadt; and the plant collectors Karl Immanuel Eberhard Ritter von Goebel (Brazil), Johann Heinrich Rudolf Schenck (Brazil), Emil Hassler (Paraguay, Guyana), and Carl Grossmann (Brazil).

Immediately after the war, Schlechter began to work on one of his most ambitious projects regarding the orchids of Tropical America: his series of publications about the orchid flora of the Andean states (*Die Orchideenfloren der südamerikanischen Kordillerenstatten*).

Communications across the Atlantic slowly resumed after the end of the war, and on August 31, 1919 Schlechter was once again able to correspond with Ames: "*At last there is a chance again to communicate with foreign countries and so I will take a chance to try to send you a letter. […] I expect the enumeration of the Central-American orchids will at present interest you most. But besides there is in print […] an enumeration of the Orchid-Flora of Venezuela … […] The Orchid-flora of Venezuela is an enumeration of all the Orchids until now known from there! A number of new species I have added, and remarks on the features of the Orchid-flora. I have found that such compilations are of the greatest use and especially for the South-American Andes-states they were badly needed.* […] *For Colombia, Ecuador, Peru and Bolivia the manuscripts are finished too and are going to be printed in the course of the next months. This work has considerable widened my knowledge of certain types, the more so as I have used the chances to study enormous materials more closely*.[8] […] *After the publication of the Orchid-floras of the Andes-states we will have a fair knowledge of the distribution of the different types, the more so as I have been making remarks in the general part on the distribution of each species and the affinities of each flora*."

Volume I of Schlechter's *Orchideenfloren der Kordillerenstaaten* (Fig. 15B) was finally published at the end of 1919. A number of new names were added to Schlechter's "network", among them Paul Rudolf Preuss, O.K.S. Passarge and Selwyn, Salomon Briceño, Everard Ferdinand Im Thurn, and F.V. McConnell and J.J. Quelch.

In the same letter of August 31, 1919, Schlechter described his personal difficulties in a country that was experiencing the trauma of the lost war: "*the difficulties are numerous ones too, because now here in Germany the educated people are in comparison with the cost of daily life altogether underpaid and the costs of printing have risen to about four times the costs of before the war. I actually would best of all like to leave Germany and go somewhere else where one would have the chance to properly continue scientific work under more favorable circumstances. But perhaps things will develop yet again more favorably; until now I can't see very brightly into the future.*"

South American orchids became the center of Rudolf Schlechter's attention during the following months. In further letters to Ames he described the progress and difficulties of his project. So, on September 24, 1919: "*For my winter work I had planned to determine the Colombian collections of the U. S. National Herbarium and of the New York Botanical Garden Herbarium. I wanted to do this work in order to get my set of Lehmann orchids ready for inclusion in my Herbarium. If your papers on the Colombian orchids are ready soon, please send them to me at your earliest convenience. They will save me the work of searching the literature for a list of Colombian species. I hope you have included, the numbers of specimens you have examined in these lists of yours and that you worked on the Lehmann collections.*"

October 22, 1919: "*My list of Colombian Orchids is ready for print and I hope to bring the whole volume out before the end of the year. […] I have described*

[8] Schlechter had studied the collections of Friedrich Lehmann from Colombia and Ecuador. Lehmann communicated with Professor H.G. Reichenbach f., the leading orchid taxonomist of the time, and after Reichenbach died in 1884, worked with Dr. F. Kraenzlin describing new species of orchids from Colombia and Ecuador. He also sent a large set of his collections to Kew, where many were identified by Robert A. Rolfe.

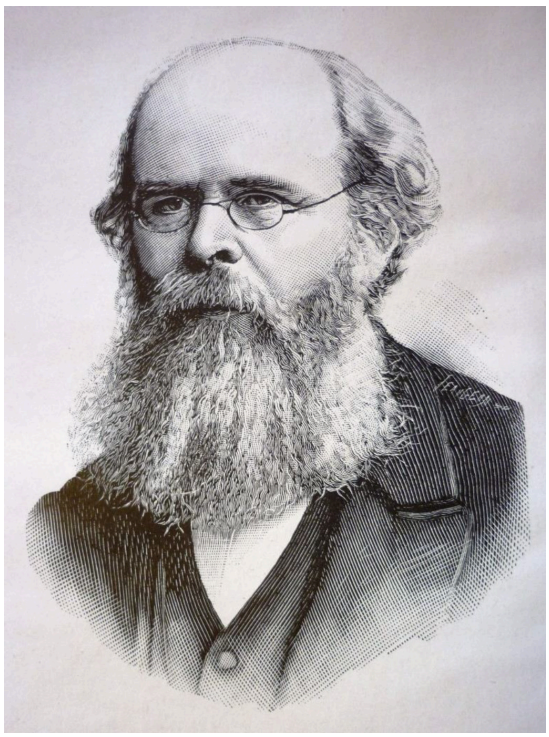


FIGURE 16. Celestin Alfred Cogniaux (1841–1916). Unknown author.

over 250 new Colombia Orchids and 5 or 6 new genera. Quite a lot of Lehmann's things are included and the plants from Sta. Martha collected by H.H. Smith… […] the more we progress with the printing of the work the more difficulties we have got to get sufficient funds for the publications together. […] Could you not perhaps interest some of the botanical circles in your country, that they might supply us with sufficient funds by suscribing for the publication of these lists? […] These lists are going to be published in five parts under the title "Die Orchideenfloren der südamerikanischen Kordillerenstaaten" I. Venezuela, II, Colombia, III Ecuador, IV Peru, V. Bolivia."

An important role in Schlechter's "network" was played by Celestin Alfred Cogniaux (1841–1916) (Fig. 16), the great Belgian botanist and specialist on South American orchids. Cogniaux had worked for years with Adolf Engler (Director of the Berlin Botanical Garden between 1889 and 1921) and Ignaz Urban (1948–1931) (Fig. 4) (Assistant Director of the Berlin Botanical Garden and Museum from 1889 to 1913), being in charge of the Orchidaceae in the monumental *Flora Brasiliensis* and later the not less important *Symbolae Antillanae seu fundamenta Florae Indiae Occidentalis*. Engler and Urban also had close working relations with Rudolf Schlechter. Therefore, when Cogniaux had to retire because of his age and health[9], Schlechter took over as his logical successor, describing the Orchidaceae in volume VII (fascicle IV, August 1913) and volume VIII (fascicle I, February 1920) of the *Symbolae Antillanae.* Thus, on November 11, 1919, Schlechter was able to write to Ames: "*I have not made a list of the Lehmann determinations, but Cogniaux before he died has sent me, as he wished that I should continue his work on the South-American orchids, a book in which he had entered all the determinations that he has found of the different collectors in literature and that he made himself*."

In the above-mentioned letter of August 31, 1919, Schlechter proposed to Ames that they take part in a new, ambitious project: a new and updated version of John Lindley's famous work, *Folia Orchidaceae*[10]: "*In fact, I very much hope that we will do yet a lot of work under combined authorship. I am much reckoning on you for the eventual cooperation on the 'Folia Orchidaceae', because as such I would think it best to bring out a future monograph of the Orchidaceae. This has the advantage that one can choose the genera as one has got material for the work.*"

Schlechter wrote to Ames several times about this idea until, after months of impatient pressure, on April 23, 1920, Ames finally replied: "*I am very much interested in the new 'FOLIA'. I would enjoy working with you, although I am afraid that the difference in our speed would throw the bulk of the labor on your shoulders. I am an intermittent worker; that is I am a slave of inclination, and there are months at a stretch when I find botanical work of any kind a perfected form of torture. You might not enjoy collaboration with a man who wanders from the job.* […] *I have in mind a painstaking, thorough job of each genus or section of a genus we attack.* […] *Although we would of course*

[9] In 1901 Cogniaux had retired from his chair in Natural History at Verviers on a pension, which enabled him to devote the whole of his time to botany. His latest completed work was on the orchids of the West Indies, which came out in volume VI of the *Symbolae Antillanae*.

[10] Lindley, J. 1852–1859. *Folia Orchidacea. An Enumeration of the Known Species of Orchids.*

work independently on the genera we undertook to do, we ought to agree at the beginning that we would submit our manuscript to the other man before final going to the press […]." This however could not stop Schlechter, who replied on May 9, 1920: "*What you write about your own way of working intermittently cannot hinder us. I am myself, this I know, a fairly hard worker and will see to it that the work progresses. It is my ambition, and I hope it will be yours too, that we should be able to finish a monograph of all the Orchidaceae before our lives are finished.* […] *For the title of the work I would propose 'Folia Orchidaceae' by Oakes Ames and R. Schlechter"*. And he continued: "*... my plans are the following. We could work out the different genera separately, starting of course with the smallest ones, but at the same time bringing out now and then a larger one. The descriptions and the general way of publishing should be similar to the one adopted by Lindley, but each genus gets a systematical number, for which, as they are now fairly known, with slight alteration we could adapt the numbers as they are given in my book 'Die Orchideen'*."

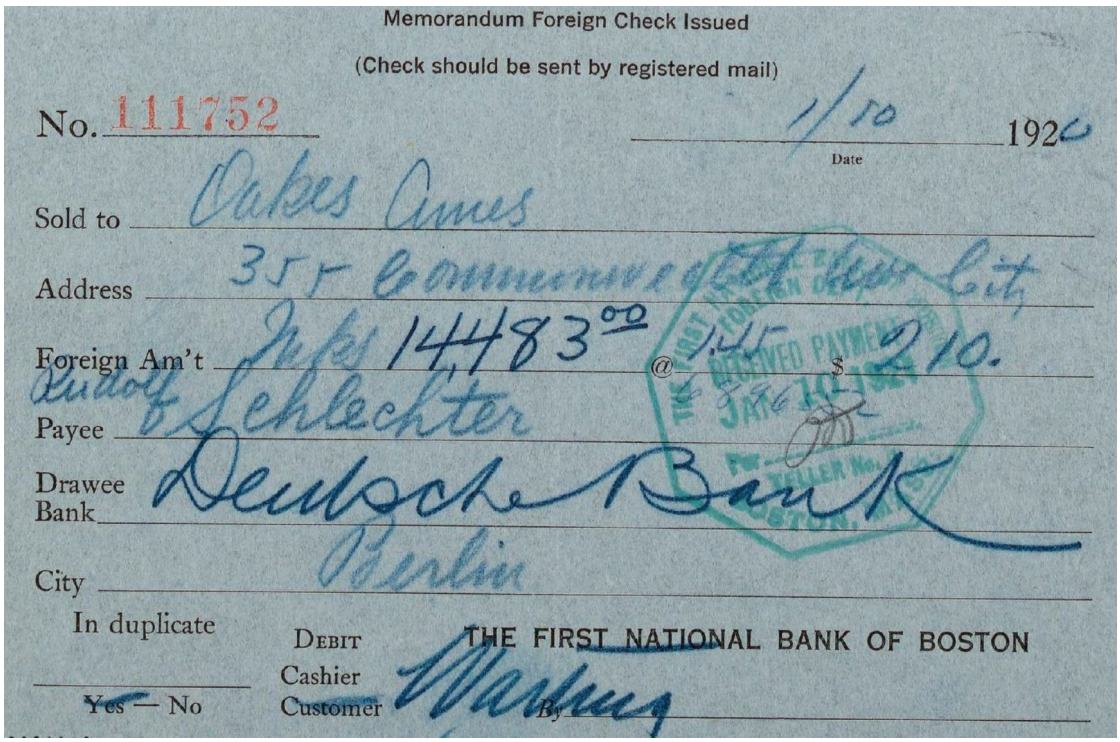
Meanwhile, Schlechter continued working and publishing on South American orchids. The remaining years of his short life (1919–1925) were at the same time among his most productive. A large number of his publications during that period made reference to South-American orchids. One of his most outstanding accomplishments was the completion of his series about the orchid floras of the Andean states, his famous *Orchideenfloren der südamerikanischen Kordillerenstaaten*.

The above-mentioned volume I (Venezuela, 1919) was followed in 1920 by volume II, Colombia; in 1921 by volumes III Ecuador and IV, Peru; and finally, in 1922, by volume V, Bolivia.

After finishing volume II, Schlechter ran out of funds for the remaining three volumes. Having received no answer to his petition to Ames of October 1919, Schlechter touched the same subject again on December 17, 1920: "*As I have written to you already, my manuscripts with the compilations of the orchid floras of Ecuador, Peru and Bolivia are ready for print since a long time. Printing costs have however got so high here on account of our bad valuta, that Fedde has no funds to go on with the publication.* […] *...at the present state of our valuta this would roughly cost about 450 Dollars* […] *Would it not be possible for you to help me in this matter by recommending me perhaps to some firm or by getting the suscriptions together?*" On January 8th, 1921 Ames replied: "*Now with regard to Dr. Fedde and the monographs of the orchids of Ecuador, Bolivia, etc. I can advance $ 450 out of my own pocket and if this suggestion meets with your approval let me know and I will send you the amount. If you approve of the suggestion perhaps you will see to it that I receive my copies on a very high grade of paper. I will give orders to have one hundred dollars sent to you to-morrow. When you receive this you can start printing and the balance will be forwarded when I hear from you that my suggestion is welcome. I am very anxious to help orchidology in every way and it is a great pleasure to hasten the monographs to which you have referred.*" The arrangement was confirmed after Schlechter had promised that *the money would be well applied* (January. 27, 1921), and so Schlechter was able to write in the epilogue of his *Orchideenfloren* (Bolivia, vol. V, 1922): "*I was fortunate that Prof. Oakes Ames, in Boston, put at my disposal the means which guaranteed the completion of the printing of this work.*" Ames finally sent $210 to Schlechter to begin printing, the rest came soon afterwards (Fig. 17).

Ames and Schlechter's relationship lasted over the years and it was undoubtedly a fruitful one. While Ames had the economic means to pursue his interests, from which Schlechter drew great benefits, Schlechter was the higher botanical authority in this partnership. As an example of this, the *International Plant Names Index* from Kew Botanic Gardens (status April 2019) cites a total of 7,712 new species and combinations described by Schlechter, while for Oakes Ames it mentions just 1,627. Ames continuously sent orchid specimens to Berlin for determination, and Schlechter profited from Ames, who untiringly made the greatest efforts to procure new orchid specimens: In a letter dated June 25, 1921 Ames wrote: "*I have just sent a collector to South America with the Mulford Biological Exploration Expedition to the Amazon basin*[11]*. This, I am sure will be good news for you as there will be a set of duplicates for your collection. As the expedition*

[11] Ames refers to Orland Emile White (1885–1972) from the Brooklyn Botanic Garden, who was one of the two botanists of the expedition, assisted by Martin Cárdenas, a Bolivian botanist.



Memorandum Foreign Check Issued

(Check should be sent by registered mail)

No. 111752 1/10 1920

Date

Sold to Oakes Ames

Address 35 r Commercial Exchange Bldg, Lit

Foreign Am't Mks 14483.00 @ 4.45 $ 210.

Payee Rudolf Schlechter

Drawee Bank Deutsche Bank

City Berlin

In duplicate

Yes — No

Debit

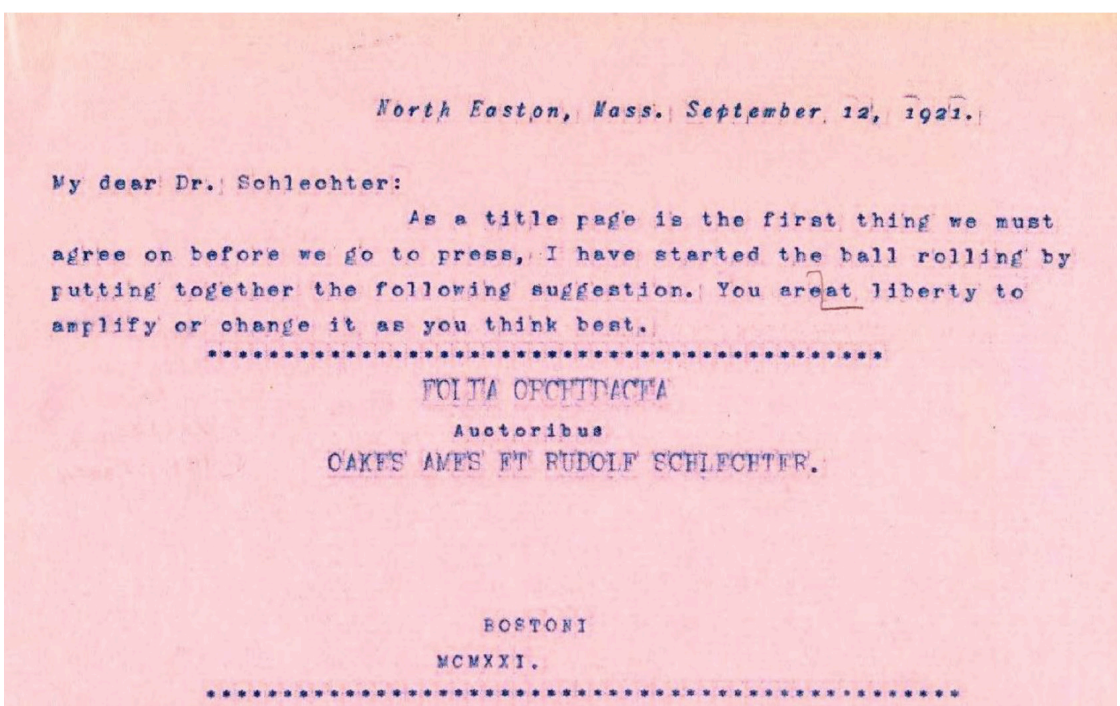
Cashier

Customer

THE FIRST NATIONAL BANK OF BOSTON

By Warren

FIGURE 17. A - Carbon-copy of Ames' check to Schlechter, Jan. 10, 1920 ($210 U.S: Dollar equivalent to 4,483 German marks!).



North Easton, Mass. September 12, 1921.

My dear Dr. Schlechter:

As a title page is the first thing we must agree on before we go to press, I have started the ball rolling by putting together the following suggestion. You are at liberty to amplify or change it as you think best.

****

FOLIA ORCHIDACEA

Auctoribus

OAKES AMES ET RUDOLF SCHLECHTER.

BOSTONI

MCMXXI.

****

FIGURE 18. Ames' proposed draft of a title page for the new "Folia Orchidacea".

is to be in the field for fifteen months, most of the time in unexplored territory, there should he some new material for us." At the same time, work on the *Folia Orchidaceae* continued: on September 12, 1921, Ames sent a draft of his proposed title page for the *Folia Orchidaceae*: FOLIA ORCHIDACEAE / AUCTORIBUS / OAKES AMES ET RUDOLF SCHLECHTER / BOSTON / MCMXXI (Fig. 18).

In what would be his last trip outside of Germany, again financed by Ames, Schlechter spent two weeks at the Reichenbach Herbarium in Vienna, studying and making tracings of Reichenbach's orchid types from the Philippines.

In March of 1922 Ames made the decision to travel to Europe and meet Schlechter in person: "*I want to let you know that I have decided to sail for England on June 28th, and that I am planning to be in Berlin either in July or August. I feel that we must discuss through some better medium than letters the details of our proposed undertaking, therefore I am coming to you, reluctantly on the one hand, eagerly, on the other. To leave home now means many sacrifices. But I cannot see how we can arrive at a working agreement without sitting face to face for a while. And, furthermore, the pleasure and profit of a meeting with you will repay me a thousandfold for the penalties of travel and the loss of results to be obtained by a summer of work at home.*"

In August of 1922, Ames arrived in Berlin and had finally the opportunity of meeting Rudolf Schlechter in person. Ames described the moment with these words: "*In the Orchid Herbarium of Harvard University there is a watercolor drawing which represents a flower of Stanhopea Ruckeri. This drawing is, in my estimation, of unusual interest because the original specimen from which it was made was instrumental in introducing Schlechter to me in a crowded railroad station in Berlin* (Fig. 19). *At this time I lacked knowledge of what Schlechter looked like, and he was in complete ignorance of what I might look like. […] As I walked along the platform I saw a man of medium height coming toward me, pushing his way slowly through the out-going crowd. He held a large spray of Stanhopea Ruckeri in his outstreched hand. It was not necessary for me to say: "Dr. Schlechter, I presume?", The glorious spray of Stanhopea Ruckeri was a flauntig badge of his identity*" (Ames, 1944: 106).

FIGURE 19. *Stanhopea ruckeri*. Watercolor in the Orchid Herbarium of Harvard University. Archives of R. Jenny.

Meanwhile, Schlechter's 'network' continued growing as new names were added to the already long list of purveyors to his herbarium. Worthy of mention are: Albert William Bartlett (British Guiana), F. Schickendanz (Argentina), Wilhelm Gustav Franz Herter, Georg Huebner, Joao Geraldo Kuhlmann (Brazil), Herbert Huntington Smith, Erich (Eric) Bungeroth, H. Hopf, Werner Hopp, Gustav Schmidtchen, K. Sonntag, Richard Schnitter, M.A. Stübel, Wilhelm Kalbreyer (Colombia), E. K. Köhler, A. Köhler, Alexander Weberbauer, and Serafín Filomeno (Peru) and Jose Steinbach (Bolivia).

Back to the *Folia Orchidaceae*. Progress was seemingly slow. Impatiently, Schlechter wrote on November 25, 1922: "*What about our 'Catalogue of Orchids', and what about the 'Folia'? I am very anxious to start.*" But Ames did not have good news for Schlechter. On December 14, 1922 he wrote:"*[…] the present time seems very unpropitious for any*

heavy undertaking in the way of printing. […] *a few days ago I mailed to you a little pamphlet which I had privately printed because our magazines are very much hampered by the printing conditions in this country and by a falling off of subscriptions with increases in the cost to subscribers.*" The situation in the United States as well as in Germany did not improve, and the project of a new *Folia Orchidacea* was not mentioned again in Ames' and Schlechter's correspondence, a correspondence that slowly started to fade away. For the first time there appeared disagreement between the two botanists. In a letter dated December 16, 1923, Ames complained[12]: "*I am sorry that your remarks under Epidendrum ionophlebium on page 120, indicate that you regard my treatment of E. Hoffmannii as breach of trust. Before going to Europe in the summer of 1922, 1 devoted the greater part of the winter of 1921 to a critical and bibliographical study of Epidendrum, and it was at this time, not after my return from Europe, that I had arrived at the conclusions published in several numbers of Schedulae Orchidianae. […] 1 have no desire to forestall you or to use your confidences for publication. If that spirit had governed my work I could have rushed into print with Powell's new species, long before you published your paper, because I had a nearly complete set from the Kew Herbarium in my possession at a time when Powell had given me every reason to be hostile*."

A growing rivalry on Ames' part can be found in his correspondence with Charles H. Lankester (1879–1969) (Fig. 20), a British subject who had arrived in Costa Rica in 1900 and stayed in this country (with brief interruptions) until his death. Lankester began collecting orchids, of which Ames described over 100 species that were new to science. The same is the case in Ames' correspondence with Charles Wesley Powell (1854–1927), an American orchid collector from Panama's Canal Zone.

A few phrases from Ames' letters to Lankester give a good idea of how, in Ames' opinion, German botany in general and Schlechter in particular were endangering the supremacy of U.S. botany in tropical America: "*We must work fast if we hope to keep abreast of the Germans. I was surprised to see how far reaching their efforts have been to secure a monopoly of tropical American species*" (Sept. 17, 1922) …. "*If you decide to make specimens for me, please begin as soon as possible. Time is very precious*" (October 10, 1922). "*I wish we could get out another number of Sched. Orch. based on your work. We might beat Schlechter and give him food for thought*" (May 28, 1923).

FIGURE 20. Charles H. Lankester (1879–1969) in his farm in Costa Rica. Courtesy of Ricardo Lankester.

As to his correspondence with Powell, Ames wrote on September 14, 1921: "*I understand that, you are now sending specimens to Rudolf Schlechter of Berlin. Although Dr. Schlechter and I are colleagues and at this time are working jointly on a monograph of the orchids of the world, it seems to me too bad that American material should be sent abroad. We surely can do the work in this country and I intend to do my best to handle material that is sent in to me for determination. Now that my poor friend Rolfe has gone I feel that it is my duty to do my best to keep up orchidology for English speaking people, not that I think for a minute that science is national, but that I dread to contemplate the future if our types are to be buried in a foreign land*." To which Powell replied on October 10: "*Before replying to the main questions*

[12] Ames refers to Schlechter's publication of 1923, Additamenta ad Orchideologiam Costaricensem. *Repertorium specierum novarum regni vegetabilis*, XIX, Berlin.

in your letter of the 14th I wish to clear myself of the unsaid, but the implied charge of unpatriotism in sending my specimens to Europe instead of to the U.S. I am a native of Virginia and my forbears have a recorded and traceable history in that State since the year 1635, hence I could not be unpatriotic."

The misunderstanding was soon forgotten, but Ames used every opportunity to keep Powell aware of the German competition. December 12, 1922: "*I wish we could keep Schlechter out of the American field. Otherwise there is bound to be a great deal of confusion owing to the simultaneous publication of species. I hope you will come to agree with me that it is for the best interests of American science to dissuade correspondents from sending material to Berlin.*" Powell replied on December 20: "*After about a week I will write Dr Schlechter telling him of our new arrangement, and that under it I feel that I am under the obligation to send all future specimens to you. This will give him time to receive my letter of today with the money, and to put the matter in the hands of the printers. Thus insuring that he will not hold it up. Sub-rosa, I do not trust the Germans, not to engage in a little spite work.*" Ames had won the game. Powell enclosed a draft of the letter he intended to send to Schlechter: "*My dear Dr Schlechter: I have entered into a contract with Dr Oakes Ames, of Boston, to make a complete orchideological survey of the Isthmus of Panama -– he financing the undertaking. My men are now out going thither and yon in pursuit of this end. As it is incompatible with this contract that I should send any specimens from this time to any other person or garden than to him; specimens in future, can only be procured from him.*"

But these phrases can give us a wrong picture. In spite of the growing rivalry, Ames respected and admired Schlechter throughout his life. Let us see other expressions, again in Ames' correspondence with Lankester: "*From the South of France, Col. Godfrey writes that Schlechter is seriously ill... I have not heard from Schlechter for over four months, and I had begun to fear that he was angry or in some way provoked by some act of mine*" (March 23, 1924).

Personal circumstances on both sides gave additional motives for the lack of communication between Ames and Schlechter, especially during the year of 1924. On April 8, Schlechter explained: "*I had already for some time the intention to write to you. My serious illness and feebleness has been preventing me from doing it before now. […] It was not only the sickness that gave me the knock-out, but also the whole financial disaster, which made us loose nearly everything that one has had.*" And Ames had reasons of his own, as he made clear on January 20, 1925: "*My co-trustee in the estate created by my father, suddenly and unexpectedly, committed suicide, about the middle of September. This sad event threw on my shoulders the full burden of business that is essential to my family. I had to begin the disagreeable task of spending most of my time in the city and in offices.*"

Finally, on December 3, 1925 came the tragic news. Ames wrote to Lankester: "*I should not have begun this letter with a reference to myself. I should have expressed to you my deep sorrow at the news that came in this noon from Alexandra Schlechter. Schlechter died early in November. I had known of his illness and on the ninth of December I sent aid to Mrs. Schlechter to meet the heavy burden of a hospital bill. But I had been led to believe that there were hopes for recovery. What a place the old world is. There comes a time when death plays round us like heat lightning. And then it begins to thin the ranks of those we called friends. It is a wonder we are able to carry on.*"

During the last years of Schlechter's life, Ames received duplicates from Schlechter's orchids (Fig. 21), and carried the cost of having pencil tracings made from a great number of Schlechter's orchid types. It is due to this fortunate decision that an important part of Schlechter's material was preserved and saved from the destruction of the Berlin Herbarium in 1943. Hundreds of drawings were prepared under Schlechter's supervision. His wife, Alexandra, took over after his death, and continued arranging to have new tracings made according to Ames' indications (Fig. 22–23A–B). In Oakes Ames' last letter to Alexandra Schlechter, in the Harvard files, dated February 14, 1926, he wrote: "*I can not thank you enough for the tracings of Stelis and Pleurothallis. These are a valuable addition to my herbarium and give me just the information I need to facilitate any work on the Costa Rican orchid flora. I have a long list of other species regarding which I would like*

FIGURE 21. A - Isotype of *Epidendrum juninense* Schltr., presently at the Oakes Ames Orchid Herbarium. Originally collectyed by A. Weberbauer in Peru. B - Isotype of *Pachyphyllum breviconnatum* Schltr., presently at the Oakes Ames Orchid Herbarium. Originally collected by A. Weberbauer in Peru.

to have similar information. Would it be too much to ask of you, that you have tracings of then made? Without tracings it will be difficult to ascertain the finer details which are essential for satisfactory work. Please help me if you can. I have underlined the species which are important so that you can select the ones to do first." The letter ends with a several-pages-long list containing Ames' desiderata. In her last recorded letter of June 25, 1926, Alexandra answers: "*I am very glad to hear the first tracings reached you safely and have found your approval. I hope by now you received the second letter with the rest of the drawings. I am happy to having been able to do something for you.*"

Other images of Schlechter's herbarium were preserved in a unique type photograph collection housed in the Field Museum of Natural History in Chicago. The collection originated in 1929, when James Francis Macbride, funded by the Rockefeller Foundation, traveled to Europe to photograph herbarium specimens of nomenclatural types. The intent was to make the photographs available to American botanists unable to finance travels to European herbaria; the widespread adoption of the loan process was not as fully developed as it is today, necessitating travel for consultation.

Over a ten years, Macbride photographed type specimens of tropical American plants at the following major herbaria: Berlin, Copenhagen, Geneva, Hanover, Hamburg, Madrid, Munich, Paris, and Vienna, using Berlin-Dahlem and Geneva as bases of operation. His sojourn in Europe resulted in more than 40,000 photographic negatives. Duplicate collections, types, and type fragments of authentic material were selected and sent to The Field Museum as exchange (Fig. 23C–D, 24). The results were of immediate importance to American systematic botany, but acquired added meaning following the destruction of parts of some European herbaria during World War II (Field Museum of Natural History 2018).

Figure 22. Drawing at the Oakes Ames Herbarium, prepared under Schlechter's supervision, of the type of *Ponthieva orchioides* Schltr. Originally collected by L. Mille in Ecuador.


A
Epidendrum bathyschistum
Caracas
1844.
Drawing of type Oakes Ames Orchid Herbarium
Epidendrum bathyschistum Schltr.
Fedde Repert. Beih. 6:36. 1919
Det.: G.A. Romero & I. Ferreras 1997
DRAWING AND ANALYSES FROM HERB. SCHLECHTER MADE UNDER SUPERVISION OF RUDOLF SCHLECHTER
RECORD OF TYPE
B
Epidendrum venezuelanum Schltr. n. sp.
Cult. Hort. John Andrewach ex Caracas
VI. 1905.
DRAWING AND ANALYSES FROM HERB. SCHLECHTER MADE UNDER SUPERVISION OF RUDOLF SCHLECHTER
RECORD OF TYPE
Drawing of type Oakes Ames Orchid Herbarium
Epidendrum Venezuelanum Schltr.
Fedde Repert. Beih. 6:39. 1919
Det.: G.A. Romero & I. Ferreras 1997
HERBARIUM OAKES AMES 26787
C
18375
D
18376

Figure 24. *Cyclopogon rimbachii* Schltr. Photograph of the type by J.F. Macbride. Field Museum of Natural History, Chicago. Collected by A. Rimbach in Ecuador.

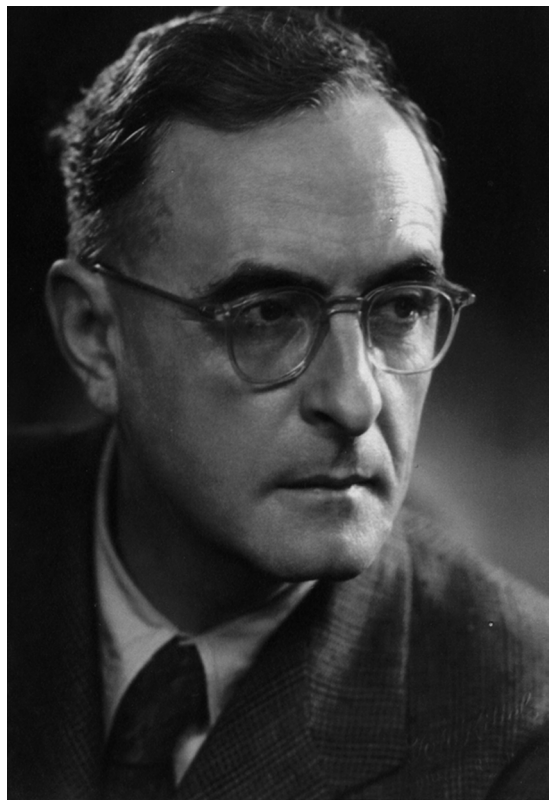


Figure 25. Rudolf Mansfeld (1901–1960). Archives of Rudolf Jenny.

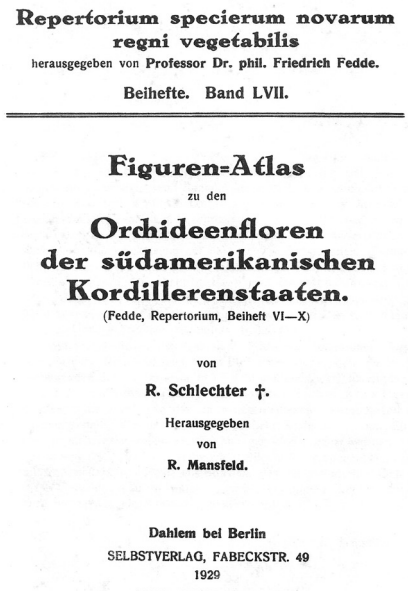
Finally, additional photographs and some pages of Schlechter's original type-written manuscripts with the description of new species have been preserved, i.e. at the Geneva Delessert Herbarium.

After Schlechter's death Rudolf Mansfeld (1901–1960) (Fig. 25) edited a *Figuren-Atlas* (Fig. 26–27). It contained 558 analytical drawings in 142 plates of South American orchids new to science and described by Schlechter in the five volumes of his *Orchideenfloren der Kordillerenstaaten*; a further proof of his incredible capacity of work. Mansfeld was for over twenty years curator of the Botanical Garden and Museum of Berlin-Dahlem, where he specialized in orchids and was responsible for the publication of several of Schlechter's unfinished works. In 1937 he suggested a revision of Schlechter's system[13]. Mansfeld's ideas were, however, largely ignored by the users of Schlechter's system.

The deaths of Celestin A. Cogniaux in 1916 and of Robert A. Rolfe in 1921, followed by that of Schlechter in 1925, marked the beginning of the decline in European orchidology. Europe's dominant position was slowly replaced by that of the United States, led by Oakes Ames, and by over a dozen formidable botanists and botanical institutions during the rest of the 20th century.

[13] Mansfeld, R. 1937. Uber das System der Orchidaceae-Monandrae. *Notizblatt des Koniglichen Bot. Gartens & Museums zu Berlin-Dahlem* 13: 666-676.

Left, Figure 23. A - Drawing at the Oakes Ames Herbarium, prepared under Schlechter's supervision, of the type of *Epidendrum bathyschistum* Schltr. Originally collected by Moritz in Venezuela. The label reads: Drawing and Analyses from Herb. Schlechter. Made under supervision of Rudolf Schlechter. B - Drawing at the Oakes Ames Herbarium, prepared under Schlechter's supervision, of the type of *Epidendrum venezuelanum* Schltr. Originally collected by K. W. John. C - *Elleanthus koehleri* Schltr. D - *Polystachya altilamellata* Schltr. C, D: photographs of the types by J.F. Macbride. Field Museum of Natural History, Chicago. Both collected by E. Koehler in Peru.



Repertorium specierum novarum regni vegetabilis
herausgegeben von Professor Dr. phil. Friedrich Fedde.
Beihefte. Band LVII.

Figuren-Atlas
zu den
Orchideenfloren der südamerikanischen Kordillerenstaaten.
(Fedde, Repertorium, Beiheft VI—X)

von
R. Schlechter †.

Herausgegeben
von
R. Mansfeld.

Dahlem bei Berlin
SELBSTVERLAG, FABECKSTR. 49
1929

FIGURE 26. Title page of Schlechter's *Figuren-Atlas*.

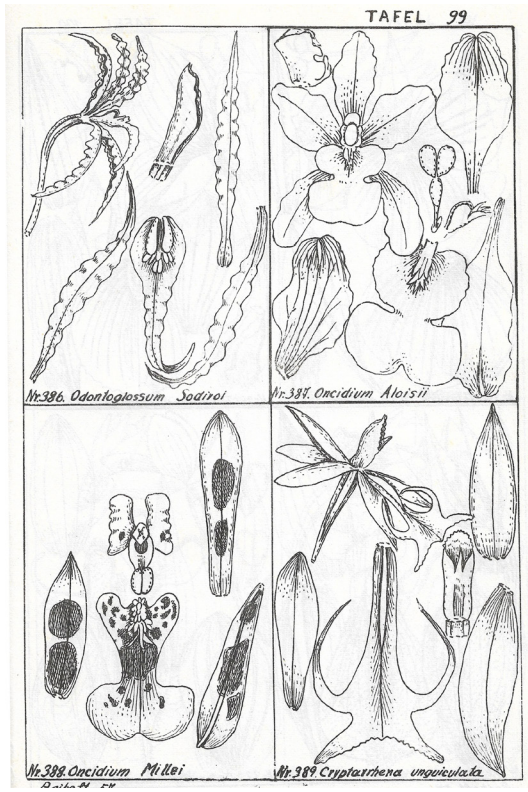


FIGURE 27. Plate 99 of Schlechter's *Figuren-Atlas*.

Rudolf Schlechter's publications on South American Orchidaceae. The following is a list of the complete publications by Rudolf Schlechter on the Orchidaceae of South America. The list is organized by countries, and divided in two sections: 1) national and regional orchid floras, specific collectors; 2) publications on specific orchid tribes and subtribes, genera or species. Within each country, the publications are in chronological order. In addition, Schlechter's collectors and other members of his 'network' are listed. Finally, we show the genera and species new to science described by Schlechter from each of the South American countries. Probably neither list, whether of publications, collectors or plant names, is complete. Although the authors have made all efforts researching in available material, one or the other name, or publication, may have escaped their attention.

BRAZIL (Fig. 28)

National and regional orchid floras, specific collectors

1901 Schlechter, R. *Orchidaceae.* In Pilger, R. *Beitrag zur Flora von Mattogrosso. Botanischer Bericht über die Expedition von Dr. Herrmann Meyer nach Central-Brasilien 1899*. Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 30: 149–150.

1914 Schlechter, R. *Orchidaceae.* In Pilger, R. *Plantae Uleanae novae vel minus cognitae.* Notizblatt des Königlichen Botanischen Gartens und Museums zu Berlin, Vol. 6: 120–126.

1919–1920 Schlechter, R. *Orchidaceae novae et criticae, Decas LXX (Additamenta ad Orchideologiam Brasiliensem).* Repertorium specierum novarum regni vegetabilis, Vol.17: 267–272.
Schlechter, R. *Beiträge zur Kenntnis der Orchidaceenflora von Paraná*. Repertorium specierum novarum regni vegetabilis., Vol. 35: 1–108.

Figure 28. Map of Brazil and the Guyanas, 1855. Colton's Atlas of the World Illustrating Physical and Political Geography, Vol 1, New York.

1922 Schlechter, R. & Hoehne, F.C. *Contribuções ao Conhecimento das Orchidáceas do Brasil.* Anexos das Memorias do Instituto de Butantan: Seccao de Botanica 1(2): 5–48.

1922 Schlechter, R. *Über einige interessante, neue Orchidaceen Brasiliens.* Archivos do Jardim Botanico do Rio de Janeiro, vol. 3: 289–293.

1925 Schlechter, R. *Die Orchideenflora von Rio Grande do Sul.* Repertorium specierum novarum regni vegetabilis., Vol. 35: 1–108.
Schlechter, R. *Beitraege zur Orchideenkunde des Amazonas-Gebietes, I. Orchidaceae Kuhlmannianae; II. Orchidaceae Huebenerianae.* Repertorium specierum novarum regni vegetabilis., Vol. 42: 67–82; 82–150.

1926 Schlechter, R. *Beiträge zur Kenntnis der Orchidaceenflora von Parana. II. Orchidaceae Hatschbachianae*. Repertorium specierum novarum regni vegetabilis, Vol. 23: 32–71.
Schlechter, R. & Hoehne, F.C. *Contribuções ao Conhecimento das Orchidáceas do Brasil.* Archivos de Botânica do São Paulo 1: 203–216.

1929 Schlechter, R. *Einige neue Orchideen des Itatiaya (Brasilien).* Repertorium specierum novarum regni vegetabilis, Vol. 27: 296–301.

1940–1945 Hoehne, F.C. *Flora Brasilica.* Vol. 12(2): 378. Graphicars, Romiti & Lanzara, São Paulo.

Specific orchid tribes and subtribes, genera or species

1906 Schlechter, R. *Ueber einige neue Orchidaceen.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol.1: 4–6.
Schlechter, R. *Über eine neue Bifrenaria.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol.1, 1906–1907: 25

1910 Schlechter, R. *Orchidaceae novae et criticae, Decas XI*. Repertorium specierum novarum regni vegetabilis., Vol. 8: 453.
Schlechter, R. *Orchidaceae novae et criticae, Decas XIV-XV*. Repertorium specierum novarum regni vegetabilis., Vol. 8: 561.

1912-1913 Schlechter, R. *Orchidaceae novae et criticae, Decas XXXV*. Repertorium specierum novarum regni vegetabilis., Vol.11: 41–47.

1914 Schlechter, R. *Oncidium concolor Hook. und Oncidium ottonis Schltr., zwei nahe verwandte Arten.* Orchis, Mitteilungen des Orchideenausschusses der Deutschen Gartenbau-Gesellschaft, vol. 8: 57–61.
Schlechter, R. *Neu und seltene Gardenorchideen VI.* Orchis, Mitteilungen des Orchideenausschusses der Deutschen Gartenbau-Gesellschaft, vol. 8: 131–137.

1915 Schlechter, R. *Neue und seltene Garten-Orchideen, VII.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 9: 56–60.

1917 Schlechter, R. *Eine neue Laelia-Art.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol.11: 72–74.
Schlechter, R. Über eine neue *Stanhopea*-Art. Notizblatt des Botanischen Gartens und Museums zu Berlin - Dahlem, Vol.6(62): 483-484.

1917–1919 Schlechter, R. *Orchidaceae novae et criticae, Decas LXV*. Repertorium specierum novarum regni vegetabilis, Vol. 16: 353–358.

1918 Schlechter. R. *Orchidaceae novae, in caldariis Horti Dahlemensis cultae.* Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem, Vol.7 (66): 268–280.
Schlechter. R. *Die Gattung Aganisia Ldl. und ihre Verwandten.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 12: 24-42.
Schlechter. R *Die Gattung Restrepia H. B. u. Kth.* Repertorium specierum novarum regni vegetabilis., Vol. 15: 255-270.

1919 Schlechter, R. *Die Gattung Brassavola R. Br.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 13: 39-46; 56-62; 68-79.
Schlechter. R *Orchidaceae novae, in caldariis Horti Dahlemensis cultae. II.* Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem, Vol.7 (66): 323–330.

1919–1920 Schlechter R. *Studium zur Klärung der Gattung Rodriguezia Ruiz et Pav.* Repertorium specierum novarum regni vegetabilis., Vol. 16: 416–417.
Schlechter. R. *Orchidaceae novae et criticae, Decas LXVI-LXVII.* Repertorium specierum novarum regni vegetabilis., Vol. 16: 437–450.

1920 Schlechter, R. *Versuch einer systematischen Neuordnung der Spiranthinae*. Beihefte zum Botanischen Centralblatt. Zweite Abteilung, Systematik, Pflanzengeographie, angewandte Botanik 37(2): 317–454.
Schlechter, R. *Orchidaceae novae et criticae, Decas LXVIII*. Repertorium specierum novarum regni vegetabilis., Vol. 17: 12–18.

1921 Schlechter, R. *Orchidaceae novae et criticae, Decas LXX*. Repertorium Specierum Novarum Regni Vegetabilis 17: 267–272.

1921–1924 Schlechter, R. *Orchidaceae novae, in caldariis Horti Dahlemensis cultae III*. Notizblatt des Botanischen Gartens und Museums zu Berlin - Dahlem, Vol. 8: 117–126.

1925 Schlechter. R. *Orchidaceae novae et criticae, Decas LXXVIII-LXXIX*. Repertorium specierum novarum regni vegetabilis, Vol. 21: 330–343.

Schlechter's network in Brazil (orchid collectors, growers and other purveyors)

- Aquino, Franzisco (?), collected 1921–1922.
- Bello, O. (?), collected 1907.
- Blossfeld, Robert (1882–1945), orchid grower in Potsdam.
- Beyrodt, Otto (1879–1923). Orchid grower in Marienfelde, Germany, around 1900–1923.
- Bornmüller, Alfred (1868–1947), collected 1904–1907.
- Brade, Alexander Curt (1881–1871), collected 1910–1871.
- Burger, L. (?), collected 1922.
- Campos Porto, Paulo (1889–1968), collected 1917–1936.
- Christian, F. (?), collected ca. 1920.
- Czermak, Josef (?), collected 1897–1899
- Dusen, Per Karl Haljmar (1855–1856), collected 1895–1916.
- Dutra, João (1862–1939), collected 1925.
- Fürstenberg, Baron Max (Maximilian) von (1866–1925), owner of an orchid collection ca. 1900–1910.
- Gehrt, August (?), assistant to F.C. Hoehne, collected 1917.
- Goebel, Karl Immanuel Eberhard Ritter von (1855–1932), collected 1890–1913.
- Grossmann, Carl (?), collected 1903–1908.
- Hatschbach Sobrinho, Albino (1890–1974). collected 1919–1925.
- Hennis, Wilhelm (1856–1943), orchid grower in Hildesheim.
- Herter, Wilhelm Gustav Franz (1884–1958), collected 1913–1934.
- Hoehne, Frederico Carlos (1882–1959), collected 1911–1938.
- Hübner, Georg August Eduard, (1862–1935), collected 1920–1929.
- John, Karl Wilhelm (?). Orchid grower in Andernach-on-the Rhine, Germany, around 1910.
- Jürgens, Carlos (?), collected 1906–1921.
- Kley, Urbano (?), collected 1910–1920.
- Koch, Christian Theodor (1872–1924), collected 1904–1913.
- Kuhlmann, João Geraldo (1882–1948), collected 1912–1943.
- Lützelburg, Phillip von (1880–1948), collected 1913–1934.
- Magalhães Gomes, Carlos Thomas (1855–1944), collected 1894.
- Moura, Juliano Trajano (1867–?), collected 1888–1890.

- Pilger, Robert Knud Friedrich (1876–1953), collected 1899–1900.
- Reineck, Eduard Martin (1869–1931), collected 1899–1908.
- Schenck, Johann Heinrich Rudolf (1860–1927), collected 1886–1887.
- Schnittmeyer, Max (?), collected 1916.
- Schwacke, Karl August Wilhelm (1848–1904), collected 1889.
- Ule, Ernst Heinrich Georg (1854–1915), collected 1893–1912.
- Wendt, H. (?), collected 1907–1912.
- Wettstein, Richard (1863–1931), collected 1901.
- Zehntner, Leo (?), collected 1912.

Orchids described by R. Schlechter from Brazil (Dusen & Schltr. / Schltr. & Campos Porto / Hoehne & Schltr./ Schltr. ex Hoehne/ Schltr. ex Mansf. / Schltr. ex Pabst, in some cases)

The following is a list of the orchids described by R. Schlechter as new to science from Brazil, as enumerated in the aforementioned bibliography (only basionyms):

New orchid genera

Centrogenium Schltr.
Cladobium Schltr.
Fractiunguis Schltr.
Huebneria Schltr.
Leaoa Schltr. & Campos-Porto
Lyroglossa Schltr.
Mesadenus Schltr.
Otostylis Schltr.
Pseudostelis Schltr.
Pteroglossa Schltr.
Rodrigueziopsis Schltr.
Tracheosiphon Schltr.
Xerorchis Schltr.

New orchid species

Aganisia brachypoda Schltr.
Bifrenaria fuerstenbergiana Schltr.
Bipinnula ctenopetala Schltr.
Brassavola multiflora Schltr.
Brassia angustilabia Schltr.
Brassia huebneri Schltr.
Brassia iguapoana Schltr.
Brachystele bracteosa Schltr.
Brachystele spiranthoides Schltr. ex Mansf.
Bulbophyllum paranaense Schltr.
Bulbophyllum perii Schltr.
Camaridium amazonicum Schltr.
Camaridium vandiforme Schltr.
Campylocentrum dutraei Schltr.
Campylocentrum hatschbachii Schltr.
Campylocentrum pubirhachis Schltr.
Campylocentrum zehntneri Schltr.
Capanemia angustilabia Schltr.
Capanemia hatschbachii Schltr.
Capanemia juergensiana Schltr.
Capanemia paranaensis Schltr.
Capanemia perpusilla Schltr.
Catasetum appendiculatum Schltr.
Catasetum brachybulbon Schltr.
Catasetum colossus Schltr.
Catasetum huebneri Schltr.
Catasetum linguiferum Schltr.
Catasetum mocuranum Schltr.
Catasetum negrense Schltr.
Catasetum polydactylon Schltr.
Centrogenium macrophyllum Schltr.
Cleistes australis Schltr.
Cranichis bradei Schltr.
Cryptophoranthus dusenii Schltr.
Cryptophoranthus juergensii Schltr.
Cryptophoranthus similis Schltr.
Cyanaeorchis minor Schltr.
Cyclopogon aphyllus Schltr.

Cyclopogon bradei Schltr.
Cyclopogon dusenii Schltr.
Cyclopogon dutraei Schltr.
Cyclopogon graciliscapa Schltr.
Cyclopogon hatschbachii Schltr.
Cyclopogon iguapensis Schltr.
Cyclopogon langei Schltr.
Cyclopogon multiflorus Schltr.
Cyclopogon paulensis Schltr.
Cyclopogon platyunguis Schltr.
Cyclopogon saxicolus Schltr.
Cyclopogon subalpestris Schltr.
Cyclopogon trifasciatus Schltr.
Cyrtopodium falcilobum Hoehne & Schltr.
Cyrtopodium dusenii Schltr.
Cyrtopodium lissochiloides Hoehene &Schltr.
Cyrtopodium paranaense Schltr.
Diacrium amazonicum Schltr.
Dichaea cogniauxiana Schltr.
Dipteranthus bradei Schltr.
Elleanthus pusillus Schltr.
Encyclia acuta Schltr.
Encyclia flabellifera Hoehne & Schltr.
Encyclia huebneri Schltr.
Encyclia laxa Schltr.
Encyclia oxyphylla Schltr.
Encyclia tarumana Schltr.
Epidendrum alexandri Schltr.
Epidendrum amazonicum Schltr.
Epidendrum burgeri Schltr.
Epidendrum goebelii Schltr.
Epidendrum hatschbachii Schltr.
Epidendrum huebneri Schltr.
Epidendrum iguapensis Schltr.
Epidendrum kuhlmannii Schltr.
Epidendrum magelhaesi Schltr.
Epidendrum minarum Hoehne & Schltr.
Epidendrum pedale Schltr.
Epidendrum pseudodifforme Hoehne & Schltr.
Epidendrum regnellianum Hoehne & Schltr.
Epidendrum versicolor Hoehne & Schltr.
Fractiunguis brasiliensis Schltr.
Galeandra captoceras Schltr.
Galeandra huebneri Schltr.
Galeandra paranaensis Schltr.
Galeottia negrensis Schltr.
Habenaria achroantha Schltr.
Habenaria amazonica Schltr.
Habenaria bahiensis Schltr.
Habenaria belloi Schltr.
Habenaria bradei Schltr.
Habenaria butantanensis Hoehne & Schltr.
Habenaria campos-portoi Schltr.
Habenaria christiani Schltr.
Habenaria crassipes Schltr.
Habenaria culmiformis Schltr.
Habenaria duckeana Schltr.
Habenaria dusenii Schltr.
Habenaria dutraei Schltr.
Habenaria edentula Schltr.
Habenaria flaccifolia Schltr.
Habenaria geehrtii Hoehne & Schltr.
Habenaria georgii Schltr.
Habenaria heleogena Schltr.
Habenaria heterophylla Schltr.
Habenaria hoehnei Schltr.
Habenaria itatiayae Schltr.
Habenaria juergensii Schltr.
Habenaria kleyi Schltr.
Habenaria kuhlmannii Schltr.
Habenaria leaoana Schltr.
Habenaria luetzelburgii Schltr.
Habenaria marupaana Schltr.
Habenaria melanopoda Hoehne & Schltr.
Habenaria minarum Hoehne & Schltr.
Habenaria nana Schltr.
Habenaria ovatipetala Schltr.
Habenaria pilgeri Schltr.
Habenaria pleiophylla Hoehne & Schltr. (Fig. 29)
Habenaria polygonoides Schltr.
Habenaria polyrhiza Schltr.
Habenaria rolfeana Schltr.
Habenaria sampaioana Schltr.
Habenaria sartoroides Schltr.
Habenaria sceptrum Schltr.
Habenaria schnittmeyeri Schltr.
Habenaria staminodiata Schltr.
Habenaria trimeropetala Schltr.
Habenaria verecunda Schltr.
Hexadesmia cearensis Schltr.
Isochilus brasiliensis Schltr.
Koellensteinia hyacinthoides Schltr.
Laelia bahiensis Schltr.
Laelia sincorana Schltr.

FIGURE 29. *Habenaria pleiophylla* Hoehne & Schltr. In Anexos das Memorias do Instituto de Butantan, Seccao de Botanica, vol. I, fasc. II: table IV.

Masdevallia huebneri Schltr.
Masdevallia paranensis Schltr.
Maxillaria amazonica Schltr.
Maxillaria bradei Schltr. ex Hoehne
Maxillaria hatschbachii Schltr.
Maxillaria hedyosma Schltr.
Maxillaria hoehnei Schltr.
Maxillaria huebneri Schltr.
Maxillaria iguapensis Hoehne & Schltr.
Maxillaria juergensii Schltr.

Maxillaria lactea Schltr.
Maxillaria pachyphylla Schltr. ex Hoehne
Maxillaria petiolaris Schltr.
Maxillaria taracuana Schltr.
Microstylis muelleri Schltr.
Microstylis ovatilabia Schltr.
Microstylis pabstii Schltr.
Microstylis paranaensis Schltr.
Mormodes aurantiacum Schltr.
Neobartlettia kuhlmanii Schltr.
Notylia flexuosa Schltr.
Notylia longispicata Hoehne & Schltr.
Notylia platyglossa Schltr.
Octomeria albiflora Hoehne & Schltr.
Octomeria alexandri Schltr.
Octomeria brachypetala Schltr.
Octomeria bradei Schltr.
Octomeria campos-portoi Schltr.
Octomeria dusenii Schltr.
Octomeria elobata Schltr. ex Pabst
Octomeria fibrifera Schltr.
Octomeria gehrtii Hoehne & Schltr.
Octomeria gracilicaulis Schltr.
Octomeria hatschbachii Schltr.
Octomeria hoehnei Schltr.
Octomeria iguapensis Schltr.
Octomeria irrorata Schltr.
Octomeria juergensii Schltr.
Octomeria lacerata Hoehne & Schltr.
Octomeria rhodoglossa Schltr.
Octomeria riograndensis Schltr.
Octomeria serpens Schltr.
Octomeria similis Schltr.
Octomeria taracuana Schltr.
Octomeria umbonulata Schltr.
Octomeria unguiculata Schltr.
Oncidium aberrans Schltr.
Oncidium albinoi Schltr.
Oncidium beyrodtianum Schltr.
Oncidium blossfeldianum Schltr.
Oncidium cogniauxianum Schltr.
Oncidium hatschbachii Schltr.
Oncidium hoehnianum Schltr. ex Mansf.
Oncidium johnianum Schltr.
Oncidium mixtum Schltr.
Oncidium ottonis Schltr.
Oncidium patulum Schltr.
Oncidium psyche Schltr.
Oncidium reisii Hoehne & Schltr.
Oncidium rhynchophorum Schltr. ex Hoehne
Oncidium zikanianum Hoehne & Schltr.
Ornithocephalus brachystachyus Schltr.
Ornithocephalus myrtiphyllus Schlt. ex Hoehne
Paradisianthus neglectus Schltr.
Pelexia bradei Schltr. ex Mansf.
Pelexia burgeri Schltr.
Pelexia dolichorhiza Schltr.
Pelexia gracilis Schltr.
Pelexia incurvidens Schltr.
Pelexia itatiayae Schltr.
Pelexia laminata Schltr.
Pelexia luetzelburgii Schltr.
Pelexia mouraei Schltr.
Pelexia polyantha Schltr. ex Mansf.
Pelexia sceptrum Schltr.
Pelexia stictophylla Schltr.
Pelexia tenuior Schltr.
Phymatidium aquinoi Schltr.
Phymatidium herteri Schltr.
Physosiphon bradei Schltr.
Physurus bidentiferus Schltr.
Physurus foliosus Schltr. ex Porto & Brade
Physurus longicalcaratus Schltr.
Physurus macer Hoehne & Schltr.
Platyrhiza juergensii Schltr.
Pleurothallis albipetala Hoehne & Schltr.
Pleurothallis alexandri Schltr.
Pleurothallis aquinoi Schltr.
Pleurothallis auriculigera Hoehne & Schltr.
Pleurothallis barbosae Schltr.
Pleurothallis biglandulosa Schltr.
Pleurothallis bradei Schltr.
Pleurothallis butantanensis Hoehne & Schltr.
Pleurothallis caldensis Hoehne & Schltr.
Pleurothallis caroli Schltr.
Pleurothallis cearensis Schltr.
Pleurothallis ciliolata Schltr.
Pleurothallis corticicola Schltr. ex Hoehne
Pleurothallis curitybensis Schltr. ex Mans.
Pleurothallis curtii Schltr.
Pleurothallis dryadum Schltr.
Pleurothallis edwallii Dusen & Schltr.
Pleurothallis gehrtii Hoehne & Schltr.
Pleurothallis hatschbachii Schltr.

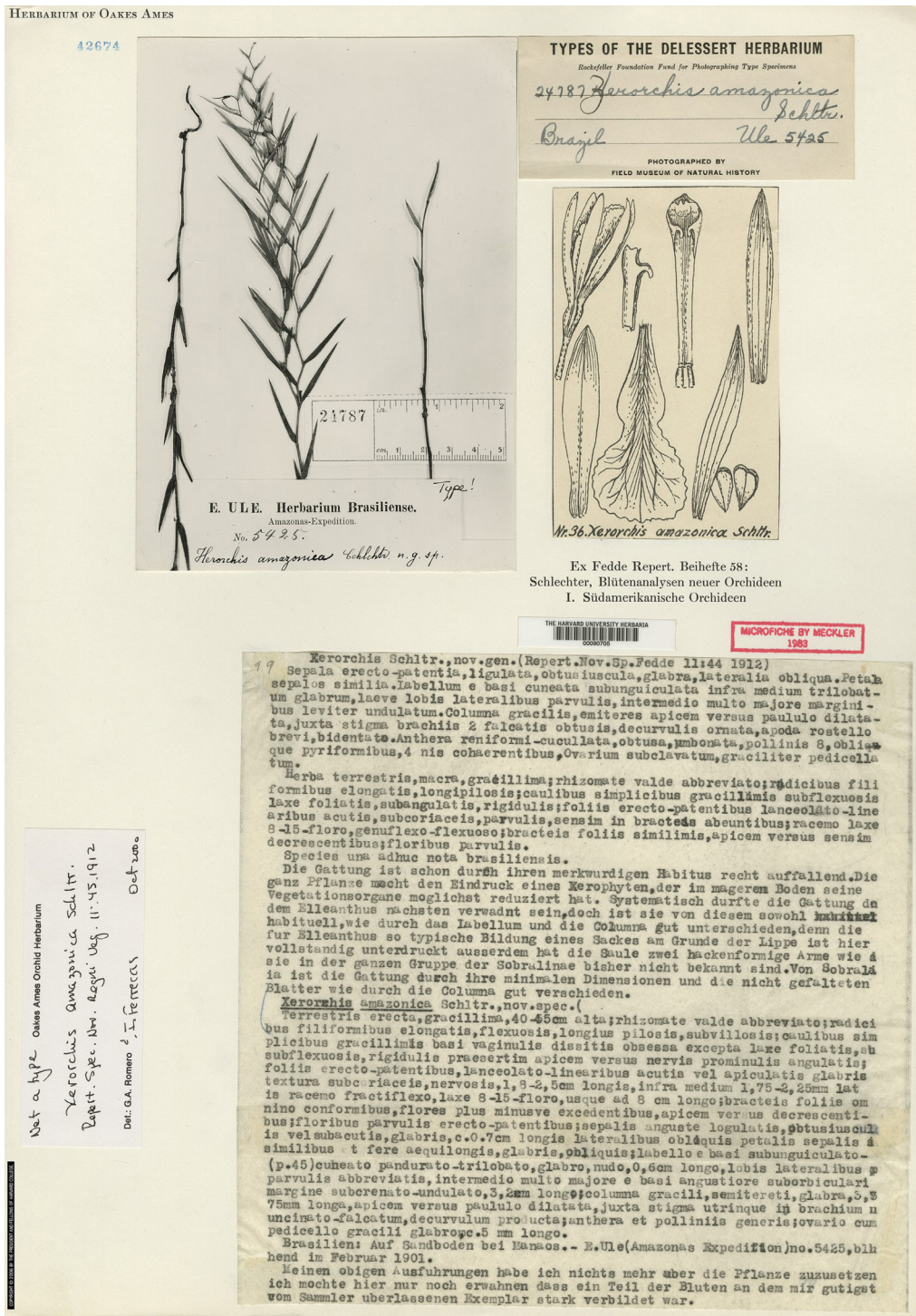


FIGURE 30. *Xerorchis amazonica* Schltr. Photograph of a specimen collected by E. Ule in Brazil, analytical drawing by R. Schlechter and Schlechter's original type-written manuscript of the description of the new species. Rockefeller Foundation.

Pleurothallis hoehnei Schltr.
Pleurothallis huebneri Schltr.
Pleurothallis iguapensis Schltr.
Pleurothallis incurvidens Schltr.
Pleurothallis insularis Hoehne & Schltr.
Pleurothallis ipyrangana Schltr.
Pleurothallis juergensii Schltr.
Pleurothallis lamproglossa Schltr.
Pleurothallis lepthantipoda Hoehne & Schltr.
Pleurothallis leucorhoda Schltr.
Pleurothallis margaritifera Schltr.
Pleurothallis microblephara Schltr.
Pleurothallis microgemma Schltr. ex Hoehne
Pleurothallis microtis Schltr.
Pleurothallis mirabilis Schltr.
Pleurothallis pauloensis Hoehne & Schltr.
Pleurothallis petersiana Schltr.
Pleurothallis rhabdosepala Schltr.
Pleurothallis sororcula Schltr.
Pleurothallis sparsiflora Schltr.
Pleurothallis stictophylla Schltr.
Pleurothallis subpicta Schltr.
Pleurothallis succedaneae Hoehne & Schltr.
Pleurothallis taracuana Schltr.
Pleurothallis transparens Schltr.
Pleurothallis vellozoana Schltr.
Pleurothallis vinosa Hoehne & Schltr.
Pogonia calantha Schltr.
Pogonia fragrans Schltr.
Pogonia humidicola Schltr.
Pogonia magnifica Schltr.
Pogonia paulensis Schltr.
Polystachya amazonica Schltr.
Polystachya bradei Schltr. ex Mansf.
Polystachya edwallii Hoehne & Schltr.
Polystachya juergensii Schltr.
Polystachya huebneri Schltr.
Polystachya micrantha Schltr.
Polystachya stenophylla Schltr.
Promenaea acuminata Schltr.
Promenaea albescens Schltr.
Promenaea catharinensis Schltr.
Promenaea dusenii Schltr.
Promenaea fuerstenbergiana Schltr.
Promenaea malmquistiana Schltr.
Promenaea paranaensis Schltr.
Promenaea paulensis Schltr.
Promenaea polysphaera Schltr.
Promenaea riograndensis Schltr.
Promenaea stricta Schltr.
Promenaea truncicola Schltr.
Pseudostelis bradei Schltr.
Rodriguezia huebneri Schltr.
Rodriguezia minor Schltr.
Sarcoglottis albiflos Schltr. ex Hoehne
Sarcoglottis alexandri Schltr. ex Mansf.
Sarcoglottis glaucescens Schltr.
Sarcoglottis juergensii Schltr.
Sarcoglottis tenuis Schltr.
Scaphyglottis amazonica Schltr.
Scaphyglottis huebneri Schltr.
Scaphyglottis ochroleuca Schltr.
Sigmatostalix amazonica Schltr.
Spiranthes sincorensis Schltr.
Stanhopea minor Schltr.
Stelis aquinoana Schltr.
Stelis calotricha Schltr.
Stelis castanea Hoehne & Schltr.
Stelis diaphana Schltr.
Stelis fragrans Schltr.
Stelis hoehnei Schltr.
Stelis huebneri Schltr.
Stelis inaequisepala Hoehne & Schltr.
Stelis itatiayae Schltr.
Stelis juergensii Schltr.
Stelis macrochlamys Hoehne & Schltr.
Stelis microphylla Hoehne & Schltr.
Stelis paoloensis Hoehne & Schltr.
Stelis porschiana Schltr.
Stelis peterostele Hoehne & Schltr.
Stelis robusta Schltr.
Stelis schenckii Schltr.
Stelis thermophilla Schltr.
Stelis wettsteiniana Schltr.
Stenorrhynchos bradei Schltr.
Stenorrhynchos foliosus Schltr.
Trachelosiphon paranaense Schltr.
Triphora amazonica Schltr.
Triphora duckei Schltr.
Vanilla angustipetala Schltr.
Vanilla bradei Schltr. ex Mansf.
Xerorchis amazonica Schltr. (Fig. 30)
Zygostates aquinoi Schltr.
Zygostates paranaensis Schltr.

The Guyanas (Fig. 28)

Specific orchid tribes and subtribes, genera or species

1910–1911 Schlechter, R. *Orchidaceae novae et criticae, Decas XVI-XVII*. Repertorium specierum novarum regni vegetabilis, Vol.10: 21–32.

1901 Schlechter, R. *Orchidaceae.* In Pilger, R. *Beitrag zur Flora von Mattogrosso. Botanischer Bericht über die Expedition von Dr. Herrmann Meyer nach Central-Brasilien 1899*. Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 30: 149–150.

1914 Schlechter, R. *Orchidaceae.* In Pilger, R. *Plantae Uleanae novae vel minus cognitae.* Notizblatt des Königlichen Botanischen Gartens und Museums zu Berlin, Vol. 6: 120–126.

1917–1919 Schlechter, R. *Orchidaceae novae et criticae, Decas LXV*. Repertorium specierum novarum regni vegetabilis., Vol. 16: 353–358.

1918 Schlechter, R. *Die Gattung Aganisia Ldl. und ihre Verwandten.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 12: 24–42.

1920 Schlechter, R. *Versuch einer systematischen Neuordnung der Spiranthinae*. Beihefte zum Botanischen Centralblatt. Zweite Abteilung, Systematik, Pflanzengeographie, angewandte Botanik 37(2): 317–454.
Schlechter, R. *Beiträge zur Kenntnis der Orchidaceenflora von Paraná*. Repertorium specierum Repertorium specierum novarum regni vegetabilis., Vol. 35: 1–108.

Schlechter's network in Guyana (orchid collectors, growers and other purveyors)

- Bartlett, Albert William (1875/76–1943), collected 1905–1906.
- Fiebrig, Karl August Gustav (1879–1951), collected 1902–1950.
- Hassler, Emil (1864–1937), collected 1895–1909, 1914, 1920–1937.
- Im Thurn, Everard Ferdinand (1852–1932), collected 1884–1906.
- Goebel, Karl Immanuel Eberhard Ritter von (1855–1932), collected 1890–1913.
- McConnell, Frederick Vavasour (1868–1914), collected 1891–1898.
- Ule, Ernst Heinrich Georg (1854–1915), collected 1893–1912.

Orchids described by R. Schlechter from the Guyanas

The following is a list of the orchids described by R. Schlechter as new to science from the Guyanas, as enumerated in the aforementioned bibliography (only basionyms):

New orchid genera

Neobartlettia Schltr.

Otostylis Schtr.

New orchid species

Epidendrum ulei Schltr.
Habenaria arecunarum Schltr.
Habenaria ernestii Schltr.
Koellensteinia roraimae Schltr.
Maxillaria rugosa Schltr.
Neobartlettia guianensis Schltr.
Pleurothallis stenocardium Schltr. (Fig. 31)

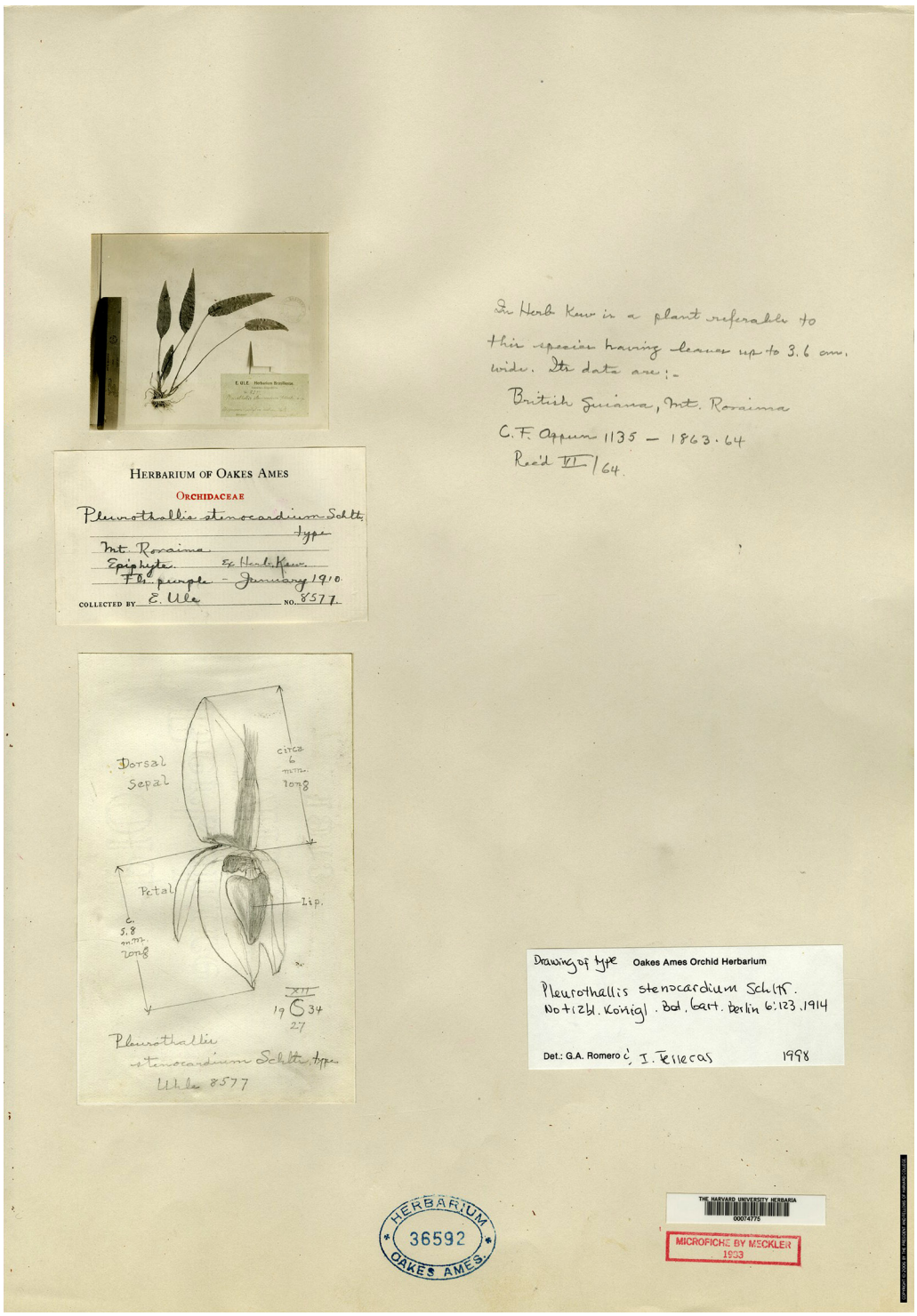


Figure 31. Isotype of *Pleurothallis stenocardium* Schltr., collected by E. Ule in British Guyana with drawing of type by C. Schweinfurth (?).

FIGURE 32. Map of Venezuela, 1900. Unknown author.

VENEZUELA (Fig. 32)

National and regional orchid floras, specific collectors

1919 Schlechter, R. *Die Orchideenfloren der südamerikanischen Kordillerenstaaten. I. Venezuela.* Repertorium specierum novarum regni vegetabilis, Beihefte, vol.6: 1–100.

Specific orchid tribes and subtribes, genera or species

1918–1919 Schlechter, R. *Zwei interessante Gattungen der Spiranthinae.* Repertorium specierum novarum regni vegetabilis, vol. 15: 416–417.

1920 Schlechter, R. *Versuch einer systematischen Neuordnung der Spiranthinae*. Beihefte zum Botanischen Centralblatt. Zweite Abteilung, Systematik, Pflanzengeographie, angewandte Botanik 37(2): 317–454.

Schlechter's network in Venezuela (orchid collectors, growers and other purveyors)

- BEYRODT, Otto (1879–1923), orchid grower in Marienfelde, Germany, around 1900–1923.
- BRICEÑO GABALDÓN, Salomón (1826–1912), collected from early 1870s on.
- GOEBEL, Karl Immanuel Eberhard Ritter von (1855–1932), collected 1890–1913.
- IM THURN, Everard Ferdinand (1852–1932), German Caura Expedition, collected 1884–1906.

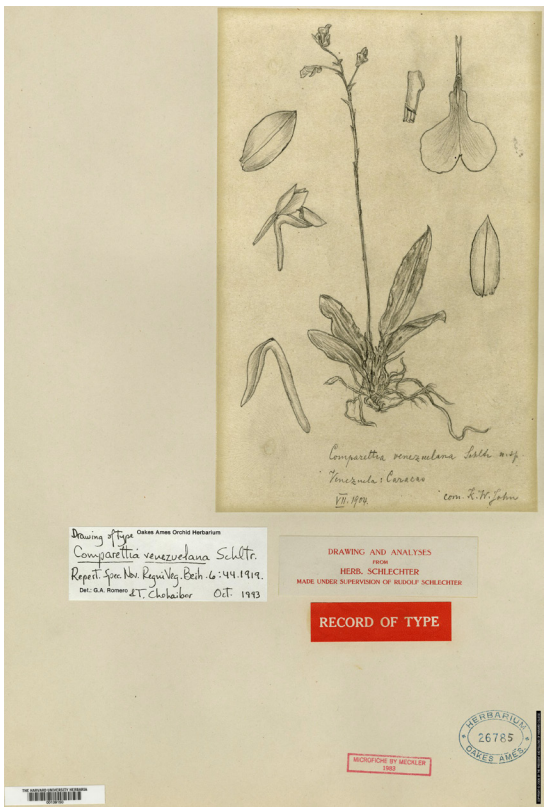


FIGURE 33. Drawing of type of *Comparettia venezuelana* Schltr., made under Schlechter's supervision. Nr. 26785 – Orchid Herbarium of Oakes Ames.

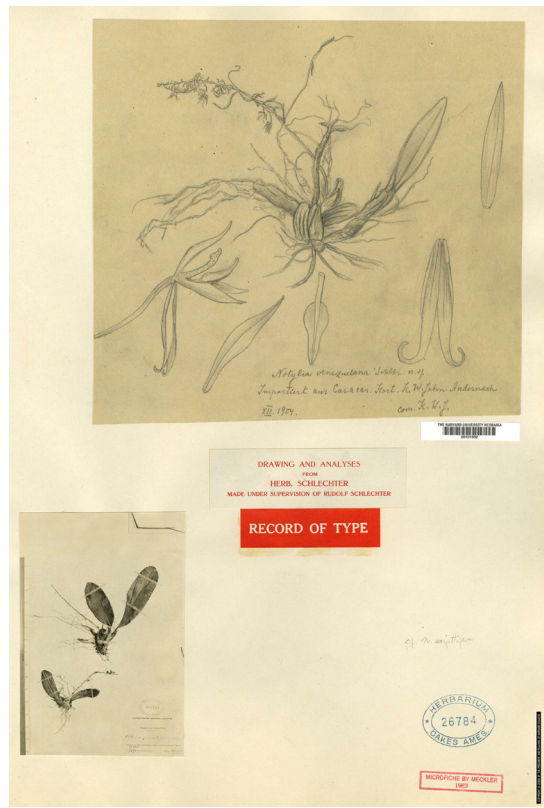


FIGURE 34. Specimen and drawing of type of *Notylia venezuelana* Schltr., made under Schlechter's supervision. Nr. 26784 – Orchid Herbarium of Oakes Ames.

- John, Karl Wilhelm (?), orchid grower in Andernach-on-the Rhine, Germany, around 1910.
- McConnell, Frederick Vavasour (1868–1914), collected 1891–1898.
- Passarge, Otto Karl Siegfried (1867–1958) and Selwyn, Jasper Henry (1819–1902), collected 1901–1902
- Pittier, Henri (1857–1950), collected ca. 1905–1950.
- Preuss, Paul Rudolf (1861–1926), collected 1899–1902.
- Ule, Ernst Heinrich Georg (1854–1915), collected 1893–1912.
- Wolter, Paul (1862–1942), orchid grower in Magdeburg-Wilhelmsburg.

Orchids described by R. Schlechter from Venezuela (Schlechter ex Knuoctomeriath in some cases)

The following is a list of the orchids described by R. Schlechter as new to science from Venezuela, as enumerated in the aforementioned bibliography (only basionyms):

New orchid genera

Centrogenium Schltr.

Discyphus Schltr.

New orchid species

Bletia pittieri
Bletia stenophylla Schltr.
Comparettia venezuelana Schltr. (Fig. 33)
Cranichis fendleri Schltr.
Cyrtopodium naiguatae Schltr.
Diacrium venezuelanum Schltr.

Elleanthus galipanensis Schltr.
Encyclia leucantha Schltr.
Encyclia recurvata Schltr.
Epidendrum bathyschistum Schltr.
Epidendrum ernstii Schltr.
Epidendrum laetum Schltr.
Epidendrum pachyanthum Schltr.
Epidendrum tricallosum Schltr.
Epidendrum venezuelanum Schltr.
Gomphichis gracilis Schltr.
Govenia ernstii Schltr.
Habenaria caracasana Schltr.
Habenaria ernstii Schltr.
Habenaria gollmeri Schltr.
Hapalorchis cheirostyloides Schltr.
Liparis fendleri Schltr.
Microstylis johniana Schltr.
Notylia venezuelana Schltr. (Fig. 34)
Physurus pittieri Schltr.
Physurus venezuelanus Schltr. ex P. Knuth
Pleurothallis insconspicuiflora Schltr. ex P. Knuth
Pleurothallis intermedia Schltr.
Pleurothallis nephrocardia Schltr.
Pogonia nana Schltr.
Scaphosepalum trachypus Schltr.
Stelis amblyophila Schltr.
Stelis calceolus Schltr.
Stelis covilleana Schltr. ex Kunth
Stelis pittieri Schltr. ex Kunth

Colombia (Fig. 35)

National and regional orchid floras, specific collectors

1920 Schlechter, R. *Die Orchideenfloren der südamerikanischen Kordillerenstaaten. II. Colombia.* Repertorium specierum novarum regni vegetabilis, Beihefte, Vol.7: 1–301.

1924 Schlechter, R. *Beiträge zur Orchideenkunde von Colombia.* Repertorium specierum novarum regni vegetabilis, Beihefte, Vol. 27: 1–182.

Specific orchid tribes and subtribes, genera or species

1906 Schlechter, R. *Über einige neue Orchidaceen.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol.1: 25.

1910 Schlechter, R. *Orchidaceae novae et criticae, Decas XIV-XV*. Repertorium specierum novarum regni vegetabilis., Vol. 8, 1910: 561–572.

1911 Schlechter, R. *Orchidaceae novae et criticae, Decas XVI-XVII*. Repertorium specierum novarum regni vegetabilis, Vol.10: 21–32.
Schlechter, R. *Neue und seltene Gartenorchideen.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol.5: 58–62.

1912 Schlechter, R. 1912. *Neue und seltene Garten-Orchideen III, IV & V.* Orchis, Mitteilungen des Orchideenausschusses der Deutschen Gartenbau-Gesellschaft, vol. 6: 6–10, 63–69, 112–119.

1913 Schlechter, R. *Orchidaceae novae et criticae, Decas XXXIX*. Repertorium specierum novarum regni vegetabilis, Vol.12: 212–246.

1914 Schlechter, R. *Die Orchideen ihre Beschreibung, Kultur und Züchtung Handbuch für Orchideenliebhaber, Kultivateure und Botaniker.*

1915 Schlechter, R. *Neue und seltene Garten-Orchideen, VIII.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, vol. 9: 49–54.
Schlechter, R. *Die Orchideen ihre Beschreibung, Kultur und Züchtung Handbuch für Orchideenliebhaber, Kultivateure und Botaniker.* Verlagsnbuchhandlung Paul Parey, Berlin.

1916 Schlechter, R. *Neue und seltene Garten-Orchideen, X.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, vol. 10: 183–190.

1917 Schlechter, R. *Die Gattung Acineta* Ldl. Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 11: 21–48.

Figure 35. Map of Colombia, Ecuador and Peru. Edward Stanford, London, 192?.

1918 Schlechter. R. *Orchidaceae novae, in caldariis Horti Dahlemensis cultae.* Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem, Vol.7 (66): 268–280.

1919 Schlechter. R. *Orchidaceae novae, in caldariis Horti Dahlemensis cultae II.* Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem, vol.7: 323–330.
Schlechter, R. *Die Gattung Cochlioda Ldl.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 13: 3–10.

1919–1920 Schlechter. R. *Ueber einige neue Orchidaceen aus Colombia.* Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem, vol. 7: 527–-532.

1920 Schlechter, R. *Versuch einer systematischen Neuordnung der Spiranthinae*. Beihefte zum Botanischen Centralblatt. Zweite Abteilung, Systematik, Pflanzengeographie, angewandte Botanik 37(2): 317–454.

1921–1924 Schlechter, R. *Orchidaceae novae, in caldariis Horti Dahlemensis cultae III.* Notizblatt des Botanischen Gartens und Museums zu Berlin - Dahlem, Vol. 8: 117–126.

1918 Schlechter. R. *Orchidaceae novae, in caldariis Horti Dahlemensis cultae.* Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem, Vol.7 (66): 268–280.

1919 Schlechter. R. *Orchidaceae novae, in caldariis Horti Dahlemensis cultae II.* Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem, vol.7: 323–330.
Schlechter, R. *Die Gattung Cochlioda Ldl.*. Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 13: 3–10.

1919–1920 Schlechter. R. *Ueber einige neue Orchidaceen aus Colombia.* Notizblatt des Botanischen Gartens und Museums zu Berlin - Dahlem, vol. 7: 527–532.

1920 Schlechter, R. *Versuch einer systematischen Neuordnung der Spiranthinae*. Beihefte zum Botanischen Centralblatt. Zweite Abteilung, Systematik, Pflanzengeographie, angewandte Botanik 37(2): 317–454.

1921–1924 Schlechter, R. *Orchidaceae novae, in caldariis Horti Dahlemensis cultae III.* Notizblatt des Botanischen Gartens und Museums zu Berlin - Dahlem, Vol. 8: 117–126.

Schlechter's network in Colombia (orchid collectors, growers and other purveyors)

- Beyrodt, Otto (1879–1923), orchid grower in Marienfelde, Germany, around 1900–1923.
- Bungeroth, E. (?–1937), collected in Bucaramanga.
- Fürstenberg, Baron Max (Maximilian) von (1866–1925), owner of an orchid collection ca. 1900–1910.
- John, Karl Wilhelm (?), orchid grower in Andernach-on-the Rhine, Germany, around 1910.
- Hartmann (?), orchid grower in Lindenhaus, Niederhöchstadt, Taunus, Germany
- Hennis, Wilhelm (1856–1943), orchid grower in Hildesheim.
- Herrenhausen, Gardens of, Hannover.
- Hopf, H. (?), collected 1923.
- Hopp, Werner (1887–?), collected 1921 (with Santiago Arévalo).
- Kalbreyer, Wilhelm (1847–1912), collected 1877-1912.
- Langlassé, Eugène (1865–1900), collected 1898–1900.
- Lehmann, Friedrich Carl (1850–1903), collected 1867–1903.
- Madero, M. (?), collector in Antioquía and Cauca 1910.
- Pittier, Henri (1857–1950), collected ca. 1905–1950.
- Schmidtchen, Gustav (?), collected ca. 1923.
- Schnitter, R. (?), collected 1920–1921.

- Schultze, Arnold (1875–1948), collected 1920–1927.
- Smith, Herbert Huntington (1851-1919), collected 1891–1898.
- Sonntag, K. (?), collected 1888.
- Stübel, Moritz Alphons (1835–1904), collected 1868–1877.
- Wocke, Erich (1863–1941), collected 1889.
- Wolter, Paul (1862–1942), orchid grower in Magdeburg, ca. 1916.

Orchids described by R. Schlechter from Colombia

The following is a list of the orchids described by R. Schlechter as new to science from Colombia, as enumerated in the aforementioned bibliography (only basionyms):

New orchid genera

Antosiphon Schltr.
Caucaea Schltr.
Centrogenium Schltr.
Cirtoglottis Schltr.
Cyrtidium Schltr.
Monophyllorchis Schltr.
Porroglossum Schltr.
Roezliella Schltr.
Sphyrastylis Schltr.
Symphyglossum Schltr.
Warreella Schltr.

New orchid species

Aa colombiana Schltr.
Aa denticulata Schltr.
Aa maderoi Schltr.
Aa nigrescens Schltr.
Acineta antioquiae Schltr.
Acineta arcuata Schltr.
Acineta beyrodtiana Schltr.
Acineta gymnostele Schltr.
Acineta hennisiana Schltr.
Acineta wolteriana Schltr.
Anguloa goldschmidtiana Schltr.
Anguloa macroglossa Schltr.
Antosiphon roseans Schltr.
Barbosella dolichorhiza Schltr.
Barbosella longipes Schltr.
Bifrenaria pickiana Schltr.
Brachtia verruculifera Schltr.
Brachystele longiflora Schltr.
Brassia cyrtopetala Schltr.
Camaridium caquetanum Schltr.
Camaridium caucanum Schltr.
Camaridium equitans Schltr.
Camaridium lamprochlamys Schltr.
Camaridium quercicolum Schltr.
Camaridium sterrocaulon Schltr.
Campylocentrum colombianum Schltr. (Fig. 36)
Catasetum blepharochilum Schltr.
Catasetum caucanum Schltr.
Catasetum inornatum Schltr.
Catasetum platyglossum Schltr.
Chondrorhyncha amabilis Schltr.
Chrysocynis triptera Schltr.
Cranichis antioquensis Schltr.
Cranichis atrata Schltr.
Cranichis brachyblephara Schltr.
Cranichis cylindrostachys Schltr.
Cranichis ovatilabia Schltr.
Cranichis pastoensis Schltr.
Cranichis pleioneura Schltr.
Cranichis polyantha Schltr.
Cranichis polyblephara Schltr.
Cranichis pycnantha Schltr.
Cranichis styctophylla Schltr.
Comparettia erecta Schltr.
Comparettia pulchella Schltr.
Cryptocentrum flavum Schltr.
Cryptocentrum gracilipes Schltr.
Cryptocentrum hoppii Schltr.
Cryptocentrum pergracile Schltr.
Cyclopogon maderoi Schltr.

FIGURE 36. *Campylocentrum colombianum* Schltr. Drawing of type, made under Schlechter's supervision. Nr. 26784 – Orchid Herbarium of Oakes Ames.

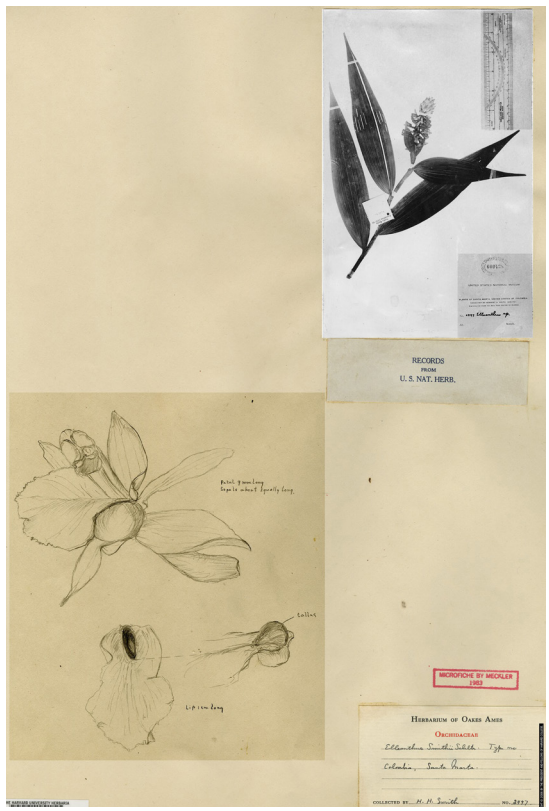


FIGURE 37. Photograph of type and analysis of flower of *Elleanthus smithii* Schltr. Oakes Ames Herbarium.

Cyclopogon spiranthoides Schltr.
Cycnoches brachydactylon Schltr.
Cyrtochilum rostratum Schltr.
Cyrtochilum simulans Schltr.
Cyrtoglottis gracilipes Schltr.
Dichaea acuminata Schltr.
Dichaea camaridioides Schltr.
Dichaea caquetana Schltr.
Dichaea lehmannii Schltr.
Dichaea selaginella Schltr.
Dichaea tenuifolia Schltr.
Dichaea trachysepala Schltr.
Dimerandra major Schltr.
Diothonea arevaloi Schltr.
Diothonea rhodochila Schltr.
Elleanthus ampliflorus Schltr.
Elleanthus bogotentis Schltr.
Elleanthus congestus Schltr.
Elleanthus grandiflorus Schltr.
Elleanthus hoppii Schltr.
Elleanthus laetus Schltr.
Elleanthus leiocaulon Schltr.
Elleanthus pastoensis Schltr.
Elleanthus smithii Schltr. (Fig. 37)
Elleanthus sphaerocephalus Schltr.
Elleanthus venustus Schltr.
Elleanthus vinosus Schltr.
Encyclia maderoi Schltr.
Epidendrum anitae Schltr.
Epidendrum arnoldii Schltr.
Epidendrum antioquense Schltr.
Epidendrum atrobrunneum Schltr.
Epidendrum baumannianum Schltr.
Epidendrum bogotense Schltr.
Epidendrum brachyschistum Schltr.
Epidendrum bungerothii Schltr.

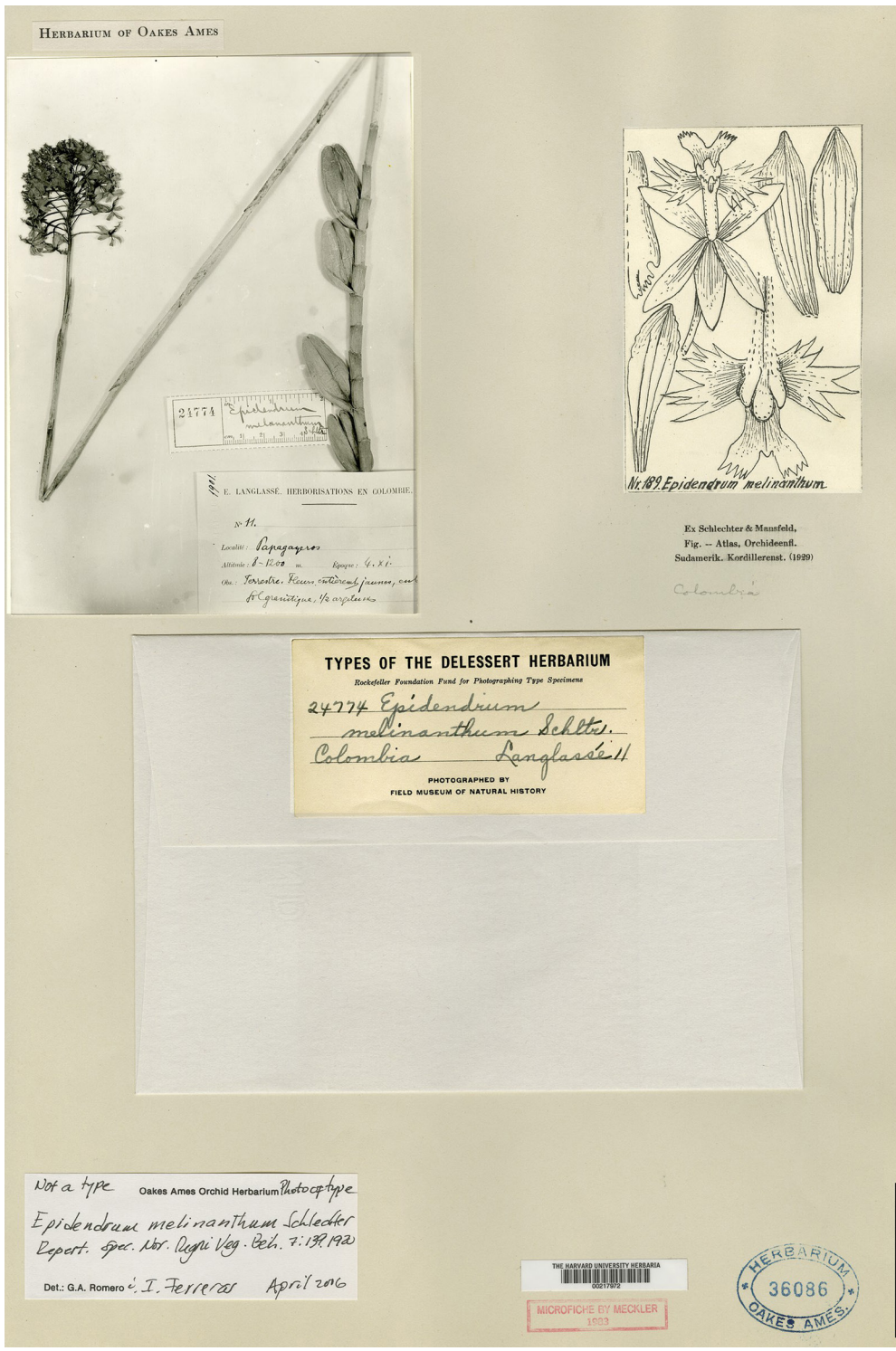


Figure 38. *Epidendrum melinanthum* Schltr. - Photograph of a specimen collected by E. Langlassé in Colombia and analytical drawing by R. Schlechter. Nr. 36086 – Oakes Ames Herbarium - Rockefeller Foundation

Epidendrum calothyrsus Schltr.
Epidendrum caquetanum Schltr.
Epidendrum caucae Schltr.
Epidendrum cebolleta Schltr.
Epidendrum commelinoides Schltr.
Epidendrum cyclopterum Schltr.
Epidendrum decurviflorum Schltr.
Epidendrum diphyllum Schltr.
Epidendrum dolichopus Schltr.
Epidendrum elleanthoides Schltr.
Epidendrum euchroma Schltr.
Epidendrum eugenii Schltr.
Epidendrum fraternum Schltr.
Epidendrum hastilabium Schltr.
Epidendrum hopfianum Schltr.
Epidendrum ionodesme Schltr.
Epidendrum juncifolium Schltr.
Epidendrum laxifoliatum Schltr.
Epidendrum leucarachne Schltr.
Epidendrum longicrure Schltr.
Epidendrum macroceras Schltr.
Epidendrum maderoi Schltr.
Epidendrum melinanthum Schltr. (Fig. 38)
Epidendrum nubigerum Schltr.
Epidendrum oreogenum Schltr.
Epidendrum oxyglossum Schltr.
Epidendrum pachyneurum Schltr.
Epidendrum pachyphyllum Schltr.
Epidendrum pachypodum Schltr.
Epidendrum pastoense Schltr.
Epidendrum peraltum Schltr.
Epidendrum persimile Schltr.
Epidendrum polychistum Schltr.
Epidendrum prasinum Schltr.
Epidendrum protractum Schltr.
Epidendrum quinquecallosum Schltr.
Epidendrum rahbdobulbon Schltr.
Epidendrum rhopalobulbon Schltr.
Epidendrum rugulosum Schltr.
Epidendrum sanguineum Schltr.
Epidendrum sanctae martae Schltr.
Epidendrum schistochilum Schltr.
Epidendrum schnitteri Schltr.
Epidendrum scytocladium Schltr.
Epidendrum smithii Schltr.
Epidendrum sororium Schltr.
Epidendrum sterroanthum Schltr.
Epidendrum sterrophyllum Schltr.
Epidendrum strictum Schltr.
Epidendrum subfloribundum Schltr.
Epidendrum suborbiculare Schltr.
Epidendrum sympodiale Schltr.
Epidendrum trifidum Schltr.
Epidendrum trimeroglossum Schltr.
Epidendrum vulcanicum Schltr.
Epidendrum werneri Schltr.
Epidendrum zipaquinarum Schltr.
Eriopsis colombiana Schltr.
Galeandra leptoceras Schltr.
Gomphichis brachystachys Schltr.
Gomphichis caucana Schltr.
Gomphichis hetaerioides Schltr.
Gomphichis lancipetala Schltr.
Gomphichis scaposa Schltr.
Gongora beyrodtiana Schltr.
Gongora hennisiana Schltr.
Govenia platyglossa Schltr.
Govenia stictoglossa Schltr.
Habenaria caucana Schltr.
Habenaria maderoi Schltr.
Habenaria schultzei Schltr.
Habenaria smithii Schltr.
Hapalorchis longirostris Schltr.
Hapalorchis trilobata Schltr.
Hexisea colombiana Schltr.
Houlettia clarae Schltr.
Houlettia unguiculata Schltr.
Huntleya brevis Schltr.
Jacquiniella colombiana Schltr.
Kefersteinia tolimensis
Koellensteinia elegantula Schltr.
Laelia johniana Schltr.
Lanium colombianum Schltr.
Lepanthes antioquensis Schltr.
Lepanthes caucana Schltr.
Lepanthes dolichopus Schltr.
Lepanthes lehmanni Schltr.
Lepanthes marginata Schltr.
Lepanthes pastoensis Schltr.
Lepanthes peperomioides Schltr.
Lepanthes rhombipetala Schltr.
Lepanthes schnitteri Schltr.
Lepanthes stenoscleros Schltr.
Lepanthes superposita Schltr.

Lepanthes trachysepala Schltr.
Lepanthes tricuspis Schltr.
Lindleyella floribunda Schltr.
Lindleyella picta Schltr.
Lindleyella saxicola Schltr.
Liparis caloglossa Schltr.
Liparis colombiana Schltr.
Lockhartia hologlossa Schltr.
Lockhartia unicornis Schltr.
Masdevallia bathychista Schltr.
Masdevallia callifera Schltr.
Masdevallia densiflora Schltr.
Masdevallia echinocarpa Schltr.
Masdevallia exilipes Schltr.
Masdevallia hoppii Schltr.
Masdevallia maculigera Schltr.
Masdevallia oligantha Schltr.
Masdevallia petiolaris Schltr.
Masdevallia pteroglossa Schltr.
Masdevallia tenuipes Schltr.
Masdevallia trichroma Schltr.
Maxillaria adscendens Schltr.
Maxillaria aequiloba Schltr.
Maxillaria angustifolia Schltr.
Maxillaria aurantiaca Schltr.
Maxillaria baumanniana Schltr.
Maxillaria bolleoides Schltr.
Maxillaria brachypoda Schltr.
Maxillaria camaridioides Schltr.
Maxillaria caquetana Schltr.
Maxillaria caucana Schltr.
Maxillaria caulina Schltr.
Maxillaria elata Schltr.
Maxillaria elegans Schltr.
Maxillaria farinifera Schltr.
Maxillaria hennisiana Schltr.
Maxillaria hoppii Schltr.
Maxillaria langlassei Schltr.
Maxillaria maderoi Schltr.
Maxillaria microblephara Schltr.
Maxillaria modesta Schltr.
Maxillaria ochroglossa Schltr.
Maxillaria parvula Schltr.
Maxillaria patens Schltr.
Maxillaria phaeoglossa Schltr.
Maxillaria pleiantha Schltr.
Maxillaria plicata Schltr.
Maxillaria saxicola Schltr.
Maxillaria schnitteri Schltr.
Maxillaria schultzei Schltr.
Maxillaria sulfurea Schltr.
Maxillaria subpandurata Schltr.
Maxillaria subulifolia Schltr.
Maxillaria tristis Schltr.
Maxillaria truncatilabia Schltr.
Maxillaria unguiculata Schltr.
Maxillaria unguilabia Schltr.
Maxillaria verecunda Schltr.
Maxillaria vestita Schltr.
Maxillaria witsenioides Schltr.
Microstylis hopii Schltr.
Microstylis mucronulata Schltr.
Microstylis polyblephara Schltr.
Monophyllorchis colombiana Schltr.
Mormodes schultzei Schltr.
Notylia oberonia Schltr.
Notylia obtusa Schltr.
Notylia rimbachii Schltr.
Octomeria colombiana Schltr.
Octomeria longerepens Schltr.
Octomeria longifolia Schltr.
Octomeria mocoana Schltr.
Odontoglossum bogotense Schltr.
Odontoglossum crispum Schltr.
Odontoglossum cristatellum Schltr.
Odontoglossum floribundum Schltr.
Odontoglossum hoppii Schltr.
Odontoglossum maderoi Schltr.
Odontoglossum schultzei Schltr.
Oncidium bryoclaudium Schltr.
Oncidium caucanum Schltr.
Oncidium hedyosmum Schltr.
Oncidium hoppii Schltr.
Oncidium maderoi Schltr.
Oncidium oberonia Schltr.
Oncidium platychilum Schltr.
Oncidium trachycaulon Schltr.
Oncidium saxicolum Schltr.
Oncidium werneri Schltr.
Ornithidium compactum Schltr.
Ornithidium cyperifolium Schltr.
Ornithidium dichotomum Schltr.
Ornithidium pastoense Schltr.
Ornithidium rhodoleucon Schltr.

Ornithidium toriferum Schltr.
Ornithidium vagans Schltr.
Ornithidium virescens Schltr.
Ornithocephalus lehmannii Schltr.
Ornithocephalus micranthus Schltr.
Pachyphyllum bryophytum Schltr.
Pachyphyllum micrangis Schltr.
Pachyphyllum micranthum Schltr.
Pachyphyllum stuebellii Schltr.
Pachyphyllum vaginatum Schltr.
Pelexia caucae Schltr.
Pelexia hamata Schltr.
Physurus caucanus Schltr.
Physurus dolichostachys Schltr.
Physurus erythrodoides Schltr.
Physurus hetaerioides Schltr.
Physurus palaceus Schltr.
Physurus procerus Schltr.
Physurus zeuxinoides Schltr.
Pitiphyllum amesianum Schltr.
Pitiphyllum antioquense Schltr.
Platystele schmidtchenii Schltr.
Pleurothallis arevaloi Schltr.
Pleurothallis belocardia Schltr.
Pleurothallis bogotentis Schltr.
Pleurothallis brachyantha Schltr.
Pleurothallis brevicaulis Schltr.
Pleurothallis caliensis Schltr.
Pleurothallis chachatoynsis Schltr.
Pleurothallis chlamydopus Schltr.
Pleurothallis citrina Schltr.
Pleurothallis cundinamarcae Schltr.
Pleurothallis cymbisepala Schltr.
Pleurothallis falcipetala Schltr.
Pleurothallis hirtipes Schltr.
Pleurothallis hopfiana Schltr.
Pleurothallis hoppii Schltr.
Pleurothallis ineziae Schltr.
Pleurothallis lancifera Schltr.
Pleurothallis langlassei Schltr.
Pleurothallis auta Schltr.
Pleurothallis lehmanniana Schltr.
Pleurothallis leontoglossa Schltr.
Pleurothallis lepanthoides Schltr.
Pleurothallis leptantha Schltr.
Pleurothallis medellinensis Schltr.
Pleurothallis melittantha Schltr.
Pleurothallis microptera Schltr.
Pleurothallis mocoana Schltr.
Pleurothallis nasuta Schltr.
Pleurothallis nubigena Schltr.
Pleurothallis nutans Schltr.
Pleurothallis ochroleuca Schltr.
Pleurothallis papillisepala Schltr.
Pleurothallis patula Schltr.
Pleurothallis pendula Schltr.
Pleurothallis peniculus Schltr.
Pleurothallis phaeantha Schltr.
Pleurothallis platycardium Schltr.
Pleurothallis platysepala Schltr.
Pleurothallis pleiostachys Schltr.
Pleurothallis potamophila Schltr.
Pleurothallis pteroglossa Schltr.
Pleurothallis pulvinipes Schltr.
Pleurothallis quadricaudata Schltr.
Pleurothallis rhaphidopus Schltr.
Pleurothallis scaphioglottis Schltr.
Pleurothallis schistopetala Schltr.
Pleurothallis schnitteri Schltr.
Pleurothallis serricardia Schltr.
Pleurothallis smithii Schltr.
Pleurothallis sororia Schltr.
Pleurothallis sotarae Schltr.
Pleurothallis spathilabia Schltr.
Pleurothallis stelidioides Schltr.
Pleurothallis trianae Schltr.
Pleurothallis werneri Schltr.
Pogonia acuminata Schltr.
Pogonia elegantula Schltr.
Pogonia maderoi Schltr.
Pogonia venusta Schltr.
Polycycnis acutiloba Schltr.
Polystachya caquetana Schltr.
Polystachya colombiana Schltr.
Ponthieva elata Schltr.
Ponthieva microglossa Schltr.
Ponthieva triloba Schltr.
Porroglossum colombianum Schltr.
Prescottia filiformis Schltr.
Prescottia gracilis Schltr.
Prescottia longifolia Schltr.
Prescottia smithii Schltr.
Pseudocentrum sphaerocorys Schltr.
Pterichis acuminata Schltr.

Pterichis tomentosula Schltr.
Restrepia antioquensis Schltr.
Restrepia caucana Schltr.
Restrepia hemsleyana Schltr.
Restrepia leontoglossa Schltr.
Restrepia serrilabia Schltr.
Rodriguezia arevaloi Schltr.
Rodriguezia macrantha Schltr.
Rodriguezia secunda Schltr.
Roezliella cucullifera Schltr.
Roezliella ibis Schltr.
Scaphosepalum platypetalum Schltr.
Scaphyglottis exilis Schltr.
Scaphyglottis genychila Schltr.
Scaphyglottis sanctae-martae Schltr.
Scaphyglottis stricta Schltr.
Scelochilus langlassei Schltr.
Schlimia pandurata Schltr.
Schomburgkia elata Schltr.
Schomburgkia schultzei Schltr.
Schomburgkia splendida Schltr.
Sertifera colombiana Schltr.
Sertifera major Schltr.
Sertifera parviflora Schltr.
Sigmatostalix caquetana Schltr.
Sigmatostalix pandurata Schltr.
Sobralia anceps Schltr.
Sobralia antioquensis Schltr.
Sobralia densifoliata Schltr.
Sobralia exilis Schltr.
Sobralia hoppii Schltr.
Sobralia kalbreyeri Schltr.
Sobralia malmquistiana Schltr.
Sobralia odorata Schltr.
Sobralia schultzei Schltr.
Sobralia splendida Schltr.
Sphyrastylis hoppii Schltr.
Sphyrastylis oberonioides Schltr.
Stanhopea hoppii Schltr.
Stelis antioquensis Schltr.
Stelis apiculata Schltr.
Stelis arevaloi Schltr.
Stelis bigibba Schltr.
Stelis bogotentis Schltr.
Stelis bracteata Schltr.
Stelis caucae Schltr.
Stelis citrina Schltr.
Stelis crassilabia Schltr.
Stelis cuculligera Schltr.
Stelis cundinamarcae Schltr.
Stelis cycloglossa Schltr.
Stelis decipiens Schltr.
Stelis dolichopus Schltr.
Stelis elegantula Schltr.
Stelis eugenii Schltr.
Stelis exilipes Schltr.
Stelis fruticulus Schltr.
Stelis hennisiana Schltr.
Stelis hoppi Schltr.
Stelis langlassei Schltr.
Stelis longiracemosa Schltr.
Stelis macropoda Schltr.
Stelis maderoi Schltr.
Stelis magnipetala Schltr.
Stelis mesohybos Schltr.
Stelis minimiflora Schltr.
Stelis mirabilis Schltr.
Stelis mocoana Schltr.
Stelis mucronipetala Schltr.
Stelis myriantha Schltr.
Stelis oligoblephara Schltr.
Stelis oxypetala Schltr.
Stelis pachyphilla Schltr.
Stelis pachystele Schltr.
Stelis pastoensis Schltr.
Stelis petiolaris Schltr.
Stelis pleistantha Schltr.
Stelis prorepens Schltr.
Stelis ringens Schltr.
Stelis scandens Schltr.
Stelis schmidtchenii Schltr.
Stelis schnitteri Schltr.
Stelis simula Schltr.
Stelis tenuis Schltr.
Stelis tolimensis Schltr.
Stelis trianaei Schltr.
Stelis umbriae Schltr.
Stelis verecunda Schltr.
Stelis virgulata Schltr.
Stelis vulcanica Schltr.
Stelis walteri Schltr.
Stelis werneri Schltr.
Telipogon caucanus Schltr.
Telipogon cycloglossus Schltr.

Telipogon gracilis Schltr.
Telipogon hoppii Schltr.
Telipogon lagunae Schltr.
Telipogon pastoanus Schltr.
Telipogon venustus Schltr.
Trachelosiphon colombianus Schltr.
Trachelosiphon cristatus Schltr.
Trichocentrum brachyceras Schltr.
Trichocentrum verruciferum Schltr.
Vanilla calyculata Schltr.
Warreella cyanea Schltr.
Xylobium modestum Schltr.
Xylobium stanhopeifolium Schltr.

Ecuador (Fig. 35)

National and regional orchid floras, specific collectors

1914–1916 Schlechter, R. *Orchidaceae novae et criticae, Decas XLII-XLVI. Additamenta ad Orchideologiam ecuadorensem I.* Repertorium specierum novarum regni vegetabilis, Vol. 14: 114–133.
Schlechter, R. *Orchidaceae novae et criticae, Decas XLVII-XLVIII. Additamenta ad Orchideologiam ecuadorensem II.* Repertorium specierum novarum regni vegetabilis, Vol. 14: 385–395.

1917–1919 Schlechter, R.. *Orchidaceae novae et criticae, Decas XLIX. Additamenta ad Orchideologiam ecuadorensem III.* Repertorium specierum novarum regni vegetabilis, Vol. 15: 49–59.

1921 Schlechter, R. *Die Orchideenfloren der südamerikanischen Kordillerenstaaten. III. Ecuador.* Repertorium specierum novarum regni vegetabilis, Beihefte, vol. 8: 1–172.

Specific orchid tribes and subtribes, genera or species

1910–1911 Schlechter, R. *Orchidaceae novae et criticae, Decas XI, XII, XIII, XIV, XV*. Repertorium specierum novarum regni vegetabilis, Vol.8: 453–58, 500–512, 561–574.
Schlechter, R. *Orchidaceae novae et criticae, Decas XVI-XVII*. Repertorium specierum novarum regni vegetabilis, Vol. 10: 21–32.

1911–1912 Schlechter, R. *Orchidaceae novae et criticae, Decas XVI-XVII*. Repertorium specierum novarum regni vegetabilis, Vol. 10: 21–32.
Schlechter, R. *Orchidaceae novae et criticae, Decas XXVI.* Repertorium specierum novarum regni vegetabilis, Vol. 10: 291–296.

1915 Schlechter, R. *Orchidaceae novae et criticae, Decas XLII-XLVI.* Repertorium specierum novarum regni vegetabilis, Vol. 14: 114–131.

1919 Schlechter, R. *Die Gattung Cochlioda Ldl.*. Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 13: 3–10.

Schlechter's network in Ecuador (orchid collectors, growers and other purveyors)

- Eggers, Henrik Franz Alexander von (1844–1903), collected 1891–1897.
- Hennis, Wilhelm ((1856–1943)), orchid grower in Hildesheim.
- Lehmann, Friedrich Carl (1850–1903), collected 1867–1903.
- Mille, Louis (Aloysius) (?–1940s), collected ca. 1896–1963.
- Rimbach, August (1862–1943), collected 1891–1934.
- Sodiro, Luigi Aloysius (Luis) (1836–1909), collected 1876–1907.

Orchids described by R. Schlechter from Ecuador

The following is a list of the orchids described by R. Schlechter as new to science from Ecuador, as enumerated in the aforementioned bibliography (only basionyms):

New orchid genera

Dipterostele Schltr.
Sodiroella Schltr.
Solenocentrum Schltr.
Symphyglossum Schltr.

New orchid species

Aa macra Schltr.
Aa rhynchocarpa Schltr.
Aa riobambae Schltr.
Aa ustulata Schltr.
Bletia ecuadorensis Schltr.
Camaridium dichotomum Schltr.
Camaridium longum Schltr.
Camaridium sodiroi Schltr.
Campylocentrum ecuadorense Schltr.
Campylocentrum rimbachii Schltr.
Catasetum sodiroi Schltr.
Cranichis cucullata Schltr.
Cranichis ecuadorensis Schltr.
Cranichis elliptica Schltr.
Cranichis sororia Schltr.
Cryptarrhena unguicalata Schltr.
Cryptophoranthus beloglottis Schltr.
Cyclopogon argyrotaenius Schltr.
Cyclopogon cranichioides Schltr.
Cyclopogon gracilis Schltr.
Cyclopogon macer Schltr.
Dichaea ecuadorensis Schltr.
Dichaea sodiroi Schltr.
Diothonea angustifolia Schltr.
Diothonea pulchra Schltr.
Diothonea sodiroi Schltr.
Diothonea viridiflora Schltr.
Dipterostele microglossa Schltr.
Elleanthus fractiflexus Schltr.
Elleanthus macer Schltr.
Elleanthus petrogeiton Schltr.
Elleanthus roseus Schltr.
Elleanthus sodiroi Schltr.
Elleanthus stenophyllus Schltr.
Elleanthus ventricosus Schltr.
Encyclia angustiloba Schltr.
Encyclia trachypus Schltr.
Epidendrum aloisii Schltr.
Epidendrum atacazoicum Schltr.
Epidendrum bifalce Schltr.
Epidendrum brachystele Schltr.
Epidendrum caloglossum Schltr.
Epidendrum calyptrochilum Schltr.
Epidendrum chimborazoensis Schltr.
Epidendrum chortophyllum Schltr.
Epidendrum cuencanum Schltr.
Epidendrum cuniculatum Schltr.
Epidendrum dasytaenium Schltr.
Epidendrum diothonaeoides Schltr.
Epidendrum fruticetorum Schltr.
Epidendrum geminatum Schltr.
Epidendrum guayasense Schltr.
Epidendrum imitans Schltr.
Epidendrum indecoratum Schltr.
Epidendrum inornatum Schltr.
Epidendrum megahybos Schltr.
Epidendrum microglossum Schltr.
Epidendrum millei Schltr.
Epidendrum miniatum Schltr.
Epidendrum mojandae Schltr.
Epidendrum monanthum Schltr.
Epidendrum neglectum Schltr.
Epidendrum neolehmannia Schltr.
Epidendrum ochranthum Schltr.
Epidendrum ornithidii Schltr.
Epidendrum ornithoglossum Schltr.
Epidendrum orthocaule Schltr.
Epidendrum pallatangae Schltr.
Epidendrum pedicellare Schltr.
Epidendrum peperomioides Schltr.
Epidendrum pergracile Schltr.
Epidendrum pichinchae Schltr.
Epidendrum piestopus Schltr.
Epidendrum platychilum Schltr.
Epidendrum podocarpophilum Schltr.
Epidendrum pteroglottis Schltr.
Epidendrum quisayanum Schltr.
Epidendrum ramistratum Schltr.
Epidendrum reichenbachianum Schltr.
Epidendrum renilabium Schltr.
Epidendrum rhacoglossum Schltr. Schltr.
Epidendrum rimbachii Schltr.
Epidendrum riobambae Schltr.
Epidendrum sarcoglottis Schltr.

Epidendrum sodiroi Schltr.
Epidendrum spathatum Schltr.
Epidendrum sphaeranthum Schltr.
Epidendrum splendidum Schltr.
Epidendrum rachychlaena Schltr.
Epidendrum tunguraguae Schltr.
Epidendrum zingiberaceum Schltr.
Epistephium lamprochyllum Schltr.
Gomphichis cranichioides Schltr.
Gomphichis sodiroi Schltr.
Govenia sodiroi Schltr.
Habenaria millei Schltr.
Habenaria sodiroi Schltr.
Kefersteinia lojae Schltr.
Lanium ecuadorense Schltr.
Lepanthes aberrans Schltr.
Lepanthes corazonis Schltr.
Lepanthes effusa Schltr.
Lepanthes elegantula Schltr.
Lepanthes macropoda Schltr.
Lepanthes macroura Schltr.
Lepanthes millei Schltr.
Lepanthes pensilis Schltr.
Lepanthes rhodophylla Schltr.
Liparis commelinoides Schltr.
Liparis millei Schltr.
Liparis nigrescens Schltr.
Masdevallia corazonica Schltr.
Masdevallia parvula Schltr.
Masdevallia sodiroi Schltr.
Masdevallia ventricosa Schltr.
Maxillaria ecuadorensis Schltr.
Maxillaria microdendron Schltr.
Maxillaria microtricha Schltr.
Maxillaria nutantiflora Schltr.
Maxillaria poicilothece Schltr.
Maxillaria sanguineomaculata Schltr.
Maxillaria stictantha Schltr.
Maxillaria stricta Schltr.
Maxillaria xantholeuca Schltr.
Microstylis lloensis Schltr.
Microstylis pichinchae Schltr.
Microstylis sodiroi Schltr.
Nasonia robusta Schltr.
Notylia ecuadorensis Schltr.
Notyliarimbachii Schltr.
Odontoglossum sodiroi Schltr.
Oncidium aloisii Schltr.
Oncidium hapalotyle Schltr.
Oncidium millei Schltr.
Oncidium sodiroi Schltr.
Ornithidium breve Schltr.
Ornithidium chrysocynoides Schltr.
Ornithidium pleurothantioides Schltr.
Ornithidium squarrosum Schltr.
Ornithocephalus bryostachyus Schltr.
Pelexia ecuadorensis Schltr.
Physosiphon inaequisepalus Schltr.
Pleurothallis aloisii Schltr.
Pleurothallis blepharopetala Schltr.
Pleurothallis cardiophylla Schltr.
Pleurothallis conchopetala Schltr.
Pleurothallis corazonica Schltr.
Pleurothallis diploglossa Schltr.
Pleurothallis ecuadorensis Schltr.
Pleurothallis fimbripetala Schltr.
Pleurothallis henrici Schltr.
Pleurothallis ignivomi Schltr.
Pleurothallis lamprochlamys Schltr.
Pleurothallis lasioglossa Schltr.
Pleurothallis lepanthopsis Schltr.
Pleurothallis lloensis Schltr.
Pleurothallis lojae Schltr.
Pleurothallis longerepens Schltr.
Pleurothallis macropus Schltr. (Fig. 39)
Pleurothallis microcharis Schltr.
Pleurothallis millei Schltr.
Pleurothallis myoxanthus Schltr.
Pleurothallis nephroglossa Schltr.
Pleurothallis nutantiflora Schltr.
Pleurothallis opeatorhyncha Schltr.
Pleurothallis otopetalum Schltr.
Pleurothallis pastazae Schltr.
Pleurothallis pichinchae Schltr.
Pleurothallis reichenbachiana Schltr.
Pleurothallis rhizomatosa Schltr.
Pleurothallis sigsigensis Schltr.
Pleurothallis sodiroi Schltr.
Pleurothallis subreniformis Schltr.
Pleurothallis superposita Schltr.
Pleurothallis tenuispica Schltr.
Pleurothallis triura Schltr.
Pleurothallis wolfiana Schltr.
Pogonia lutea Schltr.

Figure 39. *Pleurothallis macropus* Schltr. Nr. 87424 – Oakes Ames Herbarium. .

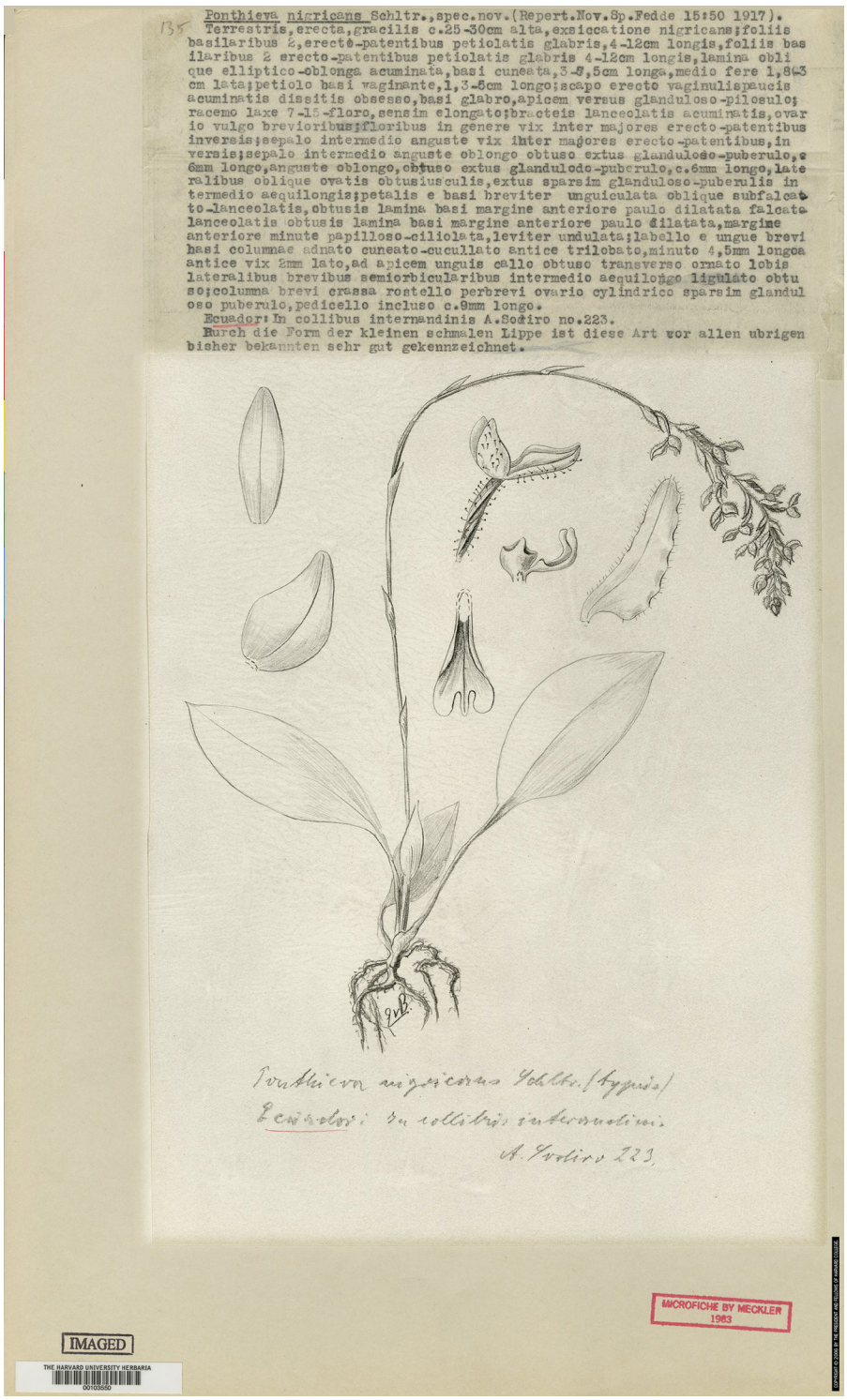


FIGURE 40. Drawing of the type of *Ponthieva nigricans* Schltr. and Schlechter's original type-written manuscript of the description of the new species. Orchid Herbarium of Oakes Ames.

FIGURE 41. Isotype of *Telipogon lehmannii* Schltr. Nr. 14728 – Orchid Herbarium of Oakes Ames.

Ponthieva appendiculata Schltr.
Ponthieva disema Schltr.
Ponthieva ecuadorensis Schltr.
Ponthieva nigricans Schltr. (Fig. 40)
Ponthieva orchioides Schltr.
Polystachya ecuadorensis Schltr.
Prescottia longipetiolata Schltr.
Pterichis pauciflora Schltr.
Pterichis seleniglossa Schltr.
Scelochilus pichinchae Schltr.
Sigmatostalix lunata Schltr.
Sobralia gracilis Schltr.
Sodiroella ecuadorensis Schltr.
Spiranthes millei Schltr.
Stelis altigena Schltr.
Stelis callicentrum Schltr.
Stelis calothece Schltr.
Stelis cordibractea Schltr.
Stelis coturcoensis Schltr.
Stelis cuencana Schltr.
Stelis hians Schltr.
Stelis lloensis Schltr.
Stelis megahybos Schltr.
Stelis millei Schltr.
Stelis perlaxa Schltr.
Stelis pilostylis Schltr.
Stelis pterostylis Schltr.
Stelis sodiroi Schltr.
Stelis superposita Schltr.
Stelis vulcanica Schltr.
Stenorrhynchos millei Schltr.
Stenorrhynchos sodiroi Schltr.
Telipogon ecuadorensis Schltr.
Telipogon lehmannii Schltr. (Fig. 41)
Telipogon pachyhybos Schltr.
Trichoceros carinifer Schltr.
Xylobium gracile Schltr.

Peru (Fig. 42)

National and regional orchid floras, specific collectors

1914 Schlechter, R. *Orchidaceae.* In Pilger, R. *Plantae Uleanae novae vel minus cognitae.* Notizblatt des Königlichen Botanischen Gartens und Museums zu Berlin, Vol. 6: 120–126.

1921 Schlechter, R. *Die Orchideenfloren der südamerikanischen Kordillerenstaaten. IV. Peru.* Repertorium specierum novarum regni vegetabilis, Beihefte, vol. 9: 1–182.

Specific orchid tribes and subtribes, genera or species

1911 Schlechter, R. *Orchidaceae novae et criticae, Decas XVIII*. Repertorium specierum novarum regni vegetabilis, Vol. 9: 161–166.

1911–1912 Schlechter, R. *Orchidaceae novae et criticae, Decas XIX-XX*. Repertorium specierum novarum regni vegetabilis, Vol. 10: 385–397.

1912 Schlechter, R. 1912. *Neue un seltene Garten-Orchideen V.* Orchis, Mitteilungen des Orchideenausschusses der Deutschen Gartenbau-Gesellschaft, vol. 6: 112–119.

1914 Schlechter, R. *Neue und seltene Gardenorchideen VI.* Orchis, Mitteilungen des Orchideenausschusses der Deutschen Gartenbau-Gesellschaft, vol. 8: 131–137.

1915 Schlechter, R. *Neue und seltene Garten-Orchideen, VIII.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 9: 49–54.
Schlechter, R. *Kleine Mitteilungen.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 9: 56–60.

1916 Schlechter, R. *Neue und seltene Garten-Orchideen, X.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 10: 183–190.

1918 Schlechter, R. *Die Gattung Aganisia Ldl. und ihre Verwandten.* Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 12: 24–42.

1919 Schlechter, R. *Die Gattung Cochlioda Ldl.*. Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 13: 3–10.

Figure 42. Map of Peru and Bolivia, 1855. Colton's Atlas of the World Illustrating Physical and Political Geography, Vol 1, New York.

1920 Schlechter, R. *Versuch einer systematischen Neuordnung der Spiranthinae*. Beihefte zum Botanischen Centralblatt. Zweite Abteilung, Systematik, Pflanzengeographie, angewandte Botanik 37(2): 317"454.

Schlechter's network in Peru (orchid collectors, growers and other purveyors)

- Beyrodt, Otto (1879–1923), orchid grower in Marienfelde, Germany, around 1900–1923.
- Forget, Louis (?–1915), orchid collector for Sander & Sons.Köhler, O. Eugene (?), collected ca. 1900–1906.
- John, Karl Wilhelm (?). Orchid grower in Andernach-on-the Rhine, Germany, around 1910.
- Köhler, Egon (father) (1866–?), Anton and Carl (sons), collected 1910–1919.
- Moore, Frederic William (1857–1949), curator of the Botanic Gardens, Glasnevin, Ireland.
- Serafín, Filomeno (1846–1922), collected ca. 1900–1910.
- Ule, Ernst Heinrich Georg (1854–1915), collected 1893–1912.
- Weberbauer, August (1871–1948), collected 1908–1948
- Wolter, Paul (1862–1942), orchid grower in Magdeburg-Wilhelmsburg.

Orchids described by R. Schlechter from Peru (sometimes ex Kraenzl.)

The following is a list of the orchids described by R. Schlechter as new to science from Peru, as enumerated in the aforementioned bibliography (only basionyms):

New orchid genera

Coccineorchis Schltr.
Neokoehleria Schltr.
Petalocentrum Schltr.
Symphyglossum Schltr.

New orchid species

Aa brevis Schltr.
Aa lechleri Schltr.
Aa pumilio Schltr.
Aa weberbaueri Schltr.
Amblostoma holochilon Schltr.
Batemania wolteriana Schltr.
Brachionidium serratum Schltr.
Brachystele lechleri Schltr.
Brassia filomenoi Schltr.
Brassia koehlerorum Schltr.
Campylocentrum loretoense Schltr.
Catasetum cruciatum Schltr.
Cochlioda beyrodtiana Schltr
Comparettia peruviana Schltr.
Coryanthes bicalcarata Schltr.
Cranichis koehleri Schltr.
Cryptarrhena acrensis Schltr.
Cryptocentrum minus Schltr.
Cyclopogon densiflorus Schltr.
Cyclopogon moyobambae Schltr.
Dipteranthus peruvianus Schltr.
Elleanthus bambusaceus Schltr.
*Elleanthus cajamarca*e Schltr.
Elleanthus caroli Schltr.
Elleanthus conchochhilus Schltr.
Elleanthus gastroglottis Schltr.
Elleanthus igneus Schltr.
Elleanthus koehleri Schltr.
Elleanthus laxifoliatus Schltr.
Elleanthus pallidiflavus Schltr.
Elleanthus porphyrocephalus Schltr.
Epidendrum bambusaceum Schltr.
Epidendrum brevicaule Schltr.
Epidendrum cajamarcae Schltr.
Epidendrum cuzcoense Schltr.
Epidendrum filomenoi Schltr.
Epidendrum fruticulus Schltr.
Epidendrum fuscum Schltr.
Epidendrum gnomus Schltr.
Epidendrum haematanthum Schltr.
Epidendrum huanucoense Schltr.
Epidendrum juninense Schltr.
Epidendrum macrodonax Schltr.
Epidendrum melinoacron Schltr.
Epidendrum nephroglossum Schltr.
Epidendrum oliganthum Schltr.
Epidendrum panicoides Schltr.
Epidendrum patulipetalum Schltr.
Epidendrum platyoon Schltr.
Epidendrum pleurobothrys Schltr.
Epidendrum splendens Schltr.
Epidendrum stenophyton Schltr.
Epidendrum tarmense Schltr.
Epidendrum unifoliatum Schltr.
Epidendrum validum Schltr.
Epidendrum vinosum Schltr.
Epistephium amabile Schltr.
Epistephium macrophyllum Schltr.
Fernandezia pulchra Schltr.
Gomphichis koehleri Schltr.
Gomphichis plantaginea Schltr.
Gongora longipes Schltr.
Gongora nigropunctata Schltr.
Isochilus peruvianus Schltr.
Koellensteinia peruviana Schltr.
Lanium peruvianum Schltr.
Lepanthes juninensis Schltr.
Lepanthes koehleri Schltr.
Lueddemannia vyvereana Schltr.
Lycaste filomenoi Schltr.
Masdevallia purpurina Schltr.
Masdevallia venusta Schltr.
Masdevallia weberbaueri Schltr.
Maxillaria abelei Schltr.
Maxillaria brachypetala Schltr.
Maxillaria calantha Schltr.
Maxillaria fuerstenbergiana Schltr.
Maxillaria koehleri Schltr.

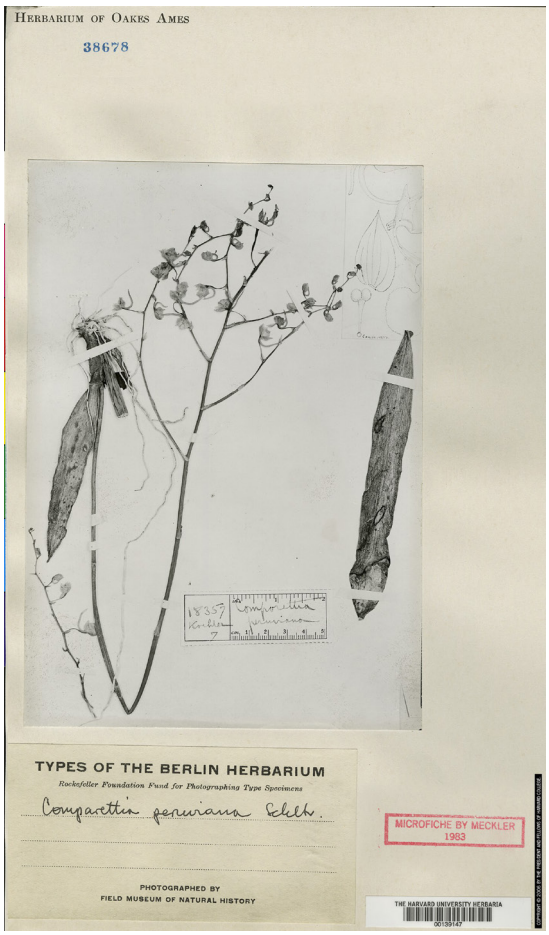


Figure 43. Photograph of type of *Comparettia peruviana* Schltr. Field Museum of Natural History, Chicago.

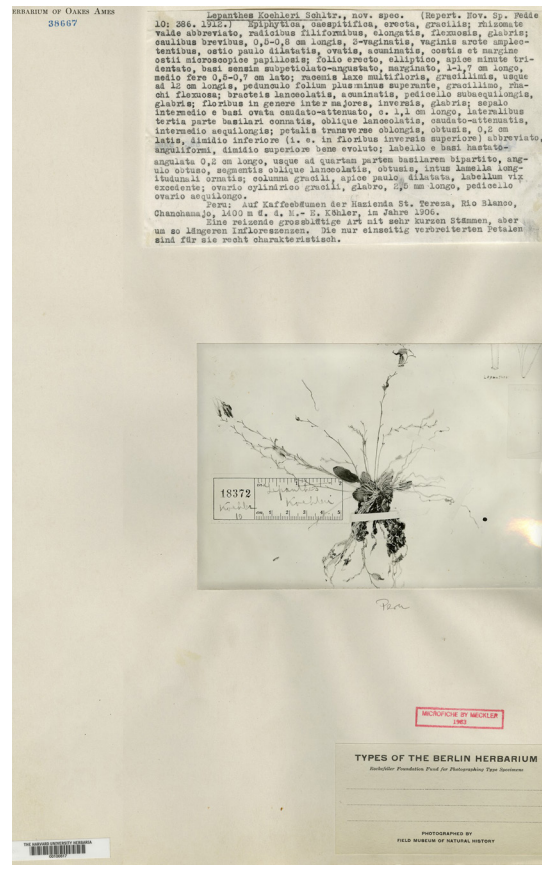


Figure 44. Photograph of the type of *Lepanthes koehleri* Schltr. and Schlechter's original type-written manuscript of the description of the new species. Nr. 38667 - Orchid Herbarium of Oakes Ames.

Maxillaria macropoda Schltr.
Maxillaria playloba Schltr.
Maxillaria weberbaueri Schltr.
Maxillaria xanthorhoda Schltr.
Neokoehleria equitans Schltr.
Neokoehleria peruviana Schltr.
Notylia coffeicola Schltr.
Notylia koehleri Schltr.
Notylia moyobambae Schltr.
Octomeria beyrodtiana Schltr. ex Mansf.
Odonglossum bellum Schltr.
Odonglossum juninense Schltr.
Odonglossum koehleri Schltr.
Odonglossum loesereniaum Schltr.
Odonglossum trilobum Schltr.
Odonglossum weberbauerianum Schltr.
Oncidium cajamarcae Schltr.
Ornithidium dolichophyllum Schltr.
Ornithocephalus longilabris Schltr.
Pachyphyllum breviconnatum Schltr.
Pachyphyllum lycopodioides Schltr.
Pachyphyllum tenue Schltr.
Petalocentrum angustifolium Schltr.
Petalocentrum pusillum Schltr.
Phragmipedium cajamarcae Schltr.
Physurus hetaerioides Schltr.
Physurus stenocentrum Schltr.
Pleurothallis angustilabia Schltr.
Pleurothallis brachyblephara Schltr.
Pleurothallis cajamarcae Schltr.
Pleurothallis chanchamayoensis Schltr.
Pleurothallis divaricans Schltr.
Pleurothallis genychila Schltr.
Pleurothallis graminea Schltr.

Pleurothallis huanucoensis Schltr.
Pleurothallis juninensis Schltr.
Pleurothallis phyllostachys Schltr.
Pleurothallis tricaudata Schltr.
Pleurothallis trimeroglossa Schltr.
Polystachya altilamellata Schltr.
Polystachya poeppigii Schltr.
Ponthieva microglossa Schltr.
Ponthieva oligoneura Schltr.
Ponthieva venusta Schltr.
Ponthieva weberbaueri Schltr.
Pterichis leucoptera Schltr.
Pterichis macroptera Schltr.
Scaphyglottis antonii Schltr.
Scaphyglottis loretoensis Schltr.
Scelochilus brevis Schltr.
Schomburgkia moyobambae Schltr.
Sigmatostalix pusilla Schltr.
Sobralia alstroemerioides Schltr.
Solenidium peruvianum Schltr.
Stelis bicallosa Schltr.
Stelis filomenoi Schltr.
Stelis inversa Schltr.
Stelis koehleri Schltr.
Stelis macra Schltr.
Stelis megistantha Schltr.
Stelis melicoides Schltr.
Stelis nephropetala Schltr.
Stelis phaeantha Schltr.
Stelis piestopus Schltr.
Stelis recurvula Schltr.
Stelis rhizomatosa Schltr.
Stelis rhomboglossa Schltr.
Stelis weberbaueri Schltr.
Stenoptera elata Schltr.
Telipogon gnomus Schltr.
Trigonidium loretoense Schltr.
Trigonidium peruvianum Schltr.
Warrea speciosa Schltr.
Xylobium filomenoi Schltr.

Bolivia (Fig. 42)

National and regional orchid floras, specific collectors

1916 Schlechter, R. *Herzog's bolivianische Pflanzen III. Orchidaceae.* Mededeelingen van's Rijks Herbarium Leiden, No.29, 1916: 57–80.

1922 Schlechter, R. *Die Orchideenfloren der südamerikanischen Kordillerenstaaten. V. Bolivia.* Repertorium specierum novarum regni vegetabilis, Beihefte, vol. 9: 1–80.

1929 R. Schlechter. *II. Orchidaceae Buchtienianae (weitere Beiträge zur Orchideenkunde von Bolivien).* Repertorium specierum novarum regni vegetabilis, Vol. 27: 27–85.

Specific orchid tribes and subtribes, genera or species

1911 Schlechter, R. *Orchidaceae novae et criticae, Decas XXIV*. Repertorium specierum novarum regni vegetabilis, Vol.10: 428–439.

1912–1913 Schlechter, R. *Orchidaceae novae et criticae, Decas XXI-XXII*. Repertorium specierum novarum regni vegetabilis, Vol. 10: 445–491.
Schlechter, R. *Orchidaceae novae et criticae, Decas XXXV*. Repertorium specierum novarum regni vegetabilis, Vol.11: 41–47.

1913 Schlechter, R. *Orchidaceae novae et criticae, Decas XXXIX-XLII*. Repertorium specierum novarum regni vegetabilis, Vol.11: 481–494.

1915 Schlechter, R. *Catasetum wredeanum n. sp.*. Orchis, Monatsschrift der Deutschen Gesellschaft für Orchideenkunde, Vol. 15: 17–20.

1920 Schlechter, R. *Versuch einer systematischen Neuordnung der Spiranthinae*. Beihefte zum Botanischen Centralblatt. Zweite Abteilung, Systematik, Pflanzengeographie, angewandte Botanik 37(2): 317–454.

Schlechter's network in Bolivia (orchid collectors, growers and other purveyors)

- Buchtien, Otto (1859–1946), collected ca. 1893–1036.
- Fiebrig, Karl August Gustav (1879–1951)., collected 1902–1950.

- Günther, Ernst Karl Franz (1870–?), collected 1920s.
- Herzog, Theodor Carl Julius (1880–1961), collected 1907–1912.
- Pflanz, Carl (1872–1925), collected 1907–1925.
- Steinbach, José (1875–1930), collected 1904–1929.
- Williams, Robert Statham (1859–1945), collected 1901–1902.

Orchids described by R. Schlechter from Bolivia

The following is a list of the orchids described by R. Schlechter as new to science from Bolivia, as enumerated in the aforementioned bibliography (only basionyms):

New orchid genera

Beloglottis Schltr.
Buchtienia Schltr.
Solenocentrum Schltr.

New orchid species

Aa chiogena Schltr.
Aa microtidis Schltr.
Aa sphaeroglossa Schltr.
Aa trilobulata Schltr.
Altensteinia fiebrigii Schltr.
Beloglottis boliviensis Schltr.
Bletia mandonii Schltr.
Brassavola multiflora Schltr.
Brassia boliviensis Schltr.
Buchtienia boliviensis Schltr.
Bulbophyllum bolivianum Schltr.
Camaridium flavum Schltr.
Camaridium vagans Schltr.
Campylocentrum apiculatum Schltr.
Catasetum gardneri Schltr.
Catasetum pflanzii Schltr.
Catasetum wredeanum Schltr.
Comparettia splendens Schltr.
Cranichis mandonii Schltr.
Cyclopogon casanaensis Schltr.
Cyrtopodium buchtienii Schltr.
Cyrtopodium pflanzii Schltr.
Dichaea anguina Schltr. (Fig. 45)
Dichaea buchtienii Schltr.
Dichaea longa Schltr.
Dichaea robusta Schltr.
Dichaea stenophylla Schltr.
Elleanthus pallidiflorus
Elleanthus scopula Schltr.
Elleanthus setosus Schltr.
Encyclia buchtienii Schltr.
Encyclia pflanzii Schltr.
Encyclia steinbachii Schltr.
Epidendrum albiflorum Schltr.
Epidendrum alopecurum Schltr.
Epidendrum bolivianum Schltr.
Epidendrum buchtienii Schltr.
Epidendrum coroicoense Schltr.
Epidendrum cuneatum Schltr.
Epidendrum herzogii Schltr.
Epidendrum humidicolum Schltr.
Epidendrum lanioides Schltr.
Epidendrum miguelii Schltr.
Epidendrum nigricans Schltr.
Epidendrum obliquum Schltr.
Epidendrum physophorum Schltr.
Epidendrum quinquepartitum Schltr.
Epidendrum syringodes Schltr.
Epidendrum theodori Schltr.
Epidendrum trichopetalum Schltr.
Galeandra fiebrigii Schltr.
Habenaria bangii Schltr.
Habenaria bermejoensis Schltr.
Habenaria buchtienii Schltr.
Habenaria herzogii Schltr.
Habenaria leptantha Schltr.
Habenaria miguelii Schltr.
Habenaria ottonis Schltr.
Habenaria petrogeiton Schltr.
Habenaria pseudorepens Schltr.
Habenaria subandina Schltr.
Habenaria theodori Schltr.
Habenaria williamsii Schltr.
Habenaria yungasensis Schltr.
Houlletia boliviana Schltr.
Kefersteinia pulchella Schltr.

FIGURE 45. Isoype of *Dichaea anguina* Schltr. and Schlechter's original type-written manuscript of the description of the new species. Nr. 26471 - Orchid Herbarium of Oakes Ames.

Lepanthes rupicola Schltr.
Lepanthes sillarensis Schltr.
Liparis otophyllon Schltr.
Lycaste neglecta Schltr.
Macradenia buchtienii Schltr.
Masdevallia bangii Schltr.
Masdevallia boliviensis Schltr.
Masdevallia brachyantha Schltr.
Masdevallia bradei Schltr. ex Hoehne
Masdevallia buchtienii Schltr. (Fig. 46)
Masdevallia herzogii Schltr.
Masdevallia setipes Schltr.
Masdevallia tubata Schltr.
Masdevallia xanthura Schltr.
Maxillaria boliviensis Schltr.
Maxillaria buchtienii Schltr.
Maxillaria compressibulba Schltr.
Maxillaria dolichophylla Schltr.
Maxillaria fallax Schltr.
Maxillaria gracilipes Schltr.
Maxillaria leucantha Schltr.
Maxillaria ongicaulis Schltr.
Maxillaria oxysepala Schltr.
Maxillaria poifolia Schltr.
Maxillaria simacoana Schltr.
Maxillaria xylobiiflora Schltr.
Microstylis boliviana Schltr.
Microstylis buchtienii Schltr.
Microstylis mixta Schltr.
Microstylis nasuta Schltr.
Microstylis ottonis Schltr.
Microstylis reichenbachiana Schltr.
Microstylis tridentula Schltr.
Neodryas herzogii Schltr.
Notylia boliviensis Schltr.
Notylia buchtienii Schltr.
Octomeria buchtienii Schltr.
Octomeria tenuis Schltr.
Odonglossum rigidum Schltr.
Oncidium bolivianum Schltr.
Oncidium buchtienii Schltr.
Oncidium herzogii Schltr.
Oncidium williamsii Schltr.
Ornithidium bolivianum Schltr.
Ornithidium rhomboglossum Schltr.
Pachyphyllum falcifolium Schltr.
Pachyphyllum herzogii Schltr.
Pachyphyllum minus Schltr.
Pelexia fiebrigii Schltr.
Physosiphon andinum Schltr.
Physosiphon herzogii Schltr.
Physurus anchoriferus Schltr.
Physurus buchtienii Schltr.
Physurus herzogii Schltr.
Pleurothallis amblyopetala Schltr.
Pleurothallis boliviana Schltr.
Pleurothallis buchtienii Schltr.
Pleurothallis bulbophylloides Schltr.
Pleurothallis coffeicola Schltr.
Pleurothallis dolichocaulon Schltr.
Pleurothallis frutex Schltr.
Pleurothallis guentheri Schltr.
Pleurothallis herpethophyton Schltr.
Pleurothallis herzogii Schltr.
Pleurothallis ottonis Schltr.
Pleurothallis papuligera Schltr.
Pleurothallis rhopalocarpa Schltr.
Pleurothallis sanjanae Schltr.
Pleurothallis scleropus Schltr.
Pleurothallis simacoana Schltr.
Pleurothallis spathata Schltr.
Pleurothallis tenuiflora Schltr.
Pleurothallis triptera Schltr.
Pleurothallis tripterocarpa Schltr.
Pleurothallis triquetra Schltr.
Pleurothallis umbraticola Schltr.
Pleurothallis yungasensis Schltr.
Polystachya boliviensis Schltr.
Polystachya simacoana Schltr.
Ponthieva elegans Schltr.
Pterichis boliviana Schltr.
Pterichis saxicola Schltr.
Pterichis silvestris Schltr.
Pterichis yungasensis Schltr.
Sarcoglottis herzogii Schltr.
Scaphyglottis boliviana Schltr.
Sobralia boliviensis Schltr.
Sobralia buchtienii Schltr.
Sobralia caloglossa Schltr.
Sobralia fructicetorum Schltr.
Sobralia herzogii Schltr.
Spiranthes goodyeroides Schltr.
Stelis atrobrunnea Schltr.
Stelis buchtienii Schltr.
Stelis casanaensis Schltr.
Stelis lexa Schltr.

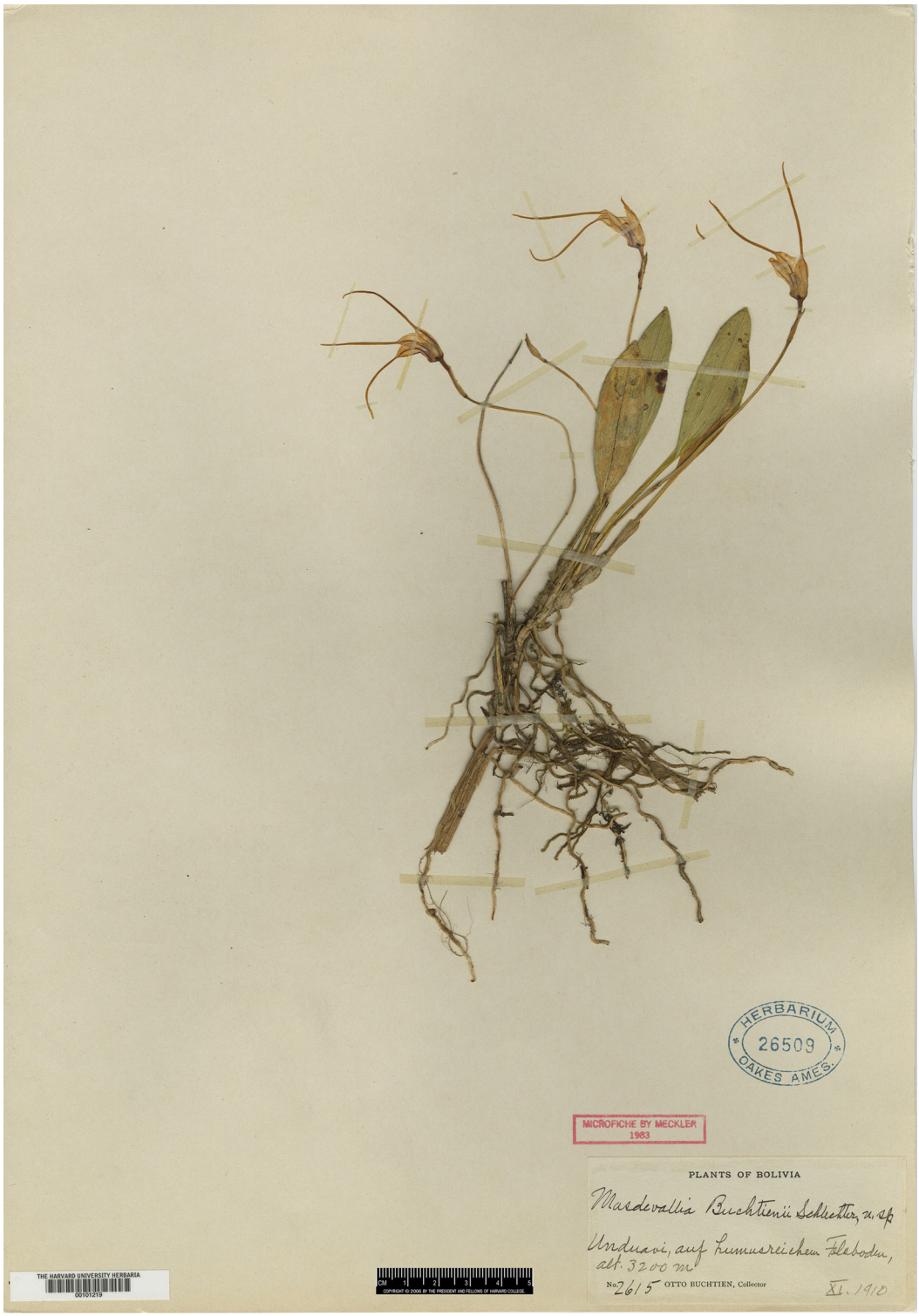


FIGURE 46. Isotype of *Masdevallia buchtienii* Schltr. Nr. 26509 - Orchid Herbarium of Oakes Ames.

Stelis herzogii Schltr.
Stelis heterosepala Schltr.
Stelis laxa Schltr.
Stelis mandoniana Schltr.
Stelis microtathanta Schltr.
Stelis naviculigera Schltr.
Stelis ottonis Schltr.
Stelis phaeomelana Schltr.
Stelis polycarpa Schltr.
Stelis saxicola Schltr.
Stelis simacoensis Schltr.
Stelis trianguliflora Schltr.
Stelis vagans Schltr.
Stelis virens Schltr.
Stelis xanthantha Schltr.
Stelis yungasensis Schltr.
Stenoptera plantaginea Schltr.
Trizeuxis andina Schltr.
Xylobium flavescens Schltr.
Xylobium latifolium Schltr.
Zygopetalum bolivianum Schltr.

Chile (Fig. 47)

With the exception of a few articles on the climate of the orchid-rich countries of the sub-continent, Schlechter did not publish anything on the orchids of Chile. The reason, as he states in the prologue to his last volume on the orchid-floras of the Andean countries (V. Bolivia, 1922) was the appearance in 1910 of Karl Reiche's *Orchidaceae Chilenses, ensayo de una monografía de las Orquideas de Chile*[12], under the assumption that not many novelties could be expected in the short period of time elapsed since its publication.

However, in his Monograph on the Spiranthinae (1920) Schlechter published a new combination: *Brachystele unilateralis* (Por.) Schltr.

[12] Reiche, K. 1910. *Orchidaceae Chilenses, ensayo de una monographia de las Orquideas de Chile.* Anales del Museo Nacional de Chile, vol. 18.

Argentina (Fig. 47)

Specific orchid tribes and subtribes, genera or species

1917–1919 Schlechter, R. *Orchidaceae novae et criticae, Decas LIV*. Repertorium specierum novarum regni vegetabilis, Vol.15: 210–217.
Schlechter, R. *Orchidaceae novae et criticae, Decas LXV*. Repertorium specierum novarum regni vegetabilis., Vol. 16: 353–358.

1920 Schlechter, R. *Versuch einer systematischen Neuordnung der Spiranthinae*. Beihefte zum Botanischen Centralblatt. Zweite Abteilung, Systematik, Pflanzengeographie, angewandte Botanik 37(2): 317–454.

Schlechter's network in Argentina (orchid collectors, growers and other purveyors)

- Hieronymus, Georg Hans Emmo (1845–1921), collected 1872–1883.
- Wendt, H. (?), collected 1907–1912.

Orchids described by R. Schlechter from Argentina

The following is a list of the orchids described by R. Schlechter as new to science from Argentina, as enumerated in the aforementioned bibliography (only basionyms):

New orchid genera

Pteroglossa Schltr.

New orchid species

Aa achalensis Schltr.
Aa lorentzii Schltr.
Aa schickendanzii Schltr.
Chloraea reticulata Schltr.

FIGURE 47. Map of Chile, Argentina, Paraguay & Uruguay by Pablo Ludwig, 1914.

Paraguay (Fig. 47)

Specific orchid tribes and subtribes, genera or species

1910–1911 Schlechter, R. *Orchidaceae novae et criticae, Decas XVI-XVII*. Repertorium specierum novarum regni vegetabilis, Vol.10: 21–32.

1917–1919 Schlechter, R. *Orchidaceae novae et criticae, Decas LXV*. Repertorium specierum novarum regni vegetabilis., Vol. 16: 353–358.

1920 Schlechter, R. *Versuch einer systematischen Neuordnung der Spiranthinae*. Beihefte zum Botanischen Centralblatt. Zweite Abteilung, Systematik, Pflanzengeographie, angewandte Botanik 37(2): 317–454.

1925 Schlechter. R. *Orchidaceae novae et criticae, Decas LXXVIII-LXXIX*. Repertorium specierum novarum regni vegetabilis, Vol. 21: 330–343.

Schlechter's network in Paraguay (orchid collectors, growers and other purveyors)

- Fiebrig, Karl August Gustav (1879–1951), collected 1902–1950.
- Hassler, Emil (1864–1937), collected 1895–1909, 1914, 1920–1937.
- Rojas Vera, Teodoro (1877–1954), collected 1907–1944.
- Wendt, H. (?), collected 1907–1912.

Orchids described by R. Schlechter from Paraguay

The following is a list of the orchids described by R. Schlechter as new to science from Paraguay, as enumerated in the aforementioned bibliography (only basionyms):

New orchid species

Habenaria amambayensis Schltr.
Habenaria deistelii
Habenaria fiebrigii Schltr.
Habenaria schindleri
Oncidium emilii Schltr.
Oncidium minutiflorum Schltr.
Oncidium ostenianum Schltr. (Fig. 48)
Ponthieva hassleri Schltr.

Uruguay (Fig. 47)

The only mention to orchids from Uruguay in Schlechter's publiactions are new combinations in the genus *Brachystele*, which he published in his monograph on the Spiranthinae (1920): *B. arechavaletae* (Kränzl.) Schltr., *B. camporum* (Lindl.) Schltr. and *B. dilatata* (Lindl.) Schltr.

Additional literature

Ames, O. (1944). Destruction of the Schlechter Herbarium by Bombing. *American Orchid Society Bulletin*, 13(4).
Ames, O. (1979). *Jottings of a Harvard botanist.* Botanical Museum of Harvard University. Cambridge, Massachusetts.
Cribb, P. (2010). The life and travels of Friedrich Carl Lehmann. *Lankesteriana,* 10(2–3), 9–30.
Fibeck, W. (2012–2014). Rudolf Schlechter (1872–1925). Leben und Wirken einer Orchideologenlegende. *Orchideenjournal*, 19(1), 119–127 (Part 1); 19(4), 163–170 (Part 2); 20(2), 71–81 (Part 3); 20(4), 161–169 (Part 4); 21(2), 59–68 (Part 5).
Fibeck, W. (2015). "Es gibt noch viel zu tun." Zum 90. Todestag von Rudolf Schlechter. *Orchideenjournal* 22(4), 145–147.
Field Museum of Natural History (2018). Berlin negatives. Retrieved at https://www.fieldmuseum.org/node/5186.
Harvard University (2018a). Correspondence files of the Oakes Ames Orchid Herbarium. 1909–1960. *Correspondence between Oakes Ames, Rudolf Schlechter and Alexandra Schlechter*.
Harvard University (2018b). Correspondence files of the Oakes Ames Orchid Herbarium. 1921–1924. *Correspondence between Oakes Ames and Charles W. Powell*.

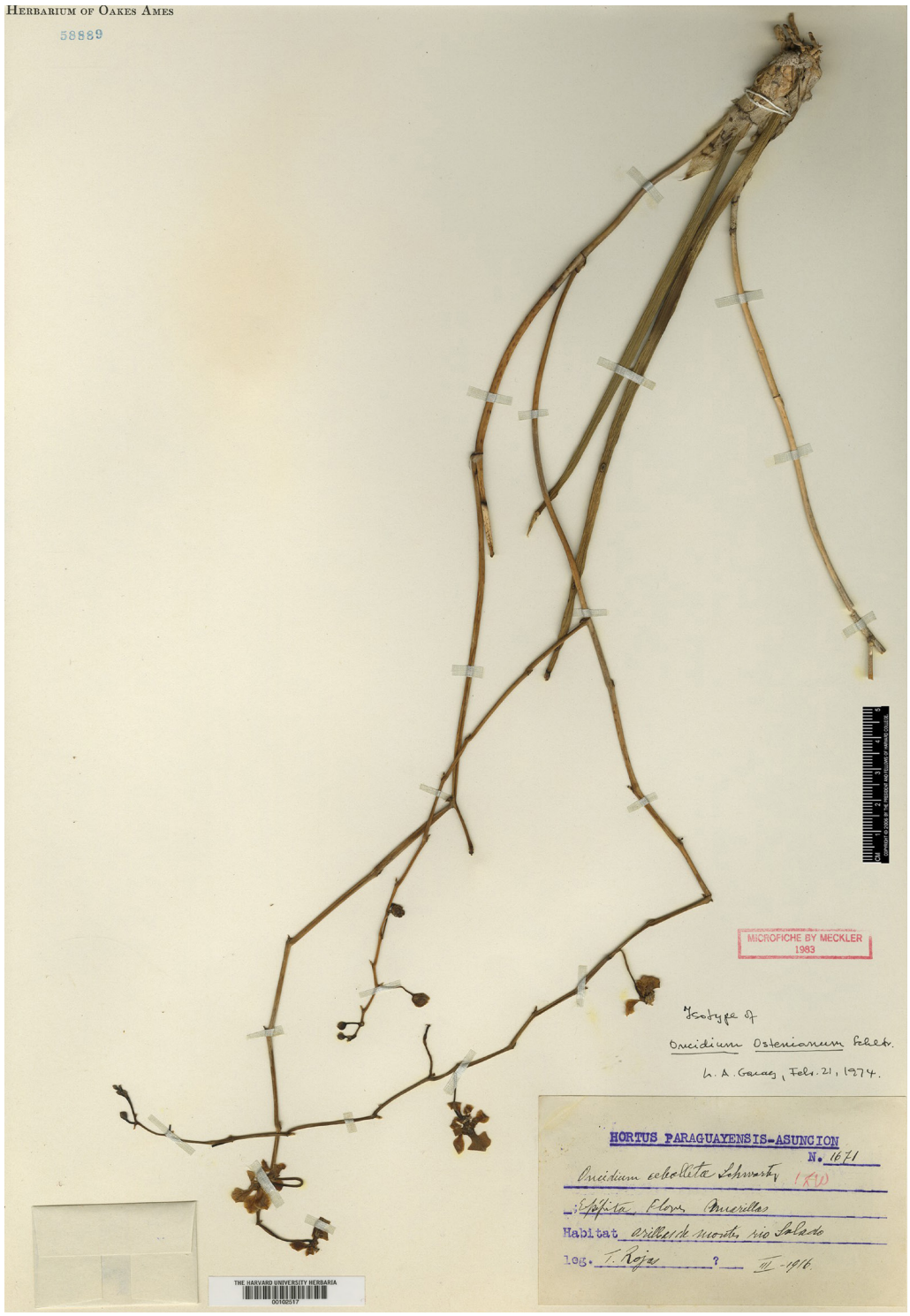


FIGURE 48. Isotype of *Oncidium ostenianum* Schltr.collected by T. Rojas in Paraguay. Nr. 58889 – Orchid Herbarium of Oakes Ames.

Harvard University (2018c). Correspondence files of the Oakes Ames Orchid Herbarium. 1922–1962. *Correspondence between Oakes Ames and Charles H. Lankester.*

Kew Botanic Gardens (2019). International Plant Names Index. Retrieved at https://www.ipni.org/

Loesener, T. (1926). Rudolf Schlechters Leben und Wirken. *Notizblatt des Botanischen Gartens und Museums Berlin-Dahlem*, 9(80), 912–958.

Morales, C. (2006). Cien años de la Sociedad Alemana de Orquideología (1906–2006). *Lankesteriana*, 6(3), 91–94.

Natural History Museum (2013). Schlechter, Friedrich Richard Rudolf (1872–1925). Retrieved at JStor.

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

Reinikka, M. A. (1995). *A History of the Orchid.* Timber Press, Portland, Oregon.

Schultz, M. (2013). The Orchid Types of the Herbarium Hamburgense (HBG). *Verhandlungen des Naturwissenschaftlichen Vereins in Hamburg*, 47, 5–145.

Schonland, S. (1897). *Report of the Committee of the Albany Museum*. Grahamstown, South Africa.

Senghas, K. (2002). *Leben und Wirken von Rudolf Schlechter. In Bibliographie der Orchideen-kunde und Rudolf Schlechter, Biographie / Bibliography of Orchidology and Rudolf Schlechter, Biography*. Sonderabdruck aus Schlechter, Die Orchideen. 3. Auflage, Band I, Literatur- und Registerband. Berlin, Parey Buchverlag. S. v–xi, 1–146.

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  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).
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  4. More than six authors: Nobody *et al.* (1991) or (Nobody *et al.* 1991).
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- 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.
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- Abbreviate units of measurements without a period, e.g., km, mm, ft, mi, and so forth; temperatures are as follows: 20°C.
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  5. Journal article: Nobody, A. B. (1991). The effect of light on growth. *Title of Journal*, 3(1), 15–20. doi: insert DOI when it is available.
  6. Manuscripts accepted for publication but not yet published: Nobody, A. B. (In press). Name of the journal or publisher. The name of the journal where the paper was accepted must be indicated, the volume number should be included if known.
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