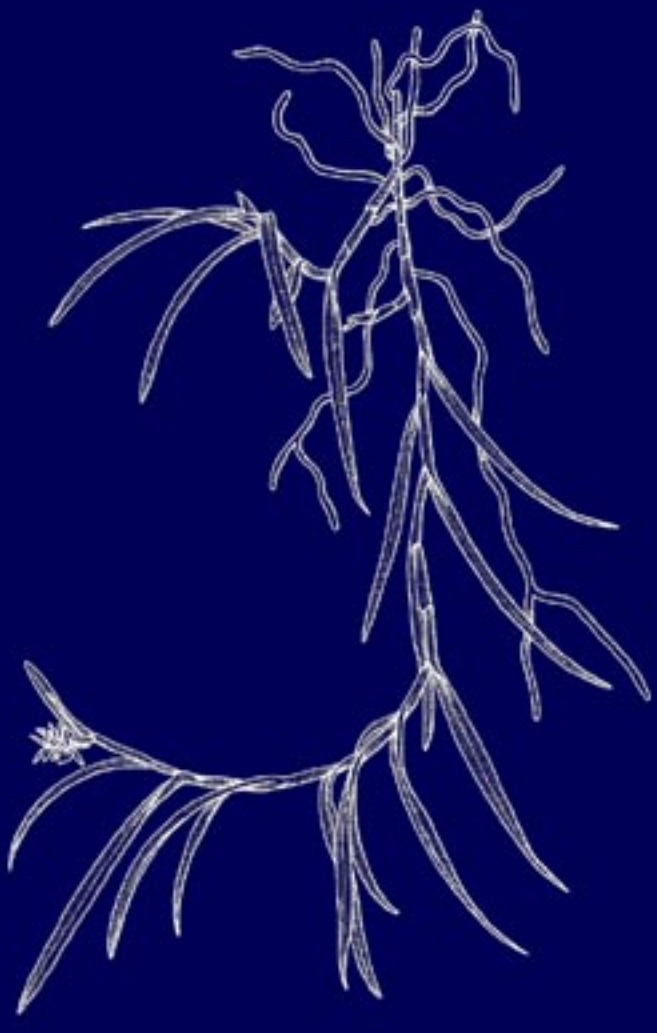
ISSN 1409-3871

LANKESTERIANA

VOL. 8, NO. 2 AUGUST, 2008



THE INTERNATIONAL JOURNAL ON ORCHIDOLOGY

ISSN 1409-3871

LANKESTERIANA

VOL. 8, No. 2 AUGUST 2008

THE INTERNATIONAL JOURNAL ON ORCHIDOLOGY

LANKESTERIANA

THE INTERNATIONAL JOURNAL ON ORCHIDOLOGY

Effective publication date: August 29, 2008

Layout: Jardín Botánico Lankester.
Cover: Plant of *Epidendrum zunigae* Hágsater, Karremans & Bogarín. Drawing by D. Bogarín.
Printer: Litografía Ediciones Sanabria S.A.
Printed copies: 500

Printed in Costa Rica / Impreso en Costa Rica

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

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

LANKESTERIANA 8(2): 23-31. 2008.

CAPSULE DEVELOPMENT, *IN VITRO* GERMINATION AND PLANTLET ACCLIMATIZATION IN *PHRAGMIPEDIUM HUMBOLDTII, P. LONGIFOLIUM* AND *P. PEARCEI*

MELANIA MUÑOZ[1] & VÍCTOR M. JIMÉNEZ[2]

CIGRAS, Universidad de Costa Rica, 2060 San Pedro, Costa Rica
Jardín Botánico Lankester, Universidad de Costa Rica, P.O. Box 1031, 7050 Cartago, Costa Rica
[1]melaniamunozg@yahoo.com; [2]victor.jimenez@ucr.ac.cr

ABSTRACT. Capsule development from pollination to full ripeness was evaluated in *Phragmipedium longifolium*, *P. pearcei* and *P. humboldtii*. Besides, seed viability, analyzed in each capsule by means of the tetrazolium chloride staining, was determined. Considering seed viability, germination rate was corrected and expressed as the rate of viable seeds that germinated in the presence and absence of light, on Knudson C and on half-strength Murashige and Skoog culture media. Capsule length remained constant during the evaluation period, while the diameter increased during the first 6-8 weeks and then stagnated. Capsule opening occurred 16 weeks after pollination in *P. longifolium*, after 9.8 weeks in *P. pearcei* and after 32 weeks in *P. humboldtii*. Seed viability averaged 44.7% in *P. longifolium*, 82.3% in *P. pearcei* and 34.3% in *P. humboldtii*. No significant effect of light conditions was evident in any of the species. However, a higher proportion of seeds of *P. longifolium* and *P. pearcei* germinated earlier on half-strength Murashige and Skoog medium than on Knudson C. Only 2.9% of the viable seeds of *P. humboldtii* germinated, while approximately 40% germination occurred in the other two species. Initial growth of the embryos was better in the dark on Knudson C medium, compared to the other treatments studied. Further growth of the seedlings took place under light conditions. Developed plants formed roots and were successfully acclimatized in the greenhouse.

KEY WORDS: capsule development, *in vitro* seed germination, pollination, *Phragmipedium*, terrestrial orchids, tetrazolium chloride, tropical orchids

Introduction

Slipper orchids belonging to the genus *Phragmipedium* (Subfamily Cypripedioideae Lindl.) are distributed in Meso and South America (Cox *et al.* 1998, Dressler 2003). They are seriously threatened because of alteration and destruction of their habitat and over collection from their natural environment (Arditti 1992, Salazar 1996).

Use of *in vitro* protocols has been foreseen as a successful approach for ex-situ conservation and reintroduction of endangered orchids (Stenberg and Kane 1998, Decruse *et al.* 2003, Sarasan *et al.* 2006). Plants regenerated from seeds have a broader genetic background than those developed by clonal propagation methods. Therefore, the former meet the goals of a reintroduction program better, in the sense of warranting sufficient genetic resources in the reintroduced population to undergo adaptive evolutionary change (Guerrant and Kaye 2007).

This strategy has been successfully employed for the reintroduction of the orchid species *Bletia urbana* (Rubluo *et al.* 1989), *Ipsea malabarica* (Gangaprasad *et al.* 1999) and *Spiranthes brevilabris* (Steward *et al.* 2003). An additional advantage of mass-propagating orchids for conservation purposes is that increasing availability of plants from preferred species with adequate phytosanitary standards and at affordable prices would reduce illegal collection from the wild populations (Ramsay and Dixon 2003, Salazar and Mata 2003).

Propagation of *Phragmipedium* through seeds does not seem to be extremely difficult, because commercial formulations for asymbiotic germination in this genus are available. However, the composition

of the culture media has remained elusive to the scientific community for commercial reasons. Most research on this and related genera is limited to studies on systematics and evolution (e.g., Cox *et al.* 1997, 1998). Investigations on phenology in this genus, describing characteristics of seed capsules and their development, are scarce (Arditti and Ghani 2000).

When proper conditions for germination are to be assessed, it is important to know the viability of the seeds under study. This allows distinguishing the proportion of seeds that do not germinate as a consequence of unfavorable germination conditions from those seeds that are not capable of germinating at all due to lack in viability. The most common method used to evaluate seed viability is the tetrazolium ($C_{19}H_{15}ClN_4$) stain. Dehydrogenases, which are active in living tissues, reduce the colorless tetrazolium chloride to a red compound, coloring viable seeds. The intensity of the tint could vary from pink to dark red (Singh 1981). This technique has been successfully used to test viability of orchid seeds (Lauzer *et al.* 1994, Vujanovic *et al.* 2000).

The aims of this study were to describe the development of *P. humboldtii, P. longifolium*, and *P. pearcei* capsules, to evaluate the seed viability and to establish a method for *in vitro* germination of mature seeds and for growing and acclimatizing plantlets of these three *Phragmipedium* species aiming at conservation.

Materials and methods

Pollination of flowers and capsule development. — Manual pollination of flowers of *Phragmipedium humboldtii, P. longifolium*, and *P. pearcei*, growing at Lankester Botanical Garden, Universidad de Costa Rica, was conducted using pollen from a different plant. Capsule length, diameter and color were evaluated weekly, until full maturity. The time taken for each capsule to open was also recorded.

Seed viability. — The percentage of viable seeds was determined in each ripe capsule using the method of tetrazolium stain (Singh 1981). For that purpose, four subsamples of each of the two *P. humboldtii,* one *P. longifolium,* and four *P. pearcei* capsules were placed in tetrazolium chloride (1%, pH 6-7), in a water bath (30°C) and in dark conditions for 24 h. Subsequently, they were transferred to Petri dishes and the percentage of viable (stained) seeds was determined with aid of a stereomicroscope (model 222279, Nikon). Seeds from the corresponding capsules were used in the germination studies.

In vitro *germination*. — Seeds from open capsules were sterilized in sodium hypochlorite (NaOCl, 0.6% w/v) and Tween 20 (1 drop/100 ml) for 10 min. They were subsequently screened through sterile Albet ® filter paper (quantitative quality), in the laminar hood. They were then rinsed three times with sterile distilled water, while adhered to the filter paper and, after decanting the water of the last rinse, distributed evenly, with a scalpel (blade No. 22) on 20 ml of semisolid culture medium contained in 90 mm-Petri dishes.

Knudson C (Knudson 1946) and half-strength Murashige and Skoog (1962) mineral salts, both supplemented with 1 mg l^{-1} thiamine, nicotinic acid and pyridoxine, together with 20 g l^{-1} sucrose, were compared for seed germination. pH was adjusted to 5.7 and media gelled with agar (0.8%). Media were autoclaved at 1.05 kg cm^{-2} for 25 min.

Additionally, two light regimes were evaluated during germination: dark conditions and photoperiod of 12 hours (10.9 µmol m^{-2} s^{-1}, Sylvania Supersaver Cool White, 32 W, F48%12/CW/SS). Cultures were grown at 25±1°C.

To determine the percentage of germination, three squares, of 1 cm^2 each, were drawn in each Petri dish. Areas of the Petri dishes in which individual seeds could be clearly observed using a stereomicroscope were selected to draw the squares. Total number of seeds in each section was counted at the first day of culture. Afterwards, the number of germinating seeds (those in which rupture of the testa occurred by the enlarging embryo) was assessed weekly. Three Petri dishes were evaluated for every combination of culture medium, light condition and species. Considering seed viability, germination rate was corrected and expressed as the rate of viable seeds that germinated in each treatment. For example, if 50% of the seeds of a capsule with a 50% germination rate, according to the tetrazolium test, germinated on culture medium, it was considered that 100% of the

viable seeds germinated. Besides, the percentage of dead protocorms (those that turned brown after germination) was calculated.

Protocorms growing in the dark were transferred to the same light conditions of the other treatment after six weeks of culture. Growing protocorms were subcultured every six weeks on the corresponding culture medium. Only actively growing and green protocorms were selected and individually subcultured. When the plantlets reached 1 cm in height, they were transferred into glass flasks (150 ml), eight plants per flask. Later on, when they were 2-3 cm tall, only five plants were cultured per flask.

Plants were acclimatized approximately 15 months after culture beginning, when they were 4-5 cm tall and had 2-3 roots around 1 cm in length. For that purpose, all remnants of the gelled culture medium were carefully removed from the roots with running water. One plant was potted per plastic container (3 x 3 x 4 cm), carefully covering the roots completely with the potting mix (peat moss). Plants were placed under mist irrigation (4 s watering every 15 min during the daylight hours). After six months in the greenhouse, the average number of roots and the size of the longest root were annotated.

Statistical analysis. — Capsule length and diameter, as well as the effect of culture medium and light conditions on germination for each species were analyzed with a multivariate test of significance (for repeated measures). Days needed for full maturity were compared between genotypes with an analysis of variance. Subsequently, the Post hoc Tukey's Honest-Significant-Difference-Test (HSD) for unequal N (Spjotvoll/Stoline) was used to determine significant differences in the parameters tested ($p<0.05$). All analyses were conducted using Statistica 6.1 (StatSoft Inc., Tulsa, Oklahoma, U.S.A.).

Results

Pollination of flowers and capsule development. — Blooming was observed in plants of *P. longifolium* and *P. pearcei* during the entire year, while *P. humboldtii* plants bloomed only in May and June. All manual-pollinated flowers (three of *P. humboldtii,* nine of *P. longifolium* and 16 of *P. pearcei*) developed capsules.

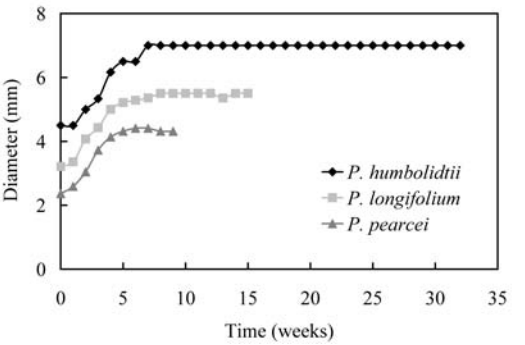


Figure 1. Diameter measured in capsules of *P. humboldtii, P. longifolium* and *P. pearcei* during development.

Capsule development, from pollination to opening, took longer in *P. humboldtii* (32±0.6 weeks), than in *P. longifolium* and *P. pearcei* (16±2.05 and 9.8±0.6 weeks, respectively).

Significant differences ($p<0.001$) were measured in the capsule size of the three species (Fig 1). Largest capsules were those of *P. humboldtii*, with an average length of 182.7±3.2 mm and a diameter of 7.0±0.2 mm one week before opening. Capsules of *P. longifolium* were 60.02±2.0 mm in length and 5.6±0.1 mm in diameter, while those of *P. pearcei* were 42.5±1.4 mm in length and 4.2±0.1 mm in diameter at the same moment (Fig. 1). During development, length of the capsules did not vary in any of the species studied ($p>0.05$), while diameter increased during the first 6-8 weeks after pollination and then remained constant (Fig 1).

Capsules of *P. humboldtii* were light green and pubescent (Fig. 2A), while those of *P. longifolium* were dark purple without pubescence (Fig. 2B); capsules of *P. pearcei* were green-purple or totally purple, with short hairs (Fig. 2C). The capsules did not present notable changes in color or pubescence degree during maturation, except for those of *P. humboldtii,* which turned yellow 4-6 weeks before opening.

Seed viability. — A great difference in seed viability was observed between *P. pearcei* and the other species (Fig. 3). Average seed viability in the capsules of *P. humboldtii* was 34.3%, in *P. longifolium* 44.7% and in *P. pearcei* 82.3%. When the seed viability among different capsules of a single species was compared, values ranging from 20 to 80% were observed in *P. pearcei* and from 18 to 51% in *P. humboldtii*.

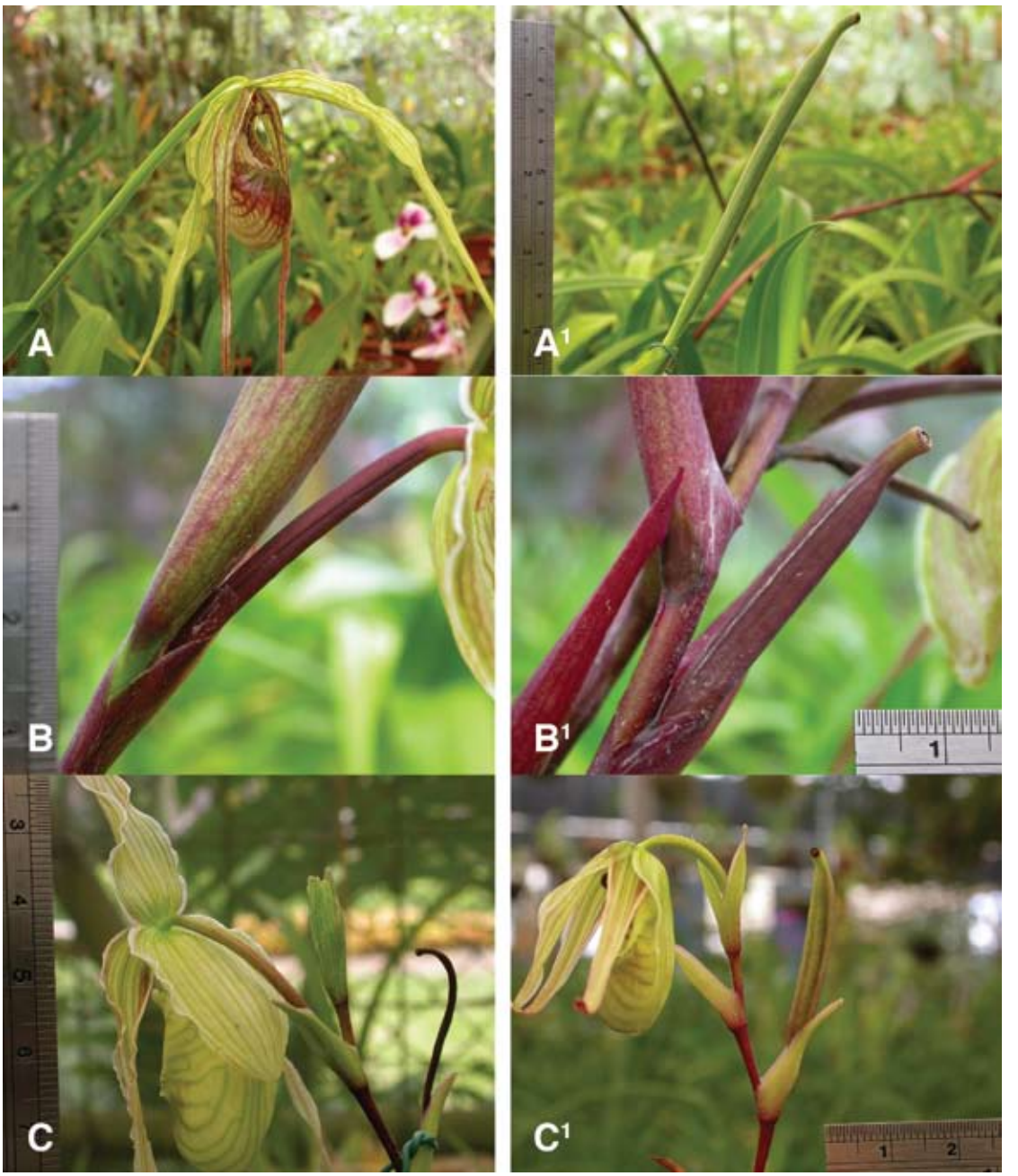


FIGURE 2. Development of capsules of *P. humboldtii* (A, A[1]), *P. longifolium* (B , B[1]) and *P. pearcei* (C , C[1]) at pollination day (left) and one week before capsule opening (right).

In vitro germination. — In order to consider only the viable seeds when calculating germination rate, percentage of seeds that germinated in the culture medium was corrected with the rate of viable seed measured for each capsule, as described in Materials and Methods. The corrected percentage of germination was lower in *P. humboldtii* (2.9%) than in *P. pearcei* (38.7%) and *P. longifolium* (41.3%), without significant differences between the last two (Fig. 3). Developing protocorms that subsequently died were observed only in *P. pearcei* (Fig. 3).

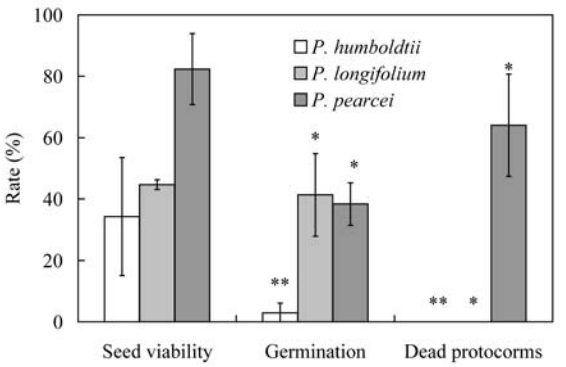


Figure 3. Seed viability, germination rate corrected with the percentage of seed viability of each capsule and death rate of germinated seeds in *P. humboldtii, P. longifolium* and *P. pearcei.* Data represent the mean of at least three replicates ± SD. *Four weeks after sowing. **Eight weeks after sowing.

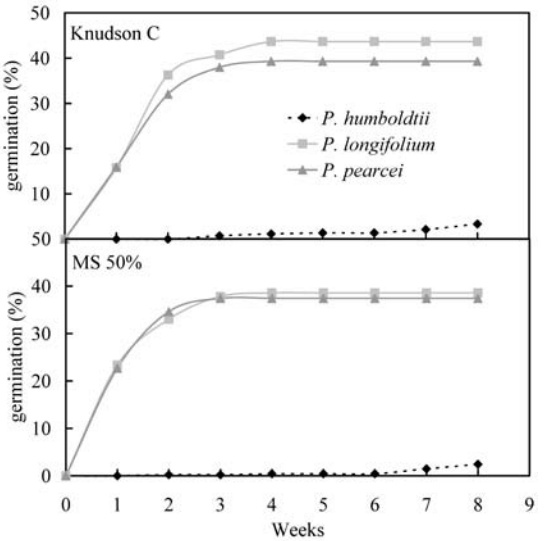


Figure 4. Germination rate in seeds of *P. humboldtii, P. longifolium* and *P. pearcei* along time on Knudson C and half-strength Murashige and Skoog media (MS 50%).

Viable seeds of *P. longifolium* and *P. pearcei* started geminating during the first two weeks of culture. Afterwards, the germination rate decreased until, at week four, no additional germinating seeds were observed. On the other hand, germination in *P. humboldtii* occurred in a very low rate, with only a slight increase during the evaluated period of eight weeks (Fig. 4).

Culture medium had a significant effect on seed germination (Table 1), evident in *P. longifolium* and *P. pearcei* only during the first week by a higher germination rate on half-strength Murashige and Skoog medium. Thereafter, seed germination in these two species behaved very similarly (Fig. 4), without significant differences according to the Post-Hoc Tukey's Honest-Significant-Difference-Test (HSD) for unequal N (Spjotvoll/Stoline).

No effect of the light conditions tested could be observed on seed germination in any of the evaluated species ($p>0.05$) as presented in Table 1. However, among the protocorms cultured on the Knudson C medium, a higher growth rate was observed afterwards in those germinated under dark conditions. The protocorms germinated in the dark were placed under a photoperiod of 12 hours of light after six weeks of culture, and one week later they began to change their color from white to green. By that time,

Table 1. Multivariate test of significance of seed germination corrected with the viability rate for each capsule of the three *Phragmipedium* species studied in response to culture medium and light conditions.

Source of variation	Test	Value	F	Effect df	Error df	p
Intercept	Wilks	0.031021	226.4653	4	29	0.000000
Species (A)	Wilks	0.038002	29.9406	8	58	0.000000
Culture medium (B)	Wilks	0.451880	8.7941	4	29	0.000089
Light conditions (C)	Wilks	0.757612	2.3195	4	29	0.080649
A×B	Wilks	0.469325	3.3328	8	58	0.003338
A×C	Wilks	0.421866	3.9122	8	58	0.000948
B×C	Wilks	0.691800	3.2299	4	29	0.026159
A×B×C	Wilks	0.454910	3.4992	8	58	0.002320

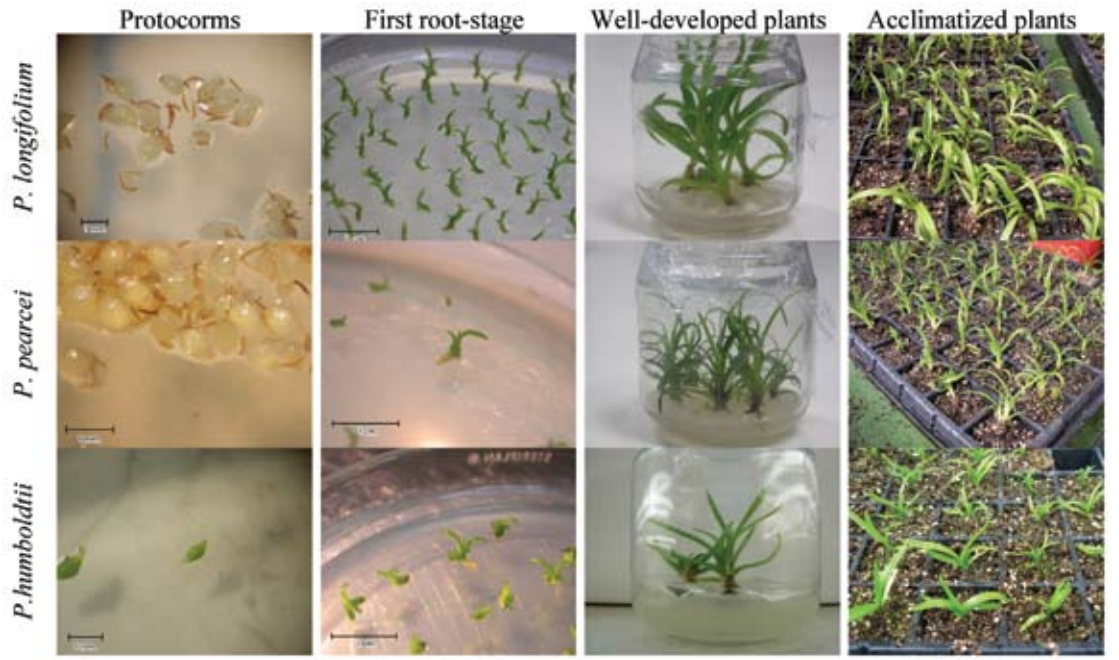


FIGURE 5. Stages during *in vitro* development of *P. pearcei, P. longifolium* and *P. humboldtii* cultured on MS 50%.

the protocorms of *P. pearcei* and *P. longifolium* began to develop the first leaf. On the other hand, the first leaf of *P. humboldtii* appeared in the eighth week of culture. The seedlings of *P. pearcei* and *P. longifolium* developed two or more leaves within the first three months, and began to develop roots in 3.5 months (Fig. 5). The plantlets of *P. humboldtii* developed their leaves in three months too, but began to develop roots only after five months in culture (Fig 5). Higher growth rate and better leaf development was observed with Knudson C (data not shown).

All plants were successfully acclimatized after ca. 15 months of culture *in vitro* (Fig. 5). After six months in the greenhouse, each plant of *P. pearcei* had 7.3±2.5 roots, with the longest one measuring 10.4±1.7 cm in length. At the same moment, the plants of *P. longifolium* had 3.6±0.9 roots, the longest one with 11.7±3.5 cm.

Discussion

The time it takes an orchid capsule to reach full-maturity varies according to genus and species. Times registered in this work for *P. pearcei, P. longifolium* and *P. humboldtii* (10, 16 and 32 weeks, respectively) were considerably shorter than those measured in other species belonging to the Cypripedioideae subfamily. For example, *Paphiopedilum callosum* capsules required between 47 and 48 weeks to open (Arditti 1992). Moreover, it is not unusual to observe differences in this respect between species belonging to the same genus. For example, while capsules of *Laelia gouldiana* needed 17 weeks to open, those of *L. purpurata* required 31 weeks. Similarly, in *Dendrobium kingianum* the time until full ripeness was 20 weeks, while in *D. nobile* it was 41 weeks (Arditti 1992).

Capsule development in the three *Phragmipedium* species studied characterized by an initial growing period of around eight weeks, followed by a maturation period in which the fruit did not increase in size until opening (Fig. 1). This growing pattern is commonly observed in many fruits. It is characterized by a sigmoid arrangement, in which cell division and elongation initially occur, followed by growth halt and finally the fruit reaches maturity (Agustí 2000). Those phases could vary in duration, depending on the species or genotype, as it was observed in the three *Phragmipedium* species studied here.

Knowing the time the capsule of a particular orchid species requires until full maturity is very useful to determine proper harvesting time for *in vitro* germination. Ripe capsules usually have larger amounts of viable seeds than unripe ones. Moreover, collecting seeds after capsule opening usually reduces success during *in vitro* establishment due to contamination problems and damage caused by the sterilization process, and should be avoided when possible.

Seed viability measured in *Phragmipedium* (Fig. 3) is similar to that observed in other terrestrial orchids. For example, the seed viability of *Cypripedium acaule* varied from 20% to 40% in the capsules studied by Lauzer *et al.* (1994), and the viability of *Calopogon tuberosus* was 35% in the study conducted by Kauth *et al.* (2006). High values, as measured in *P. pearcei* in this study, have been observed in mature capsules of *Ophrys* (Kitsaki *et al.* 2004). Given that seed viability can vary significantly among capsules within the same species (up to 60%, as observed in *P. pearcei*), it is important to evaluate viability in each capsule. This is necessary to assess the real effect of particular conditions on seed germination based on the actual amount of viable seeds per capsule.

The seeds of *P. pearcei* and *P. longifolium* germinated faster (2-3 weeks) (Fig. 4) than those of several terrestrial orchids. Henrich *et al.* (1981) showed that 7-12 weeks were necessary for the beginning of germination in 17 terrestrial orchid species. In the study of Shiau *et al.* (2002), the seeds of *Anoectochilus formosanus* germinated eight weeks after sowing. On the other hand, there are other terrestrial orchids that germinate faster, as in the case of *C. tuberosus,* whose seeds germinated one week after sowing and reached the maximum germination in 4-6 weeks (Kauth *et al.* 2006).

The percentage of germination in terrestrial orchids varies among species. Henrich *et al.* (1981) found 100% germination in *Orchis fucssi* and *Epipactis gigantea*, 75% in *Goodyera oblongifolia* and *Spiranthes romanzoffiana*, 50% in *Platanthera stricta* and *Orchis macula*, and 25% in other seven species, *Platanthera dilatata*, *Liparis laeselii* and *Cypripedium reginae* among them. These authors also measured very low germination rates (1%) in *Cypripedium calceolus, C. candidum, Plantanthera hiperboria* and *P. flava*. However, they did not evaluate the viability of the seeds used; therefore the real percentage of germination of viable seeds could not be determined.

The seeds of *P. humboldtii* had very low germination rate (2.9%) in spite of their relatively high viability (34.3%). However, the large quantity of seeds in each capsule (data not shown) and the low rate of dead protocorms (Fig. 3) allowed the regeneration of enough plants using the protocol developed in this work for conservation and reintroduction of this species.

It has been considered that both germination and embryo staining (e.g., with tetrazolium chloride) are comparable viability tests. However, although the latter test has been successfully employed with epiphytic tropical orchids and several European and North American terrestrial orchids, there are some reports on inconsistencies in several species, probably attributed to variation in the permeability of the seed coat (reviewed by Vujanovic *et al.* 2000). In one of these cases, Lauzer *et al.* (1994) did not find any correlation between the percentage of germination and the percentage of seeds stained with tetrazolium chloride in *Cypripedium acaule*. They attributed these differences to a prolonged pretreatment with NaOCl (40 min with 0.6% w/v NaOCl, as compared to 10 min with the same concentration in our study), a compound that can promote dormancy release in terrestrial orchid seeds (St-Arnaud *et al.* 1992).

Numerous orchid species grow better in the dark, mainly during the first phases of development. Activated carbon has also been used to darken the culture medium and, in this way, improve germination (Arditti and Ernst 1993). In some species, the role of light during germination is not clear; for example, some authors recommend germination of *C. tuberosus* in the dark and others in light conditions (reviewed by Kauth *et al.* 2006). The light or dark treatments did not have any effect over germination in the *Phragmipedium* species studied. However, larger protocorms in the three species were obtained in dark conditions. The protocorms that germinated in the dark were white because they do not produce

chlorophyll; when they were placed in the light, the chlorophyll synthesis began, and their color changed to green, as observed in other orchids (Arditti & Ernst 1993).

A considerable number of culture media has been successfully employed and even devised specifically for orchid seed germination, some of them being only slight modifications of others (Arditti 1967). Knudson C (Knudson 1946) and Murashige and Skoog (1962) mineral salts are probably the most commonly used formulations for asymbiotic germination of orchid seeds. Since the latter one contains high amounts of nitrogen, especially in form of ammonium, dilutions are frequently employed, such as in this investigation. For many orchids, the effect of media on germination and development appears to be genotype dependent. When Knudson C and half-strength Murashige and Skoog media were compared, some genotypes developed better in the former and others in the latter (Johnson and Kane 2007). There are also examples of equal response in both media (Roy and Banerjee 2002). This behavior could be related to the differences in the ammonioum:nitrate ratio of both media. Contrary to the results obtained with *Phragmipedium* in this work, half-strength Murashige and Skoog promoted better development of the developing seedlings of hybrid *Vanda*, as compared to Knudson C (Johnson and Kane 2007).

Although, to the best of our knowledge, acclimatization of *in vitro*-generated *Phragmipedium* orchids has not been reported in the scientific literature, this task should not be very difficult, since it seems to be routinely conducted by commercial growers. Very high survival rates during acclimatization, as reported in the present work, indicate that plants generated *in vitro* were in adequate conditions and could adapt with few problems to the reduced relative humidity in the greenhouse and become autotrophic. This seems to be the case in the present work, since 100% success was obtained in this step.

In this work an efficient protocol for seed germination and plantlet growth of three *Phragmipedium* species was described. The combination of Knudson C medium and culture in the dark during the first six weeks seems to be appropriate to reach a good germination percentage and initial protocorm development. Following the method described in this work it was possible to grow plants of the three *Phragmipedium* species studied and to achieve their acclimatization in the greenhouse. A great quantity of plants could be produced by *in vitro* germination, maintaining larger genetic variability than with clonal propagation. This is a useful tool for the conservation of these species.

Acknowledgments. This investigation was partially funded by the Universidad de Costa Rica (project number VI-814-A6-107). Authors wish to thank J. Warner for facilitating the plants used in this study and for additional support. Helpful comments from anonymous reviewers are gratefully acknowledged.

Literature cited

Agustí, M. 2000. Crecimiento y maduración del fruto. *In*: Azcón-Bieto, J. & M. Talón (eds.). Fundamentos de Fisiología Vegetal. Mc Graw-Hill, Madrid, Spain, 419-433.

Arditti, J. 1967. Factors affecting the germination of orchid seeds. Bot. Rev. 33: 1-97.

Arditti, J. 1992. Fundamentals of orchid biology. John Wiley & Sons, U.S.A. 691 p.

Arditti, J. & R. Ernst. 1993. Micropropagation of orchids. John Wiley & Sons, New York, U.S.A. 682 p.

Arditti, J. & A.K.A. Ghani. 2000. Numerical and physical properties of orchid seeds and their biological implications. New Phytol. 145: 367-421.

Cox, A.V., A.M. Pridgeon, V.A. Albert & M.W. Chase. 1997. Phylogenetics of the slipper orchids (Cypripedioideae, Orchidaceae): nuclear rDNA ITS sequences. Plant Syst. Evol. 208: 197-223.

Cox, A.V., A.M. Pridgeon & M.W. Chase. 1998. The utility of DNA sequence data in orchid systematics: an example from the slipper orchids (Cypripedioideae). *In*: C.E.B. Pereira (ed.). Proceedings of 15th World Orchid Conference. Naturalia, France, 265-273.

Decruse, S.W., A. Gangaprasad, S. Seeni & V.S. Menon. 2003. Micropropagation and ecorestoration of *Vanda spathulata*, an exquisite orchid. Plant Cell Tiss. Organ Cult. 72: 199-202.

Dressler, R.L. 2003. Orchidaceae. *In:* Hammel, B.E., Grayum, M.H., Herrera, C. & Zamora, N. (eds.). Manual de plantas de Costa Rica, vol III: Monocotiledóneas (Orchidaceae-Zingiberaceae). Missouri Botanical Garden. Saint Louis, Missouri, U.S.A., 1-595.

Gangaprasad, A.N., W.S. Decruse, S. Seeni & S. Menon. 1999. Micropropagation and restoration of the endangered Malabar daffodil orchid *Ipsea malabarica.* Lindleyana 14: 38-46.

Guerrant, E.O. & T.N. Kaye. 2007. Reintroduction of rare and endangered plants: common factors, questions and approaches. Austr. J. Bot. 55: 362-370.

Henrich, J.F., D.P. Stimart & P.D. Ascher. 1981. Terrestrial orchid seed germination *in vitro* on a defined medium. J. Amer. Soc. Hort. Sci. 106: 193-196.

Johnson, T.R. & M.E. Kane. 2007. Asymbiotic germination of ornamental *Vanda*: in vitro germination and development of three hybrids. Plant Cell Tiss. Organ Cult. 91: 251-261.

Kauth, P.J., W.A. Vendrame & M. Kane. 2006. *In vitro* seed culture and seedling development of *Calopogon tuberosus*. Plant Cell Tiss. Organ Cult. 85: 91-101.

Kitsaki, C.K., S. Zygouraki, M. Ziobora & S. Kintzios. 2004. *In vitro* germination, protocorm formation and plantlet development of mature versus immature seeds from several *Ophrys* species (Orchidaceae). Plant Cell Rep. 23: 284-290.

Knudson, L. 1946. A new nutrient solution for the germination of orchid seed. Amer. Orchid Soc. Bull. 15: 214-217.

Lauzer, D., M. St-Arnaud & D. Barabé. 1994. Tetrazolium staining and *in vitro* germination of mature seeds of *Cypripedium acaule* (Orchidaceae). Lindleyana 9: 197-204.

Murashige, T. & F. Skoog. 1962. A revised medium for rapid growth and bioassays with tobacco tissue culture. Physiol. Plant. 15: 473-497.

Ramsay, M.M. & K.W. Dixon. 2003. Propagation science, recovery and translocation of terrestrial orchids. *In:* Dixon, K.W., S.P. Kell, R.L. Barrett & P.C. Cribb (eds.). Orchid conservation. Natural History Publications, Malaysia, 259-288.

Roy J., & N. Banerjee. 2002. Optimization of *in vitro* seed germination, protocorm growth and seedling proliferation of *Vanda tessellate* (Roxb.) Hook Ex G Don. Phytomorphology 52: 167-178.

Rubluo, A., V. Chávez & A. Martínez. 1989. *In vitro* seed germination and re-introduction of *Bletia urbana* (Orchidaceae) in its natural habitat. Lindleyana 4: 68-73.

Salazar, G.A. 1996. Conservation threats. *In:* Hágsater, E & V. Dumont (eds.). Orchids - Status survey and conservation action plan. IUCN. Gland, Switzerland and Cambridge, U.K., 6-10.

Salazar, V.M. & M. Mata. 2003. Micropropagación y conservación de orquídeas mexicanas en el Jardín Botánico Clavijero. Lankesteriana 7: 151-153.

Sarasan, V., R. Cripps, M.M. Ramsay, C. Atherton, M. McMichen, G. Prendergast & J.K. Rowntree. 2006. Conservation *in vitro* of threatened plants – progress in the past decade. *In Vitro* Cell. Devel. Biol. – Plant 42: 206-214.

Shiau, Y.J., A.P. Sagare, U.C. Chen, S.R. Yang & H.S. Tsay. 2002. Conservation of *Anoectochilus formosanus* Hayata by artificial cross-pollination and *in vitro* culture of seeds. Bot. Bull. Acad. Sin. 43: 123-130.

Singh, F. 1981. Differential staining of orchid seeds for viability testing. Amer. Orchid Soc. Bull. 50: 416-418.

St-Arnaud, M., D. Lauzer & D. Barabé. 1992. *In vitro* germination and early growth of seedlings of *Cypripedium acaule* (Orchidaceae). Lindleyana 7: 22-27.

Stenberg, M.L. & M.E. Kane. 1998. *In vitro* seed germination and greenhouse cultivation of *Encyclia boothiana* var. *erythronioides,* an endangered Florida orchid. Lindleyana 13: 101-112.

Steward, S.L., L.W. Zettler & J. Minso. 2003. Symbiotic germination and reintroduction of *Spiranthes brevilabris* Lindley, an endangered orchid native to Florida. Selbyana 24: 64-70.

Vujanovic, V., M. St-Arnaud, D. Barabé & G. Thibeault. 2000. Viability testing of orchid seed and the promotion of colouration and germination. Ann. Bot. 86: 79-86.

LANKESTERIANA 8(2): 33-42. 2008.

STANHOPEINAE MESOAMERICANAE IV: LAS *CORYANTHES* DE CHARLES W. POWELL

GÜNTER GERLACH[1] & GUSTAVO A. ROMERO-GONZÁLEZ[2]

[1] Botanischer Garten München-Nymphenburg, Menzinger Str. 65, D-80638 München, Germany; gerlach@extern.lrz-muenchen.de

[2] Orchid Herbarium of Oakes Ames, Harvard University Herbaria, 22 Divinity Avenue, Cambridge, Massachusetts 02138-2020, U.S.A.; romero@oeb.harvard.edu

ABSTRACT. The descriptions of *Coryanthes hunteriana* and *Coryanthes powellii* described by Schlechter are critically compared. We conclude that the same species was described twice. Because of the loss of the holotypes, the specimens collected by Powell with the same collection number at AMES, K and MO are discussed in detail.

RESUMEN: Se comparan críticamente las descripciones de *Coryanthes hunteriana* y *Coryanthes powellii* ambas descritas por Schlechter. Concluimos que la misma especie se describió dos veces. Como los holotipos se perdieron, se discuten en detalle las muestras existentes del colector Powell en los herbarios AMES, K y MO con el mismo número de colección de los tipos.

ZUSAMMENFASSUNG: Die Beschreibungen von *Coryanthes hunteriana* und *Coryanthes powellii*, beide beschrieben von Schlechter, werden kritisch verglichen. Wir kamen zu dem Schluß, daß ein und dieselbe Art zweimal beschrieben wurde. Wegen dem Verlust der Holotypen werden die existierenden Herbarbelege des Sammlers Powell in den Herbarien AMES, K und MO mit denselben Sammelnummern der Typen eingehend diskutiert.

KEY WORDS: Orchidaceae, Stanhopeinae, *Coryanthes*, Powell, Schlechter, Panamá, Costa Rica

La morfología de las flores del género *Coryanthes* Hook. es sumamente complicada, y casi imposible de describir con palabras. Cada lector puede hacer interpretaciones diferentes de las descripciones y por consiguiente es de gran importancia acompañarlas de un dibujo y, de ser posible, de fotografías mostrando las flores desde diferentes ángulos.

De las dos especies descritas por Rudolf Schlechter de Panamá (*C. hunteriana* y *C. powellii*) no existen dibujos, pero sí algunas fotografías las cuales, por cierto, al parecer no estuvieron al alcance del autor (al menos él no las mencionó en sus descripciones). En la época de Charles W. Powell (1854 — 1927), quien colectó y cultivó orquídeas principalmente de Panamá desde principios de siglo pasado hasta su muerte, el proceso de tomar e imprimir fotografías de plantas era difícil y relativamente costoso, y por estas razones hay pocas y su calidad no es buena.

Aquí debemos aclarar que el sistema de numeración de muestras empleado por Powell no se ajusta al que está en uso hoy en día: sus números agrupaban especimenes que de acuerdo a su criterio representaban la misma especie, irrespectivamente de donde y cuando hubieran sido colectados y preservados (mientras que ahora numeramos las colecciones de herbario siguiendo el criterio de McNeill et al., 2006: 8, pié de página 1, "... a single gathering of a single species... made by a collector at one time"). En este artículo precisamente tratamos de elucidar las diferentes especies de *Coryanthes* que Powell distribuyó bajo un mismo número de colección. En algunos casos se puede descartar que algunas de estas muestras puedan ser tipos, porque la fecha que aparece en los rótulos es diferente a la citada en el protólogo. El caso de las muestras sin fecha es ambiguo, aunque en el pasado se han propuesto como lectotipos (Christenson 1991). Aquí continuamos asumiendo que los especímenes sin fecha son tipos,

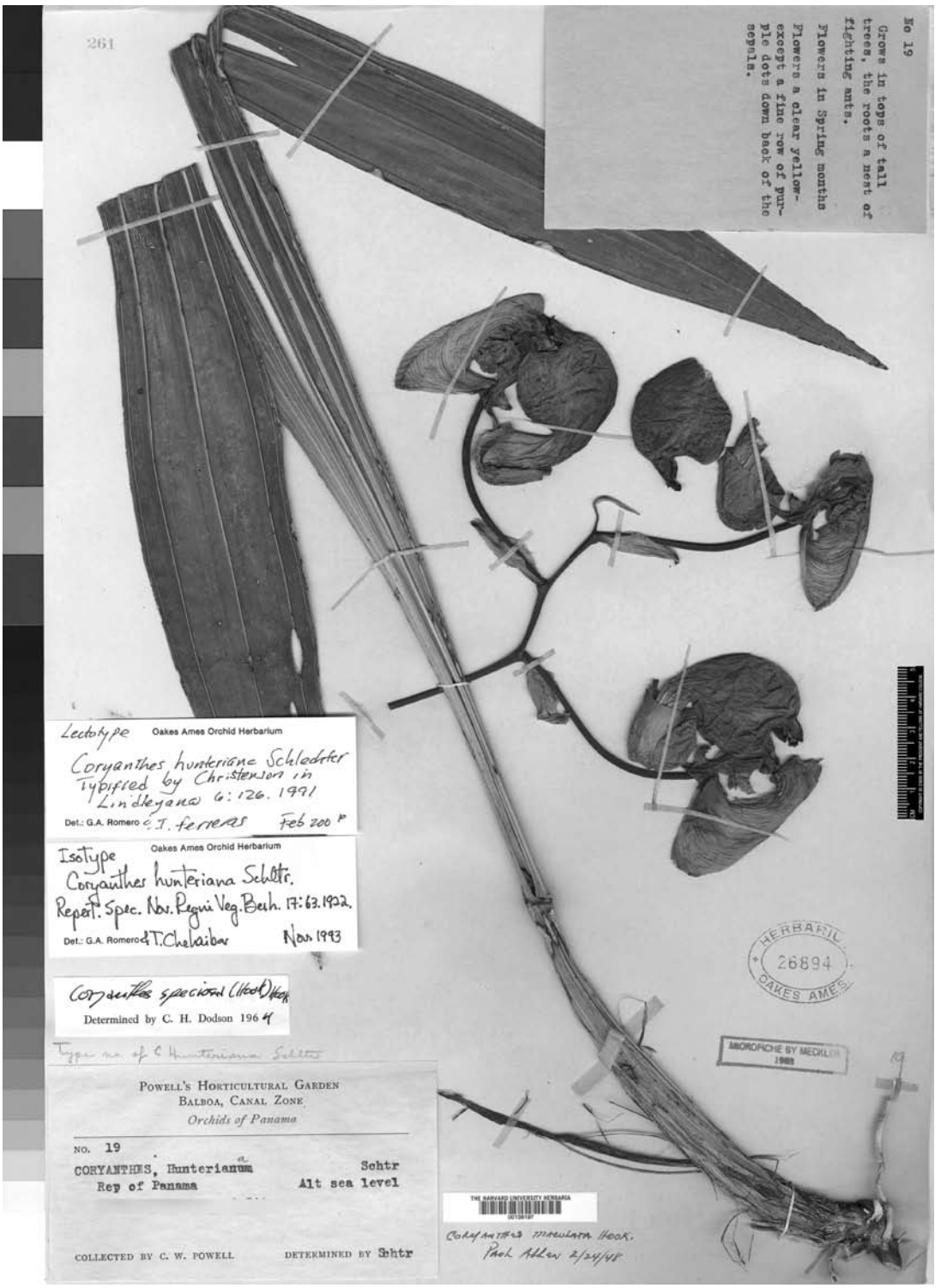


FIGURA 1. Lectotipo de *Coryanthes hunteriana* Schltr., AMES (26894).

Tabla 1. Comparación de las descripciones originales en latín de *Coryanthes hunteriana* Schltr. y *C. powellii* Schltr.

Coryanthes hunteriana	***Coryanthes powellii***
sépalos: "*sepalo intermedio plus minusve crispato, ovato-suborbiculari, apiculato, vix 3 cm longo et lato, lateralibus oblique dolabriformibus, a basi usque in apicem 6,5 cm longis, supra basin margine anteriore sublobato-dilatatis*;"	sépalos: "*sepalo intermedio orbiculari, obtuso, c. 2,5 cm longo et lato, lateralibus dolabriformibus acuminatis, antice basin versus sublobato-dilatatis, e basi usque apicem c. 7 cm longis*;"
pétalos: "*petalis oblique lanceolato ligulatis, margine crispatis, c. 3,5 cm longis*;"	pétalos: "*petalis oblique ligulatis, obtusiusculis, undulatis 3,5 cm longis*;"
hipoquilo: "*labelli hipochilio ovatli-cucullato, apice subacuto, dorso glabro, latere utrinque striguloso-tomentello, 2,5 cm longo, medio fere 1,8 cm alto*,"	hipoquilo: "*labelli ungue 1,7 cm longo, hypochilio cucullato, obtuse acuminato, dorso glabrato, lateribus linea strigillosa ornato, 2,7 cm longo, medio 1,8 cm alto*,"
mesoquilo: "*mesochilio canaliculato, nudo, hypochilium, paululo tantum superante,*"	mesoquilo: "*mesochilio canaliculato, nudo, hypochilium, paulo sed manifeste superante*,"
epiquilo: "*epichilio generis cucullato, c. 4 cm longo, lobis lateralibus amplis semiovato-triangularis, obtusis, antice truncatis, intermedio multo minore semiovalis, trilobulata*"	epiquilo: "*epichilio ovali-cucullato, c. 4 cm longo, lobis lateralibus amplis semiovatis, antice valde obtusis, intermedio multo minore oblongo-triangulo trilobulato*,"

aunque siempre podrán ser cuestionados (K. Gandhi, comunicación personal, 2008).

De las *Coryanthes* de Powell existen cuatro fotografías. Todas estas fotografías están montadas en muestras con su número 19. De éstas, una representa *C. misasii* G. A. Romero & G. Gerlach, dos representan *C. panamensis* G. Gerlach y la cuarta tal vez se pueda asignar a una de las dos especies descritas por Schlechter (*C. hunteriana, C. powellii*).

Las muestras tipos de Schlechter, depositadas en el Herbario de Berlin, fueron destruidas durante la Segunda Guerra Mundial (Merrill, 1943; Ames, 1944). Aunque Schlechter elaboró bosquejos de la mayoría de sus especies y envió copias a su amigo y colega Oakes Ames (Universidad de Harvard, E.E.U.U.; Ames, 1944), no se conocen dibujos de las *Coryanthes* de Powell. De manera que solamente nos pueden ayudar a elucidar sus dos especies panameñas de *Coryanthes* las muestras de Powell hoy en día presentes en el Herbario de Orquídeas de los Jardines Reales de Kew (K), en el Herbario de Orquídeas de Oakes Ames en la Universidad de Harvard (AMES) y en el Herbario de Jardín Botánico de Missouri (MO).

En estos tres herbarios hemos localizado siete muestras que llevan el número 19 de Powell, las que, de acuerdo al criterio de Powell y a la descripción de Schlechter, deben pertenecer todas a *Coryanthes hunteriana*. Además, hay dos muestras de herbario con el número 156 de Powell que, siguiendo de nuevo a Powell y a Schlechter, serían asignadas a *C. powellii*. Christenson (1991) lectotipificó las muestras destruidas en Berlin y aclaró que hubo un error en la cita del número del tipo de esta última especie (Schlechter, por error propio o por un error tipográfico, citó el número 158 de Powell en el protólogo aunque no hay duda que debió haber citado el número 156).

Enseguida examinamos una lista de las

FIGURA 2. Lectotipo de *Coryanthes powellii* Schltr., K. Reproducido con gentil permiso del Board of Trustees of Royal Botanic Gardens, Kew.

Figura 3. Hija de Charles W. Powell (originalmente montada en la muestra AMES 31853) con *Coryanthes panamensis*.

Figura 4. *Coryanthes hunteriana* Schltr., Powell 156 (conservado en líquido en AMES); la flecha muestra el hipoquilo alargado y truncado, el carácter más distintivo de la especie.

muestras existentes de *Coryanthes* de Powell con algunos comentarios.

Bajo Powell 19 — todo este material se ha identificado como ***Coryanthes hunteriana*** **Schltr.**

1) AMES 26894: *Lectotypus* (Fig. 1), no contradice el protólogo, sin fecha; labelo 5,9 cm alto;
2) AMES 25007: *Isolectotypus*, no contradice el protólogo, sin fecha; labelo 5,7 cm alto;
3) AMES 25008: la planta, por falta de flores, no es determinable, la muestra incluye una foto de *C. misasii*, tiene fecha del 5 de mayo de 1923;
4) K (sin número de herbario): *Isolectotypus*, cinco flores de *C. panamensis*, dos fotografías (la del habito no se puede determinar, la de la flor la identificamos como *C. panamensis*), tiene fecha del 15 de noviembre de 1918; labelo 6,3 cm alto;
5) MO 955890: no contradice el protólogo, sin fecha; labelo 5,6 cm alto;
6) AMES (sin número de herbario) Powell 3546 y Powell 19 (ambas anotaciones sobre rótulo), con fecha de abril de 1924;
7) AMES 31853: Powell 19 y Oakes Ames 3519; una flor y una foto de la hija de Powell (Fig. 3) con una flor de *C. panamensis*, con fecha de marzo de 1924.

Bajo Powell 156 — todo este material se ha identificado como ***Coryanthes powellii*** **Schltr.**

1) K (sin número de herbario): *Lectotypus* (Fig. 2), una una flor montada al revés, la flor mas delgada que la de *C. hunteriana*, tiene fecha del 4 de mayo de 1920, labelo 5,9 cm alto;
2) AMES 26893: se parece a AMES 26894 y todavía más a AMES 25007 (*C. hunteriana*), sin fecha; labelo 5,8 cm alto.

En este material de herbario se encuentran dos especies de *Coryanthes* adicionales que fueron descritas

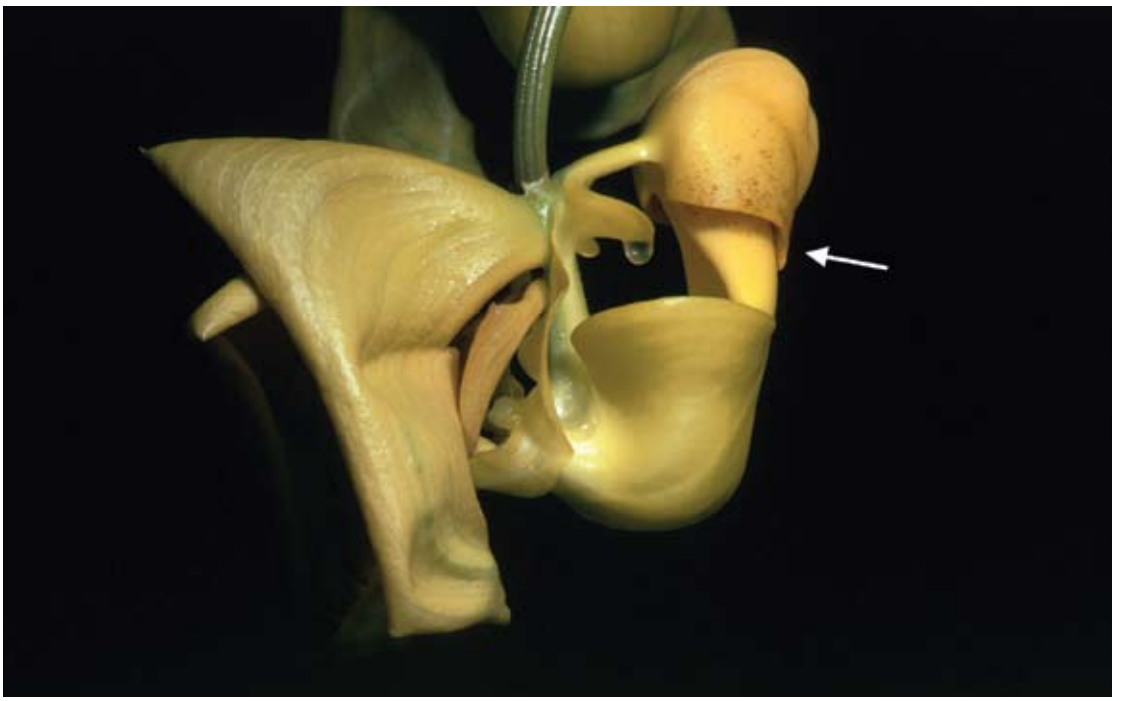


Figura 5. *Coryanthes hunteriana* Schltr., Panamá, Prov. Panamá, cerca de Arraiján, 02/2948, vista lateral; la flecha muestra el hipoquilo alargado, el carácter más distintivo de la especie. Foto G. Gerlach.

Figura 6. *Coryanthes hunteriana* Schltr., Panamá, Prov. Panamá, cerca de Arraiján, 02/2948, vista dorsal; la flecha muestra el hipoquilo alargado y truncado, el carácter más distintivo de la especie. Foto G. Gerlach.

Figura 7. *Coryanthes hunteriana* Schltr., Costa Rica, Prov. Limón, Río Pacuare, O-18363 (forma rosada que representando el color de tipo de *C. horichiana*). Foto G. Gerlach.

Figura 8. *Coryanthes panamensis* G. Gerlach, Panamá, Prov. Panamá, Río Piedras (zona del canal) O-18594 (fotografía del material del holotipo), vista lateral. Foto G. Gerlach.

Figura 9. *Coryanthes panamensis* G. Gerlach, Panamá, Prov. Panamá, Río Piedras (zona del canal) O-18594 (fotografía del material del holotipo), vista dorsal. Foto G. Gerlach.

décadas después como *C. misasii* G.A. Romero & G. Gerlach (Gerlach & Romero 1990) y *C. panamensis* G. Gerlach (Gerlach & Schill 1993). Comparando las flores de las llamadas *C. hunteriana* y *C. powellii*, no encontramos diferencias que justifiquen el estatus de *C. powellii* como especie o subespecie. Comparando las descripciones originales (i.e., los protólogos) de las dos especies tampoco se detectan grandes diferencias. Además, aquí enfatizamos que estas descripciones se basan en caracteres que tienen poco peso para distinguir las especies. La tabla 1 contrasta las descripciones originales en latín.

Trabajando con material extenso del género *Coryanthes*, tanto cultivado como de herbario, hemos determinado que los caracteres que permiten identificar las especies (i.e., los caracteres diagnósticos) no están siempre incluidos en las descripciones. Gerlach (1993) diferenciaba su *C. panamensis* por el ápice del hipoquilo profundamente trapeziforme y sinuado ("*... Cum apice hypochilii profundo trapeziforme-sinuato*"). En sus descripciones Schlechter mencionó al caracter del hipoquilo: "*apice subacuto*" en *C. hunteriana* y "*hypochilio cucullato, obtuse acuminato*" en *C. powellii*. En realidad, el hipoquilo se ve subagudo o obtuso acuminado en todas las flores menos en aquellas que nosotros hemos identificado como *Coryanthes panamensis* y *C. misasii*. Estas dos últimas especies no presentan el carácter del ápice del hipoquilo mencionado por Schlechter (Fig. 8 — 12) y por consiguiente no se pueden confundir con sus conceptos de *C. hunteriana* o *C. powellii*. Comparando todo este material con los números mencionados 19 y 156 de Powell, creemos que Schlechter tuvo en sus manos la misma especie pero en dos oportunidades con diferentes números y, sin darse cuenta, la describió dos veces (un error que este

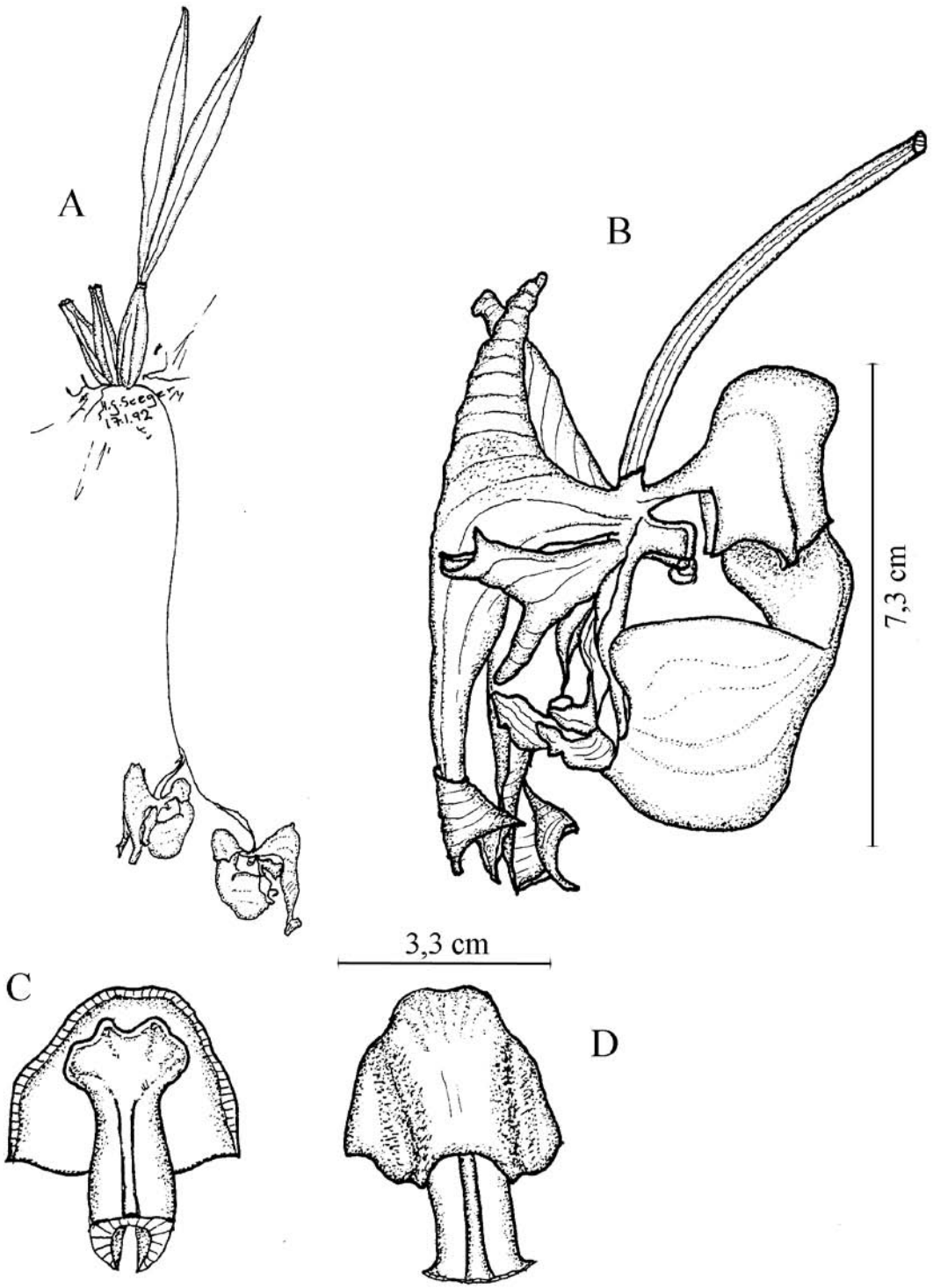


Figura 10. *Coryanthes panamensis* G. Gerlach. - A. habito, - B. Flor en vista lateral, - C. Osmoforo, partes del hipoquilo removido, - D. Hipoquilo en vista dorsal. Dibujo por H.G. Seeger.

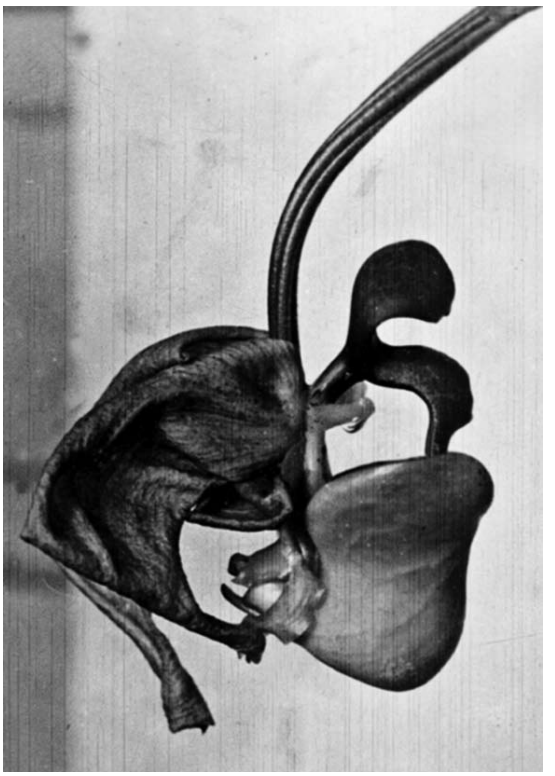


Figura 11. Fotografía de *Coryanthes misasii* G. A. Romero & G. Gerlach (originalmente montada en la muestra AMES 25008).

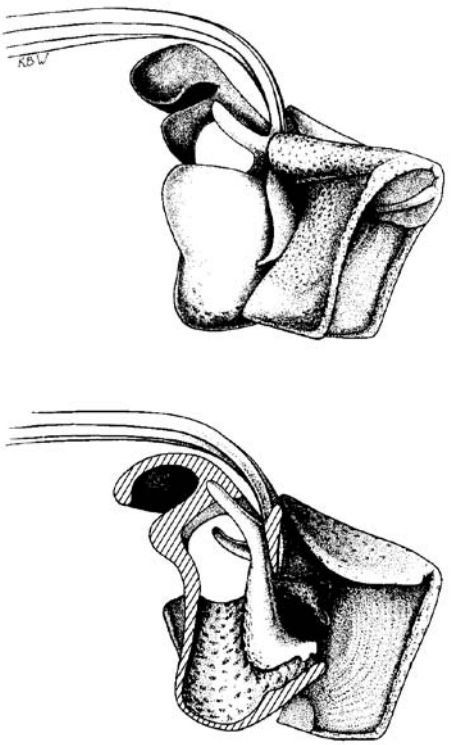


Figura 12. *C. misasii* G. A. Romero & G. Gerlach. Dibujo por K. Brown-Wing.

autor cometió en varias oportunidades). Esta hipótesis se apoya en la falta de diferencias significativas en las flores prensadas por Powell con estos números y la falta de diferencias importantes en las descripciones de Schlechter de *C. hunteriana* y *C. powellii* (Tabla 1). Basándonos en estos argumentos, referimos a *C. powellii* a la sinonímia de *C. hunteriana*.

Allen (1949) fue el primer botánico en relegar las dos especies de Schlechter a la sinonimía a *Coryanthes maculata* Hook., aunque también incluyó en su lista de sinónimos a *C. albertinae* H. Karst. y *C. splendens* Barb. Rodr. Pensamos que el concepto de *Coryanthes* de Allen era muy amplio y que incluía muchas especies que ahora son aceptadas separadamente por muchos autores, como *C. albertinae*, restringida a Venezuela, *C. maculata,* un elemento típico de la Flora del escudo Guayanés, y *C. splendens,* un sinónimo de *C. speciosa* (Hook.) Hook., una especie endémica de Brasil.

Debido a la falta de caracteres diagnósticos descritos por Schlechter que pudieran servir para identificar *Coryanthes hunteriana*, aquí complementamos su descripción para que esta especie pueda ser identificada con seguridad en el futuro. Se distingue fácilmente por la forma del ápice del hipoquilo: en vista lateral éste se ve largamente elongado (Fig. 5 y 7) y en vista dorsal truncado o obtuso (Fig. 4 y 6). En la mayoría de las especies de la sección *Coryanthes* del género *Coryanthes* (en Mesoamérica no hay reportes de la otra otra sección) el ápice del hipoquilo se ve emarginado y sinuado (por ejemplo en *C. panamensis*, Fig. 8, 9 y 10) o agudo, pero en ningún caso truncado o obtuso.

La interpretacion de *C. hunteriana* por Gerlach & Schill (1993) en su monografía del género *Coryanthes* estuvo errada: la especie ilustrada con este nombre hoy se asigna a *C. picturata*, la especie más común en Mesoamérica, que se encuentra desde México hasta Panamá. Es bastante variable y tiene formas unicolores de color crema o amarillo pálido igual que formas punteadas o manchadas. La especie que está ilustrada

en la misma obra con el nombre *Coryanthes picturata* (Gerlach & Schill 1993: página 79, figura 10 y página 146 figuras 90 & 91), tampoco fue correctamente interpretada: ésta fue descrita diez años más tarde como *C. kaiseriana* G. Gerlach (Gerlach & Dressler 2003).

Para concluir, hoy en día el conocimiento y los datos que tenemos disponibles de *Coryanthes* claramente son mucho mejores que en el pasado, debido a una mejor infraestructura de información y a que se han colectado más muestras de las diferentes especies del género. Las especies de *Coryanthes* descritas por Schlechter de Panamá ya han sido colectadas en Costa Rica, aunque las flores presentan una coloración algo diferente (Fig. 7). Supuestamente por causas de la descripción pobre en caracteres y por falta de ilustraciones, Jenny (1986) la describió como *C. horichiana* sin darse cuenta que se trataba de la *C. hunteriana*.

Agradecimientos. Agradecemos a los herbarios y los curadores del Royal Botanical Gardens, Kew en Inglaterra (K), y del Jardín Botánico de Missouri, San Louis, Missouri, E.E.U.U. (MO), por permitirnos estudiar sus colecciones y publicar algunas de sus muestras. Los autores agradecen el apoyo financiero de la Sociedad de Orquideología de Arizona (Orchid Society of Arizona, a G.A.R.-G.).

Literatura citada

Allen, P.H. 1949. Flora of Panama. Part II. Fascicle 4. (Orchidaceae, third part). Ann. Miss. Bot. Gard. 36(1): 66-69.

Ames, O. 1944. Destruction of the Schlechter Herbarium by bombing. Amer. Orchid Soc. Bull. 13: 105-106.

Christenson, E.A. 1991. Mesoamerican orchid studies II: Powell's panamanian orchidaceae. Lindleyana 6(3): 124-132.

Gerlach, G. & Romero, G.A. 1990. Beiträge zur Gattung Coryanthes Hook. VI: Coryanthes gernotii und Coryanthes misasii zwei neue Orchideen aus den Wäldern Südamerikas. Die Orchidee 42(2): 64-68.

Gerlach, G. & Schill, R. 1993. Die Gattung *Coryanthes* Hook. (Orchidaceae); Eine monographische Bearbeitung unter besonderer Berücksichtigung der Blütenduftstoffe. Tropische und subtropische Pflanzenwelt 83: 1-205.

Gerlach, G. & Dressler, R. 2003. Stanhopeinae Mesoamericanae I. Lankesteriana 8: 23-30.

Jenny, R. 1986. Einige Notizen zur Gattung Coryanthes Hooker und eine neue Art: *Coryanthes horichiana*. Die Orchidee 37(3): 124-132.

McNeill, J. [Chairman]. 2006. International Code of Botanical Nomenclature (Vienna Code). A. R. G. Gantner Verlag, Ruggell, Liechtenstein.

Merrill, E. D. 1943. Destruction of the Berlin Herbarium. Science 98, No. 2553: 490-491.

Schlechter, R. 1922. Beiträge zur Orchideenkunde von Zentralamerika. I. *Orchidaceae Powellianae Panamenses*. Repert. Spec. Nov. Regni Veg. Beih. 17: 1-95.

LANKESTERIANA 8(2): 43-52. 2008.

THE BOTANICAL CABINET

Rudolf Jenny

Moosweg 9, 3112 Allmendingen, B Bern, Switzerland
RJOrchid@gmx.ch

There are a few famous examples of seldom seen botanical periodicals. The orchid plates published in journals like Curtis's Botanical Magazine and Edwards's Botanical Register have been reprinted, but many others are known only from the originals locked away in libraries. A good example is Loddiges' Botanical Cabinet, published in 20 volumes with 2000 plates between 1817 and 1833. The history of this journal and its content must be seen in relation to the Loddiges & Sons Nursery, in Hackney.

At the beginning of the 19th century, tropical orchids were almost unknown in Europe, though some illustrations and descriptions were known from expeditions in tropical countries, along with herbarium material collected on such expeditions. Nobody had a clear idea of the richness of forms and species in this family, and tropical orchids were treated more or less as mere curiosities of the plant kingdom. This situation would change dramatically about 1840, when the orchid fever in England started to spread, first through the island and then also - beginning in Belgium - through continental Europe. It was a part of the life-style of rich people to build up an orchid collection, and the names of nurseries like Sander, Linden, Low and Veitch, all trying to satisfy the growing market for plants from tropical countries, became famous.

Right at the beginning of this development, we find the name of Joachim Conrad Loddiges (fig. 1) and his establishment in Hackney, London. Joachim Conrad Loddiges was born in 1738, the son of a gardener working for a nobleman in Vristbergholzen near Hannover in Germany. He was trained as a gardener between 1758 and 1761 with Joseph Conrad Wefer in Velzen, near Haarlem in the Netherlands. After finishing his education he went to England to start in the best tradition of his family as gardener with J. B. Sylvester in Hackney, London. In 1771 Conrad took over a small import-nursery from John Busch, with its stock of customers and suppliers. Conrad was a very keen and intelligent businessman, but his starting capital was so low that that he couldn't pay Busch for the nursery at one time, but by 1777 he had paid everything and owned a small but flourishing and profitable nursery with a small shop for seeds. In the same year Loddiges published the first edition of a whole series of catalogues as "A catalogue of plants and seeds which are sold by Conrad Loddiges, nursery and seedsman, at Hackney, near London." We have a handwritten copy by Conrad Loddiges (member of the fifth generation, great-great-grandson of Joachim Conrad Loddiges, or great-grandson of George Loddiges) of this first catalogue published in the year 1914, copied from the original of Sir Joseph Banks (which is now kept in the British Museum). The editions 2 to 8 are very seldom seen, we know only handwritten copies of those catalogues from the Lindley library. In 1804 there were already 9 orchids mentioned, all of them as *Epidendrum,* in *1807* there were still 6 *Epidendrum* listed and in 1811 13 (some of them now known as *Cymbidium* or *Oncidium* species). The orchid catalogues of 1839, 1841 and 1844 list a tremendous number of species, in *Stanhopea* alone, Loddiges offered in 1839 23 species (some unnamed), in 1841 53 species, and in 1844 65 species. Obviously Loddiges was both fascinated by *Stanhopea* and able to cultivate them rather well. Interestingly enough, some colored illustrations of different *Stanhopea* species are known that were not published in the Botanical Cabinet; one of them is *Stanhopea insignis* var. *major* (Fig. 2). The drawing has a label dated 4 October 1844, and the handwritten remark: "drawn in Loddiges' garden." It is quite unclear where these drawings are. Xerox copies showed up in the collection of Herman Sweet, but we have been unable to locate the originals.

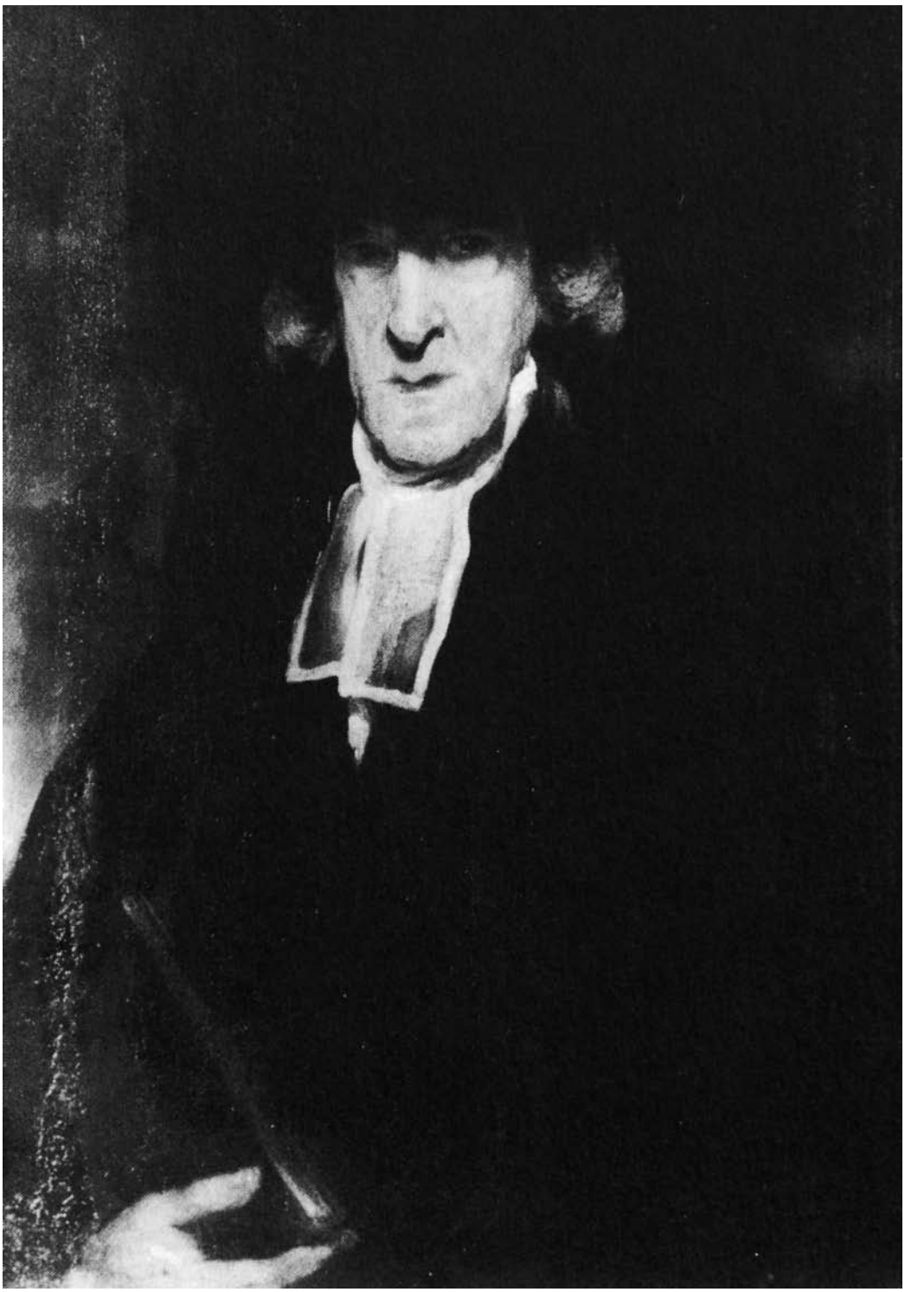


FIGURE 1. Joachim Conrad Loddiges, portrait by John Renton, son of the headgardener at Loddiges' nursery.

About the year 1790 Loddiges started to import living plants from other continents, especially from the United States of America. In 1776 his first son William was born, and in 1786 his second son George (Fig. 3): both later joined the company. Therefore, Conrad changed the name of the company to Loddiges & Sons. When Conrad Loddiges died at the age of 87 years, on 13 March 1826, he still was not an English citizen, but he owned the best known and most famous company for the importation of exotic plants in Great Britain. Already in 1800 his nursery was the largest in Great Britain and also the most profitable. According to some authors, Loddiges & Sons was then the largest nursery in the world (Yearsley, 2000). In 1818 Loddiges erected the first, at the time, gigantic, steam-heated palm house, 24 years before Kew got its famous palm house. The technology that Loddiges used for the building and the steam heating system was revolutionary. To the great surprise of the visitors it was even possible to produce artificial rain in the house. In those years, the loss of plants during their transport from outside Europe was dramatic. Loddiges himself mentioned that only 1 plant out of 20 would survive transport. The invention of Wardian cases - in effect, small, transportable greenhouses - changed the situation and dramatically reduced the loss. The Wardian case was invented by Nathaniel Bagshaw Ward, physician and examiner in botany to the Society of Apothecaries in London (1791-1868). By using Wardian cases, only 1 out of 20 plants was lost during transport and this change was one of the reasons for the "Orchid fever" in the second half of the 19th century. Loddiges & Sons was one of the very first companies to realize the tremendous advantage of the Wardian cases, and started to use them immediately after their invention.

Loddiges started to import tropical orchids around 1812; in 1826 his catalogue listed 84 species. Conrad and especially his son George saw the tremendous business possibilities with orchids quickly, and consequently they treated orchids as one of the mainstays of their business. Like many other nurseries, Loddiges also worked together with a number of professional collectors who supplied the nursery in Hackney with material, and from time to time also with new species collected all

FIGURE 2. *Stanhopea insignis* var.*major*, drawing from Loddiges collection, detailed origin unknown.

FIGURE 3. George Loddiges, portrait by John Renton, son of the headgardener at Loddiges' nursery, from the collection of the Royal Horticultural Society in London.

over the world. Hugh Cumming was one of those early collectors, travelling for Loddiges. In 1839, 13 years after Conrad Loddiges died, his son George published the first orchid catalogue, including 1024 different species in 25 different genera. In 1844 the last catalogue was published by Loddiges, and it included no less than 1900 species. In those years, the competition from other nurseries became a problem for Loddiges, other nurseries started to employ collecters and to import huge numbers of plants from tropical areas. To make the situation worse, George Loddiges faced problems concerning the property on which the nursery was built, and he was also faced with dramatically increased air-pollution, which was very damaging to the plant stock.

When Geoge Loddiges died, in 1846, his son Conrad took over the nursery, together with George's brother William. William Loddiges died only 5 years later, and so Conrad junior became owner of the nursery. In the ensuing years the nursery had more and more problems with its competitors. The expanding city of London added pressure to the nursery, and the contracts for the property were cancelled. Another very serious problem was air pollution which badly damaged the plants. George Loddiges had built a new greenhouse for orchids, but in 1853 the final decision was made to close the establishment. Loddiges and sons had to clear out everything, together with the large palm house and all other greenhouses. In 1852 Joseph Paxton erected the famous Crystal Palace in London, and sold the complete collection of about 300 palms to Paxton. Thirty-two horses were used to transport the largest palm, with a weight of 15 tons, to its final place in the Crystal Palace. In two big auctions, the complete orchid collection was sold in 1856 and 1857. Many plants of the famous collection had been sent to the Royal Botanic Gardens in Kew by Conrad junior before the auctions. Conrad Loddiges junior died in 1856, and with him disappeared a great dynasty of nurserymen and a great nursery, the best in its time and the first in England to import plants in great numbers. Loddiges and Sons had the most complete and largest collection of palms in the world, a collection of roses that included all known species and hybrids, a collection of tropical ferns with more than 100 species, and, last but not least, a collection of trees and shrubs of more than 3000 species, of which it was said that it included every single tree and shrub that could be cultivated in England without a greenhouse. Aside from his activites in the nursery, Geoge Loddiges found time to do many other things, he was vice-president of the Royal Horticultural Society in London and member of the Linnean Society, the Zoological Society and the Microscopy Society. He owned a collection of preserved hummingbirds with more species than all other collections in the world together.

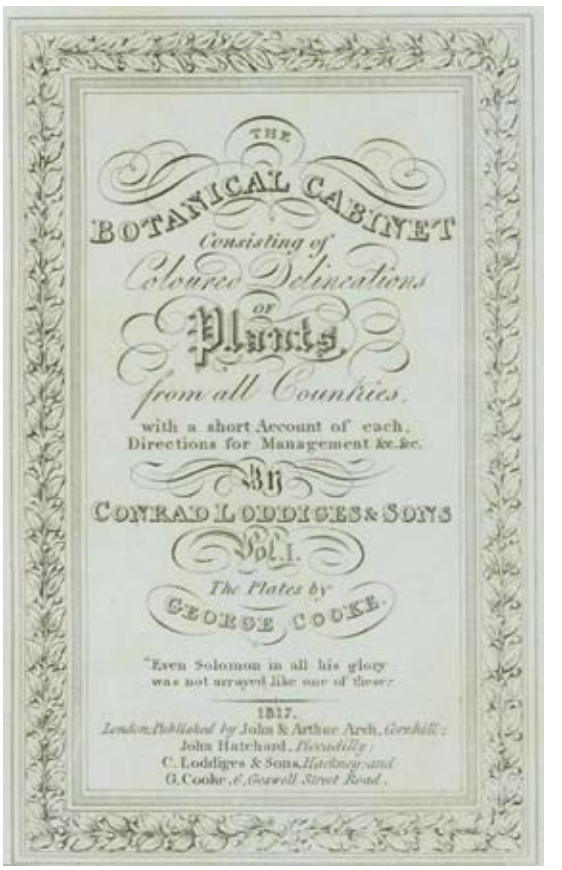
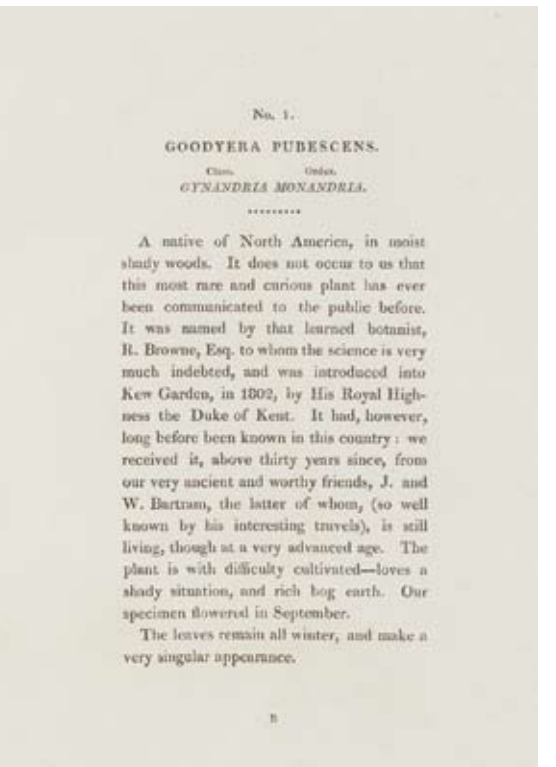

THE
BOTANICAL CABINET
Consisting of
Coloured Delineations
OF
Plants
from all Countries,
with a short Account of each,
Directions for Management &c. &c.
By
CONRAD LODDIGES & SONS
Vol. I.
The Plates by
GEORGE COOKE.
"Even Solomon in all his glory
was not arrayed like one of these."
1817.
London, Published by John & Arthur Arch, Cornhill;
John Hatchard, Piccadilly;
C. Loddiges & Sons, Hackney; and
G. Cooke, 6, Goswell Street Road.

FIGURE 3. Frontpage of Vol.1 of the *Botanical Cabinet* from 1817.

The genus *Loddigesia* Sims (1808, Leguminosae) was dedicated to Conrad Loddiges (father) and quite a few orchids carry the name Loddiges, either for Conrad Loddiges, or George Loddiges, his son:

Physosiphon loddigesii Lindley (1835)
Lepanthes lodddigesiana (Swartz) Rchb.f. (1856)

FIGURE 4. *Goodyera pubescens*, the first plate in the whole series from 1817.



No. 1.

GOODYERA PUBESCENS.

Class. Order.
GYNANDRIA MONANDRIA.

.....

A native of North America, in moist shady woods. It does not occur to us that this most rare and curious plant has ever been communicated to the public before. It was named by that learned botanist, R. Browne, Esq. to whom the science is very much indebted, and was introduced into Kew Garden, in 1802, by His Royal Highness the Duke of Kent. It had, however, long before been known in this country: we received it, above thirty years since, from our very ancient and worthy friends, J. and W. Bartram, the latter of whom, (so well known by his interesting travels), is still living, though at a very advanced age. The plant is with difficulty cultivated—loves a shady situation, and rich bog earth. Our specimen flowered in September.

The leaves remain all winter, and make a very singular appearance.

FIGURE 5. Text of the plate of *Goodyera pubescens*, from the *Botanical Cabinet* for 1817.

Octomeria loddigesii Lindley (1836)
Dendrobium loddigesii Rolfe (1887)
Cirrhaea loddigesii Lindley (1832)
Acropera loddigesii Lindley (1833)
Cycnoches loddigesii Lindley (1832)
Cattleya loddigesii Lindley (1821)

Already Conrad Loddiges had the idea of presenting his plants to a broader public in an illustrated form, and so George started in 1817 to publish his own series of publications under the name "*Botanical Cabinet*." The full title is "The Botanical Cabinet consisting of coloured delineations of plants from all countries with a short account of each, directions for management &c. &c.", with the added maxim "Even Solomon in all his glory was not arrayed like one of these." (Fig. 3). In its essence, this periodical was simply an illustrated catalogue or an illustrated supplement for the catalogues of the nursery. The idea was to publish the best and most interesting plants available in the nursery as coloured illustrations - photographs were not yet available at that time - together with some information about origin and culture and a short description. The *Botanical Cabinet* was, except for the Curtis's *Botanical Magazine* and Edwards's *Botanical Register*, one of the very first periodicals of this kind to be published. The editor tried to make clear that his *Botanical Cabinet* was not intended to be a competitor of Curtis's *Botanical Magazine*. George Loddiges contacted John Sims, from 1800 until 1826 the editor of the *Botanical Magazine* (vol. 14 to 53), before he started the publication and explained the situation to him. The very short texts accompanying the plates in *Botanical Cabinet* reflect Loddiges' effort to avoid any conflict with a well established and scientifically accepted journal like Curtis's *Botanical Magazine*.

The first part was published in May 1817, the last part of volume 20 was distributed in December 1833. Each month one part with ten completely hand-coloured plates was published for five shillings, in parallel a cheaper version with only partially coloured plates was sold for two shillings and six dimes. The twenty volumes included a total number of 2000 plates, 131 of them were orchids, many of them created by George Loddiges, himself. A number of drawings originated from Edward William Cooke and Jane Loddiges. Jane was the daughter of Conrad Loddiges (and sister of George) and E. W. Cooke was her husband. Edward William Cooke was a landscape and marine painter, born in 1811 in Pentonville, London. The drawings made by E. W. Cook and Jane Loddiges,together with those from George Loddiges himself, and other involved artists like T. Boys, Miss Rebello, W. Miller, P. Heath and J. P. Heath were engraved by George Cooke, father of E.W.Cooke, printed and then coloured by different artists. George Cooke was born 1781 in London and was a line-engraver by profession. The originals from E. W. Cooke and Jane Loddiges were offered in 1929 by their grandson to the Bombay Natural History Society. The originals of all drawings are kept today in the collection of the British Museum. In a letter of October 1879, E. W. Cooke stated that all 2000 engraved copper plates were stolen by one of Loddiges' men from his library in the garden. The exact publication dates of all 2000 plates between May 1817 (Vol. 1, fasc. 1, t. 1 - 10) and December 1833 (Vol. 20, fasc. 10, t. 1991 - 2000) are published in Stafleu in Taxonomic Literature and by Garay in the journal Taxon (1969).

The plates are almost perfect, and the colour reflects reality and is not - unlike many later similar publications like Flore des Serres or Lindenia - exaggerated. The very first plate published in 1817 was an orchid: *Goodyera pubescens* (Fig. 4, 5), described in 1813 by Robert Brown. Loddiges received it much earlier from J. and W. Bartram and had it since about 1785 in cultivation. Kew received it from the Duke of Kent in 1802. As Loddiges wrote: "The plant is with difficulty cultivated -- loves a shady situation, and rich bog earth. Our specimen flowered in September." The original drawing was made by George Loddiges himself.

FIGURE 6. *Ficus setacea*, from *Botanical Cabinet*, Vol. 12.

As explained above, only 131 plates of the 2000 were orchids, and it is interesting to see that most of them represent species that are not too difficult to transport from their home to England and rather easy of culture, or, more honestly, hard to kill. Cultivation of orchids during Loddiges' time was rather different from today's ideas about cultivation and only really tough plants could survive. This is not the place to write much about plants other than orchids, but I would like to show at least a few examples, *Ficus setacea* (t. 1138) from vol. 12 (Fig. 6) after a drawing by T. Boys and *Passiflora herbertiana* (Fig. 7) from vol. 14, both are very good examples to document the high quality of the drawings.

Plate 585 from 1822 takes a very special place in the whole series, it is *Cypripedium venustum* (Fig. 8). The very first species of the genus *Paphiopedilum* was described and illustrated by John Sims only two years earlier in Curtis Botanical Magazine as *Cypripedium venustum*. We don't know who the artist of this plant was, but under the impression of the strange, beautiful plant and flower, Loddiges wrote: "The view of such pleasing and astonishing

Figure 7. *Passiflora herbertiana,* from *Botanical Cabinet*, Vol. 14.

FIGURE 8. *Cypripedium venustum* from *Botanical Cabinet*, 1822.

FIGURE 9. *Cycnoches Loddigesii* from 1833, the last plate in the work.

productions of Divine power and Goodness is an endless source of gratitude, wonder and delight. Under the influence of such impressions, who indeed can avoid exclaiming with the inspired penman of old, "O Lord, how manifold are Thy works; in wisdom hast Thou made them all."

Also the last published plate (no. 2000) is an orchid: *Cycnoches loddigesii* (Fig. 9) described and named by John Lindley. The plant was collected by John Henry Lance, barrister and at that time commissary judge in Surinam and imported by Loddiges in 1830, it flowered in Loddiges' culture in 1832 for the first time, the drawing was made by Jane Loddiges and shows the male flowers of the species. Beneath the few words about *Cycnoches loddigesii*, Loddiges also explained why he would stop the publication of the Botanical Cabinet with Vol. 20; he wrote: "Having been enabled to complete our twentieth volume, and thus to place two thousand plants before the public, our labours are closed; the precarious state of our draughtsman's health not permitting him to go on any farther."

Though only about 131 of all the plates of the Botanical Cabinet show orchids, the whole work is an invaluable addition to any library, it documents the first steps of the orchid fever in England.

Literature Cited

Garay, L.A. 1969. Dating of the Botanical Cabinet and of Paxton's Flower Garden, Taxon 18:709 – 712.
Loddiges, G. 1804. Catalogue, handwriting.
Loddiges, G. 1807. Catalogue, handwriting.
Loddiges, G. 1811. Catalogue, handwriting.
Loddiges, G. 1814. A catalogue of plants and seeds Ed.9: 35 – 40.
Loddiges, G. 1818. A catalogue of plants Ed.11: 3 – 11.
Loddiges, G. 1820. A catalogue of plants and seeds Ed.12: 3 – 13.
Loddiges, G. 1823. A catalogue of plants and seeds Ed.13: 3 – 11.
Loddiges, G. 1826. A catalogue of plants and seeds Ed.14: 3 – 18.
Loddiges, C. 1914. The following lists are compiled…..
Loddiges, G. 1839. Orchideae in the collection of Conrad Loddiges and Sons : 1 – 24.
Loddiges, G. 1841. Orchideae in the collection of Conrad Loddiges and Sons : 1 – 40.
Loddiges, G. 1844. Orchideae in the collection of Conrad Loddiges and Sons :1 – 45.
Loddiges, G. 1849. A catalogue of plants and seeds : 1 – 82.
Solman, D. 1995. Loddiges of Hackney, the largest hothouse in the world, Hackney Society, John Straker ed.
Stafleu, F. 1981. Taxonomic Literature 3(Lh-O): 133 – 137; Bohn, Scheltema & Holkema, Utrecht.
Yearsley, G. 2000. Conrad Loddiges & sons, the first orchid nursery; Orchid Review 108:116 – 121.

LANKESTERIANA 8(2): 53-74. 2008.

NEW SPECIES AND RECORDS OF ORCHIDACEAE FROM COSTA RICA

Diego Bogarín[1,2,5], Adam Karremans[1,2] & Franco Pupulin[1-4]

[1] Jardín Botánico Lankester, Universidad de Costa Rica, P. O. Box 1031-7050 Cartago, Costa Rica.

[2] Centro de Investigación en Orquídeas de los Andes "Ángel Andreetta", Universidad Alfredo Pérez Guerrero, Extensión Gualaceo, Ecuador.

[3] Harvard University Herbaria, Cambridge, MA, USA.

[4] Marie Selby Botanical Gardens, Sarasota, FL, USA.

[5] Author for correspondence: diego.bogarin@ucr.ac.cr

Abstract. We present and illustrate 11 new records of Orchidaceae from Costa Rica, and propose a new combination in *Acianthera* for *Pleurothallis aberrans*. *Barbosella orbicularis* and *Myoxanthus speciosus*, previously recorded from Costa Rica on the basis of doubtful vouchers, are confirmed to occur in the country and illustrated from Costa Rican vouchers. *Warmingia margaritacea* is reduced to the synonymy of *Warmingia zamorana*, a species previously known only from Ecuador. A new species, *Epidendrum zunigae* is described. This species is similar to *E. guanacastense* and *E. isomerum*, from which it differs by the narrow, lanceolate leaves, the greenish flowers, the apical half of the column purple with the clinandrium white, the sepals 11 mm long, and the creamy yellow, cordiform, acute, bicallose lip, wich is somewhat convex in natural position.

Resumen: Presentamos e ilustramos 11 nuevos registros de Orchidaceae para Costa Rica, y proponemos una nueva combinación en *Acianthera* para *Pleurothallis aberrans*. Se confirma la presencia en el país de *Barbosella orbicularis* y *Myoxanthus speciosus*, registradas anteriormente con base en registros dudosos, y las dos especies se ilustran con material costarricense. *Warmingia margaritacea* se reduce a la sinonimia de *Warmingia zamorana*, una especie previamente conocida solamente del Ecuador. Se describe una nueva especie, *Epidendrum zunigae*. Esta especie es similar a *E. guanacastense* y *E. isomerum*, de los cuales difiere por las hojas estrechas, lanceoladas, las flores verduzcas, con la mitad apical de la columna morada y el clinandrio blanco, los sépalos 11 mm de largo y el labelo cordiforme, agudo, bicalloso y amarillo crema, el cual es algo convexo en posición natural.

Key words: *Acianthera aberrans*, Costa Rica, *Epidendrum zunigae*, floristics, new records, Orchidaceae, *Warmingia zamorana*.

Despite its well established tradition in botanical exploration, which started in 1846 with the visit of Oersted (1846), Costa Rica is still far from having a complete inventory of its orchidaceous flora. The establishment of large and documented collections of living plants at Lankester Botanical Garden, associated with an increasing access to critical documentation, have been the key to improve our understanding of orchid diversity in Costa Rica.

After the publication of the most recent and complete treatment of the family by Dressler (2003) new species have been added on a regular basis to the country's inventory. As part of the general activities of botanical exploration, documentation and orchid identification carried out at Lankester Botanical Garden, we present the following new records for the flora of Costa Rica and a new species:

1. ***Acianthera aberrans*** (Luer) Pupulin & Bogarín, ***comb. nov.***
   Basionym: *Pleurothallis aberrans* Luer, Selbyana 2(4): 382. 1978. Type: Panama. Veraguas: epiphytic in tree north of the continental divide, alt. ca. 700 m., above Santa Fé, 6 September 1976, *C. Luer & R.L. Dressler 1628* (holotype, SEL). *Aberrantia aberrans* (Luer) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 253. 2004, *nom. inval*. *Aberrantia*

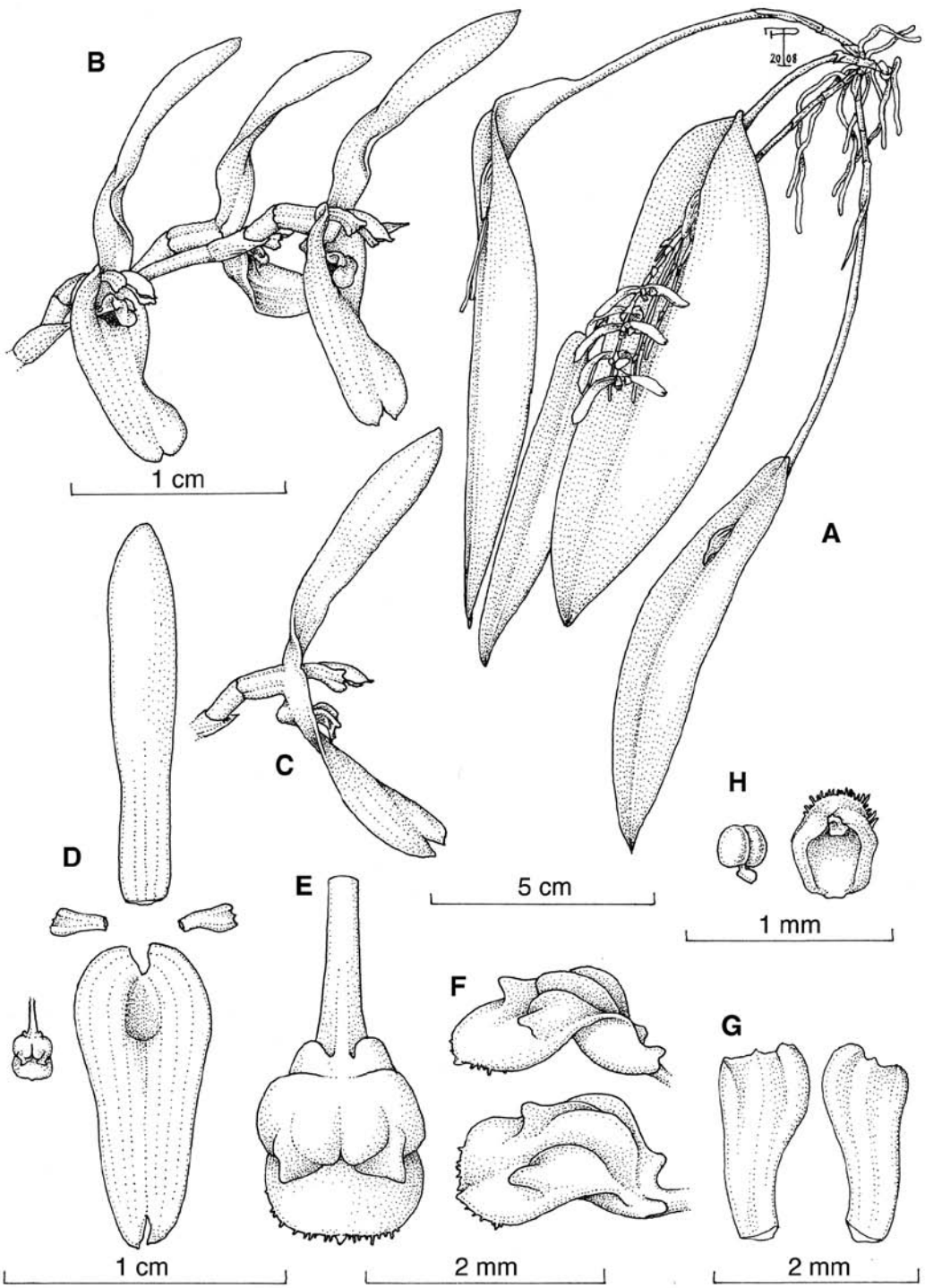


FIGURE 1. *Acianthera aberrans* (Luer) Pupulin & Bogarín. A. Habit. B. Apex of inflorescence. C. Flower, side view. D. Dissected perianth. E. Lip, frontal view. F. Lip, lateral views. G. Petals, lateral views. H. Pollinarium and anther cap. Drawing by F. Pupulin based on *Pupulin et al. 4857* (JBL-spirit).

aberrans (Luer) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 103: 310. 2005.

Distribution: Costa Rica, Panama and Ecuador.

Etymology: from the Latin *aberrans*, "away from the usual", in reference to the unusual characteristics of the species, according to its author.

Habitat in Costa Rica: epiphytic in tropical rain forest in the Caribbean lowlands at 275 m of elevation.

Costa Rican material studied: Heredia: Sarapiquí, Horquetas, road to Rara Avis, ca. 6 km, granja La Selva, 10º20'15"N 84º00'15" W, 275 m, tropical rain forest, secondary vegetation with large remnant trees, along the edge of pastures, 26 July 2003 *F. Pupulin 4857, M. Pupulin, C. Pupulin, C. Ossenbach & B. Arias* (JBL-spirit!) (Fig. 1, 15-A).

Although this species has not been yet analyzed by molecular phylogenetic techniques, morphological features suggest that it belongs to the genus *Acianthera* Scheidw. Luer (1978) stated that it vegetatively resembles to *Pleurothallis circumplexa* Lindl., *P. pacayana* Schltr., and *P. pantasmi* Rchb.f. (all now included in the genus *Acianthera*) because the inflorescence emerges from the blade of the leaf above the base. Also, he noted that the green, glabrous, gaping flowers in the short raceme resemble those of *Pleurothallis cogniauxiana* Schltr., *P. decipiens* Ames & C.Schweinf., and *P. verecunda* Schltr. (as well as many others), all of them also transferred to the genus *Acianthera* by several authors (Pridgeon & Chase 2001, Luer 2004). Its bicallose, truncate petals ending into a short apiculum, as well as the long claw of the lip, are unusual features of this species. Luer (2004, 2005) considered these floral details, together with the pair of pointed calli laying near the center of lip (rounded in our specimen) as critical features to segregate *Pleurothallis aberrans* into the monotypic genus *Aberrantia* Luer. We consider the monotypic genus *Aberrantia*, only defined by subtle floral features, congeneric with *Acianthera*. According to Luer (2003a), the voucher cited by Pupulin (2002a) is from Panama. Here, we cite a Costa Rican voucher for this species.

2. ***Barbosella orbicularis*** Luer, Selbyana 3 (1, 2): 10. 1976. Type: Panama. Panamá: La Eneida, region of Cerro Jefe, epiphytic, alt. 1000 m, 25 December 1967, *R. L. Dressler 3285* (holotype, SEL).

Distribution: Costa Rica, Panama, Colombia, Ecuador and Venezuela.

Etymology: from the Latin *orbicular*, rounded, in allusion to the characteristic shape of the lenticular leaves.

Habitat in Costa Rica: Epiphytic in tropical wet forest along the Caribbean watershed of the Central Volcanic range at about 500 m of elevation.

Costa Rican material studied: Limón: Siquirres, Siquirres, Alto Guayacán, ca 500 m, camino de Siquirres hacia Turrialba, terrenos de "Costa Rican Amphibian Research Center", en árbol viejo de pilón (*Hyeronima* sp.) en potrero, bosque húmedo tropical, colectada por B. Kubicki, 30 septiembre 2005, *D. Bogarín 1949* (JBL-spirit) (Fig. 2, 15-B).

This species had been cited for Costa Rica by Pupulin (2002a) based on a plant cultivated at Lankester Botanical Garden. Unfortunately, the plant never flowered, although it was clearly a specimen of *B. orbicularis*. It was excluded from the flora of Costa Rica by Luer (2003b), because of the absence of a proper voucher. Fertile material now available leaves no doubt of the occurrence of this species in Costa Rica.

Among Costa Rican species of *Barbosella*, *B. orbicularis* is the most distinctive. It is easily recognized by the creeping habit, the rounded smooth, overlapping leaves and the purplish flowers with a 3-lobed lip.

3. ***Brenesia lappiformis*** (A.H.Heller & L.O.Williams) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 95: 255. 2004. *Pleurothallis lappiformis* A.H.Heller & L.O.Williams, Fieldiana, Bot. 31: 42. 1964. *Myoxanthus lappiformis* (A.H.Heller & L.O.Williams) Luer, Monogr. Syst. Bot. Missouri Bot. Gard. 15: 38. 1986; *Echinella lappiformis* (A.H.Heller & L.O.Williams) Pridgeon & M.W.Chase, Lindleyana 16: 253. 2001, *nom. illeg.*; *Echinosepala lappiformis* (A.H.Heller &

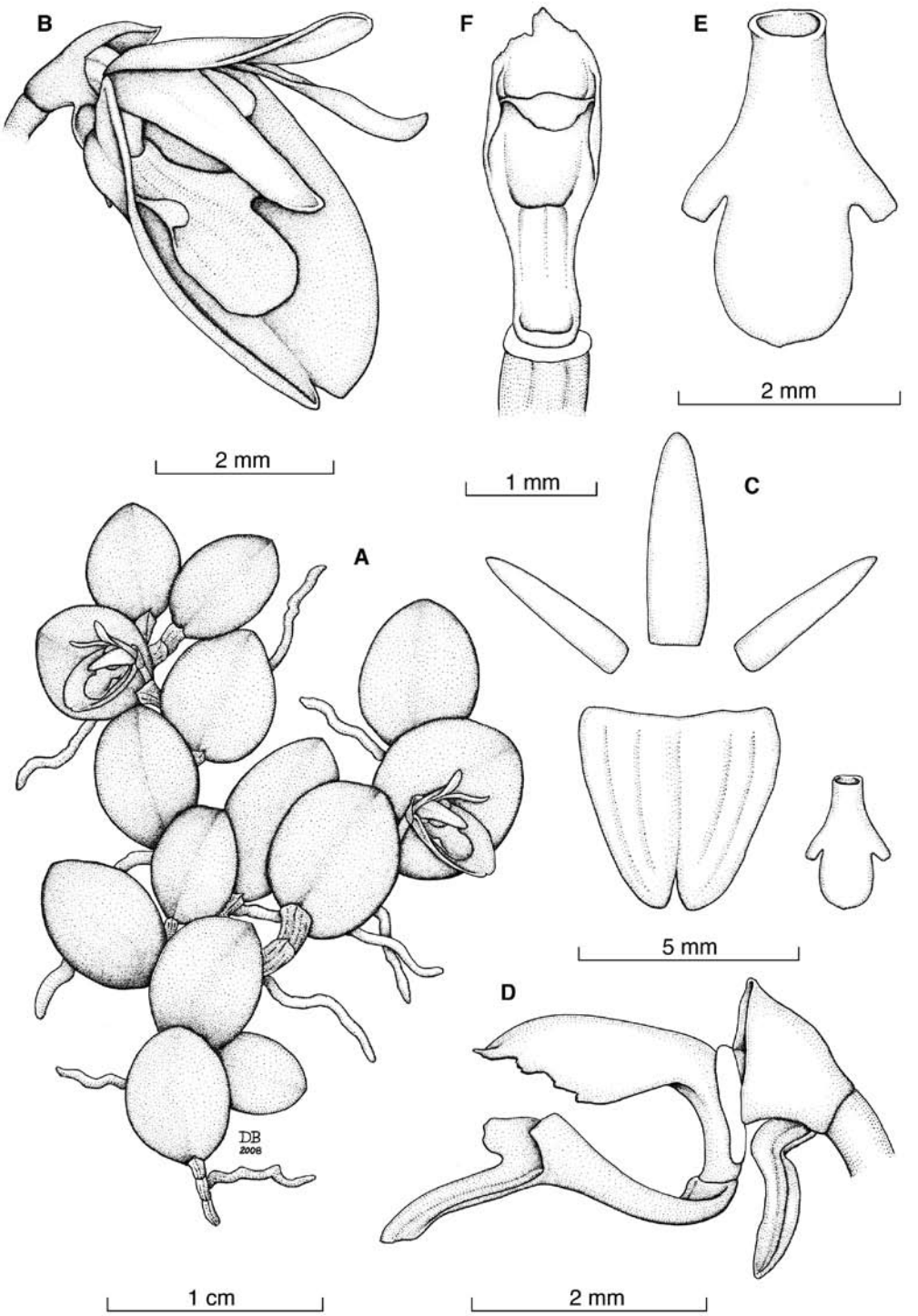


FIGURE 2. *Barbosella orbicularis* Luer. A. Habit. B. Flower. C. Dissected perianth. D. Column and lip, lateral view. E. Lip. F. Column, frontal view. Drawing by D. Bogarín based on *Bogarín 1949* (JBL-spirit).

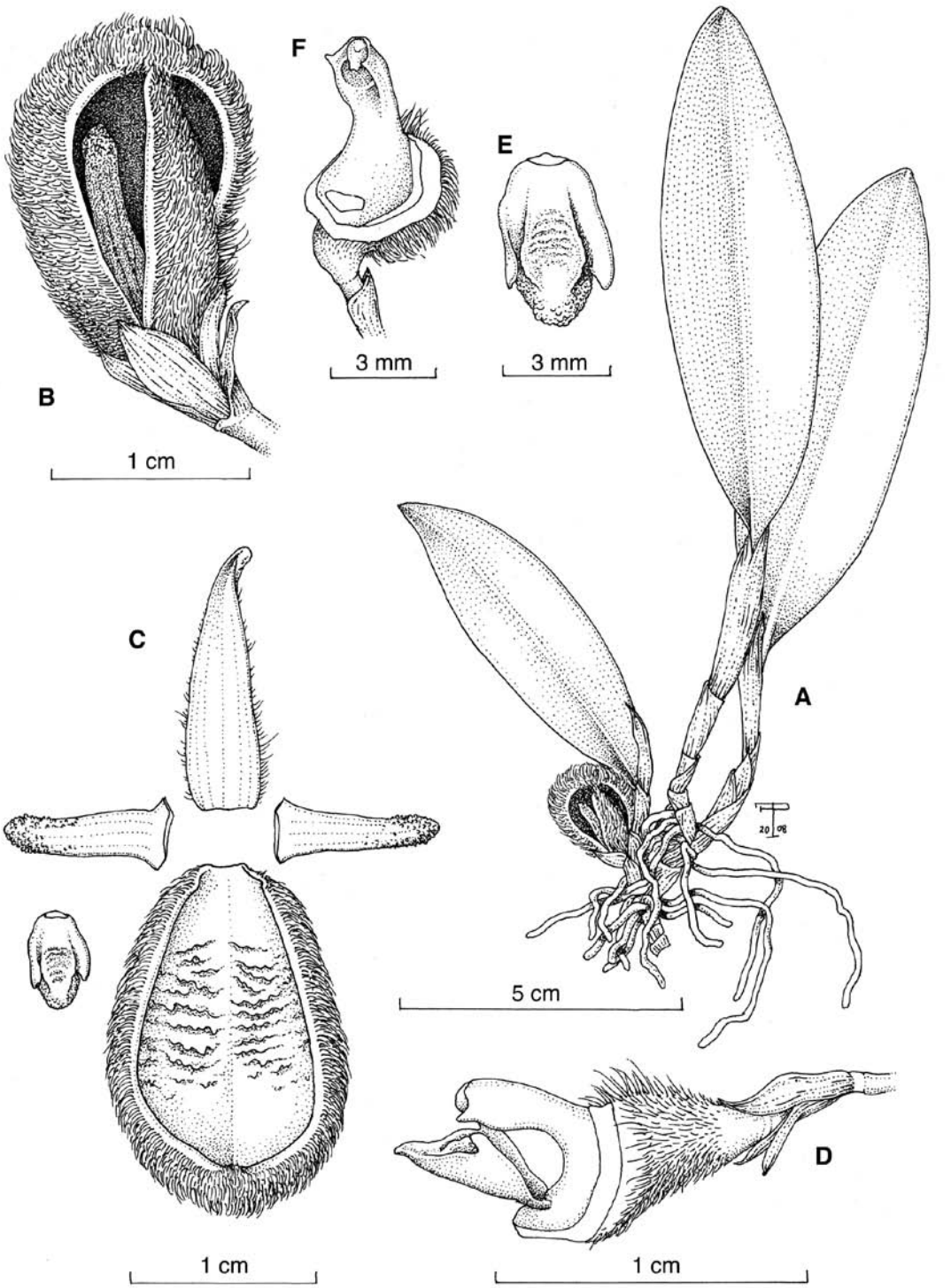


Figure 3. *Brenesia lappiformis* (A.H.Heller & L.O.Williams) Luer. A. Habit. B. Flower. C. Dissected perianth. D. Column and lip, lateral view. E. Lip. F. Column, frontal view. Drawing by F. Pupulin based on *Bogarín 890* (JBL-spirit)

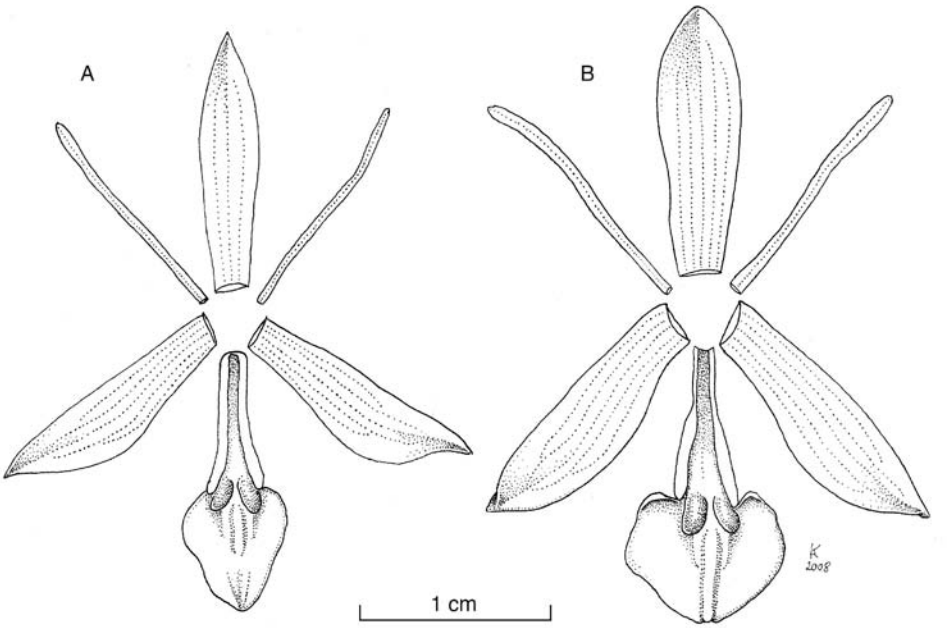


FIGURE 4. Comparison of dissected perianths of *Epidendrum adnatum* (A) and *E. maduroi* (B). ILLUSTRATION VOUCHERS: A, *Bogarín 2378* (JBL-spirit); B, *Bogarín 601* (JBL-spirit). Drawings by A. Karremans.

L.O.Williams) Pridgeon & M.W.Chase, Lindleyana 17: 101. 2002. Type: Nicaragua: Chontales: epiphytic at Pistacho Peak near Babilonia Mine, alt. 650 m, July 1962, *A. Heller 6620* (holotype, F, not seen).

DISTRIBUTION: Nicaragua, Costa Rica Venezuela, Ecuador.

ETYMOLOGY: from the Latin *lappiformis*, "stone-shaped" or "bur shaped", in reference to the round and hard consistency of the flowers.

HABITAT IN COSTA RICA: epiphytic in tropical wet forest, premontane belt transition, and premontane wet forest, basal belt transition, along the Caribbean lowlands.

COSTA RICAN MATERIAL STUDIED: Heredia: Sarapiquí, Horquetas, *C. Ossenbach 265* (JBL-spirit!). Limón: Pococí, Guápiles, carretera Braulio Carrillo, ca. 2 km hacia abajo de la entrada del Teleférico del Bosque Lluvioso, en lomas a orilla de la carretera, 520 m, 10°11'33"N 84°54'27"W, bosque muy húmedo tropical transición a premontano, epífitas en árboles caídos en bosque secundario, 9 julio 2004, *D. Bogarín 890 & F. Pupulin* (JBL-spirit!) (Fig. 3, 15-C).

This species is distinguished by the dark purple, hairy flower, with the tip of the narrow dorsal sepal touching the apex of the synsepal. The sepals are rugose-verrucose in the inner surface. A closely related species, *Brenesia stonei* (Luer) Luer, endemic to Costa Rica, is distinguished by the broad dorsal sepal, free from the synsepal, spathulate, rugose petals and narrowly uncinate lateral lobes of the lip.

4. ***Epidendrum maduroi*** Hágsater & García-Cruz, Icon. Orchid. (Mexico) 3: pl. 352. 1999. Type: Panama: Chiriquí: Norte de Guadalupe, Cerro Punta, Volcán Barú, 2000-3000 m, collected 15 March 1981, pressed 22 February 1983, *E. Hágsater & R.L. Dressler 6468* (holotype, AMO, not seen; isotype, MO, not seen).

DISTRIBUTION: Costa Rica and Panama.

EPONYMY: dedicated to Andrés Maduro, owner of Finca Dracula, Panama, where the collectors were based when collecting the type.

HABITAT IN COSTA RICA: epiphytic in premontane

and montane wet forests in the Central Cordillera at elevations of 1400-1800 meters.

Costa Rican material studied: Alajuela: San Ramón, Piedades Norte-Zapotal, camino entre el Cerro Azahar hacia Los Bajos y San Antonio de Zapotal, Finca de Don Guillermo, 10°10'07.9"N 84°35'50.3" W, 1423 m, bosque pluvial premontano, epífitas en bosque secundario, 24 marzo 2005. *D. Bogarin 1465*, *F. Pupulin*, *A.C. Rodríguez & E. Salas* (JBL-spirit!). Heredia: San Rafael, camino del Monte de La Cruz hacia el Refugio de Vida Silvestre Cerro Dantas, a orillas del Río Nuevo y la Quebrada Cabra, Reserva Forestal Cordillera Volcánica Central, 1800 m, 10°5'45"N 84°02'02"W, bosque pluvial premontano, epífitas en bosque secundario, 7 enero 2004, *D. Bogarin 601, D. Lobo & A. Vargas*. (JBL-spirit!) (Fig. 4, Fig.15-D).

Epidendrum maduroi belongs to the *E. albertii* group (Hágsater 1999a). Plants of *E. maduroi* have probably been confused as both *E. adnatum* and *E. lankesteri*, described from Costa Rica. *Epidendrum maduroi* can be distinguished from both species by the wider, 8 mm vs. 4-5 mm, unlobed, widely ovate-subchordate vs. slightly lobed, narrowly ovate lip (Ames 1923, Ames & Schweinfurth 1925).

5. ***Epidendrum orthodontum*** Hágsater & L.Sánchez, Icon. Orchid. 3: t. 361. 1999. Type: Panamá: Provincia Chiriquí: Cuesta de Las Palmas, southern slopes of Cerro de La Horqueta, humid forest, 1700-2100 m, 17 March 1911, *H. Pittier 3220* (holotype, US-677617, not seen; isotype, AMES-22677, photo).

Distribution: Costa Rica and Panama.

Etymology: from the Greek *ortho*, "erect" and *odonto*, "tooth" in reference to the erect tooth at the apex of the column.

Habitat: plants of this species were found growing in montane wet forest at around 2500 m elevation in the Cordillera de Talamanca.

Costa Rican material: Alajuela: La Palma de San Ramon, 1250 m, 11 octubre 1922, *Brenes 337* (CR); La Palma, 24 de octubre 1922, *Brenes (7) 337* (AMES, photo; CR); La Palma de San Ramon, 1250 m, 4 de noviembre 1924, *Brenes (1114) 256* (NY, not seen). Cartago: El Guarco, San Isidro, Madreselva, Tres de Junio, Carretera Interamericana Sur, km 67, 9°40'27.4" N 83°51'66.5" W, 2530 m, bosque pluvial montano, en bosque secundario a orillas de la carretera, 20 de enero 2008, *A. Karremans 2255*. (JBL-Spirit!) (Fig. 5).

Epidendrum orthodontum is similar to *E. nutantirhachis* Ames & C. Schweinf., but it can be distinguished by the trilobed lip, the larger flowers (sepals 10-12 mm vs. 8-9 mm long; petals 9-10 mm vs. 6-8 mm long), and the erect mid tooth of the column, forming a 90° angle with column (vs. semierect, forming a 45° angle with the column) (Hágsater 1999b).

6. ***Epidendrum scharfii*** Hágsater & Dodson, Icon. Orchid. 2: t. 185. 1993. Type: Ecuador. Pichincha: along river and hillside opposite town of Tandapi at km 55 Santo Domingo to Quito road, 31 December 1986, *C. Dodson & T. Dodson 16757* (holotype, RPSC, not seen).

Distribution: Costa Rica, Colombia and Ecuador. This species may well occur in Panama.

Eponymy: dedicated to Colonel Paul Scharf, bird watcher and occasional orchid collector in Quito, Ecuador.

Habitat in Costa Rica: plants of this species grow on both the Atlantic and Pacific watersheds of the Talamanca range, in premontane wet forests at elevations between 700 to 1200 m.

Costa Rican material studied: Cartago: border between Turrialba and Jiménez, La Suiza, Pejivalle, road to Esperanza, on hills close to Quebrada Puente, 9º48'46.0"N 83º39'10.0"W, 750 m, premontane wet forest, epiphytic in secondary vegetation along the sugar cane plantations, 5 February 2007, *F. Pupulin 6500, D. Bogarín & R.L. Dressler* (JBL-spirit) (Fig. 6, 15-E). Cartago: Límite entre Turrialba y Jiménez, La Suiza, Pejivalle, camino a Esperanza, en lomas cerca de la Quebrada Puente, 9°48'46.0"N 83°39'10.0" W, 738 m, bosque muy húmedo premontano, epífitas en bosque secundario a la orilla de cañaverales, 1 mayo 2008, *D. Bogarín 4835, A. Karremans, Y. Kisel &*

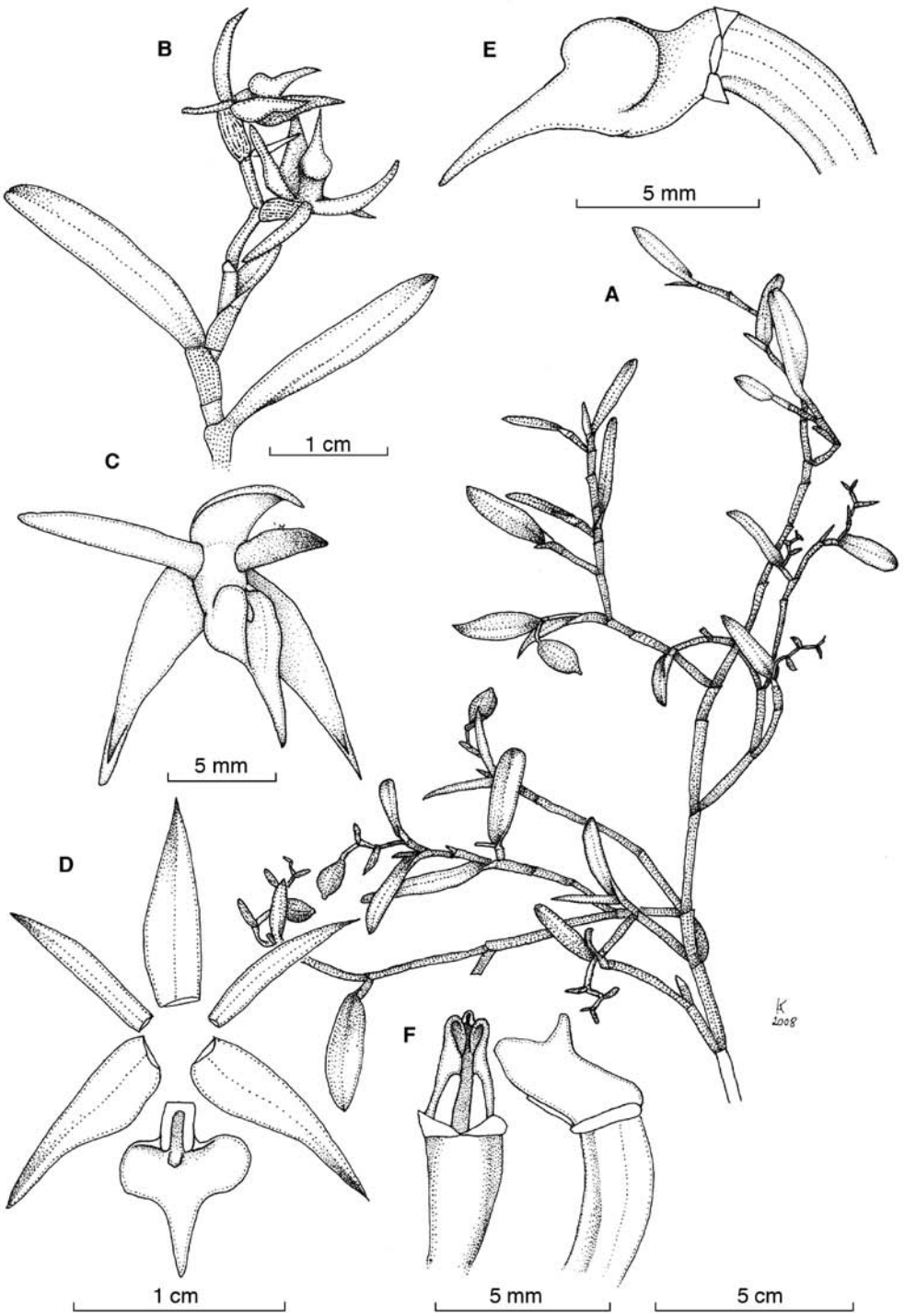


FIGURE 5. *Epidendrum orthodontum* Hágsater & L.Sánchez. A. Habit. B. Inflorescence. C. Flower. D. Dissected perianth. E. Column and lip, lateral view. F. Column, frontal and lateral view. Drawing by A. Karremans based on *Karremans 2255* (JBL-spirit).

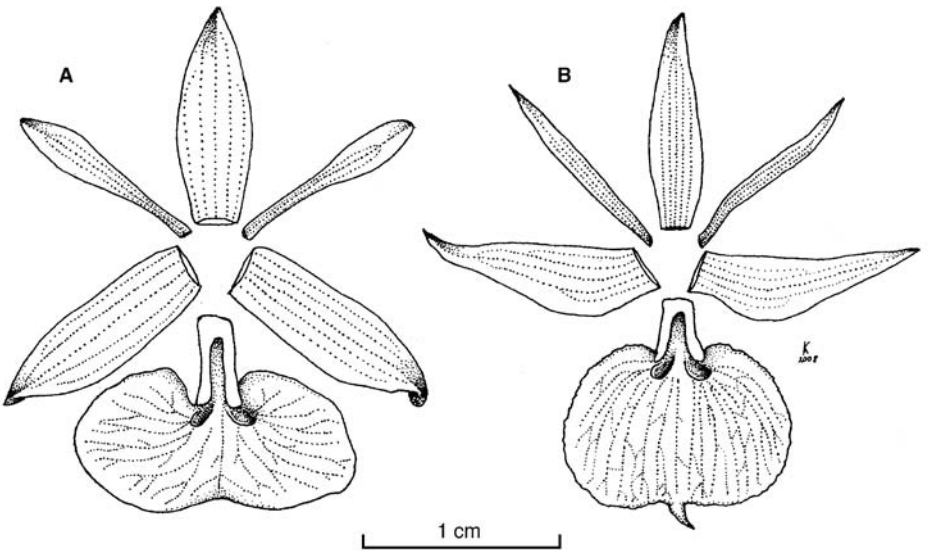


Figure 6. Comparison of dissected perianths of *Epidendrum scharfii* (A) and *E. dentiferum* (B). Illustration vouchers: A, *Pupulin 6500* (JBL-spirit); B, *Karremans 1485* (JBL-spirit). Drawings by A. Karremans.

R. Phillips (JBL-Spirit). Puntarenas: Coto Brus, Las Cruces (entrada a Concepción), 1212 m, 8°46'55.68"N 82°57'51.36"O, 29 abril 2006, *C. Ossenbach 570 & P. Casasa* (JBL-spirit).

Epidendrum scharfii belongs to the *Epidendrum difforme* group. It is closely related to *Epidendrum dentiferum* Ames & C. Schweinf., but the latter has white-green flowers, acuminate segments, linear petals and lateral sepals forming a 90° angle with the dorsal sepal (vs. green flowers, obtuse segments, elliptic petals, and sepals forming a 120° angle in *E. scharfii*). It is also similar to *E. gregorii* which has shorter and wider sepals and petals and a bilobed lip, with each lobe obliquely notched on the distal margin.

7. ***Epidendrum stellidifforme*** Hágsater & Dodson, Icon. Orchid. (Mexico) 4: t. 487. 2001. Type: Ecuador: Carchi: Maldonado, 1500 m, 2 October 1981, *L. Werling & S. Leth-Nissen 147* (holotype, AMES, photo; isotype, QCA, not seen).

Distribution: Costa Rica, Colombia and Ecuador. This species may well occur in Panama.

Etymology: from the Latin *stella*, "star", in reference to the shape of the dry flowers and *difforme* for the group to which the species belongs.

Habitat in Costa Rica: epiphytic in tropical wet forest, premontane belt transition, on the eastern slope of the Miravalles Volcano at 650-700 m of elevation.

Costa Rican material studied: Alajuela: Upala, Bijagua, Zapote, desvío a la izquierda después del puente sobre Río Zapote en sentido Bijagua-Pueblo Nuevo, ladera este del Volcán Miravalles, siguiendo la margen del Río Zapote, 10°44'37.4"N 85°05'14.9"W, 650-700 m, bosque muy húmedo tropical, transición a premontano, epífitas en bordes de potreros y árboles aislados, 30 abril 2006*, D. Bogarín 2814, F. Pupulin, A. Rambelli & J. Rambelli* (CR, JBL-Spirit) (Fig. 7, 15-F).

Epidendrum stellidifforme belongs to *Epidendrum difforme* Jacq. group. It is similar *to Epidendrum hunterianum* Schltr., from which it can be distinguished by the larger (16 x 16 mm vs. 14 x 14 mm), shallowly three lobed, mucronate lip, the acute-acuminate sepals and petals, and the narrower (2.5-3 mm vs. 3.5-4 mm), narrowly elliptic (vs. elliptic) petals. The type species differs from the Costa Rican material in the acuminate, flat lip, and the smaller plants with shorter and narrower leaves (Hágsater 2001). The Colombian *Epidendrum killipii* Hágsater & L. Sánchez*,* is very similar to this species, and may prove to be the same. According to the protologue, the ovary of *E. killipii* is not inflated, but the drawing of the type shows both a cylindric,

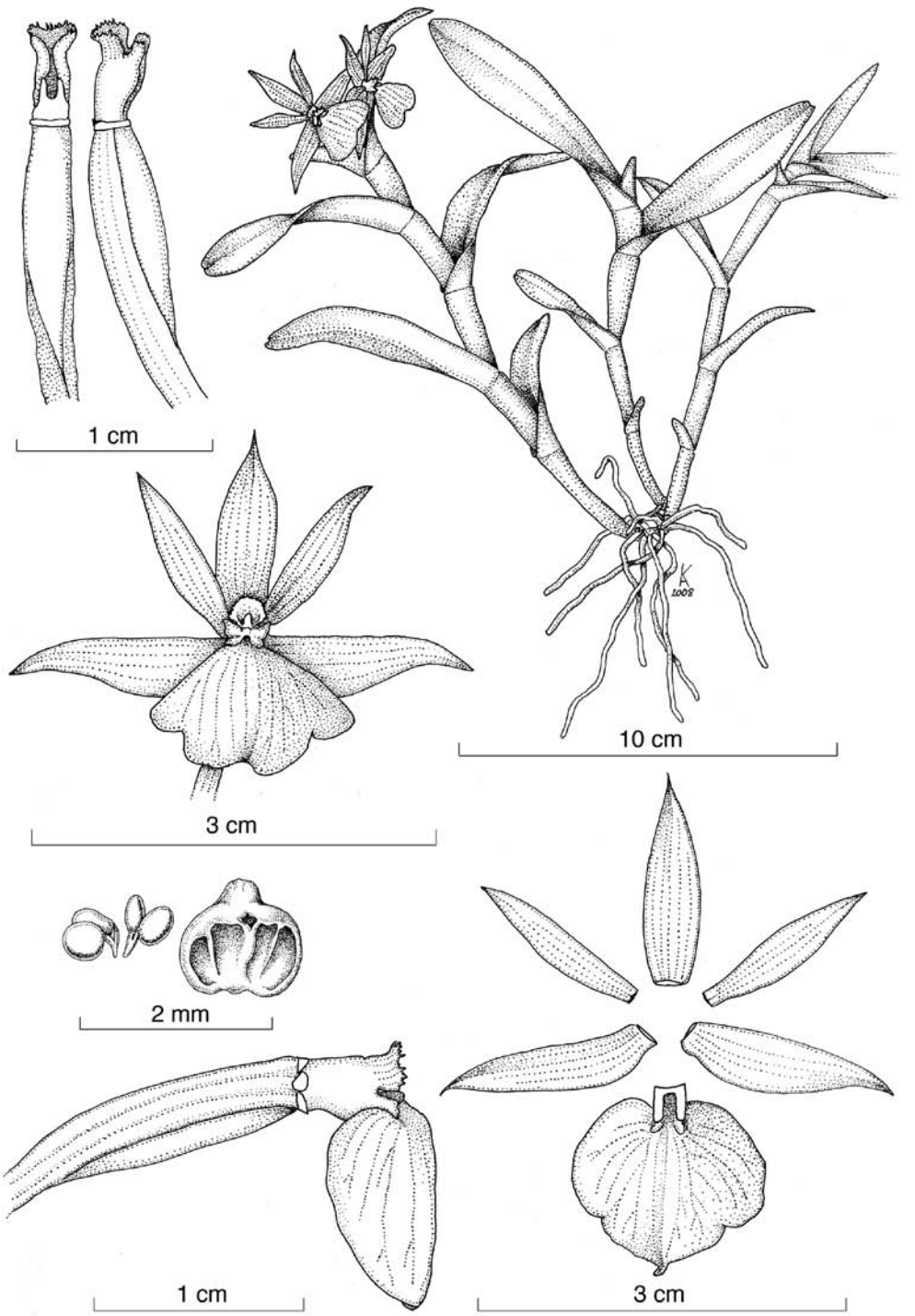


FIGURE 7. *Epidendrum stellidifforme* Hágsater & Dodson. A. Habit. B. Flower. C. Dissected perianth. D. Column and lip, lateral view. E. Column, frontal and lateral view. F. Pollinarium and anther cap. Drawing by A. Karremans based on *Bogarín 2814* (JBL-spirit).

narrow ovary in lateral view, and an inflated ovary in longitudinal section (Hágsater 1999c). If conspecific, the name *E. killipii* has priority.

8. ***Epidendrum zunigae*** Hágsater, Karremans & Bogarín, ***sp. nov***.

TYPE: Costa Rica. Puntarenas: Osa, Sierpe, Mogos, alrededores de Quebrada Porvenir, ca. 3 km norte de Alto de Mogos, 8°46'36.5"N 83°21'23.6" W, 126 m, bosque muy húmedo tropical, epífitas bosque secundario, 30 marzo 2006, *D. Bogarín 2680, J. Zúñiga & Curso de Botánica Forestal-UCR* (holotype, JBL-spirit) (Fig. 8, 15-G).

Species Epidendro guanacastensi Ames & C. Schweinf. similis, floribus majoribus viridulis, labello acuto bicalloso, apice columnae purpurea, clinandrio albo differt.

Plant epiphytic, monopodial, pendent, branching herb. *Roots* basal, from the main stem, fleshy, filiform, thin. *Stems* terete, somewhat flexuous, incipiently branched near the base of the main stem. *Leaves* numerous, distributed throughout the stems; sheath tubular, minutely rugose; blades linear-lanceolate, acuminate, short mucronate, coriaceous, slightly carinate, those on the main stem ca. 12, similar in size. *Inflorescence* apical, produced from the main stem, and presumably form the secondary branches; peduncle reduced. *Floral bracts* longer than the ovary, amplexicaul, imbricating, ovate-oblong, rounded. *Flowers* 3, distichous, greenish, the lip creamy yellow, column green at base, the apical half purple, clinandrium-hood white. *Ovary* terete, smooth, thin. *Sepals* partly spreading, narrowly elliptic, acute, 5-veined, margin slightly revolute, entire. *Petals* partly spreading, linear-elliptic, acute, 5-veined, margin entire, spreading. *Lip* entire, cordiform, acute, spreading, slightly convex in natural position, margin entire, spreading; bicallose, the calli thickened at the base and ending in low keels, with a prominent median keel stretching from the base of the lip to the apex. *Column* somewhat arching upwards above the middle, short, internally provided with a pair of lateral thickenings at the height of the rostellum, and forming a narrow channel; clinandrium hood prominent, funnel-shaped, fleshy, margin entire; rostellum at the middle of the column, slit. *Anther* obovate, 4-celled.

Distribution: Known only from the lowlands in front of the Osa Penninsula, near the Pacific coast of southern Costa Rica.

Eponymy: named in honor of José Daniel Zúñiga Delgado, research assistant at Jardín Botánico Lankester, who participated in the type collection. He photographed and preserved flowers in alcohol thus permitting its classification.

Habitat and ecology: epiphytic in secondary tropical wet forest at 100-150 m of elevation in the southern Pacific lowlands in Peninsula de Osa. Flowering in cultivation in November.

Epidendrum zunigae belongs to the *Epidendrum ramosum* group, which is characterized by the monopodial, branching stems, the spike-like, distichous inflorescence, and to the *Epidendrum isomerum* subgroup, which has long, pendent plants, very narrow, acute leaves, and 1- (rarely 3-) flowered inflorescences. *Epidendrum zunigae* is recognized by the narrow, lanceolate leaves, the greenish flowers with sepals to 11 mm long, the creamy yellow lip, the apical half of the column marked with purple, with a white clinandrium, and the cordiform, acute lip, somewhat convex in natural position. It resembles *E. isomerum* Schltr., which has 3-11 x 0.1-0.3 cm leaves, a single-flowered inflorescence produced from short flowering branches, green to yellowish green flowers, with very narrow floral segments, sepals 15-16 mm long, the lip rhombic-triangular, acute, with a "V" shaped callus. It is also similar to *E. guanacastense* Ames & C. Schweinf., which has thicker stems, and a zigzag inflorescence with 2-3 flowers, sepals 8-10 mm long, a cordiform, rounded lip, and the callus "Y" shaped.

9. ***Lockhartia chocöensis*** Kraenzl. in H.G.A.Engler (ed.), Pflanzenr., IV, 50(83): 19. 1923. Type: Colombia: Choco, *Triana s.n.* (holotype, W).

Distribution: Costa Rica, Colombia, Ecuador, Venezuela and Peru.

Etymology: named from the Choco region in Colombia, the place from where the type specimen was collected.

Habitat in Costa Rica: epiphytic in secondary forest in tropical wet forest premontane belt transition in the Caribbean watershed of Tilarán range.

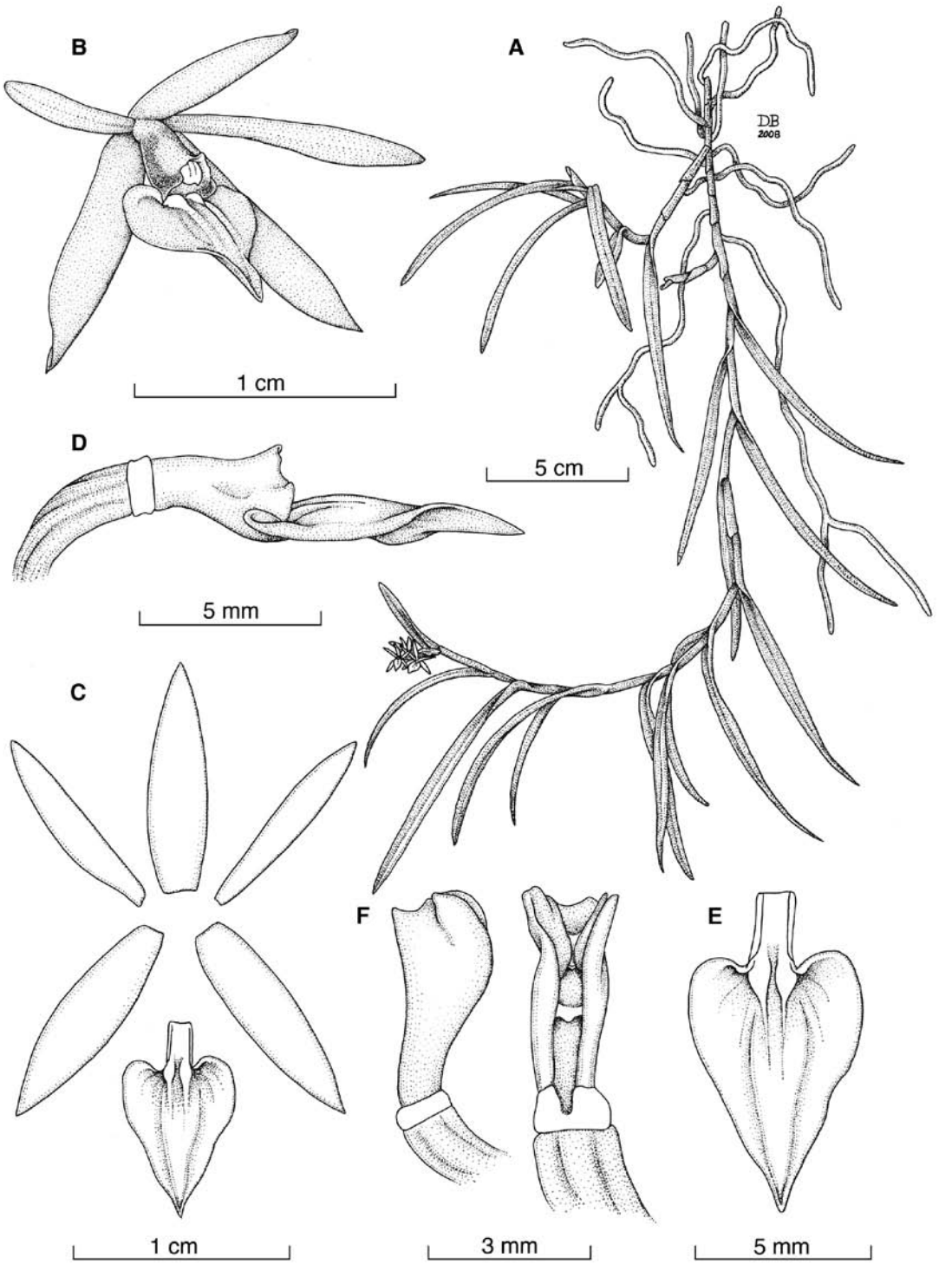


FIGURE 8. *Epidendrum zunigae* Hágsater, Karremans & Bogarín. A. Habit. B. Flower in natural position. C. Dissected perianth. D. Column and lip, lateral view. E. Lip. F. Column, lateral and frontal view. Drawn by D. Bogarín from the holotype.

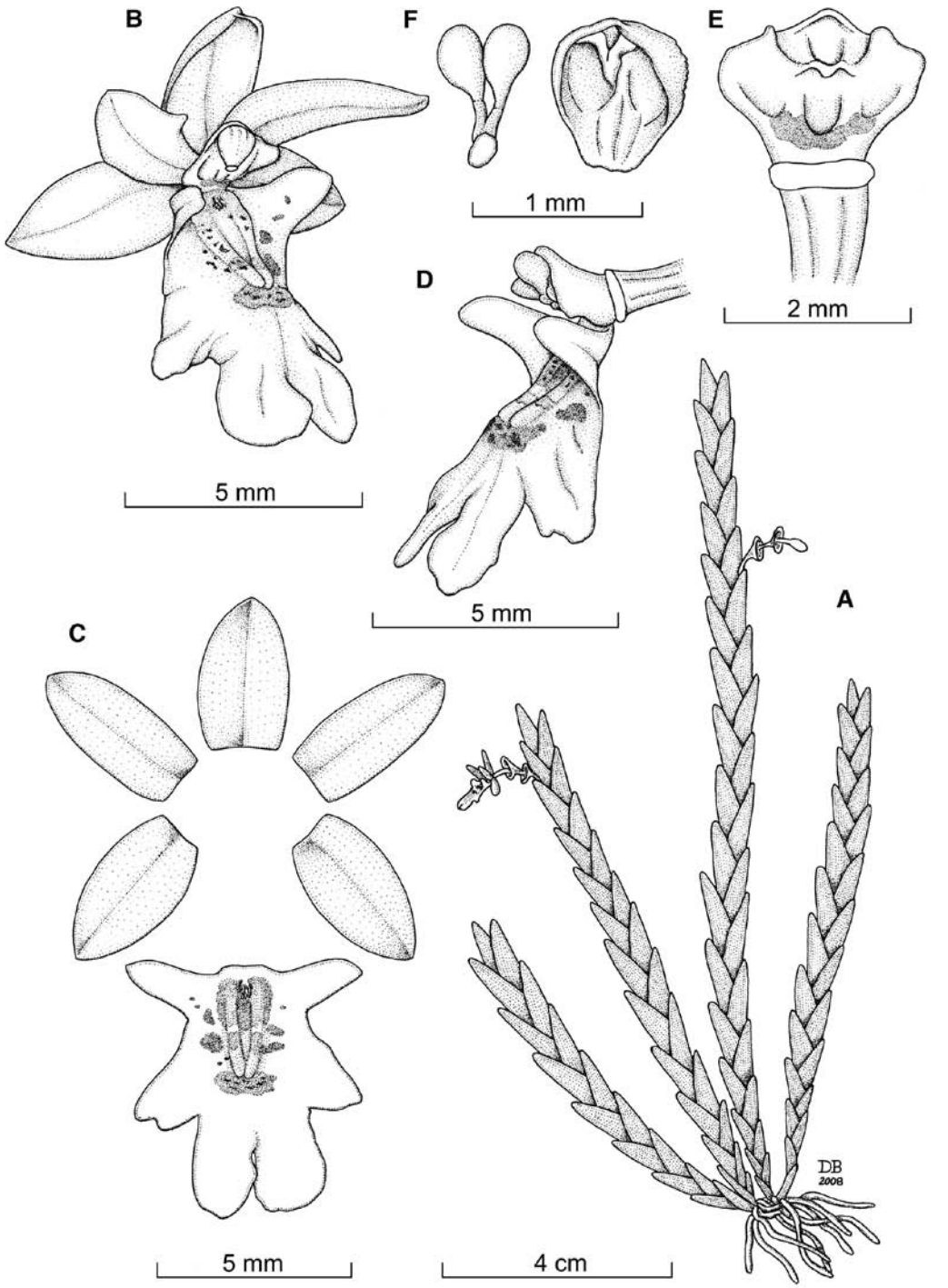


Figure 9. *Lockhartia chocöensis* Kraenzl. A. Habit. B. Flower in natural position. C. Dissected perianth. D. Column and lip, lateral view. E. Column, frontal view. F. Pollinarium and anther cap. Drawing by D. Bogarín based on *Bogarín 2352* (JBL-spirit).

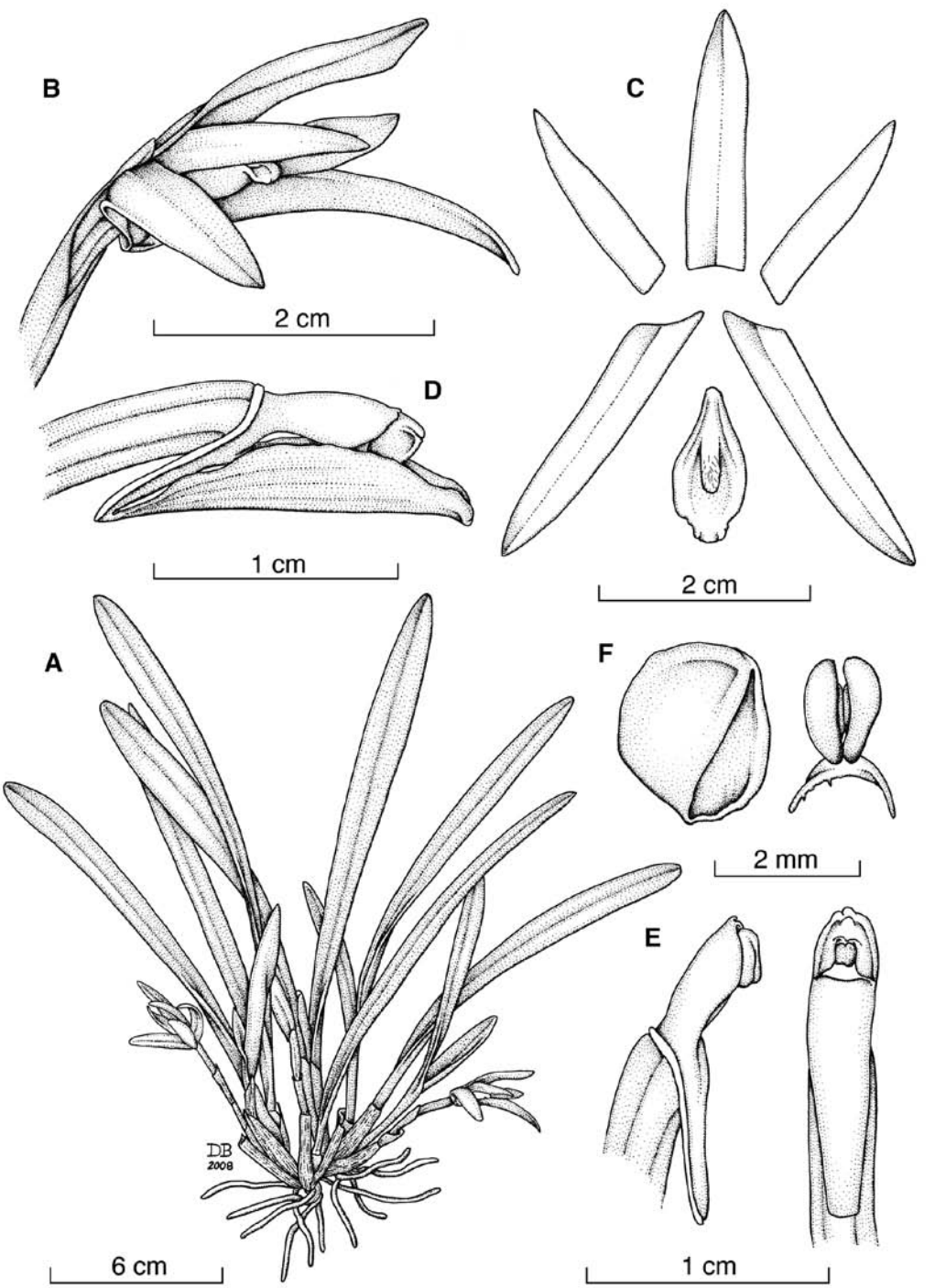


FIGURE 10. *Maxillaria bolivarensis* C.Schweinf. A. Habit. B. Flower in natural position. C. Dissected perianth. D. Column and lip, lateral view. E. Column, lateral and frontal view. F. Pollinarium and anther cap. Drawing by D. Bogarín based on *Whitten 2030* (JBL-spirit).

Costa Rican material studied: Alajuela: Upala, Aguas Claras de Buenos Aires, Hotel Termales Azules, camino por la ladera del Volcán Rincón de La Vieja, hasta las cataratas, 700-2000 m, 6 abril 2004, *A. Karremans 271* (JBL-spirit!). Upala, Bijagua, Zapote, desvío a la izquierda después del puente sobre Río Zapote en sentido Bijagua-Pueblo Nuevo, ladera este del Volcán Miravalles, siguiendo la margen del Río Zapote, 10°44'37.4"N 85°05'14.9"W, 650-700 m, bosque muy húmedo tropical, transición a premontano, epífitas en bordes de potreros y árboles aislados, 1 febrero 2006, *D. Bogarín 2352, R.L. Dressler, R. Gómez & A. Rojas* (JBL-spirit!) (Fig. 9, 15-H).

This species is similar to *Lockhartia micrantha* Rchb.f., but the lip is six-lobulate with a pair of narrow basal lobules folding upward, two acute lobules placed at the middle, and two apical, rounded lobules. The callus is made up by two parallel keels running to the middle and convergent at apex. The illustration shown in Garay and Dunsterville (1966), and identified as *L. chocöensis*, is consistent with the specimens studied from Costa Rica. *Lockhartia lankesteri* Ames, based on a collection by C.H. Lankester from Aguas Zarcas, San Carlos, in the Atlantic lowlands of Costa Rica, has been reduced into the synonymy of *L. micrantha*. With the discovery of *L. chocöensis* populations in Upala, close to the San Carlos region, it is now probable that *L. lankesteri* is a later name for *L. chocöensis*. The drawing of the lip from the holotype of *L. lankesteri* at AMES (AMES-101030) is somewhat schematic however it shows two small lobes at the middle of the lip. A careful rehydratation of the flowers of the type should clarify the status of *L. lankesteri*.

10. ***Maxillaria bolivarensis*** C.Schweinf., Bot. Mus. Leafl. 20: 22. 1962. Type: Venezuela. State of Bolívar, Region of Urimán, forest mesa of Apradatepuí, at 950 m, August 13, 1953, *L. Bernardi 780* (holotype, MER, not seen; isotype, AMES-69561, photo).

Distribution: Costa Rica, Venezuela, Ecuador and Peru. The Costa Rican records are not so far away from Nicaraguan boundary. This species may well occur in Nicaragua, Panama and Colombia.

Etymology: from the State of Bolívar, Venezuela where the type specimen was collected.

Habitat in Costa Rica: epiphytic in tropical wet forest along the Caribbean lowlands.

Costa Rican material studied: Heredia: Sarapiquí, Horquetas, above Horquetas, Terra Folia Reserve, near Rara Avis, wet premontane forest, epiphytic, 10º18' 14" N 84° 01' 36" W, 500 m, 21 July 2003, *M. Whitten 2030 & M. Blanco* (JBL-Spirit!); Sarapiquí, Magsasay, ribera del Río Peje, 180 m, 31 diciembre 2005, *C. Ossenbach 507 & J.F. Casasa* (JBL-Spirit!) (Fig. 10, 15-I).

This species is easily recognized by the inconspicuous pseudobulbs, the linear-oblong, coriaceous leaves less than 1.5 cm wide, and the smooth clinandrium and anther cap. In Costa Rica, *Maxillaria confusa* Ames & C.Schweinf. is superficially similar to *M. bolivarensis*, however its conspicuous pseudobulbs, broader subcoriaceous leaves (up to 3 cm wide), fringed clinandrium and ciliate anther cap are useful features to recognize this species.

11. ***Myoxanthus speciosus*** (Luer) Luer, Selbyana 7: 51. 1982. *Pleurothallis speciosa* Luer, Selbyana 3: 392. 1977. Type: Panama: Chiriquí: epiphytic in cloud forest above Guadalupe, ca. 2000 m, 13 September 1976, *C. Luer & H. Butcher 1371* (holotype, SEL).

Distribution: Costa Rica and Panama.

Etymology: from the Latin *speciosus*, "splendid", in reference to its showy flowers.

Habitat in Costa Rica: epiphytic in lower montane rain forest at 2450 m of elevation in Talamanca range.

Costa Rican material studied: San José-Cartago: Dota-El Guarco, Jardín, entre La Chonta y Cañón, km 56 carretera Interamericana, Finca Santa María de La Selva, 9°41'27.5"N 83°55'20.3" W, 2450 m, epífita en bosque pluvial montano bajo, en árboles de potreros principalmente sobre *Drymis winteri, Alnus acuminata* y *Quercus* sp, 19 febrero 2005, *D. Bogarín 1420, C. Ossenbach & F. Pupulin* (JBL-spirit!) (Fig. 11).

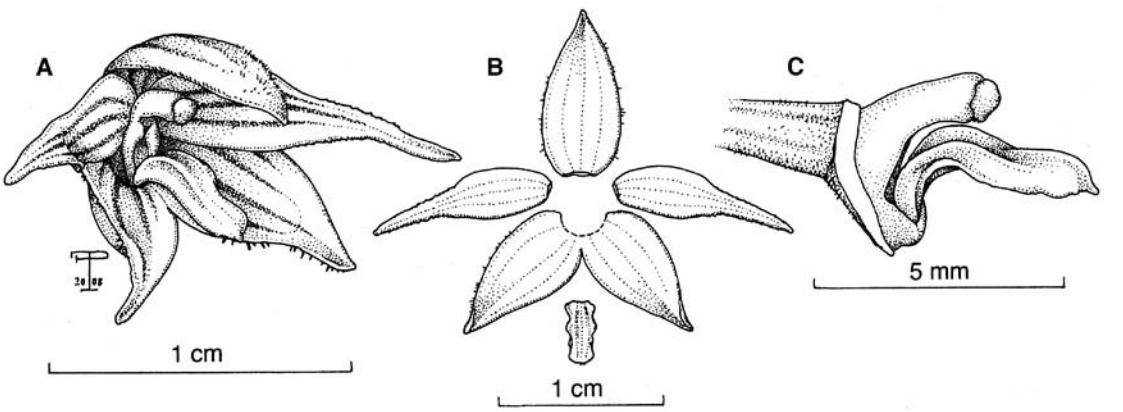


FIGURE 11. *Myoxanthus speciosus* (Luer) Luer. A. Flower in natural position. B. Dissected perianth. C. Column and lip. Drawing by F. Pupulin based on *Bogarín 1420* (JBL-spirit).

Pupulin (2002a) and Luer (2003) cited this species for Costa Rica based on a plant cultivated in Switzerland and collected in "Cordillera de Talamanca, Sierra Hills near Corazón de Jesús, alt. 2100 m" in Puntarenas Province (*Jenny P-25*, MO). Luer (2003c) stated that its origin is doubtful in all the collection details including the country. However, material collected near Cerro de La Muerte, along the Panamerican Highway and flowered in the living collections at Lankester Botanical Garden confirms the presence of this species in Costa Rica.

12. ***Scaphyglottis robusta*** B.R.Adams, Phytologia 64: 253. 1988. Type: Panama. Panama: El Llano-Carti-Tupile road, 10-12 km N of Inter-Am. Highway, 9 January 1975, *Luteyn & Wilbur 4679* (holotype, DUKE, not seen).

DISTRIBUTION: Costa Rica and Panama.

ETYMOLOGY: from the Latin *robustus,* "stout" in reference to the robust and strong appearance of this species compared with other members of the genus.

HABITAT IN COSTA RICA: epiphytic in tropical wet premontane forest to 1150 m of elevation in the Caribbean watershed of the Talamanca range.

COSTA RICAN MATERIAL STUDIED: Cartago: Jiménez, La Esperanza, floreció en cultivo en la colección de Julio Carmona, La Suiza de Turrialba, 22 marzo 2006, *D. Bogarín 2662* (CR, JBL-Spirit) (Fig. 12, 15-J). Turrialba, Pacayitas, calle a La Suiza, ca. km 8, 9º52'29.9"N 83º35'03.6"W, 1150 m, bosque húmedo premontano, 4 de marzo 2007, *A. Karremans 1661 & D. Karremans* (JBL-Spirit).

This species is similar in habit to *Scaphyglottis modesta* (Rchb.f.) Schltr.; however, it can be distinguished by the larger habit, the yellow-greenish to bright green flowers (vs. white with reddish-purplish stripes in *S. modesta*. Antillean plants have dull, yellow-greenish to brownish-green), the spathulate lip (vs. 3-lobed) and the prominent wings of the column. *Scaphyglottis anneliesae* Brieger, a *nomen nudum* published without a description or any indication of the type, has been attributed to Costa Rica. Adams (1993) studied Brieger's accompanying photographs and suggested that it is referable to *S. robusta*. However in describing *S. robusta*, he only cited Panamanian material. Here, we report the presence of *S. robusta* in Costa Rican based on two collections.

13. ***Sobralia bouchei*** Ames & C.Schweinf., Schedul. Orchid. 10: 4. 1930. Type: Panama. March-April 1930, 2200 feet, terrestrial and epiphytic, *A.M. Bouché s.n.* (holotype, AMES-35595, photo).

DISTRIBUTION: Nicaragua, Costa Rica and Panama.

EPONYMY: in honor of Adrien M. Bouché, who collected the type specimen.

HABITAT IN COSTA RICA: epiphytic or terrestrial in

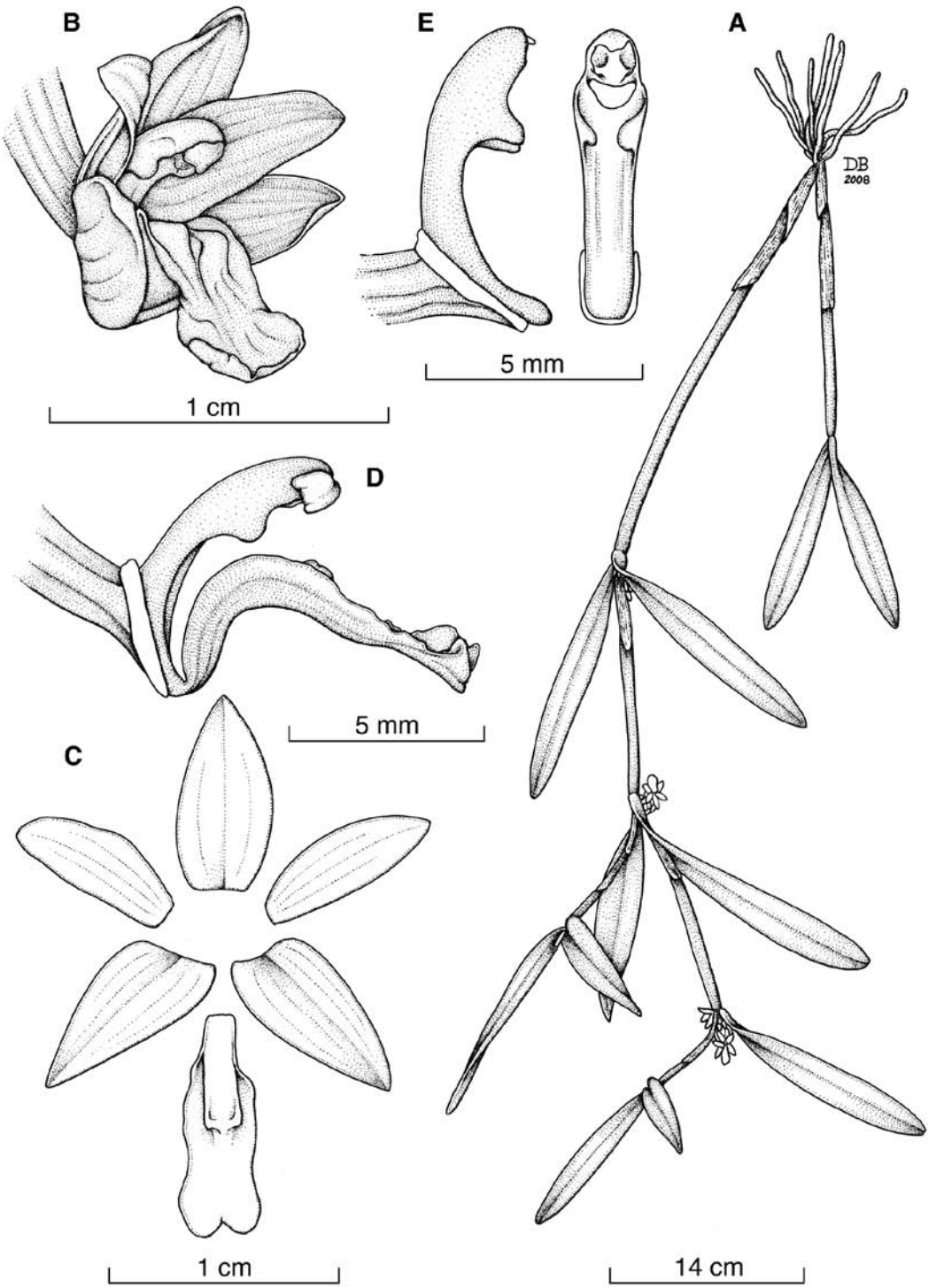


Figure 12. *Scaphyglottis robusta* B.R. Adams. A. Habit. B. Flower in natural position. C. Dissected perianth. D. Column and lip, lateral view. E. Column, lateral and frontal view. Drawing by D. Bogarín based on *Bogarín 2662* (JBL-spirit).

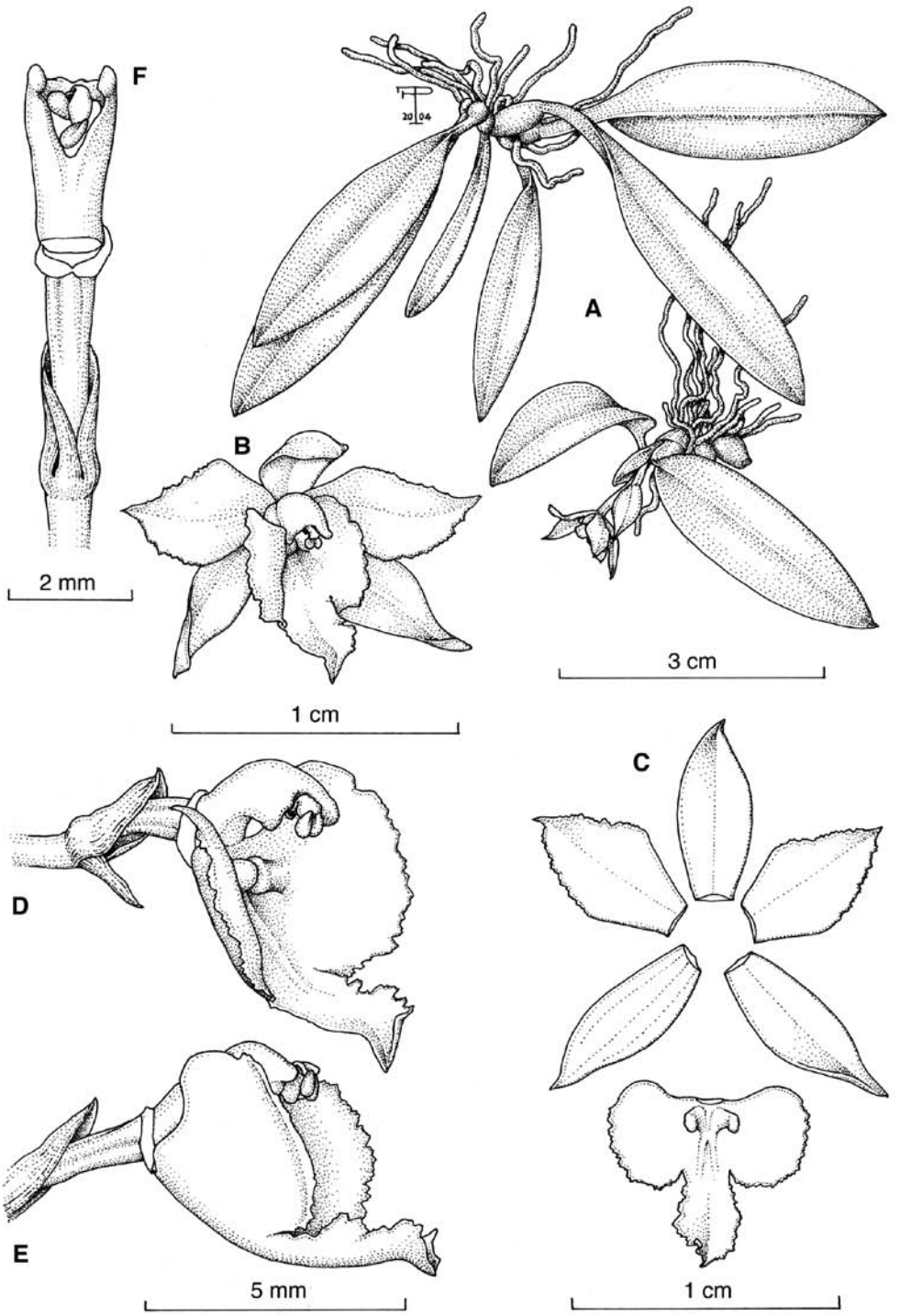


FIGURE 13. *Warmingia zamorana* Dodson. A-B. Habit. C. Flower. D. Dissected perianth. E. Column and lip, three-quarter view. F. Column and lip, lateral view. G. Column, ventral view. In E-G the pollinarium is bending toward the stigma, whereas the viscidium is still in place. Drawing by F. Pupulin based on *Karremans 452* from Costa Rica (JBL-spirit).

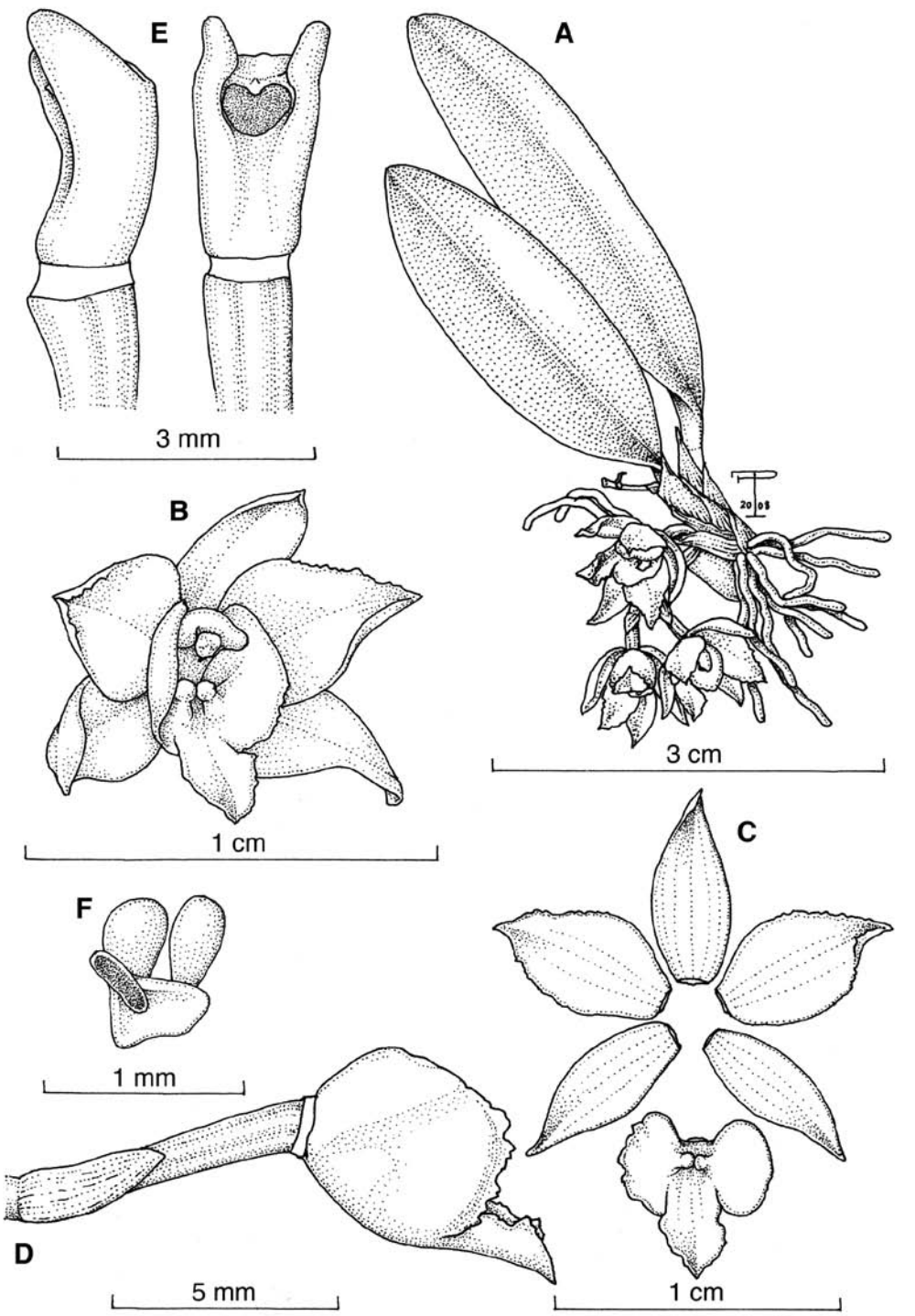


Figure 8. *Warmingia zamorana* Dodson. A. Habit. B. Flower in natural position. C. Dissected perianth. D. Column and lip, lateral view. E. Column, lateral and ventral view. F. Pollinarium. Drawing by F. Pupulin based on *Medina s.n.* from Ecuador (CIOA-spirit).

roadcuts in tropical wet premontane forest to 900 m of elevation in the Caribbean watershed of the Talamanca range.

Costa Rican material studied: Cartago: Turrialba, Tayutic, carretera entre Tayutic y Jicotea, Platanillo, laderas del Río Platanillo, siguiendo la margen del río, 9°49'27.46"N 83°33'13.29"W, 878 m, bosque muy húmedo premontano, 1 abril 2008*, D. Bogarín 4201, A. Russell & R. Samuel* (JBL-Spirit).

This species is easily recognized by the pink flowers and the strongly ruffled purple lip with 7 crisped golden-yellow keels. The leaves are bright green and smooth. Plants from Panama and cultivated at Lankester Botanical Garden produce fully opened flowers. Nevertheless, the plant collected in Costa Rica has flowers self-pollinated and developing fruits. This condition has been also observed in Nicaraguan material (Dressler, pers. comm. 2008). *Sobralia triandra* A.H.Heller & A.D.Hawkes described from Nicaragua could be conspecific with *S. bouchei*.

14. ***Warmingia zamorana*** Dodson, Icon. Pl. Trop., II, 6: t. 599. 1989. Type: Ecuador. Zamora-Chinchipe: Zamora, 1000 m, August 1968, *C. H. Dodson 3842* (holotype: SEL). *Warmingia margaritacea* B. Johans., Lindleyana 7: 194. 1992, ***syn. nov***. Type: Costa Rica. [Cartago]: Turrialba, C.A.T.I.E., epiphytic on *Hibiscus* sp. forming hedge, 600 m, 19 November 1988, *B. Johansen & M. Sørensen 138* (holotype: C, not seen).

Distribution: Costa Rica and Ecuador.

Etymology: named from the city of Zamora in southern Ecuador, the locality of the type specimen.

Habitat in Costa Rica: epiphytic in premontane wet forest on garden trees and bushes in Turrialba region.

material studied. Costa Rica. Cartago: Turrialba, frente al edificio principal del Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) en cerca viva a la par de un tubo de agua, 2 a 3 flores pendientes, 3 noviembre 2003, *A. Karremans 452.* (JBL-spirit) (Fig 13, 15-K). Turrialba, CATIE. Frente al Edificio Principal del CATIE, sobre una cerca viva de *Hibiscus* sp., al lado de un tubo de agua. 9°53'22" N - 83°39'12" W, 600 m, 4 noviembre 2005, *A. Karremans 1123* (JBL-spirit). Ecuador. Zamora-Chinchipe a lo largo del Río Zamora entre 600 a 800 m, *H. Medina s.n.* (CIOA). Morona-Santiago: cerca de Patuca, *H. Medina s.n.* (CIOA-spirit) (Fig. 15-L).

This species was first recorded from Costa Rica in 1992 by Johansen as a new species named *W. margaritacea*. The plant was collected at CATIE campus in Turrialba, Costa Rica, growing in *Hibiscus* sp. fences (Johansen 1992). After its description, the species had been long known only by the type collection (Atwood 1999, Dressler 2003). Fifteen years later, in November 2003, botanical exploration carried out at CATIE revealed more populations of this species growing in *Hibiscus* sp. (Pupulin 2004, 2005).

With a careful analysis of the type specimen of *W. zamorana* as well as of Ecuadorian material cultivated from the Zamora-Chinchipe region, we conclude that the characters used to separate *W. margaritacea* from *W. zamorana* are inconsistent, and both species should be considered conspecific. Johansen (1992) stated that *W. margaritacea* can be distinguished from *W. zamorana* by the coriaceous, lanceolate, subfalcate leaves, the pauciflorus inflorescence, the rhombic petals, the rigid column appendices and the self-pollinated flowers. However, this set of features were also observed in living specimens of *W. zamorana* from Ecuador. Morevover, Johansen stated that the flowers of *W. margaritacea* are pure ivory and pearly appearance, contrasting *W. zamorana* as having a yellow lip callus (Dodson 1989), but the callus of all the examined Costa Rican records is bright yellow in color (a photograph is given in Pupulin 2005). The serrate petals and the three-lobed lip with a bilobate yellow callus were also observed in both Ecuadorian specimens from Zamora and Costa Rican material collected at CATIE. Although we have still not found a wild population of this species outside of CATIE, some plants have been collected growing in *Cupressus lusitanicus* trees.

Warmingia zamorana has not been recorded yet in the orchid floras of Panama and Colombia, the two countries in the middle of its distribution. Nevertheless, that disjunction may be attributed to undercollection of these small and easily overlooked epiphytes. It is remarkable that similar examples of disjunction in the orchid floras of Costa Rica

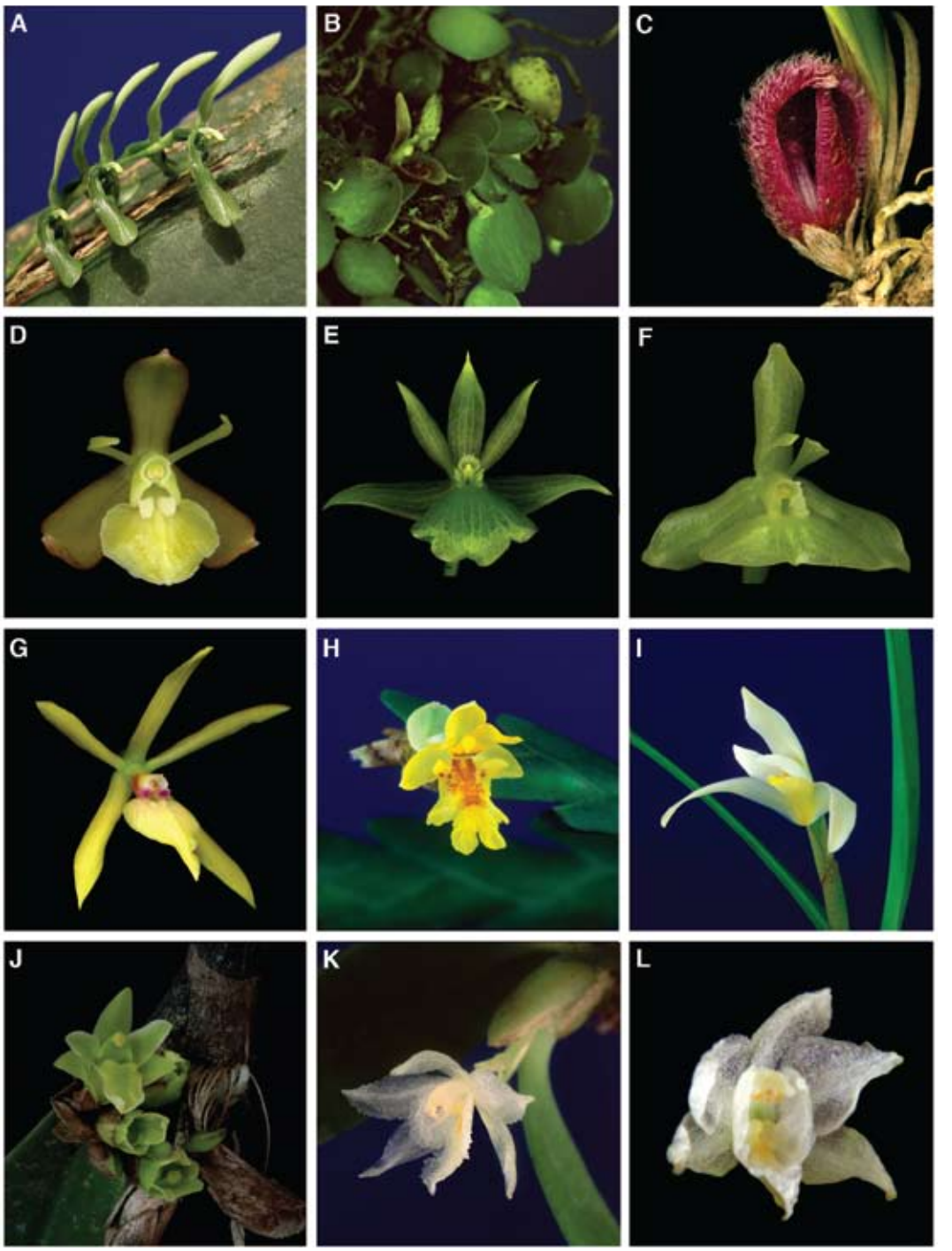


Figure 15. Pictures of: A. *Acianthera aberrans*. B. *Barbosella orbicularis*. C. *Brenesia lappiformis*. D. *Epidendrum maduroi*. E. *Epidendrum stellidifforme*. F. *Epidendrum scharfii*. G. *Epidendrum zunigae*. H. *Lockhartia chocoensis*. I. *Maxillaria bolivarensis*. J. *Scaphyglottis robusta*. K. *Warmingia zamorana* (Costa Rica). L. *Wamingia zamorana* (Ecuador).

and Ecuador were documented in the case of *Ornithocephalus montealegrae* Pupulin, originally described from the Turrialba region in Costa Rica (Pupulin 2002b) and recorded in Ecuador by Dodson (2003), and in *Epidendrum scharfii, E. stellidifforme, Lockhartia chocoensis* and *Maxillaria bolivarensis*, discussed in this paper.

Acknowledgements. We want to thank Robert L. Dressler and Eric Hágsater for their invaluable support and their useful comments on the paper. Hugo Medina and José Daniel Zúñiga who assisted part of this study. The scientific services of Ministerio del Ambiente y Energía de Costa Rica (MINAE) and its Sistema Nacional de Áreas de Conservación (SINAC) for issuing the Scientific Passport N. 1281 under which wild species treated in this study were collected, and the Ministerio del Ambiente of Ecuador, for the permits issued for the managing of the *ex-situ* orchid collections at Gualaceo and El Pangui, Ecuador. To the Vicerrectoría de Investigación of the University of Costa Rica for providing support under the project N. 814-A7-015 "Inventario y taxonomía de la flora epífita de la región Mesoamericana".

Literature Cited

Adams, B.R. 1993. A taxonomic revision of the genus *Scaphyglottis* Poepp. & Endl. (Orchidaceae-Epidendroideae). Ph.D. dissertation, Southern Illinois University, Carbondale.

Ames, O. 1923. Additions to the orchid flora of Central America. Schedul. Orch. 4 : 45.

Ames, O & C. Schweinfurth. 1925. New or noteworthy species of orchids from the American Tropics. Schedul. Orch. 8 : 41.

Atwood, J.T. 1999. *Warmingia* Rchb.f. Pages 172-173 in: Burger, W. (Ed.). Flora Costaricensis. Family #39 Orchidaceae: Tribe Maxillarieae: Subtribes Maxillariinae and Oncidiinae. Field., Bot., n.s. 40.

Dodson, C.H. 1989. *Warmingia zamorana*. Icon. Pl. Trop., II, 6: t. 599.

Dodson, C.H. 2003. Native Ecuadorian Orchids. Volume IV: *Oncidium-Restrepiopsis*. Dodson Trust, Sarasota, Florida. USA.

Dressler, R.L. 2003. Orchidaceae. Pages 1-595 in: Hammel, B.E., M.H. Grayum, C. Herrera and N. Zamora (Eds.). Manual de Plantas de Costa Rica. Vol.3. Monogr. Syst. Bot. Missouri Bot. Gard. 93.

Garay, L. A. & G.C.K. Dunsterville. 1966. Venezuelan Orchids Illustrated. Volume IV. Andre Deutsch Limited, London. England.

Hágsater, E. 1999a. *Epidendrum maduroi*. Icon. Orchid. (Mexico). 3: 352.

Hágsater, E. 1999b. *Epidendrum orthodontum*. Icon. Orchid. (Mexico). 3: 361.

Hágsater, E. 1999c. *Epidendrum killipii*. Icon. Orchid. (Mexico). 3: 342.

Hágsater, E. 2001. *Epidendrum stellidifforme*. Icon. Orchid. (Mexico). 4: 487

Johansen. B. 1992. *Warmingia margaritacea* sp. nov. (Orchidaceae) from Costa Rica and a review of the genus. Lindleyana 7(4):194-198.

Luer, C.A. 1978. Icones Pleurothallidinarum (Orchidaceae). Miscellaneous new species in the Pleurothallidinae. Selbyana 2(4): 367-390.

Luer, C.A. 2003a. *Pleurothallis*. Pages 386-452 in: Hammel, B.E., M.H. Grayum, C. Herrera and N. Zamora (Eds.). Manual de Plantas de Costa Rica. Vol.3. Monogr. Syst. Bot. Missouri Bot. Gard. 93.

Luer, C.A. 2003b. *Barbosella*. Pages 22-24 in: Hammel, B.E., M.H. Grayum, C. Herrera and N. Zamora (Eds.). Manual de Plantas de Costa Rica. Vol.3. Monogr. Syst. Bot. Missouri Bot. Gard. 93.

Luer, C.A. 2003c. *Myoxanthus*. Pages 339-342 in: Hammel, B.E., M.H. Grayum, C. Herrera and N. Zamora (Eds.). Manual de Plantas de Costa Rica. Vol.3. Monogr. Syst. Bot. Missouri Bot. Gard. 93.

Luer, C.A. 2004. Icones Pleurothallidinarum XXVI: *Pleurothallis* subgenus *Acianthera* and three allied subgenera; A Second Century of New Species of *Stelis* of Ecuador; *Epibator*, *Ophidion*, *Zootrophion*. Monogr. Syst. Bot. Missouri Bot. Gard. 95: 1-265.

Luer, C.A. 2005. Icones Pleurothallidinarum XXVII: *Dryadella* and *Acronia* sect. *Macrophyllae-Fasciculatae* (Orchidaceae). Monogr. Syst. Bot. Missouri Bot. Gard. 103: 1-311.

Oersted, A.S. 1863. L'Amérique Centrale: recherches sur sa flore et sa géographie physique. Imprimerie de Bianco Luno Par F.S. Muhle. Copenhague.

Pridgeon, A.M. & M.W. Chase. 2001. A phylogenetic reclassification of Pleurothallidinae (Orchidaceae). Lindleyana 16: 235-271.

Pupulin, F. 2002a. Catalogo revisado y anotado de las Orchidaceae de Costa Rica. Lankesteriana 4:1-88.

Pupulin, F. 2002b. Exploring for orchids: *Ornithocephalus montealegrae* is described from Costa Rica. Orchids, Mag. Amer. Orchid Soc. 71(11): 1016-1019.

Pupulin, F. 2004. El regreso de la *Warmingia*. Epidendrum 23:3-5.

Pupulin, F. 2005. The Pearl *Warmingia*: a rare Oncidioid enters cultivation. Orchids, Mag. Amer. Orchid Soc. 74(4): 282-285.

LANKESTERIANA 8(2): 75-78. 2008.

BOOK REVIEWS

Hágsater, E. & M. Soto (eds.). 2008. **Icones Orchidacearum. Fascicle 10. Orchids of Mexico. Part 4**. Herbario AMO, México D.F., México. Pp. i-xxxvi, plates 1001—1100. Published on June 11, 2008.

Under the experienced editorship by Eric Hágsater and Miguel Soto, the Herbario AMO delivers the fourth part of "Orchids of Mexico", fascicle 10 of the series *Icones Orchidacearum*. The volume is dedicated to the late Federico Halbinger Mosig (1925—2007), a short biography of whom is provided by Hágsater and Soto, together with checklists of the taxa named after him and those described or transferred by Halbinger, as well as a complete bibliography of the great Mexican orchidologist.

In line with the last issues of the *Icones Orchidacearum*, particular attention is given to the typification and stabilization of nomenclature, with a much needed effort to neotypify the species originally proposed by La Llave and Lexarza, and by Richard and Galeotti (the last case made more problematic by the absence of type specimens for several taxa). Unlike the previous releases of the series, the new fascicle eliminates the short English descriptions to provide more information in the Spanish version and to augment the space devoted to the very ample chapters on specimen citation and bibliographic references. Even so, in some cases, the length of the texts obliged the editors to include part of the specimen citations and the references in 21 additional pages of appendices to list all the vouchers known to the authors

The emphasis of the volume is on the genera *Barkeria* (5 spp.), *Isochilus* (4 spp.), *Prosthechea* (11 spp.), and *Rhynchostele* (9 spp.), but the treatment also includes interesting taxa as the Mexican endemic *Lockhartia galeottiana* A. Rich ex Soto Arenas [typified by *Ophrys imbricata* Sessé & Moc. (1890)], *Cuitlauzina pendula* La Llave & Lex., and *Homalopetalum pumilio* (Rchb.f.) Schltr. (both neotypified in the volume), as well as some well-known species important in horticulture (i.e., *Guarianthe skinneri*, *Rhynchostele* spp.).

Six new taxa (i.e., *Bletia villae* Soto Arenas, *Encyclia halbingeriana* Hágsater & Soto Arenas, *Isochilus oaxanus* Salazar & Soto Areas, *Maxillaria chimalpana* Soto Arenas & Salazar, *Rhynchostele cervantesii* subsp. *halbingeriana* Soto Arenas & Hágsater, and *R. maculata* subsp. *oestlundiana* fo. *perotensis* Soto Arenas & R. Jiménez) and eight new names, combinations and/or status changes [*Camaridium punctostriatum* (Rchb.f.) Soto Arenas, *Lockhartia galeottiana*, *Myoxanthus congestus* (A. Rich. & Galeotti) Soto Arenas, *Oestlundia ligulata* (La llave & Lex.) Soto Arenas, *Prosthechea squalida* (La llave & Lex.) Soto Arenas, *Rhyncholaelia digbyana* subsp. *fimbripetala* (Ames) Soto Arenas, *Rhynchostele maculata* subsp. *oestlundiana* (L.O. Williams) La llave & Lex.) Soto Arenas & R. Jiménez fo. *oestlundiana*, and *Stelis platystylis* (Schltr.) R. Solano & Soto Arenas] are proposed in the work, making it a necessary reference for any serious library on Neotropical botany.

Consistently with the other volumes of the series, the fourth part 4 of "Orchids of Mexico" adopts the new classification system based on phylogenetic analysis of molecular data, even when the authors express their doubts about some of the actual generic circumscriptions. The framework of the taxonomic system is basically that suggested by the ongoing series of *Genera Orchidacearum*, and the editors' decision to strictly follow this system is an appreciable attempt to maintain a common (and hopefully standing) "language" in orchid nomenclature.

With a very few exceptions, of standard quality, most of the botanical illustrations included in Orchids of Mexico, part 4, are outstanding for the information they convey and the artistic interpretation of the depicted subjects. In particular, the work of Rolando Jiménez Machorro (who produced 51 of the 100 illustrations) has seemingly reached its full maturity; worthy of note are also the composite plates by Marco Antonio López-Rosas, whose inked drawings are among the most informative in contemporarly botanical production.

Franco Pupulin
Lankester Botanical Garden, University of Costa Rica

Oakeley, H.F. 2008. ***Lycaste*, *Ida* and *Anguloa*. The essential guide**. Published by the author, Bekenham, United Kingdom, and printed by Cambrian Printers, Aberystwyth, U.K. Large 30.5 x 30.5 cm volume, pp. (v) 445, 1400 color photogaphs. 1st edition published on May, 2008.

A complete, gorgeously illustrated, superbly printed and perfectly bound large book represents the long-waited and ultimate work on *Lycaste*, *Ida*, and *Anguloa* by Henry Francis Oakeley, the recognized specialist in these orchid groups of increasing horticultural importance.

As in his previous, small-sized "essential guide" to *Lycaste* (Oakeley 1993), the author claims for completeness: "If is not in here it has not been described". In fact, the total numbers of recognized species, subspecies (varieties in the actual treatment) and natural hybrid in *Lycaste* and *Ida* (both treated under the former genus in the old guide) are significantly different in the new, amply augmented monograph. When split apart into two genera, the previous work by Oakeley recognized 24 species, 7 subspecies and 8 natural hybrids of *Lycaste*, and 22 species of *Ida*. In the present work *Lycaste* includes 31 species (5 of which are described as new and 4 elevated to specific rank by the author), 33 varieties (23 new) and one (new) subvariety, and 14 natural hybrids (7 of which described in this treatment). *Ida* has 39 species, 7 of which described in the text, 11 varieties (5 new) and 3 natural hybrids, all newly proposed in the book. A natural intergeneric hybrid between *Lycaste* and *Ida* is also included: x *Lycida mathiasae*. The treatment of *Anguloa* does not differ significantly from the recent monographs published by the author (Oakeley 1999a, 1999b, 1999c, 1999d, 1999e) and, according to Oakeley's guide, the genus comprises today 9 species, 5 varieties, and 4 natural hybrids, one of them (*Anguloa* x *speciosa*) described in this volume.

For each of the nearly 150 species, natural hybrids and varieties included in the volume, the text provides a full description, etymology, historical notes, taxonomic discussion, distribution and voucher citations, and bibliography. Of these, the chapters on taxonomic history and bibliographic references are particularly worthy, amply documented and with frequent, direct references to the original sources, while the citation of herbarium specimens is generally of limited use due the relative paucity of the consulted herbaria. Species and hybrids are listed alphabetically within each genus, following a criterion that makes easier to find any specific taxon, but on the other hand obscures the phylogenetic relationships among closely related (albeit alphabetically distant) species. The taxonomic treatments are preceded by chapters on the history of the discovery and the introduction of the three genera, their general and distinguishing features, and artificial keys to the species of *Anguloa*, *Ida*, and *Lycaste*. An ample, final chapter is devoted to the cultivation of the species of these three genera, including accounts on their pollination and the preparation of herbarium specimens. Dr. Oakeley is the holder of the National Plant Collection for *Anguloa*, *Ida* and *Lycaste* in the United Kingdom, and his more than 50 years long acquaintance with the growing secrets of these plants is well evident in this chapter. Two large Appendices complete the book. The first is devoted to "Synonyms and errors", and the author enlists over 300 invalid, misapplied, and synonymous names that plagued the complex taxonomic history of the involved genera and have been used at some time but have to be considered incorrect or redundant. The second Appendix is an "Annotated bibliography" with almost one thousand bibliographical citations (including indications of the presence of plates/pictures/photographs), and references to relevant websites and travel accounts involving *Anguloa*, *Ida*, and *Lycaste* in their habitats.

The taxonomic novelties include the following new species: *Lycaste angelae* Oakeley (with var. *alba* Oakeley and var. *rubra* Oakeley), *L. crystallina* Wubben ex Oakeley, *L. fuscina* Oakeley, *L. occulta* Oakeley and its var. *alba* Oakeley, *L. panamensis* Fowlie ex Oakeley, *Ida angustipetala* Oakeley, *I. castanea* H. James ex Oakeley, *I. ejirii* Oakeley, *I. jimenezii* Oakeley, *I. munaensis* Oakeley, *I. priscilae* I. Portilla ex Oakeley, and *I. shigerui* Oakeley. *Lycaste plana* 'Measuresiana' B.S. Williams, *L. macrophylla* subsp. *puntarenasensis* Fowlie, *L. macrophylla* var. *viridescens* Oakeley, and *L. macrophylla* subsp. *xanthocheila* Fowlie are elevated to specific rank, while *L. plana* Lindl. is sunk under a variety of *L. macrophylla*.

The whole book is splendidly illustrated. Large, crisp photographs of outstanding quality by the author himself show one or (more commonly) several views of the flower (and variations within species), with a special attention to taxonomic relevant features, and the plant habit, in many cases accompanied by shots of the plants in-situ. For most of the older taxa, original type illustrations and/or critical historic illustrations are perfectly reproduced to help the reader understand original species concepts. Whenever possible, the book even includes portraits of the dignitaries honored with the species names. For each of the species, the author also presents an impressive series of macro- and microphotographs showing anatomical and morphological features that are relevant to identify the species. These normally include views of the dissected lip (adaxial and lateral), the callus, the column, and the pollinarium, but other features (like the shape and ornament of the pseudoulbs) are also presented when they are considered taxonomically relevant.

As the author admits in his preliminary notes, the use of types throughout the work is "more loose than as defined by the International Code of Botanical Nomenclature", and this unfortunately happens in several opportunities. *Lycaste panamensis* Fowlie ex Oakeley is indicated in the text as a *stat. nov.*, but no reference is made to any basionym (in fact, *Lycaste macrophylla* subsp. *panamensis* Fowlie is a *nomen nudum*). In several cases (i.e. *L. dowiana*, *L. lasioglossa*), the author "chooses" a holotype, while in other cases he designates a lectotype when a holotype or isotype ostensibly is in existence (i.e., *L. candida*, *L. tricolor*). Doubts may be expressed about the applicability of the name *Lycaste candida* Lindl. This name was just cited by Lindley as a provisional name, but in the same text the author himself considered it (erroneously) a synonym of *L. leucantha*. Thus, by a strict application of the Rules of Nomenclature, the name *L. candida* was not accepted by its own author, and was thus invalid. The next available name should be, in this case, *L. brevispatha* Klotsch 1871, regarded by Oaekeley as a synonym of *L. candida*. Other, objection cases are typifications that ignore the available materials. Thus, for example, *Lycaste bradeorum* Schltr. is neotypified with a cultivated plant reportedly from San Isidro del General, in southern Costa Rica, ostensibly outside the natural distribution of this species, which is limited to the northern, dry areas of the Guanacaste province and its Nicaraguan neighbors. At the Ames Orchid Herbarium of the Harvard University is kept a copy of the original Schlechter's drawings of *L. bradeorum*, which could have been selected as a more appropriate lectotype. Another taxonomic point is the apparent frequence of natural hybrids in some groups of species, which can be regarded with some suspicion. Costa Rican *L. candida* (probably an invalid name) and *L. brevispatha* (if distinct) have been traditionally difficult to tell apart on the basis of their amply variable flower morphology. Now, Oakeley maintains *L. candida* for populations with markedly three-lobed lip, and creates *L. angelae* for plants with broadly diamond-shaped, obscurely lobed lip (his photographs of *L. angelae* var. *rubra*, however, show flowers with distinctly 3-lobed lip), resolving all the intermediate forms through the description of a supposed new natural hybrid, *L.* x *daniloi*, which is stated to be "much commoner than either species".

All in all, Oakeley's book is an extraordinary work, based on a long, deep and intimate knowledge of the groups under study, and a fundamental piece to understand the diversity and complexity of the involved species. There are no doubts that this splendid monographs will stand for a long time as the essential reference of future students of these three genera.

Franco Pupulin
Lankester Botanical Garden, University of Costa Rica

Literature cited

Oakeley, H.F. 1993. *Lycaste* species, the essential guide. Vigo Press, London.

Oakeley, H.F. 1999a. A revision of the genus *Anguloa* (in Japanese, with type descriptions in Latin and picture captions in English). All Japan Orch. Soc. Orch. 38: 17—38.

Oakeley, H.F. 1999b. Revision der Gattung *Anguloa*. Orchidee (Hamburg) 50(1): 21—28; 50(3): 34—42; 50(4): 51—56.

Oakeley, H.F. 1999c. Revisión del género *Anguloa*. Revision of the genus Anguloa. Orquideología 159—213.

Oakeley, H.F. 1999d. Ein herziening van het Geslacht *Anguloa*. Orchideeën 4: 63—80.

Oakeley, H.F. 1999e. *Anguloa*, the species, the hybrids, and a checklist of Angulocastes. Orch. Digest 63(4) Suppl.: 1—32.