SUPPLEMENTARY INFORMATION

Decoupled evolution of floral traits and climatic preferences in a clade of neotropical Gesneriaceae.

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Appendix S1. Phylogenetic analysis and relative divergence time estimation

The *Codonanthopsis, Codonanthe* and *Nematanthus* clade has ca. 52 species and is distributed throughout the Neotropical rainforest with a center of diversity in the Brazilian Atlantic forest (BAF). Recent phylogenetic and biogeographic analyses of the Neotropical Gesneriaceae have shown that the CCN group is divided in two sister clades (Perret et al. 2013). One is composed of *Codonanthe* sensu stricto and *Nematanthus* (39 species) that are endemic to the BAF (Chautems 2009), while the other includes *Codonanthopsis* (13 species) that occurs throughout the tropical rainforest of Central America, northern South America and Amazonia (Chautems and Perret 2013). We sampled 27 *Nematanthus*, 8 *Codonanthe* and 11 *Codonanthopsis* species, as well as 13 outgroup species representing different Episceae genera and other related Neotropical tribes such as Gesneriaeae (*Gesneria humilis*), Gloxineae (*Kohleria spicata*) and Sinningiaeae (*Sinningia schiffneri*). This taxonomic sample includes all known species in the three genera CCN except *C. anisophylla, C. chiricana, N. mirabilis, N. striatus*, and the probable hybrid species *N. kuhlmannii* and *N. mattosianus* for which plant material was not available. All sampled species were sequenced for two nuclear (ITS, ncpGS) and four plastid regions (*atpB-rbcL* spacer, *rpl16* intron, *rps16* intron, *trnL-trnF* spacer) using the procedure described in Perret et al. (2013). Voucher information and Genbank numbers for *trnL-trnF* and *rps16* sequences are published in Perret et al. (2013). Genbank numbers for other markers are provided in Table S1. We used MAFFT (Katoh and Kuma 2002) and Guidance (Penn et al. 2010) to align sequences and subsequently remove all sites with a confidence score below 0.8; the final matrix contained 4,484 bp. We identified the GTR+G model of substitution as the best model for each DNA region, using AIC method as implemented in the *phymltest* function in R (*ape* package; Paradis et al. 2004). The only exception was the *ncpGS* gene, which was modeled with HKY85+G.

We used these models in Bayesian inference (BI: MrBayes 3.2; Ronquist et al. 2012) and all model parameters were unlinked across gene partitions. We performed two runs of BI for the complete alignment matrix, where each run consisted of four chains of $10^7$ generations, sampling every $10^7$ steps. We determined chain convergence and burn-in length (20% of the sampled generations) by examining trace plots of each parameter in Tracer v.1.4 (Rambaut and Drummond 2007). A consensus tree was calculated by removing the burn-in period
and combining the two runs. Phylogenetic relationships and relative divergence times were estimated with a relaxed clock model applying uncorrelated log-normal prior distribution for the rates of substitution and a Yule prior on the rates of speciation using BEAST (Drummond et al. 2012). Each DNA region was treated as a separate data partition, allowing parameters of each region to be unlinked. Three independent analyses were performed by including either all 46 species sampled, the 38 species with morphological data or the 43 species with climatic data (see below). All three analyses included two independent runs of $2 \times 10^7$ generations each. The CCN clade was constrained to be monophyletic based on previous studies (Clark et al. 2012; Perret et al. 2013). Due to the absence of closely related fossils in the CCN clade, difficulties to align sequences from fast evolving genes in higher taxa, and the multiple issues of secondary calibrations (Sauquet et al. 2012), an accurate absolute divergence-time estimation for this group is problematic. However, our analyses did not require absolute times of divergence because our goal is to compare the evolution of different traits within the CCN clade. We therefore used BEAST to produce ultrametric trees by setting the prior for the time of the most recent common ancestor of CCN clade to an almost fixed root of 1 (normal distribution with mean=1, sd=1e-06). We also carried out a MrBayes (v3.2; Ronquist et al. 2012) analysis for comparison (See Figure S6). Finally, we examined the evolution of three binary traits: geographic distribution, pollination syndromes, and floral orientation (see Table S1). The biogeographic data was obtained from Perret et al. (2013), while information on pollination syndromes and resupination was obtained from available field observations of pollinators (see Table S2) and observations on living plants. Ancestral state reconstructions were performed using the Maximum Clade Credibility (MCC) tree and the function *rayDISC* (root=maddfitz) in the corHMM R package (Beaulieu et al. 2013).
Appendix S2. Visualization of continuous trait evolution

Trait simulations for each trait used the MCC tree of the BEAST analyses used the functions sim.rates (phytools R package, Revell 2012), for the multiple BM model, and OUwie.sim (Ouwie R package, Beaulieu et al. 2012) for the OU models. The sim.rates function allows for multiple BM rates of evolution, here estimated by rjMCMC (geiger R package, see above) and mapped on each branch of the phylogenetic tree. The OUwie.sim function requires OU parameters and tree painted with the defined selective regimes. All parameters were set according to the model selected for each trait (Table 1) and the root states were based on BM maximum likelihood estimation, even for OU models, because of the impossibility to estimate root state under these models.
| Taxon Name                      | Voucher Code                  | Origin                  | tmrlF | rps16 | atpB-rbcL | ITS       | ncpGD | rplF | QD | FB | PQ |
|--------------------------------|-------------------------------|-------------------------|-------|-------|-----------|-----------|-------|------|----|----|----|
| Nematanthus carinata            | NA                            | Cultivated CJBG AC-3105 (Amazon) |       |       |           |           |       |      |    |    |    |
| Nematanthus discolor            | NA                            | Cultivated CJBG AC-3351 (Equador) |       |       |           |           |       |      |    |    |    |
| Nematanthus eburneus            | NA                            | Cultivated CJBG AC-3330 (Equador) |       |       |           |           |       |      |    |    |    |
| Nematanthus gibbosa             | NA                            | Cultivated CJBG AC-1139 (Brazil) |       |       |           |           |       |      |    |    |    |
| Nematanthus gregarius           | NA                            | Cultivated CJBG AC-1147 (Brazil) |       |       |           |           |       |      |    |    |    |
| Nematanthus leonii              | NA                            | Cultivated CJBG AC-1169 (Brazil) |       |       |           |           |       |      |    |    |    |
| Nematanthus punctatus           | NA                            | Cultivated CJBG AC-1355 (Papua) |       |       |           |           |       |      |    |    |    |
| Nematanthus saccatus            | NA                            | Cultivated CJBG AC-1301 (Equador) |       |       |           |           |       |      |    |    |    |
| Nematanthus teixeiranus         | NA                            | Cultivated CJBG AC-1101 (Equador) |       |       |           |           |       |      |    |    |    |
| Nematanthus wiehleri            | NA                            | Cultivated CJBG AC-109 (Central America & Colombia) |       |       |           |           |       |      |    |    |    |
| Nematanthus wettsteinii         | NA                            | Cultivated CJBG AC-2013 (Brazil) |       |       |           |           |       |      |    |    |    |
| Peixoto                         | NA                            | Cultivated CJBG AC-605 (Equador) |       |       |           |           |       |      |    |    |    |
| Peixoto                         | NA                            | Cultivated CJBG AC-109 (Central America & Colombia) |       |       |           |           |       |      |    |    |    |
| Peixoto                         | NA                            | Cultivated CJBG AC-2013 (Brazil) |       |       |           |           |       |      |    |    |    |
| Peixoto                         | NA                            | Cultivated CJBG AC-605 (Equador) |       |       |           |           |       |      |    |    |    |

*Note: Values in italics correspond to sequences reported in Perret et al. 2013. Binary trait information for geographic distribution (GD, 0 = other biomes, 1 = BAF), pollination syndrome (PS, 0 = bee-pollinated and 1 = hummingbird-pollinated).*
| Species          | Locality                                  | Nematanthus-lineage | Visitors                        | Reference                          |
|------------------|-------------------------------------------|---------------------|---------------------------------|------------------------------------|
| *N. brasiliensis*| Mangaratiba, Reserva Ecológica Rio das Pedras, RJ (30m) | Nematanthus-A       | *Phaetornis ruber* Ramphodon naevius* | (SanMartin-Gajardo and Vianna, 2010) |
| *N. fissus*      | Caraguatatuba, SP (50-100m)               | Nematanthus-A       | Thalurania glaucopis*           | (Buzato et al., 2000)              |
| *N. fluminensis* | Caraguatatuba SP (50-100m)               | Nematanthus-A       | *Phaetornis ruber*              | (Buzato et al., 2000)              |
| *N. fornix*      | Campos do Jordão, SP (1400-1600m)         | Nematanthus-B       | Leucochloris albicollis*        | (Buzato et al., 2000)              |
| *N. fornix*      | Itatiaia National Park (900-1200m)        | Nematanthus-B       | Phaethornis eurynome*           | Wolowski et al. 2013               |
| *N. fritschii*   | Estação Ecológica Estadual Juréia-Itatins, SP (800-900m) | Nematanthus-A       | Ramphodon naevius*              | (Franco and Buzato, 1992)          |
| *N. gregarius*   | Boracéia forest reserve, SP (800-900m)    | Nematanthus-B       | Leucochloris albicollis*        | Snow and Snow 1986                 |
| *N. sericeus*    | Cunha, SP (1000-1100m)                    | Nematanthus-B       | Clytolaema rubricauda*          |                                    |
| *N. strigilosus* | Serra da Piedade, MG (1400-1740m)         | Nematanthus-B       | Colibri serriostris*            | Vasconcelos & Lombardi 2001        |
| *N. strigilosus* | Serra do Caraça, MG (1200-2020m)          | Nematanthus-B       | Thalurania glaucopis*           | Vasconcelos & Lombardi 2001        |
| Species          | Location                      | Flower Type | Bird          | Author            | Year  |
|------------------|-------------------------------|-------------|---------------|-------------------|-------|
| *N. lanceolatus* | Itatiaia National Park (900-1200m) | *Nematanthus-A* | *Phaethornis eurynome* | Wolowski et al. | 2013  |
| *N. crassifolius*| Itatiaia National Park (900-1200m) | *Nematanthus-A* | *Phaethornis eurynome* | Wolowski et al. | 2013  |

*a* nectar robber

* Phaethornithinae

+ Trochilinae
Table S3. Mean values for floral traits used for the principal component analyses. Abbreviations in figure S1.

| Species                  | obs  | DIL  | DOL  | DVL  | DOV  | DTH  | DTV  | LTU  | DRH  | DRV  | DNH  | DNV  | LAN  | LST  |
|--------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Codonanthe arbuscens     | 4.0  | 3.3  | 15.2 | 33.0 | 17.3 | 18.0 | 18.0 | 48.8 | 4.7  | 6.1  | 5.7  | 8.5  | 31.1 | 30.0 |
| Nematanthus australis    | 4.0  | 3.3  | 15.2 | 33.0 | 17.3 | 18.0 | 18.0 | 48.8 | 4.7  | 6.1  | 5.7  | 8.5  | 31.1 | 30.0 |
| Nematanthus arrowifolius | 5.0  | 3.3  | 15.2 | 33.0 | 17.3 | 18.0 | 18.0 | 48.8 | 4.7  | 6.1  | 5.7  | 8.5  | 31.1 | 30.0 |
| Nematanthus breviceps    | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  |
| Nematanthus carinatus    | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  |
| Nematanthus corniculata  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  |
Table S4. List of the herbaria where specimens have been examined for occurrence data. Acronyms follow Index Herbariorum (http://sweetgum.nybg.org/ih/).

| Abbreviation | Herbarium name |
|-------------|----------------|
| B           | Botanischer Garten und Botanisches Museum Berlin-Dahlem, Zentraleinrichtung der Freien Universität Berlin |
| BHCB        | Universidade Federal de Minas Gerais |
| BM          | British Museum of Natural History |
| BOTU        | Herbario Irina Delanovna Gontschajnov |
| BR          | National Botanic Garden of Belgium |
| CEPEC       | Herbario do Centro de Pesquisas do Cacau |
| CESJ        | Herbario Leopoldo Kiefer |
| E           | Royal Botanic Garden, Edinburgh |
| ESA         | Herbario Da Escola Superior de Agricultura Luiz de Queiroz |
| F           | Herbarium Botany Department, Field Museum of Natural History |
| G           | Conservatoire et Jardin botaniques de la Ville de Genève |
| GFJP        | Herbario Guido F. J. Pabst, Faculdade Redentor |
| GH          | The Gray Herbarium |
| GUA         | Herbarío Alberto Castellanos, FEEMA, Servicio de Ecología Aplicada, DIVEA, DEP, FEEMA |
| HAS         | Herbario Alarich Rudolf Holger Schultz, Fundação Zoobotânica do Rio Grande do Sul |
| HBR         | Herbario Barbosa Rodrigues, Universidade Federal de Santa Catarina |
| HPL         | Herbario, Instituto Plantarum de Estudos da Flora Ltda |
| HRCB        | Herbario Rioclarense, Instituto de Biociências, Universidade Estadual Paulista |
| HUEFS       | Herbario, Departamento de Ciências Biológicas, Universidade Estadual de Feira de Santana |
| IAC         | Herbario, Centro de Recursos Genéticos Vegetais e Jardim Botânico, Instituto Agronômico de Campinas |
| IAN         | Herbario, Laboratório de Botânica, Embrapa Amazônia Oriental |
| IAS         | Indiana Academic of Science |
| ICN         | Herbario ICN, Departamento de Botânica |
| INPA        | Herbario, Coordenação de Pesquisas em Botânica, Instituto Nacional de Pesquisas da Amazônia |
| JPB         | Herbario Lauro Pires Xavier |
| K           | Herbarium, Royal Botanic Gardens |
| M           | Herbarium, Botanische Staatsammlung München |
| MBM         | Herbario, Museo Botánico Municipal |
| MBML        | Herbario, Museo de Biología Mello Leitão |
| MG          | Herbario, Museu Paraense Emílio Goeldi |
| MO          | Herbarium, Missouri Botanical Garden |
| NY          | New York Botanical Garden |
| P           | Museum National d'Histoire Naturelle |
| PACA        | Herbario Anchieta, Instituto Anchietao de Pesquisas/UNISINOS |
| PEL         | Herbario, Universidad Federal de Pelotas |
| R           | Herbario, Departamento de Botánica, Museo Nacional |
| RB          | Herbario, Instituto de Pesquisas, Jardim Botânico do Rio de Janeiro |
| RU          | Herbarium, Agricultural Botany Department, University of Reading |
| S           | Herbarium, Swedish Museum of Natural History |
| SEL         | Herbario, Marie Selby Botanical Gardens |
| SP          | Herbario, Instituto de Botânica |
| SPSPF       | Herbario Dom Bento José Pickel, Divisão de Duasomia, Seção de Madeiras e Produtos Florestais |
| UB          | Herbario, Universidade de Brasília |
| UEC         | Herbario, Instituto de Biologia, Jab, Universidade Estadual de Campinas |
| UFP         | Herbario, Universidade Federal de Pernambuco |
| UPCB        | Herbario, Universidade Federal do Paraná |
| US          | United States National Herbarium, Smithsonian Institution |
| VIC         | Herbario, Universidad Federal de Vigo |
| VIES        | Central Herbarium UFES, Federal University of Espírito Santo |
| W           | Herbarium, Naturhistorisches Museum Wien |
| WAG         | Nationaal Herbarium Nederland, Wageningen University branch, Wageningen University |
| WU          | Herbarium, Faculty Center Botany, Department of Plant Systematics and Evolution, Universität Wien |
| Z           | Joint Herbarium of the University of Zurich and the ETH Zurich |
Table S5. PC loadings for morphological and climatic preferences. Description of floral morphology traits in legend of table S2.

| Floral morphology      | Climatic variables                          | PC1    | PC2    |
|------------------------|---------------------------------------------|--------|--------|
| Trait                  | PC1  | PC2  | Trait                  | PC1    | PC2    |
| DHL                    | -0.245 | -0.4611 | Mean annual Temperature | 0.8634 | -0.0221 |
| DOH                    | -0.261 | -0.3972 | Mean diurnal range     | -0.1525 | 0.3717  |
| DVL                    | -0.2837 | -0.2485 | Isothermality          | 0.8417 | 0.2029  |
| DOV                    | -0.3023 | 0.0141 | Temperature Seasonality | -0.8939 | -0.205  |
| DTH                    | -0.2518 | -0.2276 | Max Temperature warmest month | 0.7341 | -0.0214 |
| DTV                    | -0.2834 | 0.2393 | Min Temperature coldest month | 0.8974 | -0.0448 |
| LTU                    | -0.2964 | 0.2212 | Annual Range Temperature | -0.8103 | 0.0541  |
| DRH                    | -0.2803 | -0.2169 | Mean Temperature wettest | 0.6648 | -0.1729 |
| DRV                    | -0.2895 | -0.0512 | Mean Temperature driest | 0.9166 | 0.0331  |
| DNH                    | -0.2981 | 0.0468 | Mean Temperature warmest | 0.7347 | -0.1172 |
| DNV                    | -0.2792 | 0.2209 | Mean Temperature coldest | 0.9094 | 0.0338  |
| LAN                    | -0.2719 | 0.377 | Annual precipitation   | 0.6345 | 0.0668  |
| LST                    | -0.2555 | 0.4085 | Precipitation wettest month | 0.5838 | 0.31    |
|                        |      |      | Precipitation driest month | 0.2853 | -0.3951 |
|                        |      |      | Precipitation seasonality | -0.0432 | 0.6337  |
|                        |      |      | Precipitation wettest month | 0.5802 | 0.2775  |
|                        |      |      | Precipitation driest month | 0.3482 | -0.3728 |
|                        |      |      | Precipitation warmest month | -0.1408 | -0.0159 |
|                        |      |      | Precipitation coldest month | 0.6944 | 0.0165  |
|                        |      |      | Altitude               | -0.473 | 0.3528  |
Table S6. AICc values for the complete set of OU models. Regimes in pollinator type and geography are explained in the main text. Model parameters: $\alpha$ = selection strength, $\sigma^2$ = rate of evolution, and $\theta$ = state means. OUM assumes different $\theta$ and a single $\alpha$ and $\sigma^2$ acting on the selective regimes. OUMV with different $\theta$ and $\sigma^2$, OUMA with multiple $\alpha$, and OUMVA with multiple $\alpha$ and $\sigma^2$ per selective regime. The preferred OU model for floral size was OUMV and floral shape the OUMVA, with regimes according to pollination syndromes. For mean and seasonality in temperature the model OUM and precipitation seasonality model OUM, with regimes determined by geography, were selected.

| Models          | Pollination syndrome | Geography |
|-----------------|----------------------|-----------|
|                 | OUM  | OUMV | OUMA | OUMVA | OUM  | OUMV | OUMA | OUMVA |
|                 | AICc | AICc | AICc | AICc   | AICc | AICc | AICc | AICc   |
| Morphology PC1  | 189.2001 | 172.9199 | 189.5848 | 173.1399 | 195.8302 | 187.4603 | 192.4959 | 139.0627 |
| Morphology PC2  | 88.0996 | 90.609 | 83.7823 | 79.5401 | 108.8082 | 103.3185 | 109.6878 | 106.0105 |
| Climate PC1     | 134.387 | 136.9541 | 136.9557 | 142.1494 | 124.4231 | 126.9841 | 125.4141 | 126.2922 |
| Climate PC2     | 102.8038 | 105.3339 | 105.2334 | 107.1134 | 100.5768 | 100.6149 | 101.8 | 102.9673 |
Table S7. Model fit comparison correcting for measurement error (ME). Bold indicate the selected model. Asterisk indicates that the error was not estimated for this type of model, but fixed with the error estimated under a single BM model.

| MORPHOLOGY PC1         |      |      |      |
|------------------------|------|------|------|
|                        | Model | AICc | AICc incorporate error | Estimated ME |
| BM                     | 190.9718 | 190.4220 | 1.4296 |
| OU single              | 187.7321 | 190.2145 | 0.3425 |
| EB (ac)                | 193.3461 | 192.9283 | 0.8944 |
| EB (dc)                | 187.7321 | 190.2145 | 0.3429 |
| OUWie_OUM              | 189.2001 | 191.7122 | 0.5557 |
| OUWie_OUMV             | 172.9199 | 175.1343 | 0.3681 |
| OUWie_OUMA             | 189.5848 | 188.0949 | 2.2075 |
| OUWie_OUMVA            | 173.1399 | 172.0341 | 0.4584 |
| Multiple rates         | **152.2585** | **160.0260** | * |

| MORPHOLOGY PC2         |      |      |      |
|------------------------|------|------|------|
|                        | Model | AICc | AICc incorporate error | Estimated ME |
| BM                     | 104.3669 | 106.7198 | 0.0000 |
| OU single              | 106.6641 | 109.1489 | 0.0000 |
| EB (ac)                | 106.7412 | 109.2261 | 0.0000 |
| EB (dc)                | 106.6641 | 109.1489 | 0.0000 |
| OUWie_OUM              | 88.0996  | 91.8741  | 0.4759 |
| OUWie_OUMV             | 90.6090  | 94.6933  | 0.4646 |
| OUWie_OUMA             | 83.7823  | 91.1330  | 0.3894 |
| OUWie_OUMVA            | **79.5401** | **83.6943** | 0.1677 |
| Multiple rates         | 102.3854 | 102.3854 | * |

| CLIMATIC PREFERENCES PC1 |      |      |      |
|-------------------------|------|------|------|
|                        | Model | AICc | AICc incorporate error | Estimated ME |
| BM                     | 134.5776 | 134.3708 | 0.5960 |
| OU single              | 135.6864 | 136.8080 | 0.5960 |
| EB (ac)                | 136.9015 | 139.3226 | 0.0000 |
| EB (dc)                | 136.5797 | 136.8080 | 0.5960 |
| OUWie_OUM              | **124.4231** | **125.0787** | 0.8193 |
| OUWie_OUMV             | 126.9841 | 127.7904 | 0.8193 |
| OUWie_OUMA             | 125.4141 | 127.2266 | 0.8086 |
| OUWie_OUMVA            | 126.2922 | 130.0933 | 0.8086 |
| Multiple rates         | 130.7428 | 131.8210 | * |

| CLIMATIC PREFERENCES PC2 |      |      |      |
|-------------------------|------|------|------|
|                        | Model | AICc | AICc incorporate error | Estimated ME |
| BM                     | 115.0848 | 100.7321 | 0.6284 |
| OU single              | 100.5829 | 102.5151 | 0.5514 |
| EB (ac)                | 117.4086 | 103.1693 | 0.6284 |
| EB (dc)                | 100.5829 | 102.5151 | 0.5514 |
| OUWie_OUM              | 100.5768 | 102.8283 | 0.2988 |
| OUWie_OUMV             | 100.6149 | 106.6520 | 0.4666 |
| OUWie_OUMA             | 101.8000 | 106.6175 | 0.4673 |
| OUWie_OUMVA            | 102.9673 | 105.5555 | 0.0855 |
| Multiple rates         | **95.1331** | **95.0651** | * |
Figure S1. Floral measurements used for the principal component analysis. A-C: *Nemantanthus fritschii*, D: *Codonanthe devosiana*. Photographs used with permission from Manuel Faustino. Abbreviations as follows: DHL: corolla horizontal diameter; DVL: corolla vertical diameter; DOH: horizontal diameter of the corolla opening; DOV: corolla vertical diameter at the corolla opening; DTH: Maximum horizontal tube diameter; DTV: Maximum vertical tube diameter; LTU: Dorsal tube length; DRH: Horizontal diameter of the tube constriction anterior to the nectar chamber; DRV: Vertical diameter of the tube constriction anterior to the nectar chamber; DNH: Horizontal diameter of the nectar chamber; DNV: Vertical diameter of the nectar chamber; LAN: Length from the anther base to the ovary; LST: Length from the stigma base to the ovary.
Figure S2. Phylogenetic reconstruction with outgroup species. Blue bars correspond to the 95% highest posterior density. Values above branches are Bayesian posterior probabilities. Names on bars denote tribes of the *Gesnerioideae* subfamily.
Figure S3. Ancestral state reconstructions. Maximum likelihood ancestral state reconstruction (corHMM R package), details of states in text. ER and ARD, equal rates and all rates different models, respectively.
Figure S4. Panel a) Principal component analysis of 38 CCN species based on 13 floral traits. Colors correspond to the clades according to the legend. Species names: 1, *N. punctatus*; 2, *N. Albus*; 3, *N. wiehleri*; 4, *N. fluminensis*; 5, *N. crassifolius*; 6, *N. brasiliensis*; 7, *N. corticola*; 8, *N. fritschi*; 9, *N. tessmannii*; 10, *N. villosus*; 11, *N. maculatus*; 12, *N. fissus*; 13, *N. pycnophyllus* 14 *N. monanthos*; 15, *N. jolyanus*; 16, *N. hirtellus*; 17, *N. gregarius*; 18, *N. bradei*; 19, *N. sericeus*; 20, *N. teixeiranus*; 21, *N. strigillosus*; 22, *N. serpens*; 23, *N. wettsteinii*; 24, *N. australis*; 25, *C. venosa*; 26, *C. cordifolia*; 27, *C. devosiana*; 28, *C. serrulata*; 29, *C. carnosa*; 30, *C. gracilis*; 31, *C. uleana*; 32, *C. caribaea*; 33, *C. macradenia*; 34, *C. elegans*; 35, *Codonanthopsis ulei*; 36, *N. fornix*; 37, *C. mattos-silvae*; 38, *C. corniculata*. Panel b) Principal component analysis of climatic preferences in 43 CCN species, and geographical distribution by subclade. The distribution map was produced in this study. Species names: 1 *Codonanthe calcarata*, 2 *Codonanthe caribaea*, 3 *Codonanthe carnosa*, 4 *Codonanthe cordifolia*, 5 *Codonanthe crassifolia*, 6 *Codonanthe devosiana*, 7 *Codonanthe erubescens*, 8 *Codonanthe gibbosa*, 9 *Codonanthe gracilis*, 10 *Codonanthe luteola*, 11 *Codonanthe macradenia*, 12 *Codonanthe mattos-silvae*, 13 *Codonanthe serrulata*, 14 *Codonanthe uleana*, 15 *Codonanthe venosa*, 16 *Codonanthopsis dissimulata*, 17 *Codonanthopsis ulei*, 18 *Nematanthus albus*, 19 *Nematanthus australis*, 20 *Nematanthus bradei*, 21 *Nematanthus brasiliensis*, 22 *Nematanthus corticola*, 23 *Nematanthus crassifolius*, 24 *Nematanthus fissus*, 25 *Nematanthus fluminensis*, 26 *Nematanthus fornix*, 27 *Nematanthus fristchi*, 28 *Nematanthus gregarius*, 29 *Nematanthus hirtellus*, 30 *Nematanthus jolyanus*, 31 *Nematanthus kautskyi*, 32 *Nematanthus lanceolatus*, 33 *Nematanthus maculatus*, 34 *Nematanthus monanthos*, 35 *Nematanthus punctatus*, 36 *Nematanthus pycnophyllus*, 37 *Nematanthus sericeus*, 38 *Nematanthus strigillosus*, 39 *Nematanthus teixeiranus*, 40 *Nematanthus tessmannii*, 41 *Nematanthus villosus*, 42 *Nematanthus wettsteinii*, 43 *Nematanthus wiehleri*. Photographs 3, 6, 17-20, 23, 26, 27, 30, 32 and 34 by Mauro Peixoto, photographs 2, 4, 5, 7, 9, 10-16, 22, 29, 31, 33, 35 by John Clark, photographs 1, 8, 28 by Alain Chautems, and photograph 25 by Bernard Renaud. All photographs were used under permission requests from the owners.
Figure S5. Comparison of phenotypic space and multi-rates BM model from raw (upper panel) and log-transformed (lower panel) morphological measurements.
Figure S6. Credibility tree from MrBayes with outgroup sequences included. Numbers on nodes are posterior probabilities for each clade.
References

Beaulieu, J. M., B. C. O’Meara, and M. J. Donoghue. 2013. Identifying hidden rate changes in the evolution of a binary morphological character: the evolution of plant habit in campanulid angiosperms. Systematic Biology. 62:725–37.

Buzato, S., M. Sazima, and I. Sazima. 2000. Hummingbird-pollinated floras at three Atlantic forest sites. Biotropica 32:824–841.

Chautems, A. 1988. Révision taxonomique et possibilités d’hybridations de Nematanthus Schrader (Gesneriaceae), genre endémique de la forêt côtière brésilienne. Dissertationes Botanicae. 112:1–226.

Chautems, A. 2009. Gesneriaceae. Pp. 285–288 in J. Stehmann, R. Forzza, A. Salino, M. Sobral, D. Costa, and L. Kamino, eds. Plantas da floresta Atlântica. Rio de Janeiro.

Chautems, A., and M. Perret. 2013. Redefinition of the neotropical genera Codonanthe (Mart.) Hanst, and Codonanthopsis Mansf. (Gesneriaceae). Selbyana 31:143–157.

Clark, J. L., M. M. Funke, A. M. Duffy, and J. F. Smith. 2012. Phylogeny of a Neotropical clade in the Gesneriaceae: more tales of convergent evolution. International Journal of Plant Sciences. 173:894–916.

Drummond, A. J., M. A. Suchard, D. Xie, and A. Rambaut. 2012. Bayesian Phylogenetics with BEAUti and the BEAST 1.7. Molecular Biology and Evolution. 29:1969–1973.

Franco, M. A., and S. Buzato. 1992. Biologia floral de Nematanthus fritschii (Gesneriaceae). Revista Brasileira de Biologia. 52:661–666.

Katoh, M., and M. Kuma. 2002. MAFFT: a novel method for rapid multiple sequence alignment based on fast Fourier transform. Nucleic Acids Research. 30:3059–3066.

Paradis, E., J. Claude, and K. Strimmer. 2004. APE: Analyses of Phylogenetics and Evolution in R language. Bioinformatics 20:289–290.

Penn, O., E. Privman, H. Ashkenazy, G. Landan, D. Graur, and T. Pupko. 2010. GUIDANCE: a web server for assessing alignment confidence scores. Nucleic Acids Research. 38:23–28.

Perret, M., A. Chautems, A. O. De Araujo, and N. Salamin. 2013. Temporal and spatial origin of Gesneriaceae in the New World inferred from plastid DNA sequences. Botanical Journal of the Linnean Society. 171:61–79.

Rambaut, A., and A. J. Drummond. 2007. Tracer v1.4.

Revell, L. J. 2012. phytools: an R package for phylogenetic comparative biology (and other things). Methods Ecoloy and Evolution. 3:217–223.

Ronquist, F., M. Teslenko, P. van der Mark, D. Ayres, A. Darling, S. Hohna, B. Larget, L. Liu, M. A. Suchard, and J. Huelsenbeck. 2012. MrBayes 3.2: Efficient bayesian phylogenetic inference and model choice across a large model space. Syst. Biol. 61:539–542.

Rosinni, J. and Chautems, A. 2007. Codonanthe gibossa Rossini & Chautems (Gesneriaceae), a new species from the State of Espírito Santo, Brazil. Candollea. 62: 215-220.

Sanmartin-Gajardo, I., and J. R. Viana. 2010. Pollination of Nematanthus brasiliensis: An epiphytic Gesneriaceae endemic to the Southern Atlantic Forest of Brazil. Selbyana 30:216–220.

Sauquet, H., S. Y. W. Ho, M. a Gandolfi, G. J. Jordan, P. Wilf, D. J. Cantrill, M. J. Bayly, L. Bromham, G. K. Brown, R. J. Carpenter, D. M. Lee, D. J. Murphy, J. M. K. Sniderman, and F. Udovicic. 2012. Testing the impact of calibration on molecular divergence times using a fossil-rich group: the case of Nothofagus (Fagales). Systematic Biology. 61:289–313.

Snow, D. W., and B. K. Snow. 1986. Feeding ecology of hummingbirds in the Serra do Mar , southeastern Brazil. Rev. Ornitolologia Neotropical. 012:286–296.

Vasconcelos, M., and J. Lombardi. 2001. Hummingbirds and their flowers in the campos rupestres of southern
Wolowski, M., T.-L. Ashman, and L. Freitas. 2013a. Community-wide assessment of pollen limitation in hummingbird-pollinated plants of a tropical montane rain forest. Annals of Botany. 112:903–10.

Wolowski, M., C. F. Saad, T.-L. Ashman, and L. Freitas. 2013b. Predominance of self-compatibility in hummingbird-pollinated plants in the Neotropics. Naturwissenschaften 100:69–79.