Directional phyllotactic bias in calatheas (*Goeppertia*, Marantaceae): a citizen science approach

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Abstract

Lateral organs arranged in spiral phyllotaxy are separated by the golden angle, $\approx 137.5^\circ$, leading to handedness: either clockwise or counter-clockwise. In some species, leaves are asymmetric such that they are smaller and curved towards the side ascending the phyllotactic spiral. As such, these asymmetries lead to mirroring of leaf shapes in plants of opposite phyllotactic handedness. Previous reports had suggested that the pin-stripe calathea (*Goeppertia ornata*) may be exclusively of one phyllotactic direction, counter-clockwise, but had limited sampling to a single population. Here, we use a citizen science approach leveraging a social media poll, internet image searches, and in-person verification at nurseries in four countries and two continents to demonstrate that calatheas (*Goeppertia spp.*) around the world are biased towards counter-clockwise phyllotaxy. The possibility that this bias is genetic and its implications for models of phyllotaxy that assume handedness is stochastically specified in equal proportions is discussed.

Introduction

Phyllotaxy is the arrangement of leaves and other lateral organs on a plant. The most common phyllotactic pattern is spiral, in which lateral organs are separated by the golden angle, $\approx 137.5^\circ$, derived from the Fibonacci sequence (Jean, 2009; Prusinkiewicz and Lindenmayer, 2012). We ascend the genetic spiral of a plant starting at the base of the shoot axis where the oldest leaves are located and follow successively younger

leaves up towards the shoot apex where the youngest leaves are initiating. The direction of the ascending genetic spiral is either clockwise or counter-clockwise (**Fig. 1**). Early studies across numerous, diverse plant species not only found that the ratio of clockwise and counter-clockwise individuals in a population tend to be 50:50 (De Vries, 1903; Koriba, 1914; Ikeno, 1923), but also that phyllotactic direction is not heritable (Imai, 1927). Although not spiral phyllotaxy, a special case of seeds from alternating rows of maize ears and other grass inflorescences producing seedlings in which the left or right side of the first leaf would overlap the other was reported by Compton (1912). In this case, too, phyllotactic direction is not heritable and the result of developmental constraints. Another potential influence on phyllotactic direction is the environment. Considering phyllotactic direction in a number of herbaceous and woody species in the South Atlantic region of the United States, Allard (1951) found that overall results tended towards a 50:50 ratio in aggregate. However, in keeping track of the same species sampled in different locations or times a number of sub-samples significantly deviated from a 50:50 ratio, at odds with the overall results. Even when performed correctly, the interpretation of statistical results can yield false positives or represent under-sampled environmental effects. Especially when untangling genetic and environmental effects, it is imperative that sampling is broad and robust to avoid spurious conclusions.

Spiral phyllotactic handedness impacts asymmetry at an organismal level through the same mechanism by which phyllotaxy itself arises: the plant hormone auxin (Kuhlemeier, 2007). Auxin is sufficient to direct the location of leaf primordium initiation

90 (Reinhardt *et al.*, 2000). When considered with the intracellular localization of the auxin
 91 efflux carrier PIN-FORMED1 (PIN1) within the shoot apical meristem (Reinhardt *et al.*,
 92 2003) that directs auxin toward neighboring cells with high auxin concentrations
 93 (Benková *et al.*, 2003), computational modeling can recapitulate spiral phyllotactic
 94 patterning (Smith *et al.*, 2006). Similar mechanisms of self-organization directed by
 95 auxin and PIN1 operate after leaf initiation, patterning venation (Scarpella *et al.*, 2006),
 96 the margin (Bilsborough *et al.*, 2011), and leaflets (Koenig *et al.*, 2009). A fundamental
 97 relationship between leaf primordia and auxin efflux leading to spiral patterning is that
 98 the incipient leaf (P0, plastochron 0) acts as an auxin sink and that older primordia

Figure 1: Phyllotactic leaf asymmetry. Phyllotactic handedness, either clockwise (orange) or counter-clockwise (blue), is determined ascending the phyllotactic spiral from the base of the plant to its tip. In clockwise phyllotaxy, the ascending (anodic) side (magenta) of the leaf is right and the descending (cathodic) side (purple) of the leaf is left, while in counter-clockwise the relationship is reversed. Because the incipient leaf (P0) is an auxin sink while older primordia (such as P1) are auxin sources, the descending side of the leaf is exposed to higher auxin levels, leading to leaf asymmetries that manifest on opposite sides of leaves in clockwise and counter-clockwise phyllotaxy.

(such as the neighboring next oldest leaf primordium, P1) are auxin sources. Because of the handedness of spiral phyllotaxy, the ascending (anodic) side of the P0 (closer to the shoot apical meristem) might receive less auxin than the descending (cathodic) side (away from the shoot apical meristem and closer to the P1) because of the proximity of the P1, an auxin source (**Fig. 1**). Considering the effects of auxin on leaf venation and margin development, the above scenario might create morphological asymmetries in the mature leaf. Because the ascending side of

the leaf is the right-hand side in clockwise phyllotaxis and the left-hand side in counter-clockwise phyllotaxis, such asymmetry would be expected to manifest as mirror images in plants with opposite phyllotactic directions (**Fig. 1**). Morphometric analysis of tomato and *Arabidopsis* leaves, auxin localization in leaf primordia and their curvature, and computational modeling of auxin asymmetries in the shoot apical meristem all confirm auxin-dependent mirroring of leaf asymmetry arising from opposite phyllotactic directions (Chitwood *et al.*, 2012a).

Independent of the above auxin-based mechanism and subtle statistical morphometric leaf asymmetries, Korn (2006) described easily observable morphological features that corresponded with the ascending (anodic) side of leaves, and thus phyllotactic direction. In *Syngonium podophyllum*, the midrib curves and leaf coils towards the ascending side of the leaf; in *Acalypha virginica* the axillary bud on the ascending side is smaller than the descending side; in *Croton variegatus* 'Banana' a secondary blade is only initiated on the ascending side of leaves; and in *Aglaonema crispum*, the smaller half of the leaf is ascending (Korn, 2006). As the ascending side is the right side of the leaf in clockwise phyllotaxis and the left side in counter-clockwise phyllotaxis, phyllotactic direction was also recorded. All of the above species had shoots of both phyllotactic directions. Leaf asymmetry was also described for *Goeppertia ornata* (referred to as *Calathea ornata* in Korn, 2006), in which the ascending side of leaves was smaller than the descending side. Remarkably, of the 26 shoots examined arising from nine plants, all were counter-clockwise (Korn, 2006). Assuming a null hypothesis of a 50:50 ratio, the p-value of all 26 shoots displaying counter-clockwise phyllotaxy is 3.414×10^{-7} and

0.0027 for all nine plants (Chi-squared goodness of fit test). If all shoots are of the same phyllotactic handedness, then any leaf asymmetries will be exclusively restricted to the same physical side. Korn (2006) reports all 132 leaves from the 26 shoots examined having smaller ascending sides, which together with the knowledge that all shoots were counter-clockwise means that it was exclusively the left sides of the *Goeppertia ornata* (*Calathea ornata*, Korn, 2006) leaves that were smaller than the right side. This report of exclusive counter-clockwise handedness in a species—with strong effects on leaf asymmetry—has important implications for phyllotactic theory, in which the null hypothesis assumes that spiral phyllotaxy is stochastically patterned in a 50:50 ratio.

Here, we leverage a citizen science approach to see if indeed calatheas (*Goeppertia spp.*) are biased towards a counter-clockwise phyllotactic direction. Using the popularity of calatheas as houseplants and social media, we initiated a Twitter poll to which 105 people responded. The results of the poll showed a strong bias of calathea plants exhibiting counter-clockwise compared to clockwise phyllotaxy, as inferred from the handedness of leaf shape. To verify the results beyond the poll, we undertook two approaches. First, we examined plants from Google image searches of calathea species and scored phyllotactic direction based on the appearance of leaves. Next, we verified phyllotactic direction in nurseries across four different countries and two continents. Together, our results demonstrate that cultivated calatheas exhibit a strong bias in phyllotactic direction, across numerous independent observations across the world and upon personal verification by the authors. Hypotheses regarding the origin of

the bias are discussed, with implications for a possible genetic origin of phyllotactic handedness in calatheas.

Materials and Methods

While referring to our study taxa, we aim to reflect the most recent taxonomic changes and promote ease of use. *Calathea*, as formerly defined, is polyphyletic, and was recently split into two main groups (Borchsenius *et al.* 2012). One clade (*Calathea II*) is more closely related to *Ischnosiphon* than the rest of *Calathea*, and retains the generic name. A second clade (*Calathea I*), including all of our study species, is now included in the genus *Goeppertia*. We still refer to these generally as “calatheas” here and in the Twitter poll in order to facilitate name recognition but adopt the most recent binomials throughout (**Table 1**).

A Twitter poll was initiated 20 July 2020. An explanatory figure was posted with the poll that asked readers “Is your Calathea a Lefty or a Righty?”, showing example calathea leaves of each hand (**Fig. 2A**). The leaf images were taken from Korn (2006), with attribution stating that the figure had been modified by reflection for demonstration (the left-handed images were the original image; the right-handed leaves were modified by reflection). Left and right-handed designations were selected to make it easier for the public to determine the handedness of their leaves and do not correspond to helical conventions of handedness (and in fact, they can be interpreted as opposite of helical conventions). For example, left-handed leaves were described as “Left side smaller”

and “Leaf curved towards left” with corresponding arrows pointing left. The poll itself reiterated the description of right- and left-handed leaves (**Fig. 2B**). Participants in the poll could respond “My plant is left-handed”, “My plant is right-handed”, or “Neither of the above”. The poll lasted for one week, after which it was closed, and results were made publicly available.

Figure 2: Twitter poll and results. **A)** Diagram showing poll participants example calathea leaves to orient them to leaf handedness. This figure was modified by reflection from the original figure of Korn (2006) for example (left-handed leaf images are the original images, right-handed leaf images have been reflected). A note of the modification from Korn (2006) was made in the original image (bottom left hand corner). **B)** Final poll results, made public after the poll ran for a week, are shown.

To verify the Twitter poll results, calathea images from Google image search were used by the authors (**Fig. 3**). Five calathea species (that are popular as houseplants) were queried: *G. lancifolia*, *G. makoyana*, *G. orbifolia*, *G. ornata*, and *G. roseopicta*. The first 50 non-redundant images from the search were saved and the links from where they originated were recorded. Images of *Aloe polyphylla* were similarly curated as a control. The three authors scored each image as -1, 0, +1 for left-handed, neither, and right-handed, respectively. “Neither” is a category that encompasses plants with both left-

194 and right-handed leaves in equal ratios, leaves
195 that do not have handedness, or plants where
196 left- or right-handed determination could not be
197 made for any number of reasons. The three
198 scores were averaged. *A. polyphylla* images
199 were scored once and not averaged as
200 phyllotactic handedness was obvious.

201
202 In-person verification of plants was undertaken
203 by the authors by examining calathea plants at
204 local nurseries. All available calathea plants at

205 each location were examined and a photo was taken with a marker to ensure that
206 manipulation by reflection had not taken place. Each author scored the respective
207 plants they examined as -1, 0, +1 for left-handed, neither, and right-handed,

208 respectively. Plants were examined in nurseries at the following locations: La Tinaja,
209 Guanajuato Mexico; Hull, UK; Brussels, Belgium; Austin, Texas USA (**Fig. 4, Table 1**).

210 The number of plants and species at each location was as follows: Mexico, 28 plants
211 total, 8 *G. makoyana*, 14 *G. ornata*, 5 *G. picturata*, 1 *G. zebrina*; United Kingdom, 106
212 plants total, 6 *G. concinna*, 15 *G. lancifolia*, 4 *G. louisae*, 31 *G. majestica*, 6 *G. orbifolia*,
213 1 *G. ornata*, 7 *G. picturata*, 23 *G. roseopicta*, 2 *G. rubifarba*, 1 *G. warscewiczii*, 10 *G.*
214 *zebrina*; Belgium, 8 plants total, 4 *G. concinna*, 1 *G. ornata*, 2 *G. roseopicta*, 1 *G.*
215 *rufifarba*; United States, 17 plants total, 16 *G. louisae* 'Maui Queen', 1 *G. zebrina*.

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Figure 3: Google image search results. The first 50 images for each species (*G. lancifolia*, *G. makoyana*, *G. orbifolia*, *G. ornata*, and *G. roseopicta*) by Google image search were scored for handedness as left (-1), neither (0), or right (+1) by each of the three authors and averaged. Shown are the counts for each species for each averaged score. Colors indicating each species are provided in legend.

Figure 4: Handedness in nursery-inspected plants. Numbers of *Goeppertia* species (vertical axis) with left- (L), neither (N), or right-handedness (R) at four different locations (horizontal axis). Color intensity (purple) indicates the number of plants (indicated by text).

Statistical analyses were performed in R (R Core Team, 2019). All visualizations were made using ggplot2 (Wickham, 2016). For tests of bias in handedness from Korn (2006), the Twitter poll, and nursery inspections, Chi-squared goodness of fit test was used with the `chisq.test()` function. For the Google image search results, a two-tailed Wilcoxon signed rank test was used with the `wilcox.test()` function.

Results

The Twitter poll yielded 105 responses: 49.5%, 52 responses “My plant is left-handed”; 10.5%, 11 responses “My plant is right-handed”; 40%, 42 responses “Neither of the above” (**Fig. 2B**). Disregarding “Neither of the above” responses and testing against a null hypothesis of 50:50 left-to-right handed, Chi-squared goodness of fit test rejects the null hypothesis ($p = 2.398 \times 10^{-7}$).

For the scoring of handedness from Google image search results, five species with 50 images each were scored and averaged between the three authors (**Fig. 3**). A two-sided Wilcoxon signed rank test was used to test the null hypothesis that the average of

the distribution for each species was 0 (neither). For each species, the null hypothesis was rejected with the following p-values: *G. lancifolia*, $p = 1.808 \times 10^{-9}$; *G. makoyana*, $p = 3.885 \times 10^{-10}$; *G. orbifolia*, $p = 1.931 \times 10^{-8}$; *G. ornata*, $p = 2.041 \times 10^{-9}$; *G. roseopicta*, $p = 4.879 \times 10^{-10}$. The distributions for each species were heavily skewed towards -1, indicating left handedness and counter-clockwise phyllotaxy. *Aloe polyphylla* was used as a control to ensure that images downloaded from the internet had not been reflected. The phyllotactic direction in this species is obvious and images were qualitatively scored as clockwise (28 images) and counter-clockwise (22 images). A Chi-squared goodness of fit test does not reject the null hypothesis of a 50:50 ratio ($p = 0.3961$).

Handedness of plants was verified in person at nurseries in four countries (**Fig. 4; Table 1**). Because the authors could verify plant handedness in person, each plant was simply scored as left-handed (-1), neither (0), or right-handed (+1). A Chi-squared test was used with a null hypothesis assuming equal proportions of each category. In all locations the null hypothesis was rejected: La Tinaja, Gto. Mexico $n = 28$ and $p = 9.592 \times 10^{-7}$; Hull, UK $n = 106$ and $p = 8.689 \times 10^{-16}$; Brussels, Belgium $n = 8$ and $p = 0.0003355$; Austin, TX USA $n = 17$ and $p = 0.01365$. If plants at all locations are combined, 159 plants were measured with a p value of 4.034227×10^{-25} . Overall, 109 plants were scored as left-handed, 50 as neither, and 0 as right-handed.

Discussion

The Twitter poll provided a global platform to sample truly independent responses (**Fig. 2**). Respondents did not know the results of the poll before they responded, and once results were publicized, the poll closed. There was no way respondents could be biased by previous responses. Unlike a common garden experiment in which local environmental effects are highly controlled for but the extrapolation of results to different environments is limited, the Twitter poll results are globally sampled. Each respondent purchased or propagated and grew their calathea plant in a truly unique environment. For an easy to measure, qualitative trait, such a poll allows for a robust survey of the overall proportion of handedness in calatheas from numerous, independent sources across the world. Nonetheless, there are caveats. Although strong leaf asymmetry and clear instructions make it easy to infer phyllotactic direction, participants may have made mistakes, or at worst fabricated results. In the case of fabrication, the question is such that responses would be random (there is no reason to select one response over another). Twitter users that wanted to see results without participating may have voted for either “Neither of the above” or “My plant is left-handed”/“My plant is right-handed” with equal probability. Compared to results from the Google image search and in-person inspection of plants at nurseries by the authors, the Twitter poll has an exceptionally high proportion of responses for “neither” (40%) as well as the ratio of right-to-left handed (17.5:82.5), indicating that more than likely responses to these categories are inflated. By discounting the “neither” responses altogether and focusing on testing the ratio of right-to-left against a null hypothesis of 50:50, the null hypothesis is rejected ($p = 2.398 \times 10^{-7}$). This result is likely robust, as the above-mentioned sources of error act to support the null hypothesis, not the alternative.

Two methods were used to verify the Twitter poll result. The first was Google image searches of specific calathea species (**Fig. 3**). This method still relies on others taking photos of plants and assumes that the photos have not been reflected. Like the Twitter poll, it should be noted that the source of error (the photographer reflecting the photo) works in support of the null hypothesis, not the alternative. Additionally, the *Aloe polyphylla* results indicate that, at least for this species, reflection did not affect the observed ratio of 50:50 in phyllotactic handedness. Unlike the twitter poll, the authors themselves scored each of the images, averaging across their responses (-1 for left, 0 for neither, and +1 for right). The null hypothesis that the mean of the distribution was zero was rejected for each species, and there was a strong left-handed bias for each species. The second method to verify results was in-person visits by each of the authors to nurseries across four countries and two continents (**Fig. 4, Table 1**). Here, the authors could rely on their own expertise to score the plants. Among 159 plants, none were scored as right-handed and all were scored as either left-handed or neither. Together the original results of Korn (2006), the Twitter poll, scoring of images from Google image search, and in person inspection, we conclude that leaves in calatheas are highly skewed to left-handed, indicating counter-clockwise phyllotaxy. This bias is found in cultivated populations throughout the world. We only reject (strongly) the null hypothesis that the ratio of clockwise to counter-clockwise is 50:50 in calatheas, as we cannot support the hypothesis that phyllotaxy in calatheas is exclusively counter-clockwise.

Besides the original report by Korn (2006) of exclusive phyllotactic direction in *Goeppertia ornata* (*Calathea ornata*), another report is in banana (*Musa*; Skutch, 1927; 1930) where it is reported to be clockwise: “The spiral in which the leaves are arranged is always left-handed; it rises from the right to the left of an observer facing the stem” (Skutch, 1927). As an effect of the fixed phyllotactic direction, leaf morphology is impacted as well: “Every banana leaf I have ever examined closely was rolled in the same way, the right half covered by the left” (Skutch, 1930). These statements need to be verified, similar to those for calatheas here, and there is at least one published work with illustrations of leaf asymmetry of both hands contradicting this claim (Argent, 1976). If true, it is suspicious that *Goeppertia* and *Musa* are both members of the Zingiberales. One hypothesis is that because of rhizomatous growth and propagation by division, biased phyllotactic handedness is preserved through propagation of limited wild collections of these taxa. However, most commercial calathea and banana propagation is now through tissue culture (Chen and McConnell, 2006; Banerjee and de Langhe, 1985). Considering the production of shoot apical meristems *de novo* during tissue culture, it is expected that phyllotactic direction would be reset. Further, although rare, seed propagation in calatheas is possible and does occur. It is unlikely that so many species would exhibit strong phyllotactic biases in the same direction as observed here because of propagation by division alone. A genetic mechanism specifying the bias in phyllotactic direction is more likely.

A genetic bias in handedness is not unprecedented. Twining in vines is predominantly counter-clockwise (right handed helices). Similar to *Goeppertia*, this bias is observed

throughout the world, indicating a strong genetic component independent of environment (Edwards *et al.*, 2007). Another example of directional asymmetry is *Alstroemeria*, in which the resupinate leaves exclusively twist in a counter-clockwise direction. The phyllotactic ratio is unaffected and 50:50 in *Alstroemeria* but leaves from clockwise phyllotactic plants are smaller than those from counter-clockwise plants, perhaps from a conflict arising between counter-clockwise resupination and clockwise phyllotaxy (Chitwood *et al.*, 2012b). There is also a molecular basis for directional asymmetries, where microtubule mutants in *Arabidopsis* create directional helices, but phyllotactic direction is not impacted (Furutani *et al.*, 2000; Hashimoto, 2002). This is despite a connection between microtubules and phyllotaxy (Heisler *et al.*, 2010). If genetic, the fixed phyllotactic handedness in *Goeppertia* (and potentially other members of Zingiberales) is singularly unique. Across disparate species, phyllotaxy is reported to occur equally in opposite directions (De Vries, 1903; Koriba, 1914; Ikeno, 1923; Imai, 1927), a non-heritable trait that is stochastically determined. The widespread bias in independently grown calathea plants across the world reported here from citizen scientists, which verify the original observations by Korn (2006), demonstrate unknown mechanisms at play, and that current models of phyllotaxy are incomplete.

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Author Contributions

DHC conceived the study. BD, FC, and DHC designed the study. BD, FC, and DHC conducted data gathering and phenotyping. Twitter Calathea Poll Participants provided data. DHC performed statistical analyses. BD, FC, and DHC wrote, edited, and reviewed the manuscript.

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Data and Coding Availability Statement

All data, code, and original images necessary to reproduce this work can be found on figshare at https://figshare.com/articles/dataset/Directional_phyllotactic_bias_in_Calathea_spp_Marantaceae_a_citizen_science_approach/13140434

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Figure Legends

Figure 1: Phyllotactic leaf asymmetry. Phyllotactic handedness, either clockwise (orange) or counter-clockwise (blue), is determined ascending the phyllotactic spiral from the base of the plant to its tip. In clockwise phyllotaxy, the ascending (anodic) side (magenta) of the leaf is right and the descending (cathodic) side (purple) of the leaf is left, while in counter-clockwise the relationship is reversed. Because the incipient leaf (P0) is an auxin sink while older primordia (such as P1) are auxin sources, the descending side of the leaf is exposed to higher auxin levels, leading to leaf asymmetries that manifest on opposite sides of leaves in clockwise and counter-clockwise phyllotaxy.

Figure 2: Twitter poll and results. A) Diagram showing poll participants example calathea leaves to orient them to leaf handedness. This figure was modified by reflection from the original figure of Korn (2006) for demonstration (left-handed leaf images are the original images; right-handed leaf images have been reflected). A note of the modification from Korn (2006) was made in the original image (bottom left hand corner). **B)** Final poll results, made public after the poll ran for a week, are shown.

Figure 3: Google image search results. The first 50 images for each species (*G. lancifolia*, *G. makoyana*, *G. orbifolia*, *G. ornata*, and *G. roseopicta*) by Google image search were scored for handedness as left (-1), neither (0), or right (+1) by each of the three authors and averaged. Shown are the counts for each species for each averaged score. Colors indicating each species are provided in legend.

Figure 4: Handedness in nursery-inspected plants. Numbers of *Goeppertia* species (vertical axis) with left- (L), neither (N), or right-handedness (R) at four different locations (horizontal axis). Color intensity (purple) indicates the number of plants (indicated by text).

Table 1: A list of our study taxa in its old classification under the genus *Calathea*, and their new and correct binomial nomenclature after Borchsenius *et al.* (2012).

Previously known as	Most recent binomial nomenclature <i>sensu</i> Borchsenius <i>et al.</i> (2012)
<i>Calathea concinna</i> (W.Bull) K.Schum.	<i>Goeppertia concinna</i> (W.Bull) Borchs. & S.Suárez
<i>Calathea lancifolia</i> (Boom)	<i>Goeppertia lancifolia</i> (Boom) Borchs. & S.Suárez
<i>Calathea louisae</i> (Gagnep.)	<i>Goeppertia louisae</i> (Gagnep.) Borchs. & S.Suárez
<i>Calathea majestica</i> (Linden) H.Kenn.	<i>Goeppertia majestica</i> (Linden) Borchs. & S.Suárez
<i>Calathea makoyana</i> (É.Morren)	<i>Goeppertia makoyana</i> (É.Morren) Borchs. & S.Suárez

<i>Calathea orbifolia</i> (Linden) H.Kenn.	<i>Goeppertia orbifolia</i> (Linden) Borchs. & S.Suárez
<i>Calathea ornata</i> (Linden) Körn.	<i>Goeppertia ornata</i> (Linden) Borchs. & S.Suárez
<i>Calathea picturata</i> K.Koch & Linden	<i>Goeppertia picturata</i> (K.Koch & Linden) Borchs. & S.Suárez
<i>Calathea roseopicta</i> (Linden ex Lem.) Regel	<i>Goeppertia roseopicta</i> (Linden ex Lem.) Borchs. & S.Suárez
<i>Calathea rufibarba</i> Fenzl	<i>Goeppertia rufibarba</i> (Fenzl) Borchs. & S.Suárez
<i>Calathea warscewiczii</i> (L.Mathieu ex Planch.) Planch. & Linden	<i>Goeppertia warscewiczii</i> (L.Mathieu ex Planch.) Borchs. & Suárez
<i>Calathea zebrina</i> (Sims) Lindl.	<i>Goeppertia zebrina</i> Nees

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