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Measuring relative flower size in *Anthurium* (Araceae) as a continuous quantitative character

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Abstract

Relative flower size (RFS) was studied quantitatively in natural populations of *Anthurium erskinei* (one population) and *A. talmonii* (two populations) to investigate its potential as a taxonomic descriptor. RFS is defined as the ratio of spadix diameter and transverse floral width in the same region of the spadix. Variation was examined within and between inflorescences, populations and species. Within a single spadix, RFS may vary significantly between basal and upper spadix zones but usually not between basal and middle zones. Within populations, RFS does not differ significantly between spadix zones. Log-transformed RFS values showed significant inter-population differences. In nested ANOVA, between-species variance accounted for >90% of total variance. In *A. talmonii* between-population within-species variance amounted to >78% of total variance (mean RFS values), and within-spadix-zone within-spadix variance accounted for >31% of total variance (individual values). Bootstrap sampling showed that five pairs of flower and spadix diameter measurements per spadix would provide an adequate estimate of mean RFS for each population. The study suggests that RFS can be a useful quantitative taxonomic floral character for comparing species and populations in the genus *Anthurium*.

Key-words: Morphometrics, phenological phases, spadix diameter; spadix zones, transverse flower width

Introduction

Various taxonomists who have studied the mega-genus *Anthurium* Schott (1829: 828) (Araceae) in recent years have noted the need to focus more attention on comparing floral structures, which have been relatively neglected as species descriptors (Temponi 2006, Nadruz Coelho *et al*. 2009, Carlsen & Croat 2013). By contrast there are studies of floral developmental morphology in species of the genus by Jean & Barabé (2001), Jeune & Barabé (1998, 2002) and Barabé & Lacroix (2008). Croat (1980) published a pioneer paper on patterns of floral phenology in the genus.

Croat & Bunting (1979), in their now classic methodological paper on *Anthurium* species descriptions, proposed a technique for estimating flower size relative to spadix diameter. This character had been neglected in taxonomic descriptions, despite the wide inter-species variation that can be seen in *Anthurium* spadices, both in absolute flower size and in flower size relative to spadix diameter. Their method consists of estimating by eye the number of flowers visible in the two main spirals (parastichies) when viewing the spadix from one side.

This character has been used by subsequent taxonomists of *Anthurium* (e.g. Carlsen & Croat 2007), but it has not previously been investigated as a continuous quantitative character, nor has its within-species or within-population variation been studied statistically. Flower size and spadix diameter vary considerably between the different phenological phases as the spadix passes from anthesis to fruiting stage and the effect of these changes on relative flower size has also not been studied. Instead of treating relative flower size (here abbreviated to RFS) as a meristic variable in the manner of Croat & Bunting (1979), we have defined it as a ratio of two linear measurements, the spadix diameter and the transverse width of a flower in the same part of the spadix, making the variable a dimensionless decimal number. The overall objective of the present study was to investigate the potential of RFS as a continuous quantitative taxonomic character for differentiating species and infra-specific taxa using statistical methods. The variation of RFS was studied

2B) and in the present case is an effective species discriminator while floral width is not. In *Anthurium erskinei* and *A. talmonii* the flowers, e.g. of the basal zone, do not differ significantly in transverse width (Mann-Whitney $U = 3340$, $P = 0.5313$), whereas the spadix diameters do (Mann-Whitney $U = 378.5$, $P = 3.874E\text{-}21$). Our RFS represents a scaling of the spadix diameter by floral width and is a relatively simple, statistically tractable variable. Caution is needed nevertheless in the statistical treatment of ratios (see discussions by Sokal & Rohlf 1995, pp.16–19 and Simpson *et al*. 2003, pp. 13–19), which we sought to mitigate by using all 25 possible quotients of spadix diameter and floral transverse width within each spadix zone, in order to better capture the full range of variation.

The two species investigated here were deliberately chosen because of their contrasting flower-spadix proportions. They are easy to distinguish in leaf shape, peduncle length, spathe size, shape and attitude, spadix shape and berry colour. Against this clear background of two distinct taxa, the study sought the limits of variation of RFS and its diagnostic value, given the availability of field-collected material from well-characterized populations. The inclusion of two populations of *A. talmonii* allowed us to compare RFS variation at two different taxonomic levels. While the difference in RFS between the species was expected, the inter-population difference shown here was less so and this suggests that RFS could be usefully applied in quantitative infra-specific comparisons. However, as with most other morphological characters, it is also to be expected that in some species and population comparisons, RFS will not differ significantly.

Our results also suggest that different spadix shapes may influence within-spadix patterns of RFS variation. More detailed morphological studies could well demonstrate underlying differences, related to floral and spadix ontogeny, which our taxonomically oriented approach has overlooked. Theoretical morphological studies of flowers in *Anthurium* have not so far focussed on relative flower size. Barabé & Lacroix (2008) studied the ontogeny of the early stages of the flowers of *Anthurium jenmanii* Engler (1905: 72–73). Jean & Barabé (2001) studied phyllotactic patterns in *Dracontium* Linnaeus (1753: 967) and *Anthurium* using mathematical models, which revealed discontinuous transitions in the phyllotactic sequence. Jeune & Barabé (1998, 2002) studied the shape of flowers in *Monstera* Adanson (1763: 470) and *Anthurium* and the interactions of physical and biological constraints, which differed in the two examples. However, they mentioned differences in flower density within the spadices.

Besides application to taxonomic delimitation, quantitative data on floral characters is increasingly important in studies of pollination biology in Araceae. Chouteau *et al.* (2008) and Gibernau *et al.* (2010) have studied a range of quantitative characters of pollen, flowers, ovules and stigmas and computed character syndromes using multivariate analyses which correspond to different classes of pollinator.

This study indicates that relative flower size (RFS) can be a useful quantitative character at species and infra-specific levels. It has the potential for wider application in the taxonomy of Araceae as a descriptor for species delimitation in other relatively species-rich genera with numerous bisexual flowers, e.g. *Pothos* Linnaeus (1753: 968), *Monstera*, *Rhaphidophora* Hasskarl (1842: 11), *Rhodospatha* Poeppig (1845: 91) and *Spathiphyllum* Schott in Schott & Endlicher (1832: 22).

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