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Original Research

# Pollination by nitidulid beetles in the hemi-epiphytic aroid *Monstera lentii* (Araceae: Monsteroideae)

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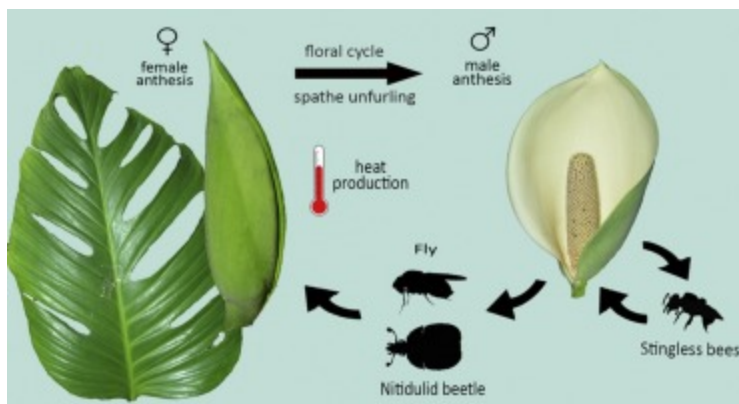
## Highlights

- Pollination studies from bisexual aroids are underrepresented in the literature.
- The pollination mechanisms of the Neotropical genus Monstera are misunderstood.
- *Monstera lentii* exhibited traits associated to cantharophily.
- Nitidulid beetles were the most abundant visitors to inflorescences.
- Drosophilid flies were also visitors and potential pollinators.

## Abstract

Among aroids (Araceae family) with bisexual flowers, the reproductive biology of the neotropical genus *Monstera* (Subfamily Monsteroideae) is misunderstood. Nothing is known about the reproductive phenology and the sparse evidence on its pollination system is equivocal, suggesting both bees and beetles as pollinators. In order to elucidate the pollination system and reproductive behavior of *Monstera*, we documented the floral cycle, spathe movement, floral visitors, and heat production of the inflorescence, and the flowering and fruiting phenology of *M. lantii* in a montane forest in Costa Rica. We found that *M. lantii* was mainly visited and likely pollinated by nitidulid beetles (*Cychrocephalus corvinus*, Nitidulidae) from the Mystropini tribe, which were mainly known as palm pollinators so far. In this mutualism, the beetles use the floral chamber as shelter, mating place, and probably as brood site. Drosophilid flies also visited the inflorescences and might participate in a mixed-pollination system, while stingless bees are considered as pollen robbers. Flowering and fruiting peaks occurred during the rainy season. Floral development was protogynous, a mechanism likely to prevent self-pollination. We concluded that pollination in *M. lantii* represents a highly dependent system on biotic pollinators for successful fruit set which likely contributes to an out-crossed mating system. Our findings indicate that pollination systems of bisexual aroids are more diverse than previously suggested.

## Graphical abstract



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## Introduction

The Araceae family (aroids) is among the most diverse flowering plants in tropical and subtropical regions, with ca. 3750 species distributed among 125 genera worldwide (Boyce and Croat, 2016). Aroids are herbaceous monocotyledons characterized by displaying diverse growth habits; from mostly terrestrial to epiphytic and hemi-epiphytic (Bown, 2000). The characteristic reproductive structures of aroids have a common design composed of a leaf-like bract (spathe) that subtends and sometimes encloses the spike (spadix); a terminal fleshy axis that bears the small and highly modified flowers (Grayum, 1990). Two groups within Araceae are distinguished according to their sexual expression, one of them consists of bisexual basal groups (bearing hermaphroditic flowers) from the Pothoideae and Monsteroideae subfamilies; and the other comprises monoecious species (bearing staminate and pistillate flowers arranged in separated sections of the spadix) mainly from the Aroideae subfamily (Cusimano et al., 2011, Grayum, 1990).

Pollination mechanisms of aroids have been mostly documented in monoecious genera of the subfamily Aroideae from the neotropics (*Dieffenbachia*, *Philodendron*, and *Xanthosoma*) and paleotropics (*Amorphophallus*, *Arisaema*, and *Arum*) (reviewed in Gibernau, 2003, Gibernau, 2011). Pollination of aroids involves insects (mainly beetles, flies, and bees), dichogamous (protogyny) floral development, and short anthesis periods (1–2 d) in monoecious species versus longer periods in bisexual species. Among monoecious groups, the spathe frequently encloses the spadix, a floral chamber develops and heat is produced by the spadix (Gibernau and Barabé, 2000, Gibernau and Barabé, 2002, Gibernau et al., 1999, Maia et al., 2010). Heat production or thermogenesis has been associated to the emission of volatiles to attract pollinators (mainly beetles and flies) during floral anthesis (Gibernau and Barabé, 2002, Gottsberger and Amaral, 1984, Gottsberger et al., 2013, Seymour, 1999) and insect thermic reward (Seymour et al., 2003). In some cases, insects are attracted to the floral chamber by deceptive means, imprisoned and later released through movement of the spathe in a mechanism known as “trap-pollination” (Dafni, 1984). Pollination by trap mechanisms have appeared at least ten times in the aroid family and is present in 27 genera (Bröderbauer et al., 2012).

The few pollination studies of bisexual aroids include species from the subfamilies Pothoideae (*Anthurium*) and Monsteroideae (*Monstera* and *Spathiphyllum*) (Etl et al., 2017; reviewed in Gibernau, 2003, Gibernau, 2011, Gibernau, 2016). These groups apparently do not develop a floral chamber nor trap-pollination mechanisms (Bröderbauer et al., 2012). The pollination ecology of *Monstera* (60 spp.) has received little attention and the scanty evidence is contradictory (Gibernau et al., 2010). *Monstera* is exclusive to Tropical America and one major center of diversity locates in southern Mesoamerica between Costa Rica and Panama (Grayum, 2003). Stingless bees have been reported as visitors to inflorescences

when the spathe is fully opened (Madison, 1977, Ramírez and Gómez, 1978); while beetle pollination was suggested by Chouteau et al. (2007). Thus far, the latter work is the only detailed pollination study available from a *Monstera* species. Chouteau et al. (2007) described a pattern of spathe unfurling, formation of a floral chamber and heat production in *M. obliqua* in French Guiana. Additional cases of thermogenesis in the genus have been reported for *M. adansonii* and *M. deliciosa* from cultivated plants *ex-situ* (Chouteau et al., 2009). At present, however, it is unclear the potential role of the floral chamber and thermogenesis in the pollination system of *Monstera*.

Knowledge on pollination systems of bisexual aroids is necessary to understand the evolution of pollination mechanisms in this diverse plant family (see Bröderbauer et al., 2012, Chartier et al., 2014, Gibernau et al., 2010). Documenting the reproductive biology, phenology and pollinators of rare and geographically restricted plant species provides key information for their conservation. The aim of this study is to increase the knowledge on the pollination systems of bisexual aroids by studying the pollination ecology and reproductive phenology of a *Monstera* species endemic to humid and cloud montane forests from southern Mesoamerica. We tested for cantharophily in *Monstera lentic* as previously documented for *M. obliqua* (Chouteau et al., 2007). We specifically aimed at describing (i) the floral cycle in relation to spathe movement and floral visitors/pollinators, (ii) the pattern of thermogenesis, (iii) the population flowering and fruiting phenology, and (iv) the female reproductive success and spontaneous self-pollination.

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## Section snippets

### Study site and species

Field work was conducted in a montane cloud forest fragment in the vicinity of the Central Valley of Costa Rica, Cartago province (9°52'–9°54'N, 83°57'–84°00' W), known as Cerros La Carpintera, which is on the northern limit of the Talamanca Mountain Range. The mountainous terrain rises from 1500 to 1850m asl, and the forested area (ca. 840ha) is a mixture of irregular primary forest remnants intermixed with old growth secondary forest (+75 y old) covering the ridge and upper slopes and...

### Inflorescence development, anthesis, and floral visitors

Inflorescences emerged from the upper leaf axils and each plant produced an average of 4.8 ( $\pm 2.9$  S.D.) inflorescences during the study year. The spathe enclosing the spadix was in

vertical position while the peduncle remained covered by the petiole sheath. The floral cycle at the inflorescence level initiated when the spathe started to unfurl and terminated when it was fully opened, after 8–9 days. During that period, we identified three stages associated to changes in spathe behavior, sexual...

## Discussion

This study is the second documenting *Monstera* pollination and the first documenting the pollination ecology of *Cychrocephalus corvinus*; a species from the Mystropini tribe also known as “sap beetles” which have been documented to be mainly palm pollinators (Kirejtshuk and Couturier, 2010)....

## Acknowledgements

Roberto Cordero (Universidad Nacional de Costa Rica) and Paul Hanson (Universidad de Costa Rica) commented an early manuscript. Carlos Vilela (Universidade de São Paulo, Brazil, drosophilid flies), Paul Hanson (Universidad de Costa Rica, bees), and Andrew Cline (California Department of Food & Agriculture, USA, nitidulid beetles) identified the insects. The National Meteorological Institute (IMN) kindly provided the weather data. Marc Gibernau provided valuable comments. To the staff of Campo...

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2024, Journal for Nature Conservation

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### [A case for studying biotic interactions in epiphyte ecology and evolution](#)

2022, Perspectives in Plant Ecology, Evolution and Systematics

#### *Citation Excerpt :*

...Some bromeliad species seem to have one primary pollinator, but more frequently are visited by many pollinator species (Aguilar-Rodríguez *et al.*, 2014). Aroids have diverse pollination and reproduction strategies, including mutualisms with both specialist and generalist insects and birds (Bleiweiss *et al.*, 2019; Gibernau and Chartier, 2010; Prieto and Cascante-Marín, 2017), and some epiphytic cacti are pollinated by bats (Tschapka *et al.*, 1999). Pollination strategies are less well-characterized for other groups of vascular epiphytes, but most seem to rely heavily on relatively rare visits of animal pollinators (Madison, 1977; Mondragón *et al.*, 2015)....

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## Bird visitation to a high Andean *Anthurium* (Araceae) in Eastern Ecuador

2019, Flora: Morphology, Distribution, Functional Ecology of Plants

*Citation Excerpt :*

...However, the pollination systems of only a tiny fraction of aroid species have been studied in any detail. Notably, recent investigations suggest that even subtle variations on the basic aroid inflorescence form constitute specializations for very different arthropod pollinators, distinguishing species adapted for pollination by bees, beetles, or flies (Croat, 1980; Gibernau, 2011; Gibernau et al., 2010; Prieto and Cascante-Marín, 2017). Thus, the true diversity of aroid visitors and pollination systems is probably underestimated....

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## A new Costa Rican species of *Drosophila* visiting inflorescences of the hemi-epiphytic climber *Monstera lantii* (Araceae)

2018, Revista Brasileira de Entomologia

*Citation Excerpt :*

...By the third or fourth day of the cycle, the stigmas begin to look wet and shiny, a slight bittersweet odor is produced, and a few (4–8) flies arrive in the floral chamber. For the next few days, an average of 28 ( $\pm 24$  S.D.) individuals of *Drosophila* stay in the floral chamber, wander along the spadix and copulate, until the end of the floral cycle when they leave (Prieto and Cascante-Marín, 2017). Flies, description and imaging....

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## Revision of *Monstera* (Araceae: Monsteroideae) of Central America ↗

2024, Phytotaxa

## Patterns and drivers of heat production in the plant genus *Amorphophallus* ↗

2023, Plant Journal



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