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The Bulb Garden

~Gardening with Bulbs ~

What's Inside...

Shining a light on bulbils: *Globba* L. (Zingiberaceae)

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Flowering plants display an exceptional diversity of asexual and sexual reproductive mechanisms. Both asexual and sexual modes represent alternative reproductive mechanisms that plants may adopt in order to counter temporally or spatially variable environments. In plants, it is common to find that a single individual may resort to either mode, resulting in a "mixed reproductive strategy." Investigating the conditions under which plants opt for a mixed reproductive strategy can allow us to explore the evolution of reproductive strategies as a response to environmental, ecological, and physiological stresses. Further, plants with mixed reproductive strategies help us understand how reproductive modes can shape their population genetic structures, since in plants we can find underlying trade-offs such as asexual reproduction resulting in increased inbreeding rates, and sexual reproduction resulting in increased outcrossing rates.

In plants, the most common type of asexual reproduction is clonal reproduction (i.e., vegetative propagation by asexual propagules), in which parental genotypes produce vegetative propagules (via rhizome, pseudovivipary, runner, sucker, stolon, and other structures) which are capable of independent growth and reproduction (Meeus et al. 2007, Ashokan and Gowda 2018). One example of asexual propagules is the bulbil (Fig. 1). Bulbils are typically asexual, enlarged, corky, storage root-forming structures that can also act as propagules (Box et al. 2006). For horticulturists, bulbils are a convenient method of propagation because they can withstand extended periods of adverse conditions, and therefore can be easily stored for several months before planting. In the plant genus *Globba* (Zingiberaceae), horticulturists have specifically exploited bulbils because of this ease of propagation, especially where certain genotypes are preferred and a breed/variety/species needs to be conserved in horticulture. However, very little is known of the phylogenetic origin of bulbils in

Fig. 1

G. multilofra *G. schomburgkii* *G. clarkei* *G. sessiliflora*

Globba cont'd

Globba, or about their role as an efficient reproductive strategy (although see Box and Rudall 2006).

The Zingiberaceae constitutes the largest family within the plant order Zingiberales, which comprises c. 53 genera and more than 1,300 species (Ivanovic et al. 2021). Members of this family are perennial, rhizomatous herbs which usually grow in moist, shady places (Saha et al. 2020). *Globba* L. is the fourth-largest genus within Zingiberaceae and one of the three genera within the tribe Globbeae, the other two being *Gangnepainia* and *Hemiorchis* (Cao et al. 2019). Plants are herbaceous, rhizomatous, and perennial, and may bear multiple inflorescences (from multiple ramets) which emerge from a single genet (rhizome). Currently, the genus *Globba* comprises at least 120 species distributed from Sri Lanka and Southeast Asia to Australia. In India, it is represented by 14 species which are confined to a few states in the Western Ghats and North East India (Joe et al. 2019). Plants within this genus are popular as ornamentals, variously known as "Dancing Girls," "Weeping Goldsmith," "Snowball," "Singapore Gold," "White Dragon," and "Ruby Queen," highlighting the delicate, attractive shape of the flowers. Many species, such as *Globba winitii* and *Globba sherwoodiana*, have become popular in horticulture due to their showy, colorful bracts, along with their delicate flowers. Flowers in this genus are characteristic pf the Zingiberaceae in possessing a single stamen and epigynous nectaries, and the anthers are unique in having triangular lateral appendages that are diagnostic of subgenera and sections within the tribe Globbeae. The labellum is attached to the filament and acts as a landing platform for pollinators, and the style is held tightly in position across the curvature of the filament like a bowstring (Box and Rudall 2006).

Besides sexual reproduction, most if not all *Globba* species can reproduce asexually by rhizomes and bulbils. Bulbils have been suggested to be rare in tropical and subtropical plants, but *Globba* is unusual in being a tropical species that invests heavily in vegetative reproduction by means of bulbils (Box and Rudall 2006). Bulbils have also been identified as a very important character in this genus, routinely used to identify many species (e.g., *G. marantina*, *G. schomburgkii*). The Tropical Ecology and Evolution Laboratory (TrEE lab) at IISER Bhopal has been studying the ecology and evolution of many taxa within the plant family Zingiberaceae (gingers) since 2013.

One of our interests has been to investigate ecological factors that may have shaped the evolution of bulbils in *Globba*, and also how this strategy may have helped the genus diversify in the Asian tropical understory. As part of the proposed Pacific Bulb Society grant, we specifically addressed whether both ecological and phylogenetic tools could be used to understand the evolutionary significance of bulbils and how they may present ecological advantages to plant species that may be using a mixed-reproductive strategy (i.e. presence of both asexual and sexual reproduction) within the same plant.

Although fieldwork for this study was planned for 2020, due to the pandemic, field experiments were carried out only in 2021, from July through October, which represents the flowering period for *Globba*; this matches the monsoon season in the Western Ghats. Further, due to pandemic-induced limited access to field locations across India, all studies were carried out only within the southern state of Kerala (Fig. 2). In total, we studied three species (Fig.3) of *Globba* (*Globba sessiliflora* Sims, *Globba orixensis* Roxb. and *Globba marina* L.) across 28 different locations. Ecological experiments included documenting and quantifying floral opening time, pollinator visits, nectar quantification, stigma receptivity, and quantifying reproductive success by estimating fruit set rates. Compatibility experiments to test selfing and outcrossing rates were carried out by setting up four crossing experiments (autogamy, selfing, geitonogamy [transfer of pollen by a vector but on the same plant], and xenogamy) in the wild. While all three species were studied in the wild, here we summarize the ecological and reproductive biology results only for *Globba marantina*, since we have the most

Globba cont'd

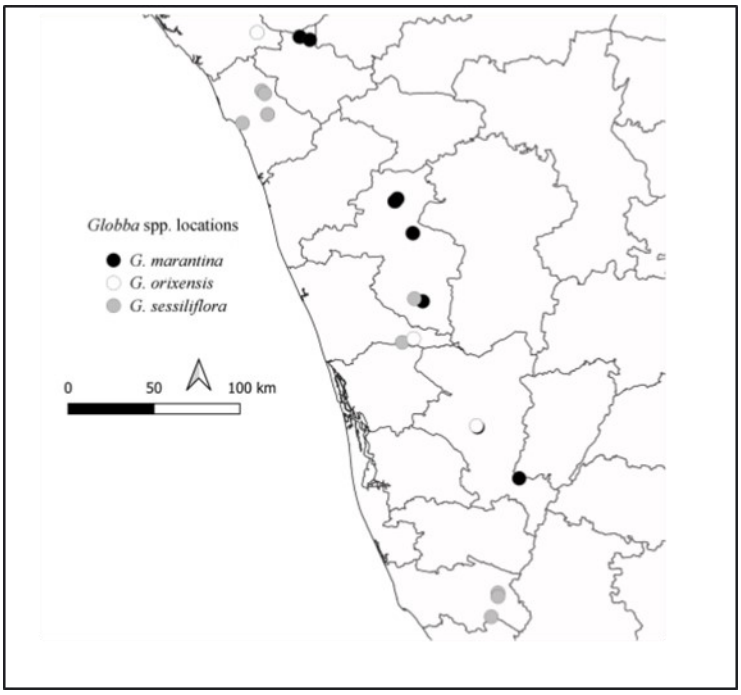

Fig 2: Study sites of three *Globba* spp. within the state of Kerala, India.

extensive sampling (n = 11 populations) for this species because of its wide distribution. All herbarium vouchers are deposited at BHPL, IISER Bhopal, India.

Globba marantina produces 1–2 flowers per inflorescence and predominantly relies on asexual reproduction by bulbils and rhizomes for propagation. Among the three species, *G. marantina* was observed to be an obligate asexual, while both *G. sessiliflora* and *G. orixensis* were facultative asexual plants. In *G. marantina*, bulbils were present throughout the inflorescence, that is on lower as well as upper bracts, as well as in the axils of leaves. Each bulbil is ovoid, brownish-yellow in its young stage, and becomes dull yellow when mature (Fig 3: Flowers of *Globba* subsp. studied). Note the presence or absence of the anther appendages and labellum shape as diagnostic features.

Flower opening time for this species was between 2:00 and 3:00 am, and anther dehiscence was observed between 9:00 and 11:00 am. Nectar energy ranged from (1-5 Kcal per flower) and peak nectar was observed at 12:00 pm (9 hours after the time of anthesis); stigma receptivity was highest at 9:00 am and 12:00 pm (6 and 9 hours after the time of anthesis). We observed zero fruit set in all of the 40 hand-pollination experiments, where 10 flowers from different genets were used in each of the four pollination treatments (autogamy, selfing, geitonogamy, and xenogamy), which suggests that the formation of bulbils in this species is not due to pollen limitation.

No natural visitors or pollinators were observed on *Globba marantina* in the studied populations, and bulbils were present in all populations. This suggests that propagation in *G. marantina* is strictly vegetative, and that most individuals in a population may be clonal. Given these observations, we also infer that despite the lack of pollinators, an asexual mode of reproduction may be a critical factor in maintaining the population size in this species. Among the three species, *G. marantina,* which is an obligate asexual species, showed higher clumping of local population sizes (n=200-350/400 m^2) when compared to the sexual species *G. sessiliflora* and *G. orixensis.* We suggest that since bulbils can survive adverse environmental conditions and can establish faster than seedlings of completely sexual species, bulbils probably provide a survival and establishment advantage. *G. marantina* was present in more diverse habitats ranging from tropical evergreen, moist deciduous to dry deciduous forest, compared to its facultative asexual congeners, which supports the theory of geographic parthenogenesis, i.e., distinct distribution of asexually reproducing species when compared to their sexual relatives. The distribution success of this species provides an insight into the role and advantage of bulbils

Fig. 3

A. *Globba marantina* B. *Globba orixensis* C. *Globba sessiliflora*

Globba cont'd

as an efficient reproductive strategy.

Our future studies include field experiments to study the ecological, physiological, and genetic relevance of bulbils as an important reproductive strategy in other *Globba* species. Finally, we think that knowledge of the reproductive system of a plant species in its natural habitat can be very important for plant breeders, who may be interested in increasing the propagation of their desired genotypes in controlled greenhouse conditions.

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A love affair with *Hippeastrums*

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I have been in love with *Hippeastrum* ever since I can remember: the vibrant colors, the speed of growth and the shiny green leaves, growing left and right. I was 10 years old when my great-grandfather gave me my very first *Hippeastrum*, the original 'Mont Blanc'. It had only two pristine white flowers and very tall, thin, dark green leaves. I was so excited; a journey had begun. In this article I would like to share my experience of growing this genus for so many years.

When it comes to *Hippeastrum*, one cannot do much wrong; it is a fairly easy-to-grow bulbous plant that is mostly sold around the Christmas holiday because its big, colorful flowers bring joy in the darkest time of year. *Hippeastrum* are commonly called "Amaryllis," a marketing name, and they have become a very successful commercial plant, with numerous new hybrids registered each year. *Hippeastrum* and *Amaryllis* are closely related and similar in appearance, and during more than one period, botanists lumped both under the name *Amaryllis*. The genus *Hippeastrum* comes from South and Central America, while the true *Amaryllis* is native to South Africa.

This article is solely based on my own experience with *Hippeastrum* here in northern Europe (Berlin, Germany), where summers are relatively warm and winters rather mild. Fall and spring are short and unpredictable in regard to temperature, and usually drier than the rest of the year.

Preparation and planting of newly purchased bulbs. If you get a hippeastrum as a cut flower, its beautiful blooms will impress you in a vase for a week or two. If you get it as a potted plant, you simply place the pot in a sunny, warm location in your house and follow the instructions it came with (more on this below). Alternatively, you can get it as a dry dormant bulb, which you need to plant yourself. I prefer to get the dry bulbs and have the full experience: planting, the first sign of a flowering scape, flowering, and