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POLLINATION BIOLOGY OF *NILGIRIANTHUS WIGHTIANUS* (NEES) BREMEK. (ACANTHACEAE) IN UPPER BHAVANI, NILGIRI MOUNTAINS, SOUTHERN INDIA

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ABSTRACT
We examined the breeding system and pollination mode of *Nilgirianthus wightianus* (Acanthaceae), a common endemic shrub found > 2000 masl in the Upper Bhavani locality of the Nilgiri plateau. *Nilgirianthus wightianus* is a rare shrub belongs to *Strobilanthes* genera. This population was monocarpic, similar to many other *Strobilanthes* in peninsula India; it flowered from August to October 2004, and died en masse in 2005. We conducted experiments to determining the breeding system and to see whether the population was pollinator limited. Controlled pollination experiment showed that autogamy and self-pollination produced lower fruit set than cross and open-pollination. However, the fruit set of hand self and cross pollination did not differ significantly. Thus, *Nilgirianthus wightianus* was completely self-compatible and showed high levels of natural fruit set, indicating that it was not pollinator limited. *Apis cerana indica* and birds such as the White-Eye (*Zosterops palpebrosa*) were common visitors.

KEYWORDS: India, pollination mode, reproductive biology, *Strobilanthes,* Western Ghats.

INTRODUCTION

In flowering plants, a highly diverse array of floral traits and reproductive system have evolved, varying from obligated cross-fertilization to obligated or promoted self-fertilization were widespread phenomenon (Takebayashi and Morrell, 2001; Castro *et al*., 2008). Although selfing presents selective advantages on reproductive assurance and crossing increases genetic diversity that reduces the risk of inbreeding depression (Castro *et al*., 2008). During hand-pollination treatments plant may produce more seeds than naturally pollinated controls, then reproduction is being limited, not by energy levels, but by pollinator activity. However, not all species are pollinator limited, thus pollinator limitation of reproductive output seems to be a common phenomenon in flowering plants. More than 80% of insect pollinators were evolved for pollination among wild plant species (Thomann *et al*., 2013). However, pollination efficiency and behaviour may vary depends on climate, habitat and pollinators activity. In most flowering plants, pollinators such as bees, diverse insects, flies and birds have made significant contribution for high level of fruit set under natural conditions. However, bees and birds were effective pollinators in rare shrubs (Whelan *et al*., 2009).

In India, the Western Ghats is well known for its high levels of plant endemism. One genera of plants, namely the *Strobilanthes* (Family Acanthaceae) are hyper diverse in this region. The *Strobilanthes* are known to flower gregariously at periodic intervals and the die en masse (Gamble, 1967; Sharma *et al*., 2008). *Strobilanthes kunthianus*, which occurs in the grasslands of the higher elevations of the Western Ghats is a well known and its spectacular mass flowering at 12 year intervals have been well documented. However, the distribution and biology of the other species are little known, and large scale habitat destruction over the Western Ghats probably places many of these species under threat of extinction.

Large scale habitat conversion and destruction has taken place in the Nilgiris over the past century. Kumar (1995) has estimated that about 50% of the montane shola forests (from almost 86000 ha to about 4225 ha), the 70% of the grasslands have been destroyed (from 29875 ha to about 4700) from 1849 to 1992. *Strobilanthus spp.,* are predominantly found in the grasslands and shola margins, and are therefore extremely vulnerable to loss of grasslands. A better understanding of the ecology and reproductive biology of *Strobilanthes* species would provide insights that would enable better management policies and practices.

Nilgirianthus wightianus is a fairly common Nilgiri endemic (Noble 2004). This species occurs in small populations along the edges, grasslands and rock faces in the Mukurti National Park (11 14. 735’ latitude N and 76 28. 506’ longitude E), Sispara (11 12. 180’ latitude and 76 26. 399’ longitude E) in the south-west Nilgiris.

We selected a population that gregariously flowered in Upper Bhavani area from August to October 2004. This population was found along the roadside and open cliff faces. It was surrounded by grassland interspersed with introduced Acacia on one side and a shola forest on the other. The population of *N. wightianus* has widespread in the restricted region of Upper Bhavani Reserve Forest and

Mukurti National Park in the Nilgiri Mountains. But the information of reproductive biology was remains unclear. Thus, this study can be first report and can provide the preliminary information of pollination biology on *N. wightianus* from this unique ecosystem.

METHODOLOGY

Study site

The study area was located in the Upper Bhavani Reserve Forest (11° 14' N and 76° 33' E), about 60 km southwest of Ootacamund, the headquarters of the Nilgiri district. Western Ghats, southern India. The elevation in the study area is above 2200-2300 m.

Methods

We selected fourteen plants from this population and conducted hand pollination experiments to determine the breeding system and to see whether the population was pollinator limited. Mature flower buds in each of the four plants received the following four treatments:

1. Open pollination: flower buds were tagged and fruit set at maturity was recorded,
2. Autogamy: Mature flower buds were tagged and bagged with a cloth mesh bag, and fruit set at maturity was recorded.
3. Hand self pollination: Mature flower buds were tagged and bagged; the buds upon opening were hand self-pollinated with pollen collected from the same plant, rebagged and fruit set followed until maturity, and
4. Hand cross-pollination: Mature flower buds were tagged and bagged and the buds upon opening were hand cross-pollinated with pollen collected from two or three other plants and then re-bagged and fruit set followed until maturity.

The self-incompatibility index (ISI) was calculated. ISI for hermaphroditic plants is the ratio between the percentage fruit set resulting from a (hand) self-pollination over (hand) cross-pollination. Species with ratios < 0.25 are considered self-incompatible and those with ratios > 0.25 as self-compatible (Subasi and Guvensen, 2011; Mohandass, 2013). Flower visitors were recorded through direct observations. The percentage of fruit set was calculated from total number of flowers among different treatments. A chi-square test was used to calculate the comparison on percentage of fruit set among different treatments.

RESULTS & DISCUSSION

The plants were less than a meter in height and produced a large number of flowers. The flowers were light violet and bluish in colour with a darker maroon centre (Fig. 1). The length of the flower was from 3.5 to 4 cm (n = 22 flowers). The flowers were protandrous with the anthers dehiscing before the stigma became receptive. The flowers produced copious nectar and lasted for two days. Autogamy and hand self-pollination produced similar level of mean fruit set 50.95 ± 4.19% and 54.04 ± 4.66% respectively. Hand cross-pollination produced the mean fruit set 74.64 ± 4.92% and open pollination produced the mean fruit set 97.62 ± 2.38% by experimental treatments. Open pollination was significantly higher fruit set than autogamy and hand self-pollination ($\chi^2 = 9.52$, DF =1, P = 0.002 and $\chi^2 = 4.87$, DF = 1, P = 0.027) respectively. However, there was no significant difference found between cross and open pollination treatment ($\chi^2 = 1.28$, DF= 1, P = 0.26) and between cross and self-pollination treatment ($\chi^2 = = 3.52$, DF= 1, P = 0.06), respectively. Moreover, the ratio of percentage of fruit set between self and cross pollination showed 0.72 (more than > 0.25 ratio). Thus, it indicates that the plant was completely self-compatible and showed high levels of natural fruit set, indicating that it was not pollinator limited (Fig. 2). The flowers received visits from bees, butterflies and moths, flies and white-eyes (*Zosterops palpebrosa,* Aves). Observations indicated that the commonest visitor was *Apis cerana.* Flocks of white-eyes visited the flowers and a rare long-tongued moth (*Syntomis sp*.) was also a visitor (Table 1). However, *Apis cerana* (honey bee) and *Zosterops palpebrosa* (bird) were effective pollinators for *N. wightianus* during peak flowering period.

FIGURE 1. Flowers of *Nilgirianthus wightianus* in the Upper Bhavani regions of Nilgiri Mountains, India.
TABLE 1. Common floral visitors to *Nilgirianthus wightianus*, Nilgiri Mountains, India.

Species	Taxon
Flies	Diptera
Apis cerana	Hymenoptera
Trigona sp.	Hymenoptera
Syntomis sp.	Lepidoptera
Zosterops palpebrosa (White eyes)	Birds
Graphium sarpendon (Blue bottle)	Lepidoptera

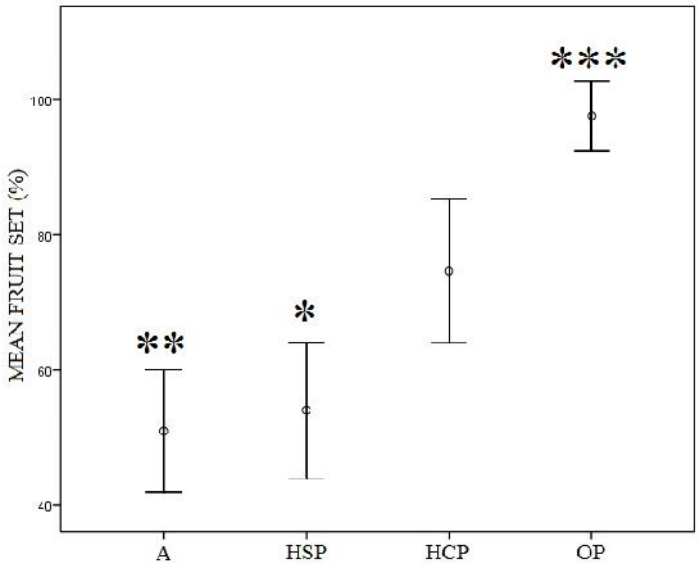

FIGURE 2. Controlled pollination experimental results showed the mean fruit set (%) of autogamy (A), hand self-pollination (HSP), hand cross-pollination (HCP) and open pollination (OP) treatments of *Nilgirianthus wightianus*, Nilgiri Mountains, India.

Note: * indicates mean fruit set significantly differed between hand self-pollination (HSP) and open pollination (OP) *(< 0.05)*; ** asterisk indicates mean fruit set differed significantly between autogamy (A) and open pollination (OP) *(<0.002).*

Our study results suggested that *N. wightianus* is a capable of producing self-fertilized however; it highly depends on pollinators to produce high level of fruit set. We observed *Apis cerana* and *Zosterops palpebrosa* were effective pollinators. Moreover flies, butterflies, moths might be relatively contribute for pollination, thus indicates *N. wightianus* was not pollinator limited under natural environment. Plant species of floral traits that facilitate pollination efficiency in most aspects of reproduction (Ashman and Majetic, 2006; Sharma *et al*., 2008). The floral features of *N. wightianus* were tubular in structure, nectar as a reward and purple blue color that highly facilitates pollination efficiency. Moreover, our observation shows that both social bees (*Apis cerana* and *Trigona sp*.) and birds (*Zosterops palpebrosa*) are important visitors to the flowers of *N. wightianus*. In Kakachi, two of the three were pollinated by social bees (*Apis spp.),* and *Strobilanthes luridus* was visited predominantly by birds (Devy and Davidar, 2006).

Controlled pollinations on *N. wightianus* clearly showed that the species is self-compatible. However, autogamy and self-pollination fruit set was lower that seems to showed slight inbreeding depression (Ramsey and Vaughton, 2000). Although it requires more pollen deposition through foraging pollinators. *Nilgirianthus wightianus* is a uniform distribution in which the distance of neighboring individuals is maximized and open tolerant in the shola-grassland ecosystem. The distance of pollen transfer ensures cross and open pollination fruit was higher under natural environment. *Strobilanthes spp.,* are widely distributed in the Western Ghats and > 50 species are considered to be endemic to the Western Ghats. Studies on three species of *Strobilanthes* in the Kakachi region of the southern Western Ghats have shown that these species were self-compatible (Devy and Davidar, 2006). *Strobilanthes kunthianus* is a semelparous species with synchronized flowering once in 12 years and showed self-compatible (Sharma *et al*., 2008). Therefore it is likely that self-compatibility is a trait common among the *Strobilanthes*. However, more studies need to be conducted on the ecology and pollination biology of this little known group.

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