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Floral biology of *Ceiba speciosa* (A. St.-Hil.) Ravenna (Malvaceae)

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ABSTRACT

Floral biology of *Ceiba speciosa* syn. *Chorisia speciosa* (Malvaceae) was recorded during a period of two years (2013-2014).It is a large tree with palmately compound leaves which fall during the months of November and December followed by mass production of colourful large flowersin the month of December and continues till the end of March. Flowers consist of five light green sepals, five large colourful petals, monoadelphous with a staminal tube enclosing long style terminating into a five-lobed stigma. Fruit is a loculicidal pear shaped capsule with large number of seeds covered with silky foss. Purple sunbird (*Cinnyris asiaticus*), honey bees (*Apis dorsata*) and butterflies are the floral visitors. They visit the flowers for obtaining the copious nectar(142±25ml/flower) secreted by the corona and accumulated at the base of staminal tube. The nectar consists of 20-25% sucrose congenial for both sunbirds and honey bees in morning hours.

Keywords: Silk floss tree, honey bees, purple sunbirds, butterflies, corona.

Ceiba speciosa (A. St. Hil.) Ravenna (= *Chorisia speciosa* A. St. Hil.) earlier a member of the family Bombacaceae, which is now merged under Malvaceae (Judd and Manchester 1997, Bayer *et al.* 1999).The family Malvaceae includes 243 genera and 4225 species (Judd *et al.* 2008). In India, there are 22 genera and about 125 species (Edwin *et al.* 2005). *Ceiba speciosa* is commonly known as floss-silk tree, Kapok, Silk-floss tree and in hindi as reshumrui. *Ceiba speciosa*, when in flower, is considered one of the most beautiful trees of the world. It is native to Brazil, Paraguay, Uruguay, Bolivia and Argentina, but is now popular in several tropical and subtropical parts of the world for its showy flowers. The, present communication provides information on floral biology of *Ceiba speciosa* syn. *Chorisia speciosa* (Malvaceae).

Role of plant reproductive biology plays an important role in biodiversity conservation (Moza and Bhatnagar 2007). This is important because, the evolutionary success and survival of plants and angiosperms in particular is largely determined by the efficacy of their reproductive performance. Due to increasing and immediate concern for augmenting food supply, knowledge on reproductive biology bas been utilized mostly for herbaceous crops. Trees have not received the attention they deserve due to several difficulties e.g. their large size, prolonged juvenility, long life cycles, in frequent flowering and inaccessible flowers in conducting researches (Tandon *et al*. 2005). Conservation and genetic improvement efforts of Indian tree species suffer from lack of detailed information on reproductive biology.

MATERIALS AND METHODS

Present observations were recorded from twelve trees (seven growing in Dholpur House, Shahjahan Road, and five in Lodhi garden) New Delhi.

Phenology—Phenological events (time of leaf fall, leaf renewal, flowering and fruiting period fruit and seed formation) were recorded for two years (2013-2014). Dimensions of flowers, their parts were measured as described by Kearns and Inouye (1993). Population flowering phenology was studied by counting number of flowers on marked branches periodically throughout flowering period. The beginning, peak and end of flowering, as well as the relative flowering intensity (average number of flowers/ inflorescence x average number of inflorescences/ individual) was registered following the procedure after Dafni (1992). The flowering magnitude was measured from the percentage of simultaneously open flowers in a day. Time of opening of flowers, anther dehiscence, and stigma receptivity was studied. Time of opening of new flowers i.e. when the petals refluxed to expose the androecium and gynoecium was recorded in the marked floral buds.

Floral morphology—Floral development was examined in 3 to 5 flowers on 12 marked plants growing at two sites in New Delhi at an interval of 2 h throughout flowering. The dimensions of 3-5 flowers/marked 12 plants were measured. Measurements of the flower size were made concerning to the diameter and length of the corolla (at the base and at its wider part), its depth and form; length of staminal tube were measured with the help of scale and Vernier's Calliper. The depth of the corolla tube was measured by inserting a pin into the corolla until it touched the nectar and the pin was measured on a scale (Plowright 1987, Kearns and Inouye 1993).

Flower longevity—Flower longevity was determined by marking 50 floral buds on different branches/plant (Gill *et al.* 1998). The flowers were observed at regular intervals until the corolla withered. These changes were observed every day throughout flowering.

Ovules/flower—Number of ovules/flower were recorded by the method after Stelly *et al.* (1984). Floral buds fixed in F.A.A. were hydrated and stained and destained in Mayer's hemalum and 2.0% acetic acid for 1-2 days respectively.

Rinsed with tap water, dehydrated, infiltrated, and cleared with methyl salicylate.The number of ovules was counted in cleared ovaries.

Nectaries and nectar—Nectaries were located on different floral parts using neutral red (Meeuse 1982). Volume of nectar from open individual flowers (25 from each marked plant) was measured using 20 µl calibrated capillary tubes. Nectar volume was computed with the following equation after Crudenand Herman(1983):

$$\frac{\text{mm of nectar in the capillary tube}}{\text{mm total length of tube}} \times \text{volume of tube calibratedcapillary} = \text{volume of nectar}$$

Nectar was sampled in fresh open flowers at 2 h intervals every day for 2 days at the time of anthesis.Sugar concentration in the nectar collected at different hours was evaluated by a light refractometer (Bausch & Lomb). Paper chromatographic method was used for separating sugars in nectar samples by three descending solvent systems as described by Grant and Beggs (1989).

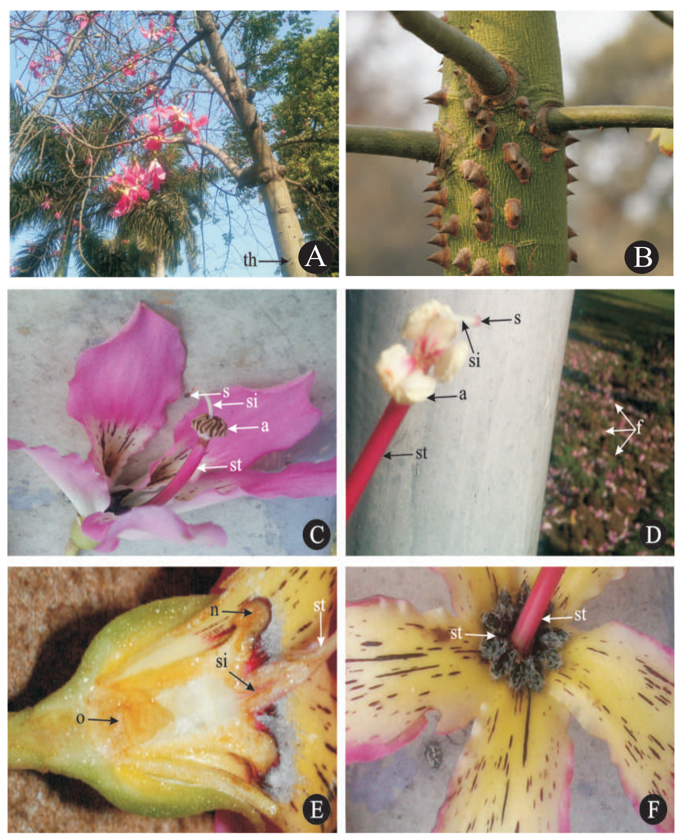
RESULTS AND DISCUSSION

Habit—*Ceiba speciosa* is a deciduous tree and it is cultivated mostly for ornamental purposes outside of private gardens around the world. The tree of *Ceiba speciosa* reaches 25±4 m in height and its stem is cylindrical and studded with thick conical prickles (Figs. 1A, B), measuring up to 3±1 m in girth (n=12). In younger trees, the stem is green but with ages it turns to gray (Gibbs and Año 2003). The branches are horizontal and also covered with prickles (Figs. 1A, B). The leaves are compound, palmate with 5-7 long elliptical, pointed leaflets.

Phenology—Trees begin to lose their leaves by mid-October and renew them in late February. The leaf fall is followed by floral bud initiation in November and during December and January when there is mass production of colourful large flowers and flowering continues till February. Between flowering and leafing out, the trees produce large number of pear-shaped fruits.

Floral morphology—The flowers are large pink and appear solitary or borne in small clusters in the axils of terminal branches in December when the tree is nearly bare (Figs. 1A, B). The flowers are large, pentamerous, hermaphrodite, hypogynous and actinomorphic (Fig. 1C).They measure 12±2 cm (n=50) in diameter and their shape is superficially similar to hibiscus flowers. Calyx consists of four bell shaped light green persistent bell shaped sepals fused into a cup like structure. Corolla (10±2 cm long) consists of five contorted, polypetalous petals of pink and white colour united at the base of the staminal tube (Fig. 1C). The upper 3/4 part (7±1 cm) of the petalsis broad and uniformly pink, while the lower 1/4 part (3±1 cm) is narrow and white with dark red dashes (n=60) (Fig. 1F). Androecium consists of five stamens in monoadelphous condition (Fig. 1D). The filaments are fused to form a long staminal tube (11±2 cm; n=60) and anther lobes are compactly arranged at the top of the staminal tube (Figs. 1C, D, F). Anthers dehisce by a longitudinal slit (Fig. 1 D). At the base of the staminal tube there is a cream-coloured bell-like or vase-like structure with a maroon or dark-red-lobed rim covered with fuzzy white hairs called as 'corona' (Figs. 1 E, F).Gynoecium consists of five carpels, syncarpus, and ovary superior, 5-locular, with axile placentation and 2 ovules in each locule. Style is much elongated and passes through thestaminal tube and raise the wet and papillate stigma either nearly 3±1 cm above the anthers (Figs.1C, D, E).

Flowering phenology–The flowers present diurnal anthesis.Flowers open in the morning between 06.00 to 07.00 h and anthers dehisce between 06.30 to 07.30 h and stigma becomes receptive at 08.00 h and remains receptive till 16.00 h. Large number of young floral buds and mature flowers abscise without forming fruits (Fig. 1 D). Flowers with diurnal anthesis generally are brightly colored in order to attract diurnal insects, such as honeybees and butterflies (Luo*et al.* 2011, Marques *et al.* 2015).



Fig, 1 A–F *Ceiba speciosa.* A. Tree in bloom, B. Spines on stem, C. Mature flower, D. Reproductive structures, E. longitudinal section of a flower showing gynoecium and nectary, F. Flower showing mature nectaries at the base of stamina tube (a: anthers-dehisced; f: abscised flowers; n:nectaries; o:ovary; s: stigma; si: style; st: stamina tube; th:thorns).

Floral visitors— Purple sunbird (*Cinnyris asiaticus*), honey bees and butterflies are the main floral visitors. They visit the flowers in the morning hours when copious nectar is secreted by the nectaries present on corona.The honey bees and butterflies insert their proboscis at the base of the staminal tube to collect nectar but they fail to come in contact with the reproductive structures which are 10-15 cm above the nectaries present at the base of ovary due to their small size. Thus, they seem to be nectar thieves and have no role in pollinating the tree species. Many butterfly species visit flowers from which they imbibe nectar (see Adrienne *et al.* 1985). According to Maloof and Inouye (2000) the nectar robbers may be cheaters or mutalists. These skippers may have occasionally pollinated their nectar flowers and evidently functioned mainly as nectar thieves. On the other hand, the sunbirds while collecting nectar from the base of the stamina tube come in contact with the dehisced anthers. The pollen sticks on their mouth parts and on dorsal surface and on their visit to other flower they transfer pollen to the stigmatic surface while collecting nectar from the base of the staminal tube.

Nectar— At the base of stamina tube are present five bi-lobed corona with 5-lobed dark red-rim which secrete copious nectar (142±25ml/flower) at the beginning of anthesis (Fig. 1E). The nectar consists of sucrose, glucose and fructose and dominated by sucrose (20-25%).

Several investigators have also recorded the flowering phenology, pollination biology, breeding system in some members of the family Malvaceae. Gribel *et al.* (1999) observed mass flowering and high nectar production/flower in *Ceiba pentandra*. The flowers of this species were visited by wide range of nocturnal (bats, marsupials, night monkeys, hawk moths) and diurnal (bees, wasps, hummingbirds) animals, but only phyllostomid bats, (*Phyllostomus hastatus* and *Phyllostomus discolour*) played a relevant role in promoting cross-pollination. According to Young (2002) diurnal visitors are bees, flies and wasps and flowers that are open for >12 h may be both diurnal and nocturnal pollinators. Ruan *et al.* (2005) observed floral traits and pollination modes in *Kasteletzkya virginica* (Malvaceae). A mature flower of *Kasteletzkya virginica* has a monoadelphous androcecium that bears 20-30 anthers and surrounds an exterted five-branched style with synstylous base. Stylar movements occurred if stigma has not received pollen by insect pollinators and stigma could or could not contact with the anthers at the end of the anthesis day.Machado and Sazima (2008) compared the role of *Apis mellifera* with other native pollinators while studying floral biology and the breeding system of *Melochia tomentosa* (Malvaceae) in a semi-arid region in Brazil.They observed that the pink, bright-colored flowers are distylous and homogamous. The trichomatic nectary is located on the inner surface of the connate sepals, and the nectar (ca. 7 ml) is accumulated in the space between the corolla and the calyx. Nectar sugar concentration reaches an average of 28%. The results of controlled pollination experiments show that *M. tomentosa* is self-incompatible. In spite of being visited by several pollen vectors, flower attributes of *M. tomentosa* show melittophily, and *A. mellifera* was the most frequent visitor and the principal pollinator. The nocturnal visitors (bats and sphingid moths) and bees have been recorded in *Pachira aquatica* member of the family Malvaceae by Hernández-Montero and Sosa (2015).According to them, the main nocturnal visitors were bats and sphingid moths while bees were the main diurnal visitors. They concluded that *P. aquatica* is an outcrossing species with a pollination system originally specialized for bats and sphingid moths.

Fruiting— Formation of fruits starts in the end of March and continues till the end of April. However, formation of fruits is (10-12%/plant). The fruits are oval shaped (18±5 cm long) loculicidal capsules which dehisce through locules into 5 valves to release seeds covered with silky white floss. The seeds are black and bean sized. Fruit and seed-set percentage is only 5-8% and 12-18% respectively. Reduction in fruit set in several trees is also attributed to abscission of large number of young floral buds, mature flowers and their parts. Several factors including pathogens are known to cause floral abscission and ultimate reduction in fruit set in several plants (Kozlowsky 1973). Lloyd (1980) postulated that in one reproductive session the level of maternal expenditure of an angiosperm plant is determined by a temporal series of controls on the number of potential fruit in which an investment is made. This hypothesis has three parts: A. The amount of maternal expenditure is regulated at many developmental units, particularly single flowers and fruit, at three principal sequential stages – the determination of flowers, the development of ovaries and the maturation of fruit. B. At each stage, the initiation or continuation of an investment requires an amount of available resources above a certain threshold. Hence maternal expenditure is continually adjusted to the resources available at each developmental site. C. The pattern of controls that maximizes the maternal fitness of a plant is selected.

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