



## Pollination Mechanism and Role of Insects in *Sida cordifolia*. I

Dushyant Kumar Singh, Rajneesh Kumar Agnihotri\*, Gurpreet Singh, Showkat Ahmad Ganie, Rajendra Sharma

Department of Botany, School of Life Sciences, Khandari Campus, Dr. B. R. Ambedkar University, Agra, India.

\*Corresponding author's E-mail: [rk\\_agnihotri@rediffmail.com](mailto:rk_agnihotri@rediffmail.com)

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### ABSTRACT

*Sida cordifolia* is a small perennial herb usually 20 cm to 1 m in height. The plant is used medicinally in different countries and is a source of many potent and powerful drugs. Flowers of *S. cordifolia* are slightly protandrous, opening and closing times of flower are temperature and light dependent. Bright yellow coloured flowers of *sida cordifolia* have been studied for its pollination biology and role of insects at Agra region. Mode of pollination indicated that *S. cordifolia* is both self and cross pollinated as fruit-set took place in bagged inflorescence. Breeding experiments indicated 80% fruit-set by open pollinated flowers while self pollinated flowers exhibited 60%. Cross-pollination was achieved by geitonogamy and xenogamy in which flowers exhibited 70% and 50% fruit-set by xenogamy and geitonogamy, respectively. The fruit formation was not merely dependent on the formation of viable gametes but also on primary (pollen and nectar) and secondary attractants (yellow colour, odour, fully open architecture and high floral density) which influenced insects and brought out reproductive success. On the basis of visitation rate and pollen load on their body parts honey bees (*Apis* spp.) and butterflies (*Pieris* spp.) were found to be the most efficient pollinators during the entire flowering period.

**Keywords:** Cross pollination, fruit-set, pollination biology, *Sida cordifolia*, xenogamy.

### INTRODUCTION

Pollination is a crucial ecological process in which pollen is transferred, thereby enabling fertilization and sexual reproduction in flowering plant. Pollination biology provides a framework to test a diverse array of paradigm in several sub-disciplines of biology, co-evolution, behavioral ecology, community ecology, population genetics, mutation selection, speciation and evolution. The knowledge of pollination mechanism is gained firstly by Darwin, as early as reproductive structure to receptive stigma, is the first male/female interactive step in the reproductive process. Flowering and fruiting are important stages of the life history of plants with both ecological and evolutionary consequences.<sup>1,2</sup>

The general syndrome of biotic pollination is that the flowers produce a primary attractant (pollen and nectar) and secondary attractant (odour, colour, floral density etc.) that attract pollinators. Pollination biology in several members of Malvaceae has been investigated by large number of investigators.<sup>3-6</sup> The presence of lipids, proteins, organic acids, phenolics, saponin glycoside and sugars in nectar is of great significance in relation to nectar foraging and consequently pollinator activity of a wide range of entomophiles insects and other visitors.<sup>7</sup> Nectar and pollen grains are the principle food components for these insects.

*S. cordifolia* L. belongs to family Malvaceae, commonly known as Indian ephedra because of the presence of alkaloid ephedrin. It is a small perennial herb usually 20 cm to 1 m in height. In English it is known as country mallow. It is native of tropical and subtropical part of Africa, Australia, China, Nepal, Srilanka, Bhutan and Pakistan. In India the genus is represented by 5 species,

however, *S. cordifolia* is the most common wild herb representative occurring in different tropical and subtropical parts.<sup>8</sup>

The fruit, roots and the whole plant of *S. cordifolia* are used medicinally in different countries and are a source of many potent and powerful drugs. It is used in the treatment of bronchial asthma, cold, flu, chills, headache, nasal congestion, cough and sneezing<sup>9</sup>, weight loss<sup>10</sup>, bleeding piles and urinary diseases.

Keeping in view the worthy importance of this medicinal herb, the present study was carried out to determine the mode of pollination mechanism and role of insects in pollination of this plant growing at different parts of Agra region.

### MATERIALS AND METHODS

The present investigation on role of insects in pollination mechanism in *S. cordifolia* L. was marked for observation. Twenty five flowers/plants were sampled to record the floral morphology, plant pollinator interaction and fruit-set percentage. Number of pollen/flower was studied by various methods given by.<sup>11</sup> Pollination mechanism under different environmental conditions were studied. Observations on identification and types of pollinators, their population and foraging behaviour were recorded. The insects with maximum efficiency of visitation were labeled as major pollinators. The insect visiting efficiency (IVE) was calculated following.<sup>12,13</sup>

$$IVE = \frac{\text{No. of flowers visited by the insect in one unit time}}{\text{Total No. of flowers available}}$$

The mode of pollination was evaluated by bagging the emasculating mature buds and hand pollination. Different

pollinators, their population types and visitation rates were recovered.

Breeding behavior (autogamy, geitonogamy and xenogamy) was tested using controlled pollination studies in emasculated and bagged flowers. Self and cross-pollination experiments were performed by dusting pollen obtained from freshly dehisced anthers on the receptive stigma. The pollinated flowers were re-bagged and observed periodically for fruit formation.<sup>14</sup> After 6–10 days from pollination, bags were removed and each pollinated flower was observed. The flowers which showed fruit formation were counted as successful pollination. Foraging behaviour of insects was recorded. Pollination efficiency of different insects was checked by observing pollen load on their body parts. Pollen load was studied by mounting them in basic fuchsin gel and examined under microscope according to the procedure reported previously.<sup>11</sup>

The specimens of visiting insects were identified at Department of Zoology, School of Life Sciences, Khandari campus, Dr. B.R. Ambedkar University, Agra.

Pollen tube growth resulting from both self and cross-pollinations were investigated using fluorescence technique.<sup>14</sup> Floral visitors and their behaviour were recorded from 01.30 h until 03.30 h. Pollinators were determined based on frequency of visits and the visiting behaviour i.e. legitimate visits on the basis of contact with the reproductive parts (anthers and stigma). Data on daily maximum and minimum temperature and relative humidity during the entire flowering period were collected from Department of Environmental Sciences, School of Life Sciences, Khandari campus, Dr. B. R. Ambedkar University, Agra.

## RESULTS AND DISCUSSION

Flowers were small in size (1.4 cm diameter), bright yellow, pentamerous, cyclic, actinomorphic and arranged in short upward pedicels with solitary axillary inflorescence. Flowering occurred throughout the year their Flower opening and closing time varied depending on temperature, light and relative humidity. Anthers and stigma matured just after the anthesis of flower. The flowers remained fresh and active during the afternoon. Self pollination was accomplished when the petals began to close and push the stamen inward towards the stigma, the longer anthers making direct contact. The open pollinated flowers showed 80% fruit-set, while the self pollinated flowers exhibited 60% fruit-set. Cross pollinated flowers reported 70% fruit set by xenogamy and 50% fruit-set by geitonogamy. Fruit formation starts after 3 - 5 days of anthesis and fruits matured approximately in 2 weeks after fruit formation. *S. cordifolia* is reported to be both self and cross pollinated plant. The flowering occurs throughout the year and flower opening and closing time varied depending on temperature and light. Fruit set by xenogamy was more than geitonogamy. This is in agreement to the previous findings of<sup>15</sup> who studied the *Abutilon indicum* and reported that cross pollinated flowers showed 80 % fruit –set by xenogamy and 60% by geitonogamy<sup>16</sup> had reported a kind of mechanical self pollination due to the bending down of the tissues connecting to the viscidium and the pollinia in *Cymbidium sinense*.

The different insects visited the plant during the entire flowering period, their vector order, syndrome and nature is presented in Table 1.

**Table 1:** Insects belonging to different orders responsible for pollination in *S. cordifolia*

Vector order	Common name	Zoological name	Syndrome name	Nature	Most Efficient pollinator
Hymenoptera	Honey bees	<i>Apis dorsata</i> , <i>Apis indica</i>	Melitophily	PC and NR	Honey bees ( <i>Apis dorsata</i> , <i>Apis indica</i> ) and Butterflies ( <i>Pieris sp.</i> , <i>Limnitis sp.</i> )
	Small bee	<i>Melliopona</i> spp.	Melitophily	PC	
	Large ant	<i>Campestris polistis</i>	Formicophily	PC and NR	
Diptera	House fly	<i>Musca nebula</i>	Myophily	PC	
	Melon fruit fly	<i>Bactrocera</i> spp.	Myophily	NR	
Lepidoptera	Butterflies	<i>Pieris sp.</i> ; <i>Limnitis sp.</i>	Psycophily	PC and NR	
Coleoptera	Beetle	<i>Coccinella punctata</i>	Cantharophily	NR	

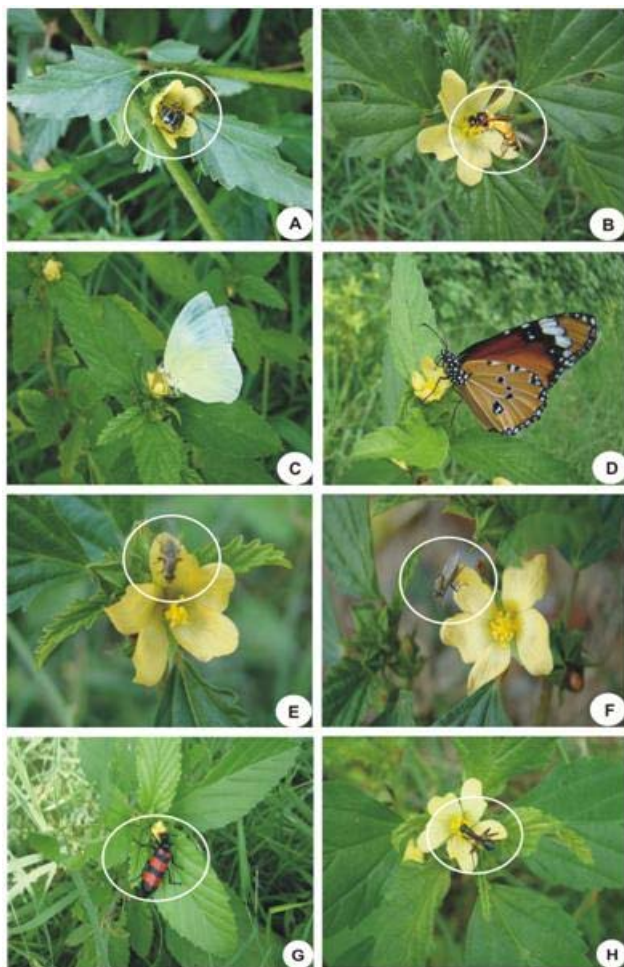
Where PC – Pollen carrier, NR- Nectar robber

Different types of insects visited the flower included Honey bees (*Apis dorsata*) (Fig. 1A) and *Apis indica* (Fig. 1B); Butterflies (*Pieris sp.*) (Fig. 1C) and *Limnitis sp.* (Fig. 1D); Housefly (*Musca nebula*) (Fig. 1E); Melon fruit fly (*Bactroceae* spp.) (Fig. 1F); Beetles (*Coccinella punctata*) (Fig. 1G); Black ant (*Componotus campestris*) (Fig. 1H) and Grasshopper (*Craspedontus sp.*). The insects visit the flowers mostly from 1400 – 1530 h for nectar and pollen. A butterfly was found to make 25 – 28 visit/hour. While a honey bee made 20 – 22 visit/hour during 1400 – 1500h.

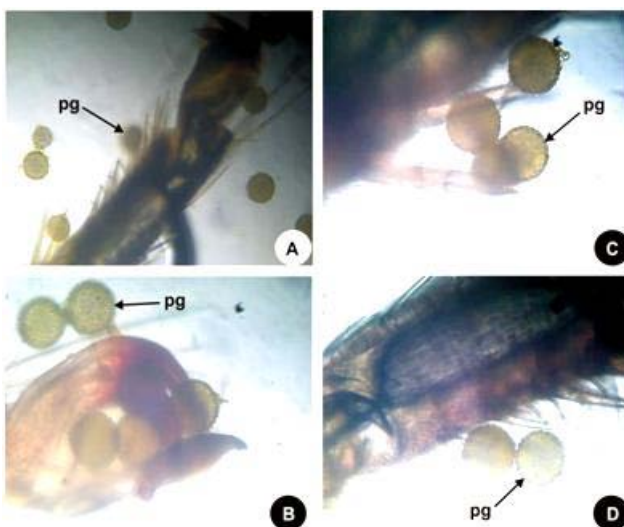
The activity of all butterflies started just after the opening of flower and they behaved in same manner.

Based on visit duration, visitation percentage and pollen load on the body parts of the pollinators, honey bees and butterflies were found to be the most efficient pollinators (Table 1 and 2) and (Fig. 2 A & B). Honey bees and butterflies frequently took part in pollination by transferring the pollen to the stigma of the same or different flowers. Honey bees and butterflies alighted on petals then collected the pollen grains, from here insect

also tried to suck the nectar by inserting its proboscis into nectaries.



**Figure 1:** A-F, Pollinators of *S. cordifolia*. A. Honey bee (*Apis dorsata*); B. *Apis indica*; C. Butterfly (*Pieris spp.*); D. (*Limenistis ssp.*); E. House fly (*Musca nebula*); F. Melon fruit fly (*Bactrocera species*); G. Beetle (*Coccinella punctata*) and H. Black ant (*Campestris polistis*)



**Figure 2:** A–D. Pollinators of *S. cordifolia* showing pollen load on legs of A. honey bee (*Apis dorsata*), B. Butterfly (*Pieris Spp.*) C. Large ant (*Campestris polistis*) and D. housefly (*Musca nebula*).

**Table 2:** Pollen pickup's by various pollinators as revealed by observing pollen load on their body parts.

Pollen vectors	Mean no. of PGs/insect load	Most efficient pollinator
Honey bee ( <i>Apis dorsata</i> )	68	Honey bees and butterflies
Housefly ( <i>Musca nebula</i> )	12	
Butterflies ( <i>Pieris spp.</i> )	54	
Large ant ( <i>campestris polistis</i> )	10	

During the activity pollen were deposited on legs and ventral body parts. Melon fruit fly and Beetle were the common visitors (without any pollen load). They also alight on petals without touching the reproductive organs and inserted their proboscis into the tube of flower where nectaries were located at the base of flower to suck the nectar then turn their attention towards the other flower of the same plant or other plant. They were nectar thief and cannot be classified as a pollinator.

The plant pollinator interaction plays a very significant role in the formation of fruits. It was observed that fruit formation was not only dependent on the formation of viable gametes but also on primary and secondary attractants. The pollen and nectar of the flower function as the primary attractants whereas, the yellow colour, odour and density functions as the secondary attractants for the pollinators in this plant species. 17 reported that primary attractants (pollen and nectar) and secondary attractants (blossom, colour, odour and arrangement) influenced the plant pollinator interaction, which played a significant role in the formation of fruits. According to<sup>18</sup> *Cassia tora* L. provide primary and secondary attractants as bright coloured yellow flowers with plenty of pollen as enough rewards for the foragers and pollinators to survive. A variety of insects regularly visit the flowers of *S. cordifolia* but Honey bees and Butterflies seems to be responsible for pollination by transferring pollen grains from their body parts which are adhered while visiting the flowers.

It could be concluded that the present study provides detail information on the pollination mechanism of *S. cordifolia* to discuss the probable consequences of pollinator behavior for the reproductive success of *S. cordifolia*.

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