RESEARCH ARTICLE

# PLANT - POLLINATOR AND PLANT – HERBIVORE INTERACTIONS - A COMPARATIVE STUDY IN TWO SPECIES OF *LUFFA*

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**Abstract:** Among various plant–animal interactions occurring around us, pollination and herbivory are prominent ones. While the former exemplifies a mutualistic relationship, the latter is reverse of it. Pollinators by their visits influence both quantity and quality of pollen reaching the surface of stigma [6] [13]. Herbivores on the other hand affect plant by impairing its foliage, deterring pollinators and cause loss of pollen and ovules [9] [5]. In order to analyze these relationships and their correlation with reproductive success, studies were conducted in two species of *Luffa* (family – Cucurbitaceae) namely *L. cylindrica* and *L. acutangula* growing in Jammu division of J&K state, India (area of study). Interestingly one among the two was found to be reproductively more efficient and less affected by herbivory.

**Keyword**: Pollinator, Herbivory, Mutualistic relationship, Reproductive efficiency

## INTRODUCTION

Reproductive success of the plant depends on both pollinators and herbivores. Pollination brought about by the pollinators represents an interesting aspect of plant reproduction. Pollinators deposit large amount of pollen on the stigma and thereby influence seed quality and quantity both by generating greater competition among pollen grains for ovule fertilization [15]. Herbivores on the other hand reduce the resource availability and hence have an indirect impact on plant reproduction [10]. In order to analyze the affect of pollinator and herbivores on reproductive efficiency detailed studies were carried out in two species of *Luffa* namely *L. cylindrica* and *L. acutangula* growing in Jammu division of J&K state, India. Present communication elaborates on the details of the same.

## MATERIAL AND METHOD

This study is based on two species of *Luffa* namely *L. cylindrica* and *L. acutangula*. While most of the observations in both the species were made on the plants raised in Botanical garden, University of Jammu, few observations in *L. acutangula* were made on the plants growing wild in Birpur and Purmundal area of Samba District (Alt – 384masl, Loc – N32º34', E75º07') of Jammu and Kashmir State. Observations were made during the peak blooming season of the vines (August – November) on a set of 10 plants of each species. Temperature and relative humidity during this period ranged between 24.2 to 32.6ºC and 75.36 to 89.36%.

### Methods

**a) Flower morphology**

Studies on detailed structure of flower was made using 10 inflorescences from each species. Various parameters including structure of flower, number of essential and non essential parts, floral rewards and arrangement of these flowers on inflorescence were recorded in the field at regular time interval.

**b) Insect visitors and pollination ecology**

Vines of both the species were observed at regular time interval during the vegetative as well as during their full blooming period for various insect visitors. Voucher specimens were collected, identified and classified as visitors, robbers and pollinators on the basis of their activity and pollen load on different body parts. These insects were identified at the Entomology Research Lab, Department of Zoology, University of Jammu, Jammu.

**c) Fruit and seed set**

Percentage fruit and seed set on open pollination was estimated in both species using following formula

$$\% \text{ age fruit set} = \frac{\text{Number of fruits formed per 100cm branch}}{\text{Number of female flowers per 100cm branch}} \times 100$$

$$\% \text{ age seed set} = \frac{\text{Number of seeds formed per fruit}}{\text{Total number of ovules per female flower}} \times 100$$

## RESULT AND DISCUSSION

Species of *Luffa* i.e. *L. cylindrica* and *L. acutangula* are annual climbing vines that pass a brief vegetative phase of approximately three months (May to July) and initiate their flowering in the month of August; flowering period extends for a maximum of 3 ½ months in *L. cylindrica* and 2 months in *L. acutangula* in the subtropical climates of Jammu, where the study has been carried out.

Sex expression in both the species is uniform; they are monoecious. Monoecy is infact the most common sex expression in family Cucurbitaceae [14] [2]. First flowers to differentiate and open on the vine of both

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the species are male flowers (on lower nodes); female flowers appear on the middle nodes and here they coexist with the male flowers. The upper nodes bear only pistillate flowers in *L. acutangula* and both staminate and pistillate flowers in *L. cylindrica* [7].

Staminate flowers in both the species are borne in axillary racemes, while female flowers are solitary. Flowers of *L. cylindrica* are large (male flower – 9.06cm ± 0.13; female flower – 10.1cm ± 0.08) and bright yellow in colour, where as in *L. acutangula* they are small (male flower - 4.5cm ± 0.06; female flower – 5.22cm ± 0.11) and pale yellow. Arrangement of stamens varied in the two species (Table 1). They are free and 5 in number in *L. cylindrica* and are grouped as 3 stamens showing 2+2+1 arrangement in *L. acutangula*. Several authors [4] [3] suggest that basic stamen number in the family is 5, whereas 3 stamen condition in many cucurbits is derived by union of adjacent stamens. Pollen production per male flower averages 60,994 ± 798.9 in *L. cylindrica* and 7,577 ± 191.9 in *L. acutangula*.

Pistillate flowers are borne singly on short peduncles in both the species. Carpels are three in number and fused with short styles terminating into trilobed, dry and papillate stigma at the apex and an inferior ovary at the base. Male flowers in both the species are nectariferous bearing cup shaped nectary at the base of stamens. A ring shaped nectary is also present at the base of the style in *L. cylindrica* where as it is absent in female flowers of *L. acutangula* (Table 1). The same has been reported earlier [1] also.

The two species of *Luffa* referred above match in their gross morphology and sex expression but vary vividly in their floral phenology. *L. cylindrica* is diurnal with opening of flowers initiating at 0530 to 6000 hrs with male flowers opening first (0530 hrs) followed by the opening of female flowers (0545 hrs) (Table 1). *L. acutangula* is nocturnal with male flower opening initiating at 1730 hrs followed by the opening of female flowers (around 1750 hrs). Blooming period extends for approximately 12 hrs to 14 hrs respectively in *L. cylindrica* and *L. acutangula*. The flowers once closed, do not open again.

Both the species are self fertile and insect pollinated. Cucurbits infact are reported to be predominately entomophilous with bees playing the most essential role [11] [12]. Both the taxa investigated were found to be visited by a variety of insects, but larger number of visitors were recorded in *L. cylindrica* due to favourable features including diurnal blooming, huge pollen production (60,994 per male flower) and nectar production in flowers of both sexes [7]. A total of 14 insect visitors were found visiting the flowers of this species, out of which 12 are legitimate visitors these include Butterflies, Honey bee, Sweat bee, Giant resin bee, Australian blue band bee, Small carpenter bee, Bumble bee, Syrphid flies, Skipper butterfly, Red fire ant, Black garden ant and Ghost ants, rest two insect visitors are herbivores these are *Aulacophora* sp. and *Epilachna* sp. *L. acutangula* on the other hand is nocturnal with less showy pale yellow flowers. Pollen production is slightly less in the species and nectar that serves as the primary attractant is absent in female flowers of the species and as a result a total of 9 insect visitors were recorded visiting the vine, of which only two insect visitors i.e. Ghost ant and Moths (family pyralidae) were the legitimate visitors. The rest 7 insect species were either robbers (Red eyed butterfly, Red fire ant, Harvestor ant, Black garden ant, Hawkmoth) or herbivores (*Aulacophora* sp. and *Epilachna* sp.) (Table 1).

Both *L. cylindrica* and *L. acutangula* are visited by two species of herbivores i.e. *Aulacophora* sp. (Pumpkin beetle) and *Epilachna* sp. (Mexican bean beetle). It is very uncommon that a herbivore would also act as a pollinator on the same plant where it causes herbivory. It was however observed in *L. cylindrica* where *Aulacophora* sp. cause herbivory of both vegetative and reproductive tissue and also aids in the pollination while carrying out the act of herbivory on the same plant. A pollen load of 100 – 120 pollen grains was observed on its body parts. In *L. acutangula* on other hand it causes immense damage to both vegetative and reproductive tissue along with *Epilachna* sp. Earlier studies on *Aulacophora* sp. reveal that this herbivore causes serious damage to various cucurbit crops thereby resulting in decrease of yield by 30 – 100% [8].

Various factors such as nocturnal opening, low pollen production, absence of nectary in female flower, heavy damage of vegetative tissue affecting photosynthetic efficiency and floral tissue affecting pollination service lead to a dip in the reproductive efficiency of *L. acutangula* in terms of fruit set (25.07% ± 2.4) and seed set (20.19% ± 2.54) (Fig. 1). On the other hand diurnal opening, showy flowers, high pollen production (60, 994), frequent insect visitations, presence of rewards in both the sexes, low herbivore damage with an additional benefit of pollination makes *L. cylindrica* reproductively much more efficient in terms of high fruit set (74.5% ± 1.4) and seed set (60.35% ± 2.13) (Fig. 1).

## CONCLUSION

Large flower size, diurnal opening, presence of nectary in both male and female flowers, low herbivory damage, high insect visitors and pollen production makes *L. cylindrica* the most legitimately pollinated species and this determines its reproductive efficiency when compared to *L. acutangula*. This is thus the reason for its cultivation and emergence as an important cash crop in different areas.

**Table 1.** Details of flower morphology, flower phenology, pollinators and reproductive output in *L. cylindrica* and *L. acutangula*

| S.No | Character | *L. cylindrica* | *L. acutangula* |
|---|---|---|---|
| 1 | **Flower colour** | Bright yellow | Pale yellow |
| 2 | **Diameter of flower** | **Male** – 9.06 ± 0.13<br>**Female** – 10.1 ± 0.08 | **Male** – 4.55 ± 0.06<br>**Female** – 5.22 ± 0.11 |
| 3 | **Flower opening** | **Male** – 0530 – 0600<br>**Female** – 0545 – 0600 | **Male** - 1730 – 1800<br>**Female** – 1750 - 1800 |
| 4 | **Duration of flower opening** | **Male** – 11 hrs 30 mins<br>**Female** – 12 hrs 15 mins | **Male** – 14 hrs 30 mins<br>**Female** – 14 hrs 40 mins |
| 5 | **Floral rewards** | **Male** – Pollen (60,994 ± 798.90/male flower) and nectar<br>**Female** – Nectar | **Male** – Pollen (7,577 ± 191.96/male flower) and nectar<br>**Female** – Nil |
| 6 | **Insect visitors** | **Pollinators** - Butterflies, Honey bee, Sweat bee, Giant resin bee, Australian blue band bee, Small carpenter bee, Bumble bee, Syrphid flies, Skipper butterfly, Red fire ant, Black garden ant and Ghost ant<br>**Herbivores** – *Aulacophora* sp. and *Epilachna* sp. | **Pollinators** – Moths and Ghost ants<br>**Robbers** - Red eyed butterfly, Red fire ant, Harvester ant, Black garden ant, Hawkmoth<br>**Herbivores** – *Aulacophora* sp. and *Epilachna* sp. |
| 7 | **Total number of insect visitors** | 14 | 9 |
| 8 | **Legitimate visitors** | 12 | 2 |
| 9 | **% age fruit set on open pollination** | 74.5 ± 1.4<br>(62.5 – 88.8) | 25.07 ± 2.4<br>(0 – 37.5) |
| 10 | **% age seed set on open pollination** | **Healthy** - 50.24 % ± 2.13<br>(39.78 – 73.51)<br>**Shrivelled** - 10.11 % ± 1.67<br>(8.11 – 23.06) | **Healthy** - 17.85 % ± 15.37<br>(8.6 – 40.8)<br>**Shrivelled** - 2.34 % ± 0.24<br>(1.34 – 2.67) |

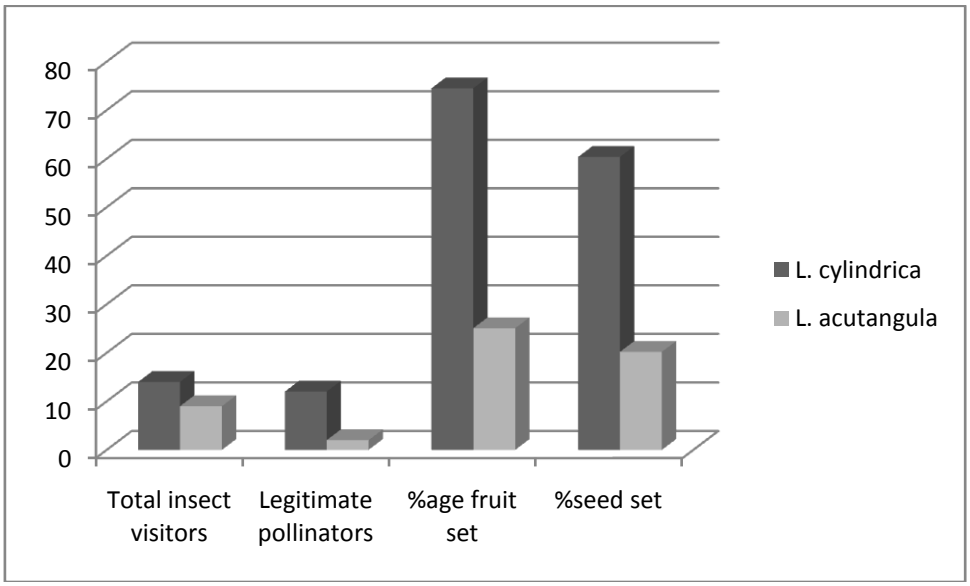


**Fig. 1.** Insect visitors and their influence on fruit set and seed set in *L. cylindrica* and *L. acutangula*

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