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RESEARCH ARTICLE

BOTANY

MECHANISM OF POLLINATION IN *TRIBULUS TERRESTRIS* L. (ZYGOPHYLLACEAE)

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ABSTRACT

Orange yellow coloured flowers of *Tribulus terrestris* L. have been studied for its pollination biology at Agra region. Mode of pollination indicated that *T. terrestris* was both self and cross pollinated as there was fruit-set in bagged inflorescence. The potential of the self-pollination was found to be 100% seed-set. Cross-pollination was achieved by both geitonogamy and xenogamy. The fruit formation was not merely dependent on the formation of viable gametes, but also on primary attractants (pollen and nectar) and secondary attractants (orange – yellow colour, odour, small size and fully open architecture and high floral density) that influenced visitors and brought out reproductive success. Honey bees *Apis spp*. and butterflies *pieris* and *limenitis sps*. were found to be the most efficient pollinators during the entire flowering period.

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KEYWORDS

Tribulus terrestris, pollination biology, floral architecture, fruit-set, seed-set and cross pollination.

INTRODUCTION

Pollination is a crucial ecological process that aids sexual reproduction in flowering plants. Plant pollination is a critical stage in plant reproduction and thus in the maintenance and evolution of species and communities (Machads and Lopes, 2004). The earliest record of pollination mechanism in plants is by Darwin (1877). Reddi *et al*. (1981) had reported self and cross – pollination in *Tribulus terrestris*. Chaturvedi (2009) has described a new device of self-pollination due to proliferation of apical region of the column in *Cymbidium sinense* (Jacks. ex. Ander) willd. f. from Nagaland. 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. Wilcock and Neiland (2002) have assigned the decline of many ornithophilous and entomophilous plants to unsuccessful pollination because of the loss of their pollinators.

Tribulus terrestris L. belonging to zygophyllaceae is a medicinally important herbaceous plant. It is used as a constituent tonics in Indian ayurveda practice, where it is known by its sanskrit name, "**gokshura**". The fruit, roots and the whole plant is used for the medicinal purpose. The species are distributed mainly in the tropics and subtropics, arid zones in particular extending into temperate regions. Despite of its high medicinal value limited information is available on its reproductive biology. Therefore, focus of present study is to provide a detailed account of the pollination biology of *T. terrestris* growing at Agra.

MATERIALS AND METHODS

Pollination biology of *Tribulus terrestris* has been studied at Agra region. Pollination mechanism under different environmental conditions were studied, observations on identification and types of pollinators, their population and foraging behaviour of various insects visiting flowers for reward were recorded. The representative specimens of visitors were collected and identified in the school of Life Sciences, Khandari Campus, Dr. B.R. Ambedkar University, Agra. The insects with maximum efficiency of visitation were labelled as major pollinators. Pollination efficiency of different pollinators was checked by observing the pollen load (Kearns and Inouye, 1993). The insect visiting efficiency (IVE) was calculated following Bingham and Orthner 1998.

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

Controlled pollination

- Floral buds of suitable size were selected and opened carefully, causing minimal disturbance to the floral parts, all the anthers were excised (emasculation) with forceps.
- The emasculated buds were bagged with the help of muslin bag.
- On the day of natural pollination, the bags were carefully opened and a few pollen from freshly dehisced anthers were rubbed on the receptive surface of the stigma.
- The pollinated flowers were rebagged.
- 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.

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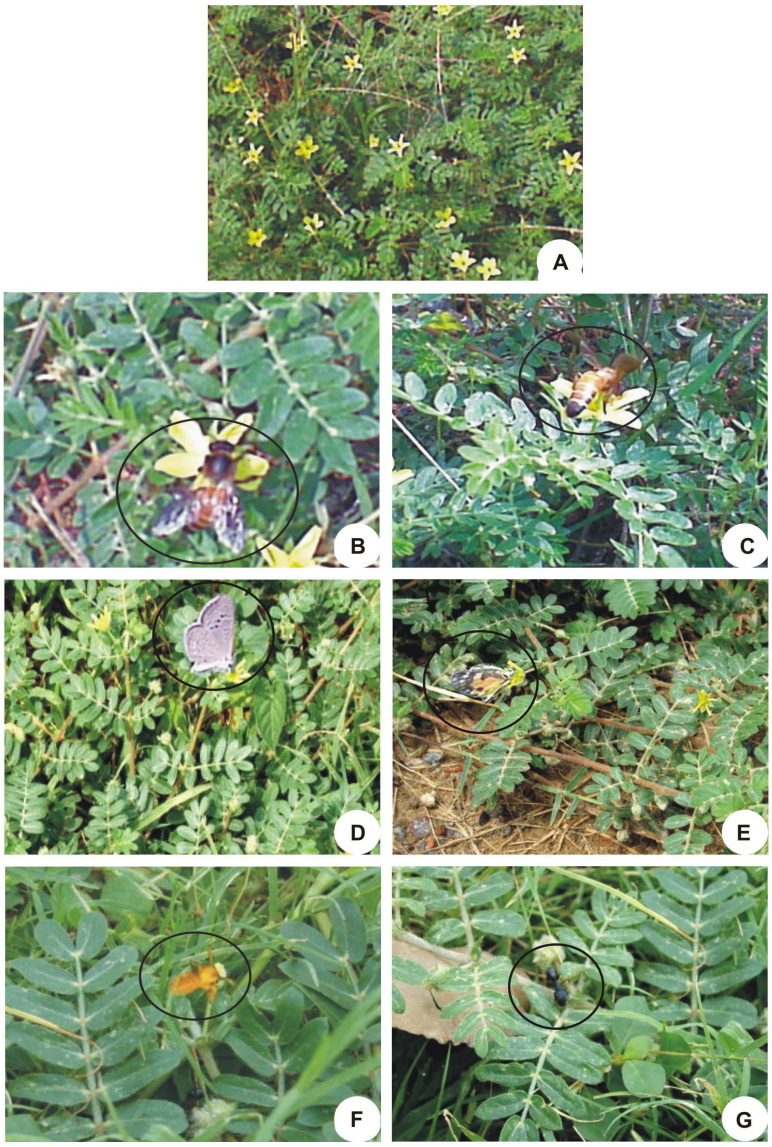
RESULTS AND DISCUSSION

Flowers in *T. terrestris* were yellow in colour, small in size and were arranged in short upward pedicels with solitary axillary inflorescence (Fig. 1A).



Figs. 1A - 1G showing floral density and pollinators of *T. terrestris*; (A) plant in full bloom; (B) honey bee (*Apis dorsata*); (C) honey bee (*Apis indica*); (D) butterfly (*Pierris* sps.); (E) butterfly (*Limenitis* sps.); (F) wasp (*Polistis orientalis*) and (G) black ant (*Componotus campestris*)

The mode of pollination indicated that *T. terrestris* was both self and cross pollinated plant as there was fruit-set in bagged inflorescence. It was interesting to note that it showed both geitonogamy and xenogamy. The flowers were cross pollinated by insects alongwith being self-pollinated, which occurred at the end of each flowers receptive period (within one day). 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 potential of this

system was 100% seed-set. Fruits matured approximately in 2 weeks after fruit formation.

Chaturvedi (2009) 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*.

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 orange yellow colour, odour and density functions as the secondary attractants for the pollinators.

Wyatt (1981) 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.

Table 1
Visitors and pollinators belonging to different orders responsible for pollination in Tribulus terrestris.

S. No.	Vector order	Common name	Zoological name	Syndrome term	Nature	Most Efficient pollinator
1	Lepidoptera	Butterflies	Pieris sp. Limenistis sp.	Psycophily	NR and PC	Honey bees (*Apis dorsata* and *Apis indica*) and Butterflies (*Pierris* sp. and *Limenitis* sp.)
2	Hymenoptera	Honey bees	*Apis dorsata, Apis indica*	Melitophily	PC	
		Black ant	*Componotus campestris*	Formicophily	NR and PC	
		Wasp	*Polistis orentalis*	Melitophily	PC	
3	Coleptera	Beetle Weevil	*Coccinella punctata Protocerius* sp.	Cantharophily	Visitor	
4	Diptera	Housefly	*Musca nebulo*	Myophily	PC	

Where
PC – Pollen carrier : NR-Nectar robber : V-Visitor.

From the Table 1 it was observed that *T. terrestris* flowers invited a variety of visitors and pollinators during the entire flowering period. They included Honey bees (*Apis dorsata*) (Fig. IB) and *Apis indica* (Fig. IC); Butterflies (*Pieris* sp. (Fig. ID) and *Limenitis* sp. (Fig. IE); Wasps (*Polistis orientalis*) Fig. 1F); Housefly (*Musca nebulo*); Beetles (*Coccinella punctata*); Weevil (*Protocerius* sp.) and Black ant (*Componotus campestris*) (Fig. 1G). Based on visit duration, visitation percentage and pollen load, the honey bees and butterflies were found to be most efficient pollinators.

Similarly, beetle and butterflies were reported the most efficient pollinators by Solomon *et al*. (2006) in *Acacia caesia* (Mimosaccae); Tidke and Patil (2005) in *Crotolaria serisca* and Singh and Dhakre (1999) in *Anthrophalous chinensis* (Rubiaceae).

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