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POLLINATION ECOLOGY OF *CROTALARIA SERICEA* RETZ.

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The pollination ecology of *Crotalaria sericea* Retz. was investigated at four sites in Amravati, Maharashtra. Plants start blooming form the second week of October and reach the peak in November. Flowers are typically papilionaceous and anthesise during 06.00 – 08.00 h. Five elongated adnate anthers dehisce between 09.00-12.00 h. one day before anthesis while the other five anthers dehisce during 12.00-16.00 h. on the day of anthesis. Pollen viability is > 95 %. Stigma becomes receptive after anthesis and remains receptive for two days. Nectaries at the base of anther filaments produce nectar with average of 2.56 µl in the morning and 0.56 µl in the afternoon per flower. Autogamy is dominant mode of pollination. Conspicuous inflorescence, attractive and coloured flowers, pollen mass and nectar are the attractants for pollinators. Flowers are visited by several insects such as *Apis florea, A. dorsata, A. indica, Xylocopa* sp., *Danaus missyppus, Teris hectata, Calochrysophs shabo, Danais chrysippus*, thrips and blister beetle. Blue bees and *Xylocopa* sp. are the pollinators.

Key words: *Crotalaria sericea* , pollination ecology, *Xylocopa*.

Crotalaria sericea Retz. (Fabaceae) is known for its economic importance (Anonymous, 1950, Agrawal, 1986 and Chopra *et al.*, 1986). It is useful in treating scabies and impetigo and the stem yields low quality fibre for mats and nets. A yellow dye obtained form the plant is used for coloring fabrics. The seeds, leaves and stem contain monocrotaline which has the beneficial effect of lowering the blood pressure. To my knowledge, there are no studies on pollination ecology of this species. This report presents observations on floral biology and pollination ecology of *C. sericea*.

MATERIAL AND METHODS

Studies on *Crotalaria sericea* were carried out during the year 1992-98 at four study sites: two natural populations, one growing in Pohra forest and the other on the Campus of Amravati University, and two cultivated populations, one at the Botanical Garden, Vidya Bharati Mahavidyalaya, Amravati and the other on a Residential Garden in Amravati. Amravati District lies between 20.32^0 to 21.46^0 North latitude and 76.37^0 to 78.27^0 East longitude. For collection of blooming phenological data, the plants were visited on alternate days and the period from the opening of the first flower up to the opening of the last flower was taken as the flowering period. Flower buds were collected at different stages of development and carefully dissected under a stereomicroscope to study the relative position of the anthers and stigma, and the details of pollination.

To asses the pollen production per flower, the method of Nair and Rastogi (1963) was adopted. Pollen ovule ratio was calculated as per Cruden (1977). To determine the pollen viability, tetrazolium test (Lakon, 1942) was used. Stigma receptivity was tested by pollinating flowers at different stages and also by observing the stigmatic surface with the help of hand lens (10 X). The quantity of nectar produced was measured by graduated capillaries at different times after opening of the flower. Sugar concentration was estimated by a hand refractometer (Metzer make) and analysis of nectar was done for the presence of glucose by GOD-POD method (Trinder, 1969 and Tietz, 1976). The breeding system was determined through manual pollinations.

The flower visitors were observed at different study sites at different hours and identified by the Entomology Department, Agriculture College, Nagpur. Census of flower visitors at initial, peak and final phases of flowering period was taken to note the consistency and frequency of foraging visitors. The

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number of flowers visited by the visitor, time spent on particular flower and pollen pick-up was recorded. Flowers were plucked on their opening day and subsequently on the second day at 17.00 h to determine depletion of pollen from anthers and its deposition on the stigma.

RESULTS

Flowering phenology:

Plants of *Crotolaria sericea* come up at natural sites after the first monsoon rains. They start blooming from the second week of October and reach the peak during November. Second flush of flowering in some plants was observed during the month of January when both number and size of flowers get reduced. The cultivated plants initiated flowering after 80 – 85 days of sowing; the flowering ceased by the second week of January.

Floral morphology:

The flowers are borne on terminal or axillary racemes. The average number of inflorescence per plant is twelve. Each inflorescence produce 20-50 flowers. Flowers are typically papilionaceous with yellow, broadly ovate standard with a strong midrib. The androecium consist of 10 dimorphic monadelphous stamens, five larger with narrow elongated adnate anthers on short filaments and five smaller globose basifixed anthers on long filament. Filaments and anthers are free above the bent part of staminal tube. The monocarpic gynoecium lies in the staminal tube and the latter in the keel.

Anthesis and anther dehiscence:

Flowers anthesize during 06.00 to 08.00 h. The first group of five narrow elongated adnate anthers dehisces during 09.00 to 12.00 h one day before anthesis and the second group of 5 globose basifixed anthers dehisces during 12.00 – 04.00 h on day of anthesis. The pollen mass released by anthers one day before anthesis is pushed towards the tip of the keel with the elongation of filaments of smaller anthers. The stigma become receptive after anthesis and remains receptive for two days.

Pollen productivity, P/O ratio and viability:

Wild populations produced 277686.33 ± 5575.68 pollen grains per flower while those under cultivation produced 150720 ± 7368.19. Pollen ovule ratio in the wild populations was 13223.14; however, under cultivation it was 8373.33. Pollen viability in globose long filamentous anther was 92.77% and in the elongated short filamentous anthers it was 96.05%.

Nectar production:

Nectar secretion was observed between 09.00 to 10.00 h and 17.00 to 18.00 h; it was 2.56 μl and 0.56μl per flower respectively. Total glucose present in the nectar was 736 mg/dl.

Breeding behaviour:

Results of various pollinations treatments revealed (Table 1) that *C. sericea* is self-pollinated. Fruit set was absent in flowers tested for apomixis (bagging of emasculated flowers), it was 90-100% in flowers tested for autogamy (bagging of mature flower buds), 65-75% in those tested for allogamy (manual cross-pollination), 5-10% in emasculated flowers allowed to open-pollinate by insects), and 100% in flowers under open pollination.

Table: 1 Fruit set percentage in different pollination treatments (N=20 for each treatment).

Treatment	Sample size No. of flowers	No. of flowers set fruits	Fruit set (%)	Average fruit set
Apomixis	20	00	00	00
	20	00	00	
	20	00	00	
	20	00	00	
Autogamy	20	20	100	96.25
	20	18	90	
	20	19	95	
	20	20	100	
Allogamy	20	14	70	68.75
	20	13	65	
	20	15	75	
	20	13	65	
Insect pollination	20	02	10	8.75
	20	01	05	
	20	02	10	
	20	02	10	
Open pollination	20	20	100	100
	20	20	100	
	20	20	100	
	20	20	100	

Flower visitors dynamics and behaviour:

A number of insect species visited the flowers (Table 2). The activity of pollinators starts after the

opening of the flowers. The insect activity diminished during cloudy days. *D. crysippus* visits withered flowers also. The bright yellow flowers represent flag type blossom. The vexillum is the chief advertising organ of the blossom. Insects visit the flowers to collect pollen and nectar. The blue bee lands on alae, chews a hole in it and enters inside to collect the pollen in its pollen basket. It also tries to enter from the underside of the alae and carries a large pollen load of 3864 pollen grains.

Table 2. Floral visitors' census in *C. sericea*.

Forager type	Forage Type	Length of visit (sec.)	Time of visit	pollen load	Flower visited per trip	Visit frequency
Blue bee	P	12-25	11 am – 4 pm	3864	6-8	F
A. florea	P	15-60	12 am – 4 pm	1226	4-6	O
A. indica	P,N	18-90	10 am – 3 pm	980	3-6	O
A. dorsata	P,N	7-9	11 am – 5 pm	60	2-3	R
D. missyppus	N	10-600	10 am – 5.30 pm	13	3-4	F
T. hectata	N	5-13	3 pm	0	1-2	R
Euploea core	N	5-15	4 pm	0	1-2	R
D. chrysippus	N	15-500	11 am – 5 pm	0	2-3	O
Papilio umamenon	N	5-10	11 am	0	1-2	R
P. hectar	N	5-10	11 am – 2 pm	0	1-2	R
Xylocopa sp.(large)	N	10-15	9 am - 5 pm	96	3-5	F
Xylocopa sp.(small)	N	10-15	10 am – 3 pm	0	2-3	R
Thrip	N	Reside	10 am – 3 pm	18	1	F
Caterpillar	F	Reside for long time	9 am – 5 pm	-	1	O
Blister beetle	F	Long time	9 am – 5 pm	-	1	O
Grass hopper	N	30-90	1 am – 5 pm	-	1	R
Spider	IF	Long time	7 am – 6 pm	-	1	F
Housefly	-	10-15	11 am – 5 pm	-	1	R
Mosquito	-	10-15	11 am – 5 pm	-	1	R

P = Pollen, N = Nectar, F = Flower; F = Visit frequently, O = Visit occasionally, R = Visit rarely; IF = Insect forager

A. florea enters deep inside the alae from this hole and robs the pollen. Several *Xylocopa* spp. are found hovering around the blossom. They alight on the alae and thrust the mouth between the anther filaments and middle line of vexillum to collect the nectar. During this activity, alae and carina are depressed and the style emerges out from the carina and the stigma touches the underside of the abdomen of *Xylocopa*. When it leaves the flower after tripping, the floral parts resume their original position and pollen transfer takes place.

Frequently visiting butterfly was *D. missyppus* as observed at all the study sites. The butterfly lands on the alae and inserts the long proboscis towards the nectarines at the base of the carpel. Other butterflies also behaved similarly but their visits were not so frequent as *D. missyppus*. Other occasional visitors were caterpillar, grasshopper, housefly, mosquito, spider and blister bee. The spiders were found to mimic the colour of petals and caught the flower-visiting insects. Thrips were commonly found within the glued petals. The data on flower visited, time spent and pollen load carried out by different visitors was also noted (Table 2).

Maximum numbers of pollen grains (345 pollen) were deposited on the stigma on the day of anthesis. The rate of pollen depletion was found to increase during insect activity.

Discussion

The large inflorescence, bright yellow flowers, gregarious flowering and pollen and nectar as rewards in *C. sericea* is important in attracting insects as has been reported in several other species (Percival, 1965; Faegri and Pijl, 1971). The flowers in *C.sericea* open in morning between 06.00 to 08.00 h and belongs to the early morning group of plants (Percival, 1965). There is time gap between dehiscence of anthers on short filament and those on long filament. The released pollen mass is concealed in the keel thus they fall under the category of closed flower type (Faegri and Pijl, 1971). Due to elongation of filaments of small globose anthers pollen mass comes within close proximity of stigma. Pollen release, anthers in close proximity to the stigmatic papillae and receptivity of stigma are synchronized resulting in autogamy. However, the colour, corolla architecture and presence of nectar are the contrivances for promoting entomophily. Thus insects and flowers mutually ensure reproductive success (Kevan and Baker, 1983).

Pollen production per flower has been known to vary within and among plants in a certain population (Willson and Burley, 1983; Nakamura and

Wheeler, 1992). The pollen production per flower in natural populations was 277686.33 ± 5575.68; however in cultivated populations it was 150720 ±7368.19. Cruden (1977) reported that the pollen-ovule ratio was found to be a much better indicator of breeding system. In autogamous species *C.sericea* P/O ratio was found to be higher than that suggested by Cruden (1977). The variation due to some factors not directly associated with the breeding system, may prohibit the use of pollen ovule ratio for comparing outcrossing rates within species.

The stigma receptivity is an important factor in achieving the process of fertilization and plays an important role in successful completion of post-pollination events. Stigmas become receptive after flower opening and remain receptive for two days. Change in flower colour and closing of flower indicates the loss of stigma receptivity (Gori, 1983; Lamont, 1985). The secretion of nectar synchronizes with the activity of pollinators. Its quantity is depleted towards evening and also the flower age defines the quantity of nectar secreted (Willson and Bertin, 1979).

Though the flower shows different clues to attract the pollinator it was found to be primarily autogamous. Karoly (1994) stated that for many self-compatible insect pollinated species, the outcrossing rate is likely to result from the interactions of plants traits and local pollination ecology. Similar observations were also made in other papilionaceous plants (Patil and Rathi, 1987; Rahman and Patil, 1986). Although *C. sericea* is predominantly autogamous, some outcrossing does occur as indicated by tripping following visits of some insects.

A number of visitors visit the blossom of *C. sericea* either to collect pollen or nectar or both. The dominant visitors are blue bee and *Xylocopa* species. Keel blossoms are best understood as an adaptive response of plants to the dilemma of strong competition for pollen between flowers and bees (Westerkamp, 1997). Bee visitors can only handle such flowers. Papilionate flowers are closely associated with long tongued bees and butterflies. Bees are good pollinators for legumes (Deodikar and Suryanarayana, 1977). During the visit bees collect pollen either by entering inside the alae and keel or by making the hole in the keel. *Xylocopa* alights on the flower and then insert the proboscis towards nectary; during this act stigma and pollen mass come out of the alae and carina and touch the abdomen of the insect. The time spent on flower is defined by reward level (Galen and Plowright, 1985). Pyke (1981) also reported that pollinator visit to flowers are related to the amount of nectar present in them. The foraging rate of different flower visitors and time spent differs widely (Kevan and Baker, 1983).

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