Pollination mechanism in *Coriandrum sativum* Linn. (Apiaceae)

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**Abstract.** Exposed nectar, abundant pollen production, zygomorphic flowers and compact umbels are the contrivances which attract in large numbers a wide variety of insect species to coriander flowers. Some of these visitors carry coriander pollen from one flower/umbel to another and by so doing act as potential pollinators; others are only casual visitors.

**Keywords.** Apiaceae; pollination; pollen load; hymenopterans.

1. **Introduction**

Grant (1949) considered Umbelliferae unspecialized in respect of pollination system on account of uniform floral structure and the presence of exposed nectar. Bell (1971) also suggested that each visitor to the umbels can be a potential pollinator. Although, several workers recorded insect visitors of umbellifers (Muller 1883; Grant 1949; Bohart and Nye 1960; Hawthorn *et al* 1960; Bell 1971; Grace and Nelson 1981; Schlessman 1982; Lindsey 1984; Koul *et al* 1986), only a few (Bohart and Nye 1960; Bell 1971; Grace and Nelson 1981; Schlessman 1982; Lindsey 1984; Koul *et al* 1986) have attempted to distinguish between casual visitors and actual pollinators. This communication which presents observations on some aspects of the reproductive biology of *Coriandrum sativum* is an attempt in this direction.

2. **Materials and methods**

Pollination studies were conducted on two populations, each having more than 500 plants, of *C. sativum*, one raised in the University Botanical Garden and the other in the nearby Gujjar Nagar, both at Jammu. The role of wind as a pollinating agent was checked by hanging glass slides smeared with Mayer’s albumin from T-shaped wooden stands fixed at varying distances all round the experimental plots at a height of 0.6–2 m above the soil surface. The slides were checked for pollen at 24 h intervals. The mode of pollination was determined by bagging young flowers and umbels and following them for fruit set.

Observations on insect visitors were made by collecting insects from umbels throughout the day at 30 min intervals for 5 days. The visiting insects were identified up to the level of order and where possible up to species. Some insects which could not be identified have been given accession numbers for reference. The pattern of insect movement on the umbels was also recorded. Pollinators and casual visitors were distinguished on the basis of the pollen load on their body parts.

Impact of umbel density, symmetry and shape on insect visitation was determined by deforming certain umbels and recording the percentage frequency of
insect visits. Fruit set was estimated by comparing the number of fruits formed with the number of hermaphrodite flowers present in different umbel orders.

3. Results

3.1 Bagging experiments

None of the 32 flowers bagged individually produced any fruit. On the contrary, 59–68% fruit set was recorded from bagged umbels. This indicates failure of selfing at the level of individual flower but considerable selfing at the level of umbel.

3.2 Wind pollination

Examination of the slides exposed around the experimental plots revealed 0–6 coriander pollen grains per slide. Of the 19 slides scored, only 4 carried 2–6 coriander pollen grains, others had none. Obviously, very little coriander pollen is air borne and therefore wind seems to play no role in the pollination of this species.

3.3 Insect pollination

Umbels of *C. sativum* are visited by a variety of insects right from the initiation of anthesis to the cessation of stigma receptivity. The visual impact of the compound umbel, presence of exposed nectar and availability of abundant pollen are the major attractants and rewards for the insects visiting the umbels.

3.3a Nectar: The nectar is secreted from the stylopodium, a bulbous structure capping the ovary. The secretion starts when the flowers reach anther dehiscence stage and continues until the stigma receptivity ceases. The secretion starts every day at 7:00 or 8:00 h and ceases around 15:00 h. The amount of nectar secreted during the receptive phase of the stigma exceeds that secreted during the dehiscence of anthers. The number of insects visiting umbels of Gujjar Nagar cultivation, before and during the receptive phase of stigma is 83 and 129 respectively (for a period of 4 h). The insects visiting the umbels during the receptive phase are mostly lepidopterans.

3.3b Pollen: The pollen discharge from anthers continues for a long time on account of non-synchrony in the dehiscence of anthers within the flower and the umbel. Each anther of the hermaphrodite and staminate flower produces $1,385.6 \pm 84.9$ and $1,198.0 \pm 62.2$ pollen grains respectively in the plants raised at the University Botanic Garden and $1,693.1 \pm 86.1$ and $1,352.0 \pm 56.9$ in the plants of the Gujjar Nagar fields. The total number of pollen grains produced per hermaphrodite flower is 6,928 and 8,465.7 in the University and Gujjar Nagar populations respectively.

3.3c Visual impact: The colour, symmetry and the size of umbel offer visual attraction to insects. Although small individually, flowers of coriander produce mass effect on aggregation into umbellets and umbels. The density and compactness
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of umbels determine their visual impact. The density increases from primary to higher order umbels. Aggregation of flowers into umbels also provides convenient landing for large sized insects. When umbel density and symmetry were altered by clipping off 2-4 umbellets from the umbel, the number of insect visitors declined. Thus, whereas the number of insects visiting intact umbels is about 131, in the umbels subjected to surgery the number is only 46. The reduction in pollinator frequency could be the cumulative effect of decrease in pollen output (caused by elimination of some umbellets) and alteration in umbel symmetry.

Coloured petals, stigma and anthers also offer attraction to insects during the early stages of anthesis. Since insects continue visiting umbels even after the dehiscence of anthers and senescence of petals, it appears that petal and anther colour has only secondary role as an attractant.

3.3d *Umbel visitors:* Data on the variety, frequency and behaviour of insect visitors were recorded at different intervals of the day during May-June, 1984 and February-March, 1985. The plants were surveyed for insect visitors only after they had come to full bloom.

Umbels of coriander were visited by a variety of insects. In all, 36 species representing 9 orders were collected from the umbels of different plants. The break up is presented in table 1.

During June, 1984, the Gujjar Nagar population yielded a total catch of 367 insects belonging to 18 species whereas the Botanic Garden population (during February-March, 1985) attracted a total of 21 species. Three species (*Apis mellifera*, 1 *Eristalis* sp. and Acc. no. 1) were found to be common between the two populations. The difference in insect fauna of the two populations is a consequence of seasonal difference. While the Gujjar Nagar population was scanned for pollinators in June, the plants raised in the University Botanical Garden were studied in February-March.

The relative frequency and the quality of visitors varied on sunny and cloudy days (figure 1). The lepidopteran or hymenopteran insects dominated during the sunny days but dipterans were most common on cloudy days.

The diurnal activity of the insects also varied. In the Gujjar Nagar field, on sunny days, insects started visiting umbels around 7:00 h. The frequency of visitors was

<table>
<thead>
<tr>
<th>Table 1. Details of insect visitors to umbels.</th>
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<tbody>
<tr>
<td><strong>Order</strong></td>
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<tr>
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</tr>
<tr>
<td>Diptera</td>
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<tr>
<td>Hymenoptera</td>
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<tr>
<td>Lepidoptera</td>
</tr>
<tr>
<td>Coleoptera</td>
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<td>Orthoptera</td>
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<tr>
<td>Hemiptera</td>
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<td>Homoptera</td>
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<td>Odonata</td>
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<td>Isoptera</td>
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very low during early hours; it picked up slowly and reached the peak between 11:00 and 12:00 h. Most of the hymenopterans visit umbels between 9:30–12:00 h. The lepidopterans, particularly butterflies (Acc. no. 14) dominated up to 12:00 h. On sunny days of February and March, 1985, the number as well as variety of insect visitors increased up to 13:00 h. and declined thereafter. Insect activity was hectic between 10:00–15:00 h. with the peak at 12:00–13:00 h. Two hymenopterans, *A. mellifera* and *A. florea* and one dipteran (Trachinid fly) were the most frequent visitors in the two fields.

On cloudy days the number of insect visitors reduced considerably. The most dominant were the dipterans, bearing Acc. nos 1, 21, 26, 32 and 33. Hymenopterans were very few. Hymenopterans start their visits from 9:00 h and continue up to 17:30 h with the peak reaching between 11:30–12:30 h. *A. mellifera* also makes a few trips.

### 3.4 Pollinators

The insects collected from coriander umbels were screened for the quality and quantity of the pollen attached to their body. Of the 36 insect species collected, only 21 carried coriander pollen (table 2). Insects of different orders also exhibit distinct
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Table 2. Quantity of coriander pollen carried by insects of different orders.

<table>
<thead>
<tr>
<th>Number of pollen grains</th>
<th>Number of insect species</th>
<th>Insect orders</th>
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<tbody>
<tr>
<td></td>
<td>Hymenoptera</td>
<td>Diptera</td>
</tr>
<tr>
<td>A Less than 100</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>B 100-250</td>
<td>6</td>
<td>(Acc. no. 1)</td>
</tr>
<tr>
<td></td>
<td>(Acc. nos 4, 12, 16, 17, 28 and 29)</td>
<td>(Acc. nos 9 and 33)</td>
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<tr>
<td>C 250-500</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Eristalis sp. (Acc. no. 31), Trachinid fly, syrphid fly and Acc. nos 20 and 36</td>
<td></td>
</tr>
<tr>
<td>D 500-1000</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>(Eris sp. <em>Apis florea</em>)</td>
<td>Eristalis sp. (Acc. nos 3 and 32)</td>
</tr>
<tr>
<td>E More than 1000</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(Apis mellifera)</td>
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</tr>
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</table>

Numbers represent the number of insect species.

In their pollen carrying capacity, hymenopterans being more efficient than others (table 2). Maximum pollen was attached to the tibia of hind limbs which bear pollen baskets or the bristles.

3.4a Behaviour of pollinators: The insect pollinators land at the centre or periphery of the umbel, move about for some distance and then fly to another umbel of the same or a neighbouring plant. In the process of their movement on the umbel, pollen grains from dehisced anthers stick to different parts of the insect's body. Hymenopterans, such as *A. mellifera*, *A. florea*, *Eris* sp. and Acc. nos 4, 12, 16, 28 and 29 land on the umbel, crawl over briskly for 5–25 s and then fly to another umbel. The large dipterans (Trachinid fly, syrphid fly, *Eristalis* sp. and Acc. nos 9 and 32) make quick movements but individual insects stay on the umbel for 5–50 s. Smaller dipteran flies bearing Acc. nos 1 and 33 are sluggish, move very slowly and stay for as long as 20–140 s. The lepidopteran, butterfly (Acc. no. 14) visits on sunny days, lands at the periphery of the umbel, crawls for 20–90 s and then flies over to a close-by umbel. The orthopteran bearing Acc. no. 22 makes very slow movements and its stay on the umbel varies between 25–180 s.

4. Discussion

Correlation between inflorescence size and seed set has been demonstrated in *Catalpa speciosa*. Reduction induced in the number of flowers in the inflorescence of this species led to low fruit set (Stephenson 1979), suggesting that large sized inflorescence represents an adaptation for boosting seed production. However, in carrot, modifications imposed in the umbel by clipping off nearly half the umbellets had no adverse effect on insect visitation (Bell 1976). In coriander, deformation of umbels reduced insect visitation. The difference in the response of different species to surgery may be caused by the difference in the original size of the umbels in these species. Coriander umbels are smaller than those of carrot. Therefore, even minor
changes alter umbel density and reduce visual impact impoverishing the material rewards for the insects.

The concept of promiscuous pollination system in Umbelliferae (Grant 1949) has been refuted by several workers (Bell 1971; Grace and Nelson 1981; Lindsey 1984; Koul et al 1986). In \textit{C. sativum} as well all insects visiting the umbels are not pollinators. Of the 36 insect species collected from coriander umbels, only 21 carried varying loads of coriander pollen. The hymenopterans turn to be best pollinators for coriander as they also do for carrot and fennel (Koul et al 1986) and for species of \textit{Zizia} and \textit{Thaspium} (Lindsey 1984).

Self pollination does not operate at the level of individual flower in \textit{C. sativum}. Individual flowers do not produce any fruit on bagging but individual umbels do. In the latter case, the fruit set is around 59–68\% which is lower than the fruit set in the open pollinated-umbels (75.37–84.15\%). Fruit set in the open pollinated umbels suffers when they are deprived of the anthers from bisexual and the male flowers (Gupta et al 1986). Decline in fruit set from open flowers is attributed to reduced insect visitation due to reduction in the visual impact of flowers and in the material rewards, like pollen and nectar. These results suggest that \textit{C. sativum} is self-compatible but not fully self fertilizing at individual flower level. However, at the level of umbel geitonogamy operates successfully.

As in most other umbellifers, flowering in coriander is sequential resulting in the formation of different umbel orders (Gupta et al 1986). The maturation of male and female sex-organs (anther dehiscence and stigma receptivity) at different timings results in an overlap between staminate and pistillate phase within an umbel as well as among umbels of different orders (figure 2). Insect visitation between umbels of the same plant results in geitonogamy and between umbels of neighbouring plants leads to xenogamy.

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{figure2.png}
\caption{Diagrammatic representation of the temporal relation between anther dehiscence and stigma receptivity in different umbel orders of \textit{C. sativum}.}
\end{figure}
Acknowledgement

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