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Flower-insect interaction in pollination

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Abstract. Pollination is one of the most fascinating aspects of interaction between plants and insects. The extent of interdependence is regulated by phenology, floral characters as well as by form, structure and behaviour of the pollinators. During evolution flowers have developed various strategies for attracting insects.

We have studied the biology of pollination in *Lantana camara*, a pernicious weed. The colour variant used in this study bears yellow flowers at anthesis which subsequently change to orange, scarlet and magenta. Lantana is self-compatible but needs insects for pollination. Thrips have been found to be consistent and regular pollinators. They visit only yellow flowers and avoid flowers of other colours. Colour change is triggered by pollination and functions in the partitioning of the pollinator and consequently helps in conserving pollinator energy. Whereas butterflies visit lantana in two seasons, thrips are associated with it all through the year and play an important role in seed production. By adapting to thrips pollination *Lantana* has become highly widespread.

Keywords. Anthecology; entomophily; floral pigments; *Lantana camara*; thrips; weed biology.

General Account

Green plants are the primary producers and all non-green plants and animals depend on them for sustenance. Insects have been associated with plants during their long course of evolutionary history.

Interactions between plants and insects can vary from extreme degrees of hostility and antagonism to dependence as in lac and silk insects or mutualism as in pollination of figs, *Aristolochia*, *Salvia*, *Yucca*, *Vanda* and *Ophrys*.

Like astronomy and bird watching, the study of insects and their role in pollination and gall making has been one of man's earliest curiosities. Over centuries both amateurs and specialists have generated a large amount of information on the structure, classification, feeding habits, behavioural patterns and life-cycles of insects and plants.

This meeting which has brought together people working in diverse areas such as entomology, pathology, botany and chemistry is an important one as it would provide an opportunity to exchange knowledge and excitement not only about the fundamental aspects of plant-insect interactions but also in finding answers to some of the important world questions such as control of plant diseases and insect pests.

In combating insect-vector borne infectious diseases of man and other vertebrates, a good deal of scientific know-how has been gathered and various methods of control have been developed.

Overpopulation, continuing food shortage, ravages of plant diseases, especially those caused by viruses, mycoplasma, and the alarming extent of degradation of the environment through chemical pollutants and pesticides, spread of exotic weeds and other pressing problems demand more desperate strategies for action. These call for a greater understanding of the interrelations between plants and insects.

Among the various interrelations between plants and insects, pollination has been the most fascinating one and is regulated by phenology, floral characters as well as by form, structure and habits of the pollinators. There are numerous examples of coevolution of insects and flowers. Coevolution may be usefully defined as an evolutionary change in a trait of the individuals in one population in response to a trait of the individuals of a second population, followed by an evolutionary response by the second population to the change in the first (Janzen 1980).

One of the main factors in the rapid rise and evolutionary diversification of the angiosperms during the cretaceous era was the development of the flower into a highly efficient structure for cross-pollination and seed dispersal. This led to a far greater degree of genetic recombination and rapid colonisation of habitats which were comparatively unsuitable for their ancestors.

The basic trends in floral evolution have been reduction in size of floral components, concealment of nectaries, fusion of floral parts, aggregation of flowers into inflorescences and development of attractants for pollinators. The attractants needed to lure the pollen-vectors are broadly classified as primary and secondary. The first include food, supplied in the form of pollen, nectar, fleshy petals and other floral tissues, food bodies and various secretions including the stigmatic exudate. Secondary attractants range from odour, visual attractants (colour, shape and number of floral parts), breeding ground for insects, protection and brood place, and sexual attraction (Faegri and van der Pijl 1971).

Beetles are considered as general primitive pollinators. Bees and butterflies are more specific in their movements. Bees collect pollen and nectar and are adapted to nectariferous flowers or those producing abundant pollen. Bee-pollination is of immense significance because bees are the most important pollinators of economic crops (Proctor and Yeo 1972).

Recently, there has been a resurgence in the interest of studying the role of small insects in anthecology. These were probably overlooked earlier because of their size. Thysanoptera, considered as phytophagous and gall-making insects have now gained importance because of their involvement in pollination of members of the Compositae (Ananthakrishnan 1982; Ananthakrishnan *et al* 1981 a, b; Gopinathan *et al* 1981), Ericaceae and of palms and beet (Annand 1926; Billes 1941; Shaw 1914; Syed 1979).

Pollination in *Lantana camara*

Our attention to study pollination in *Lantana camara*, an exotic troublesome shrub was drawn by the fact that it bears flowers which are yellow at anthesis and change their colour to orange, scarlet and finally magenta. It was of interest to establish the cause of flower colour change. *Lantana* was reported to be pollinated by butterflies (Dronamraju 1958; Schemske 1976; Barrows 1976). As fruit set was noted in all the months of flowering, it became important to ascertain the nature of the regular pollinators.

Six stages of flower development were recognized. Phenological events including the time of anthesis, time of pollination, duration of each stage on the inflorescence, pollen germination, pollen tube growth etc were studied. Pollination was established as the trigger for petal colour change. This led to the elucidation of the nature of pollination and pollinating agents. Bagging experiments using both butter paper and nylon mesh bags showed that the flowers were self-pollinated but needed a small insect vector. The insect pollinators were two species of thrips namely *Thrips hawaiiensis* and *Haplothrips tenuipennis* (Mathur and Mohan Ram 1978).

An year-round study of thrips populations, floral density, fruit set and butterfly visitations revealed that thrips are consistently associated with fruit set. Even in the absence of butterflies fruit set occurs; hence they cannot be the regular pollinators. Butterflies probably visit lantana flowers only to collect nectar.

Thrips were associated with only yellow flowers on the inflorescence. This is also the receptive stage for pollination. The next question to be answered was: what attracts thrips to yellow flowers? Is it colour, odour, food substances or a place to breed? Experimental studies to elucidate these factors showed that thrips were attracted to yellow coloured sticky panels ('stickem'-coated formica panels) suspended on the bushes as well as yellow coloured rubia cloth discs kept in a petri plate.

Under field conditions thrips feed on the copious stigmatic exudate and the abundant pollen grains present inside the yellow flowers. On account of the constriction of the corolla below the region of the stigma, the thrips are unable to reach the base of the flower to gain access to the stored nectar. While feeding the thrips move about within the flowers, effecting pollination. Experiments have indicated that thrips can be artificially fed on sugary substances like diluted jaggery and sucrose solution.

Experimental bud opening under *in vitro* conditions has shown that the yellow petal colour does not change to orange if left unpollinated. Those flowers pollinated in nature show colour change even when their corollas are excised and placed on agar.

The pigments involved in colour alterations in flowers were analysed both qualitatively and quantitatively using standard methods of solvent extraction, solvent separation, paper and thin layer chromatography for purification, cochromatography, *Rf* values in standard solvent systems and spectral analysis. The major pigments were identified as β-carotene, (the yellow pigment) and delphinidin monoglucoside (the red pigment).

The anthecological events occurring in lantana are summarized in figure 1. Buds are pink-tipped, they open into yellow flowers. These are pollinated by thrips subsequent to which they change colour to orange the next day. This colour change is due to enhanced synthesis of anthocyanin as a consequence of pollination. As anthocyanin synthesis continues, the orange flowers change colour to magenta after passing through scarlet. Ovary development becomes evident by the magenta colour stage.

It is important to note that adaptation to thrips pollination in lantana is secondary to butterfly pollination but has enhanced seed production and has contributed to the widespread distribution of this weed. There are many other plants in which post-anthesis shift in flower colouration occurs and it will be rewarding if the significance of pigment shift in relation to pollination is established.

Conclusions

Pollination biology began as a purely observational science and fascinated the scientist and the amateur alike. However, there has been a justifiable shift from the purely descriptive accounts on pollination towards experimentation, quantification of data and behavioural studies. Pollination has become a part of intra-floral ecology involving energetics, and is gradually being developed on an ecosystem basis and its value in the

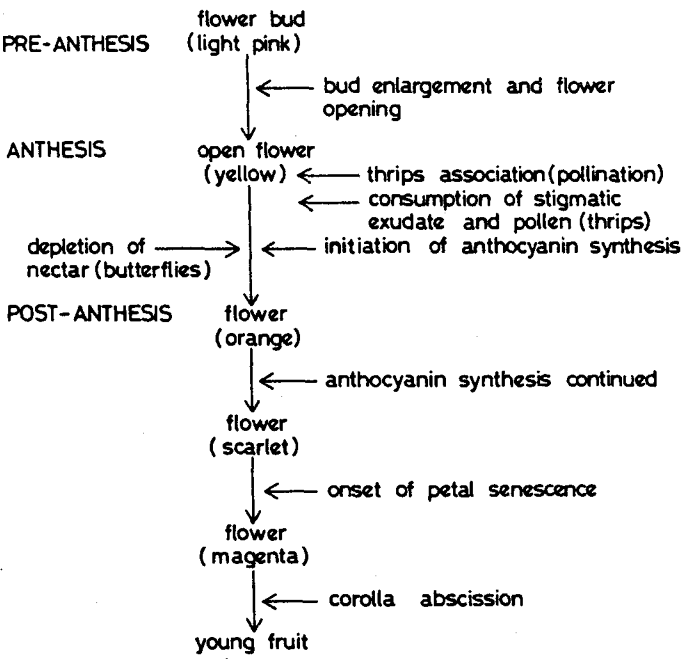

Figure 1. Anthecological events in *Lantana camara*.

understanding of biological evolution has been recognized. Techniques such as spectral analysis, colorimetry, electroantennography, stereoscopic light system, visual-sound analysis, micro-chromatography and scanning electron microscopy are currently being pressed into service to solve anthecological problems (Richards 1978).

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