

## Butterflies and pollination biology

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**Abstract.** Most butterflies with the characteristic long proboscis feed on floral nectar, and the *Heliconius* butterfly feed on pollen as well. They rely mostly on flower colour for locating and identifying the flowers. While foraging on nectar, they carry pollen on their body parts. Evidence is available indicating that the flower-visiting butterflies need not function in every case as pollinators. *Leptidea synapis* forages at the flowers of *Viola* and *Lathyrus* without performing the reciprocal pollination service. The butterflies as a group have the tendency to visit a few flowers on a plant and then fly to another plant with the result of maximising xenogamy. The need for detailed studies over different geographical regions is stressed to fully evaluate the role of butterflies as pollen vectors.

**Keywords.** Floral nectar; proboscis; foraging; pollination; xenogamy; pollen vectors.

### 1. Introduction

Butterflies in the insect order Lepidoptera combine aesthetic appeal with a diversity of problems of scientific interest. One such problem, which is also of practical importance, is their interaction with the plants. Being holometabolus insects, they develop in a series of distinct morphological stages. The larvae, commonly referred to as caterpillars, are entirely phytophagous thriving on the leaves, especially of dicotyledonous plants. The adults of most species obtain their largely carbohydrate diet from the nectar of flowers. Thus over the entire period of their active life, the butterflies engage in a spectrum of plant-feeding relationships which are often very complex involving coevolution and obligate mutualism; such interaction can be a major factor in generating patterns of diversity in both the partners (Enrich and Raven 1965; Gilbert 1972, 1975). We attempt here to summarise the present state of knowledge in butterfly-flower interactions that result in pollination.

### 2. Flower visiting butterflies

Not all butterflies are flower-visiting. Only those more evolved species and in which the mouth-parts are represented by a long, thin proboscis adapted for feeding on liquid diet pay their visits to flowers. Such members include all species of Danaiids, Vanessas, Nymphalids, the majority of males of Lycaenids, Papilios, Pierids and Hesperids (Wynter-Blyth 1957).

### 3. What do the butterflies get from flowers?

The flowers are exploited by the butterflies for nectar, the only source of carbohydrate for them. Baker and Baker (1973) showed that butterfly nectars tend to have sucrose

dominance and are not very viscous. Further, the nitrogen requirement is met from the aminoacids in nectar; therefore the butterfly nectars are normally rich in aminoacids (Baker and Baker 1975; Baker 1978). There is only one known instance of butterflies getting aminoacids from pollen. The neotropical butterflies of the genus *Heliconius* collect pollen on their tongues, add nectar, and then drink the nectar that contains aminoacids that have been leached out of the pollen (Gilbert 1972). Nectar may also satisfy the water requirement of butterflies. Vogel observed a great increase in the number of butterfly visits to flowers during a drought, driven there by the need for water (see Percival 1965).

#### 4. Locating and identifying the flowers

Butterflies are diurnal in their activity and visit many flowers that open in the morning using innate and imprinted "search images" (Swihart 1971). They rely entirely or exclusively on floral colour for locating, identifying and feeding from the flower. Most species have innate colour preference and show fidelity to colour variations; in some cases these may be modified by experience or training. They can distinguish between various colours of yellow. The members of advanced families such as Nymphalids and Pierids are sensitive to both yellow/orange and red, whereas the primitive Hesperidae are sensitive only to yellow/orange and may not see red (Ilse 1928; Swihart 1969, 1970, 1972). Some show a preference also for blue colours (Ilse 1926; Ilse and Vaidya 1956). Trichromatic colour vision has been demonstrated in Pieridae (Eisner *et al* 1969) and Nymphalidae (Struwe 1972 a, b). When the butterflies are attracted by the colour of the flowers, scents may act as nectar markers, and in such flowers there will be a change in quality and quantity of the scent emitted near the nectary (Schremmer 1973).

Detailed features of the flowers, such as the "dissection" (the ratio of perimeter to area) of the corolla may also be important identifying characters (Ilse 1932). The typical butterfly blossom is one with a narrow tube and flat rim as seen in *Lantana* and *Buddleia*. Butterflies sucking nectar out of narrow tubes, frequently florets of Compositae, is a common feature (Proctor and Yeo 1972; Faegri and Pijl 1979). In certain blossoms as in *Caesalpinia pulcherrima* and *Cadaba fruiticosa*, the long distance between sexual organs and nectar source is of positive value for the correct use and placing of the proboscis. But like bees, butterflies also utilise other blossom types.

#### 5. Pollination by butterflies

While foraging at the flowers for nectar, the pollen grains adhere to the various butterfly body parts such as proboscis, head, thorax, legs, wings; the exact pollen region depend on the floral architecture, more so whether the essential organs are exerted or concealed within the corolla. The pollen thus adhered is likely to be transferred on the stigmatic surface when the butterfly moves to another conspecific flower, thus performing pollination. However, authentic cases of butterfly pollination are few and relate to plant species as *Caesalpinia pulcherrima* (Cruden and Hermann-Parker 1979), *Asclepias syriaca* (Percival 1965), *Aesculus californica* (See Moldenke 1976), *Platanthera ciliaris* (Smith and Snow 1976), *Phlox* species (Grant and Grant 1965; Levin and Berube 1972), *Anguria* (Gilbert 1975) and *Cadaba fruiticosa* (authors' observation).

In *Caesalpinia pulcherrima*, the stiff filaments afford a good landing place and the narrow tube containing the nectar is nicely suitable for butterfly proboscis. Butterflies belonging to Papilionidae, Pieridae, Hesperidae and Nymphalidae effect pterygotribic pollination in this plant. The pollen grains are held together by viscin threads, which results in the clumped dispersion of pollen on the butterfly wing. Of the four families of butterflies, Papilionidae are the effective pollinators because they flutter their wings continuously while foraging at the flower. These approach the flowers from above and in front, thus maximising anther and/or stigma-wing contact.

*Asclepias syriaca* is pollinated by *Danaus plexippus*. The gland of the pollinia is situated midway between both the anthers and coronal cups and immediately above the narrow slit leading to the stigmas. The gland clamps firmly round the insect's leg which later slips into the slit as the insect shifts its position while drinking the copious nectar in the coronal cups. When the insect pulls its leg out, the pollinia also come away and may be carried to other flowers. The butterfly has to exert considerable force to extricate its leg from the groove, and only the larger, stronger ones can do this. Others are trapped and flutter until they die.

*Aesculus californica* is pollinated by butterflies of the genera *Euphydryas* and *Strymon*. It is interesting to note that all species of *Aesculus* secrete a nectar that is poisonous to bees, interfering with the normal development of the larva.

The butterfly *Papilio troilus* is the most frequent pollinator of the orchid *Platanthera ciliaris* with bright orange coloured flowers. The butterfly directly alights on the raceme, and supports itself by its legs on several flowers with constant wing motion. As the proboscis is lowered to the nectary, the head comes in contact with the viscidium of pollinarium. Upon withdrawing from the flower, the pollinarium is firmly cemented to the butterfly's head and is pulled out of the half anther cell, then as the butterfly searches for nectar from another flower, the pollinium usually brushes against the stigmas and results in several massula getting deposited on the stigmatic surface located just above the opening to the nectary.

The *Phlox pilosa* and *P. glaberrima* rely for their reproductive success on several species of butterflies (*Colias*, *Pieris*, *Danaus* and *Polities*). The proboscis carry hundreds of pollen grains out of the corollas. Though some pollen are removed during flight from one plant to another because of proboscis coiling, considerable amount of pollen is deposited on the stigmas, thus effecting pollination.

*Anguria* is the little-known, inconspicuous cucurbit genus which provides pollen and nectar sources for *Heliconius* and is pollinated by that butterfly. All species of *Anguria* are dioecious and they produce flowers in an inflorescence on a long peduncle if male, in pairs at each node if female. These flowers have unequal sex ratios and they provide food for any *Heliconius* throughout its life by the continuous production of pollen and nectar. The nectar production during the brighter hours train the butterflies to the male plants position and they collect pollen during semi-darkness. The stigmatic surface of the female flowers is covered with pollen-sized bumps and mimics as the male flower to attract butterflies (Gilbert 1975).

*Cadaba fruticosa* is pollinated by *Colotis eucharis*, *C. danae* and *Anaphaeis aurota*. These alight on the elongated gynandrophore with a tubular nectarial appendage arising from base. While foraging, the abdomen and wings make contact with the stamens and gynoecium.

Contrary to the above mutualistic relationship between butterflies and flowers, Wiklund *et al* (1979) basing their observations with the wood white butterfly *Leptidea*

*sinapis* and its nectar plants—*Viola carina*, *V. riviniana* and *Lathyrus montanus*, advanced a hypothesis that butterflies as a group may have evolved to occupy a parasitic mode of life as adults, feeding on the nectar of flowers without pollinating them. But in view of certain authentic cases of butterfly pollination on record such generalisation as to the relationship between butterflies and flowers becomes inviable.

## 6. Host specificity and flower constancy

There are no known instances illustrating a strict one-to-one relationship between butterflies and their plants. However, few instances of plant species visited exclusively or mostly by butterflies are on record. Such plant species are those mentioned earlier as being pollinated by butterflies.

To what extent butterflies are instinctively flower constant is not clear. Christy observed a group of butterflies (*Vanessa*, *Colias*, *Parnassius*, *Pieris*) making predominantly (75%) conspecific visits, while Bennett found the same kinds of butterflies making predominantly (78%) interspecific visits (see Grant 1949). Levin and Berube (1972) found that the *Colias* butterflies in the mixed population of *Phlox pilosa* and *Phlox glaberrima* exhibited a distinct preference to the former species. Cruden and Hermann-Parker (1979) observed on *Caesalpinia pulcherrima* that the butterflies visited four to six flowers, then flew to another tree. A drifting behaviour has also been recorded on *Tribulus terrestris* (Subba Reddi *et al* 1981), *Sapindus emarginatus* (Subba Reddi *et al* 1983), *Jatropha gossypifolia* (Reddi and Subba Reddi 1983) and *Senecio* (Schmitt 1980). Knoll suggested that the relative degree of constancy might depend on the relative abundance of the nectar resource (see Grant 1949). If the resource is bountiful, the butterflies tend to remain constant. That such a trend may not always be expected is evident from the observations on *Sapindus emarginatus* which provides an abundant resource, thus pointing to their drifting behaviour which is of paramount importance to the plants they pollinate because such tendency maximises the delivery of xenogamous pollen, and minimises selfing or geitonogamy. Such behaviour is still more crucial for the self-incompatible species. Schmitt (1980) found in *Senecio* populations exposed to butterfly as well as bumble bee pollinations that the gene (pollen) dispersal has been considerably greater in butterfly pollinations.

## 7. The length of time spent at flowers

The number of flowers visited per unit time and the time spent at the flowers is an indication of the mobility of the insects, which in turn speaks of the effectiveness to utilize the floral resource. Each species of butterfly differ from the other in the length of time spent, and the time spent by the same species on different plants also differ (table 1). Cruden (1976) related the length of foraging visits to the amount of accumulated nectar. When little nectar is available the visits are short, but many flowers are visited. When relatively large amounts of nectar accumulate, the butterfly requires more time to extract the nectar, and fewer flowers are visited. It is predicted that when more time is spent at flowers and fewer flowers are visited, fruit-set is lowered, and seed-set is maximised because of the increased pollen transfer that results from spending longer time at each flower. Conversely, visiting many flowers results in the maximisation of fruit-set and tend to result in lower seed-set.

**Table 1.** Length of time spent by different butterflies at the flowers of different plant species.

Butterfly type	Time spent (sec)	
	Male	Female
<i>Sapindus emarginatus</i> (Subba Reddi et al 1983)		
<i>Baoris zelleri</i>	9.3	10.8
<i>Euploea core</i>	8.0	10.8
<i>Jatropha gossypifolia</i> (Reddi and Subba Reddi 1983)		
<i>Catopsilia crocale</i>	2.1	3.3
<i>Premna latifolia</i> (authors' observation)		
<i>Papilio polytes</i>		1.5
<i>Antigonon leptopus</i>		
<i>Catopsilia pomona</i>		1.2
<i>Danaus chrysippus</i>		1.3
<i>Hypolimnas bolina</i>		2.1
<i>Hypolimnas missipus</i>		5.2
<i>Papilio polytes</i>		2.3
<i>Precis lemonias</i>		10.3
<i>Tros hectar</i>		1.2
<i>Zetides agamemnon</i>		2.3
<i>Duranta repens</i>		
<i>Catopsilia pomona</i>		13
<i>Euploea core</i>		2
<i>Euploea crassa</i>		18
<i>Papilio polytes</i>		4
<i>Precis lemonias</i>		16
<i>Telchinia violae</i>		14
<i>Zetides agamemnon</i>		23
<i>Cadaba fruticosa</i>		
<i>Anaphaeis aurota</i>		3.1
<i>Colotis danae</i>		2
<i>C. eucharis</i>		1

## 8. Conclusion

In conclusion, it can be said that the information on flower-visitation and pollination by butterflies is very meagre. This is also evident from the limited treatments of it in the books on pollination biology as of Percival (1965), Proctor and Yeo (1972), Faegri and Pijl (1979) and in such reviews as that of Baker and Hurd (1968) and Vogel (1978). Eventhough verne Grant as early as 1949 felt this lacuna, no attempts have been made to rectify this defect. Detailed studies in this fascinating and challenging field of inquiry over different geographical regions are needed for a proper evaluation of butterflies as utilisers of floral nectar and as pollen vectors.

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