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INTRODUCTION

The common milkweed, *Asclepias syriaca* L., is remarkably adapted for cross pollination by insects. Its pollen sacs (pollinia) are often found attached to the appendages of bees, wasps, butterflies, and other insects that visit milkweed for its nectar (Judd, 1955; Matheson, 1951; Müller, 1883).

In the summer of 1966 and 1967 I collected numerous pierid and nymphalid butterflies associated with milkweed plants in Michigan in order to examine them for their pollen-carrying capability. Species of butterflies collected were *Colias interior* Scudder, *C. eurytheme* Boisduval, *Pieris rapae* (L.), and *Speyeria aphrodite* (Fab.). These insects were taken while feeding on or flying near milkweed plants between 3 July and 22 July each year--the period when milkweed was in full bloom--in Crawford, Montmorency, and Oscoda Counties, Michigan.

THE MILKWEED FLOWER AND POLLINATION

Müller (1883) and Matheson (1951) discuss the flower structure and the role played by insects in the transfer of pollinia of the milkweed.

The flowers are massed into umbels, the calyx and corolla of each are reflexed so that the 5 smooth glossy stamens surrounding the pistil are fully exposed (Fig. 1A). Each stamen unites with its fellows in a way which forms a slit between them. There is a clip-like organ (corpusculum) at the apex of each slit (Fig. 1A) which unites the concealed anther sacs (pollinia) in pairs by short strap-like retinacula (Fig. 1B). The stigmatic surfaces lie within the slits.

Normally, an insect visiting the flower for nectar slips on the smooth surface of the stamens and gets its foot in the slit between them. Then as the insect draws its foot up the slit, the clip clamps onto the hairs, claw, or segment of the tarsus. When the insect frees its foot it carries away the whole pollinial apparatus. The paired pollinia are moist and divergent when first extracted but soon rotate inward as they dry so their surfaces become nearly parallel (Fig. 1B). They then fit easily into similar slits, stick to the stigmatic surfaces, and break away from the clip when the insect visits a new flower. The clip remains attached to the insect.

OBSERVATIONS

In all, 236 pollinia (or clips) were observed on 107 butterflies out of 1144 butterflies collected. All the species studied were capable of picking up the pollinia but the data indicate that some species carry far more pollinia than others. Pollinia were very scarce on *Colias*, common on *Pieris*, and abundant on *Spey-*

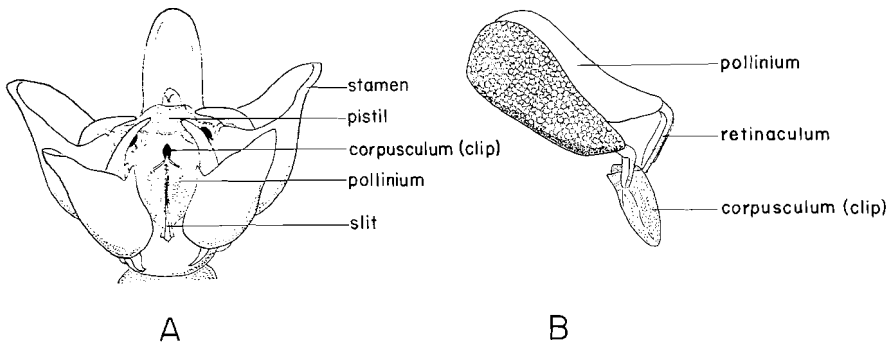

Fig. 1. Common milkweed. A, upper part of single flower; B, pollinial apparatus.

eria. Speyeria carried more than twice as many pollinia as *Pieris* and more than 100 times as many as *Colias* (Table 1). *Pieris* and *Speyeria* frequently carried more than one pair of pollinia, but only one *Colias* out of 894 specimens examined had two pollinia attached to its extremities (Table 2). *Pieris* and *Speyeria*, which were netted in far less numbers than *Colias*, had some representatives with as many as 8 and 6 pollinia respectively.

Pollinia were located on all 3 pairs of legs of *Pieris* and *Colias* but only on the meso- and metathoracic legs of *Speyeria*. The "brush-feet" of *Speyeria* are probably incapable of acquiring pollinia. Most of the pollinial clips were attached to the claws or terminal tarsal segments. The maximum number of clips on one foot was five--on one *Speyeria*. In addition, five clips with one or both pollinia were attached to the proboscises of five butterflies; 3 on *Pieris* and one each on a *Colias* and a *Speyeria*. All were very near the tip so feeding was probably hindered or prevented.

Table 1. Summary of milkweed pollinia per species of butterfly.

Species	No. butterflies collected	Percentage butterflies with pollinia	Mean no. pollinia per butterfly
Colias spp.	894	0.7	0.01
Pieris rapae	156	23.7	0.61
Speyeria aphrodite	94	67.0	1.43

Table 2. Frequency of butterflies carrying different numbers of pollinia.

Species	Frequency of butterflies by number of pollinia: 0	1	2	3	4	5	6	7	8	Total butterflies
Colias spp.	888	5	1	0	0	0	0	0	0	894
Pieris rapae	119	15	8	3	5	3	2	0	1	156
Speyeria aphrodite	31	25	23	5	4	4	2	0	0	94
										1,144

DISCUSSION

Speyeria aphrodite appears to be the most capable pollen carrier of the milkweed visitors in the area of this study. It was not ascertained if *Speyeria* was the best milkweed pollinator there, but the numerous individuals collected with naked clips suggest it was at least a very good pollinator. *Pieris rapae* was a fair pollen carrier, while *Colias interior* and *C. eurytheme* were very poor carriers. These last three species are similar in size and structure and they appear to visit milkweed with almost equal regularity, so the variability was probably due mostly to behavioral differences. Perhaps *Colias* manages to grasp the flower better and thus prevent slipping on the stamens, or if it slips perhaps it does not recover its foothold in a way that is conducive to pollen collecting.

It is not surprising that some of the butterflies had pollinia attached to their proboscises. All of the species studied probe across a flower to reach the nectaries located behind the anther sacs. This probing sometimes places the curved proboscis in the groove or slit near the clip, so that a sudden movement upward would cause the clip to catch hold. Judd (1955) found calliphorid flies with pollinia clasped to the labellum of the labium indicating they too were searching for nectar.

LITERATURE CITED

Judd, W. W. 1955. Mites (Anoetidae), fungi (*Empusa* spp.) and pollinia of milkweed (*Asclepias syriaca*) transported by calyptrate flies. Canad. Entomol. 87:366-369.

Matheson, R. 1951. Entomology for introductory courses. Second edition. Ithaca, N.Y.

Müller, H. 1883. The fertilization of flowers. London.

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REVIEWS OF RECENT LITERATURE

THE POCKET ENCYCLOPEDIA OF PLANT GALLS. Arnold Darlington. New York: Philosophical Library, 1968. 191 pp. $7.50.

Plant galls or cecidia have always fascinated and bewildered the biologist and the layman, and only recently has there been much attention paid to the biology of gall makers and the physiology of gall development. There are several 'early' definitive books on galls by British, German, and American authors, but most are out of print or are replete with errors. Few are useful for quick identification of galls in the field.

This pocket encyclopedia definitely fills a vacancy not occupied by other works on galls. It is one of the "Blandford Colour Series" of books on natural history subjects, and is thus similar to the American Field Guide Series in style and method of usage. Though published in the United States it is based entirely upon representative galls of Great Britain.

The book is divided into several brief introductory chapters, a section composed of colored plates, and a long annotated list of British galls. In the introductory chapters the author introduces the reader to fundamentals of