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COMPOSITES AS HOST PLANTS AND CRYPTS FOR *SYNCHLORA AERATA* (GEOMETRIDAE)

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ABSTRACT. Thirteen genera of Asteraceae have been recorded as host plants of the geometer moth *Synchlora aerata.* These flower-feeding larvae not only live on their food plants but also use the host plants as sources of raw material to disguise themselves. The larvae cut off flower parts, entire flowers, and even entire inflorescences and attach them to spiculiferous processes on their dorsal surface. If this floral covering is removed the larvae immediately replace the camouflage; furthermore, the larvae maintain the effectiveness of the covering by replacing withered floral parts with fresh ones. Adaptation to the use of host plant material as camouflage enables the larvae to exploit, with greater safety from predators a greater range of potential food plants.

Little is known of the life history of the larvae of geometer moths. On the basis of their structure and behavior in relation to concealment from predators, the larvae so far described can be divided into three distinct groups: 1) those that are slender and twig-like; 2) those with moderate dorsolateral processes bearing specialized hooks for the attachment of plant fragments as an aid to concealment, and 3) those with large dorsolateral processes not specialized for the attachment of plant matter (Ferguson, 1969). Of interest here are the behavioral characteristics and host plant relations of *Synchlora aerata* with the Asteraceae (=Compositae). *Synchlora aerata* belongs to the second of the above groups.

Larvae of *S. aerata* were observed on, and collected from, two species of *Liatris* on the coastal plain of North Carolina in Carteret Co., and on three species of *Solidago* on the piedmont of North Carolina in Orange Co. They have also been reported on seven other composite genera (Table 1). Larvae of *S. liquoraria liquoraria* and *S. frondaria* have also been reported on composites (Table 1).

METHODS AND MATERIALS

The larvae were collected and transplanted to terraria where their feeding behavior, and their use of plant fragments as camouflage, could be observed. The response of the larvae was studied under the following conditions: 1) when camouflage was removed by artificial means, and 2) when host plants were changed. In the latter case,

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TABLE 1. Summary of the species of *Synchlora* and their known composite host plants.

Species	Host plants	Citation
S. aerata (Fabricius) Dyar	*Ambrosia* sp.	Ferguson (1969)
	Coreopsis sp.	Ferguson (1969)
	Erigeron canadensis	Ferguson (1969)
	Rudbeckia hirta	Ferguson (1969)
	Rudbeckia sp.	Ferguson (1969)
	Ageratum sp.	Anonymous (1890)
	Eupatorium sp.	Anonymous (1890)
	Liatris graminifolia	Treiber*
	L. spicata var. *resinosa*	Treiber*
	Solidago canadensis	Treiber*
	S. nemoralis	Treiber*
	S. pinetorum	Treiber*
	Aster sp.	Dyar (1960)
S. liquoraria liquoraria Guenee	*Artemisia californica*	Comstock & Dammers (1937)
	Solidago sp.	Comstock & Dammers (1937)
S. frondaria Guenee	*Bidens* sp.	Ferguson (1969)
	Pluchea odorata	Ferguson (1969)
	Chrysanthemum sp.	Kimball (1965)

* First report.

larvae feeding on *Liatris* were transplanted to *Solidago* and vice versa. One individual was successfully reared and was the basis for identification as *Synchlora aerata*. Voucher specimens of both the larval stage and adult stage have been deposited into the U.S. National Museum, Dept. of Entomology, Smithsonian Institution.

FEEDING AND LOADING BEHAVIOR

Observations on feeding and camouflage-loading behavior were first made on *Liatris spicata* var. *resinosa* (Fig. 1). In each case, the larvae began dissecting individual flowers by cutting the corolla tube vertically between lobes for a distance of 1–2 mm, then cutting perpendicularly to the long axis of the corolla tube for nearly its entire circumference. The corolla was further dissected into fragments with 1 to 3 lobes. The cut edge of each section was passed through the larva's mouth, and carefully attached to a spiculiferous process on its back (Fig. 2). As the fragments were passed through the mouth of the larva, a mucilaginous substance was secreted by the larva onto the fragments, this substance seems to play a role in maintaining turgor in these fragments. Next, the style (and in a few cases pappus hairs) were bitten off and also treated as described above. The larva then

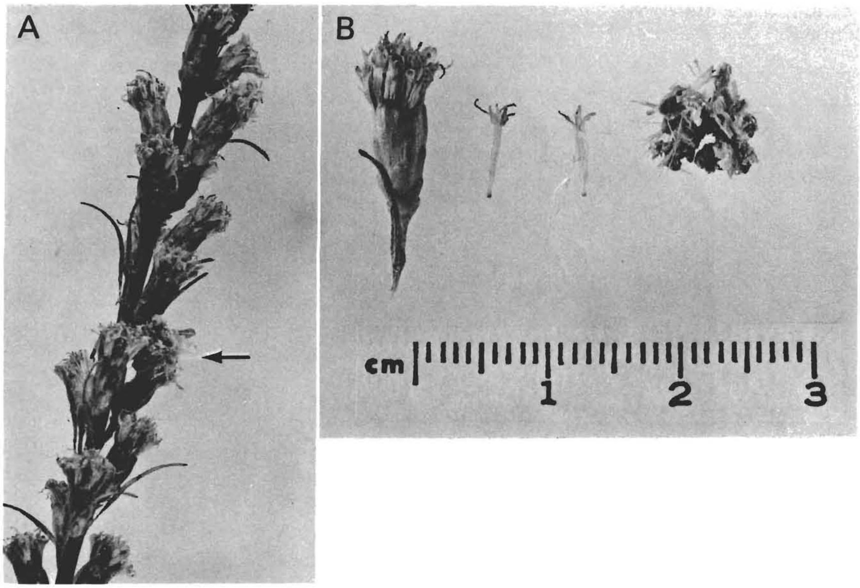
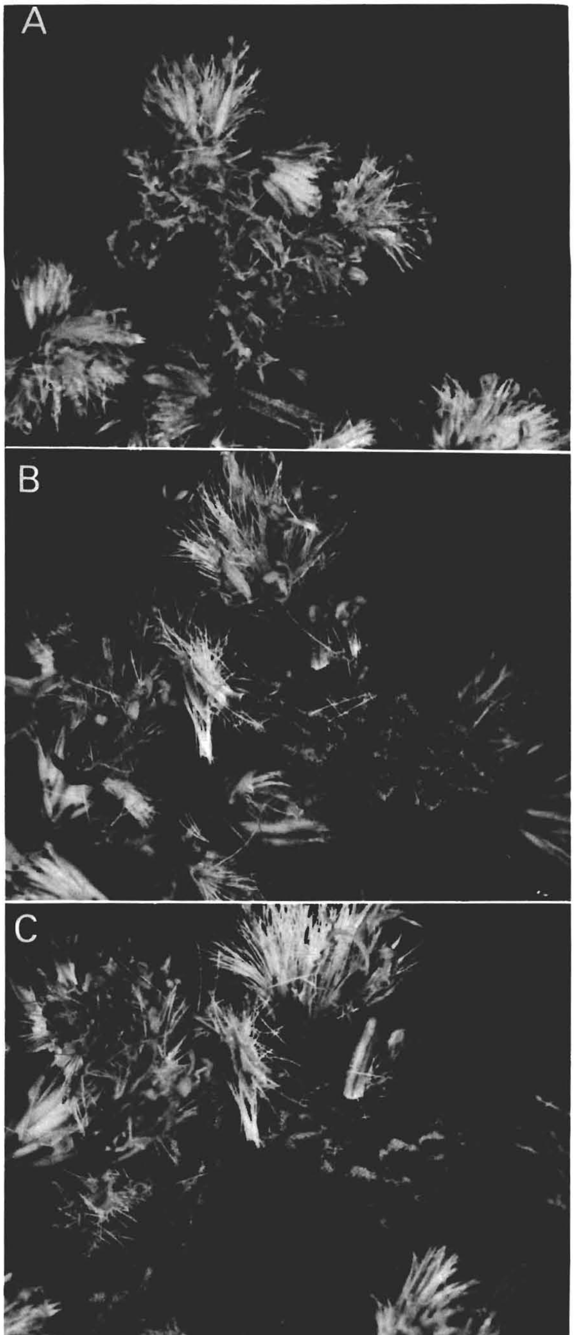


FIG. 1. Macrophotographs of the larva of *Synchlora aerata* on *Liatris spicata* var. *resinosa*; (A) inflorescence stalk of *L. spicata* var. *resinosa* with arrow pointing to the location of a fully camouflaged larva and (B) a comparison of the size of an inflorescence and of a flower of *L. spicata* var. *resinosa* with a fully camouflaged larva.

devoured the anther sacs and pollen, which apparently provide its chief source of nourishment, although some corolla and stylar tissue was also observed being ingested. In no case was the ovary of the flower damaged.

Even when the disguise is complete, maintenance is required. Two kinds of maintenance are recognized: 1) the addition of a mucilaginous substance, which appears to maintain turgor in the plant fragments, and 2) the replacement of "older" missing, lost, or wilted tissue with "new" tissue. Apparently, the "old" tissue is either ingested by the larvae or discarded at some point and subsequently replaced. Thus the loading process is more or less continuous.

The feeding behavior on *Solidago* flowers was similar to the behavior observed when feeding on *Liatris*, that is, the principal nourishment was derived from the anthers and pollen, as well as from occasional feeding on stylar and corolla tissue. However, the camouflage-loading behavior was different. On *Solidago* the floral dissecting process described above was omitted. Instead of dissecting corolla fragments, the larva bit off entire inflorescences and attached them to its back in the manner described for *Liatris* (Fig. 2). Apparently, frag-


A
B
C

ments from the larger flowers of *Liatris* were sufficient to provide a camouflage; however, in the small-flowered *Solidago* species, flower fragments were insufficient to effect a viable camouflage. Both types of loading behavior, described above, were exhibited by the same larva.

In order to better understand the loading behavior and the relationship between feeding and loading, three larvae were artificially denuded. The larvae immediately began to feed and load alternatively until their camouflage was complete. In similar experiments on *Chrysopa slossonae* (Neuroptera) Eisner et al. (1978) found that the relative priority the larvae give to these two activities is variable and is dependent on the degree of satiation. However, in the case where the larvae were denuded and hungry, the larvae divided their time between loading and eating. In addition, denuded larvae, as well as larvae with a complete disguise, were transplanted from *Liatris* to *Solidago* and vice versa. The denuded larvae again began to feed and load until the disguise was complete. The larvae, with a complete camouflage of plant material from the first host plant, were observed to replace these plant fragments with floral material from the second host plant. Replacement proceeded in the same manner as observed in the maintenance process. Whether or not the difference in host plant was recognized by the larvae can only be conjectured; however, the result was a complete change of the larvae's covering to match the new host plant.

DISCUSSION

The adaptation of loading plant fragments, flowers, and/or inflorescences as a disguise by the larvae of *Synchlora aerata* effects an apparently successful camouflage against winged predators. More importantly, this adaptation enables the larvae to feed on a variety of related host plant species rather than being restricted to a specific host plant, as in the case with adaptations to special marking or coloration, due to predator pressure. This adaptation is viewed as an important evolutionary adaptation enabling the larvae of *S. aerata* to exploit a greater range of potential food plants. This conclusion is supported by the relatively large number of composite genera that have been recorded as host plants.

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FIG. 2. Macrophotographs of the larva of the geometer moth *Synchlora aerata* on the goldenrod *Solidago canadensis*; (A) showing the orientation and arrangement of goldenrod inflorescences attached to the dorsal surface of a larva; (B) dorsal view of larva after removal of a portion of its camouflage, and (C) lateral view of larva after removal of a portion of its camouflage.

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Journal of the Lepidopterists' Society
33(4), 1979, 244

A NEW METHOD OF INDUCING COPULATION IN *PHYCIODES THAROS* (NYMPHALIDAE)

While engaged in breeding experiments using various populations of *Phyciodes tharos* Drury, I happened on a method of inducing copulation that may be widely applicable to other butterfly species. It proved extremely difficult to achieve matings by the hand-pairing technique or in small cages using several population cultures of *P. tharos* in my laboratory. The difficulty appeared to be both an unusually low level of courtship activity in the males and an unusually low proclivity toward acceptance by the females. However, I noticed that stray males that had escaped from the mating cages and flown to a large screened window often showed greatly increased aggressive behavior and sexual approaches toward each other. Females placed on the screen near courting males still refused to mate, but when they were restrained by holding the wings together over the back with a pair of flat forceps, the males were often able to copulate. Greater success was achieved by stroking the female's abdomen on the male's antennae to elicit repeated copulation attempts and by moving the female's abdomen to bring her genitalia into contact with the male's. If the female was released at this point, she still attempted to avoid copulation and would often dislodge the male by her struggles. I had better success by pinching the forceps handle with a spring-type clothespin and putting the clothespin across the mouth of a small jam jar. The quiescent male then hung from the female's abdomen until copulation was complete, when he dropped to the bottom of the jar. This method may prove to give better results than either cage or hand-pairing for a number of difficult species.

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