A Preliminary Study of Seed Predators of Platte Thistle in the Nebraska Sandhills

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A PRELIMINARY STUDY OF SEED PREDATORS OF PLATTE THISTLE

IN THE NEBRASKA SANDHILLS*

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The biology and infestation patterns of three seed-feeding insects were investigated in Platte thistle populations (*Cirsium canescens* Nutt.). The insects have been identified as *Paracantha culta* (Wiedemann), *Orellia occidentalis* (Snow), and *Homoeosoma stypticellum* (Grote). Factors determining infestation patterns were studied by collecting 75 post-bloom heads from three Sandhills sites on June 16, 1977. Mean number of insects per head was 0.55 for *P. culta*, 4.3 for *O. occidentalis*, and 3.3 for *H. stypticellum.* Insects were present in 97 percent of the heads. Competition between species was reduced by differences in time of active growth of the insects within a head and by their segregating spatially into different heads.

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INTRODUCTION

Understanding the effect of insects on plant populations is basic to the biological control of weeds. Although most studies have assessed the effect of introduced insects on plants (e.g., Kok and Surles, 1975), the study of natural populations can add considerably to this understanding (Huffaker, 1962). One naturally occurring plant-insect system is Platte thistle, *Cirsium canescens* Nutt., and its seed predators, *Paracantha culta* (Wiedemann) (Diptera: Tephritidae), *Orellia occidentalis* (Snow) (Diptera: Tephritidae), and *Homoeosoma stypticellum* (Grote) (Lepidoptera: Pyralidae). Larvae of these insects feed in developing flower heads and significantly reduce seed production. Eklund (1970), studying this system in northeastern Colorado, found 94.5 percent of the heads had insect damage and estimated that these species reduced seed production 39.5 percent.

In this paper, we will present the known biology of these species and discuss a preliminary study of their infestation patterns within three Platte thistle populations. The following questions will be considered: (1) Are infestation rates different at different sites? (2) Are most thistle heads attacked by at least one seed predator? (3) Is there a difference in head selection by the three insects, and, if so, what are the determining factors?

BIOLOGY

Cirsium canescens. Platte thistle is restricted to sandy soils and is found throughout the Sandhills region of Nebraska. Wind-dispersed seeds germinate in April and May and many seedlings die as they grow into the rosette stage. These rosettes may require one, two, or more growing seasons to reach maturity. The composite flowers, characteristically yellow-white, bloom from mid-May through late June. Seed production is the only method of reproduction and terminates the life of the plant.

Paracantha culta. This fly, characterized by its wing pattern, feeds on all *Cirsium* thistles in Nebraska, and has also been reported on *Carduus, Cynara,* and *Helianthus* species

(Wasbauer, 1972; Morihara and Balsbaugh, 1976). The female selects the bud stage of head development as the oviposition site (Fig. 1) and lays her eggs among the bracts on the outside of the developing flower head from late April through May. The eggs hatch in a few days and the larvae bore toward the center of the head, using mouthhooks to feed on the soft, developing seeds. After development through three instars, the barrel-shaped larvae pupate within the head and adults emerge during seed dispersal.

Orellia occidentalis. Platte thistle and yellowspine thistle (*Cirsium ochrocentrum* A. Gray) are hosts of this banded winged fly in Nebraska. Wasbauer (1972) lists *Cirsium* species and *Cnicus parryi* A. Gray as hosts. The female prefers oviposition in heads between late bud and partial bloom, when the florets are accessible but not yet exerted (Fig. 1). She inserts her long ovipositor into the florets of the head and deposits eggs 5-10 mm below the top of the florets. The emerging larvae crawl down the floret tube and begin feeding on the developing seeds. After they consume these seeds, they move to adjacent ones to continue their feeding. During the late third instar, the elongate larvae leave the head, drop to the soil, and burrow. These larvae diapause until the following spring, when they pupate and emerge as adults.

Homoeosoma stypticellum. The larvae of this moth were found on Platte thistle and tall thistle [*Cirsium altissimum* (L.) Spreng.] in this study, and were also reported by Heinrich (1956) on *Cirsium* and *Rhus* species. The spherical eggs are laid among the florets of heads in bloom. Thus, this insect is the last of the three considered here to attack the developing flower heads (Fig. 1). The larvae, which feed on developing seeds following pollination, grow through five instars before pupating. Early instars are white with brown stripes; the later instars are blue with contrasting reddish brown bands. Also, the early instars feed on seeds within heads determined by the ovipositional preference of the adult females, whereas the later instars travel between heads and plants to find sufficient food. When mature, the larvae drop to the ground, burrow into the soil, and diapause until the following spring.
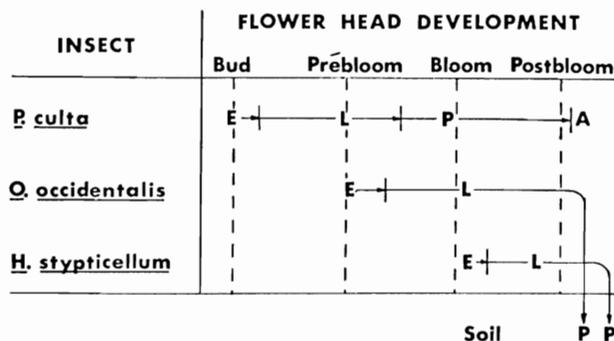

Figure 1. Life cycles of three insect species in Platte thistle heads. E, egg; L, larva; P, pupa; A, adult.

METHODS

To study the infestation patterns of the insects, we collected 75 post-bloom heads on June 16, 1977, from three Nebraska sites. The sites are 5 km east of St. Paul (Howard County), 14.6 km north of Greeley (Greeley County), and 13.8 km west of Spalding (Greeley County). The St. Paul and Spalding sites have high plant densities; the Greeley site has a less dense stand. During collection of heads, we recorded the location of the head on the plant, total number of heads per plant, plant height, and number of plants within a distance of one meter. During dissection of the heads, the diameters were recorded and numbers of each insect species present were determined.

RESULTS AND DISCUSSION

Table I lists the mean number of each species per head at each site. The St. Paul site had a significantly higher population of *P. culta* than the other two, possibly because *P. culta* has several generations per year, each on different *Cirsium* species, and the St. Paul site was the only site near populations of other *Cirsium* species. Thus, *P. culta* was limited in sites lacking other *Cirsium* hosts. The high infestation rates of *O. occidentalis* may be related to host density. The Greeley site, which had the lowest density of plants, had the lowest numbers of *O. occidentalis*. *H. stypticellum* infestations were high at the Greeley and Spalding sites and relatively low at the St. Paul site. In all species at all sites the variance associated with the mean number per head was greater than the mean, indicating the dispersion pattern of all three species is clumped (Southwood, 1966). This clumping is probably due to the females laying clutches of several eggs in a few heads instead of spreading eggs over many heads.

Of the 75 heads collected, 21 percent contained *P. culta*, 77 percent contained *O. occidentalis*, and 77 percent contained *H. stypticellum*. Six heads (8 percent) were infested with all three insects, and only two heads (3 percent) had no insects. Thus, in terms of the presence of the insects, the heads were being used extensively for food.

The infestation of the heads by any two of the species should be independent if the insects select heads at random. To test this independence, we computed correlations between numbers per head for each pair of the three species (Table II). In this and later analyses, the *H. stypticellum* population was divided into two components based on age. The distribution of early instars depends on the ovipositional site preferred by the female, and the distribution of the late instars on their movements between heads and plants. The correlation coefficients of *H. stypticellum*, although not significant, are interesting. Early instars of the caterpillar were found in the same heads with fly larvae, but later instars were found in heads without fly larvae. Apparently, the last instar was moving to heads with a lower infestation rate of tephritids.

TABLE I

Mean Number of Insects Per Head

Insect Species	Site		
	St. Paul	Greeley	Spalding
P. culta	1.2	0.2	0.2
O. occidentalis	5.5	2.3	5.1
H. stypticellum	1.6	4.2	4.1

TABLE II

Interspecific Correlation Coefficients of Number Per Head and their Probability

Species	O. occidentalis	H. stypticellum	
		Instar I-III	Instar V
P. culta	-0.23 (.05)	0.20 (.08)	-0.16 (.18)
O. occidentalis	-------	0.06 (.58)	-0.12 (.30)
H. stypticellum Instar I-III	-------	-------	0.08 (.49)

The only significant correlation was between the two tephritids, and this was a negative correlation. Thus, heads having large numbers of P. culta had small numbers of O. occidentalis and vice versa. This will be discussed in detail later.

To analyze some of the factors involved with infestation patterns, we computed multiple regression models to compare the number of individuals per head with the observations recorded, such as head diameter and plant height. Each model used an indicator variable to compensate for site differences. From these models, the best was chosen for each species, using the criteria of maximizing statistical significance and r^2.

For P. culta, the best model related the number of larvae per head to the head diameter (Table III). As the head diameter decreased, the number of larvae per head increased, as

TABLE III

Regression Models Relating Infestation Rate with Various Observations

Species	"Best" Model
P. culta	4.1 - 0.12 (Head Diameter)
O. occidentalis	-8.2 + 0.42 (Head Diameter)
H. stypticellum	
Instar I-III	none significant at .05 level
Instar V	-6.6 + 3.9 (Head Location on Plant) + 0.2 (Plant Height)

shown by the negative sign on the coefficient. For this model, the general test of regression was significant at the .05 level; r^2 was 0.30, which is interpreted as explaining 30 percent of the variation in the data; and the inclusion of head diameter into the model was highly significant (P < .001). We do not believe that head diameter is important for oviposition site selection by this species; rather, heads that have P. culta larvae in them tend to grow more slowly and therefore are smaller than uninfested heads.

The best model for O. occidentalis also includes the head diameter term, but in the opposite way of P. culta (Table III). Larger heads tend to have more larvae, probably because of ovipositional preference. For this model, the general test of regression and inclusion of the head diameter term were highly significant (P < .001), and the model explained 26 percent of the variation. This indicates that the separation of species seen in the correlation analysis results from oviposition site selection by O. occidentalis. This separation is clear when the head diameter is considered. Using a 27 mm head diameter as the reference point, 91 percent of the O. occidentalis were in heads larger in diameter, whereas 85 percent of the P. culta were in smaller heads. Since O. occidentalis oviposits in heads after P. culta are actively growing, there are two possible mechanisms of oviposition site selection to cause this separation. First, O. occidentalis may use size as the criterion for selecting heads for oviposition, and second, it may detect and avoid P. culta by chemotaxis.

Using the number of early instar larvae of H. stypticellum for a regression model, we found no model that was statistically significant at the .05 level. This may reflect random choice of oviposition sites by the female moths.

The best model for the last instar of *H. stypticellum* includes two terms, the location of the head on the plant and plant height (Table III). In this model the value of head location was greater toward the bottom of the plant; thus, more larvae were collected on heads at the bottom. The mean number of larvae per head from the lowest head on the plants was 3.8, while the mean for all other heads was only 1.8. Also, more larvae were found on the taller plants. For this model, the general test of regression as well as the incorporation of head location and plant height into the model were all significant at the .01 level, and 38 percent of the variation was accounted for in the model. The importance of these factors in the model apparently is related to the movement of larvae between plants. As they travel between plants, the larvae tend to establish themselves on larger plants. Also, once they find a new plant, they tend to stay in the first head they find as they crawl up the plant.

CONCLUSIONS

In this study we have shown that the three insect species are compatible with each other and effectively infest nearly all of the heads of a Platte thistle population. Competiton between insect species is reduced in two ways. First, the stage of head development chosen for oviposition by each species is different, and, therefore, their periods of active growth within a head occur at different times. Second, *P. culta* and *O. occidentalis* tend to segregate into different heads, while *H. stypticellum* larvae tend to move to uninfested heads as they grow, thus reducing interspecific competition by occupying heads not infested by the flies. Therefore, the insect species can partition their food supply in time and space, thereby decreasing seed production among the developing thistle heads.

ACKNOWLEDGEMENTS

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