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SEED PREDATORS OF VELVETLEAF (MALVACEAE: *ABUTILON THEOPHRASTI*) WEED

Timothy J. Gibb
Department of Entomology
Purdue University
West Lafayette, Indiana 47907

ABSTRACT: Propagation of an annual weed depends upon the production and survival of its seeds. Any factor which reduces weed seed number or vigor should prove agronomically beneficial. A survey of insects associated with reproductive-age velvetleaf weed was conducted. Five species, *Heliothis zea* and *H. virescens* (Noctuidae), *Liorhyssus hyalinus* and *Niestrea louisianica* (Rhopalidae), and *Althaeus folkertsi* (Bruchidae) were determined to negatively impact the number of viable velvetleaf seeds produced in Indiana. Understanding the extent of natural seed predation and the life history of those insects involved is essential for integrating biological control tactics into an overall pest management strategy.

INTRODUCTION

Effective integrated weed management depends, in part, on an understanding of the life history, including natural seed mortality, of each weed species. Velvetleaf (Malvaceae: *Abutilon theophrasti*) continues to be an annual weed of major concern to soybean growers throughout Indiana and the Midwest.

Velvetleaf weed depends on seed production, survival, and germination as well as seedling establishment to ensure survival the following year. Velvetleaf is a short-day plant, flowering and producing seeds in the late summer or fall. It produces a conspicuous compound seed vessel or capsule which may contain up to 13 carpels of three seeds each. Seeds grow to maturity within the capsule and are distributed on the ground when plants dry down in the fall.

Effective integrated weed management may be enhanced by capitalizing on any factor or combination of factors which limits the production of viable velvetleaf seeds. Insect seed predators may reduce annual weed propagation, if they can successfully interfere with seed production (Goeden, *et al.*, 1974). Despite recent advances in weed biological control technology, little has been reported on the insect fauna naturally associated with this troublesome weed. A survey of arthropods associated with velvetleaf weeds was conducted, and the potential of three beneficial biological control agents was assessed.

MATERIALS AND METHODS

Velvetleaf plants occurring in soybean and corn fields, roadsides, and vacant waste places were visually inspected during seed pod development. Arthropods were collected, identified, and counted over a three week period during August to determine identification and relative abundance. Samples were grouped according to class and feeding behavior. Those arthropods that were determined to have a potential negative effect on velvetleaf survival, because of their seed destruction and abundance, were studied in more detail.

To characterize the extent of seed damage, cages made from half pint paper cartons were constructed. Carton ends were replaced by nylon bridal veil netting to allow air circulation and light penetration. Cages were mounted around pre-selected fully formed but still green seed capsules chosen at random in the field. Foam weather stripping was used to cushion the cages against the fragile stems. Cages were further secured to a main branch of the weed for additional support. Insect treatments were added to the cages in a randomized block design and maintained for a period of seven days after which the insects were removed and the capsule allowed to mature normally within the cage. Caged capsules, free of insects, served as controls. Each treatment was replicated 12 times. Seeds remaining at harvest were weighed and allowed to germinate to assess the physiological impact of the feeding.

To further quantify the extent of *Heliothus* feeding on velvetleaf seed, 100 late instar larvae were collected from velvetleaf and starved for 24 hours in individual cages. Three freshly excised green capsules of a consistent size and age were then added to each cage. After 24 hours, the larvae were removed and head capsules were measured for instar determination. Velvetleaf capsule damage was assessed by counting the number of seeds missing per carpel. Fecal pellets produced were collected for damage/dry fecal weight correlations.

Effects of insect feeding were assessed by microscopic examination to determine differences in morphology and by seed weight. Seeds also were scarred and placed between layers of water saturated blotter paper in petri dishes at room temperature for three days (Horowitz and Taylorson, 1984) to determine germinability.

RESULTS AND DISCUSSION

Twenty-five families of arthropods were consistently found throughout the sampling (Table 1). When counts of all arthropods were grouped according to feeding behavior, 14% were entomophagous, 22% were non-seed feeding phytophagus or saprophagus insects and 63% fed on seeds.

The five insect species that fed on seed pods appeared to cause the greatest negative effect on production and survival of velvetleaf seed due to (1) the nature of injury and to (2) the relative numbers in which they occurred. The larvae of two species of caterpillars (Lepidoptera: Noctuidae), *Heliothis virescens* (F.) and *H. zea* (Boddie) were found in high numbers throughout the samples. Two species of scentless plant bugs (Hemiptera: Rhopalidae), *Liorhyssus hyalinus* (F.) and *Niestrea louisianica* (Sailer) also occurred in relatively high numbers. A small seed beetle (Coleoptera: Bruchidae), *Althaeus folkertsi* (Kingsolver) also was discovered and named during this study (Kingsolver, *et al.,* 1989).

Corn earworms. Cage studies on velvetleaf reaffirmed the well-known voracious feeding habits of *Heliothis* larvae. Upon addition to the cage, the larvae proceeded almost immediately to attack the capsule and often entered it entirely, consuming all the seeds present. Within two days, mid- and late-instar larvae devoured almost all plant tissue inside the cages. Often, the larvae then began boring into the foam weather stripping below the capsule.

It was also determined that the larvae, depending on the instar, could consume many seeds in a relatively short period of time. The number of seeds consumed was strongly correlated (R^2=0.862) with the dry weight of the fecal pellets produced. (This correlation is sufficiently strong to merit the use of "dry weight of fecal pellets produced," a more

Table 1. Arthropods associated with reproductive velvetleaf weeds.

Family	Common Name	Incidence
Entomophagus insects		5.3%
Mantidae	Praying mantis	
Chrysopidae	Green lacewing	
Reduviidae	Assassin bug	
Coccinellidae	Lady Beetle	
Anthocoridae	Minute pirate bug	
Arachnids		8.7%
Thomisidae	Crab spider	
Salticidae	Jumping spider	
Oxyopidae	Lynx spider	
Araneidae	Orb-weaving spider	
Dictynidae	Dyctnid spider	
Philodromidae	Philodromid crab spider	
Total Entomophagus arthropods		14.0%
Non-seed-feeding phytophagus/saprophagus insects[a]		22.9%
Scutelleridae	Shield-back bug	
Muscidae	Muscid	
Formicidae	Ant	
Acrididae	Grasshopper	
Gryllidae	Snowy tree cricket	
Miridae	Plant bug	
Lycaenidae	Copper	
Pentatomidae	Stink bug	
Meloidae	Blister beetle	
Chrysomelidae	Corn rootworm	
Seed-feeding insects		63.1%
Noctuidae	Corn earworm (23.3%)	
Rhopalidae	Scentless plant bug (27.9%)	
Bruchidae	Seed beetle (11.9%)	
Total phytophagous/saprophagous insects		86.0%

[a] Homopterans noted but not counted include Diaspididae (scale), Aphidae (aphids), and Aleyrodidae (whitefly).

time and labor efficient measurement, for predicting the "number of seeds consumed" in future caging studies.)

Both *Heliothis* species can develop from egg through to adult on the velvetleaf plant. Substantial seed mortality no doubt occurs through the feeding of this insect on velvetleaf each year. Because this pest is well known for its' destruction of several agriculturally produced commodities, its' potential for use as a biological control of velvetleaf is low. Nevertheless, it has been shown to impact the survivorship of velvetleaf weed seeds even at current levels.

Scentless plant bugs. Results of caging studies showed a significant reduction in seed weight and an increase in seed mortality due to feeding by both *L. hyalinus* and *N. louisianica* nymphs placed in the cage (Table 2). When compared to the controls, affected seeds were overall shrunken and very blackened and malformed at the site of feeding injury. The seed testa retained the general shape of the seed, but the endosperm within was shriveled and nearly nonexistent, leaving an empty shell. Seeds from cages where eight nymphs fed weighed significantly less than did seeds from control cages. Seeds from cages where 15 nymphs were fed were significantly less than either control seeds or seeds fed on by eight nymphs. Although 99% of the control seeds germinated, none of the seeds that were fed on by Rhopalids did so. Low mobility, relative ease of rearing, effect on velvetleaf seed, high potential fecundity, and high host specificity qualify *L. hyalinus* and *N. louisianica* for further consideration and study as potential biological control agents against velvetleaf.

Velvetleaf seed beetle. Study of the host plant relationships of *Althaeus* revealed two host plants, velvetleaf and flower-of-an-hour (*Hibiscus trionum*), both of the family Malvaceae.

Although only 2% of the known bruchid species attack Malvaceae (Johnson, 1981), the biology of *A. folkertsi* appears to be fairly characteristic of the group as a whole. The eggs are deposited within the center crevice of full-size green capsules, where the carpels meet. There, the eggs may be semi-protected from predators, parasites, and accidental abrasion and desiccation. Egg placement, color, and size require that an investigator spread open individual capsules and microscopically search in order to find them. After eclosion, the first instar bores down through the carpel walls and into the developing seed. No preference was found for seed location within the carpel by *A. folkertsi*, although the top seed is nearest to the site of oviposition.

The site on the seed where the larva pentrates soon heals over but always retains a bright red scar on its surface as evidence of this wound.

Larvae inside the seed go through an undetermined number of instars. Prior to pupation, the last instar chews a ring approximately 1.0 mm in diameter very close to the upper surface of the testa to facilitate later adult emergence. This ring appears from the outside as a small white circle atop the seed and is very characteristic of *A. folkertsi* infestation in both of its host seeds. The larva pupates, still within its feeding chamber, and after eclosion, the adult simply pops off the weakened operculum and emerges. Seed weight was significantly reduced as a result of *A. folkertsi* feeding (Table 2). Dissection of an infested seed reveals an almost completely hollowed out shell, partially refilled with larval frass. Germination could not be induced in velvetleaf seeds afterwards.

Althaeus folkertsi does not lend itself well to laboratory rearing and as yet detailed knowledge of its behavior is not available. Although mating was observed in captivity, caged adults could not be induced to oviposit on velvetleaf capsules either in the laboratory or in cages in the field.

In nature, the beetles were usually collected from velvetleaf flowers, where they appeared to be taking nectar, or on the capsules themselves. In the laboratory, adults fed from a solution of sucrose in a cotton swab.

In late season, the adults appear to cluster together after emergence, possibly an

Table 2. Seed weight analysis of seeds fed on by scentless plant bugs (Rhopalidae: *Liorhyssus hyalinus* and *Niestrea louisianica*) and by seed beetles (Bruchidae: *Althaeus folkertsi*).

Treatment	N	Mean Wt. (mg)[a]	Germination (%)
Control (caged)	189	9.90 a	99 a
Control (non-caged)	110	9.27 a	97 a
Bruchidae	177	5.06 b	0 b
Rhopalidae (8)	217	3.23 c	0 b
Rhopalidae (15)	196	1.89 d	0 b

[a] Means followed by the same latter are not significantly different (P<0.05).

overwintering behavior.

The geographical distribution of *A. folkertsi* is probably the same as that of its only known host plants. It has been collected throughout the eastern one-half of the United States with spotty collections along the Mississippi Valley, North Carolina, and Florida (Kingsolver, *et al.*, 1989). It has been reared from both velvetleaf and flower-of-an-hour seeds taken in Indiana, Kansas, and Iowa.

The importance of seed destruction by bruchids is well known (Southgate, 1979). Certain seed destruction together with high host specificity may set *Althaeus* apart as an ideal candidate for velvetleaf biological control. Further behavioral and biological knowledge of *A. folkertsi* is essential, including developing methods of artificially rearing and/or augmenting natural populations, before its' true biocontrol potential can be assessed.

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