Effects of Weeds on the Diversity and Abundance of Insects in Soybeans¹

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ABSTRACT Sweep-net sampling and pitfall trapping were used to survey insects in weedy and weed-free soybean habitats. Weedy soybean habitats consisted of (1) grassy soybeans; (2) soybeans with broadleaf weeds; and (3) soybeans with broadleaf weeds and grasses. Insect species diversity was greater in weedy soybean habitats than in weed-free soybeans. Greatest diversity of species occurred in the mixed-weed soybean habitat. The most important phytophagous insect on soybeans in Indiana, the Mexican bean beetle, *Epilachna varivestis* Mulsant, was most abundant in weed-free soybeans. Predators were most abundant in weedy soybeans. *Coleomegilla maculata* (DeGeer) was most abundant in weedy soybean habitats, whereas *Orius insidiosus* (Say) and *Nabis* spp. were most abundant in soybean habitats with grasses and mixed weeds. In the pitfall trapping study, *Harpalus* spp. were more abundant in soybean habitats with grasses and mixed broadleaf and grass weeds.

Annual weeds are often a major component of soybean fields, yet little is known of insect-weed interactions in soybeans. Several studies indicated that weeds increase the diversity and abundance of insects in soybeans. Balduf (1923) surveyed the insect fauna of soybeans and surrounding vegetation in Ohio. He reported that most of the 209 species collected were associated with weeds. In Minnesota, Kretzschmar (1948) reported that weedy soybeans had a larger and more diverse insect fauna than weed-free soybeans. In Arkansas, Tugwell et al. (1973) made sweep-net collections in soybeans and a weed host, *Desmodium* sp., growing adjacent to the soybeans. Of 133 species collected from *Desmodium* sp., 93 were also collected on soybeans.

Although plant species diversity is generally associated with a diverse insect fauna, monocultures sometimes support a greater herbivore load than diverse plantings. Pimental (1961) and Smith (1976) found that colonizing aphids were more attracted to weed-free brussels sprouts, *Brassica oleracea* L., than sprouts grown with weeds. Tahvanainen and Root (1972) suggested that diverse vegetational communities exude so many different chemicals that herbivores may be confused and consequently seek simpler floral systems.

This study was conducted to determine how annual weeds affect the diversity and abundance of insects in soybeans.

Materials and Methods

Research was conducted in southern Indiana during the summers of 1978 and 1979. The study area was a 5.7-ha field which had been in continuous soybeans for several years. The field was divided into 12 plots (30.5 by 30.5 m), with each of the four treatments (weed-free, broadleaf weeds, grass weeds, and mixed weeds) replicated three times in a randomized complete block design.

Trifluralin (1.75 liters/ha) was applied preplant to broadleaf-weed plots to control grasses, and metribuzin

(0.83 kg/ha) was applied preplant to grass-weed plots to control broadleaf weeds. Weed-free plots and border areas were kept virtually weed free by preplant application of metribuzin and trifluralin at the rate above, cultivation, postemergence herbicide sprays of bentazon and Hoe 23408, and hand hoeing. Mixed-weed plots were not sprayed with herbicides. Feral grass populations were too low for plot establishment. Thus, foxtail, *Setaria* spp., seed was sown with a hand-held seeder in grass and mixed-weed plots at 4.4 kg/ha and 2.2 kg/ha, respectively. Grasses established in these plots were various types of foxtail; giant, *S. faberii* Herm., yellow, *S. lutescens* (Weigel) Hubb., and green, *S. viridis* (L.) Beauv.; and barnyardgrass, *Echinochloa crusgalli* (L.) Beauv. Two to three grass plants were established per broadleaf weed to give an equivalent plant biomass for grasses and broadleaf weeds. Feral broadleaf weeds were sufficient for plot establishment. Broadleaf weeds used in the plots were black nightshade, *Solanum nigrum* L.; lambsquarter, *Chenopodium album* L.; and jimson weed, *Datura stramonium* L. Other broadleaf weeds were removed by hand hoeing. Weed density in soybean habitat plots was ca. 2 to 3 broadleaf weeds and 4 to 10 grasses, respectively, per m² of soybeans. This density was maintained by hand hoeing throughout the sampling period.

Within a replicate, habitat plots were separated by 15.2-m-wide buffers of weed-free soybeans, whereas buffers 30.5 m wide separated the replications. Each study plot was surrounded by a buffer of weed-free soybeans at least 30.5 m wide.

The study field was planted to 'Bonus' soybeans, an *Epilachna varivestis* Mulsant-susceptible cultivar in maturity group IV, in north-south rows 76 cm apart. By the end of June, weeds in habitat plots were established at the desired density to initiate sampling. Two pitfall traps were centrally placed in each of the plots. Each trap consisted of a galvanized metal cylinder (ca. 26.7 cm tall and 11.4 cm in diameter). Into this cylinder was placed a 360-ml collection bottle containing a 50:50 mixture of ethylene glycol and 70% ethanol used as a preservative. An aluminum funnel, ca. 11.4 cm in diameter at the top and tapered to 1.9 cm at the tip, was

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placed into the collection bottle. The bottle and funnel were then placed into the cylinder in the ground. The funnel top was flush with the soil surface to permit cursorial insects to fall into the trap. Pitfall traps were drained and refilled with preservative after rain. All specimens were preserved in ethanol.

Sweep-net sampling consisted of making a set of 10 sweeps across two rows of soybeans and interspersed weeds while walking down the row (Kogan and Herzog, 1980). A 38-cm-diameter sweep-net was used. Two sampling areas were randomly selected for sweeping in each habitat plot each week. Sampled areas were chosen so that contiguous rows would not be sampled in successive weeks. Rows adjacent to pitfall traps were never sampled by sweep-net. Sweep-net sampling and pitfall trap collecting were done on the same day each week in late morning. Soybean developmental stages were recorded by the method of Fehr et al. (1971). Sampling began when soybeans were in the sixth-node (V6) stage of development and continued through physiological maturity (R7). Weekly sampling was performed for 11 weeks in 1978, and 10 weeks in 1979.

A square-root transformation of the data was performed to stabilize variance and improve normality. Analysis of variance was used to analyze the data (0.05 level), and Duncan's multiple range test (0.05 level) was used to separate mean differences in types and numbers of insects when significant analysis of variance was obtained.

Results and Discussion

From the 1,008 sweep and pitfall collections made, 207 determinations to species were made, 55 others to genus, and 43 to family (listing available upon request). Insect diversity differed significantly in the four soybean habitats. As shown in Table 1, significantly more insect taxa were collected per sweep-net sample in the weedy soybean habitats than in weed-free soybeans for both study years. A gradient of species diversity occurred in soybean habitats in 1979, with greatest diversity in the mixed-weed habitat, least in weed-free. Diversity of taxa collected by pitfall trap also varied with soybean habitat. Significantly more taxa were collected per pitfall trap per week in weedy than weed-free soybeans (Table 1). The mixed-weed habitat supported the greatest insect diversity in 1979, but did not differ significantly from other weedy habitats in 1978.

Abundance of many foliar insects varied significantly between different soybean habitats. *E. varivestis*, the primary soybean pest species in Indiana, was significantly more abundant in weed-free soybeans than in all weedy soybean habitats (Table 2). Significantly more beetles were collected in 1978 in the grass-weed than in the mixed-weed soybean habitat. However, there were no significant differences noted among weedy soybean habitats in 1979. Of the primary predators found in soybeans, *Coleomegilla maculata* (DeGeer) was more abundant in all weedy soybean habitats than in weed-free soybeans (Table 2). No significant differences were noted between weedy habitats. *Orius insidiosus* (Say) was significantly more abundant in grass and mixed-weed soybean habitats than in broadleaf weed or weed-free soybean habitats (Table 2). In 1978, numbers of *O. insidiosus* collected in soybeans with mixed weeds were significantly lower than in grassy soybeans. However, in 1979, collections in these two habitats were not significantly different. This was probably due to better grass establishment in mixed-weed plots in 1979. *Nabis* spp. were most abundant in grassy soybeans in 1978, and in grass and mixed-weed habitats in 1979 (Table 2). Low counts in the mixed-weed habitats in 1978 were likely due to poor grass establishment. Abundance of *Nabis* spp. did not differ significantly in broadleaf weed and weed-free soybean habitats.

Of the insects collected by pitfall trapping, only *Harpalus* spp. showed significant differences in abundance among soybean habitats (Table 3). In 1978, significantly higher trap catches were made in soybeans with grasses than in other soybean habitats. A relatively low mean trap catch in the mixed-weed habitat was once again probably due to poor grass establishment in 1978. In 1979, catch of *Harpalus* spp. was greatest in grass-weed and mixed-weed habitats.

These data suggest that weed-free soybeans support fewer species and a lower abundance of insects than do weedy soybeans. *E. varivestis* appears to prefer weed-free soybeans to weedy soybeans. Several major predators which feed on *E. varivestis* (Deitz et al. 1976) prefer weedy to weed-free soybeans. *E. varivestis* may reach higher population levels in weed-free soybeans because of (1) stronger olfactory or visual cues to host plants in weed-free soybeans; (2) reduced mortality in weed-free soybeans where predators are scarce and host seeking is minimal; and (3) more favorable microcli-

Table 1.—Mean number of insect taxa collected per sweep-net sample and pitfall trap per week in four soybean habitats*

Soybean habitat	Sweep-net		Pitfall trap/week	
	1978	1979	1978	1979
Weed free	7.8a	6.8a	8.2a	14.7a
Broadleaf weeds	12.9b	11.7b	10.5b	17.9b
Grass weeds	13.6b	13.4c	11.6b	18.8bc
Mixed weeds	14.0b	14.9d	10.7b	20.4c

*Means followed by the same letter do not differ significantly at the 0.05 level (Duncan's multiple range test).

Table 2.—Mean number of *E. varivestis* Mulsant and predators collected per sweep-net sample in four soybean habitats^a

Soybean habitat	<i>E. varivestis</i> predators							
	<i>E. varivestis</i>		<i>Coleomegilla maculata</i> (DeGeer)		<i>Orius insidiosus</i> (Say)		<i>Nabis</i> spp.	
	1978	1979	1978	1979	1978	1979	1978	1979
Weed free	8.5a	7.5a	0.1a	0.1a	0.6a	0.8a	0.4b	0.1b
Broadleaf weeds	1.6bc	2.2b	0.5b	0.3b	0.9a	1.1a	0.4b	0.2b
Grass weeds	2.7b	0.9b	0.6b	0.3b	3.9c	5.4b	0.8a	0.4a
Mixed weeds	0.9c	1.0b	1.0b	0.3b	2.5b	4.2b	0.2b	0.4a

^aMeans followed by the same letter do not differ significantly at the 0.05 level (Duncan's multiple range test).

Table 3.—Mean number of *Harpalus* spp. collected per pitfall trap per week in four soybean habitats^a

Soybean habitat	1978	1979
Weed free	7.9a	10.6a
Broadleaf weeds	12.1a	11.7a
Grass weeds	30.4b	36.7b
Mixed weeds	14.3a	36.6b

^aMeans followed by the same letter do not differ significantly at the 0.05 level (Duncan's multiple range test).

matic conditions in weed-free soybeans. Predators are likely attracted to weedy soybean habitats as a result of the abundance of prey species (unpublished data) and diversity of habitat conditions. Flowering weeds may supply pollen for *O. insidiosus* (Dicke and Jarvis 1962) and *C. maculata*, whereas microclimate may be more favorable for predators in weedy soybeans. *Harpalus* spp. appear to prefer soybeans with grasses, which is consistent with findings that certain species of *Harpalus* readily eat foxtail seeds in laboratory tests (Lund and Turpin 1977).

By considering the impact of weeds on the faunal community of soybeans, we can more accurately predict pest and predator population dynamics. This should assist research and extension personnel in designing integrated pest management programs for soybeans.

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