ENTOMOPHAGA, 21 (2), 1976, 217-221

PREDATION BY *XYLOCORIS FLAVIPES* [*HEM.* : *ANTHOCORIDAE*] : INFLUENCE OF STAGE, SPECIES AND DENSITY OF PREY AND OF STARVATION AND DENSITY OF PREDATOR

G. L. LeCato

Stored-Product Insects Research and Development Laboratory, Agric. Res. Serv., U.S.D.A., Savannah, Georgia 31403, U.S.A.

When the efficacy of the predaceous bug *Xylocoris flavipes* (Reuter) was tested in the laboratory as a biological control agent against stored-product insects, it attacked eggs more than larvae, pupae, or adults and early-stage larvae of *Tribolium castaneum* (Herbst) more than late-stage larvae. The predator also killed more larvae of *T. castaneum* than larvae of *Attagenus megatoma* (F.). The density of predator and prey regulated the capture rate of the predator. Predation by *X. flavipes* was uninfluenced by starvation for as much as 96 hr.

Jay *et al.* (1968) and Press *et al.* (1975) reported that *Xylocoris flavipes* (Reuter) showed promise in suppressing populations of stored-product insects. LeCato & Davis (1973) found that *X. flavipes* killed significantly more of certain instars of some species of stored-product insects, and LeCato (unpublished data) found that the black carpet beetle, *Attagenus megatoma* (F.), was the less preferred prey among several species of stored-product insects exposed to *X. flavipes* in a warehouse. Press *et al.* (1974) concluded that *X. flavipes* preferred beetle larvae over moth larvae. LeCato (1975) studied the influence of habitat on predation. Still, questions remained concerning the influence of the stage, species, and density of prey and of the effect of starvation and density of the predator. The following study was undertaken to answer these questions.

PROCEDURES AND RESULTS

All tests were conducted at 28 ± 2°C and 50 ± 10 % RH with an alternating 12-hr light and dark cycle. The insects used in the study were obtained from stock cultures maintained at the Stored-Product Insects Research and Development Laboratory, Savannah, Georgia, U.S.A.

Test 1 — Stage of prey

For determination of the stage of prey preferred by *X. flavipes*, five each of adults or early-stage nymphs (instars 1-3) of the predator that had been starved for 24 hr were exposed 48 hr to 10 each of eggs, larvae (instars 2-5), pupae, and adults of the red flour beetle, *Tribolium castaneum* (Herbst). In some tests, the bugs were exposed to all stages of the prey simultaneously; in others, they were exposed to each stage separately. The exposure arenas were 0.24-liter jars that had been inverted so the insects walked on filter paper that was secured with a metal retaining ring. About 0.2 g of flour beetle medium was placed on the filter paper as food for adults and larvae of *T. castaneum* so as to reduce their preying on eggs or pupae when all prey were exposed simultaneously to *X. flavipes*. The percentage killed was determined by holding eggs and pupae for hatching and adult emergence, respectively. The test, like the following tests, was replicated 9 times.

When all stages of *T. castaneum* were exposed to *X. flavipes* (table 1), both the adult predators and the early-stage nymphs preferred the eggs and killed few adults. Also, early-stage nymphs preyed more on eggs than the adults did, probably because of their small size.

TABLE 1

Kill of each stage of Tribolium castaneum (10 *each*) *in* 48 *hr by* 5 *adults or early-stage nymphs of* Xylocoris flavipes

Stage of *X. flavipes* exposed	Percent kill (±SE) of indicated stage of *T. castaneum*			
	Eggs	Larvae (instars 2-5)	Pupae	Adults
Adults				
Each stage of prey separately	100	70 ± 4	60 ± 7	2 ± 1
All stages of prey collectively	66 ± 6	49 ± 4	69 ± 6	0
Early-stage nymphs				
Each stage of prey separately	100	62 ± 7	44 ± 8	1 ± 1
All stages of prey collectively	93 ± 2	38 ± 6	50 ± 6	0

When each separate stage of prey was exposed to adults and early-stage nymphs of *X. flavipes*, both ages of predators attacked more larvae than when they were exposed to all stages collectively; the reverse was true for pupae. The adult predators generally attacked more larvae, pupae, and adults than did early-stage nymphs.

Thus the impact of *X. flavipes* on prey populations results from predation on immature forms. Probably more eggs are consumed because they are smaller and immobile. This explanation is supported by the data of LECATO & DAVIS (1973) who found that the size of the prey influenced predation by *X. flavipes*. However, even the immature forms of *T. castaneum* are larger than many stored-product insects, so the degree of predation on the immature stages was surprisingly high. Predation on adult beetles was low, apparently because *X. flavipes* has difficulty inserting its proboscis into the sclerotized exoskeleton of adults.

TEST 2 — SPECIES OF PREY, DENSITY OF PREDATOR

In the test to determine the preferred species of prey and the optimum density of the predator, either 2, 4, or 6 adults of early-stage nymphs of *X. flavipes* starved for 24 hr were exposed 48 hr to 10 each of early (1-3) or late (4-6) stage larvae of *A. megatoma* (non-preferred) or *T. castaneum* (preferred prey) separately or in combination. All insects were tested in 0.24-liter jars in 25 g of rolled oats.

TABLE 2

Kill of larvae of Tribolium castaneum *and* Attagenus megatoma (10 *each*) *in* 48 *hr by adults or early-stage nymphs of* Xylocoris flavipes

Species and stage of prey	Percent kill (± SE) of prey of indicated densities					
	Adults			Early-stage nymphs		
	2	4	6	2	4	6
			Species separated			
Early-stage larvae						
T. castaneum	74 ± 8	90 ± 6	99 ± 1	43 ± 3	70 ± 5	92 ± 3
A. megatoma	17 ± 4	26 ± 4	29 ± 4	8 ± 2	19 ± 3	24 ± 2
Late-stage larvae						
T. castaneum	37 ± 4	44 ± 4	63 ± 5	17 ± 2	24 ± 2	33 ± 4
A. megatoma	0	7 ± 2	10 ± 2	1 ± 1	4 ± 2	6 ± 2
			Species combined			
Early-stage larvae						
T. castaneum	67 ± 4	91 ± 3	97 ± 2	40 ± 4	62 ± 3	82 ± 3
A. megatoma	6 ± 3	8 ± 3	13 ± 3	1 ± 1	7 ± 2	9 ± 3
Late-stage larvae						
T. castaneum	31 ± 5	39 ± 3	57 ± 4	14 ± 2	21 ± 4	31 ± 4
A. megatoma	0	0	0	1 ± 1	0	0

From table 2, adults and early-stage nymphs of *X. flavipes* preyed more on early- and late-stage larvae of *T. castaneum* than on larvae of *A. megatoma* and killed few larvae of *A. megatoma* even when they were exposed only to that species. *Xylocoris flavipes* killed more early-stage than late-stage larvae of both species, and adult *X. flavipes* generally killed more prey than did early-stage nymphs. The predator killed progressively more prey as density was increased from 2 to 6, but fewer prey were killed per predator.

Xylocoris flavipes is known to kill more prey of certain species and stages, but it really does not discriminate in choosing prey and will attack a broad spectrum of species with a relatively high degree of success (JAY *et al.*, 1968; LECATO & DAVIS, 1973). Some species are apparently more resistant to attack because of such factors as size, defensive behavior, and morphology. The difference in the number of *A. megatoma* killed in the presence and absence of alternative prey (*T. castaneum*) (table 2) is a good example : when the alternate prey was available, the predator survived by preying on the preferred alternate; when no alternate was present, it attacked the non-preferred species.

There are several possible reasons why *A. megatoma* is less preferred : 1. Larvae of *A. megatoma* are somewhat larger and harder than those of *T. castaneum*; 2. larvae of *A. megatoma* are setaceous and darker than those of *T. castaneum*; and 3. larvae of *A. megatoma* may possess a chemical that repels the predators.

TEST 3 — STARVATION OF PREDATOR, DENSITY OF PREY

In the test to determine the effect of starvation of the predator and the density of the prey, early- or late-stage larvae of *T. castaneum* (1, 2, 4, or 8) were exposed to

TABLE 3

Kill of larvae of Tribolium castaneum *in 24 hr by starved adults or nymphs of* Xylocoris flavipes

Stage and density of prey	Percent (±SE) and number (in parentheses) of prey killed by predators starved indicated hours before exposure					
	0	24	48	72	96	120
			Adult predators			
Early-stage larvae						
1	100 (1.0)	78 ± 15 (0.8)	100 (1.0)	100 ± (1.0)	44 ± 18 (0.4)	(a)
2	78 ± 12 (1.6)	72 ± 12 (1.4)	89 ± 7 (1.7)	72 ± 12 (1.4)	50 ± 11 (1.0)	—
4	69 ± 7 (2.8)	67 ± 10 (2.7)	78 ± 9 (3.1)	86 ± 7 (3.4)	47 ± 11 (1.9)	—
8	39 ± 77 (3.1)	43 ± 7 (3.4)	57 ± 7 (4.6)	56 ± 8 (4.4)	36 ± 7 (3.3)	—
Late-stage larvae						
1	33 ± 17 (0.3)	78 ± 15 (0.8)	78 ± 15 (0.8)	78 ± 15 (0.8)	56 ± 18 (0.6)	—
2	33 ± 8 (0.7)	44 ± 10 (0.9)	33 ± 8 (0.7)	44 ± 6 (0.9)	33 ± 8 (0.7)	—
4	19 ± 4 (0.8)	25 ± 4 (1.0)	19 ± 4 (0.8)	19 ± 6 (0.8)	25 ± 0 (1.0)	—
8	11 ± 1 (0.9)	14 ± 1 (1.1)	10 ± 2 (0.8)	19 ± 3 (1.6)	15 ± 3 (1.2)	—
			Nymph predators			
Early-stage larvae						
1	67 ± 17 (0.7)	100 (1.0)	100 (1.0)	89 ± 11 (0.9)	100 (1.0)	100 (1.0)
2	39 ± 16 (0.8)	72 ± 12 (1.4)	89 ± 11 (1.8)	94 ± 6 (1.9)	89 ± 7 (1.8)	89 ± 11 (1.8)
4	42 ± 11 (1.7)	50 ± 10 (2.0)	78 ± 5 (3.1)	89 ± 4 (3.8)	72 ± 10 (2.9)	58 ± 13 (2.3)
8	28 ± 7 (2.2)	28 ± 7 (2.2)	60 ± 8 (4.9)	61 ± 7 (4.9)	42 ± 7 (3.3)	64 ± 6 (5.1)
Late-stage larvae						
1	33 ± 17 (0.3)	56 ± 18 (0.6)	78 ± 15 (0.8)	56 ± 18 (0.6)	67 ± 17 (0.7)	100 (1.0)
2	22 ± 12 (0.4)	33 ± 12 (0.7)	28 ± 9 (0.6)	39 ± 7 (0.8)	39 ± 7 (0.8)	44 ± 14 (0.9)
4	11 ± 4 (0.4)	19 ± 6 (0.8)	17 ± 4 (0.7)	17 ± 4 (0.7)	33 ± 44 (1.3)	17 ± 4 (0.7)
8	10 ± 2 (0.8)	11 ± 3 (0.9)	10 ± 2 (0.8)	13 ± 2 (1.0)	17 ± 5 (1.2)	15 ± 6 (1.2)

(a) Mortality of adults of *X. flavipes* starved 120 hr was 95 %.

1 adult or to 1 nymph (instars 1-5) of *X. flavipes* in inverted 0.24-liter jars. *Xylocoris flavipes* was starved for 24, 48, 72, 96, or 120 hr before the test. Mortality of *T. castaneum* was determined after 24 h r.

Adults and nymphs of *X. flavipes* again killed more early-stage than late-stage larvae (table 3). Predation by adults and nymphs did not differ significantly. As the density of prey increased, the percentage of prey killed decreased, and the number of prey killed increased. Thus, the density of the predator (table 2) and the density of the prey (table 3) act as potential controls of the kill by the predator (SALT, 1974).

The number of hours the predator starved (up to 120 for nymphs and 96 for adults) did not significantly influence the percentage or number of prey killed. However, after 120 hr starvation, 95 % of the adult *X. flavipes* were dead.

Because predation was high when *X. flavipes* was starved and because periods of starvation are normal for most predators, *X. flavipes* appears to be an excellent biological control agent against stored-product insects.

ACKNOWLEDGMENT

I thank Jeanette COLLINS, Biological Laboratory Technician, and R. T. ARBOGAST, Research Entomologist, both of the Stored-Product Insects Research and Development Laboratory, A.R.S.-U.S.D.A., Savannah, Georgia 31403, U.S.A., for performing laboratory tests and for counsel, respectively.

RÉSUMÉ

Prédation par *Xylocoris flavipes* [*Hem : Anthocoridae*]:
influence du stade, de l'espèce et de la densité de la proie,
du jeûne et de la densité du prédateur.

En laboratoire, le prédateur *Xylocoris flavipes* (REUTER) s'alimente davantage aux dépens des œufs que des larves, des nymphes et des imagos et aux dépens des trois premiers stades larvaires de *Tribolium castaneum* (HERBST) de préférence aux derniers stades. Le prédateur préfère les larves de *T. castaneum* à celles de *Attagenus megatoma* (F.). La densité de prédateurs et de proies détermine le taux de capture par le prédateur. La prédation par *X. flavipes* n'est pas influencée par un jeûne de 96 heures.

REFERENCES

JAY, E., DAVIS, R. & BROWN, S. — 1968. Studies on the predacious habits of *Xylocoris flavipes* (REUTER) [*Hemiptera : Anthocoridae*]. — *J. Ga. Entomol. Soc.*, 3, 126-130.

LECATO, G. L. — 1975. Habitat influencing predation by *Xylocoris flavipes* (REUTER) [*Hemiptera: Anthocoridae*]. — *Am. Midl. Nat.*, 93, 510-512.

LECATO, G. L. & DAVIS, R. — 1973. Preferences of the predator *Xylocoris flavipes* [*Hemiptera: Anthocoridae*] for species and instars of stored-product insects. — *Fla. Entomol.*, 56, 57-59.

PRESS, J. W., FLAHERTY, B. R. & ARBOGAST, R. T. — 1975. Control of the red flour beetle, *Tribolium castaneum*, in a warehouse by a predaceous bug, *Xylocoris flavipes*. — *J. Ga. Entomol. Soc.*, 10, 76-78.

PRESS, J. W., FLAHERTY, B. R. & LECATO, G. L. — 1974. Interactions among *Tribolium castaneum* [*Coleoptera : Tenebrionidae*], *Cadra cautella* [*Lepidoptera: Pyralidae*], and *Xylocoris flavipes* [*Hemiptera: Anthocoridae*]. — *J. Ga. Entomol. Soc.*, 9, 101-103.

SALT, G. W. — 1974. Predator and prey densities as controls of the rate of capture by the predator *Didinium nasutum*. — *Ecology*, 55, 434-439.