COMPATIBILITY OF *XYLOCORIS FLAVIPES* (HEMIPTERA: ANTHOCORIDAE) AND *VENTURIA CANESCENS* (HYMENOPTERA: ICHNEUMONIDAE) FOR SUPPRESSION OF THE ALMOND MOTH, *CADRA CAUTELLA* (LEPIDOPTERA: PYRALIDAE)

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ABSTRACT

The predaceous bug *Xylocoris flavipes* (Reuter) was combined with the parasitic wasp *Venturia canescens* Gravenhorst to assess their compatibility in suppressing the almond moth, *Cadra cautella* (Walker). Each natural enemy was applied at 10, 20, 30, 40 and 50 insects for each ca. 1000 *C. cautella*. Significantly greater ($P < .0001$) suppression of *C. cautella* was obtained by the combination of *X. flavipes* and *V. canescens* at all levels. This demonstrated that the combination of *X. flavipes* and *V. canescens* is likely to enhance suppression of *C. cautella* in field applictions.

Key Words: *Xylocoris flavipes, Venturia canescens, Cadra cautella,* almond moth, compatibility, biological control

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INTRODUCTION

Biological control in food storages is being considered as a promising alternative to insecticidal control of stored-product insects. Two promising biological control agents against storage insect pests are the predaceous bug, *Xylocoris flavipes* (Reuter) and the parasitic wasp, *Venturia* (= Nemeritis) *canescens* (Gravenhorst). *Xylocoris flavipes* is cosmopolitan and preys on many stages of a large number of stored-product Lepidoptera and Coleoptera. Its life history and biology were described by Arbogast (1978). *Venturia canescens* is a solitary, parthenogenic endoparasite which generally attacks late instars of stored-product pyralids. *Venturia canescens* differs from some stored-product insect parasites in that its host is not paralyzed and remains active until pupation. This trait makes it potentially suitable for use in combination with *X. flavipes* since *X. flavipes* tends not to prey on active late instar stored-product pyralids (LeCato and Davis 1973). The life history of the *V. canescens* wasp was described by Corbet and Rotheram, (1965).

Combining parasites or predators to suppress stored-product insect populations is potentially more advantageous than when either is used singly. According to the sequence theory propounded by L. O. Howard and W. E. Fiske, the most favorable combinations of natural enemies would be those that tend to parasitize or prey on different stages of the same host (Debach 1974). One such compatible combination of the larval parasite *Bracon hebetor* Say and the egg parasite *Trichogramma pretiosum* (Riley) suppressed the Indian meal moth *Plodia interpunctella* (Hubner) and the almond moth *Cadra cautella* (Walker), in farmers' stock peanuts (Brower and Press, unpublished data). In that test, greater moth suppresion was obtained using the combination than by either parasite used separately.

Incompatible combinations should likewise be avoided since some parasites or predators may adversely affect each other. Press et al. (1977) reported that *B. hebetor* suppressed *V. canescens* when the two species were combined in laboratory test to suppress *C. cautella.* Press et al. (1974) also observed that *X. flavipes* had a deleterious effect on *B. hebetor* when the two species were combined in the laboratory to suppress *P. interpunctella* populations.

The purpose of this study was to evaluate whether *X. flavipes* would be compatible with *V. canescens* for use against *C. cautella,* a major pest of stored foods in tropical and sub-tropical climates. This information is necessary before field tests can be successfully conducted.

MATERIALS AND METHODS

Cadra cautells eggs (24-h-old) were collected from laboratory cultures, then placed into each of 4 wide-neck 3.78 liter jars, using a volumetric scoop that delivered ca 1000 eggs (1037.4 ± 32.8). Each jar contained 250 g of a medium described by Boles and Marzke (1966). Ten ca. 48-h-old *X. flavipes* adults (5♂ + 5♀) were added to 2 of the jars. All 4 jars were capped with perforated screw lids that were lined with filter paper inserts to prevent the insects from escaping while still allowing ventilation. The jars containing the insects were placed in an incubator maintained at 30 ± 1°C and 55 ± 5% RH under an alternating 12 hr light-dark cycle for 2 wk. At this time 10 24-h-old *V. canescens* adults were added to one of the jars containing *X. flavipes* and an equal number to one of the remaining 2 jars not having *X. flavipes*. The remaining jar without either *X. flavipes* or *V. canescens* served as the control. After incubating the cultures for an additional 4 wk, the number of surviving adult moths were tabulated. The same procedure was followed using levels of 20, 30, 40, and 50 natural enemies per jar. All tests were replicated 5 times. The analysis of these data is based on a simple multiplicative-effects survival model involving only two survival (or equivalent mortality) rates. S_v and S_x represented the survival rate of *C. cautella* from egg to adult, when there was either 10 *V. canescens* or *X. flavipes* present, respectively, as the only cause of mortality. The anticipated survival rate of the other levels and combinations of parasites is $S_{vi} = (S_v)^i$, $S_{xi} = (S_x)^i$ and $S_{ci} = (S_vS_x)^i$ for *V. canescens, X. flavipes* or their combination, respectively. The treatment levels of 10, 20, 30, 40 and 50 were coded by i = 1, 2, 3, 4 and 5, respectively. These data provided estimates of S_{vi}, S_{xi} and S_{ci} for each level (i). The paramenters $S_v = (1\text{-}M_v)$ and $S_x = (1\text{-}M_x)$ were estimated by takings logs, e. g. $\log(S_{vi}) = i \log(S_v)$, of the survivor rate data and then using SAS PROC GLM to get a weighted linear regression fit to the data. Back-transformation of the regression slopes $\log(S_v)$ and $\log(S_x)$ provided the estimates of S_v and S_x. For each data point, the weights used were the reciprocal variance of the observed survivor rates S_{vi}, S_{xi} and S_{ci}. Such a weighted regression is not critical but gives more precise estimates of S_v and S_x.

RESULTS AND DISCUSSION

The mortality of *C. cautella* was determined for each natural enemy or their combination at all levels of introduction using the equations $M_{Vi} = 1\text{-}(.7447)^i$, $M_{xi} = 1\text{-}(.5572)^i$ and $M_{ci} = 1\text{-}[(.5572)(.7447)]^i$ where M = mortality and i = level of

Table 1. Mean percent suppression of the almond moth by the predator *Xylocoris flavipes*, the parasite, *Venturia canescens*, or by a combination of both insects (5 Replications).

		Percent suppression ± S. E.		
No. parasites or predators	adult ± S. E. (Control)	*V. canescens*	*X. flavipes*	Combination*
10	1000.8 ± 18.9	20.4 ± 4.74	50.2 ± 2.15	64.2 ± 2.73
20	1046.6 ± 20.3	22.0 ± 2.32	75.6 ± 1.36	89.2 ± 2.06
30	1008.0 ± 15.2	42.0 ± 3.22	84.6 ± 1.78	92.8 ± 0.86
40	1004.2 ± 9.4	53.4 ± 4.61	87.6 ± 1.60	94.4 ± 1.03
50	1072.4 ± 33.7	76.2 ± 4.41	93.4 ± 1.29	98.6 ± 0.24

*Combination had equal numbers of each species as listed.

parasite-predator introduction (1-5). The correlation between the observed suppression and the predicted suppression was $r^2 = 0.8563$. Suppresion for each level of natural enemies was significantly different ($P < .0001$) from all other levels shown in the columns in Table 1. Thus the obvious trend of *C. cautella* mortality increasing as the number of suppressing insects increased was observed with each natural enemy or their combination. The mean *C. cautella* suppression was also significantly different ($P < .0001$) between each biocontrol agent or their combination (rows) at each level of introduction. This indicated that the two insect species act independently and are not antagonistic. *Xylocoris flavipes* used singly produced greater suppression of *C. cautella* than did *V. canescens* used singly at each respective level of introduction (Table 1).

Xylocoris flavipes was able to produce greater suppression of *C. cautella* under the conditions of this test for several reasons, the first being that the egg stage was readily available at the time *X. flavipes* was introduced and each bug would have the opportunity to consume relatively large numbers of eggs. A second factor that probably contributed *X. flavipes* greater suppression of *C. cautella* was that *X. flavipes* nymphs hatched and subsequently fed on *C. cautella* prior to the introduction of *V. canescens;* therefore, many more predaceous bugs than *V. canescens* were present at the time *V. canescens* was introduced. Thirdly, by the time *V. canescens* were introduced, some of the late instar *C. cautella* were probably not readily accessible to the parasite because of webbing, which becomes more abundant with time and increased larval size.

This study showed that *X. flavipes* and *V. canescens* were compatible for use as biological control agents against stored-product pyralids such as *C. cautella.* Studies conducted by LeCato and Davis (1973) support this by showing that *X. flavipes* prefers the early instars of the relatively large stored-product pyralids and is not very effective against the late instars. Thus it is unlikely that *X. flavipes* would prey on the late instars that *V. canescens* parasitizes, especially since parasitized moth larvae remain active until pupation (Narayanan 1931). Under field conditions many stages of the pyralid moths would be present simultaneously; therefore, concurrent releases of *X. flavipes* and *V. canescens* would likely reduce the pest population more quickly, because *X. flavipes* would prey mostly on the eggs and early instars while *V. canescens* would parasitize the late instars. This combination of predaceous bug and parasitic wasp would also be advantageous if stored-product Coleoptera were present, since *X. flavipes* is a general predator that also preys on most stored-product beetles (Jay et al. 1968, LeCato et al. 1977).

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