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An Integrated Approach to *Adoretus* Control in Hawaii and American Samoa

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Abstract—The Chinese rose beetle, *Adoretus sinicus* (Coleoptera: Scarabaeidae), is a pest with a large host range in Hawaii. Damage is caused by the adults and is characterised by interveinal feeding on host plant leaves. Similarly, the rose beetle, *Adoretus versutus,* effects significant feeding damage on many plant types in American Samoa.

Studies are being conducted in Hawaii and American Samoa to develop control strategies for these rose beetles. These studies include: 1) feeding and mating observations, 2) screening of commercially available lures for adults, 3) trials with fungi and nematodes for larval control, and 4) observations of adult feeding patterns.

Introduction

In Hawaii, the Chinese rose beetle, *Adoretus sinicus* Burmeister has been identified as a common pest of a large number of plants including many of substantial economic importance (Habeck 1964). Damage is characterized by extensive interveinal feeding on leaves by the adult, which affects the photosynthetic ability of the plant (Furutani & Arita 1990), resulting in delayed maturation and reduced fruit yield.

Similarly the rose beetle, *Adoretus versutus* Harold, causes significant feeding damage on a wide range of agriculturally important plants in American Samoa. As with *A. sinicus,* the damage is caused by interveinal feeding on host plant leaves.

Because their extensive feeding can result in severe damage to many important crops, control strategies for both beetles need to be developed. Preliminary data indicate that some behavioral characteristics are shared by these beetles, suggesting that the development of similar control strategies may be possible. However, to date, very little research has been conducted which can be applied toward control measures.

In continental United States, the Japanese beetle, *Popillia japonica* Newman (Coleoptera: Scarabaeidae), causes damage similar to that of rose beetles to a large number of plants (Flemming 1972). Due to the economic importance of the Japanese beetle much effort has been expended on control strategies which include the use of traps with synthetic lures and microbial control agents.

Materials and Methods

Observations were made at night on the feeding and mating activity of *A. sinicus* and *A. versutus* between April 1991 and April 1992 on taro and grapes in American Samoa and snap beans and corn in Hawaii. The number of beetles engaged in each type of activity was recorded on an hourly basis.

Commercial Japanese beetle traps (Klein & Edwards 1989) with the following scarab beetle synthetic lures were tested: butyric acid, valeric acid, hexanoic acid, anethole, beta ionone, cinnamyl acetate, geraniol, n-butyl sorbate, cinnamyl alcohol, octyl butyrate, estragole, isosafrole, 4-(p-methylphenyl) 2-butanone, phenylethyl propionate + eugenol + geraniol, 75% of (valeric acid + hexanoic acid + octyl butyrate + t-2-nonanol) + 25% (trioctanoin), valeric acid + hexanoic acid + octyl butyrate + 1-nonanol and valeric acid + hexanoic acid + octyl

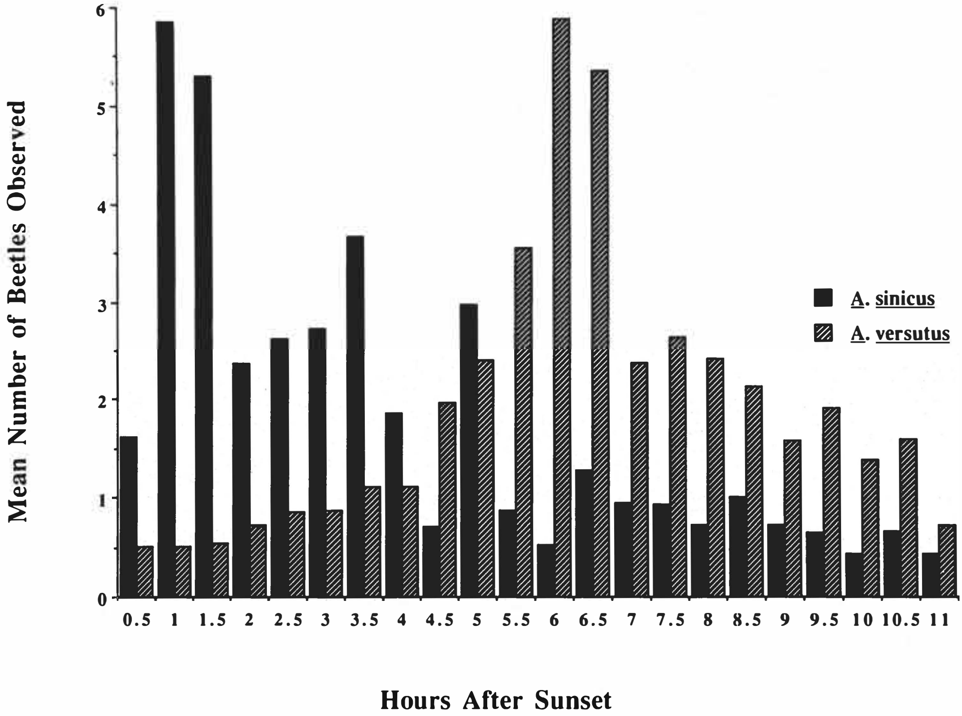

Figure 1. Mean number of *A. sinicus* and *A. versutus* beetles observed feeding at varying times after sunset.

butyrate + t-2-nonanol. The lures and traps were obtained from the U.S.D.A., Ohio Agricultural Research and Development Center, Wooster, Ohio. Each lure was tested in a trap suspended 1 metre above the ground during the period that the beetles were most active (1900 to 2400 h) and the number of beetles attracted to each lure recorded.

Since *M. anisopliae* had already been demonstrated as a control agent against another scarab (Young 1974), three cultures of *M. anisopliae* (M346, M2151 and M2162) were obtained from the University of Hawaii, Department of Entomology, Honolulu, for trials against *A. sinicus* larvae. Each strain of *M. anisopliae* was inoculated on Saborough-dextrose agar plates and held in a growth chamber at 25°C for two weeks. Field collected Chinese rose beetle larvae were rolled in each of the cultures and then transferred to 120 ml containers with 60 cc of pre-moistened soil from Kilauea, Hawaii. The containers were held at 25°C and mortality counts taken 168 h after treatment. Fifty *A. sinicus* larvae were treated with each fungal culture.

The nematodes, *Steinernema carpocapsae* (Weiser), from Biosys, and *Heterorhabditis* sp., MB7 (Maui isolate), have been shown to be ineffective as control agents for *A. sinicus* adults (Hara et al. 1989). However, tests have not been conducted on larvae. The nematodes were obtained from the University of Hawaii, Beaumont Experiment Station, Hilo, Hawaii. One ml of 1,000 nematodes/ml stock solution was added to a 120 ml container containing 60 cc of pre-moistened soil from Kilauea and one field collected larva added. The containers were then held at 25°C and mortality counts made 96 hrs after treatment. Each treatment was replicated 45 times. All dead *A. sinicus* larvae were held for an additional two days and dissected for the presence of nematodes.

Preferential feeding by *A. sinicus* has been observed on plants treated with ethephon (Arita et al. 1988) and on leaves with high carbohydrate levels (Furutani & Arita 1990). To extend these observations, trials were conducted with snap bean plants grown in the greenhouse to the 3 true leaf plus bifoliates stage. The plants were placed in wooden cages with 10 field collected *A. sinicus* beetles. After 24 h the area of each leaf consumed by the beetles was measured with a leaf area metre (LI-3000A; LICOR, Lincoln, Nebr. 68504). The experiment was replicated 50 times.

Field assessment of *A. versutus* feeding damage on 31 grape vines was conducted in American Samoa. Leaf position was assigned according to its location at the top, middle or bottom of the vine. The total feeding damage in each category was ranked on a scale of 1 to 6 (1 = 5 to 20% defoliation, 2 = 21 to 35% defoliation, 3 = 36 to 50% defoliation, 4 = 51 to 65% defoliation, 5 = 66 to 90% defoliation, 6 = 91 to 100% defoliation).

Results and Discussion

(i) Feeding and mating behavior of *A. sinicus* and *A. versutus* adults.

The results of the nightly feeding activity for *A. sinicus* and *A. versutus* are presented in Fig. 1. In *A. sinicus*, feeding activities commence approximately 30

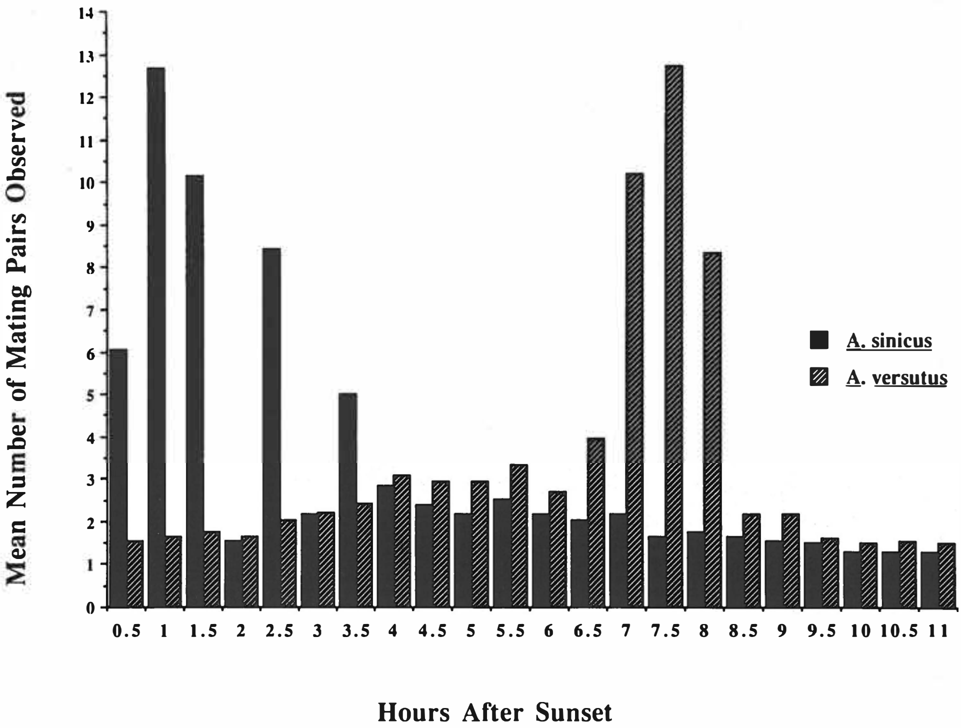

Figure 2. Mean number of mating pairs of *A. sinicus* and *A. versutus* beetles observed at varying times after sunset.

Table 1. Mortality of *A. sinicus* larvae 168 h after exposure to *Metarhizium anisopliae.*

Treatment	% Dead	% Infected
Control	82	0
M2162	94	6
M2151	77	10
M346	88	5

minutes after sunset and beetles were observed in large numbers feeding on the upper surface of host plant leaves. In *A. versutus*, the feeding activity peaks about 6 hours after sunset.

The results for mating activity are presented in Fig. 2 which shows definite peak mating periods for both species. In *A. sinicus*, mating commences soon after sunset with feeding and thereafter steadily decreases throughout the night. The peak mating period for *A. versutus* occurs about 7 hours after sunset, slightly after the peak feeding period. Preliminary observations indicate that pheromones may be involved in the attraction of both species to mating sites within the host plant

Table 2. Mortality of *A. sinicus* larvae 96 h after introduction of Biosys and MB7 nematodes.

Treatment	% Dead	% Infected
Control	27	33*
Biosys	29	92
MB7	22	100

*naturally occurring nematodes were presumably present in the soil

field. Further investigation is needed to identify the pheromones and to assess their potential in a trapping system.

(ii) Screening of synthetic Japanese beetle lures.

The lures were primarily food attractants and were selected on the basis that some food attractants may be shared by scarabs. However, none of the lures tested attracted either species. There was some success in utilizing live *A. sinicus* beetles to attract further beetles and work is being conducted to identify the factors involved.

(iii) Screening of *Metarhizium anisopliae* on *A. sinicus* larvae.

The trials of *M. anisopliae* on *A. sinicus* larvae show high mortality in the control (Table 1) which may have been caused by handling (Habeck 1964). The controls showed no signs of fungal infection. Although the three strains of *M. anisopliae* were capable of infecting Chinese rose beetle larvae, the low levels of mortality suggest that none is a promising control agent.

(iv) Screening of *Steinernema carpocapsae* and *Heterorhabditis* sp. on *A. sinicus* larvae.

The trials of *S. carpocapsae* and *Heterorhabditis* on *A. sinicus* larvae resulted in low mortality by either nematode (Table 2), although dissections of the corpses indicated that, when death occurred, it was caused by the nematodes. The percent infestation was very similar to that obtained with adults (Hara et al. 1989). The results indicate that these two strains of nematode are not promising as control agents for *A. sinicus* larvae.

(v) Feeding patterns of *A. sinicus* and *A. versutus* adults.

A. sinicus exhibits a preference for the most recently mature leaves located at the uppermost part of the snap bean plant. There was 6.26 ± 1.30% consumed at the uppermost position, 2.68 ± 0.59% at leaf position 2, 1.79 ± 0.56% at leaf position 3, and 2.28 ± 0.83% at the lowest leaf position. By contrast, *A. versutus* displayed the reverse feeding response, with the greatest feeding on the lower leaves and the least on the younger leaves. On a scale of 1 to 6, the lower leaves had a rating of 5.5, the middle leaves 4.5 and the upper leaves 3.2. Both beetles display a feeding preference which may be in response to individual plant products found in differing amounts in different locations in the plant (Arita et al. 1988). It may prove rewarding to identify the plant products used by these beetles in selecting a food source.

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