
Tests were conducted to determine the effectiveness of various row covers for excluding certain insect pests from broccoli, Brassica oleracea L. Italica group, and summer squash, Cucurbita pepo var. melopepo (L.) Alef., plantings. Kimberley Farms (Kimberley-Clark Corporation) and Agronet (CDK International Corporation) fabric row covers effectively excluded Lepidoptera from broccoli, as well as several species of flea beetles and striped cucumber beetles, Acalymma vittata (F.) from summer squash. A slit, clear-plastic row cover was also effective in excluding pests of squash, but allowed more lepidopterous insects to reach broccoli plants than the fabric row covers. None of the row covers was initially successful in excluding Delia spp. from broccoli plantings. The presence of Delia spp. adults under row covers was most likely the result of life stages in the soil before the placement of the row covers and the subsequent development and emergence of the adults. Once in place, however, row covers appeared to be successful in preventing the entrance of the adults from the outside into the covered plantings. Delays in maturation of broccoli and summer squash were detected during one year for plants under row covers. No significant differences, however, were found in the total harvest means for head or fruit numbers and weights.


A series of tests done in commercial and research apple (Malus domestica Borkh.) orchards during 1986-1988 evaluated different trap designs and treatment thresholds for apple maggot, Rhagoletis pomonella (Walsh). No difference in catch efficiency in unsprayed trees was observed among Ladd yellow-panel-plus-red-hemisphere traps, red wooden-sphere traps, and Olson sphere traps covered with standard, brushable, or diluted adhesive mixtures. Of 10 trap designs that we tested in 20 commercial orchards, all sphere traps baited with synthetic apple volatiles were more effective at catching apple maggot adults than were unbaited sphere traps, which caught more adults than did yellow-panel traps. In a test using the baited traps to time control sprays in commercial orchards, we achieved acceptable levels of control with a catch action threshold of eight adults per trap. With this threshold, 70% fewer sprays (2.8 fewer applications) were applied than in a calendar-based program. Trials in 16 blocks scouted by growers with baited traps and a threshold of five adults per trap for timing sprays resulted in 0.6 fewer applications and no difference in fruit infestation levels, compared with blocks sprayed according to the growers' conventional schedules. Despite the use of a threshold of five adults per trap, which was chosen to be more conservative than that in the research trials, growers did not always follow the recommended treatment guidelines. The use of this trapping system has been incorporated into current commercial pesticide recommendations for New York apple growers.
Bioassays of treated field-aged leaves were conducted in 1998 and 1999 to determine the efficacy of various chemicals for control of striped cucumber beetle (SCB), *Acalyymma vittatum*. In 1998, imidacloprid (GAUCHO 480F) as a seed treatment was evaluated on cucumber (*Cucumis sativis*), cv. Pioneer, and squash (*Cucurbita maxima*), cv. Mini Green Hubbard. Three rates, 1.0 mg, 5.0 mg and 10.0 mg a.i./seed.


The floral volatiles from two cultivars of *Cucurbita maxima* Duchesne (squash) have been identified by vacuum steam distillation and gas chromatography-mass spectrometry. Spectral data were obtained for 31 major components, and the structures of 22 of these were verified by comparison with authentic standards. The mixtures are comprised of low molecular weight aliphatic alcohols and aldehydes, monoterpenoids, sesquiterpenoids, indole, and aromatic alcohols, aldehydes, and methyl ethers. The aromatics are similar to known attractants of cucurbit-feeding beetles in the chrysomelid genus *Diabrotica* (corn rootworms and cucumber beetles), and indole has previously been determined to be an attractant of these insects.


Cultivars representing three species of *Cucurbita* were examined for blossom preference by *Diabrotica* spp. *C. maxima* cultivars were found to be preferred by *D. undecimpunctata howardi* over those of *C. pepo* and *C. moschata*. *D. virgifera virgifera* preferred *C. maxima* and the “Connecticut Field” cultivar of *C. pepo*. *C. moschata* and other cultivars of *C. pepo* were not preferred. Cultivars were examined for differences in floral volatile release, blossom cucurbitacin content, and pollen content of male blossoms contained cucurbitacins. Cultivars of *C. moschata* contained the largest quantities of pollen, but all three species contained relatively large quantities. The data indicate a correspondence of *D. u. howardi* distribution in the field with high volatile release rates and high cucurbitacin levels that are found in *C. maxima* blossoms. *D. v. virgifera* distribution appears to be somewhat independent of these factors since this species was abundant in blossoms of a *C. pepo* cultivar as well cultivars of *C. maxima*.
Fractionation of headspace volatiles from *Cucurbita maxima* blossoms by high-performance liquid chromatography resulted in the isolation of a single component which was highly active in an electroantennogram bioassay on *Diabrotica undecimpunctata howardi* antennae. This compound was identified as indole by gas chromatography-mass spectrometry. Field-trapping bioassays were conducted which indicated that indole is a potent attractant of the western corn rootworm, *D. virgifera virgifera*, and the striped cucumber beetle, *Acalymma vittatum*. The southern corn rootworm, *D. u. howardi*, did not respond, despite its strong EAG response. The sex ratio of *D. v. virgifera* found in indole-baited traps varied seasonally. Males were trapped in abundance in late July and later September, 1983, while females were more abundant August and early September. The effectiveness of indole as a *D. v. virgifera* attractant also varied seasonally. A prolonged period of depressed trap catches occurred in early August 1983, during the silking and tasseling period of the corn in the field where trapping was carried out.


Esfenvalerate was sprayed on green pepper and pumpkin plants at 7.0 g (AI)/ha to control adult striped cucumber beetle, *Acalymma vittatum* (Fabricius), and spotted cucumber beetle, *Diabrotica undecimpunctata howardi* (Barber). Following spraying, residues of esfenvalerate on the two crops were determined and adult insects were swept and counted. Esfenvalerate was extracted using n-hexane from representative plant samples collected at different time intervals following spraying for residue analysis. Determination of residues using gas chromatography (GC-ECD) indicated initial deposits of 3.34 and 1.18 ppm on pumpkin and pepper leaves, respectively. Only trace levels were detected on pepper fruits on day 21 (0.0001 ppm). Half-Life values were 1.11 and 2.79 d on pumpkin and pepper fruits, respectively, whereas the values were 1.92 and 3.38 d on pumpkin and pepper leaves, respectively. Periodic sweep-net collections from treated and untreated plots revealed mean beetle reductions of nearly 100% 1h post-treatment and > 60% 2 wk after treatment on both crops. Results obtained may be useful for developing IPM strategies to reduce pesticide residues on produce.


Restricted (non-systemic) inoculation of cucurbits, green bean, tobacco, and other plants with certain viruses, bacteria, or fungi has been shown to induce persistent, systemic resistance to a wide range of diseases caused by diverse pathogens. The non-specificity of
this response has fueled speculation that it may also affect plant suitability for arthropod herbivores, and there is limited evidence, mainly from work with tobacco, which suggests that this may indeed occur. Young cucumber plants were immunized by restricted infection of a lower leaf with tobacco necrosis virus (TNV), and upper leaves were later challenged with anthracnose fungus, *Colletotrichum lagenarium*, to confirm induction of systemic resistance to a different pathogen. As has been reported before, immunization with TNV gave a high degree of protection from *C. lagenarium* reducing the number of lesions and the area of fungal necrosis by 65-93%. However, there was no systemic effect on population growth of twospotted spider mites, *Tetranychus urticae* Koch, on upper leaves, nor did restricted TNV infection of leaf tissue on one side of the mid-vein systemically affect mite performance on the opposite, virus-free side of the leaf.


One hundred and ten markers were analysed for linkage in 218 F2 plants derived from two divergent cultivars ('Vedrantais' and 'Songwhan Charmi') of *Cucumis melo* (L.). Thirty-four RFLPs, 64 RAPDs, one isozyme, four disease resistance markers and one morphological marker were used to construct a genetic map spanning 14 linkage groups covering 1390cM of the melon genome. RAPD and RFLP markers detected similar polymorphism levels. RFLPs were largely due to base substitutions rather than insertion/deletions. Twelve percent of markers showed distorted segregation. Phenotypic markers consisted of two resistance genes against *Fusarium* wilt (*Fom*-1 and *Fom*-2), one gene (*nsv*) controlling the resistance to melon necrotic spot virus, one gene (*Vat*) conferring resistance to *Aphis gossypii*, and a recessive gene for carpel numbers (3 vs 5 carpels: p).


The relationship between leaf feeding injury caused by striped cucumber beetle, *Acalyymma vittatum* (F.), and yield of winter squash, *Cucurbita moschata* Duch., was examined under field and laboratory conditions. In a field trial in 1998, individually-caged plants were artificially infested with varying numbers of beetles to create a range of injury levels. Treatments consisted of three levels of injury (1 to 25, 26 to 50, and >50%) and uninjured controls, each at the cotyledon-, first-, second-, and third-leaf stages of plant development. Under laboratory conditions, the leaf area consumed by known numbers of beetles for varying durations was quantified on cotyledon-, first-, second-, and third-leaf plants. In the field trial, winter squash was relatively tolerant of foliar injury. Total fruit mass was influenced by injury level and growth stage, but not by their interaction. Number of fruit, mass per fruit and number of marketable fruit were influenced by the interaction of factors. Maturity rating was affected by injury level alone.
In the laboratory trial, response of winter squash to varying beetle-days (number beetles x number days) depended on plant age. Based on our results, we propose conservative action thresholds of 20% injury to cotyledon plants and 50% foliar damage to first-, second-, and third-leaf plants.


This study was designed to examine the mechanisms underlying the response of herbivores to variation in the size of host plant patches. In order to explain why identical changes in patch size affect closely related herbivores in different ways, the author separated the effects of patch size alone from the confounded effects of the surrounding plant community. Further tests determined whether herbivore densities were directly affected by surrounding nonhost plants (via changes in movement patterns) and/or indirectly affected by changes in host plant size/quality caused by the surrounding nonhost plants. Population densities of three closely related insect herbivores, *Acalymma vittatum*, *Diabrotica undecimpunctata howardi* and *Diabrotica virgifera* were studied in experimental patches of squash host plants (*Cucurbita maxima*). Patches varied in size (4, 16, or 64 plants per patch) and in the nature of their edges (no tomato plant edge, and edge of tomato plants growing in the ground (= interacting nonhost plants), and an edge of tomato plants growing in pots (= non-interacting nonhost plants).


Abundances of the specialist herbivore, *Acalymma vittata* (Fab.) (Coleoptera: Chrysomelidae), were assessed in small experimental plots with three levels of plant diversity (cucumber monoculture, cucumber/corn, and cucumber/tomato) and two levels of host plant growth form (horizontal on the ground and vertical, staked up or growing up other plant species). Host plant growth form more strongly affected beetle abundances than did plant diversity; greater numbers were found on vertically growing than on horizontally growing cucumber plants. The combination of cucumber monoculture and vertical growth form supported significantly greater herbivore abundances than did any other type of plot, emphasizing a strong interaction between diversity and growth form. Beetles were not more common in monocultures with horizontal growth forms than in mixed species plots, and beetles did not respond differently to plots with corn an plots with tomatoes.

Feeding experiments demonstrated that the plant diversity under which a host plant is grown strongly influenced herbivore feeding preference. Beetles given a choice of cucumber leaves grown in monoculture and in plots with tomatoes exhibited individual differences in their food selection behavior, however a significantly greater number of beetles preferred monoculture leaves. Those individuals preferring monoculture leaves
and those individuals preferring leaves from plots with tomatoes did not differ in either absolute or relative amounts of feeding damage per leaf.

Neither plant size nor the date on which plots were colonized by beetles explained the differences in herbivore abundance. It is suggested that differences in movement patterns and plant quality contributed to the greater numbers of beetles on plants growing vertically in monocultures.


To determine the effects of plant density and diversity on the population dynamics of a specialist herbivore, the striped cucumber beetle (*Acalymma vittata* [Fab.]), cucumbers (*Cucumis sativus L.*) were planted in monocultures and in polycultures with corn (*Zea mays L.*) and broccoli (*Brassica oleracea L.*). Population densities of *A. vittata* and its insect predators, as well as cucumber growth, survivorship, and reproduction were monitored in these experimental plots. By controlling total plant density, host plant density, and plant diversity, it was possible to distinguish the effects of these three confounding variables.

Densities of *A. vittata* were 10-30 times greater in monocultures than in polycultures, both per plot and per plant, even when total plant density and host plant density were held constant. The lack of any effect of plant density on per-plot beetle abundances emphasized the importance of diversity per se in influencing beetle populations. These differences in beetle abundances caused by diversity resulted from differences in tenure time and movement patterns among plots, rather than from differences in colonization, reproduction, or predation. In mark-recapture studies, a greater proportion of beetles marked in monocultures than in polycultures was later found, and of those marked in monocultures, a greater number were later found in monocultures than in polycultures.

All measures of growth (leaf area, growth rate, and vine length) and reproduction (fruit production and number of flowers) of *Cucumis sativus* were most strongly affected by diversity, but also were affected by plant density. Both per-plot and per-plant values were greater in monocultures than in polycultures. The number of beetles was strongly correlated with the total amount of plant growth and reproduction in monocultures but not in polycultures. For plots with equal amounts of leaf area, monocultures had an order of magnitude greater number of beetles; thus, differences in host plant quantity did not explain the differences in beetle abundances between monocultures and polycultures. Numbers of beetles were much more strongly related to total plot characteristics than individual plant characteristics. Although defoliation was negligible, beetles significantly decreased cucumber survivorship and longevity by disseminating bacterial wilt disease (*Erwinia tracheiphila* [E.F. Sm.])

Experimental field plantings showed that plant diversity strongly affected the population dynamics of a specialist herbivore, the striped cucumber, *Acalymma vittata* (Fab.) (Coleoptera: Chrysomelidae). Population densities over time were characterized by two peaks in numbers (from colonization and reproduction respectively) and were consistently higher in cucumber monocultures (*Cucumis sativus* L.) than in polycultures of cucumbers, corn (*Zea mays* L.), and broccoli (*Brassica oleracea* L.). Greater abundances in monocultures appear to result from two factors: (1) per individual reproductive rates were greater in monocultures than in polycultures, and (2) mark-recapture studies confirmed that beetles stay in monocultures for a longer period of time than in polycultures. Differences in predation did not appear to contribute to the overall differences in herbivore abundances. The primary impact of *A. vittata* on its host plant, *C. sativus* is the dissemination of bacterial wilt disease, *Erwinia tracheiphila* (E. F. Sm.). Greater numbers of beetles led to greater plant mortality in monocultures. It is suggested that factors other than numbers of beetles (e.g., shading, allelopathy, microclimate) are more important in influencing plant reproduction, since cucumber plants in monocultures had greater yields than did plants grown in polycultures. However, time of beetle colonization strongly affected plant parameters, indicating that the length of time during which herbivores are interacting with plants is of critical importance to plant survivorship, and thus reproduction.


The influence of host plant patch size on the population densities of three herbivorous insect species was investigated in seven sizes of experimental patches of squash plants (from 1 to 144 plants). Responses to patch size differed significantly for the three herbivore species, which are closely related but differ in the degree to which they require cucurbits as hosts. The number of individuals of *Acalymma vittatum* (the striped cucumber beetle) per plant was significantly greater in small patches (1-4 plants) than in larger patches (16-144 plants). The spotted cucumber beetle or southern corn rootworm (*Diabrotica undecimpunctata howardi*) was most abundant in intermediate-sized patches (64 or 100 plants). Population densities of *Diabrotica virgifera* (the western corn rootworm) were more variable, but tended to increase with increasing patch size.

**Baker, P. B. and Robinson, R. W. 1985. Evaluations of selected Cucurbita accessions for cucumber beetle complex resistance. The Station. 31:2-8.**

The objective of this study was to select plants from field plantings of numerous lines and cultivars that expressed resistance to the striped and spotted cucumber beetles by antixenosis (nonpreference), for use in squash breeding programs. Although there was some variation from one season to another and in different plantings in the same year, there was generally a good agreement in different tests of the same cultivar or line. Zucchini-type varieties of *Cucurbita pepo* (‘Ambassador’, ‘Dark Green Zucchini’, ‘Black
Jack’, ‘President’) were more susceptible to cucumber beetles than Scallop-type cultivars (‘Scallop’, ‘Scallopini’, ‘Peter Pan’, ‘Patty Green Tint’), Table-queen cultivars (‘Table King’, ‘Table Ace’, ‘Royal Acorn’, ‘Table Queen’), and Straightneck-type cultivars (‘Slendergold’, ‘Early Prolific Yellow Straightneck’). There is considerable opportunity for Cucurbita breeders to develop improved cultivars by selecting for reduced cucurbitacin content and thus for cucumber beetle resistance.


Field trials to test the efficacy of insecticidal semiochemical baits for management of the southern corn rootworm, Diabrotica undecimpunctata howardi Barber, in peanuts were conducted in 1992, 1993, and 1994 in North Carolina and Virginia. The baits contained a mixture of cucurbitacins as a feeding arrestant, volatile feeding attractants (1,2,4-trimethoxybenzene, indole, and trans-cinnamaldehyde), and carbaryl as a toxicant. Results were similar in both North Carolina and Virginia. In 1992 and 1993, there were no statistically significant differences in in-shell yield because of treatment. Numerically highest yields were always obtained in the chlorpyrifos-treated plots; numerically lowest yields occurred in the semiochemical bait-treated plots in 1993 and 1994. In 1994, in-shell yield was significantly higher in the chlorpyrifos-treated than in granular semiochemical bait-treated peanuts. Percentage of undamaged pods was highest in chlorpyrifos-treated and lowest in bait-treated peanuts. Possible reasons for lack of efficacy of baits as applied are discussed relative to the biology of southern corn rootworm in peanuts.


Field trials to test the efficacy of insecticidal semiochemical baits for management of the southern corn rootworm, Diabrotica undecimpunctata howardi Barber, in peanuts were conducted in 1992, 1993, and 1994 in North Carolina and Virginia. The baits contained a mixture of cucurbitacins as a feeding arrestant, volatile feeding attractants (1,2,4-trimethoxybenzene, indole, and trans-cinnamaldehyde), and carbaryl as a toxicant. Results were similar in both North Carolina and Virginia. In 1992 and 1993, there were no statistically significant differences in in-shell yield because of treatment. Numerically highest yields were always obtained in the chlorpyrifos-treated plots; numerically lowest yields occurred in the semiochemical bait-treated plots in 1993 and 1994. In 1994, in-shell yield was significantly higher in the chlorpyrifos-treated than in granular semiochemical bait-treated peanuts. Percentage of undamaged pods was highest in chlorpyrifos-treated and lowest in bait-treated peanuts. Possible reasons for lack of
efficacy of baits as applied are discussed relative to the biology of southern corn rootworm in peanuts.


Data on responses of the striped cucumber beetle, Acalymma vittatum (F.); and the spotted cucumber beetle Diabrotica undecimtectata howardi Barber, to lamp sources of electromagnetic radiation have been extracted from experiments conducted over a 15-year period in Lafayette, Ind. Trap collections using various lamps are indicated, with blacklight fluorescent lamps, green fluorescent lamps, and combinations of these showing greatest attraction. Influence of trap design and placement are also indicated. Omnidirectional designs, use of suction fans, and placement at 12-foot height all increased collections.


Ten isolates of E. tracheiphila were compared by their ability to metabolize carbon sources, their serological reactivity and pathogenicity. In Biolog assays (Biolog Inc., Hayward, CA) isolates metabolized 15-26 of 95 carbon sources. All isolates reacted with polyclonal antibodies produced against ATCC type isolate 33245 (DAS-ELISA), and caused wilt in cucumbers. No serological reactions were observed with E. amylovora, E. carotovora, E. herbicola and E. stewartii. After 1 year in culture on nutrient agar supplemented with peptone at room temp., isolates caused wilt. On nutrient agar with additional glucose, colonies grew rapidly but lost pathogenicity. Although the isolates vary in carbon metabolism, they are serologically similar and distinguished from other Erwinia sp. By ELISA. Detection of E. tracheiphila in wild plant species and cucumber beetles in greenhouse studies implicates their importance in survival and disease outbreaks.


Influence of feeding by adult striped cucumber beetle (STCB), Acalymma vittatum (F.), and spotted cucumber beetle (SPCB), Diabrotica undecimtsectata howardi Barber, on summer squash, Cucurbita pepo L., was investigated. Greater defoliation and higher mortality occurred with STCB than SPCB, but differences in subsequent foliar and reproductive productivity were not significant. When 10 or more beetles of either species were placed on plants at the cotyledon or first true leaf stages for 2 wk, seedling mortality
was the primary cause of yield reduction. Surviving plants infested at the cotyledon stage produced lower early season yields than plants infested at the third true leaf stage. Surviving plants infested at the second and third true leaf stages were typically able to compensate for growth delays caused by seedling damage before fruit production.


Fifteen jack-o’-lantern and three processing-pie pumpkin (Cucurbita pepo L.) Cultivars were tested in the greenhouse and field for their susceptibility at different stages to Erwinia tracheiphila, the causal agent of bacterial wilt. The bacterium is vectored by cucumber beetles (Acalymma vittatum (F) and Diabrotica undecimpunctata howardi Barber). Each variety was artificially inoculated with E. tracheiphila in the greenhouse at cotyledon, first, second, third, forth and fifth true leaf, first flower and first female flower growth stages to discern if maturity confers tolerance to the disease. Field experiments compared the sublethal effects of E. tracheiphila inoculated plants with water-inoculated plants on pumpkin fruit yield and quality. The cotyledon stage was most susceptible to infection (22% of plants killed). At the 3-4 leaf stage, no plants died owing to bacterial wilt. Howden, Baby Boo, and Happy Jack inoculated at the cotyledon stage were the most susceptible jack-o’-lantern cultivars, with 18%, 15%, and 13%, respectively, of the inoculated plants dying. Only 5% of all the processing pumpkins inoculated at any stage died from bacterial wilt. Eighteen percent, 90% and 100% of infected plants that started to wilt 2 weeks after inoculation at the cotyledon, first true leaf and second true leaf stages, respectively, recovered and continued to grow. None of the most susceptible cultivars recovered from initial wilting. Infected plants that survived did not have significantly different yields or quality of pumpkin fruit compared with plants inoculated with water.


A semiochemical-based toxic bait was compared with the standard treatment weekly carbaryl sprays, for control of adult striped cucumber beetle, Acalymma vittatum (F.) in cantaloupe in 1991 and 1992. The striped cucumber beetle transmits the bacterium Erwinia tracheiphila (Smith) Bergey, Harrison, Breed, Hammer and Huntion, which causes bacterial wilt in cantaloupe. The toxic dry bait contains 0.3% carbaryl, a feeding stimulant (cucurbitacin, 5.0%), and several floral attractants (0.5%). In 1992, a dry-flowable bait (liquid-bait) also was tested. The baits reduced beetle numbers on cantaloupe plants but not as quickly as the carbaryl spray. It took < 2 h to eliminate beetles with carbaryl spray treatments and 24-48 h with dry- or liquid-bait treatments. However, dry bait continued to control beetles for 7 d, but beetle populations increased in carbaryl spray and liquid-bait treatments 4-5 d after application. Beetle damage and percentage of plants with bacterial wilt by first harvest were similar in the carbaryl and
bait treatments. Significantly more flowers were pollinated and more early fruit were produced in the bait treatments and the control (no insecticides) compared with the carbaryl spray treatments. In 1991, dry-bait treatments had significantly greater yields than carbaryl treatments because of an outbreak of aphids in the carbaryl spray treatment. Final yields in 1992 were similar for carbaryl and both bait treatments.


A scheduled, weekly spray program was compared with a program that determined the need for treatment based on sampling (threshold) and an untreated control for management of the striped cucumber beetle, Acalymma vittatum (F.), a vector of the pathogen that causes bacterial wilt in muskmelon. Treatments were compared at 2 locations during 2 yr for their effects on prevention of bacterial wilt, melon yield, and net income. Insecticides were applied in the threshold treatment whenever beetle populations reached or exceeded a threshold of 0.5 beetle per plant before melon fruit appeared, and 1 beetle per plant when fruit set. Yields in the threshold treatment were equal to or better than the schedule treatment at 3 of the 4 study sites. The threshold treatment generated higher net income than the other treatments. In addition to economic considerations, the use of fewer insecticide sprays for striped cucumber beetle management is favorable for protecting natural enemies, insect pollinators, and prolonging the usefulness of a limited number of insecticides registered for use on muskmelon by reducing selection for resistance.


Striped cucumber beetles, Acalymma vittatum (F.), were tested for their ability to vector Erwinia tracheiphila, the causal agent of bacterial wilt, to muskmelon plants. Beetles were tested from 3 locations in a large muskmelon production area in southwestern Indiana over a 4-yr period. Individual beetles were allowed to feed on muskmelon plants for 0, 12, 24, 48, and 72 h every 4 wk during the growing season. The percentage of infected beetles that transmitted the pathogen to plants was recorded. There were no significant differences among years or collection locations for the percentage of infective striped cucumber beetles. In the early part of the season, approximately 1% of overwintering beetles were found to be infective. The 2nd generation of beetles collected in July, August, and September had much higher percentages of infective beetles (8-12%). There was little variation in percentage infectivity of beetles in May or June over the 4-yr period, and high variation in beetle infectivity later in the season. When beetles fed on plants for 12 h, only 0.05% could transmit the pathogen. At 24 and 48 h of feeding, approximately 2% of beetles were infective, whereas at 72 h of feeding, 5% of beetles were infective. There was a significant interaction between collection date of beetles and
their feeding duration. At the longest feeding period of 72 h, < 2% of the beetles that were collected in May or June was infective, whereas 10% of the beetles were infective in July, August, and September. This study indicates that only 1% of the overwintering striped cucumber beetles in southwestern Indiana can infect muskmelon plants with *E. tracheiphila*. This should enable researchers to develop thresholds for this pest, reducing the need for unnecessary insecticide applications.


Bacterial wilt is one of the most important plant diseases of muskmelon (*Cucumis melo* L., reticulatus group) in the Midwest and eastern United States. Little is known about the causal agent *Erwinia tracheiphila* (Smith) Bergey, Harrison, Breed, Hammer & Huntoon and requirements for successful infection. To understand these requirements better, 6 commonly grown muskmelon varieties ('Superstar', 'Legend', 'Cordelle', 'Honey Gold', 'Star Ship', and 'All Star') were used in greenhouse studies to evaluate the effect of wound characteristics and time interval between bacterial inoculation and wounding on disease incidence. The following 4 types of plant × *E. tracheiphila* interactions were tested: (1) Inoculation type where a leaf was either wounded first and bacterial inoculum was placed in the wound or plants had inoculum placed on the leaf first, and were then wounded. (2) Wound size: either small or large. (3) Inoculation level: either 1 or 2 leaves of a plant were inoculated. (4) Timing interval and inoculation where 10 different timings of infection were used (0, 0.5, 1, 2, 3, 4, 5, 6, 12, or 24 h). The percentage of plants that developed bacterial wilt was recorded. There were significant interactions in percentage of infection between muskmelon varieties and wound size. The varieties Legend and Superstar had significantly less infection when large wounds were made compared with the other varieties tested. Plants that had inoculum placed on leaves before wounding were 2.5 times more likely to develop bacterial wilt than plants that were wounded before inoculation. Plants with large wounds had 50% greater wilt incidence than plants with small wounds. There were no significant differences between 1 leaf or 2 leaves being inoculated in the development of bacterial wilt. Plants were most susceptible to infection within 2 h of wounding, but they were seldom infected if inoculated 3 h after wounding. Several 2-way, but no 3- or 4-way, interactions were significant. Information from this study should help in developing better management programs for bacterial wilt in muskmelon.


Field experiments were performed in 2 locations in Indiana in 1993, 1994, and 1995 to determine the relationship between striped cucumber beetle, *Acalymma vittatum* (F.), density and the incidence of bacterial wilt in cantaloupe. The striped cucumber beetle is the primary vector of *Erwinia tracheiphila* (Smith) Holland, the causal agent of bacterial
wilt in cucurbits, during the spring in the Midwest. Based on laboratory findings, initial densities of 0, 1, 5, and 15 beetles per cantaloupe plant were evaluated. Regression analyses showed that at beetle densities of 1-15 per plant there was a strong and significant linear relationship between numbers of beetles per plant and the percentage of cantaloupe plants with bacterial wilt. No cantaloupe plants developed bacterial wilt at a density of 0 or 1 beetle per plant during the 3-yr study at either location. To further define beetle density requirement, the densities of 0, 1, 2, 3, 4, and 5 beetles per plant were used in 1995. During these trials, there was no wilt at the 0 or 1 beetle per plant densities and significant wilt development did not occur until beetle densities reached 4 or 5 beetles per plant. Only 2 experimental trials showed significant yield losses from increasing beetle densities. In each trial, no yield loss was associated with beetle densities lower than 4 beetles per plant. Use of an economic threshold of 1 striped cucumber beetle per plant in the Midwest should greatly reduce insecticide applications in cantaloupe, while providing good control of the vector and bacterial wilt.


Ten muskmelon (*Cucumis melo* L.) cultivars were tested for their susceptibility to bacterial wilt, caused by *Erwinia tracheiphila* (Smith) Bergey, Harrison, Breed, Hammer and Huntoon and vectored by the striped cucumber beetle *Acalymma vittatum* (F). ‘Superstar’, ‘Rising Star’, ‘Pulsar’, ‘Caravelle’, ‘Cordele’, ‘Legend’, ‘Makdimon’, ‘Galia’, ‘Rocky Sweet’, and ‘Passport’ were used in field studies to determine the number of striped cucumber beetles, feeding damage, and incidence of bacterial wilt. ‘Makdimon’ and ‘Rocky Sweet’ hosted significantly more beetles than the other cultivars. These two cultivars and ‘Legend’ and ‘Cordele’ had much more feeding damage and a significantly higher incidence of bacterial wilt than the others. A greenhouse experiment was conducted with seven of the cultivars to test their susceptibility to bacterial wilt when directly inoculated with the causal agent. All cultivars were equally susceptible to the disease when it was introduced directly into the plant. Selective feeding by striped cucumber beetles was probably most responsible for ‘Makdimon’, ‘Rocky Sweet’, ‘Legend’, and ‘Cordele’ having greater incidences of bacterial wilt that then other cultivars.


Soils traditionally used for muskmelon, *Cucumis melo* L., production in Indiana were studied for their capacity to develop enhanced (rapid) rates of carbofuran (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate) breakdown. The rate of carbofuran degradation in soils with a history of carbofuran treatment was compared with similar
soils with no previous carbofuran treatment. Degradation estimates were based on bioassay with larval western corn rootworms, *Diabrotica virgifera virgifera* LeConte, and measurement of the release of C-14-CO2 from C-14-carbofuran. Uptake of carbofuran by muskmelon plants growing in enhanced (soil in which a pesticide is rapidly degraded by populations of microorganisms previously exposed to the pesticide or a structurally related compound) and nonenhanced soils was also estimated. Both estimates of degradation showed rapid loss of carbofuran occurring in history soils as opposed to a much slower rate of degradation in nonhistory soils. Plant uptake of carbofuran, measured by bioassay with striped cucumber beetle, *Acalymma vittatum* (F.), and residue analysis by gas chromatography-mass spectrometry was dependent upon the concentration of the insecticide in soil. The control of striped cucumber beetle on plants growing in history soils was reduced compared with plants growing in nonenhanced soil.


Methods for isolation, growth and storage of *Erwinia tracheiphila* are discussed. Differences in virulence and cell size and shape of several ages and isolates of the bacteria are reported. The viability of the bacterium in live and dead plants, as well as in and on seeds, is reported. The author makes suggestions about the influence of adaptation to survival in the gut of a beetle on bacterial response to culture. The reasons for difficulty in classifying this species are clarified.


Field studies were conducted in 1994 and 1995 to quantify the relationship between simulated striped cucumber beetle, *Acalymma vittatum* (F.), defoliation and yield loss in 'Carolina' cucumber. Six simulated defoliation levels (0-100%) were imposed over five time intervals in 1994 and nine simulated defoliation levels were imposed over six time intervals in 1995. Time intervals began at cotyledon, 1st, 2nd, or 3rd true-leaf, or 1st flower growth stages, and were terminated at either 1st flower or harvest. There were no significant differences among timing of defoliation treatments for continuous defoliation, and significant yield loss occurred only when defoliation was > 25% in both years. One-time simulated insect defoliation treatments showed no significant differences in timing of defoliation and significant yield loss occurred only at >50% defoliation. Simulated defoliation results were used to estimate action thresholds. Results of the studies suggest that 'Carolina' cucumber can withstand high levels of defoliation before yield loss occurs, and that *A. vittatum* damage is primarily a concern during early plant growth stages.

Adult striped cucumber beetles, *Acalymma vittatum* (F.), were sampled in 20 fields during 1991-1993 in southern Minnesota. Data in both years were collected using a fixed sample unit of consecutive plants within a row and a fixed sample size of 48. Sample units of 1 through 7 plants were separated out from each data set, and data sets for each sample unit of 1, 2, 3,... 7 plants each, were used for analysis. The sampling plan was analyzed and validated using resampling software, Resampling validation for sampling plans, which uses the Wald sequential probability ratio test to develop a binomial sampling plan. Based on actual alpha (type I) and beta (type II) error rates derived from the resampling analysis of 32-36 data sets, the optimum sample unit was determined to be 2 consecutive plants. Specifying nominal error rates of alpha = beta = 0.10, with a tally threshold = 2 and an action threshold = 0.25, the sample plan required an average of 14, 2-plant sample units per field. Actual alpha and beta error rates were 0.05 and 0.08, respectively. Analysis of the average sample number function indicated that a maximum of 29 samples would be required to classify *A. vittatum* populations near the action threshold of 0.25 proportion of samples infested with a tally threshold = 2. Binomial sampling plans should provide an efficient sampling program for use in managing *A. vittatum* infestations in cucurbits with minimal sampling costs.


Adult striped cucumber beetles, *Acalymma vittatum* (F.), were sampled in 20 fields during 1994-1995 in southern Minnesota. Data in both years were collected using a fixed sample unit of 7 consecutive plants within a row and a fixed sample size of 48. Sample units of 1 through 7 plants were separated out from each data set, and data sets for each sample unit of 1, 2, 3,... 7 plants each, were used for analysis. The sampling plan was analyzed and validated using resampling software, Resampling validation for sampling plans, which uses the Wald sequential probability ratio test to develop a binomial sampling plan. Based on actual alpha (type I) and beta (type II) error rates derived from the resampling analysis of 32-36 data sets, the optimum sample unit was determined to be 2 consecutive plants. Specifying nominal error rates of alpha = beta = 0.10, with a tally threshold = 2 and an action threshold = 0.25, the sample plan required an average of 14, 2-plant sample units per field. Actual alpha and beta error rates were 0.05 and 0.08, respectively. Analysis of the average sample number function indicated that a maximum of 29 samples would be required to classify *A. vittatum* populations near the action threshold of 0.25 proportion of samples infested with a tally threshold = 2. Binomial sampling plans should provide an efficient sampling program for use in managing *A. vittatum* infestations in cucurbits with minimal sampling costs.

*Abstract Missing*


Cantaloupe seedlings 3, 6, 9, and 12 days old were infested with 0, 1, 2, 3, and 4 striped cucumber beetles, *Acalymma vittata* (F.), or spotted cucumber beetles, *Diabrotica undecimpunctata howardi* Barber. In general, the younger the seedling and the higher the population of insects, the more quickly the seedling was destroyed. The striped beetles were more destructive than the spotted beetles to 3- and 6- day old seedlings. The opposite was true of 12-day-old seedlings, though the striped beetles ate more foliage, because the spotted beetles fed more on the stems. The average time required to destroy a 12-day-old seedling ranged from 6.1 to 10.8 days for the spotted cucumber beetle and was 15.6 days for the striped cucumber beetle.


Cucumber (*Cucumis sativus* L.) and squash (*Cucurbita pepo* L.) were grown in a replicated trial on three types of plastic mulch: solid black plastic mulch, solid aluminum-coated plastic mulch with a silver reflective appearance, and black plastic mulch with two aluminum-coated strips attached. Striped cucumber beetle (*Acalymma vittata* Fabricius) and spotted cucumber beetle (*Diabrotica undecimpunctata howardi* Barber) (Coleoptera: Chrysomelidae) counts on yellow sticky cards were obtained over eight weekly samplings. For cucumber, on the peak beetle population date, there were six times as many striped cucumber beetles in solid black plastic mulch as in aluminum-coated plastic mulch, and nearly three times as many as in black plastic mulch with aluminum strips. For squash, both striped and spotted cucumber beetle counts were significantly higher on solid black plastic mulch on three peak sampling dates than on aluminum-coated plastic mulch and black plastic mulch with aluminum strips, with counts 4.9 to 5.5 times higher in solid black plastic mulch than in aluminum-coated plastic mulch, and 2.2 to 2.6 times higher than in black plastic mulch with aluminum strips. Using a threshold of 15 beetles/sticky card, no insecticidal applications were needed on solid aluminum-coated mulch, while an average of 1.8 insecticidal applications were needed on solid black plastic mulch, and 0.8 insecticidal applications on black plastic mulch with aluminum strips. The cost of solid black plastic mulch and its insecticidal applications, $186/acre ($459/ha), was $102/acre ($252/ha) less than the cost of aluminum-coated plastic mulch without insecticidal application, $288/acre ($711/ha). However, squash fruit from plants
grown on aluminum-coated plastic mulch could be direct marketed as pesticide-free, at a price 25% higher than fruit on which pesticide had been applied. For an average yield in Virginia of 600 boxes/acre (1,482 boxes/ha) [20lb/box (9 kg/box)] of squash, this translates to a $1200/acre ($2,964/ha) increase in revenue. Yield on aluminum-coated plastic mulch was delayed by one week, but there were no significant differences in cumulative yield over 14 harvests.


*Abstract Missing*


The dried, powdered roots of buffalo gourd, *Cucurbita foetidissima*, were tested in a cornfield and shown to attract adult northern and southern corn rootworm beetles. Coupled gas chromatography-electroantennography (GC-EAG) analyses of headspace samples of the root powder showed several GC-EAG-active compounds on the antennae of female northern, southern, and western corn rootworms. Among other techniques, solid-phase microextraction and GC-mass spectrometry identified the following GC-EAG-active compounds: hexamol, nonanal, 1-octen-3-ol, benzaldehyde, benzyl alcohol, (E)-3-octen-2-one, (E,E)-3,5-octadien-2-one, and (E,Z)-3,5-octadien-2-one. EAG dose-response studies of several of the identified root powder volatiles also were performed and compared with results from known attractants. Field tests of synthetic root powder volatiles in commercial cornfields showed that northern corn rootworm adults were attracted to (E,E)-3,5 octadien-2-one. The antennae of the *Diabrotica* species and the field tests showed specificity for different geometrical isomers or 1,5 octadien-2-one, with a behavioral preference for (E,E)-3,5-octadien-2-one. In addition, we have shown that the efficacy of buffalo gourd root powder as a feeding stimulant and arrestant can be enhanced for northern and western corn rootworm adults by augmenting buffalo gourd root powder with additional (E,E) 3,5-octadien-2-one.


Applications of chemical treatments directed at adult stages of the striped cucumber beetle, *Acalymma vittatum* (F.) were made during the period when eggs were being laid that were anticipated to produce late instar larvae at the time of harvest, approximately 20 to 30 days prior to harvest. In the first study (1995), methamidophos (Monitor 2WM), two formulations of carbaryl (Sevimol, Adios) and esfenvalerate (Asana XL) all provided acceptable control when applied sequentially on three dates, beginning 35 days
prior to harvest. Systemic insecticide treatments (carbofuran, imidacloprid), applied as a band over the furrow after planting, and seed treatments with imidacloprid provided poor or unacceptable control. In the subsequent study (1996), the effect of different treatment timings was evaluated. Treatments applied 29 days before harvest provided significantly better control of later larval damage than did later treatments, 19 and 9 days before harvest. Somewhat greater control was observed with carbaryl (Sevin XLR-Plus, Adios) than with esfevalerate. The use of cucurbitacin-based feeding stimulant baits (Adios) does provide an effective treatment that is generally compatible with protection of pollinators present in fields at this time.


Large numbers of the banded cucumber beetle, *Diabrotica baleata* LeConte, can be reared in the laboratory with relatively simple equipment and at reasonable cost. The adults are fed semisynthetic diet and natural foods and the larvae are fed sprouting corn. No loss of adult vigor or fecundity was noted through 17 generations.


Antibiotic and nonpreference mechanisms are related in cucumber through the action of the bi gene and the absence of cucurbitacins. Cucurbitacins attract cucumber beetles and cause feeding whereas they have an antibiotic effect on two-spotted mites.


During 1917 and 1919, striped cucumber beetles (*Acalymma vittata*) were collected in the spring and placed in greenhouse cages with young cucumber plants. Wilt symptoms developed on these plants.


Sticky traps were used to measure how tree shelterbelts influence the abundance of crop insect pests and beneficial arthropods in muskmelon (*Cucumis melo* L.) plots in eastern Nebraska. Abundance of striped cucumber beetles (*Acalymma vittatum* Fabricius (Coleoptera: Chrysomelidae)), southern corn rootworms (*Diabrotica undecimpunctata howardi* Barber (Coleoptera: Chrysomelidae)), and northern corn rootworms (*D. barberi* Smith & Lawrence (Coleoptera: Chrysomelidae)) was similar in exposed and sheltered
plots. Western corn rootworms \{\textit{D. virgifera} LeConte (Coleoptera: Chrysomelidae)\} were significantly more abundant in exposed plots. More lady beetles (Coleoptera: Coccinellidae) and ichneumonid wasps (Hymenoptera: Ichneumonidae) were caught on traps in sheltered plots than exposed plots, especially during June. Few spiders (Arae), lacewings (Planipennia), or braconid wasps (Hymenoptera: Braconidae) were caught in either treatment.


A systematic study has been made of the genus \textit{Erwinia} and this paper reports on those organisms considered to be closely related to \textit{Erwinia amylovora} (Burrill) Winslow et al. It is suggested that the several species should be classified as varieties of \textit{E. amylovora} and the following classification is proposed:

\textit{E. amylovora} (Burrill) Winslow et al., 1920
\textit{E. amylovora} var. \textit{salicis} (Day) Martinec & Docur, 1963
\textit{E. amylovora} var. \textit{tracheiphila} (Smith) comb. nov. 1968
\textit{E. amylovora} var. \textit{quercina} (Hildebrand & Schroth) comb. nov. 1968
\textit{E. amylovora} var. \textit{nigrifluens} (Wilson et al.) comb. nov. 1968
\textit{E. amylovora} var. \textit{rubrifaciens} (Wilson et al.) comb. nov. 1968.


Sampling of cantaloupe fields was conducted during three growing seasons to determine insect pests present on melons in the lower Rio Grande Valley. Comparisons were made between two sampling methods (visual observations and a combined suction/visual technique) and three sample area sizes (1, 2, and 3 m super(2)) during two of the seasons to determine sampling precision and efficiency. Five species and one species complex of insects considered as pests were monitored. Means, relative variation (RV), and relative net precision (RNP) for sampling techniques and sample area sizes were compared. Suction sampling followed by immediate visual examination of the plant material vacuumed yielded lowest RV values and highest RNP values. The largest-size area sampled resulted in lowest RV and RNP values for both techniques. The required number of samples associated with differing degrees of precision for both methods and all sample areas was very large.


Intra- and interplant distribution of five pest species of insects were evaluated in research plots planted to cantaloupe, Cucumis melo L., over three growing seasons, fall 1983 and spring 1984 and 1985. Two species, \textit{Diabrotica undecimpunctata howardi} Barber,
spotted cucumber beetle; and *Empoasca abrupta* DeLong, western potato leafhopper, were found to be randomly dispersed. One species, *Aphis gossypii* Glover, melon aphid, was found to be overdispersed, and two species, *D. baleata* LeConte and *Acalymma vittatum* (F.), banded and striped cucumber beetles, respectively, varied between random and overdispersed. On species, melon aphid, was found to be most abundant on the basal portion of vines. Sampling precision could be increased by reducing area sampled and increasing the number of samples.


The phagostimulatory sensitivity of diabroticite (Coleoptera, Chrysomelidae, Galerucinae) species to cucurbitacins is not correlated with Cucurbitaceae specialization, indicating that other factors, including the absence of feeding deterrents, may influence host-plant affinities among these beetles. Quinoline, indole, and isoquinoline alkaloids and sesquiterpene lactones believed to antagonize gamma-aminobutyric acid/glycine Cl-ionophores mediating chemoreception were tested on squash blossom disks for antifeedant activity to four diabroticite species with different host plant Specializations. Most alkaloids were antifeedant below 30 nmol/disk. Antifeedant concentrations of sesquiterpene lactones were higher than alkaloids for all species. Oligophagous *Diabrotica virgifera virgifera* was more sensitive to quinoline alkaloids than polyphagous *D. undecimpunctata howardi*. *Diabrotica virgifera virgifera* was also more sensitive to the indole alkaloids strychnine, brucine, eburnamonine, and vincamine than *D. u. howardi*. The closely related *D. barberi* had sensitivities similar to those of *D. v. virgifera* but the more distantly related *Acalymma vittatum* was less sensitive to the antifeedants than *D. v. virgifera*. The isoquinoline alkaloid hydrastine was uniformly antifeedant to all diabroticites. All the GABA/glycine neurotoxicants tested against diabroticites were feeding deterrents and suggest that beetles share a common antifeedant mechanism.


*Acalymma vittatum* (F.) is the primary insect pest of fresh-market cucumber and melon crops in much of the eastern United States because of their herbivory and interactions with several diseases, most notably bacterial wilt. A study was conducted to determine how soil management affects viability and infectivity of an entomopathogenic nematode that may be used for the control of *A. vittatum*. Dose-mortality curves under laboratory conditions suggested several *Steinernema* spp. as potential biocontrol agents. Field injections combined with soil bioassays showed that *Steinernema riobravis* Cabanillas, Poinar & Raulston (Rhabditus: Steinernematidae) longevity exceeded *A. vittatum* immature development time in both conventional and organic soil management systems.
Mean root length densities of cucumbers increased in both soil management systems with the inclusion of nematodes. Soil management alone also influenced *A. vittatum* larval survivorship, with higher survival rates in the organic compared with the conventional soil management system. A 50% reduction in *A. vittatum* larval survival rates in both soil management systems, as determined by adult *A. vittatum* emergence, demonstrated the potential of incorporation of entomopathogenic nematodes for integrated pest management of diabroticites in commercial cucumber production.

**Elsey, K.D. 1989. Cold Tolerance of Adult Spotted and Banded Cucumber Beetles (Coleoptera: Chrysomelidae). Environmental Entomology. 18(6):1112-1116.**

Spotted and banded cucumber beetles, *Diabrotica undecimpunctata howardi* Barber and *D. balleata* LeConte, cold-acclimated and nonacclimated, shared a common range of supercooling points (-12 to -14°C); however, LD₅₀ values showed that cold-temperature survival of the spotted cucumber beetle was higher relative to the banded cucumber beetle as the exposure temperature approached 0°C. A considerable portion (41.5%) of spotted cucumber beetle adults survived ambient conditions during the winter of 1988 at Charleston, S. C., whereas all adults of the banded cucumber beetle died. Reproductive diapause did not contribute to cold hardiness in the spotted cucumber beetle, but cold acclimation increased survival to exposures of -10°C in both species.

**Ferguson, J. E. 1986. Disposition of cucurbitacin as a factor in host plant selection by diabroticite beetles and electrophoretic analysis of the coevolved genus Cucurbita. Dissertation Abstracts International B Sciences and Engineering 46(7):2185.**

Five species of Diabroticites with different host plant affinities produced an essentially identical array of metabolites when fed radiolabeled cucurbitacin B synthesized in vivo and purified from *C. maxima* seedlings. All species excreted the bulk of the cucurbitacin (67.17-94.59% total dpm); permanently sequestered a small proportion of a cucurbitacin conjugate in the hemolymph (0.98-2.76%); and apportioned the remainder between the gut, the body and the eggs (when present). Markedly different ratios between the excretory metabolites, i.e., polar vs. unmetabolized cucurbitacin, suggest that *D. v. virgifera*, a grass specialist, and *A. vittatum*, a cucurbit specialist, have lower rates of metabolic alteration than *D. u. howardi* and *D. balleata* which are polyphagous and *D. cristata* which is associated with relict prairies.

Mean lifespans for *D. balleata* and *D. v. virgifera* and male *A. vittatum* decreased significantly with continuous feeding on Cucurbita fruit containing cucurbitacins (vs. fruit devoid of cucurbitacins). The longevity of female *A. vittatum*, however, was unaffected by the presence or absence of cucurbitacin. Males of four diabroticite species consumed an average of 27.4% more artificial diet after the incorporation of 0.5 mg cucurbitacin D per g fwt diet whereas female consumption increased only 5.0%, on average. Although this suggests a lower limit of response to cucurbitacin D for males, testing for differences in limit of response was confounded by differences in male and female weight.
Four species of Diabroticites were shown for the first time to sequester cucurbitacins. While all beetles fed on an artificial pollen diet with no cucurbitacins were readily consumed by Chinese praying mantids, a significant proportion of adult *D. balteata* (72%), *D. undecimpunctata howardi* (46%) and *D. virgifera virgifera* (24%) fed on squash fruit containing cucurbitacins B and D were rejected. Moreover, even when adults did not feed on cucurbitacins, 21-24% of *Acalymma vittatum* were rejected by the mantids which is consistent with larval sequestration of cucurbitacins. The mantids failed to learn to avoid any of the beetle species despite adverse effects associated with ingestion, i.e., uncoordination, regurgitation, etc. A cucurbitacin D metabolite accumulated and was sequestered for extended periods of time in the hemolymph of all four species. In addition, female beetles that had ingested cucurbitacins laid eggs containing substantial amounts of cucurbitacins. The mantids failed to learn to avoid any of the beetle species despite adverse effects associated with ingestion, i.e., uncoordination, regurgitation, etc. A cucurbitacin D metabolite accumulated and was sequestered for extended periods of time in the hemolymph of all four species. In addition, female beetles that had ingested cucurbitacins laid eggs containing substantial amounts of cucurbitacins.

Electrophoretic analysis of *Cucurbita* isozymes revealed abundant intra- and interspecific variation of nine enzymes. A tree constructed by PAUP character analysis, however, was largely inconsistent with known cross-compatibility relationships. Phenotypes of malate dehydrogenase for *C. foetidissima*, *C. digitata*, *C. lundeliana*, *C. palmata*, *C. pepo*, and *C. texana* suggest the loss of duplicate enzyme expression in some populations of these species.


Four species of diabroticites with different host specificities are shown for the first time to sequester cucurbitacins. While all beetles fed on an artificial diet (no cucurbitacins) were readily consumed by Chinese praying mantids, a significant proportion of adult *Diabrotica balteata* (72%), *D. undecimpunctata howardi* (46%), and *D. virgifera virgifera* (24%) fed on squash fruit containing cucurbitacins B and D were rejected. Moreover, even when adults did not feed on cucurbitacins, 21-24% of *Acalymma vittatum* were rejected by the mantids which is consistent with larval sequestration of cucurbitacins. The mantids failed to learn to avoid any of the beetle species despite adverse effects associated with ingestion, i.e., uncoordination, regurgitation, etc. A cucurbitacin D metabolite accumulated and was sequestered for extended periods of time in the hemolymph of all four species. In addition, female beetles that had ingested cucurbitacins laid eggs containing substantial amounts of cucurbitacins.

**Ferguson, J. E., Metcalf, R. L, and Fischer, D. C. 1985. Disposition and Fate of Cucurbitacin B in Five Species of Diabroticites. Journal of Chemical Ecology. 11(9):1307-1321.**

Five species of diabroticites with different host-plant preferences produced an essentially identical array of metabolites when fed radiolabeled cucurbitacin B synthesized in vivo and purified from *Cucurbita maxima* Durchesne seedlings. All species excreted the bulk of the cucurbitacin (67.17-94.59% total dmp), permanently sequestered a small amount.
proportion of a cucurbitacin conjugate in the hemolymph (0.98-2.76%), and apportioned the remainder between the gut, the body, and the eggs (when present). Markedly different ratios between the excretory metabolites (i.e., polar vs. unmetabolized cue) suggest that *D. virgifera virgifera*, a grass specialist, and *Acalymma vittatum*, a cucurbit specialist, have lower rates of metabolic alteration than the polyphagous *D. undecimpunctata howardi*, *D. balleata*, and *D. cristata*, which is associated with relict prairies. Mean life-spans of *D. balleata* and *D. v. virgifera* and male *A. vittatum* decreased significantly with continuous feeding on *Cucurbita* fruit containing cucurbitacins (vs. fruit devoid of cucs). The longevity of female *A. vittatum*, however, was unaffected by the presence of cucurbitacins.

**Ferguson, J. E., Metcalf, Esther R., Metcalf, Robert L., and Rhodes, A. M. 1983. Influence of Cucurbitacin Content in Cotyledons of Cucurbitaceae Cultivars upon Feeding Behavior of Diabroticina Beetles (Coleoptera: Chrysomelidae).**

Nineteen species and 46 cultivars of *Cucurbita, Cucumis*, and *Citrullus* were analyzed for seedling cucurbitacin (Cue) content by *Diabrotica* feeding on this-layer chromatography extracts. Seedlings, leaves and fruits were monitored for damage in the field by Diabroticina. Beetle damage to the mature leaf and fruit was unrelated to seedling resistant varieties of Cucurbitaceae cultivars for integrated pest management programs. A new analytical procedure for cucurbitacins using high-pressure liquid chromatography is described.


The influence of kairomonal baits, containing curcurbitacins, bloom volatiles, and carbaryl, on Diabroticite adult survivorship and trophic interactions with cucurbits was examined. Enrichment of cantaloupes using rubidium (Rb) was developed for monitoring trophic interactions. A soil-soak method was developed to enrich plant Rb concentrations. Beetle uptake of Rb followed a rectangular hyperbola and elimination after transfer to clean plants followed an exponential decay. Models showed beetle uptake occurred within 1 h and the mark is retained up to 2 wk. Naturally occurring endogenous Rb concentrations in beetles varied with species and sex. Baselines were established to allow determination of the incidence and intensity of beetle feeding on Rb-enriched plants. In field cages, kairomonal baits reduced the probability and intensity of feeding on cucurbits by *Diabrotica undecimpunctata howardii* (Barber) and *Acalymma vittata* (F.). In one trial, kairomonal baits totally blocked feeding interactions. In field plots, baits also significantly reduced feeding incidence and intensity in *D. u. howardii* and *D. virgifera virgifera* (LeConte), but not in *A. vittata*. Where the bait reduced feeding, males showed less reduction than females. In *D. v. virgifera*, there was a higher probability of capturing live males than females regardless of kairomonal treatment. Adult survivorship was reduced by the kairomonal bait in both field and cage experiments. These novel methods
allow the monitoring of trophic interactions under field conditions in the presence of behavior-modifying semiochemicals. Hypotheses to explain variation among species and sex and implications of using kairomonal baits to manage vectoring of a pathogen are discussed.


AB: Serological assays were used to estimate the proportion of *Acalymma vittata* (F.) that harbored *Erwinia tracheiphila* (E. F. Smith) Holland, the causal agent of bacterial wilt in cucurbits. These proportions were related to the proportion of *A. vittata* that transmitted disease in single beetle caged bioassays. The serological assays classified beetles as harboring the bacteria when the titer was above approximately equal to 10(5) cells per beetle. From 7.1 to 10.7% of the *A. vittata* captured as they emerged from soil that had been in cucurbits the previous year tested positive for the presence of *E. tracheiphila*. Also, from 0 to 8.3% of beetles captured on squash traps during this time of beetle emergence tested positive. This provides strong serological evidence for *A. vittata* serving as the primary overwintering reservoir for *E. tracheiphila*. During the growing season, the proportion of beetles testing positive with serological assays varied and ranged up to approximately equal to 53, 78, and 39% in 1995, 1996, and 1997, respectively. These serological proportions were 3.6-5.1 times higher than the proportion of beetles that transmitted disease in single beetle caged bioassays, and explained 44-49% of the variation in the proportion of beetles that were able to transmit disease in the caged bioassays. We suggest the proportion of *A. vittata* that harbored at least some *E. tracheiphila* cells may be > 5 times higher than the proportion of beetles that can, alone, transmit disease in a short time. We discuss these data as supporting the hypothesis of beetle aggregation behavior as an important component of bacterial wilt epidemiology.


The systemic nitroguanidine insecticide imidacloprid was investigated in cantaloupes, *Cucumis melo* L. variety *reticulatus*, for management of *Acalymma vittata* (F.) and bacterial wilt caused by *Erwinia tracheiphila* (E. F. Smith) Holland that is vectored by this beetle. The influence of management strategies using imidacloprid upon plant growth and development, beetle population dynamics, and bacterial wilt disease incidence and severity was evaluated. Application of imidacloprid to seedlings at higher doses caused short-term marginal leaf necrosis, and biomass of seedlings was reduced in an approximately linear pattern with increasing dose on a log scale up to 0.01 g (AI) per plant. Application to seedlings at doses low enough to avoid any phytotoxicity resulted in adult *A. vittata* mortality rates that declined exponentially with time. Exponential decay models of bioassay data suggested approximately 11 d of 100% adult mortality was
achieved with low rates applied to seedlings before transplanting. Applications to seedlings delayed adult immigration, and the combination of seedling application and limited foliar sprays resulted in significant increases in yield. Addition of imidacloprid at low rates to seedlings combined with 2 foliar sprays, or application to seedlings combined with an application through drip irrigation and 2 foliar sprays, was not effective in reducing the proportion of cantaloupe plants that showed bacterial wilt symptoms but did significantly reduce severity of the disease. The results suggest that low rates of imidacloprid applied before or near the time of transplanting, at times combined with few foliar sprays, could dramatically improve crop productivity via influence upon both a herbivore and a plant pathogen vectored by the herbivore.


*Abstract Missing


Foliar insecticides applied to control the striped and spotted cucumber beetles, Acalymma vittatum (Fab.) and Diabrotica undecimpunctata howardi Barber, on watermelon, Citrullus lanatus, were of little or no value in three studies conducted in two locations over 2 years. However, an at-planting application of the systemic, soil insecticide carbofuran resulted in higher early yields, although the differences were not statistically significant in small plots. In 1991, large plots comparing carbofuran-treated watermelons with untreated watermelons in two commercial fields showed large and statistically significant increases in melon yield when carbofuran was applied, especially in early yield. Studies in 1992 and 1993 showed that the application of carbofuran at planting stimulated root and shoot growth after transplanting and increased yields when compared with untreated plots, plots treated with methyl bromide, or another soil insecticide, terbufos. These studies suggest that carbofuran may be acting as a growth stimulant, as well as an insecticide.


DAS-ELISA, immunohistochemistry and electron microscopy were used to investigate the association of the causal agent of bacterial wilt, Erwinia tracheiphila (Smith), within the beetle Acalyamma vittatum (F.). After a 24-h acquisition period, a high percentage of
individuals tested positive for *E. tracheiphila* antigen using both immunohistochemistry (100%) and DAS-ELISA (70-60%). Both assays showed that the antigen remained in beetles long after the initial acquisition, with the percentage declining during incubation. Using ELISA, the percentage decreased to 4.7% within 3 d after acquisition, then increased to 10% within 10 d and remained at 10% for 30 d. Immunoperoxidase assays of paraffin embedded gut sections were more sensitive, and showed that 95% of the beetles harbored the pathogen after 10 d and 20% after 30 d. *E. tracheiphila* antigen was present throughout the digestive tract soon after acquisition, but only small clusters of *E. tracheiphila* were observed along the alimentary canal 3 d after transfer onto clean plants. After 10 and 30 d on clean plants, *E. tracheiphila* antigen reaction was stronger and clusters of bacteria were more numerous, primarily in the posterior midgut and anterior portion of the hindgut. Scanning electron microscopy and TEM photomicrographs confirmed the presence of bacterial cells resembling *E. tracheiphila* associated with the intima of the hindgut 1 and 30 d after acquisition. This demonstrated the sensitivity of immunohistochemistry for detecting *E. tracheiphila* within its vector, and suggests a long-term extracellular endosymbiotic association of *E. tracheiphila* with the alimentary canal of *A. vittatum*.


Electrophoretic analyses of extracts of cucumber leaves infected with *Colletotrichum lagenarium* *Fusarium oxysporum* f. sp. *Cucumerinum*, *Pseudomonas lachrymans*, *Erwinia tracheiphila*, tobacco necrosis virus or cucumber mosaic virus revealed the presence of a protein band with an Rf value of 0.50-0.60 (based on mobility of bromophenol blue) on 10% polyacrylamide gel. This band was not evident in extracts of healthy or mechanically wounded leaves. The protein was not detected in uninfect ed leaves of infected plants, but it was detected in similar amounts in infected leaves and in secondarily challenged leaves of infected plants even though symptoms were not apparent on the latter. The protein had a molecular weight of approximately 16 000 d, was adsorbed on DEAE-cellulose, did not react with Schiff’s reagent, and did not have ribonuclease activity. When injected into cucumber leaves, it did not inhibit germination of conidia of *C. lagenarium* or induce resistance against disease caused by the fungus.


Temperature affected survival of *Verticillium albo-atrum* Reinke & Berthold, the causal organism of verticillium wilt on alfalfa, carried on the bodies of pea aphids, *Acyrthosiphon pisum* Harris, or the feces of grasshoppers, *Melanoplus sanguinipes* F. The pathogen survived well at -40°C; as the temperature increased the survival decreased and became very poor at 15°C. Percentage of viable *V. albo-atrum* on insect bodies and on
insect feces in samples stored at \(-40^\circ\)C for 24 mo remained unchanged. However, in samples stored at \(15^\circ\)C, no viable \(V.\ albo-atrum\) was detected on pea aphids after a storage period of 5 mo and in grasshopper feces after 21 mo. These results indicate that the pathogen carried by insect vectors could overwinter very low temperatures in alfalfa fields in the Canadian Prairies.

Harris, H.A. 1940. Comparative Wilt Induction by \(Erwinia\ tracheiphila\) and \(Phytomonas\ stewartii\). Phytopathology 30(8):625-638.

The wilt of cucumber infected with \(Erwinia\ tracheiphila\) and of sweet corn infected with \(Phytomonas\ stewartii\) has been investigated. The data recorded for the transpiration histories of the plants infected with \(E.\ tracheiphila\) and \(Phyt.\ Stewarti\) show a decrease in the transpiration losses during the initial stages of wilting. The results fluometrically recorded for stems infected with these two organisms show a marked reduction for the water flow through these stems as compared with noninfected stems. The filtrates of both \(E.\ tracheiphila\) and of \(Phyt.\ Stewarti\), from cultures of the organisms in beef-extract broth solution, induced wilting of cuttings of cucumber and sweet corn. The transpiration and fluometric data obtained suggest that the wilting induced by \(E.\ tracheiphila\) and \(Phyt.\ Stewarti\) is caused primarily by a mechanical plugging of the water-conduction system.


In Cucumber (\(Cucumis\ sativus\) L.) no linkage was detected between genes for scab resistance, \(Ccu\) or bacterial wilt resistance, \(Bw\) and the 10 seedling market genes: nonbitter cotyledon, \(bi\); glabrous, \(gl\); glabrate, \(glb\); light sensitive, \(ls\); revolute leaf, \(cr\); mottled cotyledon, \(mc\); and 2 yellow cotyledon genes, \(ye-1\) and \(ye-2\). All 12 traits were inherited monogenically. Methods were developed for the screening of scab and bacterial wilt resistance in the seedling stage.


Spotted and striped cucumber beetles (\(Diabrotica\ undecimpunctata\ howardi\) Barber and \(Acalymma\ vittata\) Fab., respectively) caused significantly more damage to bitter cucumber (\(Cucumis\ sativus\) L.) wilted by drought or infection by \(Erwinia\ tracheiphila\) E.F.S.-Holland than to bitter non-wilted plants. Bitter wilted plants had significantly more cucurbitacin than did bitter non-wilted material.

Herbert, D.A., Ang, B.N., and Hodges, R.L. 1996. Attractants for Adult Southern Corn Rootworm (Coleoptera: Chrysomelidae) Monitoring in Peanut Fields and

Field studies were conducted in 12 locations in southeastern Virginia to evaluate 3 trap attractants, 1,2,4-trimethoxybenzene, indole and trans-cinnamaldehyde (TIC), trans-cinnamaldehyde, alone, and sex pheromone (10-methyl-2-tridecanone), for monitoring adult southern corn rootworm, Diabrotica undecimpunctata howardi Barber, phenology in peanut, Arachis hypogaea L.; and to determine the relationship of trap catch to peanut pod damage as it occurred throughout the season. Pheromone traps caught more beetles than TIC or cinnamaldehyde on most sample dates and at most locations. Pheromone traps detected 2 distinct beetle peaks, the 1st between 16 and 23 June, and the 2nd between 21 and 28 July, and consistently caught more males than females. TIC and cinnamaldehyde traps caught more females in 14 out of 180 observations (15 sample dates, 12 locations) and failed to detect the 2nd beetle peak. Peanut pod damage began to increase in all locations at the end of July. Total pod damage (immature plus mature pods) exceeded 40% in all but one location. Peak damage occurred at all but 1 location on approximately 11 August. Peak pod damage by southern corn rootworm larvae consistently lagged behind the 2nd peak in the beetle population by 2.1 +/- 0.5 (+/- SEM) wk. Number of beetles trapped accounted for only 10% of the variance observed in peak pod damage. Use of pheromone traps by growers could allow for a more precise timing of insecticide applications and improve management of southern corn rootworm in peanut.


The distributions of diabroticine beetles were studied among patches of wild Cucurbita foetidessima that were undisturbed by mowing, in mowed patches, and among other wild hosts in south Texas during 1996 and 1997. Three species were commonly found in patches of wild C. foetidessima: Diabrotica balteata, Acalymma vittatum, and D. undecimpunctata howardi. D. balteata aggregated heavily on cut fruit of C. foetidessima, but A. vittatum were found in flowers even in the presence of cut fruit. D. u. howardi were found in flowers and cut fruit in roughly equal numbers. D. balteata were also found in three flowers of Argemone albiflora located among blossoming C. foetidessima plants. D. u. howardi were found on several other species of wild host plants besides C. foetidessima


Seventy-six Cucurbita pepo L. cultivars and breeding lines were evaluated under field conditions for infestation levels and defoliation (leaf area consumed by beetles) by adult
diabroticite beetles in 1992 and 1994. Striped and spotted cucumber beetles, *Acalymma vittatum* (F.) and *Diabrotica undecimpunctata howardi* Barber, respectively, were most common, but some western and northern corn rootworms, *D. virgifera virgifera* LeConte and *D. barberi* Smith and Lawrence, respectively, also were present. In general, pumpkin, delicate, acorn winter squash, scallop, and yellow straightneck summer squash types were the least infested and defoliated. Caserta/yellow, zucchini, caserta/xucchini, caserta, and precocious yellow straightneck types were the most infested and defoliated. The number of beetles per plant was correlated (*r* > 0.72) with leaf defoliation and proportion of plants infested, indicating that beetle infestation is a good predictor of damage. The cultivars and breeding lines that were the least infested and defoliated can be used in breeding programs to develop desirable genotypes with reduced beetle preference. Conversely, those genotypes that were highly preferred have potential as trap crops for these beetle pests.


Field and laboratory studies were conducted to examine the relationship between foliar feeding damage caused by striped cucumber beetle, *Acalymma vittatum* (F.) (*Coleoptera: Chrysomelidae*), and yield of pumpkin, *Cucurbita pepo* L. (var. Spookie). In field trials in 1996 and 1997, plants were artificially infested with varying numbers of beetles at the cotyledon-, first-, second-, or third-leaf stages. At harvest, fruit number, fruit mass, and fruit maturity were evaluated. Foliar feeding damage had little effect on yield other than a slight increase in number of fruit per plant for plants with 1 to 20% damage. The stage of plant development at infestation had no effect on yield, nor did the interaction of foliar feeding damage and growth stage. In a laboratory trial, varying numbers of *A. vittatum* were allowed to feed for 1, 2, 3, or 4 d on plants at cotyledon-, first-, second-, or third-leaf stages. For all stages, significant and differing positive linear relationships were observed when the percentage of foliar feeding damage was regressed against beetle-days. The results indicated that small fruited, vining pumpkins can tolerate relatively high levels of striped cucumber beetle feeding injury. Foliar feeding damage thresholds are conservatively estimated to be similar to 60% during cotyledon through third leaf stage of growth.


Field studies were conducted to characterize the yield responses of pumpkin, *Cucurbita pepo* L., and winter squash, *Cucurbita maxima* Duch., to simulated striped cucumber beetle, *Acalymma vittatum* (F.), feeding damage. Preliminary studies in pumpkin (‘Spookie’) were conducted in 1993, and more complete studies in 1994 and 1995 in pumpkin (Spookie), and in 1995 and 1996 in winter squash (‘Waltham’). Plants were
artificially injured 1 time at the cotyledon, 1st, 2nd, or 3rd true leaf stages by clipping specified percentages of leaf area from all leaves on the plant. Treatments consisted of a control treatment with no simulated injury and 4 levels of simulated injury. Pumpkin treatments were 10, 20, 40, and 80% leaf area removal in 1993 and 1994 and 20, 40, 60, and 80% in 1995. Winter squash treatments were 20, 40, 60, and 80% leaf area removal in 1995, and 10, 20, 40 and 80% in 1996. In 1993, 5 wk after planting, mean leaf, stem, and total dry weight were significantly lower on pumpkin plants subjected to greater than or equal to 20% simulated leaf injury regardless of the growth stage when the injury occurred. Injury at the 3rd leaf stage resulted in a significant reduction in the mean leaf and total dry weight of plant, across all levels of injury. At 2-3 wk before crop maturity, fruit weight and number of fruit per plant were significantly lower with 80% leaf area removal. In 1994 and 1995, and when pumpkins were grown to full maturity and apparently able to compensate for the simulated damage, neither number nor weight of marketable fruit per plant were affected significantly by simulated injury at any stage of development nor level of simulated injury. In contrast, greater than or equal to 20% and 80% leaf area removal to winter squash resulted in significant reductions in the weight of marketable fruit and/or number of marketable fruit, in 1995 and 1996, respectively. The results of this study indicate that pumpkins can tolerate relatively high levels of simulated defoliation, whereas winter squash is less tolerant. Variable results across years in winter squash may indicate an interaction between injury and plant stress caused by abiotic factors such as soil moisture availability.


Sticky traps with and without the attractant TIC (1,2,4-trimethoxybenze, indole, and trans-cinnamaldehyde) were evaluated in cucurbits for capture of striped cucumber beetle, Acalymma vittatum (F.), spotted cucumber beetle, Diabrotica undecimpunctata howardi Barber, western corn rootworm, Diabrotica virgifera virgifera LeConte, and northern corn rootworm, D. barberi Smith & Lawrence, in New York and western striped cucumber beetle, Acalymma trivittatum (Mannerheim), and western spotted cucumber beetle, Diabrotica undecimpunctata undecimpunctata Mannerheim, in California. Traps with TIC lures captured more beetles than unbaited traps for all species except for western spotted cucumber beetle in 1 of 2 California trials. Yellow traps captured more striped cucumber beetle and western spotted cucumber beetle than did white traps but did not increase capture of spotted cucumber beetle or western striped cucumber beetle. The response of the western corn rootworm and northern corn rootworm to TIC varied by time of day, the greatest response occurring around midday. Increases in TIC per trap resulted in increases in capture of western spotted cucumber beetle, western striped cucumber beetle, western corn rootworm, and striped cucumber beetle, but not for northern corn rootworm or spotted cucumber beetle. For cucurbits with short plant canopies, traps were most effective when placed close to the ground. In pumpkins with taller canopies, traps at canopy and midcanopy height captured the most beetles. The effect of trap height varied by time of day for spotted cucumber beetle, western corn
rootworm, and northern corn rootworm, and the pattern varied for the species. Sex ratio of captured beetles varied among species and time of day. Overall, western corn rootworm and northern corn rootworm were captured in greatest numbers during the middle of the day whereas the greatest captures of striped cucumber beetle occurred between 1800 and 0600 hours EST. Significantly greater numbers of striped cucumber beetle, western corn rootworm, and northern corn rootworm were captured on the downwind side of traps. Traps replaced 2 times per day had greater captures than traps replaced 1 time per day or 1 time every 2 days.


Sticky traps with and without the attractant TIC (1,2,4-trimethoxybenzene, indole, and trans-cinnamaldehyde) were evaluated in cucurbits for capture of striped cucumber beetle, *Acalyymma vittatum* (F.), spotted cucumber beetle, *Diabrotica undecimpunctata howardi* Barber, western corn rootworm, *Diabrotica virgifera virgifera* LeConte, and northern corn rootworm, *D. barberi* Smith & Lawrence, in New York and western striped cucumber beetle, *Acalyymma trivittatum* (Mannerheim), and western spotted cucumber beetle, *Diabrotica undecimpunctata undecimpunctata* Mannerheim, in California. Traps with TIC lures captured more beetles than unbaited traps for all species except for western spotted cucumber beetle in 1 of 2 California trials. Yellow traps captured more striped cucumber beetle and western spotted cucumber beetle than did white traps but did not increase capture of spotted cucumber beetle or western striped cucumber beetle. The response of the western corn rootworm and northern corn rootworm to TIC varied by time of day, the greatest response occurring around midday. Increases in TIC per trap resulted in increases in capture of western spotted cucumber beetle, western striped cucumber beetle, western corn rootworm, and striped cucumber beetle, but not for northern corn rootworm or spotted cucumber beetle. For cucurbits with short plant canopies, traps were most effective when placed close to the ground. In pumpkins with taller canopies, traps at canopy and midcanopy height captured the most beetles. The effect of trap height varied by time of day for spotted cucumber beetle, western corn rootworm, and northern corn rootworm, and the pattern varied for the species. Sex ratio of captured beetles varied among species and time of day. Overall, western corn rootworm and northern corn rootworm were captured in greatest numbers during the middle of the day whereas the greatest captures of striped cucumber beetle occurred between 1800 and 0600 hours EST. Significantly greater numbers of striped cucumber beetle, western corn rootworm, and northern corn rootworm were captured on the downwind side of traps. Traps replaced 2 times per day had greater captures than traps replaced 1 time per day or 1 time every 2 days.

Seventy-six *Cucurbita pepo* L. cultivars and breeding lines were evaluated under field conditions for infestation levels and defoliation (leaf area consumed by beetles) by adult diabroticite beetles in 1992 and 1994. Striped and spotted cucumber beetles, *Acalymma vittatum* (F.) and *Diabrotica undecimpunctata howardi* Barber, respectively, were most common, but some western and northern corn rootworms, *D. virgifera virgifera* LeConte and *D. barberi* Smith and Lawrence, respectively, also were present. In general, pumpkin, delicata, acorn winter squash, scallop, and yellow straightneck summer squash types were the least infested and defoliated, *Caserta/yellow*, zucchini, *caserta/zucchini*, caserta, and precocious yellow straightneck types were the most infested and defoliated. The number of beetles per plant was correlated (r greater than or equal to 0.72) with leaf defoliation and proportion of plants infested, indicating that beetle infestation is a good predictor of damage. The cultivars and breeding lines that were the least infested and defoliated can be used in breeding programs to develop desirable genotypes with reduced beetle preference, Conversely, those genotypes that were highly preferred have potential as trap crops for these beetle pests.


The leaf-feeding preferences of the striped cucumber beetle, *Acalymma vittatum* (F.), were determined in paired comparison tests among 8 species of New and Old World Cucurbitaceae. *Cucurbita maxima* Duch., of probable South American origin, and *Cucumis sativus* L. of Old World origin were most preferred for feeding. *Cucurbita pepo* L., *C. mixta* Pang., and *C. moschata* Poir. were intermediate in preference. These 3 cucurbits are thought to have originated in Mexico within the recorded area of present-day *A. vittatum* distribution. The least preferred were Old World species *Citrullus vulgaris* Schrad., *Cucumis melo* L., and Lagenaria siceraria (Mol.) Standl.


A culture of the striped cucumber beetle has been maintained for 2 years by using 6-8 larval rearing trays in rotation without egg sterilization. Ease of maintaining the culture and minimal requirements of labor and equipment make this method useful for continuous production of small numbers of living forms.


Alfalfa leaves infected with *Verticillium albo-atrum* were fed to leaf-chewing insects--grasshoppers (*Melanoplus sanguinipes* and *M. bivittatus*), alfalfa weevil (*Hypera postica*),
and woolly bear (Apantesis blakei)—to determine survival of the pathogen after passage through their digestive tracts. V. albo-atrum survived in the digestive tracts of all tested species, usually first appearing in the feces 1 day after feeding. The percentage of feces contaminated by V. albo-atrum varied among individuals within species and was related to the duration of feeding on diseased tissues. The average percentage of contaminated feces in adult M. sanguinipes was less than 14% after 1 day of feeding the insects with diseased tissue but increased to 49% after 3 days of feeding. V. albo-atrum was eliminated from the digestive tracts of grasshoppers by changing the diet to uninfected alfalfa leaves. The time required to be related to the level of contamination in digestive tracts, averaging 1.6 days for individuals with less than 25% of pathogen-contaminated feces and 6.1 days for those with more than 75% of contaminated feces in their digestive tracts. When grasshopper feces contaminated with V. albo-atrum were buried near roots of alfalfa seedlings, 20.8 and 13% of plants became infected and developed wilt symptoms after 6 wk in experiments 1 and 2, respectively. The role of leaf-chewing insects in the dissemination of V. albo-atrum in alfalfa and other crops is discussed.

Hummel, H. E, and Metcalf, R. L. 1996. Diabrotica Barberi and D. Virgifera Virgifera Fail to Orient Towards Sticky Traps in Maize Fields Permeated with the Plant Kairomones 4-Methoxy-Phenylethanol and 4-Methoxy-Trans-Cinnamaldehyde. 61:1011-1018

Plant parakairomones, inexpensive synthetic analogs of plant kairomones, offer alternative routes to orientation disruption of Diabrotica beetle species in Zea mays. Three disruption attempts from the late summer of 1994 and 1995 indicate modest to strong effects in adult Diabrotica populations.

1. In 1994, 4-methoxyphenylethanol (MPE), dispensed from blotter paper sources at 80g/ha on small plots of 120 square meters, disrupted orientation of D. barberi beetles toward MPE baited sticky traps at the level of 40 to 100% against untreated control plots. The same treatment disrupted D. virgifera virgifera beetles at levels between 18 and 47%.
2. In 1995, MPE treatments on 1000 square meters with 350 g/ha disrupted D. barberi at levels between 50 and 100%, D. virgifera virgifera at levels between 0 and 94%.
3. In 1995, 4-methoxy-cinnamaldehyde (MCA) test runs on small plots of 1 square meter, 9 square meters, and 25 square meters size disrupted d. virgifera virgifera at levels of 37%, 94%, and 84% respectively.


A strong linkage (~1 crossover unit) was detected between the gene Bw for resistance to bacterial wilt incited by Erwinia tracheiphila (E.F. Smith) Holland and the gene M for pistillate vs. perfect flowers in cucumber (Cucumis sativus L.).

This chapter discusses the rearing and handling of *Diabrotica virgifera* and *Diabrotica undecimpunctata howardi*. This chapter presents the critical environmental requirements, materials, handling methods, and evaluation techniques frequently used to rear or manipulate populations of the western and southern corn rootworm in the laboratory.


Quantification of the size of epiphytic bacterial populations and characterization of their composition involves definition of a sampling strategy in time and space, the choice of methods for liberating the bacteria from the leaf surface and for recovering them for subsequent determination of the number of viable or cultural cells. This literature review focuses on some of the issues related to these choices. After briefly reviewing the different types of epiphytic colonizers we consider the biological, methodological, and statistical consequences of the choice of the sampling unit and of the spatial and temporal variability of population size and composition for epiphytic bacteria. The different methods available for the detection and enumeration of naturally occurring microorganisms in the phyllosphere are discussed. Advantages and drawbacks of each are described in this review designed as a “hands-on” guide.


In field trapping studies in central Florida during the fall of 1981 and the spring, summer, and fall of 1982, more *Diaprepes abbreviatus* (L.) were captured with frass or frass extracts than with other treatments. Extracts of frass from male weevils in traps captured more males or females than extracts of frass from female weevils. Extracts of frass in methanol captured more weevils at high than at low concentration.


1. This paper analyses catches of flower thrips, grass thrips and predatory flies in water-traps of seven colours.
2. A correlation is demonstrated between type of host-plant of thrips and the relative numbers caught by traps of different colours.
3. The literature is reviewed and some general relationships with the effectiveness of different trap colours are hypothesized for: non-grass foliage insects and their predators and parasites; grass foliage insects; flower dwelling insects; predators and parasites not associated with foliage; biting insects; and woodborers.

4. This may permit trap colours to be chosen, in particular circumstances, that are ecologically selective for different types of insect.


Gel electrophoretic techniques were used to resolve allozymes representing nine known or putative genetic loci for Acalymma blandulum LeConte; Paranapiacaba tricincta (Say); Diabrotica balteata LeConte; D. barberi Smith & Lawrence; D. cristata (Harris); D. lemmicata LeConte; D. longicornis (Say); D. undecimpunctata howardi Barber; d. virgifera virgifera LeConte; D. virgifera zeae Krysan & Smith; and D. sp., an undescribed species from Mexico. The Rogers’s (modified) indices of genetic distance paralleled closely the relationships expected from existing taxonomic classifications. A phenogram constructed from the Rogers’s distances indicated the following relationships: the species from two established groups of Diabrotica formed cohesive clusters; D. barberi, D. cristata, and D. longicornis, three species with Nearctic origins, are closely related; D. barberi and D. virgifera occupy the corn field habitat by convergence; the response of males to stereoisomers of sex attractants is evolutionarily plastic; and premating isolation mechanisms are stronger among closely related sympatric species than among more distantly related allopatric species.


Cutical distribution of propagules of Phytophthora palmivora morphological form (MF) 4 (cause root rot of Piper nigrum) in the field decreases with increasing soil depth and is highest at 0.5-15 cm and very low 30-45 cm. Soil moisture and pH greatly affected survival of P. palmivora MF4. The optimum soil moisture for survival was 25-45% water-holding capacity, at soil pH 6.5-7.0. The pathogen survived at a maximum of 18 mo in its natural habitat, as assessed by continuous baiting. Fungal propagules were found in snail (Achatina fulica) feces in three pepper plantations. Sporangia survived and remained infective after passage through the alimentary canals of two snail species (A. fulica and Hemiplecta crossei).

Field tests conducted in a relict prairie using sticky traps baited with a broad range of adult diabroticine attractants showed *Diabrotica cristata* (Harris) shares some chemosensory responses with both *D. barberi* Smith and Lawrence and *D. virgifera virgifera* LeConte. *D. cristata* was attracted to estragole, β-ionone, para-methoxycinnamaldehyde, and a mixture of trimethoxybenzene, indole, and cinnamaldehyde (=TIC mixture) (attractants for adults of *D. virgifera virgifera* in corn tests), as well as eugenol, isoeugenol, and cinnamyl alcohol (attractants for adults of *D. barberi* in corn tests). Several of the active compounds, such as cinnamyl alcohol and β-ionone, are structurally distinct from the previously described eugenol-type attractants for *D. barberi* and *D. cristata* and represent new semiochemicals for the genus. In the prairie trials, *D. barberi* adults were anomalously attracted to two lures (estragole and the TIC mixture) that were not active in corn evaluations.


The attraction of *Diabrotica* spp. (Coleoptera: Chrysomelidae) to single-component and multicomponent lures was evaluated in corn fields by comparing the relative number of beetles caught on sticky traps over a 24-h period. Initial tests in 1985 showed that a mixture of veratrole (V), indole (I), phenylacetaldehyde (P), trans-anethole (A), and eugenol (E) (=VIPAE mixture) caught 26 times more *Diabrotica undecimpunctata howardi* Barber, southern corn rootworms (SCR), than untreated control traps and was at least 3 times more active than any of the traps baited with a single component. Significantly fewer *D. virgifera virgifera* LeConte, western corn rootworms (WCR), were caught on the traps baited with VIPAE mixture than those baited with 100 mg of trans-anethole. Furthermore, only SCR adults exhibited a concentration-dependent response to the VIPAE mixture. SCR response to the sequential removal of the individual components from the VIPAE mixture suggested the primary attractants to be veratrole, indole, and phenylacetaldehyde. Additional tests showed traps baited with a three-component VIP mixture (veratrole, indole, and phenylacetalehyde at 20 mg per component) caught ca. 8 times as many beetles as the expected mean additive response with the individual components; therefore, the SCR response was synergistic. The attraction and synergistic response of SCR adults to the VIP mixture was verified by similar tests conducted in 1986. The VIP mixture was also compared with a chemically related mixture consisting of 1,2,4-trimethoxybenzene (substituted for veratrole or ortho-dimethoxybenzene), indole, and *trans*-cinnamaldehyde (substituted for phenylacetaldehyde) (=TIC mixture) at dosages ranging from 1 to 30 mg per trap. Although both mixtures exhibited approximately the same activity for SCR adults, only the new TIC mixture attracted WCR adults. TIC baited traps caught ca. 6 times more WCR adults than did untreated controls at 1 mg per trap and ca. 29 times more WCR adults than controls at 30 mg per trap.
During the summers of 1984 and 1985, a variety of structurally related benzenoid compounds was evaluated in sweet corn plots as attractants for adult southern corn rootworms (SCR), western corn rootworms (WCR), and northern corn rootworms (NCR). Field response to the volatiles was measured by beetle counts on baited cylindrical sticky traps placed inside the corn plots at a height of 1 m above ground level. SCR adults were attracted late in the season (last week of August through September, 1984 and 1985) to numerous aromatic compounds, including phenylacetaldehyde, benzyl acetone, phenethyl alcohol, phenyl acetate, indole, veratrole, methyl eugenol, methyl isoeugenol, eugenol, and isoeugenol. Although many compounds attracted SCR adults late in the season, only veratrole, phenylacetaldehyde, and chavicol were significantly active in early and middle August 1985. WCR adults were attracted to a different group of compounds, namely estragole, \textit{trans}-anethole, and indole. Estragole (4-methoxy-1-allylbenzene) was an effective WCR attractant from corn tasseling in early August 1985, until the end of the trapping period in late September and early October 1985. Indole and \textit{trans}-anethole (4-methoxy-1-allylbenzene) were less effective attractants than estragole and were most active at the beginning and/or end of the corn season. Traps baited with 100 mg of estragole caught an average of 20 times more WCR adults than unbaited control traps, and the females outnumbered the males in the baited traps. Estragole dosage tests were conducted in three sweet corn plots on different dates in 1985 and the minimum effective dose ranged between 5 and 30 mg/trap. Field tests with structural analogs revealed the importance of the site of unsaturation in the allylic side chain of estragole and the effect of different ring substituents on WCF response. The phenylpropanoids, eugenol and isoeugenol, significantly attracted NCR adults, even though these beetles were in low abundance in the test corn plots. Field tests indicated there is no cross-species response by WCF and NCF adults to their related phenylpropanoid attractants. However, in late August, SCR adults do respond to some WCF and NCF attractants (indole and several eugenol analogs). Electroantennographic analysis of SCR males revealed they can perceive peripherally a wide range of benzenoid compounds.


A field of maize in Texas was used to evaluate responses of Mexican corn rootworm beetles, \textit{Diabrotica virgifera zeae} Krysan and Smith, to ten volatiles or blends of volatiles that are known attractants of other Diabrotica beetles. Traps baited with 100 mg of any of the attractants captured significantly more male and female \textit{D. v. zeae} than did unbaited traps, but the increase in capture was greater for female beetles than for males. Traps baited with a 1:1:1 mixture of trimethoxybenzene, indole and cinnamaldehyde ("TIC") captured the greatest number of females (a 50-fold increase over capture on unbaited
traps) but did not capture significantly more beetles than traps baited with a 1:1:1 mixture of veratrole, indole and phenylacetaldehyde ("VIP") or with indole alone. When this test was duplicated in South Dakota where the subspecies present is D. v. virgifera responses of females to the attractants were generally similar to those of female D. v. zaeae, although relatively more D. v. virgifera females were captured in traps baited with 4-methoxycinnamaldehyde. Male D. v. virgifera were less responsive to the volatiles than were females, but relative responses of male D. v. virgifera to the various volatiles differed from those of male D. v. zaeae. In a third study, D. v. zaeae showed little dose-response to four levels (0.1-100 mg) of 4-methoxycinnamaldehyde, although traps baited with 100 mg captured significantly more females than did traps baited with lesser amounts. The availability of non-pheromonal attractants for D. v. zaeae may prove useful to programs for managing populations of this pest species.


Leaf-disk feeding tests were conducted to determine the effect of various chemicals on southern corn rootworm, Diabrotica undecimpunctata howardi Barber, larval feeding. Ethanolic extracts of plant seeds from the family Meliaceae were all highly active feeding deterrents, while hexane extracts were ineffective as deterrents. In leaf disk feeding tests, the fungicide thiram (tetramethylthiuram disulfide), as technical material or formulated as thiram 50% or 75% (AI) was also an effective feeding deterrent. In choice tests, a thiram-based deterrents were equally effective, while in no-choice tests, thiram-75 was most effective at preventing feeding. Thiram-75 was also effective in protecting corn seedlings in a soil bioassay [missing] the field environment. It was determined that the formulation of thiram-75 used in these tests had bee contaminated with 0.87% dieldrin (by weight). The contaminated thiram-75 had a toxic action, [missing] as a deterrent effect of southern corn rootworm larvae and both factors contributed to overall feeding inhibition. Toxicity was not found in technical thiram or in thiram-50. The mode(s) of action of the various deterrents are discussed in relation to screening procedures.


*Abstract Missing


Striped and spotted cucumber beetles (Acalymma vittata and Diabrotica undecimpunctata) were captured, embedded in paraffin, sectioned, and stained. Observations of the location and condition of Erwinia tracheiphila found in the gut were
made. Bacteria were also isolated from the guts of live beetles. The author hypothesizes several mechanisms for transfer of the bacteria from beetle to plant.


A large field trial was conducted to determine if cucurbitacin baits could reduce WCR beetle populations sufficiently to reduce egg laying and thus prevent larval damage to a subsequent corn crop. The field was divided into 8 plots, four untreated and four treated with dried Cucurbita baits. Beetle abundance declined abruptly after treatment (84.8% vs 37.6% for the treated and untreated plots, respectively). After the first application, beetle counts were still higher than the threshold, so baits were reapplied 1 week later. Again, beetle densities declined sharply in the treated plots. The highest beetle mortality due to baiting was achieved one day after treatment. The sex ratio (male:female) of the beetles collected prior to and post-treatment was 0.62, whereas this ratio for the dead beetles collected was 1.56. This could indicate that the males were more likely to come in contact with the bait than the females. Other results from this study were that females in the untreated plots had the opportunity to remain alive and develop further, whereas the existing females in the treated plots were killed by the bait. There were no statistical differences for the number of eggs extracted from the soil between the untreated and treated plots.


In the absence of contact and visual stimuli, significant numbers of adult striped cucumber beetles, Acalymma vittatum (F.), were caught on veiled sticky cups containing either squash seedlings or blossoms. The role of volatile kairomones in host finding was further demonstrated by the attraction of A. vittatum adults to a synthetic odor mimic of cucurbit blossoms (a mixture of 1,2,4-trimethoxybenzene, indole, and trans-cinnamaldehyde [TIC]. From July to late August 1988, TIC-baited traps caught 4-100 times more adult beetles than controls. Although indole was the most active single component of TIC, the slope of the log-dose response curve for the TIC-baited traps was 7 times greater than the slope for the indole-baited traps. Traps baited with the three-component mixture caught twice as many beetles as the theoretical additive response based on the trap catches of the individual components. Several phenylpropanoid attractants for Diabrotica species and other squash blossom odor components also were bioassayed in field tests, but none was as active as TIC or indole.

*Abstract Missing*


In response to increased grower concerns, research was undertaken to investigate field biology, insecticide resistance and integrated management of striped cucumber beetle (SCB), *Acalymma vittatum* (F.), the most important insect pest of Cucurbitaceae in Ontario. Mini-Masner and baited yellow sticky traps revealed that, in southwestern Ontario, SCB are univoltine, overwintered adults entering cucurbit fields as plants emerge or are transplanted. Field studies found that foliar application of currently recommended azinphosmethyl or endosulfan effectively protected cucurbit foliage for only four days. Laboratory bioassays identified acetamiprid, imidacloprid, thiamethoxam, carbaryl, and cypermethrin as potentially effective alternative insecticides for SCB control. Application of imidacloprid as a planting water or seed treatment respectively protected developing seedlings for as long as four and five weeks. Trap rows of squash grown from seed treated with imidacloprid did not provide consistent protection of cucumber seedlings. Planting water and, especially seed treatments for SCB control in cucurbits could realize significant economic and environmental benefits for Ontario growers. A sustainable integrated SCB management strategy for Ontario cucurbit growers is outlined.


The potential of herbaceous weeds commonly growing in or adjacent to cucurbit crops to serve as alternate hosts and over wintering reservoirs of *Erwinia tracheiphila*, a causal agent of cucurbit wilt, was investigated. Methods for isolation, maintenance, long-term storage, and detection of *E. tracheiphila* from infected plants were developed. *E. tracheiphila* was consistently detected by enzyme-linked immunosorbent assay (ELISA) and reisolated from infected, susceptible, cucurbit species. When six common herbaceous weed species were inoculated, *E. tracheiphila* was detected in 49% (combined species) of the plants by ELISA 3 weeks after inoculation. However, we were unable to reisolate *E. tracheiphila* from these plants by standard techniques. Immunoaffinity isolation with a sensitivity of 2 CFU pet sample also failed to recover *E. tracheiphila* from weed species. Comparisons of cucumber and goldenrod inoculated with live or formaldehyde-killed *E.
tracheiphila indicated that immunoassays could detect nonviable E. tracheiphila systemically spread in plants 3 weeks post-inoculation. In these tests, the pathogen was reisolated only from cucumber plants inoculated with live E. tracheiphila. Although we could reproduce serological evidence of E. tracheiphila antigen in the weeds investigated, our results do not support the hypothesis that E. tracheiphila can infect, survive in, or overwinter in the weed species tested.


Bacteria multiplied rapidly in susceptible cucumber plants inoculated with Erwinia tracheiphila. Initial wilt of lower leaves occurred after 2 days. Histological examination showed that the bacteria migrated upward through the xylem of stem and petiole en masse, and plugging coincided with progressive wilt of adjacent leaves. Vascular deterioration was first seen 6 days after inoculation, by which time the plants were completely wilted. No wilt, plugging, or vascular deterioration were observed for resistant plants. Isolation assays demonstrated virulent bacteria in resistant plants for 10 days after inoculation, but the bacteria disappeared by the time the plants reached maturity. Transpiration decreased 1 day after initial wilt, and continued to decrease progressively as wilt developed. Respiration increased 2 days after wilt, and increased progressively for 10 days. Only slight and delayed transpiration and respiration responses occurred in resistant plants, which indicated limited multiplication. No evidence for pectolytic or cellulolytic enzyme production in vitro or in vivo was observed. Vascular plugging and wilt preceded physiological response and vascular deterioration; therefore, the primary wilting mechanism was considered to be bacterial plugging. Resistance was thought to involve a nutritional or bacterial inhibition principle that prevented continued multiplication and characteristic susceptible wilt symptoms.


Modifications of published procedures for rearing southern corn rootworms, Diabrotica undecimpunctata howardi Barber, on an artificial diet and corn are described. Approximately 30% of the larvae reared on the improved diet reach 18 mg (pupation weight) in 10 days, with <8% bacterial contamination of the diet. After six generations of selection for larval vigor, a diet strain was developed that parallels corn, with most larvae reaching 18 mg in 10 days. Using corn seedlings, a rearing technique that significantly reduces labor input and contamination is described.
The cucurbitacins are oxygenated tetracyclic triterpenoids produced as secondary plant compounds by nearly all genera of Cucurbitaceae. The very bitter and toxic cucurbitacins are effective semiochemicals acting ecologically as allomones to protect the Cucurbitaceae from attack by a variety of invertebrate and vertebrate herbivores. For the Luperini (Coleoptera: Chrysomelidae: Galerucinae) the cucurbitacins have become kairomones for host selection, affecting the behavior of this large group of 1500 species of Aulacophorina (Old World) and Diabroticina (New World) by arrest and compulsive feeding. When feeding on bitter cucurbits these beetles sequester large amounts of cucurbitacins in their blood and tissues, and these act as allomones to deter predation. Specific detoxification and excretory mechanisms of the Diabroticina enable these beetles to avoid the toxic effects of the cucurbitacins.


Olfactory synergism, where combinations of plant volatile kairomones are quantitatively more attractive to insects than the sum of attraction of the individual components, is an important but little-studied phenomenon in host plant selection and feeding and in pollination ecology. Diabroticite beetles (Coleoptera: Chrysomelidae) are strongly attracted to Cucurbita blossoms, and 2- to 3-fold olfactory synergism has been demonstrated in four species by combinations of the key blossom volatiles, 1,2,4-trimethoxybenzene, indole, and (E)-cinnamaldehyde. This TIC mixture represents an optimized Cucurbita blossom volatile kairomone mixture useful in monitoring Diabroticite populations and in studying their behavior and ecology. Indole which exhibits a spectrum of attraction to these beetles ranging from moderate for Diabrotica virgifera virgifera and Acalymma vittatum to very weak for D. barberi, is the primary synergistic component. Indole combined with 4-methoxycinnamaldehyde was significantly synergistic to D. v. virgifera at a ratios of 1:300 and produced 4-fold synergism at a ratio of 1:1. Indole combined with 4-methoxyphenethanol was less synergistic to D. barberi with 1.5- to 2-fold synergism at a 1:1 ratio. These consistent variations in diabroticite beetle olfactory responses presumably indicate evolutionary divergences in the number of relict indole antennal receptors.


*Abstract Missing*
The diabroticite rootworm beetles coevolved with plants of the family Cucurbitaceae as demonstrated by their feeding dependence on the tetracyclic triterpenoid cucurbitacins. These beetles also exhibit strong attraction to phenylpropanoid volatile components of *Cucurbita* blossoms. A mixture of 1,2,4-trimethoxybenzene, indole, and (E)-cinnamaldehyde, all blossom components, is highly attractive to the several species of diabroticite cucumber beetles and corn rootworms and is considered a simplified *Cucurbita* blossom kairomone odor. The evolutionary divergence in antennal receptor complementarity is best understood by comparing the species-specific responses of several *Diabrotica* to structural analogues of (E)-cinnamaldehyde, the major attractant for *Diabrotica undecimpunctata howardi*. Cinnamyl alcohol is a strong attractant for *Diabrotica barberi*, and 4-methoxycinnamaldehyde is an exceptional attractant for *Diabrotica virgifera*. The very closely related species *D. barberi* and *Diabrotica cristata* are most strongly attracted to 4-methoxyphenethanol, which is unattractive to the other species studied.
The characteristic bitter substances of the Cucurbitaceae act as kairomones for a large group of diabroticite beetles (Chrysomelidae, Galerucinae, Luperini), promoting host selection and compulsive feeding behavior. These beetles (e.g., *Diabrotica undecimpunctata howardi*) respond to as little as 1 mg of cucurbitacin (Cuc) B on thin-layer plates by arrest and compulsive feeding. Six species of diabroticite beetles were about 10 times more responsive to Cuc B than to Cuc E and less responsive to Cuc D, I, and L. Chloroform extracts of 18 species of *cucurbita* were developed on thin-layer chromatograms and exposed to diabroticite beetles. The feeding patterns showed pronounced beetle responses to three general Cuc distribution patterns: Cuc B and D as in *Cucurbita andreana* and *C. ecuatmezii*; and Cuc E glycoside in *C. texana*. All the diabroticites responded in exactly the same feeding patterns. The results demonstrate a coevolutionary association between the cucurbitaceae and the Luperini, during which the intensely bitter and toxic Cucs that arose to repel herbivores and protect the plants from attack became specific kairomone feeding stimulants for the beetles.


The coevolutionary association between plants of the family Cucurbitaceae and beetles of the tribe Luperini (Coleoptera: Chrysomelidae; Galerucinae) is mediated to a large extent by chemicals of the host plants. The kairomones involved in host selection by the rootworm beetles are the oxygenated tetracyclic triterpenoid cucurbitacins that act as arrestants and feeding stimulants and a number of volatile cyclic plant blossom components that act as long-range orientation cues. The complex ecological and evolutionary factors regulating the chemical ecology of host plant selection are discussed.


Adults of two closely related corn rootworms, *Diabrotica barberi* Smith and Lawrence and *D. virgifera virgifera* LeConte, are strongly attracted to two naturally occurring phenylpropanoids, eugenol and estragole respectively. The close chemical relationship of these two kairomones suggested that structure-activity studies of estragole analogues as rootworm attractants would be profitable. During the summers of 1986 and 1987, evaluations of 21 chemical compounds related to estragole revealed several exceptional attractants: 4-methoxycinnamaldehyde and 4-methoxycinnamonicnitride for *D. v. virgifera*, cinnamyl alcohol for *D. barberi*, and cinnamaldehyde for the southern corn rootworm. *D. undecimpunctata howardi* Barber.

Field tests in corn with baited sticky traps focused on changes in species specificity and magnitude of response for *Diabrotica barberi* Smith and Lawrence and *D. virgifera virgifera* LeConte when candidate lures varied by functional group, chain length, aryl substituents, saturated and unsaturated sidechains, and isosteric replacement. Cinnamyl alcohol, a major component of the blossom volatiles of *Cucurbita maxima* Duchesne, and its parakairomone (active synthetic analog), 3-phenyl-1-propanol, were significantly more attractive to *D. barberi* than eugenol in corn and were also attractive to *D. cristata* (Harris) in a reclaimed prairie. Neither compound was appreciably attractive to adult western corn rootworms *D. v. virgifera* and, as previously reported, cinnamyl alcohol is only slightly attractive to adult southern corn rootworms, *D. undecimpunctata howardi* Barber. The spectrum of rootworm responses to cucurbit blossom components and structurally related compounds amplifies the coevolutionary relationships between Diabroticites and Cucurbitacaea, shows the chemosensory specificity of odor-conditioned behavior in *Diabrotica* spp., and illustrates the potential of parakairomones as practical insect lures.


Hexane and ethanol extracts of seeds from 22 species of plants of the family Meliaceae from a number of countries were prepared. The extracts were submitted to antifeedant and toxicity bioassays utilizing fall armyworm [*Spodoptera frugiperda* (J.E. Smith)] (Lepidoptera: Noctuidae) larvae and striped cucumber beetle [*Acalymma vittatum* (F.)] (Coleoptera: Chrysomelidae) adults. Toxicity tests were also performed with brine shrimp, *Artemia salina* Leach. Feeding inhibition and mortality produced by some of these extracts were comparable to and, in certain cases, slightly greater than the effects produced by comparable neem (*Azadiracta indica* A. Juss.) seed preparations. Brine shrimp toxicity data do not extrapolate to insect activity, and vice versa.


The striped cucumber beetle, *Acalymma vittatum* (F.), and the spotted cucumber beetle, *Diabrotica undecimpunctata howardi* Barber, are important pests of cucurbits throughout Missouri. A study was conducted that examined the effects of a black plastic mulch on the soil and plant distributions of immature and adult cucumber beetles. Muskmelon plants were subjected to one of three treatments: mulch and herbicide, herbicide, or untreated (control). The presence of a black plastic mulch significantly reduced the number of beetle eggs and larvae found within the top 5 cm of soil around plants. At greater soil depths, there were no differences in egg and larval densities among
treatments. Adult cucumber beetles were most often found on the flowers of plants in all treatments.


Effective management of adult northern and western corn rootworms, *Diabrotica barberi* Smith & Lawrence and *D. virgifera virgifera* LeConte, respectively, requires knowledge of their emergence pattern so that scouting and adult insecticide applications can be accurately timed. The objective of this study was to develop and validate species- and sex-specific models that reliably predicted adult corn rootworm emergence in Iowa. Prediction began from a biofix defined as the date of first beetle emergence in a field. The models were fit with a 3-parameter Weibull function using emergence data collected in 57 Iowa cornfields over 5 yr. Models were validated with emergence data collected in 21 additional fields from a separate year. A single Pherocon CRW Trap per field was as effective as 13 emergence cages per field at detecting the biofix. Air temperature degree-days accumulated from the emergence cage biofix explained 85% of the variability in total corn rootworm emergence over 5 yr. This model explained 89% and 83% of the variability in total beetle emergence observed in the validation year from the emergence cage and Pherocon CRW Trap biofixes, respectively. These models do not eliminate scouting for adult corn rootworms but should improve the scouting efficiency by allowing growers to focus scouting to key periods, such as peak beetle emergence, when populations should be at their maximum abundance in the field.


In the early 1970s, a study was begun to find resistance to feeding in muskmelon, *Cucumis melo* L., by banded cucumber beetles, *Diabrotica balteata* LeConte. Bitter seedlings were observed to be more susceptible to feeding than nonbitter seedlings. We noticed reduced damage levels in both bitter and nonbitter seedlings in 1974. Genetic study of resistant materials showed that in addition to the recessive form of the bitter gene, *bibi*, a 2nd recessive gene, *cbl cbl*, conditioned reduced seedling susceptibility. Subsequent tests involving spotted (*Diabrotica undecimpunctata howardi* Barber), striped (*Acalymma vittata* (Fabricius)), and banded beetles on leaf disks of several *C. melo* cultivars showed that homozygous double recessive, *bibi cblcbl*, plants were more resistant to all 3 species of cucumber beetles than nonbitter, *bibi Cbl*-and bitter *Bi-Cbl*-plants. This double recessive resistance provides muskmelon breeders with germplasm which can be incorporated into breeding lines and hybrids.
The inheritance of resistance to bacterial wilt in cucumber was studied in the cross Marketer x P.I. 200818 by observing the reaction of P1, F1, F2 and B1 seedling populations in the greenhouse to inoculations with *Erwinia tracheiphila* (E.F.Sm.) Holland. The results show that resistance to bacterial wilt in the P.I. 200818 cucumber is due to a single dominant gene.

In 1992, sentinel squash plants treated with carbofuran successfully attracted and killed squash bug, *Anasa tristis* (De Geer), and cucumber beetle, *Acalymma vittatum* (F.), emerging from overwintering at 5 locations in Atoka County, Oklahoma. In 1993, responses of cucumber beetle and squash bug to carbofuran-treated squash trap plants and to Adios or Adios-AG attracticidal baits were compared in <1.0-ha plots of seedling cantaloupe, squash, and watermelon at Lane, OK. Regardless of crop, cucumber beetles and squash bug populations were highly attracted to 'Lemondrop' squash trap plants that amounted to <1% of the total crop area. Squash trap-plants attracted an estimated 39.7, 32.4, and 66.3% of the cucumber beetle population, respectively, observed in fields of cantaloupe, squash, and watermelon seedlings. In cantaloupe and watermelon, squash trap-plants attracted >90% of the estimated squash bug population but were less effective in squash. In all cases, squash trap plants treated with carbofuran killed >90 and 16-37%, respectively, of the cucumber beetles and squash bugs found on the plants. Single applications of attracticidal baits provided up to 70% cucumber beetle mortality for 3-5-d post treatment. Studies conducted in 1994 showed that significantly greater numbers of cucumber beetles, primarily *Diabrotica undecimpunctata howardii* Barber, were attracted to 'Blue Hubbard' than Lemondrop squash trap plants that were treated with systemic insecticides, carbofuran at 0.15 g (AI) or imidacloprid at 0.04 g (AI), and positioned in a field of watermelon. Imidacloprid was as effective as carbofuran, each provided >90% cucumber beetle mortality. In this study, an estimated 46.7% of the total cucumber beetle population was attracted to the squash trap plants. Results from these studies suggest that minimal plantings of systemically treated squash can be used effectively to suppress early-season populations of cucumber beetle and squash bug in seedling cantaloupe, squash, and watermelon.
Canola, *Brassica napus* L., fields were sprayed with 210ml/ha of malathion. Caged honey bees, *Apis mellifera* L., and mosquitoes, *Aedes* sp., were placed inside and outside the spray area. The correlation coefficient between malathion deposition and mortality was significant (P<.0001) and positive for bees (r=.900) and mosquitoes (r=.920). Caged bee mortality ranged from 1 to 43%, 1 km from the spray area. Malathion residues were detected in canola pollen collected in pollen traps, and blossoms collected form the field up to 12 h after spraying.


Thirty-two-hectare fields of *Brassica napus* L. (canola cultivar Westar) with an apiary of 8 or 10 colonies of honey bees, *Apis mellifera* L., were sprayed with aerially applied ultra-low-volume malathion at a rate of 210 ml/ha to simulate a mosquito control program. Sprayed colonies gained significantly less weight than control colonies for up to 28 d after spraying and had significantly lower populations than control colonies for up to 86 d after spraying. Trap counts of dead bees were significantly higher in sprayed colonies than in control colonies for 3-4 d. after spraying. Sprayed colonies collected significantly less pollen than control colonies collected for 2-3 d after spraying. The number of foragers entering sprayed colonies was significantly less for 1-2 d; there was no change in the proportion of pollen and nonpollen foragers entering colonies.


A Malaise trap is a passive flight intercept trap relying on instinctive insect behavior; strong-flying insects like dipterans and hymenopterans attempt to escape the trap by flying upwards towards light and are collected at the apex of the trap. The objective of this study was to design an easy Malaise-type trap. This modified Malaise-type trap design might be useful for insect monitoring in field experiments due to its simple construction. Advantages of this design include: (1) readily available, sturdy materials for construction including wood, PVC pipe, plastic milk jugs, staples, duct tape, and spunbonded polyester netting that all last for a season with minimal repair; (2) low cost of materials; (3) ease of transportation, installation, and removal from the field provided by compact, light weight, folding tripods; (4) durable installation in the field because tripod legs can be set firmly in the ground and excess netting covered with soil; (5) simple insect collection provided by a plastic milk jug placed at the apex of the trap and an easy-to-handle killing agent using a wide-spectrum insecticide that lasts for 3 months.

A buckwheat border was planted perpendicular to cucumber and squash rows to attract natural enemies of cucumber beetles. Sticky and modified Malaise traps were used to assess insect populations at incremental distances from the border. The density of Diptera declined from 19.5 insects/sticky card in the border to 2.8 insects/sticky card at 20 m from the border in 1995, and similar declines were seen in 1996. Densities of tachinid flies, Hymenoptera wasps, and the Pennsylvania leatherwing (*Chauliognathus pennsylvanicus*) also declined as distance from the border increased. Numbers of striped cucumber beetles (*Acalymma vittatum* Fab.) increased linearly in 1995 but decreased quadratically in 1996, and crop yields were unaffected.


The success of mixed cropping systems in nematode management is determined not only by the associated plant's ability to decrease numbers of phytoparasitic nematodes, but also on the ability of the target crop to compete successfully for nutrients and light. Field studies were conducted to investigate the effects of a legume/cucurbit intercrop and a marigold/cucurbit intercrop on the ecology of the system in terms of nematode root galling, soil nutrient concentrations, energy allocation, yield, and economic profitability. The intercrop systems were less productive and less profitable than monocultures, although no differences in energy allocation, soil nutrients, or root galling were observed. As it is likely that competition between the cucurbits and associated plants decreased the productivity of the mixed cropping systems, plants used in nematode suppressive intercrops should be chosen for their compatibility with the host crop.


In greenhouse tests, *Erwinia tracheiphila* was successfully isolated from cucurbits by 2 methods. In method A, a small quantity of sterilized water was injected into the petiole of a wilted leaf by means of a hypodermic needle and slowly withdrawn and discharged into a Petri dish containing nutrient agar. In method B, a loop-type inoculating needle was glided along the surface of a longitudinally cut petiole of an infected leaf and streaked on nutrient agar.

The multi-needle puncture inoculation method gave consistently satisfactory results under greenhouse and field conditions. Headless pins (25-30) are inserted into a cloth and cotton-padded reubber stopper, which is dipped in a suspension of the pathogen and forced through the cotyledon of the cucumber seedling. Under 2 temperature and humidity levels the multi-needle puncture method was more effective than the leaf-rub inoculation method.

Experiments were conducted to evaluate the potential for controlling striped cucumber beetle (StCB). *Acalyymma vittata* (F.), on cucumber, *Cucumis sativa* (L.), using a squash trap crop. A squash, *Cucurbita maxima* (Duch.) cv. ‘NK530’, was identified in greenhouse choice assays as being exceptionally attractive to StCB. Trap crop experiments were conducted using 50% and 15% of experimental plots planted to the trap crop. In both sets of experiments, plots which contained squash were more attractive than plots which did not. In 50% experiments, at least 70% of beetles found in plots were found on squash plants throughout the sampling period, with 90% on squash during the first 5 d. The use of a feeding deterrent on cucumbers did not significantly enhance the attractiveness of squash. In 15% experiments, over 70% of beetles were found on squash plants initially, although this number declined after 3 d. Two planting arrangements were tested and found not to differ. These experiments demonstrate strong potential for the use of this control strategy.


Studies of the striped cucumber beetle (StCB), *Acalyymma vittata* (F.), were conducted to: 1) develop predictive models for time of first colonization of cucurbit hosts in the spring, and for time of mating and oviposition activity; and 2) develop guidelines for sampling over a range of densities and precision levels. There was no apparent trend of thermal unit accumulation associated with time of first colonization, and so a degree-day model approach was abandoned. However, evidence suggests that time of first colonization is associated with daily mean temperatures greater than 12°C. A strong correlation was found between change in number of beetles per plant and the previous days’ mean temperatures. Both mating and oviposition activity were positively influenced by temperature in the range of 18 to 26°C. Access to foliage influenced maturation rate but not mating. Thresholds of mating and oviposition activity were found to be 13°C and 10°C, respectively. A high degree of aggregation of StCB adults (b=1.986) was described, and sample size estimates for three desired levels of precision under a random sampling design are presented.


*Abstract Missing*

A series of experiments in which dissected beetle parts were used to inoculate cucumber plants were conducted. It is clear that a small percentage of striped cucumber beetles harbor the wilt organism internally when they enter the cucurbit fields in the spring and there appears to be no other source for their infection than the cucurbit crop of the preceding autumn. Infections may take place from the mouth parts, at least for a limited time after feeding upon wilted plants, and infections are shown to occur when the feces of some beetles, but not all, come into contact with fresh injuries to the leaves. Infections take place only through injuries involving the vascular system. *Bacillus tracheiphilus* has been isolated directly from the viscera of wilt-fed striped cucumber beetles. Beetles of the genus *Diabrotica* (proved for two species) are the only carriers of the disease so far known in nature.


(1) In fields where wilt had largely destroyed the cucumber crop during the preceding season the disease did not appear in 1915 on cucumbers in 48 beetle-proof cages. On the other hand, wilt was very prevalent in those fields on all sides of the cages. In a large number of greenhouse tests where one out of two plants in a pot was inoculated and wilted to the ground the second plant in no case contracted the wilt. The inoculations by means of bacterial suspensions poured on the soil around potted cucumber plants showed a small but varying percentage of wilt. Root injuries were found in most of these cases of root infection. Apparently infection does not enter the uninjured root system from the soil.

(2) In all cases seeds from diseased fruits failed to produce diseased plants, and cultures from such seeds in no case gave the wilt organism, but further tests should be made.

(3) In the tests made stomatal infection did not occur.

(4) The experiments thus far completed show that cucumber beetles (*Diabrotica* spp.) are the most important, if not the only, summer carriers of the wilt organism (*Bacillus tracheiphilus*) and that at least one species (*D. vittata*) is capable of carrying the wilt over winter and infecting the spring planting of cucumbers. In the tests by the writers the squash bug (*Anasa tristis*), the flea beetle (*Crepidodera cucumeris*), the melon aphis (*Aphis gossypii*), and the twelve-spotted lady-beetle (*Epilachna borealis*) have failed to transmit the disease.

(5) In the field experiments during one season with many different varieties of cucurbits, the greatest difference in resistance was shown by varieties of squash, in which the percentage of infection varied from 0 to 100. The varieties of cucumber and cantaloupe, while showing some difference in their susceptibility to the wilt, give much less promise of control by varietal resistance.

(6) In the spraying experiments of 1915 wilt was effectively controlled by early treatments with a combination of Bordeaux mixture and arsenate of lead. Plots sprayed
with either mixture alone showed much less wilt than unsprayed plots, but control was not as complete as where the two were used together. Both field observations and greenhouse experiments indicate that the wilt control is effected through the bactericidal action of Bordeaux mixture, the insecticidal action of arsenate of lead, and the repellent action of both against the cucumber beetles.

(7) Inasmuch as it has been definitely proven that the striped cucumber beetle (D. vittata), and also the twelve-spotted cucumber beetle (D. duodecimpunctata), are the most active carriers of the bacterial wilt, it becomes necessary to control the insects in order to prevent the disease. This phase of the work will be actively undertaken in cooperation with the Bureau of Entomology during the coming season.


To prove that Erwinia tracheiphila survives in striped cucumber beetles (Acalymma vittata) over winter, net cages were established in cucurbit fields in the spring of 1914. Seedling cucumber plants in these cages were protected from beetle feeding damage until newly-emerged beetles were released into five of the cages. Wilt symptoms developed in uncovered plants and in cages with beetles, but never in cages without beetles. This suggests that wilt bacteria are carried over the winter by hibernating beetles and inoculated in to the cucumbers as the beetles feed.


Laboratory tests with striped cucumber beetle, Acalymma vittatum, adults indicated that a number of aromatic tetrahydropyranyl ethers were promising as antifeedants at dosage rates of 0.1 and 0.5%.


A series of cucurbit cultivars were compared as hosts for rearing Acalymma vittatum (F.) larvae. Cultivars were tested by using A. vittatum rearing techniques, with comparisons based on adult production, mean emergence date, and plant survival. ‘Improved Warted Hubbard’ and ‘Table Queen Ebony Acorn’ squash cultivars proved to be the best of the 12 cultivars compared. Use of a combination of five cultivars for mass production provided 60,000 adults and over 4,000,000 eggs for field research during 1982. The rearing procedure described offers vast improvement in both time and cost efficiency over previous techniques for rearing the insect.

Infective juveniles of *Neoaplectana carpocapsae* Weiser were successfully recovered in a uniform distribution from both biwall and triwall trickle tube irrigation emitters, indicating that this method of nematode distribution may be feasible in controlling soil insects in irrigated vegetables *Heterorhabditis* sp. and *N. carpocapsae* were both highly effective in laboratory experiments against striped cucumber beetle, *Acalymma vittatum* (F.), larvae. Field tests, in which *Heterorhabditis* sp. infective juveniles were introduced manually and through trickle irrigation, were inconclusive due to low levels of striped cucumber beetles, however, the technique of application of nematodes through trickle irrigation should be more thoroughly tested.


Inoculation of muskmelon seedlings with *Erwinia tracheiphila* using a 15-pin dispenser with reservoir was superior to other methods because of ease of manipulation, speed of operation, distribution of inoculum, and transmission rate on susceptible seedlings.


A decline in Midwestern muskmelon production during the past 30 years has resulted in fewer cultivars with resistance to bacterial wilt, *Erwinia tracheiphila*. Levels of resistance in 187 cultivars were assessed in field and greenhouse experiments. Resistance was most common in obsolete muskmelon cultivars and least common in current commercial hybrids. Commercially available cultivars which had resistant plants tended to be older cultivars. Of the 12 cultivars with highest frequency of resistant plants, half are obsolete. No cultivar tested was sufficiently resistant for commercial production, but resistant plants were observed in many cultivars. Burrell’s Gem, Early Wonder, and Jewel had the highest frequency of resistant plants.


Plant growth-promoting rhizobacteria (PGPR) strains INR7 (*Bacillus pumilus*), GB03 (*Bacillus subtilis*), and ME1 (*Curtobacterium flaccumfaciens*) were tested singly and in combinations for biological control against multiple cucumber pathogens. Investigations under greenhouse conditions were conducted with three cucumber pathogens: *Colletotrichum orbiculare* (causing anthracnose), *Pseudomonas syringae* pv. *lachrymans*
(causing angular leaf spot), and *Erwinia tracheiphila* (causing cucurbit wilt disease)—inoculated singly and in all possible combinations. There was a general trend across all experiments toward greater suppression and enhanced consistency against multiple cucumber pathogens using strain mixtures. The same three PGPR strains were evaluated as seed treatments in two field trials over two seasons, and two strains, IN26 (*Burkholderia gladioli*) and INR7 also were tested as foliar sprays in one of the trials. In the field trials, the efficacy of induced systemic resistance activity was determined against introduced cucumber pathogens naturally spread within plots through placement of infected plants into the field to provide the pathogen inoculum. PGPR-mediated disease suppression was observed against angular leaf spot in 1996 and against a mixed infection of angular leaf spot and anthracnose in 1997. The three-way mixture of PGPR strains (INR7 plus ME1 plus GB03) as a seed treatment showed intensive plant growth promotion and disease reduction to a level statistically equivalent to the synthetic elicitor Actigard applied as a spray.


Two hybrid cucurbits were produced that combined the genetic production of cucurbitacins as found in the wild bitter gourds, *Cucurbita andreana* Naud and *C. texana* Gray, with the high fruit yields characteristic of the domesticated cultivars of *C. maxima* Duchesne and *C. pepo* L.  Both the *C. andreana x C. maxima* and *C. texana x C. pepo* hybrids produced relatively high yields of fruit with high cucurbitacin content.  Both hybrids showed promise as attractants for population estimation of corn rootworm beetles (*Diabrotica undecimpunctata howardi* Barber and *D. virgifera* LeConte) or for use in poisoned baits using methomyl or trichlorfon with the bitter cut fruits of fruit homogenates.


Border rows of snap beans planted prior to soybeans functioned to attract and hold emerging overwintering adult *Epilachna varivestis* Mulsant.  Destruction of the trap crop generation of Mexican bean beetles resulted in protection of the adjacent soybean fields. Beetles were destroyed in the trap crop by disking, spray application of carbaryl, or release of *Pediobius foveolatus* (Crawford).  Trap crops planted prior to lima beans failed to attract and hold the beetle. A .4-hectare trap crop will cost ca. $184.00 based on 1976 costs.

Schalk, J.M., Jones, A., and Dukes, P.D. 1986. Factors Associated with Resistance in Recently Developed Sweet Potato Cultivars and Germplasm to the Banded
Recently developed breeding lines and cultivars with different field resistances to the wireworm, and the *Diabrotica*, *Systena* (WDS) complex were tested in the laboratory for antibiosis to the banded cucumber beetle (BCB) *Diabrotica balteata* LeConte. Resistance (antibiosis) was measured by the reduction in number and weight of adults emerging from the different tissues. Resistance was highest in whole roots (periderm intact). The cortex was intermediate in antibiosis while least antibiosis was recorded in the stellar tissue. Antibiosis of peridermal and cortical tissues were more pronounced early or late in the season than during mid-season. Field resistance classification to the WDS complex was correlated with BCB larval development on cortical tissue.


In 1992-1993, *Centistes gasseni* Shaw was imported into the United States, and in the laboratory successfully parasitized: southern corn rootworm, *Diabrotica undecimpunctata howardi* Barber, banded cucumber beetle. *D. balteata* LeConte; western corn rootworm, *D. virgifera virgifera* LeConte; and striped cucumber beetle, *Acalymma vittatum* (F.). Males and females of *C. gasseni* lived an average of 15.4 and 12.9 days (with a maximum of 30 and 29 days), respectively. A single female oviposited in 383 host *Diabrotica* over her lifetime, from which 158 cocoons were recovered. Additional observations on the biology and rearing of the parasitoid are presented.


Cucurbitacin E glycoside, extracted from a bitter mutant of Hawkesbury watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai (Syn. *Citrullus vulgaris* Schrad)] is the active ingredient of a feeding stimulant for the corn rootworm complex. It is the primary component of a water-soluble bait that can be combined with toxins for adult diabroticite control. Studies were conducted using phloxine B (D&C Red 28), a xanthene dye, as the toxin. This dye was efficacious against *Diabrotica undecimpunctata howardi* Barber, spotted cucumber beetle, and *Acalymma vittatum* (F.), striped cucumber beetle, in cucumber plots and could be recovered from cucumber leaves for 8 d after treatment. The average amount of dye recovered per dead spotted cucumber beetle at 8 d after treatment was 0.173 microgram. Concentrated and sugar-free fermented forms of the watermelon extract were developed and compared with the fresh juice in field applications on cucumber plants. There was no significant difference in mortality of beetles from
phloxine B-bait prepared with fresh, fermented, or concentrated extract, although in laboratory studies, fermented juice had higher feeding stimulant activity.


Florisil column chromatography and silica-gel thin-layer chromatography were excellent preparatory steps for separation of cucurbitacins in cotyledons. It was difficult to identify closely related cucurbitacins by thin layer chromatography. Unstable cucurbitacin derivatives limited the use of gas-liquid chromatography for cucurbitacin identification; however, mass spectrometry was an effective method for cucurbitacin B.


In a 2-year study, fruits from 21 plant types of 15 species from 6 genera (Citrullus, Cucumis, Cucurbita, Lagenaria, Luffa, and Momordica) of Cucurbitaceae were exposed to a natural population of Diabrotica undecimpunctata howardi Barber to determine relative attractiveness of the fruits to that insect. Analysis of cucurbitacins and their glycosides in the fruits revealed a positive correlation between their concentration and the number of spotted cucumber beetles attracted by the various plant species. This correlation demonstrated the attraction properties of low concentration (0.0-0.56 mg/g) of cucurbitacins and their glycosides. Cucurbita foetidissima H. B. K. and Cucumis dipsaceus Ehrenb., the 2 most attractive species, were high in cucurbitacin concentration. The technique of exposing fruits to D. undecimpunctata howardi has potential as a bioassay to screen cucurbitacins in the fruits of other species. Attractant cucurbitacins can be useful in population assessment and in luring the beetle to an insecticide or to an adhesive.


We conducted field studies to investigate the involvement of volatile cues in early-season host plant colonization by striped cucumber beetle, Acalyymma vittatum (F.) (Coleoptera: Chrysomelidae). Wind-directed traps were baited with male or female A. vittatum, potted cucumber (Cucumis sativus) seedlings that were of near-isogenic lines which either contained or lacked cucurbitacin, or combinations of male or female A. vittatum feeding on one or the other cucumber variety. We found no response to undamaged plants of either cucumber variety or plants that were actively being fed upon by A. vittatum females, whereas the response to volatiles associated with male A. vittatum was strong. Both male and female conspecifics and totals of up to sevenfold the number of males in
the trap lures were caught overnight. Feeding males attracted more than double the number of conspecifics that responded to nonfeeding males. Active consumption of cucurbitacin in the plant on which the males were feeding, however, had no effect on attraction. A shift in sex ratio from a male to a female bias during field colonization season also supports the hypothesis that host finding is initiated by "pioneer" males. The importance of this aggregation pheromone in early-season host plant colonization and the evolutionary and adaptive significance of this pheromone are discussed


The chrysomelid Acalymma vittatum is stenophagous, subsisting almost entirely on plants in the Cucurbitaceae, which generally contain cucurbitacins. Cucurbitacins are extremely bitter tetracyclic triterpenoids that are toxic to most organisms. As do other diabroticite beetles, A. vittatum sequester cucurbitacins, which have been shown to act as phagostimulants and arrestants. Our results reveal, however, that for A. vittatum the response to cucurbitacin diminishes with continued sequestration. Colony-reared A. vittatum were fed only roots (as larvae) and foliage of either 'Marketmore 76' (which contains a normal amount of cucurbitacin, 'bitter') or 'Marketmore 80' (a near isogenic line that contains no cucurbitacin, 'non-bitter') cucumber. Over 1200 individual beetles from the day of adult emergence to 15 days following emergence were placed in choice and no-choice arenas containing potted cotyledons of the two cucumber varieties for 24 h. In choice tests, overall preference for the bitter cucumber cultivar was maintained, but degree of preference changed with age and became significantly less for beetles reared on bitter diets. Furthermore, in no-choice tests, age, sex, dietary history, and interactions among these variables all significantly affected the feeding response to cucurbitacin. For A. vittatum reared without cucurbitacin, total consumption of the bitter cultivar increased over time. For beetles reared with cucurbitacin, total foliage consumption of the bitter cultivar declined, within nine days, to equal that of the non-bitter cultivar. Feral A. vittatum, unexpectedly, consumed more of the non-bitter than the bitter cultivar in no-choice tests. Ecological and applied implications of this variation in response to cucurbitacin are discussed.


In field studies, wind-directed traps were used to investigate the resource-based properties of the male-produced aggregation pheromone of Acalymma vittatum (F.) (Coleoptera: Chrysomelidae). Responses to early season overwintered field-collected male A. vittatum without food were compared with those feeding on pollen, and in turn these were compared with those feeding on cucurbit seedlings. These comparisons were modelled after transitions as they would occur at the initiation of A. vittatum host plant colonization. In another experiment, colony-reared male A. vittatum that had been fed
only near isogenic lines of potted cucumber (*Cucumis sativus*) seedlings that either lacked or contained cucurbitacin were placed as bait in the traps. Using the inverse relationship, which is understood for *A. vittatum*, between previous exposure and the phagostimulant response to cucurbitacin, rates of foliage consumption could be manipulated. The interaction between relative rates of host plant consumption of the males used as lures and responses to the pheromone could thus be tested. The use of *A. vittatum* reared entirely without dietary cucurbitacin as bait also enabled evaluation of the potential role of cucurbitacin in pheromone biosynthesis. Trap responses were closely correlated with the rates of feeding of the beetles in the trap lures, but cucurbitacin was neither a precursor nor a prerequisite for the pheromone. Implications for early season field colonization and the adaptive significance of this pheromone are discussed.


The influence of tissue age, pathogen infestation, intrapopulation contamination, and polymerase chain reaction (PCR) conditions were assessed as sources of error in random amplified polymorphic DNA (RAPD) analysis. DNA from young, uninfected tissue provided the most consistent results. Plants infected with *Sphaerotheca fuliginea* Schl. (ex Fr.) Poll. showed variation in RAPD banding patterns compared to those of uninfected plants. Differences in banding patterns were detectable when DNA from two inbred lines were mixed at dilution ratios of greater than or equal to 20:1 but not greater than or equal to 50:1. Differing lots of commercially available 10x reaction buffer, MgCl₂ stock solutions, and Taq DNA polymerase affected RAPD banding patterns and overall yield. For reproducibility of RAPD assays, it may be necessary to optimize reactions for specific lots of PCR reagents from either commercial or in-house sources.


Four sets of nearly isogenic bacterial wilt [*Erwinia tracheiphila* (E.F. Smith)] Holland resistant and susceptible gynoecious cucumber (*Cucumis sativus* L.) lines, along with their companion segregating generations were evaluated under replicated field conditions for flowering date, fruit quality, fruit number, and length: diameter ratio (L:D). In addition to flowering earlier, susceptible lines were higher-yielding and had longer fruits than their resistant counterparts. Although differences in fruit quality were not significant, susceptible lines were preferred by a panel of seven judges. Compared to susceptible lines, hybrid progeny were later-flowering and in some instances lower-yielding.
Fifty-three varieties within the plant family Cucurbitaceae were evaluated for plant resistance to *Diabrotica undecimpunctata howardi* Barber. Varieties were tested for foliage resistance and seedling resistance. Varieties were placed in 4 groups, based on common crop names for statistical analysis: (1) cucumbers, (2) summer squash, (3) winter squash, and (4) pumpkins, muskmelons, and watermelons. Varieties were scored on the amount of damage sustained, were given a damage index rating, and were listed as resistant, intermediate, or susceptible. Pumpkins, muskmelons, and watermelons were more susceptible than the other groups. However, greater differences occurred among varieties within a group than occurred between groups in both the seedling and foliage stages. Also it was found that resistance in one stage of plant growth did not preclude varietal resistance in another stage.


*Abstract Missing*


Efforts to explain the evolution of cucurbitacin phagostimulation in many luperine Chrysomelidae have focused primarily on the ecological benefits derived from consuming these bitter compounds. Little attention has been given to the physiological costs that may result from ingesting cytotoxic triterpenes. To understand the current factors that stabilize the response of luperines to cucurbitacins we quantified the effect of cucurbitacin consumption on larval growth rate and survivorship, adult longevity, age at Ist reproduction; and fecundity in *Acalymma vittatum* (F.), the striped cucumber beetle. Larvae that fed on roots high in cucurbitacins gained weight more quickly than, and survived as well as, larvae that developed on roots with only trace amounts of bitterness. We found no significant differences in the fitness traits of females reared from eclosion until death on diets excluding cucurbitacins, featuring 1 short pulse of cucurbitacins, consisting of a choice between cucurbitacin-laden and cucurbitacin-free food, and containing only foods rich in cucurbitacins. However, males fed 1 short pulse of dietary cucurbitacins lived significantly longer than males that ate no cucurbitacins or males that ate cucurbitacins throughout their adult lives. The data suggest that the physiological costs associated with cucurbitacin consumption in *A. vittatum* are minimal and are counteracted by advantages from short-term consumption of cucurbitacins. This is
consistent with observations of a marked gustatorial sensitivity toward cucurbitacins that disappears after beetles have consumed enough compound to embitter their tissues.


An assay designed to detect the limit of response to the phagostimulatnt cucurbitacin B was used to quantify intra- and interspecific variation in cucurbitacin perception in adults of the striped cucumber beetle, *Acalymma vittatum* (F.); the western corn rootworm *Diabrotica virgifera virgifera* LeConte; the banded cucumber beetle, *D. balleata* LeConte; and the spotted cucumber beetle, *D. undecimpunctata howardi* Barber. By controlling ontogenetic and environmental factors such as gender, age, reproductive status, prior consumption of cucurbitacins, and hunger, the assay was able to identify geographically based genetic differences in the mean and standard deviation of the limit of response to cucurbitacin B within and among the species tested. Possible sources of the variation and its implications for the use of cucurbitacin-based toxic baits against rootworm pests are discussed.


Larval host associations in luperine rootworm beetles (Chrysomelidae), including the many pest species in the subtribes Diabroticina and Aulacophorina, remain largely unknown because adults often feed on plant species and families other than those favored for larval development. Because important questions concerning the evolutionary origins, systematic relationships, and pest management of luperine rootworms require knowledge of their larval host associations, techniques that enable inference of larval host use from adult structures are needed. Using spotted cucumber beetle, *Diabrotica undecimpunctata howardi* Barber, and striped cucumber beetle, *Acalymma vittatum* (F.), as model species, this study confirms that the stable carbon isotopic signature of adult elytra (the ratio between C-13 and C-12 isotopes, expressed as delta(13)C) accurately reflects whether an individual consumed Cg plants throughout its life, C-3 plants as a larva and C-4 plants as an adult, or C-4 plants exclusively. The study also demonstrates that, because the delta(13)C of elytra is unaffected by time, easily accessible museum specimens can be used for delta(13)C assays.

**Tallamy, Douglas W. and Halaweish, Fathi T. 1993. Effects of Age, Reproductive Activity, Sex, and Prior Exposure on Sensitivity to Cucurbitacins in Southern Corn Rootworm (Coleoptera: Chrysomelidae). Environmental Entomology. 22 (5) 925-932.**
Cucurbitacins, toxic to most organisms, are arrestants and phagostimulants for diabroticite chrysomelid beetles. Little is known about variation in the response of diabroticites to cucurbitacins. To quantify the effects of age, sex, reproductive status, and prior exposure to cucurbitacins on the sensitivity to cucurbitacin B of the southern corn rootworm, *Diabrotica undecimpunctata howardi* Barber, beetles were separated by sex and grouped for treatment with diets including or excluding cucurbitacins. Sensitivity to cucurbitacins was assayed over the first 43 d of adulthood by exposing beetles in groups of five for 24 h to filter paper strips spotted with serial methanol dilutions of cucurbitacin B ranging from 800 to .1 ng/ml. The areas consumed by the beetles at each dilution were then measured, and dose-response curves for each treatment were drawn. Treatments were compared in terms of the area under the mean dose response curve (AUC). Sex, age, reproductive activity, and prior exposure to cucurbitacins all significantly affected beetle sensitivity, though prior exposure was the most consistent in its effect. Exposure to cucurbitacins for as little as 6 d permanently reduced sensitivity, whereas beetles without prior exposure remained sensitive to our assay throughout the study. Reproductive activity depressed sensitivity in males but increased sensitivity in females. These results are discussed in terms of their relevance to semiochemical diabroticite baits and also to the proposed role of cucurbitacins in protecting these beetles from predators, parasites, or pathogens.


The effect of the addition of volatile chemicals to water traps was examined for adult thrips species in New Zealand and the Netherlands. The chemicals ethyl nicotinate (3-pyridinecarboxylic acid), *p*-anisaldehyde (4-methoxybenzaldehyde), and benzaldehyde (benzoic aldehyde) increased trap capture (up to 35 times) for a number of flower-inhabiting thripid adults. Ethyl nicotinate increased trap capture of the New Zealand flower thrips, *Thrips obscuratus* (Crawford), by > 100 times. The addition of ethyl nicotinate to water traps for early-season monitoring of *T. obscuratus* in a nectarine orchard significantly increased capture of adult male and female thrips (up to 27 times), and on several occasions thrips were caught in traps with ethyl nicotinate before traps without ethyl nicotinate. The addition of *p*-anisaldehyde to sticky boards for control trapping of the western flower thrips, *Frankliniella occidentalis* (Pergande), in glasshouses increased capture of adult females between 1.8 and 6 times. Behavioral responses for thrips host-finding are discussed with emphasis on the use of volatile chemicals for thrips pest management.

Crude extracts of five plant species which in previous experiments significantly limited corn wireworm, *Melanotus communis* Gyllenhal, feeding damage were tested for deterrence of the southern corn rootworm *Diabrotica undecimpunctata howardi* Barber. When offered extract-treated and untreated corn seeds, rootworms damaged significantly fewer treated seeds than untreated seeds with four of the extracts. In a “no-choice” test design, with the tree most effective extracts, there was a significantly lower frequency of damage to treated baits compared to control baits.


*Erwinia tracheiphila* differed both in its rate of multiplication and the time at which it attained maximum populations in resistant and susceptible cucumbers. Peak bacterial populations occurred in the hypocotyl of resistant pumpkin 2 days after inoculation, whereas in the susceptible cucumber the peak did not occur until the sixth day. Bacterial populations decreased at 4 days in the hypocotyl of resistant cucumber. Population doubling times for *E. tracheiphila* in the hypocotyls of susceptible cucumber, resistant cucumber, and resistant pumpkin were 5.4, 11.2, and 5.1 hours per doubling, respectively. Four days after inoculation into the cotyledon, bacteria in the resistant cucurbits were restricted to the first internode where they died by the sixth day. In the susceptible host, bacteria had reached the third or top internode by the sixth day and remained there until death of the plant at the ninth to tenth day.


Forty-nine of 59 cucurbit species and cultivars tested were susceptible to the bacterial wilt organism *Erwinia tracheiphila*. *Cucumis leptodermis* segregated for resistance, whereas *Cucurbita sororia* and a *Cucurbita moschata* accession wilted and then recovered from the disease. *Momordica balsamina* and *Luffa acutangula* which previously had been reported to be resistant were found to be susceptible. The genus *Cucurbita* contained most of the resistant species. Fourteen cultivars of *Citrullus lanatus* were found to be susceptible when young, but tolerant as they grew older.


This study is concerned with the relation of concentration and balance of nutrient solution supplied the host on the development of two vascular diseases of cucurbits: fusarial wilt of watermelon (*Fusarium oxysporium* f. *niveum* (E.F.Sm.) Snyder and Hansen) and bacterial wilt of cucumber (*Erwinia tracheiphila* (E.F.Sm.) Holland). As the concentration of salts in balanced Hoagland’s solution increased, there was a decrease in
rate and amount of disease development in watermelon, and an increase in development of cucumber wilt. When unbalanced nutrients were supplied the hosts, the disease index of watermelon wilt was increased slightly but not significantly in low N, low K, and high P, it was reduced more decidedly but in no case significantly in high N and low P; it was increased significantly and most decidedly in high K. In cucumber plants fed unbalanced solutions, bacterial wilt was increased significantly in low N and low K solutions, while the disease indices of plants grown in low P, high N, high P, and high K solutions were either not significantly or not consistently different from those in the balanced solution.


Two inoculation methods were used to study the effect of antibiotic sprays on bacterial wilt of cucumber. A leaf-rub method, which consisted of rubbing cucumber leaves with absorbent cotton dipped in water suspensions of *Erwinia tracheiphila* (E.F.Sm.) Holland, and hypodermic injection of suspensions into the stems were effective and rapid methods in inducing bacterial wilt.

The incidence of bacterial wilt of cucumber plants, in greenhouse tests, was decreased by sprays of 100 ppm streptomycin or neomycin and by 500 ppm sprays of terramycin or penicillin when applied 24 hours before leaf-rub inoculations were made. In the case of hypodermic-injection inoculations, 100 ppm streptomycin and 500 ppm terramycin were the only sprays reducing the incidence of wilt.

The incidence of bacterial wilt, in the field, was reduced by sprays containing 100 ppm streptomycin and 200 ppm terramycin. Cucumber yields were 25 percent higher in plots sprayed with 500 ppm streptomycin.


This research investigated how the striped cucumber beetle, *Acalymma vittatum* (F.) responds to the presence of a predator, the wolf spider *Rabidosa rabida* (Walckenaer). We answered four questions. (1) Does a beetle alter its behavior in the presence of a wolf spider in a laboratory microcosm? (2) Do striped cucumber beetles in nature modify their behavior when a wolf spider is nearby? (3) If beetles do respond to the presence of a wolf spider, what types of cues do the beetles use to detect the predator? (4) Does the proximity of other beetles affect how beetles respond to the predator? In laboratory microcosms, the presence of a spider reduced the frequency at which beetles fed, but beetles did not change their feeding behavior in the presence of a nondangerous arthropod, the cricket *Achaeta domestica*. Field observations conducted at night in cucurbit gardens revealed that a spider within 15 cm of groups of beetles increased by approximate to 1.6-fold the rate at which beetles left the plant. The proportion emigrating was higher as group size increased, but group size did not affect the responsiveness to the predator. Further laboratory microcosm experiments revealed that the striped cucumber
beetle consistently relies on tactile cues and sometimes on visual cues to detect the wolf spider. In one experiment, the presence of the wolf spider affected the feeding rate of a beetle when it was on the plant, but the most consistent behavioral response to the presence of the spider was to leave the plant at a higher rate.


152 cucumber (Cucumis sativus) lines were screened for resistance to bacterial wilt (Erwinia tracheiphila). Partial resistance was identified in three plant introductions from Burma.


Field experiments were performed in 1993 and 1994 to establish varying densities of striped Acalymma vittatum (F.) and spotted, Diabrotica undecimpunctata howardi Barber, cucumber beetles in spring-planted cucumber plots, and to determine the incidence of bacterial wilt symptoms in each treatment. These data were used to develop regression models to examine the relationship between beetle density and the severity of bacterial wilt disease. Cucumber beetle numbers peaked during the first 2 wk after colonization of plants, with a rapid decline in numbers thereafter. Bacterial wilt symptoms were first observed 12-14 d after peak numbers of beetles were recorded. Critical point linear regression analyses of both year's data demonstrated a strongly linear and positive relationship between cucumber beetle density and the severity of wilt symptoms. No significant improvement was detected by fitting quadratic models. Beetle numbers recorded two weeks after colonization of plants provided the highest r² values when regressed on the percentage of wilted vines (final disease rating). Covariance analysis determined that regression slope values were not significantly different between years; therefore data for both years were pooled and a generalized model was developed. Substituting area under the disease progress curve values for the percentage of wilted vines per plant values resulted in a higher coefficient of determination (P = 0.0001, r² = 0.73, slope = 70.3, intercept = 92.6), indicating that use of the progress curve, which accounts for disease development over time, provides a better regression fit than does use of a variable that reflects measurement of disease incidence at discrete intervals. The regression analyses also indicated that even low numbers (1 per plant) of beetles during the 1st few weeks after colonization of plants will result in wilt symptoms.

Applicata. Insect feeding on cucumber mediated by rhizobacteria-induced plant resistance. 83:81-85.

Select strains of plant growth-promoting rhizobacteria (PGPR) were evaluated in greenhouse experiments with cucumber for induction of resistance against cucumber beetle (*Diabrotica undecimpunctata howardi* Barber) feeding and the beetle-transmitted cucurbit wilt disease. When beetles were given a choice between PGPR-treated and nontreated cucumber, their feeding on stems and cotyledons and the severity of wilt symptoms were significantly lower on PGPR-treated plants. HPLC analysis demonstrated that cotyledons from PGPR-treated plants contained significantly lower concentrations of the cucumber beetle feeding stimulant cucurbitacin than nontreated plants. These results suggest that a mechanism for PGPR-induced resistance against cucumber beetle feeding may involve a change in the metabolic pathway for cucurbitacin synthesis.


Field studies were conducted in 1993 and 1994 to evaluate the effects of induced resistance in cucumber by plant growth-promoting rhizobacteria (PGPR) on numbers of the spotted cucumber beetle, *Diabrotica undecimpunctata howardi* Barber, and the striped cucumber beetle, *Acalymma vittatum* (F.). Cucumber plant growth and yields were significantly (P < 0.05) greater, and populations of cucumber beetles were significantly lower, on PGPR-treated cucumber than on nontreated cucumber. On dates when peak beetle populations were present, PGPR treatment resulted in significantly (P < 0.05) greater cucumber beetle control than weekly applications of esfenvalerate insecticide. In no-choice greenhouse cage experiments with 3 cucumber cultivars, beetles infested with the cucumber wilt pathogen, *Erwinia tracheiphila*, were released and allowed to feed on PGPR-treated or nontreated cucumber plants. The incidence of cucurbit wilt disease was significantly (P < 0.05) lower on PGPR-treated cucumber plants than on nontreated plants. These results indicate that PGPR-induced resistance may be more effective than insecticides for control of cucumber beetles and cucurbit wilt disease on cucumber. Possible mechanisms for PGPR-induced resistance against cucumber beetles are discussed.


Field studies were conducted in 1993 and 1994 to evaluate the effects of induced resistance in cucumber by plant growth-promoting rhizobacteria (PGPR) on numbers of the spotted cucumber beetle, *Diabrotica undecimpunctata howardi* Barber, and the striped cucumber beetle, *Acalymma vittatum* (F.). Cucumber plant growth and yields
were significantly (P<0.05) greater, and populations of cucumber beetles were significantly lower, on PGPR-treated cucumber than on nontreated cucumber. On dates when peak beetle populations were present, PGPR treatment resulted in significantly (P<0.05) greater cucumber beetle control than weekly applications of esfenvalerate insecticide. In no-choice greenhouse cage experiments with 3 cucumber cultivars, beetles infected with the cucurbit wilt pathogen, *Erwinia tracheiphila*, were released and allowed to feed on PGPR-treated or nontreated cucumber Plants. The incidence of cucurbit wilt disease was significantly (P<0.05) lower on PGPR-treated cucumber plants than on nontreated plants. These results indicate that PGPR-induced resistance may be more effective than insecticides for control of cucumber beetles and cucurbit wilt disease on cucumber. Possible mechanisms for PGPR-induced resistance against cucumber beetles are discussed.

**A Hybrid Cucumber Resistant to Bacterial Wilt. 1939. Phytopathology. 29:996-998.**

This article reports moderate resistance to bacterial wilt (*Erwinia tracheiphila*) in progeny of a cross between Tokio Long Green and Vickery Forcing cucumber (*Cucumis sativus*). The progression of wilt through these plants is confined to the initially-inoculated leaf or shoot.

*Author’s Name Missing*