Host Finding and Acceptance Preference of the Yellowmargined Leaf Beetle, *Microtheca ochroloma* (Coleoptera: Chrysomelidae), on Cruciferous Crops

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ABSTRACT The yellowmargined leaf beetle, *Microtheca ochroloma* Stål (Coleoptera: Chrysomelidae), is an introduced pest of cruciferous crops in the southern United States, and arguably the most damaging pest of organic crucifer vegetable production in the region. Studies were conducted in the greenhouse and laboratory to investigate host finding and acceptance preference of *M. ochroloma* on four commonly grown cruciferous crops: cabbage (*Brassica oleracea* L. variety *capitata*), collards (*B. oleracea* L. variety *acephala*), napa cabbage [*B. pekinensis* (Lour.)], and turnip (*B. rapa* L.) First, adult beetles were allowed to choose among the four plants in a multiple-choice greenhouse cage experiment and host preference was evaluated by using three parameters: number of beetles on each plant, number of larvae on each plant, and plant damage ratings. The results showed that *M. ochroloma* adults actively discriminated among the four host plants, with significantly higher numbers recorded on turnip and napa cabbage than on cabbage or collards. Significantly higher numbers of larvae also were recorded on turnip and napa cabbage starting on day 10. Similarly, higher damage ratings were recorded on turnip and napa cabbage than on the remaining two hosts. Results of four-choice olfactometer experiments, which compared attraction of *M. ochroloma* to headspace volatiles of the four host plants, demonstrated that host preference is mediated primarily by plant volatiles. Both sexes were significantly more attracted to napa cabbage than to the remaining treatments, with turnip being the second most attractive plant. These results confirm that turnip and napa cabbage are two preferred host plants of *M. ochroloma*, and may support the development of a trap crop system and attractant-based strategies for managing *M. ochroloma* in crucifer production.

KEY WORDS organic crucifer production, trap crop, pest management

The yellowmargined leaf beetle, *Microtheca ochroloma* Stål (Coleoptera: Chrysomelidae) is a major pest of cruciferous crops in the southeastern United States. Native to South America, *M. ochroloma* was first reported in the United States in Mobile, AL, in 1947 on young cabbage plants (Chamberlin and Tippins 1948). It is now widely distributed in the southeastern United States with major field infestations reported in Alabama, Florida, Louisiana, Mississippi, South Carolina, and Texas (Rohwer et al. 1953, Oliver 1956, Woodruff 1974, Balsbaugh 1978, Ameen and Story 1997a). Cruciferous crops (Brassicacea) attacked by *M. ochroloma* include cabbage (*Brassica oleracea* variety *capitata*), collard (*B. oleracea* L. variety *acephala*), mustard (*B. juncea* Cosson), napa cabbage [*B. pekinensis* (Lour.) (a type of Chinese cabbage)], Japanese leafy vegetables such as mizuna and mibuna, radish (*Raphanus sativus* L.), turnip (*B. rapa* L.), and watercress (*Nasturtium officinale* L.) (Chamberlin and Tippins 1948, Racca Filho et al. 1994, Ameen and Story 1997b, Bowers 2003). These crops are typically grown using conventional production practices; however, organic pro-

duction of cruciferous crops is an emerging industry in the southeastern United States. Many cruciferous crop species are usually grown organically as mixed cropping systems in the spring and fall in Alabama and much of the region. Adults and larvae of *M. ochroloma* often feed in clusters on leaves of cruciferous crops with potential for major economic loss. In particular, *M. ochroloma* poses a major threat to organic production of cruciferous crops in the southeastern United States because only very few effective organically acceptable management tactics have been identified for *M. ochroloma* (Balusu and Fadamiro 2011, in press).

Despite its economic importance and impact on organic vegetable production, very little research has been conducted on the biology and ecology of *M. ochroloma*. In Alabama, *M. ochroloma* is a multivoltine cool season pest that typically occurs in vegetable fields from October to May. Fall activity usually commences in early October when adult beetles migrate in mass numbers from summer aestivation sites (wild mustard plants) into cruciferous crops. Although *M. ochroloma* is known to feed in the field on a wide range of cruciferous plants, it appears to show preference for certain cruciferous crops over others

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(Chamberlin and Tippins 1948, Haeussler 1951, Rohwer et al. 1953, Anonymous 1976, Oliver and Chapin 1983). Chamberlin and Tippins (1948) reported that most of the heavy field infestations of *M. ochroloma* were confined to turnip and occasionally on mustard and collards. Our field observations also indicate that *M. ochroloma* prefers certain cruciferous crops over others (R. Balusu and H. Fadamiro, unpublished data). However, no systematic study has been conducted to investigate host preference in *M. ochroloma*. Thus, the current study was conducted to evaluate host finding and acceptance preferences of *M. ochroloma* on select cruciferous crops and determine the cues that mediate its host preferences. Understanding host plant preferences may provide crucial information necessary for the development of alternative and organically acceptable management strategies, such as trap cropping, host plant resistance, and attractant-based strategies against *M. ochroloma.*

Materials and Methods

Host Plants. Four known host plants of *M. ochroloma* were compared in the study: cabbage (*B. oleracea* variety *capitata*, 'Farao F1'); collard (*B. oleracae* variety *acephala*, 'champion'); napa cabbage (*B. rapa* subsp. *pekinensis*, 'Minuet F1'); and turnip (*B. rapa* variety *rapa*, 'purple top white globe'). These host plants were selected based on their importance as locally grown cruciferous crops, as well as their known association with *M. ochroloma* (Chamberlin and Tippins 1948; Haeussler 1951; Rohwer et al. 1953; Oliver and Chapin 1983; Ameen and Story 1997a,b). Seedlings were raised from seeds purchased from Johnny's Selected Seeds (Winslow, ME) in 60-well seed trays at one seed per well under controlled greenhouse conditions ($26 \pm 2°C$ and $55 \pm 5\%$ RH). Seedlings (3 to 4 wk old) were transplanted into pots in Sunshine potting mixture #8, consisting of 70–80% Canadian sphagnum grower grade peat moss, coarse grade perlite, coarse grade vermiculite, dolomitic limestone for pH adjustment, gypsum, and wetting agent (SunGro Horticulture, WA). Plants were irrigated daily and fert-irrigated twice a week with Scotts peat lite special fertilizer (Scotts-Sierra Horticultural Product Company, Marysville, OH), a 20–10–20 water soluble N–P–K fertilizer mixture with micronutrients. Plants were grown using organic practices, and no pesticides were applied. Plants tested in the experiments were about 5 wk old after transplanting. Similar methodology was used to raise all four host plants.

Insects. Adult *M. ochroloma* collected from a commercial organic farm in central Alabama in October 2006 were used to start laboratory colonies, which were supplemented annually by field-collected adults. Adults were reared in clear plastic petri dishes (150 mm in diameter by 30 mm in height) lined with paper towels (Bounty, Procter & Gamble, Cincinnati, OH) on fresh leaves of from greenhouse grown cruciferous plants. Twenty pairs of beetles were enclosed per dish. Petri dishes were cleaned and remnants of food and frass were removed and old leaves were replaced with fresh leaves daily. To limit the effect dietary history may possibly have on the response of test insects, the beetles were reared on a mixture of four host plants (cabbage, napa cabbage, collard, and turnip) by offering a different type of host plant daily. Bounty paper towels were used as oviposition substrates. The dishes were cleaned daily with soap and 10% Clorox and then rinsed with water to maintain disease free colony. The colony was maintained at $25 \pm 2°C$, $50 \pm 10\%$ RH, and a photoperiod of 14: 10 (L:D) h.

Greenhouse Experiment. A multiple-choice experiment was conducted in the greenhouse (Auburn University Plant Sciences greenhouse facility) to evaluate host preference of *M. ochroloma* by comparing host finding (attraction) and acceptance (oviposition and feeding) behavior of adult beetles on four host plants: cabbage, napa cabbage, collard, and turnip. The test was conducted in cages (122 by 122 by 91 cm) made of PVC pipe (2 cm in diameter) frame and covered with mosquito netting (SCS Ltd., Lake Ariel, PA). The cages were arranged on a bench in the greenhouse at $25 \pm 2°C$, $50 \pm 10\%$ RH, and a photoperiod of 14: 10 (L:D) h. The four legs of the bench were placed in a tray filled with water to prevent ants and other insects from climbing into the cages.

The horizontal surface of each cage was virtually divided into four corner sections and a single potted plant (≈ 5 wk old) of each of the four host plant species (treatments) was placed in each corner section (i.e., the four host plants were simultaneously tested in each cage). The position of each treatment in the cage was determined randomly and rotated during each replication. The same individual host plants were used for the entire experiment (i.e., plant were not replaced). A group of 25 pairs of newly emerged (≈ 2- to 5-d-old), starved adult beetles were placed in a petri dish (150 mm in diameter by 30 mm high) and transferred from the laboratory to the greenhouse, 1 h before the start of the experiment for acclimation. The beetles then were released at the center of the cage by opening the petri dish lid. The experiment was replicated four times over time. The replication and rotation schemes ensured that each treatment was located in each of the four corners of the cage once.

Each cage was examined daily for a period of 19 d (based on a preliminary experiment) to evaluate host plant preference by using three parameters. First, the number of beetles on each host plant was recorded daily as a measure of host finding preference (attraction). The number of larvae on each host plant also was recorded daily as a measure of host acceptance and oviposition preference. Finally, using a method modified after Maletta et al. (2004) each plant was rated for *M. ochroloma* feeding damage (also a measure of host acceptance) on a scale of 1–6 as follows: 1, very light defoliation with <10% of damage; 2, light defoliation (10–30%); 3, moderate defoliation (30–50%); 4, heavy defoliation (50–70%); 5, very heavy defoliation (70–90%); and 6, complete (total) defoliation (>90%).

Data on number of adults, larvae, or damage rating were not normally distributed and thus were square-root transformed and first analyzed by using repeated measures multivariate analysis of variance (ANOVA) (MANOVA) with treatment (host plants) and sampling date as the main factors, and time as the repeated measures factor (Ott and Longnecker 2001, Norman and Streiner 2008, Frank et al. 2011). The assumptions of equal variances and correlations across time in the response variable and appropriateness of using the unadjusted univariate *F*-test values were based on the sphericity of the model. Because the sphericity test, which is part of the within-subject analysis, was significant, we report the value of the Wilk's λ test, which is the same as the adjusted *F*-value. Based on the results of the repeated measures MANOVA, which showed significant effects of treatment, sampling date and a significant treatment × sampling date interaction, the data were re-analyzed by using one way ANOVA followed by the Tukey–Kramer honestly significant difference (HSD) comparison test to determine significant differences among the treatments on a given sampling date ($P < 0.05$; JMP 7.0.1, SAS Institute 2007).

Laboratory Experiments. A four-choice olfactometer bioassay was used to determine the cues that mediate host plant preference of *M. ochroloma*, using methods modified after Pettersson (1970), Kalule and Wright (2004), and Chen et al. (2009). Briefly, the olfactometer (Analytical Research Systems, Gainesville, FL) consists of a central chamber (30 cm long by 30 cm wide by 6 cm high) with orifices or "arms" (17 cm long by 7 cm in diameter) at the four sides and a central orifice where mixing of the airflow from the arms occurred. The orifices were connected through Teflon-glass tube connectors to four glass chambers (22.8 cm in diameter by 40.6 cm high) with lids, which housed the test host plants for headspace volatile collection. Each glass chamber was provided with an inlet at the bottom and an outlet at the opposite top and connected through Teflon tubing and ChemTred (8 mm i.d.) connectors to a flow meter on an air delivery system (ARS Inc., Gainesville, FL), which was in turn connected to an air source fitted with charcoal filter. The inlet air was further purified (using a second set of charcoal filters placed between the flow meters and the glass chambers), pushed at a constant rate of 200 ml/min through the headspace of the test host plants in the glass chambers into the orifices, and removed by suction via a vacuum pump through the central orifice of the olfactometer at the rate of 900 ml/min. Host plants were replaced after every five replicates. The olfactometer apparatus was placed in a cardboard box (82 cm long by 82 cm wide by 61 cm high) lined with white paper and positioned under a fluorescent light source (≈100 lux) for uniform lighting.

An individual test host plant ([in 1-gal pot with the soil covered with aluminum foil paper] was placed in a glass chamber. The four host plants were tested in two separate experiments in which a set of three host plants were compared with the control glass chamber (with pot but no host plant). In the first experiment, napa cabbage, turnip, cabbage, and control were compared. Napa cabbage, turnip, collards, and control were compared in the second experiment.

For each experiment, 10 female or male starved adult beetles (2 to 4 d old) were released at the bottom of the central chamber. The beetles were allowed 40 min to make a choice among the four air fields, and those found in each arm were counted and removed. Beetles that did not walk into any of the arms within 40 min were scored as "nonresponders," and were not included in the analysis. After each test, the olfactometer was cleaned with hexane and acetone and the arms were rotated (90°) to minimize positional effect. Each experiment was replicated at least 21 times per sex. All tests were conducted at $25 \pm 1°C$ and $50 \pm 10\%$ RH. For each experiment, data on number of beetles attracted were first square-root transformed and then analyzed using ANOVA followed by the Tukey–Kramer HSD comparison test ($P < 0.05$; JMP 7.0.1, SAS Institute 2007).

Results

Greenhouse Experiment. The host finding and acceptance preference of *M. ochroloma* was evaluated by simultaneously presenting adult beetles with four host plant species: cabbage, napa cabbage, collards, and turnip. The repeated measures MANOVA showed that there were significant effects of treatment (host plants) (Wilk's λ = 0.115, Adj. df = 6, $P < 0.0001$); sampling date (Wilk's λ = 0.336, Adj. df = 36, $P < 0.0001$,); and treatment × sampling date interactions (Wilk's λ = 0.153, Adj. df = 108, $P < 0.0001$), on the number of adults, larvae, and damage ratings.
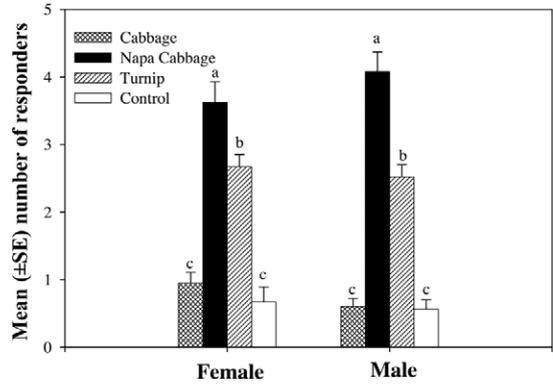
Based on the recorded significant treatment and sampling date interactions, the data were re-analyzed with ANOVA to determine treatment effect on each sampling date. The results showed that *M. ochroloma* actively discriminated among the four host plants (Fig. 1A). Significantly higher numbers ($F = 21.61$; d.f = 3, 18; $P < 0.001$) of adult beetles were recorded on turnip (50% of the beetles) and napa cabbage (35%) than on collards (7%) and cabbage (3%) 1 d after they were released in the cage. Although not significantly different, a higher number of adults were recorded on turnip than on napa cabbage. A similar trend was observed on day 2 up to day 6 after release. However, starting on day 7 after release when ≈30% of the turnip plant had been defoliated, the beetles began to move from turnip to napa cabbage. This culminated in a significantly higher number of beetles on napa cabbage compared with turnip on day 11 ($F = 169.3$; d.f. 3, 12; $P < 0.001$). This trend continued throughout the remaining observation periods: significantly higher numbers of beetles were recorded on napa cabbage than on turnip on day 19 ($F = 30.26$; d.f. 3, 12; $P < 0.001$) (Fig. 1A).

The number of larvae on each plant (Fig. 1B) was recorded as a measure of host plant acceptance and oviposition preference. No larvae were recorded on any of the test plants on days 1–8 after release of
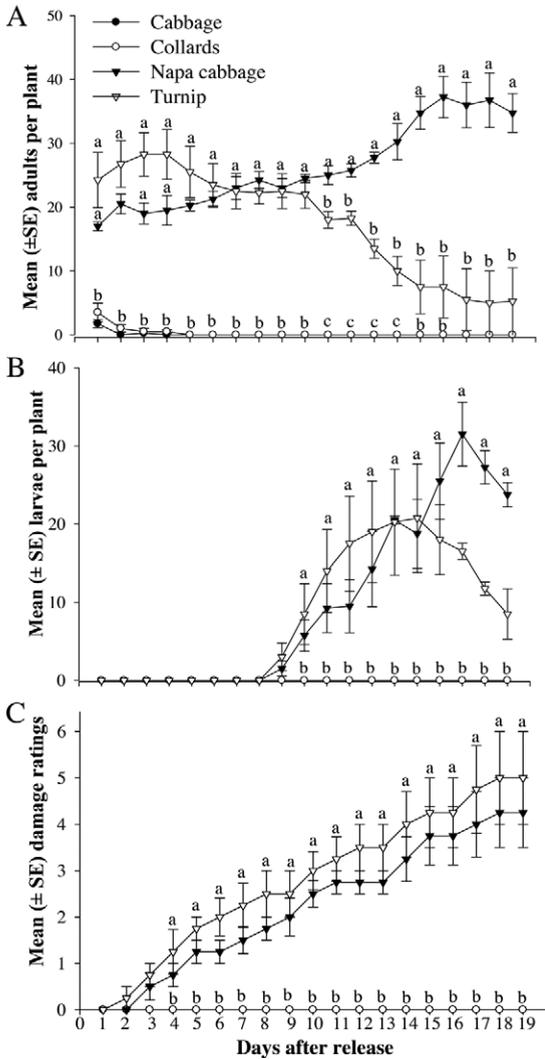
Fig. 1. Mean (±SE) number of *M. ochroloma* recorded daily on four host plants (cabbage, collards, napa cabbage, and turnip) in a multiple-choice greenhouse cage experiment (A) adults, (B) larvae, and (C) damage ratings. 25 pairs of newly emerged starved adult beetles were released per test and replicated four times. Means within each date having no letter in common are significantly different (*P* < 0.05, Tukey–Kramer HSD test).

Fig. 2. Response of *M. ochroloma* in a four-choice olfactometer to headspace volatiles of three host plants (cabbage, napa cabbage, and turnip) versus control. Figure shows mean (±SE) number of female or male beetles attracted per 40 min. Ten beetles of either sex were released per test and replicated 21 times. Means for the same sex having no letter in common are significantly different (*P* < 0.05, Tukey–Kramer HSD test).

15.3; d.f = 3, 12; *P* < 0.0002) and continuing through day 19 (*F* = 39.16, d.f = 3, 12; *P* < 0.001). The reduction in the number of larvae on turnip relative to napa cabbage from day 16 was possibly because of pupation and complete defoliation of turnip. It was observed that when turnip had been completely defoliated, some of the larvae began to feed on the root while others started to move to napa cabbage (Fig. 1B).

Plant damage ratings were generally low and not significantly different among the tested host plants on days 1–3 (Fig. 1C). However, significant differences in damage ratings were recorded among the host plants beginning on day 4 when a significantly higher (*F* = 5.14; d.f = 3, 12; *P* < 0.016) damage rating was recorded on turnip than on cabbage and collard. On day 5, significantly higher (*F* = 25.33; d.f = 3, 12; *P* < 0.0001) damage ratings were recorded for turnip and napa cabbage compared with the other two plants. This trend continued throughout the remaining observation periods (days 6–19) (Fig. 1C).

Laboratory Experiments. The results of the four-choice olfactometer experiment 1, comparing the response of adult *M. ochroloma* to headspace volatiles of napa cabbage, turnip, cabbage, and control (empty glass chamber with no host plant), showed significant differences in the behavioral response of females (*F* = 38.12; df = 3, 80; *P* = 0.0001) and males (*F* = 71.17; df = 3, 80; *P* = 0.0001) to the treatments (Fig. 2). Both sexes were significantly more attracted to napa cabbage than to the remaining treatments, with turnip being the second most attractive treatment. However, cabbage was not more attractive than control. Data from the four-choice olfactometer experiment 2 in which napa cabbage, turnip, collards, and control were compared showed significant differences in the response of female (*F* = 11.49; df = 3, 80; *P* = 0.0001) and male (*F* = 30.64; df = 3,80; *P* = 0.0001) *M. ochroloma* to the

adult beetles, because the eggs laid by the adults were yet to hatch into larvae. Very few larvae were recorded on day 9, but the numbers were not significantly different among the host plants (*F* = 2.02; d.f = 3, 12; *P* < 0.164). Significant differences in larval density were recorded among the test plants starting on day 10 (*F* = 3.80; d.f = 3, 12; *P* < 0.039), with higher numbers of larvae recorded on turnip and napa cabbage than on cabbage or collards. This trend continued until day 15 (*F* = 7.75; d.f = 3, 12; *P* < 0.039). However, significantly higher numbers of larvae were recorded on napa cabbage than on the remaining host plants starting on day 16 (*F* =
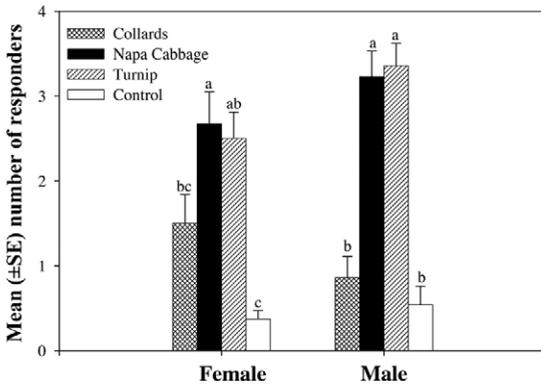
Fig. 3. Response of *M. ochroloma* in a four-choice olfactometer to headspace volatiles of three host plants (collards, napa cabbage, and turnip) versus control. Figure shows mean (±SE) number of female or male beetles attracted per 40 min. Ten beetles of either sex were released per test and replicated 21 times. Means for the same sex having no letter in common are significantly different (*P* < 0.05, Tukey–Kramer HSD test).

treatments. Females were significantly more attracted to napa cabbage than to collards or control (Fig. 3). Males also showed significantly greater attraction to napa cabbage and turnip compared with collards or control.

Discussion

The results from both the greenhouse and laboratory experiments clearly demonstrated the ability of *M. ochroloma* to discriminate among the tested host plants, preferring turnip and napa cabbage over cabbage or collards. Data from the greenhouse multiple choice experiment, which simultaneously evaluated host finding preference (i.e., attraction) and host acceptance (i.e., feeding and oviposition preference), showed that turnip was the most preferred among the tested host plants followed by napa cabbage. Although *M. ochroloma* is known to attack several cruciferous crops other than those tested in the current study (e.g., mustard, radish, Japanese leafy vegetables), our results demonstrated its preference for certain cruciferous plants such as turnip and napa cabbage, and suggest that these preferred crops may be used as trap crops for the pest. Several species of oligophagous leaf beetles (Coleoptera: Chrysomelidae) also have been reported to show preference for some host plants over others. For example, the striped flea beetle, *Phyllotreta striolata* (F.) was shown to discriminate among its host plants in the family Brassicaceae, preferring some hosts such as *Brassica oleracea*, *B. napus*, and *B. campestris* over *B. juncea* (L.) Czern and *B. nigra* (L.) Koch (Lamb and Palaniswamy 1990, Anderson et al. 1992). The Colorado potato beetle, *Leptinotarsa decemlineata* (Say) also demonstrated host preference to its host plants, preferring potato (*Solanum tuberosum* L.) over tomato (*Lycopersicon esculentum* L.) and eggplant (*Solanum melongena* L.). (Hitchner et al. 2008).

Insect host plant selection and preference is a complex phenomenon that is governed by a variety of cues, in particular olfactory and visual cues (De Wilde et al. 1969; Visser 1976; Zehnder and Speese, III 1987). Even though the host plant preference experiment conducted in the greenhouse can reveal useful information on host preference, it is difficult to determine precisely the cue(s) mediating host preference with a greenhouse cage study. Therefore, the laboratory four-choice olfactometer experiments, in which the role of visual cues in host location is eliminated (McIndoo 1926, Visser and Piron 1998), allowed a reliable evaluation of the role of plant volatiles in host preference. The results showed that host finding and acceptance preference of *M. ochroloma*, which was observed in the greenhouse experiment, is mediated by host plant volatiles. Specifically, the olfactometer results demonstrated strong attraction of both sexes of *M. ochroloma* to headspace volatiles of napa cabbage followed by turnip, generally in agreement with the results of the greenhouse experiment.

Oligophagous insects typically use plant odors as informational cues to recognize their host plants (Visser 1986). The odor may consist of general odor components (green leaf volatiles) such as alcohols, aldehydes, fatty acid derivatives and terpenoids, but specific odor components such as isothiocyanates, sulfides, and benzaldehyde are important signature compounds (Visser 1986, Jermy et al. 1988, Dickens 2000). All crucifer plants have characteristic secondary plant metabolites called glucosinolates, which are hydrolyzed by the enzyme myrosinase into isothiocyanates. Most crucifer-specific insect pests use different types of isothiocyanates as olfactory cues to locate their host plants (Louda and Mole 1991, Evans and Allen-Williams 1994). For example, the crucifer-specific seed weevil, *Ceutorhynchus assimilis* Payk, uses 3-butenyl and 4-pentenyl isothiocyanates for host-plant recognition (Free and Williams 1978, Bartlet et al. 1993). Feeny et al. (1970) showed that the flea beetles, *Phyllotreta cruciferae* and *P. striolata*, use allyisothiocyanate to locate their host plants from long range. The cabbage maggot, *Delia radicum* (L.) is also attracted by allyisothiocyanate (Finch and Skinner 1982).

Preliminary headspace volatile analyses of the host plants tested in this study suggest that the volatile profiles of napa cabbage and turnip are similar but qualitatively and quantitatively different from the profiles of cabbage and collards (R. Balusu and H. Fadamiro, unpublished data), further confirming that host preference of *M. ochroloma* is mediated primarily by host plant volatiles. Recent follow-up studies have also resulted in preliminary identification of an isothiocyanate, as a putative attractant for *M. ochroloma* (R. Balusu and H. Fadamiro, unpublished data).

Our results on host preference of *M. ochroloma* are in agreement with field observations of crop damage by the pest. Chamberlin and Tippins (1948) first reported no evidence of damage by *M. ochroloma* on young, tender, cabbage crop adjacent to a heavily infested turnip field in a commercial vegetable farm in Alabama. Similarly, many workers have reported field

observations of higher population densities of *M. ochroloma* on turnip and mustard crop compared with other crucifer crops (Haeussler 1951, Rohwer et al. 1953, Oliver and Chapin 1983). In addition, our unpublished data in commercial organic vegetable farms in south and central Alabama since 2005 also showed higher population densities of *M. ochroloma* on turnip and napa cabbage plantings relative to adjacent cabbage or collards. Ameen and Story (1997b) showed in a laboratory petri dish study that *M. ochroloma* adults and larvae prefer to feed more on turnip and mustard foliage than on collard or cabbage. We also demonstrated in a related study that although *M. ochroloma* can successfully develop on various host plants, including cabbage, collard, mustard, radish, and turnip, female beetles fed on turnip or mustard laid the highest number of eggs (Ameen and Story 1997c).

In general, our laboratory results, which showed preference of *M. ochroloma* for napa cabbage and turnip, are fairly consistent with the results of the greenhouse experiment. However, turnip was the most preferred host in the greenhouse experiment, whereas the beetles were more attracted to napa cabbage in the olfactometer bioassays. This subtle but important difference may be related to relative differences in host acceptance of turnip versus napa cabbage. The greenhouse experiment was a measure of host finding or location (i.e., chemical, visual attractiveness, or both) and acceptance (feeding and oviposition), whereas the olfactometer experiment simply evaluated chemical attractiveness of the host plants. The results suggest that napa cabbage was more attractive chemically, whereas turnip was relatively more acceptable. Host acceptance is based on many factors, including nutrient composition and balance, secondary plant metabolites, and morphological factors such as texture, pubescence, and color. Thus, it is possible that the relatively higher acceptance of turnip compared with napa cabbage, as observed in the greenhouse experiment, is related to factors other than differences in volatile profile. Clearly, further studies are necessary to determine the basis for the higher preference and acceptance of *M. ochroloma* for turnip.

In summary, our results showed that turnip and napa cabbage are two preferred host plants of *M. ochroloma*, whereas cabbage and collards are less preferred. Preference is mediated by quantitative, qualitative differences, or both in chemical volatile profiles of the host plants, but other factors appear to contribute to host acceptance. Ongoing studies on chemical analyses of various host plants and complete identification of host plant attractants may support the development of an efficient trap crop system and other attractant-based strategies for managing *M. ochroloma* in organic and conventional crucifer production systems.

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