N O T E

Role of *Lygus hesperus* (Hemiptera: Miridae) Adult Feeding on Deformation of Blackberry Fruits[1]

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Blackberry (*Rubus fruticosus* L.; Family, Rosaceae) is ranked within the top three and top 25 agricultural crops in Santa Cruz and Monterey counties in California (Central Coast), respectively. The value of blackberry in Santa Cruz Co. has been estimated at ~ US$52.8 million and has been planted on 367.5 ha (Santa Cruz County Crop Report 2019), while it has been valued at ~ US$13.5 million and grown on 91.6 ha in Monterey Co. (Monterey County Crop Report 2019). Blackberry is produced continuously from June to October on the Central Coast of California. The crowns of blackberry plants are perennial, and their canes bear fruits. Many arthropod pests pose a threat to blackberry, such as apple pandemis (leafroller), *Pandemis pyrusana* Kearfott; omnivorous leafroller, *Platynota stultana* Walsingham; orange tortix, *Argyrotaenia citrana* (Fernald); redberry mite, *Acalitus essigi* (Hassan); white apple leafhopper, *Typhlocvyba pomaria* Walh; rose leafhopper, *Edwardsiana rosae* (L.); spotted-wing drosophila, *Drosophila suzukii* Matsumura; and greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) (Bolda and Bettiga 2015, Univ. California IPM Pest Management Guidelines: Caneberries, UC ANR Publication 3437).

In recent years, widespread incidences of deformed blackberry fruits have been reported in many blackberry production farms in the Central Coast of California (Fig. 1A). Blackberry fruit deformation can be caused by insufficient pollination after irregular wind, rain, and extreme temperature events (Martin et al. 2017, Compendium of raspberry and blackberry diseases and insects. APS Press, 83–85). Adults and nymphs of the western tarnished plant bug, *Lygus hesperus* Knight (Hemiptera: Miridae), have been regularly observed on blackberry canes during the fruiting season on many farms from the mid- to late-season (S.V.J. and M.B.,

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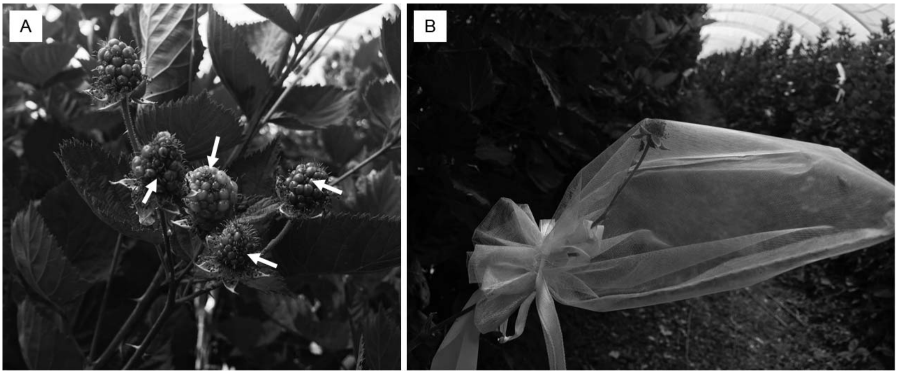

Fig. 1. (A) Blackberry fruits showing deformation (white arrows) and (B) young blackberry fruits at the petal-fall stage caged with adults of *Lygus hesperus*.

unpubl. data). In strawberry (*Fragaria* × *ananasa* Duchesne), *L. hesperus* feeding injury to embryos affects the normal growth and development of tissues adjacent to the embryo (Handley and Pollard 1993, J. Econ. Entomol. 86:505–510) causing deformed or "cat-faced" fruits. Developing strawberry fruits, approximately 10 d old after petal fall, are particularly vulnerable to *L. hesperus* feeding injury (Bolda et al. 2008, Integrated pest management for strawberries, 2nd ed. University of California, Division of Agriculture and Natural Resources Publication 3351). However, it is not clear whether *L. hesperus* feeds on developing blackberry fruits and causes injury and fruit deformation. Thus, the objective of this study was to determine whether young developing blackberry fruits develop fruit deformation after exposure to *L. hesperus* adults.

Experiments were conducted on blackberry cane "Prime-Ark 45" grown on a commercial farm in Watsonville, CA, in 2016. The canes on the farm were actively bearing flowers and fruits. The canes were grown in high tunnels and regularly irrigated. Adults of *L. hesperus* were field-collected using sweep nets from *Brassica* weeds adjacent to organic strawberry fields in Salinas, CA. They were temporarily maintained for less than 4 h at 21°C and 40% relative humidity in the laboratory in cages and used for the experiment on the same day. Blackberry fruits were individually selected on the canes and caged using a 14L × 11W cm sleeve mesh cage. All the selected fruits in the experiment were at the petal-fall stage (Fig. 1B). The experiment was conducted three times, referred to as trials 1, 2, and 3. For trials 1 and 2, the treatments were densities of 0, 1, 3, 5, and 10 *L. hesperus* adults per cage, and the treatments were replicated 15 times in a randomized complete block design. For trial 3, *L. hesperus* adult densities of 0, 3, 5, and 10 per cage were the treatments, which were replicated 10 times in a randomized complete block design. The fruits selected for various treatments within the block were not at fixed spacing because fruits at petal-fall stages were not available at regular spacing. Ten replications (blocks) were employed on a row of blackberry canes, and the remaining five replications were employed on the second row of canes. The selected fruits were caged with sleeve mesh cages, and the densities of *L.*

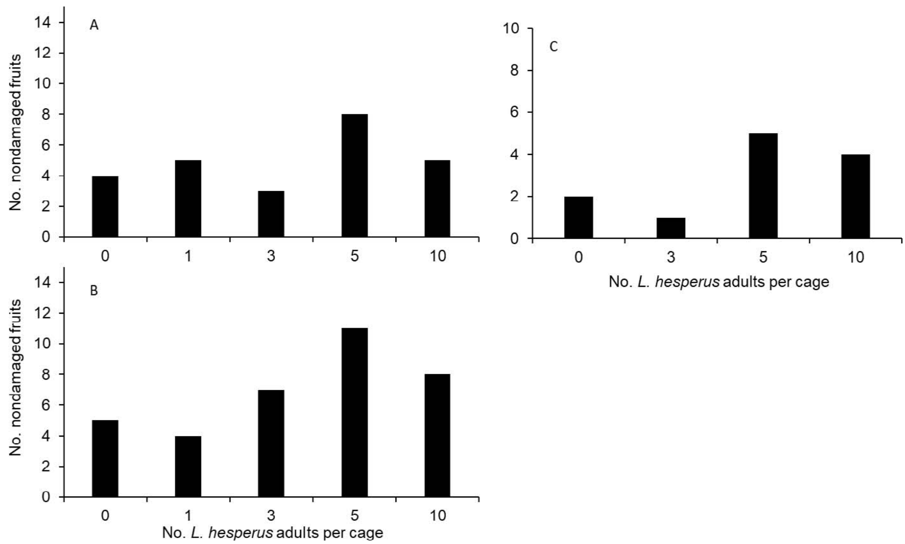

Fig. 2. The number of nondamaged fruits after exposing each fruit to various densities of *Lygus hesperus* adults in trials (A) 1 ($n = 15$), (B) 2 ($n = 15$), and (C) 3 ($n = 10$). Significant differences among bars were evaluated by comparing χ^2 odds ratios, $\alpha = 0.05$. Where no differences were observed, no letters are given.

hesperus adults (treatment) were introduced. The *L. hesperus* adults were sorted into various aspirator plastic containers for each treatment. The treatments were employed up to 18.2 m deep into the high tunnel from the edge. The *L. hesperus* adults were exposed to fruits for 24 h and were removed using aspirators after 24 h. The cages were restored after adult removal to prevent access of naturally occurring *L. hesperus* on the farm to the treatment fruits. The fruits in various treatments were evaluated 3, 5, and 2 wk after adult removal for trials 1, 2, and 3, respectively. The fruits were evaluated for any deformation, as shown in Fig. 1A, and nondeformed fruits were quantified. The *L. hesperus* adults were removed on 15 June, 26 July, and 6 September for trials 1, 2, and 3, respectively. The blackberry fruits were removed from the canes and evaluated on 5 July, 30 August, and 19 September for trials 1, 2, and 3, respectively. The temperature loggers (EL-USB-2, Lascar Electronics, Inc., Erie, PA) were placed in the high tunnel at 18.2 m at 4.6-m intervals, and the average temperature in the high tunnel was 19.8°C for all three trials. For trial 2, the weight (g) and length (mm) of the fruits were measured. These measurements were not evaluated in trials 1 and 3. Categorical data and the number of nondeformed fruits were analyzed for treatment effects using nominal logistic regression (JMP Pro 15, SAS Institute 2019, Cary, NC). The *L. hesperus* treatments were compared by examining the odds ratio between two treatments; that is, probabilities of finding the number of nondeformed fruits were compared between two treatments by examining a χ^2 value of odds ratio ($P < 0.05$). For trial 2, the data on the weight and length of the fruits were subjected to one-way analysis of variance (ANOVA) using the general linear model procedure (PROC GLM) in SAS (SAS Institute, Inc.) after log transformation (ln[x + 1]). The means were separated post-ANOVA using the Tukey HSD method ($\alpha = 0.05$).

The results showed that the number of marketable fruits was not significantly different among the *L. hesperus* treatments in trials 1 ($\chi^2 = 4.1$; df = 4; $P = 0.306$; Fig. 2A), 2 ($\chi^2 = 8.2$; df = 4; $P = 0.085$; Fig. 2B), and 3 ($\chi^2 = 5.0$; df = 3; $P = 0.169$; Fig. 2C). For trial 2, the weight (g) of the fruits was not significantly different among the ($F = 1.3$; df = 4, 47; $P = 0.269$) following density treatments: 0 (mean ± standard error [SE] = 1.24 ± 0.24 g; $n = 13$), 1 (mean ± SE = 1.23 ± 0.33 g; $n = 14$), 3 (mean ± SE = 0.93 ± 0.29 g; $n = 13$), 5 (mean ± SE = 0.53 ± 0.13 g; $n = 13$), and 10 (mean ± SE = 4.13 ± 1.85 g; $n = 12$). The lengths (mm) of the fruits were significantly lower in the 10 adult treatment (mean ± SE = 5.3 ± 1.1 mm; $n = 12$) than in the 0 (mean ± SE = 14.2 ± 1.84 mm; $n = 13$), 1 (mean ± SE = 13.4 ± 2.0 mm; $n = 14$), and 3 density treatments (mean ± SE = 11.5 ± 1.86 mm; $n = 13$) ($F = 4.4$; df = 4, 47; $P = 0.004$). There was no difference in the lengths of the fruits among the 0, 1, 3, and 5 adult treatments. Thus, the results did not conclusively suggest that deformation of blackberry fruits was caused by *L. hesperus* adults feeding during production in the high tunnel. More research is warranted to determine the influence of other factors, such as extreme temperatures and wind velocity leading to improper pollination resulting in fruit deformation.

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