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Host plant preference of *Lygus hesperus* exposed to three desert-adapted industrial crops

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ABSTRACT

The desert-adapted crops vernonia (*Centrapalus pauciflorus*), lesquerella (*Physaria fendleri*), and camelina (*Camelina sativa*) are being grown in the arid southwestern USA as potential feedstock for biofuel and/or other environmentally friendly products. A plant feeding choice test was conducted to determine the relative attractiveness of these three "new" crops to a possible insect pest, *Lygus hesperus* Knight. Adult *L. hesperus* were readily observed feeding or resting on the flowering structures of each plant type, but they were seen most often on vernonia and least often on camelina. *Lygus hesperus* readily deposited their eggs on each plant species, but again, the greatest amount of egg deposition was found on vernonia and the least on camelina. These studies indicate that *L. hesperus* might pose a threat to the production of these new crops. Moreover, the commercial expansion of these crops could significantly alter the population dynamics of the existing arthropod community. New challenges for managing this pest during regional crop production changes are discussed.

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1. Introduction

Several desert-adapted (i.e., low water and fertilizer input) industrial crops including vernonia (*Centrapalus pauciflorus* (Willd.)), lesquerella (*Physaria fendleri* (A. Gray) O'Kane & Al-Shehbaz), and camelina (*Camelina sativa* (L.) Crantz) are being grown on a relatively small scale in the Southwestern USA. Vernonia is a short season crop that is cultivated in the spring and summer months. It yields high quantities of epoxy fatty acids that are useful in the reformulation of oil-based paints to reduce the emission of volatile organic compounds that contribute to the production of smog (Perdue et al., 1986). Other potential markets for the epoxy fatty acids include eco-friendly plasticizers, additives in polyvinyl chloride, polymer blends and coatings, cosmetic, and pharmaceutical applications (Shimelis et al., 2013). The unique structure of vernolic acid may have a much wider use than epoxidized oils at about half the cost of soybean and linseed oils (Carlson and Chang, 1985). Lesquerella is a perennial mustard that is cultivated during winter and spring months (Wang et al., 2010). It is being developed as an oilseed crop for use in making eco-friendly lubricants, resins, waxes, nylons, plastics, and cosmetics (Dierig et al., 1993). Lesquerella oil can also be used for high-performance biodiesel or as an additive to diesel fuels to lessen engine damage while lowering vehicle emissions such as hydrocarbons, carbon monoxide, and particulate matter (Goodrum and Geller, 2005; Moser et al., 2008). Typically grown in the spring, camelina is a short season oil seed crop that is undergoing resurgent interest due to its potential as a biofuel feedstock (Moser and Vaughn, 2010), livestock feed (Colombini et al., 2014), and salmon feed (Hixon et al., 2014). It also yields seeds that have high concentrations of unsaturated Omega 3 fatty acids that compare favorably with other vegetable oils (Wittkop et al., 2009).

The development of these desert-adapted crops offers many exciting new possibilities as biofuel feedstocks, as well as potentially providing nutritional and medical products. However, their commercial development and integration into the existing agroecosystem, as either replacement for conventional crops (i.e., cotton or alfalfa) or as additions to a producer's cropping system, will undoubtedly influence the structure, dynamics, and function of the extant arthropod community. Of particular interest are the potential impact of arthropods on these new crops and the changes in arthropod community dynamics that may exacerbate or ameliorate pest problems in current conventional crops grown in the region.

Lygus spp. (primarily *L. hesperus* Knight) are regarded as a major threat to cotton and many other crops grown in the arid regions of

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the USA (Leigh, 1976; Leigh et al., 1988; Mauney and Henneberry, 1984; Strong, 1970). *Lygus*' status as a major pest is due to several factors. First, *Lygus* spp. are known to feed on >150 different host plants including cotton, alfalfa, canola, and many fruits, vegetables, ornamentals and weeds (Schwartz and Foottit, 1998; Young, 1986; Wheeler, 2000). Second, *Lygus* spp. often feed directly on the plant's young fruit, shoot tips, and seeds which cause fruit deformity or dislodgement (Mauney and Henneberry, 1984; Strong, 1970; Swezey et al., 2007). Third, *Lygus* bug is multivoltine, capable of having five generations per year. Fourth, they cryptically overwinter as adults and undergo a reproductive diapause. In the early spring, they become highly active and seek flowering and fruiting host plants. They tend to colonize early flowering host plants in the spring and then disperse *en masse* to a wide variety of crops (i.e., cotton) over the summer (Sevacherian and Stern, 1975). These highly nomadic and opportunistic feeders are capable of rapidly infesting a wide variety of crops throughout the year. Finally, their pest status is exacerbated by the fact that growers have very few tactics, outside of insecticides, available for *Lygus* spp. control. Unfortunately, some of these insecticides are broad-spectrum in activity and disruptive to the environment in general and the natural enemy and pollinator complexes in particular. Given these characteristics, *Lygus* spp. are poised to negate some of the major gains made in integrated pest management (IPM) over the past quarter century.

Vernonia, lesquerella, and camelina appear to be attractive to *L. hesperus* and other arthropods (i.e., other herbivore pests, natural enemies and pollinators) that are commonly encountered in cotton and alfalfa. However, the relative preference of *L. hesperus* to these three new crops is unknown. Therefore, the goal of this study was to characterize and quantify the feeding and oviposition preferences of *L. hesperus* to these three industrial crops. To this end, we conducted *L. hesperus* feeding and oviposition host plant choice tests in arenas containing flowering vernonia, lesquerella, and camelina plants.

2. Materials and methods

2.1. Test plants and insects

Individual vernonia, lesquerella and camelina plants were grown in a 0.5-gallon pots containing a standard soil mixture. The plants were maintained in a greenhouse at 18 °C (night) to 30 °C (day) and 30% relative humidity (RH). Plants were watered as needed. A 1:1 mixture of all-purpose Scotts Miracle-Gro Excel (21-5-20) and Cal-mag Miracle-Gro® Professional (15-5-15) was applied (250 ml/plant) at a rate of 1% shortly after the seeded plants emerge. All plants were approximately the same size and flowering during the host preference feeding choice bioassays. The adult *L. hesperus* used in all the bioassays were obtained from colony reared on an established artificial diet (Debolt, 1982).

2.2. Host plant feeding preference test

A feeding choice study was conducted in enclosed arenas that contained a single vernonia, lesquerella, and camelina plant. Each arena was a 61 cm tall × 35.5 cm diameter clear cylindrical cage (Fig. 1). The arenas were covered with a fine organdy mesh fabric to facilitate air exchange. The arenas were erected within a 15 × 20-m air conditioned greenhouse at the U.S. Arid-Land Agriculture Research Center, Maricopa, Arizona, USA. The greenhouse was maintained at a 35:25 °C day:night cycle and at 30% RH. Ten cages were erected on each of three different dates (30 April, 7 May and 14 May 2010), which served as blocks in the experimental design. The arenas were put on benches at chest height to facilitate the direct focal observations. The arrangement of plants within each cage was randomized. For each cage, 3–5 day-old adult *L. hesperus* ($n = 50$ per cage) were released at 14:00 at an approximate sex ratio of 1:1. The number and location (i.e., main stem, petioles, leaves, and flowering structures) of *L. hesperus* on each plant were then recorded for the next four consecutive days at 08:00, 11:00 and 14:00 h.

Fig. 1. A *Lygus hesperus* feeding/oviposition choice arena containing a flowering camelina, lesquerella, and vernonia plant.

2.3. Statistical analysis

We fitted a series of mixed linear models to assess the host plant preference of *L. hesperus*. A value of 0.5 was added to each recorded insect count to eliminate mathematical errors (i.e., taking the log transformation of zero insect counts) encountered during the process of identifying the optimal model. To ensure that the data adhered to the statistical assumptions made for the mixed linear model, the Box-Cox procedure (Box and Cox, 1964) was conducted, and Studentized deleted residuals (Kutner et al., 2004) were examined from models that accounted for plant preference, block, day, and time of day. Upon completion of these diagnostic measures, it was determined that the inverse transformation (i.e., the reciprocal of insect counts) was optimal, and that there were no outlying observations. Subsequently, the following model was fitted to the data:

$$Y_{ijklm} = \mu + \text{Plant\_Species}_i + \text{Block}_j + \text{Day(Block)}_{k(j)} + \text{Time(Day)}_{l(k)} + \varepsilon_{ijklm}, \quad \text{(i)}$$

Where Y_{ijklm} is an individual observation, μ is the grand mean, $Plant\_Species_i$ is the fixed effect of ith plant species, $Block_j$ is the random effect of jth block, $Day(Block)_{k(j)}$ is the random effect of the kth day nested within the jth block, $Time(Day)_{l(k)}$ is the random effect of the lth time of day in which insect counts were recorded within the kth day, and ε_{ijklm} is the random error term. Significant differences in the mean visitation rate on each plant species were identified by the Tukey multiple-comparison procedure (Tukey, 1953).

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