Population Biology and Prospects for Suppression of the Solanaceous Fruit Fly, *Bactrocera latifrons* (Diptera: Tephritidae)

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Introduction

Bactrocera latifrons (Hendel) is a tephritid fruit fly native to South and Southeast Asia (White and Elson-Harris 1992). First detected in Hawaii in 1983 (Vargas and Nishida 1985a), it primarily infests fruits of solanaceous plants but has also been found to infest fruits of some species of cucurbitaceous plants in Hawaii (Harris et al. 1991, 1993, White and Elson-Harris 1992, Liquido et al. 1994). Because it has been known in Hawaii for a much shorter period of time than the other three introduced tephritid fruit flies of economic importance [oriental fruit fly, *B. dorsalis* (Hendel); melon fly, *B. cucurbitae* (Coquillett); and Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann)], there has been much less opportunity to study its basic biology and ecology. One area not yet sufficiently understood is the population ecology of this species. In general, it has been observed to maintain relatively low population densities, perhaps because its wild hosts are usually sparsely distributed (making studies of wild populations difficult), and the crop species it attacks have only limited areas of production (Harris et al. 1991, 1993, Liquido et al. 1994, Peck and McQuate 2004). Higher population levels have, however, been found in areas having turkeyberry (*Solanum torvum* Sw) patches. Previous research taking advantage of *B. latifrons* population levels in areas with abundant turkeyberry patches have contributed to improved knowledge of *B. latifrons* male lure response (McQuate and Peck 2001, McQuate et al. 2004) and movement (Peck and McQuate 2004). These areas are also expected to provide a good environment for the study of the population ecology of *B. latifrons*. Because sequential flowering in turkeyberry can lead to a steady production of fruits, areas with abundant patches of turkeyberry also provide a good model system of the potential pest status of *B. latifrons* in continuously cultivated solanaceous crops, such as peppers (*Capsicum* spp.) and tomatoes (*Lycopersicon esculentum* Mill.). At present, there are no large plantings of these economically valuable species in Hawaii that are heavily infested with *B. latifrons,* although the potential for such infestation exists. Here, we report on the population levels of *B. latifrons* as they relate to turkeyberry phenology in a cattle pasture with abundant turkeyberry patches in the vicinity of Haiku, Maui.

Materials and Methods

Population monitoring. In order to monitor the *B. latifrons* population, Jackson traps baited with alpha-ionol + cade oil, the male lure for *B. latifrons* (McQuate et al. 2004), were placed, on 15 December, 2003, on turkeyberry plants in ten separate turkeyberry patches scattered throughout the cattle pasture. Patch size averaged about 18 m^2, ranging from about 9 m^2 to 30 m^2. Each trap had two small plastic baskets, each holding a 3.8 cm long x 1.0 cm diameter cotton wick, hung from the trap hangers. One wick in each trap held 2.0 ml of alpha-ionol (4-(2,6,6-trimethyl-2-cyclohexen-1-yl)-3-buten-2-ol, obtained from Bedoukian

Research, Inc., Danbury, CT), while the second wick held 1.0 ml cade oil (rectified cade oil, obtained from Penta Manufacturing, West Caldwell, NJ). Each trap also contained a sticky insert to catch attracted insects. Following deployment, traps were serviced every 2 weeks until 7 September, 2004, with the male lure recharged every 8 weeks throughout the period. Because attraction to alpha-ionol + cade oil decreases over time, a response decay curve was developed through field trials involving sterile flies (GTM, unpublished data). This curve was applied to trap catch data in this study (catch data from weeks 4, 6, and 8 were multiplied by 1.23, 1.52, and 1.87, respectively) to provide estimates of the catch expected if the lure was always fresh at the start of each two week trapping period. The adjusted average trap catch was then used as an indicator of the *B. latifrons* population size.

Documentation of flowering status of turkeyberry. At each two-week trap servicing interval, the flowering status of turkeyberry was documented by estimating (through averaging counts of 20 tips from at least three sections) the percentage of shoot tips that had at least one fully open flower.

Fruit collection and pupal recovery. At each time of trap servicing, ripe (yellow) fruits were collected by two people over about a two-hour period from throughout the pasture. Following collection, fruits were placed in screened containers which prevented any further exposure to adult tephritid fruit flies and were transported to the laboratory either at Hilo or Honolulu, where they were counted, weighed and then placed in screened containers with sand on the bottom to serve as a pupation medium for any pupating tephritid fruit fly larvae that emerged from the fruits. Total fruits collected provided an estimate of relative abundance of ripe fruits at the site for the sample period. Total *B. latifrons* pupae recovered served as an indicator of expected adult recruitment to the established *B. latifrons* population.

Results

Percentage flowering in turkeyberry, numbers of ripe (yellow) turkeyberry fruits collected over time, pupae recovered from collected turkeybery fruits, and adjusted trap catch of *B. latifrons* over time are presented in Figure 1.

Documentation of flowering status of turkeyberry. Flowering increased from 0.5% in early January up to 95% eight weeks later (8 March, 2004). A comparable pronounced shift from limited to abundant flowering between January and early March was also observed at other turkeyberry sites on Maui within about 8 km of the site described here.

Fruit collection and pupal recovery. Ripe fruits were almost absent in January – February, with no ripe fruits recovered at the 26 January, 2004 collection and only two ripe fruits recovered at each of the 12 January and 9 February, 2004 collections. Although ripe fruit abundance gradually increased after February, fruits were not abundant until June, 2004. Peak ripe turkeyberry recovery occurred on 13 July, 2004, 18 weeks after the first documented 95% flowering level. This time frame is consistent with measurements made on flagged flower clusters, where progression from a fully open flower to the beginning of the ripe stage was found to average 16 weeks. Peak pupal recovery was recorded on 27 July, 2004, two weeks after the time of peak ripe turkeyberry collection. Based on laboratory data (26.6°C, 60% RH) of Vargas and Nishida (1985b), mean duration of egg and larval stages for *B. latifrons* are estimated to be 2.3 and 8.5 days, respectively, for a total egg-larval development time of 10.8 days. The timing of increased recovery of pupae follows the increased abundance of ripe fruits available for infestation in a time frame similar to this egg-larval development time. This timing is reasonable, because the trap catch had increased to 0.45 flies/trap/day by the time of the yellow fruit collection peak, so an increased number

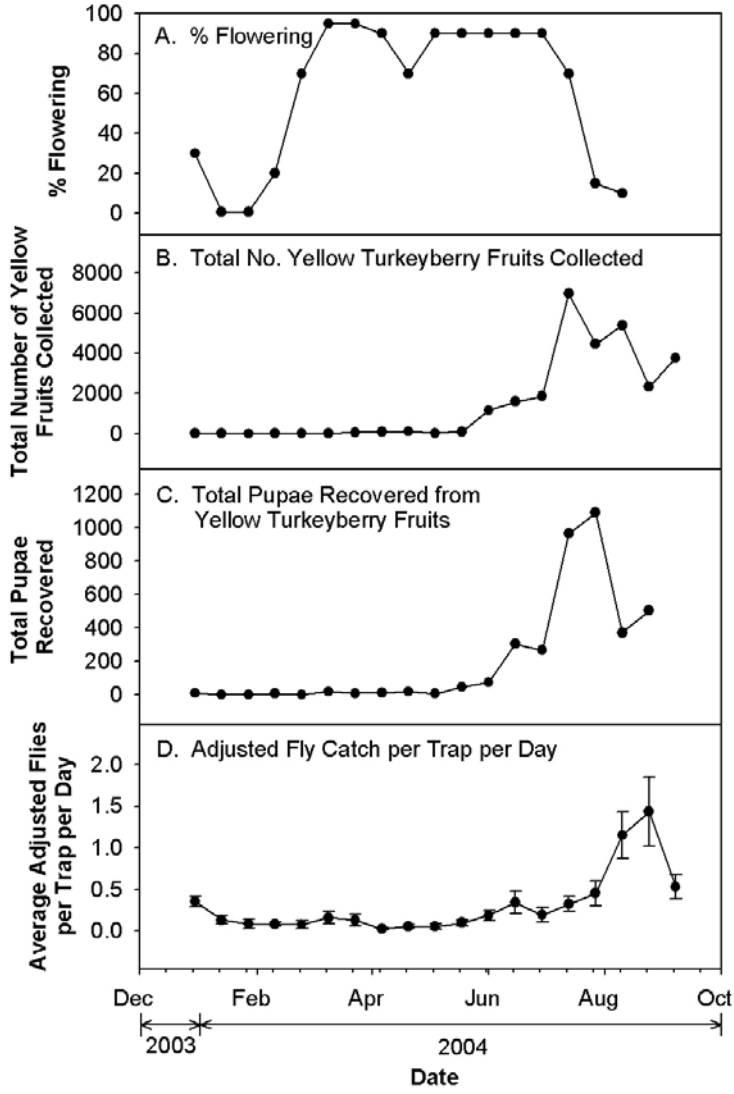

Figure 1. A. Percentage of turkeyberry branch tips with a fully open flower; B. Total number of ripe (yellow) turkeyberry fruits collected over a two hour period; C. Total number of pupae recovered from collected ripe turkeyberry fruits; and D. Average male *B. latifrons* catch per trap per day adjusted to compensate for reduced attractiveness of alpha-ionol + cade oil over the 8-wk recharge interval.

of flies old enough to respond to the male lure were present in the turkeyberry patches.

Population monitoring. Average *B. latifrons* trap catch peaked on 24 August, 2004, four weeks after the pupal recovery peak. Pupal development time, as reported by Vargas and Nishida (1985b) is 10.2 days. Response of wild adult *B. latifrons* males to alpha-ionol + cade oil was found to be 75% of peak response by 14 days old (McQuate et al. 2008). These development times support the timing of the trap catch peak coming 28 days after the pupal recovery peak.

Discussion

Although *B. latifrons* has typically been observed to maintain low population levels, we document here that it has population cycles determined by host plant fruiting cycles as seen in other tephritid fruit fly species, such as the population cycles of the oriental fruit fly developing in response to cycles of guava fruiting (Newell and Haramoto 1968). Knowledge of population cycles can help in the planning of suppression involving sterile insect technique (SIT), which has been proposed to be well suited for *B. latifrons* suppression because of the typically low population levels of this species (Vargas and Nishida 1985b). Although SIT, using current laboratory stocks (USDA-ARS-PBARC, Honolulu, HI), could be applied for control in sites where the *B. latifrons* population is maintained by weedy solanaceous plants, its use in commercial crops is currently limited by the lack of a sexing strain needed for males-only releases.

Other potential methods for tephritid fruit fly suppression include male annihilation, bait sprays, biological control, and sanitation. At this time, male annihilation is not expected to be very successful in population suppression of *B. latifrons*, because alpha-ionol + cade oil is a weak male attractant relative to methyl eugenol which has been successfully used in suppression programs for the oriental fruit fly (Steiner et al. 1970). However, no male annihilation trials have been conducted to date against *B. latifrons*. Bait sprays would be expected to have some effectiveness against *B. latifrons* as they are widely used for suppression of other tephritid fruit fly species. However, no such tests have yet been conducted. At present, biological control is not very effective against *B. latifrons*. Parasitism levels of *B. latifrons* in turkeyberry at this site are low. Out of 1895 *B. latifrons* pupae recovered from the turkeyberry collections of the present study and held individually, less than 6.0% were parasitized. The dominant parasitoid, *Fopius arisanus* Sonan (Hymenoptera: Braconidae) accounted for 4.5% (86 out of 1895 pupae) of the parasitism. Enhancement of biological control could improve suppression of *B. latifrons*. Finally, sanitation could be helpful for suppression. However, as a number of the hosts of *B. latifrons* are weeds (so no fruits are harvested), destruction of weedy hosts may be of greater benefit in suppression.

We have presented data documenting response of *B. latifrons* population levels to fruit host availability as seen in other tephritid fruit fly species. The exact timing of the peaks may, though, vary somewhat among different sites. In additional studies, beyond those reported here, timing of population peaks varied somewhat on the basic scheme presented here. We are continuing to study data collected in these other areas to better understand what role factors such as temperature, patch size, fruit load, and population size play in the population dynamics of *B. latifrons*.

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