Capture of *Bactrocera* Males (Diptera: Tephritidae) in Parapheromone-Baited Traps: Performance of Solid Dispensers with Different Loadings of Attractants and Toxicant

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Abstract. *Bactrocera cucurbitae* (Coquillett) and *B. dorsalis* (Hendel) (Diptera: Tephritidae) are important agricultural pests of the Pacific region. Detection of these species relies on traps baited with male-specific attractants, namely cue lure for *B. cucurbitae* and methyl eugenol for *B. dorsalis*. At present, these lures (plus naled, an insecticide) are applied in liquid form, although this procedure is time-consuming, and naled as well as methyl eugenol may pose human health risks. Recent field tests have shown that traps baited with a solid formulation (termed a wafer) that contains both lures (plus DDVP, an insecticide) capture as many or even more *Bactrocera* males than traps with the standard liquid lures. However, these previous studies used relatively large wafers, which would likely be inadequate for large-scale trapping programs, as fitting them into traps was inconvenient and time-consuming. The purpose of the present study was to compare captures of *B. cucurbitae* and *B. dorsalis* males in traps baited with liquids versus traps baited with different-sized wafers, which also contained different loadings of the male lures. Based on a series of field tests, we found that traps with a slightly smaller (medium-sized) wafer, which is more easily inserted and removed from the traps, performed as well or better than traps with the standard liquid lures or the original large-sized wafer. In addition, field tests with medium wafers showed that the DDVP level could be halved without any loss of trap effectiveness.

Key words: Tephritidae, detection, male lures, trapping

Introduction

Invasive fruit flies (Diptera: Tephritidae) pose a global threat to agriculture through direct damage to food crops and the accompanying trade restrictions that often result. Early detection is vital to controlling fruit flies, because it increases the probability of limiting the growth and spread of the invasive population and thus may greatly reduce the monetary costs required for eradication or suppression (Lance and Gates 1994, Papadopoulos et al. 2001). Consequently, U.S. states, such as California, Florida, and Texas, that are vulnerable to fruit fly pests operate large-scale detection and surveillance programs (IPRFFSP 2006). In California alone, for example, county, state, and federal agencies operate ≈ 47,000 fruit fly traps in five counties in the southern part of the state (K. Hoffman, personal communication).

Fruit fly traps are baited with either food-based attractants or so-called male lures (or parapheromones) (Jang and Light 1996). Regarding the latter, three male lures are typically used: (i) trimedlure (TML), which attracts males of the Mediterranean fruit fly (medfly), *Ceratitis capitata* (Wiedemann), (ii) cue lure (CL), which attracts males of the melon fly, *Bactrocera cucurbitae* (Coquillett) and related species, and (iii) methyl eugenol (ME), which attracts males of the oriental fruit fly, *B. dorsalis* (Hendel), and related species. Males

of economically important species may be attracted to either CL or ME but never to both (Hardy 1979). Traps baited with male lures are a key part of fruit fly detection programs, and although comparative data are scant (e.g., Ware 2002), male lures are considered more powerful attractants than food baits and hence more useful in detection programs.

At present, male lures for *Bactrocera* species are applied as liquids (along with a small amount of the insecticide naled) to cotton wicks, which are then placed within traps. As traps baited with the mixture of ME and CL are less effective than traps baited with either lure alone (Vargas et al. 2000), large-scale detection programs operate two sets of traps for *Bactrocera* detection. Thus, the current procedure involves considerable handling time for preparing and deploying traps as well as potential health risks resulting from accidental contact or ingestion of the insecticide. In addition, data derived from rodents suggest that ME may be carcinogenic, as subjects administered high doses showed increased incidence of liver cancer and mortality (National Toxicology Program 2000). The finding does not necessarily confirm a parallel result in humans (ME occurs in many food products without apparent health risk, Burdock 1995), but it has prompted efforts to reduce exposure of fruit fly workers to this chemical (Vargas et al. 2010).

Recently, a "wafer" was developed by Farma Tech International Corporation, North Bend, WA. It consists of a solid dispenser containing either or both ME and the CL analogue raspberry ketone (RK, which is the hydroxyl equivalent of CL [Beroza et al. 1960] as well as the insecticide DDVP (dichlorvos) as a less toxic alternative to naled. Several field studies (Vargas et al. 2009, 2010; Shelly 2010; Shelly et al. 2011; Leblanc et al. 2011) have compared *Bactrocera* captures between traps baited with liquid lures versus traps baited with wafers containing both ME and RK and found that traps baited with wafers catch similar or even greater numbers of *B. cucurbitae* and *B. dorsalis* males as traps baited with liquid lures. These results are encouraging, because use of wafers would i) reduce the handling time and health risk associated with liquid lures and ii) reduce by half the number of *Bactrocera* detection traps deployed, thus cutting expenditures on trapping supplies as well as the manpower required for trap servicing. However, relatively large wafers (length: 7.5–7.7 cm, width: 5.0–6.3 cm) were used in these previous studies, and these would likely be inadequate for large-scale trapping programs as fitting them into traps was inconvenient and time-consuming.

The purpose of the present study was to compare captures of *B. cucurbitae* and *B. dorsalis* males in traps baited with liquids versus traps baited with different-sized wafers, which also contained different loadings of ME, RK, and DDVP. In pair-wise comparisons, traps baited with liquid lures were compared against traps baited with small- or medium-size wafers (relative to the original large size wafer used in previous studies). In another experiment, traps with liquid lures were compared against traps with small, medium, or large wafers simultaneously. Finally, the capture of *Bactrocera* males was compared among medium wafers containing variable amounts of DDVP to determine whether smaller amounts of this toxicant could be employed without loss of trap effectiveness.

Materials and Methods

The methods used in the present study were similar to those described in Shelly (2010). Consequently, an abbreviated description of the protocol is presented here, and the earlier paper should be consulted for additional details.

Traps and lures. Jackson traps (Scentry Biologicals, Inc, Billings, MT) were used exclusively (following IAEA 2003). All lures, both in liquid and solid form, were obtained from Farma Tech International Corporation (North Bend, WA). In all tests described below, traps baited with liquid lures contained 6 ml of the lure (with 5% naled for CL baits and 1%

naled for ME baits; the specific gravity of both lures is approximately 1.0) applied evenly to two cotton wicks, which were then placed in a perforated, plastic basket. This basket, in turn, was suspended in the middle of the trap above the sticky insert. Three sizes of solid dispensers (or wafers) were tested: large, medium, and small (Table 1). The wafers were suspended in the Jackson traps by inserting the metal hanger through pre-made holes along one (long) side of the wafer. Note that the size designations were relative: the surface area of a medium wafer was approximately 80% of that of a large wafer, while the surface area of a small wafer was only about 28% that of a large wafer. Medium and large wafers had the same length, the medium wafer was slightly narrower and, as such, did not (when in position) touch the sticky base inside the trap. The differences in chemical composition among the wafers mirrored the size differences, i.e., a medium wafer contained approximately 87% of the ME, RK, and DDVP placed in a large wafer, while a small wafer contained about 29% of the amount of each of these chemicals in a large wafer. As the previous statement indicates, the relative amounts of ME, RK, and DDVP per wafer were uniform across the three size categories.

Trapping protocol: Different loadings of attractants in solid dispensers (Experiments 1–3). As noted above, Shelly (2010) compared captures between traps baited with liquid ME and CL versus traps baited with the large wafer containing ME and RK. In the present study, we first made 2-way comparisons between liquid lures and small or medium wafers (Experiments 1 and 2, respectively) and then conducted 4-way comparisons among the liquid lures and the small, medium, and large wafers all operating simultaneously (Experiment 3).

The 2-way comparisons were conducted in Waimanalo, Oahu, a coastal, agricultural area (< 30 m elevation) with mean monthly minimum and maximum air temperatures between 20-24°C and 28–31°C, respectively, during April-November when trapping was conducted. Traps were placed in the canopy of non-host trees (e.g., fiddlewood, *Citharexylum spinosum* L., kiawe, *Prosopis pallida* (Humb. and Bonpl. Ex Willd.) Kunth, and Norfolk pine, *Araucaria heterophylla* (Salisb.) Franco) along roads and were a minimum of 250 m apart. Traps were placed 2–3 m above ground in shaded locations.

For the 2-way comparisons, we identified 24 trap sites (trees) and used these same sites over a 6-week period of trapping. During a given week, 12 sites contained two traps, one with liquid CL and the other with liquid ME (on a given tree, these traps were placed at least 3 m apart to avoid interference; Vargas et al. 2000, Shelly et al. 2004), while the other 12 sites contained a single trap containing a wafer. The type of lure formulation (liquid or wafer) placed on particular trees was alternated weekly. Owing to the high number of captures (which over longer intervals would have covered the sticky insert and possibly blocked further captures), traps in all experiments were placed in the field (starting at approximately 1000 hrs) for only 1 d per week. When not operating in the field, the traps (with their respective liquid or solid lures but without sticky inserts) were hung in a shaded location at our laboratory at ambient temperatures similar to those in Waimanalo. Two separate 6-week trapping intervals were conducted for Experiment 1 (small wafers, October–November, 2009; April–May 2010) and Experiment 2 (medium wafers, September–October 2010; April–May 2011), respectively. The same trees served as trap sites in both study periods.

The 4-way comparison (Experiment 3), which involved simultaneous operation of traps baited with liquid lures or wafers of differing size, followed the same design as the 2-way comparisons, but 48 sites were identified, with 12 sites containing liquid lures and 12 sites each containing either a small, medium, or large wafer. Trap sites were separated by at least 100 m, and trapping was conducted over an 8-week interval. The type of lure placed on particular trees was alternated weekly, such that each lure type was present on each tree for 2 of the 8 weeks of sampling, with these 2 incidents separated by 4 weeks. Sampling was performed in two different sites: Waimanalo during May-June, 2011, and Waipahu, Oahu, during July-August, 2011. This latter site was residential but contained various host trees;

traps were placed on non-hosts, however, such as pink tecoma (*Tabebuia rosea* (Bertol.) DC.), Hong Kong orchid tree (*Bauhinia blakeana* Dunn), and the Formosan koa (*Acacia confusa* Merr.). Mean daily minimum and maximum temperatures were 25°C and 30°C, respectively, during the sampling interval at Waipahu.

Trapping protocol: Different loadings of toxicant in solid dispenser (Experiment 4). In Experiment 4, we compared trap capture of *Bactrocera* males in Jackson traps baited with medium wafers with varying levels of the toxicant DDVP (levels of ME and RK were unchanged from above, Table 1). Medium wafers were selected based on their performance in the aforementioned tests (see below). Three DDVP loadings were compared: 0.49 g (the amount contained in all above tests involving medium wafers), 0.25 g, and 0 g. Sampling was performed in two locations at two different times. In January–February, 2011, 10 traps per DDVP loading (30 traps total) were placed in non-host trees (same species as those used in Waipahu, see above) along streets in the residential area of Salt Lake, Honolulu. Trees were separated by a minimum of 50 m. Traps were operated continuously (owing to low fruit fly populations) for 6 weeks, and sticky inserts were replaced weekly and fly counts made. Traps were rotated weekly, such that traps with a particular DDVP loading occurred on each tree for 2 sampling periods separated by a 3-week interval. Mean minimum and maximum daily temperatures varied between 18–27°C during the sampling period. The same protocol was followed during June–July, 2011, when traps were operated in an agricultural area near Mililani, Oahu. Traps were placed in non-host plants, most commonly turkey berry (*Solanum torvum* Sw.) and castor bean (*Ricinus communis* L.). Mean minimum and maximum daily temperatures varied between 19-27°C during the sampling period.

Data analysis. In all experiments, raw data were normalized by square root transformation $(X + 0.5)^{1/2}$ and subject to a 2-way ANOVA, with time (week) and lure type (Experiments 1-3: liquid or wafer of given size; Experiment 4: wafers with different DDVP loadings) as the main factors. Upon detection of a significant effect of lure type, we used the Holm-Sidak test (test statistic t) for comparisons among lure types independent of the effect of time.

Results

Experiment 1: Liquid lures vs. small wafers. Results for *B. cucurbitae* were similar for the two sampling periods, with lure type having no significant effect and time having a significant effect in both periods (Table 2, Fig. 1). The interaction term was significant in one period (October–November 2009) but not the other (April–May 2010), reflecting high inter-month variability in the relative differences observed for captures in liquid- vs. wafer-baited traps. As with *B. cucurbitae*, time had a significant influence on trap catch of *B. dorsalis* in both sampling periods, but lure type also had a significant effect in one of the sampling intervals (Table 2; Fig. 2). During October–November, 2009, significantly more *B. dorsalis* males were captured in wafer- than liquid-baited traps independent of the effect of time ($t = 2.71$, $P = 0.008$). The interaction term was not significant for either sampling period for *B. dorsalis*.

Experiment 2: Liquid lures vs. medium wafers. Results for *B. cucurbitae* differed between the two sampling periods (Table 3; Fig. 3). In September-October, 2010, neither time nor lure type had a significant effect on *B. cucurbitae* captures. The interaction term was significant. In contrast, in April–May, 2011, both time and lure type had significant effects, while the interaction was not significant. In April–May 2011, traps with solid dispensers were found to capture significantly more *B. cucurbitae* males than traps baited with liquid cue lure independent of the effect of time ($t = 3.22$, $P = 0.002$).

The data obtained for *B. dorsalis* were consistent between the two sampling periods. In both intervals, both time and lure type had significant effects on trap catch, and in neither

Table 1. Sizes of individual solid dispensers (wafers) used in the study along with the amount of male attractant and toxicant (DDVP) present. The thickness of all wafers was 0.125 cm. Abbreviations: ME = methyl eugenol; RK = raspberry ketone; DDVP = 2,2-dichlorovinyl dimethyl phosphate (dichlorvos).

Relative size	Length (cm)	Width (cm)	ME (g)	RK (g)	DDVP (g)
Large	7.5	6.3	3.54	2.46	0.56
Medium	7.5	5.0	3.09	2.14	0.49
Small	5.0	2.5	1.03	0.71	0.16

case was the interaction term significant (Table 3; Fig. 4). Moreover, in both study periods, captures of *B. dorsalis* males in traps baited with wafers were significantly greater than those recorded for traps baited with liquid ME (September–October 2010: $t = 3.79$, $P < 0.001$; April-May 2011: $t = 3.58$, $P < 0.001$).

Experiment 3: Liquid lures and three sizes of wafers. Lure type had no noticeable effect on captures of *B. cucurbitae* males in either Waimanalo or Waipahu (Table 4; Fig. 5), while time significantly affected captures in Waipahu only. The interaction term was not significant for either site. Lure type had a detectable effect on captures of *B. dorsalis* males at Waipahu but not Waimanalo, whereas captures varied significantly with time at both sites (Table 4; Fig. 6). The interaction term was not significant for either site. At Waipahu, the multiple comparisons test revealed that i) traps baited with liquid ($t = 2.50$, $P = 0.01$), medium wafers ($t = 5.20$, $P < 0.001$), or large wafers ($t = 4.40$, $P < 0.001$) captured significantly more *B. dorsalis* males than traps baited with small wafers and ii) traps baited with medium wafers captured significantly more *B. dorsalis* males than traps baited with liquid lure ($t = 2.71$, $P = 0.01$). No significant difference was apparent in any other pair wise comparison.

Experiment 4: Variable DDVP loadings. At Salt Lake, only *B. dorsalis* males were captured in sufficient numbers for statistical analysis. The 2-way ANOVA revealed that both time ($F_{5, 162} = 29.7$, $P < 0.001$) and DDVP level ($F_{2, 162} = 71.1$, $P < 0.001$) had a significant effect on captures, while the interaction was not significant ($F_{10, 162} = 1.3$, $P = 0.21$). The multiple comparisons test revealed that traps baited with wafers containing 0.49 g DDVP ($t = 11.0$, $P < 0.001$) and 0.25 g DDVP ($t = 9.6$, $P < 0.001$) captured significantly more *B. dorsalis* males than traps baited with wafers lacking DDVP. Trap captures associated with the 0.49 g and 0.25 g levels were not significantly different ($t = 1.3$, $P = 0.17$). Combined over all weeks at Salt Lake, the mean numbers of *B. dorsalis* males captured per trap were 241.5 (SE = 23.4) for 0.49 g DDVP, 214.9 (SE = 20.2) for 0.25 g DDVP, and 64.8 (SE = 4.9) for 0.0 g DDVP, respectively.

Similar results were obtained for both *Bactrocera* species at Mililani. For B. *cucurbitae*, the 2-way ANOVA revealed that both time ($F_{5, 162} = 8.7$, $P < 0.001$) and DDVP level ($F_{2, 162} = 10.4$, $P < 0.001$) had a significant effect on captures, while the interaction was not significant ($F_{10, 162} = 0.8$, $P = 0.60$). The multiple comparisons test revealed that traps baited with wafers containing 0.49 g DDVP ($t = 4.0$, $P < 0.001$) and 0.25 g DDVP ($t = 3.9$, $P < 0.001$) captured significantly more *B. cucurbitae* males than traps baited with wafers lacking DDVP. Trap captures associated with the 0.49 g and 0.25 g levels were not significantly different ($t = 0.1$, $P = 0.96$). Combined over all weeks at Mililani, the mean numbers of *B. cucurbitae* males captured per trap were 190.2 (SE = 12.7) for 0.49 g DDVP, 191.2 (SE = 14.2) for 0.25 g DDVP, and 138.2 (SE = 12.0) for 0.0 g DDVP, respectively.

Table 2. Results of two-way ANOVA for Experiment 1 examining the effects of lure type (liquid or small wafer) and time (weeks since start of experiment) on capture of wild males of *B. cucurbitae* and *B. dorsalis* in Jackson traps at Waimanalo, Oahu, during two sampling periods (residual df = 132 in all cases).

	Source of variation	df	F	P
B. cucurbitae				
October–November, 2009	Lure type	1	2.33	0.13
Time	5	2.69	0.02	
Lure type x Time	5	3.95	0.002	
April–May, 2010	Lure type	1	0.35	0.55
Time	5	2.25	0.04	
Lure type x Time	5	0.07	0.99	
B. dorsalis				
October–November, 2009	Lure type	1	6.06	0.01
Time	5	43.5	< 0.001	
Lure type x Time	5	4.86	0.76	
April–May, 2010	Lure type	1	0.34	0.56
Time	1	3.21	0.01	
Lure type x Time	5	0.50	0.78	

Table 3. Results of two-way ANOVA for Experiment 2 examining the effects of lure type (liquid or medium wafer) and time (weeks since start of experiment) on capture of wild males of *B. cucurbitae* and *B. dorsalis* in Jackson traps at Waimanalo, Oahu, during two sampling periods (residual df = 132 in all cases).

	Source of variation	df	F	P
B. cucurbitae				
September–October, 2010	Lure type	1	0.05	0.82
	Time	5	2.05	0.08
	Lure type x Time	5	2.77	0.02
April–May, 2011	Lure type	1	10.34	0.002
	Time	5	3.56	0.005
	Lure type x Time	5	2.18	0.06
B. dorsalis				
September–October, 2010	Lure type	1	172.48	< 0.001
	Time	5	68.01	< 0.001
	Lure type x Time	5	0.53	0.75
April–May, 2011	Lure type	1	12.81	<0.001
	Time	1	6.68	<0.001
	Lure type x Time	5	2.00	0.08

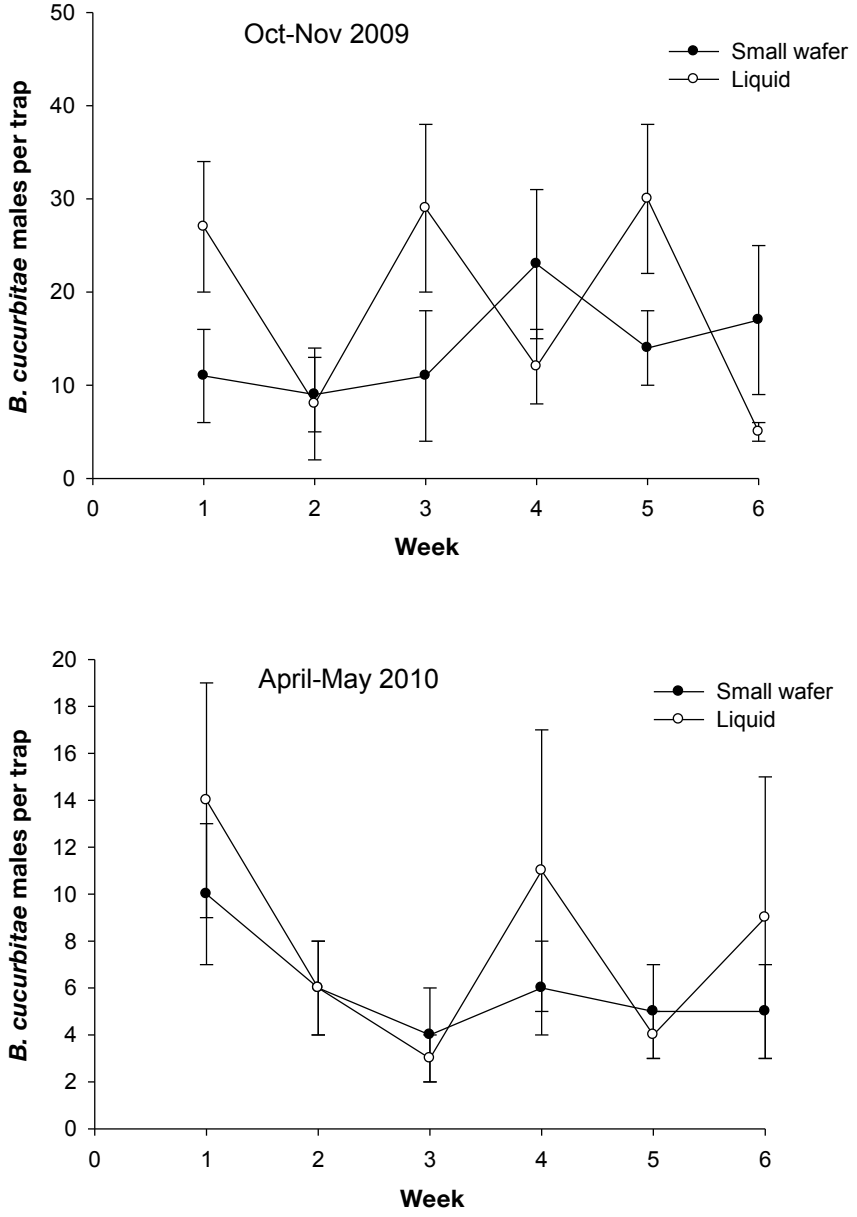

Figure 1. Number of *B. cucurbitae* males captured in Jackson traps baited with liquid CL or a small wafer containing ME and RK during October–November 2009 (top) and April–May 2010 (bottom) at Waimanalo. Symbols represent means ± SE (n = 12).

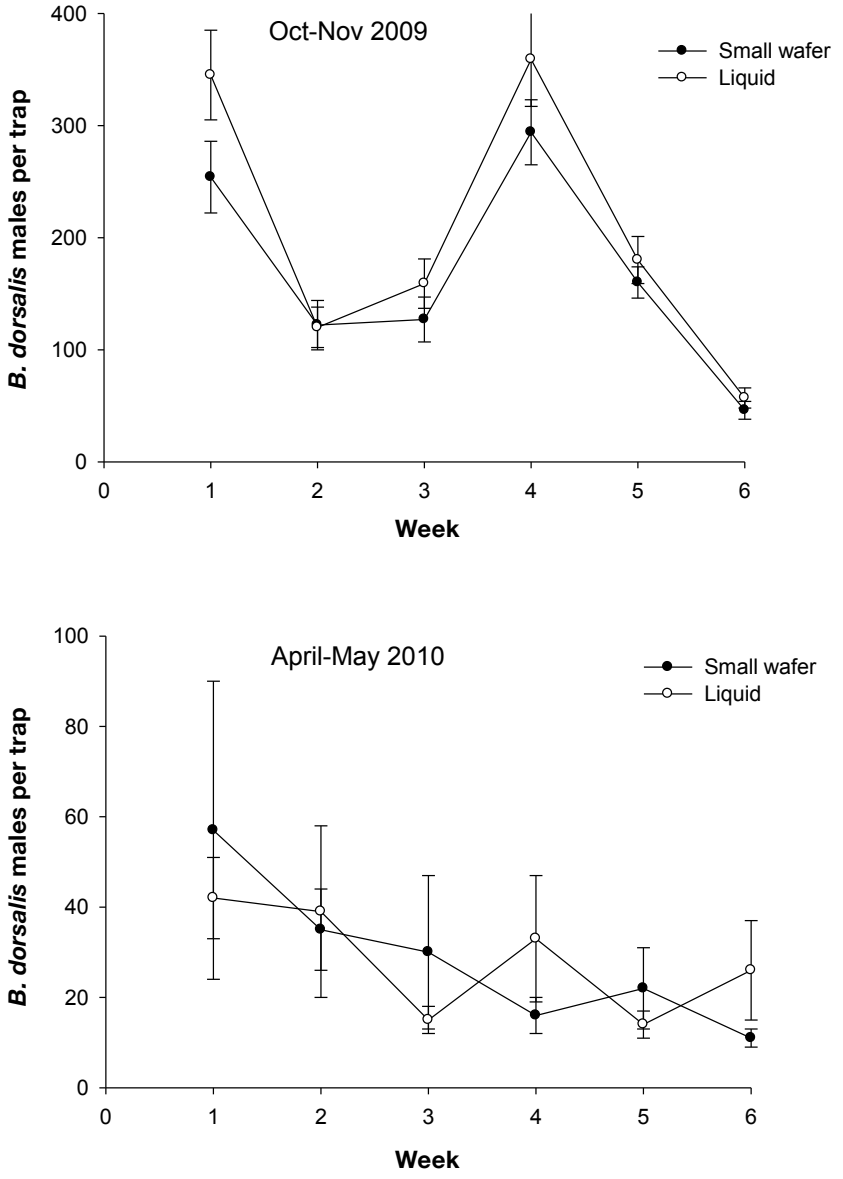

Figure 2. Number of *B. dorsalis* males captured in Jackson traps baited with liquid ME or a small wafer containing ME and RK during October–November 2009 (top) and April–May 2010 (bottom) at Waimanalo. Symbols represent means ± SE (n = 12).

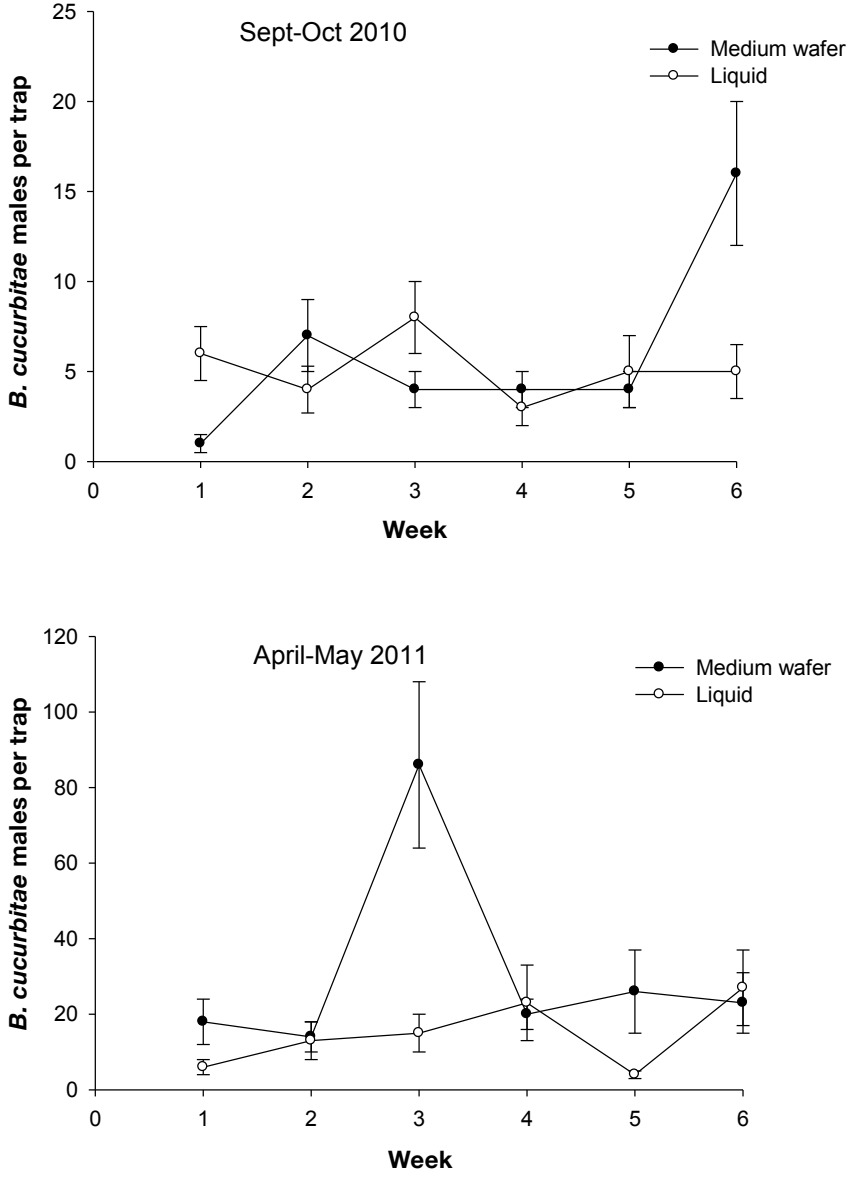

Figure 3. Number of *B. cucurbitae* males captured in Jackson traps baited with liquid CL or a medium-sized wafer containing ME and RK during October–November 2009 (top) and April–May 2010 (bottom) at Waimanalo. Symbols represent means ± SE (n = 12).

Table 4. Results of two-way ANOVA for Experiment 3 examining the effects of lure type (liquid or small, medium, and large wafer) and time (weeks since start of experiment) on capture of wild males of *B. cucurbitae* and *B. dorsalis* in Jackson traps at Waimanalo (May–June, 2011) and Waipahu (July–August, 2011), Oahu (residual df = 352 in all cases).

	Source of variation	df	F	P
B. cucurbitae				
Waimanalo	Lure type	3	1.07	0.36
	Time (week)	7	1.84	0.08
	Lure type x Time	21	0.72	0.81
Waipahu	Lure type	3	2.00	0.11
	Time (week)	7	2.45	0.02
	Lure type x Time	21	0.89	0.60
B. dorsalis				
Waimanalo	Lure type	3	0.95	0.42
	Time (week)	7	8.57	< 0.001
	Lure type x Time	21	0.56	0.94
Waipahu	Lure type	3	10.71	< 0.001
	Time (week)	7	25.15	< 0.001
	Lure type x Time	21	0.89	0.61

Likewise, for *B. dorsalis* at Mililani, the 2-way ANOVA revealed that both time ($F_{5, 162}$ = 43.5, P < 0.001) and DDVP level ($F_{2, 162}$ = 12.1, P < 0.001) had a significant effect on captures, while the interaction was not significant ($F_{10, 162}$ = 0.3, P = 0.97). The multiple comparisons test revealed that traps baited with wafers containing 0.49 g DDVP (t = 4.8, P < 0.001) and 0.25 g DDVP (t = 3.4, P < 0.001) captured significantly more *B. dorsalis* males than traps baited with wafers lacking DDVP. Trap captures associated with the 0.49 g and 0.25 g levels were not significantly different (t = 1.3, P = 0.19). Combined over all weeks at Mililani, the mean numbers of *B. dorsalis* males captured per trap were 19.8 (SE = 2.2) for 0.49 g DDVP, 18.4 (SE = 2.1) for 0.25 g DDVP, and 13.8 (SE = 1.8) for 0.0 g DDVP, respectively.

Discussion

With a single exception, traps baited with wafers containing ME and RK captured similar or greater numbers of *B. cucurbitae* and *B. dorsalis* males as traps baited with the standard liquid formulations (Table 5). This outcome was evident both in the 2-way and 4-way comparisons and in tests performed at different locations at different times of the year. Moreover, independent of their size, the wafers performed at least as well as liquid-baited wicks even though the amount of liquid lure per wick (approximately 6 g) exceeded the amount of ME or RK in the wafers. Thus, the present data are consistent with previous studies (Vargas et al. 2009, 2010; Shelly 2010; Shelly et al. 2011) in showing comparable effectiveness between the ME- and RK-laden wafers and the standard liquid lures. The only exception involved the significantly lower catch of *B. dorsalis* males in traps baited with the

Table 5. Summary of statistical comparisons of male captures between traps baited with liquid (LQ) versus traps baited with small (SW), medium (MW), or large (LW) wafers in the three field experiments. Significant differences ($P < 0.05$) are indicated by inequality signs; non-significant differences are indicated by the approximately equal symbol.

Experiment	Site	Year	*B. cucurbitae*	*B. dorsalis*
1	Waimanalo	2009	SW ≈ LQ	SW > LQ
	Waimanalo	2010	SW ≈ LQ	SW ≈ LQ
2	Waimanalo	2010	MW ≈ LQ	MW ≈ LQ
	Waimanalo	2011	MW > LQ	MW > LQ
3	Waimanalo	2011	SW ≈ LQ	SW ≈ LQ
			MW ≈ LQ	MW ≈ LQ
			LW ≈ LQ	LW ≈ LQ
3	Waipahu	2011	SW ≈ LQ	SW < LQ
			MW ≈ LQ	MW > LQ
			LW ≈ LQ	LW ≈ LQ

small wafers relative to traps baited with liquid lures in the 4-way comparison conducted at the Waipahu site (Table 5). For *B. dorsalis*, the small wafer actually outperformed liquid lures in the 2-way comparison in 2009 and performed equally to liquid lures in the 4-way comparison conducted at Waimanalo. Regarding *B. cucurbitae*, traps with small wafers captured similar numbers of males as traps with liquid lures in all cases.

Given the relatively poor performance of the small wafer for *B. dorsalis* in the one instance and the difficulty in handling the large wafer, the medium wafer appears the most suitable size among those compared. As noted above, the slightly narrower shape greatly eased the placement and removal of the medium wafer from the Jackson trap, and traps with a medium wafer captured similar or significantly greater numbers of *B. cucurbitae* and *B. dorsalis* males as traps having liquid lures (Table 5). In addition, the present results show that DDVP levels might be lessened without loss of wafer effectiveness. In comparisons with liquid baits, the medium wafers contained 0.49 g of DDVP. However, the final experiment, which involved medium wafers exclusively, showed that wafers with 0.25 g of DDVP were as effective in capturing both *B. cucurbitae* and *B. dorsalis* males as wafers with 0.49 g of DDVP, and both of these loadings were more effective than wafers that lacked DDVP completely.

In conclusion, as federal and state agencies responsible for *Bactrocera* detection develop plans to replace liquid lures with solid dispensers, data, such as those presented here, will be required to make sound decisions regarding the size and composition of the solid formulations. In this regard, the present results are best viewed as a first step toward identifying the optimal size and chemical content of *Bactrocera*-attracting wafers. Based on the present findings, it appears likely that additional field testing will identify a wafer intermediate in size and chemical loading to the small and medium wafers examined here that matches or outperforms the liquid lures. As even traps with the small wafer captured similar numbers of *B. cucurbitae* males as traps having liquid CL, it appears that ME content will ultimately determine the size and chemical loadings of the most suitable wafer, perhaps not an unexpected finding given the high volatility of ME relative to RK/CL (Vargas et al.

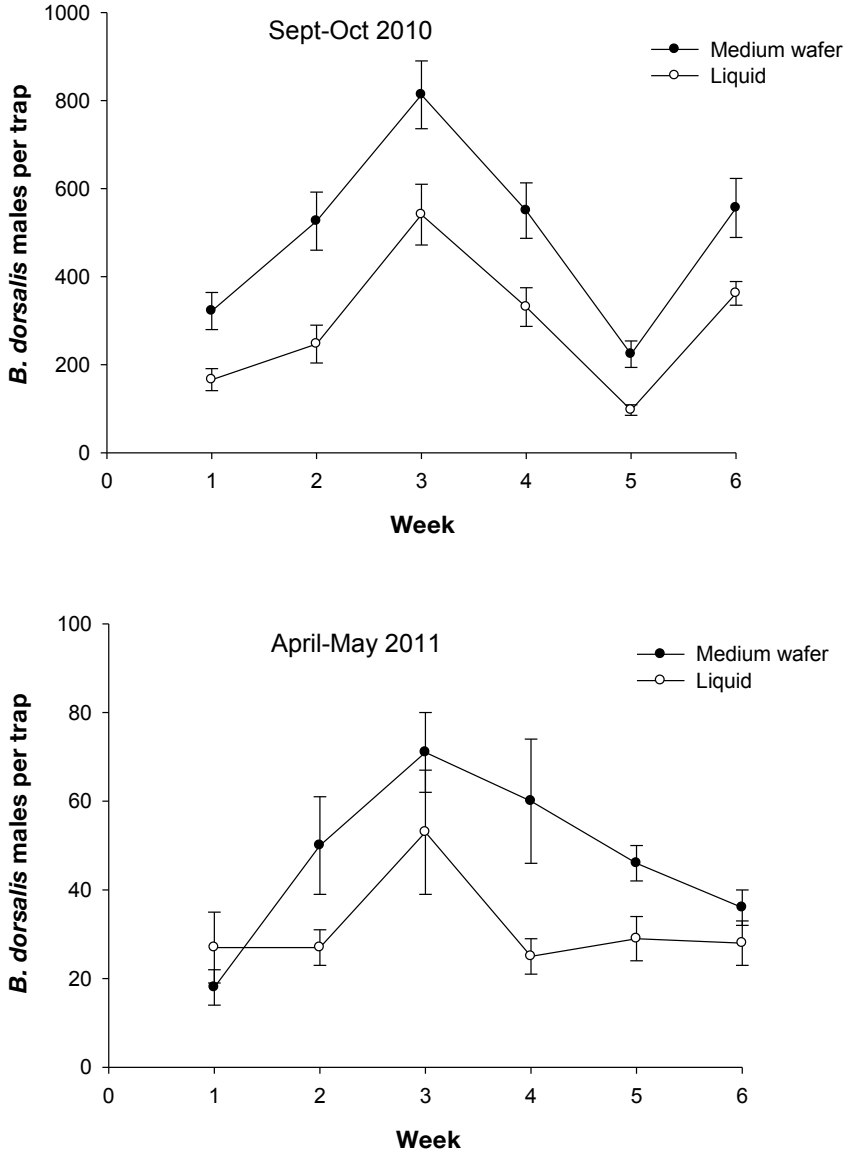

Figure 4. Number of *B. dorsalis* males captured in Jackson traps baited with liquid ME or a small wafer containing ME and RK during September-October 2010 (top) and April–May 2011 (bottom) at Waimanalo. Symbols represent means ± SE (n = 12).

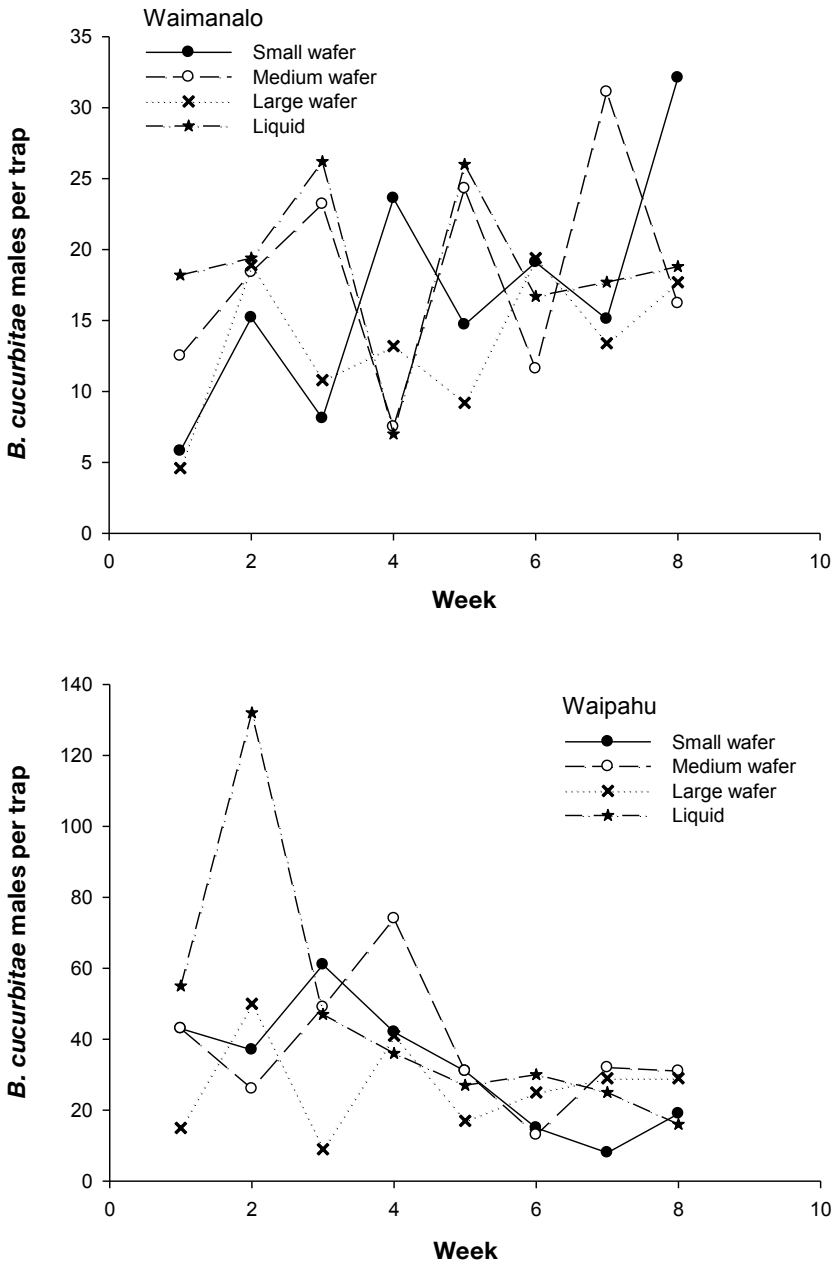

Figure 5. Number of *B. cucurbitae* males captured in Jackson traps baited with liquid CL or a small, medium, or large wafer containing ME and RK at Waimanalo (top, May–June 2011) and Waipahu (bottom, July–August 2011). Symbols represent means; error bars were omitted to increase readability.

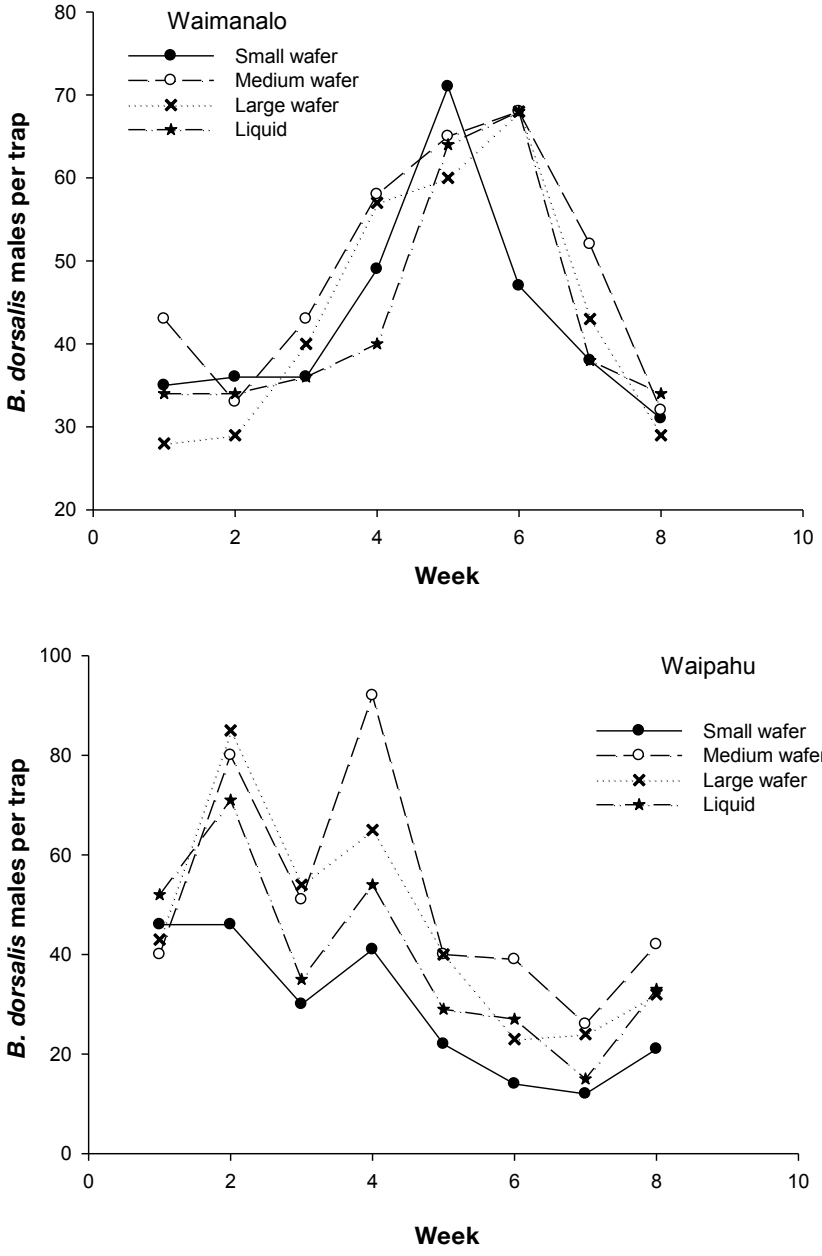

Figure 6. Number of *B. dorsalis* males captured in Jackson traps baited with liquid CL or a small, medium, or large wafer containing ME and RK at Waimanalo (top, May–June 2011) and Waipahu (bottom, July–August 2011). Symbols represent means; error bars were omitted to increase readability.

2010). As the relative amounts of ME, RK, and DDVP were similar among the differently sized wafers tested here, it is not known whether changing ME content alone would alter the attractiveness of the wafer or whether changing ME would necessitate parallel changes in RK and DDVP as well to maintain wafer attractiveness.

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