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Male and female *Popillia quadriguttata* (Fabricius) and *Protaetia brevitarsis* (Lewis) (Coleoptera: Scarabaeidae) response to Japanese beetle floral and pheromone lures

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ABSTRACT

Popillia quadriguttata (Fabricius), and *Protaetia brevitarsis* (Lewis) adults were captured with Japanese beetle, *Popillia japonica* Newman, sex attractant and floral lures at Changchun, China during July–August 2012. The floral lure (phenethyl propionate:eugenol:geraniol, 3:7:3) was attractive to male and female *P. quadriguttata* (AV: 1.2 ± 0.9; 1.1 ± 0.3; total: 2.3 ± 0.8), and was similar in attraction to the combination of the sex attractant (SA) [(R, Z)-5-(1-decenyl) dihydro-2(3H)-furanone] plus the floral lure for male (1.60 ± 0.2), female (1.30 ± 1.1) and total captures (2.9 ± 3.0). However, the SA alone captured only males in much higher numbers than when combined with the floral lure (10.0 ± 6.4). In a separate earlier test, the greatest number of *P. quadriguttata* males (12.5 ± 3.0), female (12.2 ± 1.5) and total captures (24.7 ± 2.5) was in yellow, laboratory-made, bottle traps. The floral lure also attracted female *Pro. brevitarsis* (10.0 ± 3.4), while the SA attracted only few male beetles (1.0 ± 0.2). The combination SA + floral lure captured similar females (11.0 ± 2.0) and total (14.2 ± 2.2) *Pro. brevitarsis* as the floral lure alone. Two butterflies, *Colias erate poliographus* (Motschulsky) and *Pieris rapae* (Linnaeus), were also attracted to the floral lure. These studies indicate a potential for replacing pesticides by using the Japanese beetle lures for monitoring and control of several insects in China, and that they would be useful in monitoring and eradication of two potential scarab pests, *P. quadriguttata* and *Pro. brevitaris*, in the United States and Europe.

Introduction

The Japanese beetle (JB), *Popillia japonica* Newman, is a classic example of an introduced insect becoming a serious pest in its new country. Following the beetle discovery of the beetle in a New Jersey nursery in 1916 (Fleming, 1972), efforts were undertaken to identify effective lures to be used in trapping of adults (Fleming, 1969). This work culminated with the JB female produced sex pheromone (Japonilure) being identified as (R, Z)-5-(I-decenyl) dihydro-2(3H)-furanone, synthesized (Tumlinson et al., 1977), and patented (Tumlinson et al., 1979) in the United States. About that same time, Ladd and McGovern (1980) showed the superiority of the floral lure combination of phenethyl propionate, eugenol, and geraniol (3:7:3) as an attractant for both male and female beetles. The combination of the synthetic sex attractant (SA) and the best floral lure (Ladd et al., 1981) has been the standard JB attractant for the past 30 years. Surprisingly, the addition of the SA not only increased male attraction over that of the floral lure alone, but it has a synergistic improvement in female captures (Klein et al., 1981).

There had been a considerable effort to track other scarab beetles with the JB attractants. In the Unites States, *Anomala* in Florida (Cherry et al., 1996) and *Phyllophaga* and *Cyclocephala* in Texas (Crocker et al., 1999) were attracted to present or past JB floral lures. Furthermore, JB lures have been evaluated in several foreign countries. In South Africa a number of Cetoniiae and Rutelinae scarabs were captured with eugenol and geraniol (Donaldson et al., 1986). Recently in Europe, the cetonine scarab *Potosia cuprea* (Herbst) was attracted to the three part JB floral lure in Hungary (Toth et al., 2003). Of particular relevance to this paper, in Asia, *Popillia lewisi* Arrow, *Protaetia ishigakia okinawana* Kurosawa and *Oxycetonia jecunda* Felderman were attracted to the JB floral lure at Okinawa, Japan (Klein and Edwards, 1989), and *Oxycetonia*, *Popillia*, *Anomala*, and *Holotrichia* species were attracted in South Korea (Reed et al., 1991). Lee et al. (2007) also attracted *Popillia flavosellata* Fairmaire, *Adoretus tenuimaculatus* Waterhouse, the oriental beetle, *Exomala* (=*Anomala*) *orientalis* Waterhouse, and *Maladera japonica*

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(Motschulsky) to the JB lures. Chow (1986) found that *Popillia indigonacea* Motschuosky was captured by the JB lures on Taiwan. More recently, Chen et al. (2001) recorded that *Proagopertha lucidula* (Faldermann), the apple fairy chafer, and *Oxycetonia* were captured by the JB lures in China. In addition, Chen and Li (2011) found that *Protaetia brevitarsis* (Lewis), the white spotted flower chafer (WSFC) was attracted to compounds present in the JB floral lure.

Popillia quadriguttata (Fabricius) and *P. japonica* are very closely related species and very similar in appearance, having much the same colors on the thorax and elytra, and having the same five white spots on the side of the abdomen. The two can most reliably be separated by the shape of the clypeus, trapezoidal and straight on the front of *P. quadriguttata*, and rounded on the JB (Guo, 1983; Ping, 1988; Ku et al., 1999). Claims of JB in Korea and China (Fleming, 1972) were really *P. quadriguttata* (Ping, 1988; Ku et al., 1999). Reed et al. (1991) reported that males of *Popillia uchidai* Niijima and Kinoshita were only attracted to the JB SA and neither males nor females were attracted to the floral lure. Ku et al. (1999) found that *P. uchidai* was really a synonym for *P. quadriguttata*. However, Lee et al. (2007) found that *P. quadriguttata* were highly attracted, 383 per trap, to the combined JB SA and floral lure. In China, Li et al. (1995) also captured this species with the combination lure.

Pheromones and kairomone can provide a powerful means of pest control through mass trapping, mating disruption, or lure and kill techniques on many economically important insect pests (Weinzierl et al., 2012). In addition, it has been shown (see above) that other genera and species can be attracted by the JB SA and floral lures. This provides an opportunity to exploit a commercialized lure from the JB to help protect crop yields and reduce pesticide use against other scarab pest species.

Control with female sex pheromones alone as attractants is difficult since males can mate more than once, and control may not be obtained unless more than 90% of the males are successfully removed. Such efforts would require high product and labor costs. To efficiently eliminate pest populations, there is a need to enhance the lures' attractiveness, or attract both sexes to a trap. Food attractants often attract both males and females, and in some cases, there is a synergism between food lures and the SA (Klein et al., 1981). This may be based on a situation in nature where flower smells may enhance the attractiveness of the SA in the traps (Klein and Edwards, 1989; Chen et al., 2001).

Popillia quadriguttata has been a serious pest in China, Korea and Russia, damaging flowers on horticultural crops (Sang, 1979; Lee et al., 2002). During 2012, these beetles were found on roses, and causing damage to soybean leaves in mid to late July at Changchun (Chen and Klein, personal observation). Because *P. quadriguttata* is resistant to chemicals, and has no biological control, further confirmation and optimization of captures with JB lures are needed for early detection and control of this pest. This study was conducted in Changchun to determine if pest scarabs in north-eastern China, such as the WSFC, would respond to commercially formulated JB lures. We also wished to evaluate the different responses of male and female scarabs to these lures for the first time in NE China, and to see if the synergism between the SA and floral lures noted in the JB would carry over to these species. These studies will provide tools for possible scarab control in China, as well as for surveys of invasive scarab species in the United States and Europe.

Materials and methods

Tests were conducted on the Jilin Agricultural University experimental farms at Changchun, Jilin Province, north-eastern China, during July and August, 2012. During this time, “Bag-A-Bug” type traps from Trécé (Trécé, Inc., Adair, OK, USA) (Fig. 1A), Rescue® traps (Sterling International, Inc., Spokane, WA, USA) (Fig. 1B), and laboratory-made traps (Fig. 1C) were used. Three replicates of each trap were used unless otherwise noted.

Traps

The Trécé trap (Fig. 1A) consists of two, yellow, high impact styrene, rectangular pieces (15.3 × 14 cm) that interlock at 90° angles to form the vanes or baffles of the trap. The supporting set of vanes has a 2.5-cm notch on the top edge where the two cards cross, from which a plastic loop extends to attach the trap to a supporting rod. Each vane has an extended C-shaped notch 10 cm down the outside edge for attaching a polyethylene bag to hold captured insects. The bag is 20.5 cm wide at the top and bottom and constricts to 6.5 cm at a point 18 cm down its 40.5 cm length. The top part of the bag forms a funnel beneath the plastic baffles, and the lower portion serves as the capture receptacle. The floral lure is impregnated into a felt pad (2 × 6 × 1 cm) and held in a similar sized well in a solvent resistant plastic, lure pack (6 × 10 cm). The sex lure (1 mg of Japonilure in a rubber septum) is held in its own compartment in the same pack. Flanges on both edges of the lure pack allow it to be inserted in two corresponding 7.5-cm slits on adjoining trap vanes.

The Rescue trap (Fig. 1B) is structurally similar to the Trécé trap, having four vanes and a bag to collect the insects. The trap consists of two, yellow-green, high impact styrene rectangles (13.8 × 5.3 cm) to form the supporting system and baffles of the trap. The polyethylene capture bag is rectangular in shape with a plastic slide lock seal on the bottom edge, which can be opened for removing insects. The JB floral lure, Japonilure and the sex pheromone of the oriental beetle, *Anomala* (=*Exomala*) *orientalis* are mixed and then encapsulated in ca. 50 plastic pellets. The lures are held in a green cylindrical container which is placed at the center of the vanes to maintain a 90° angle and add to the stability of the trap.

The laboratory-made bottle trap (Fig. 1C) is generally similar to JB bottle traps suggested by Klostermeyer (1985), and utilized two 1.5 l plastic water bottles. The top one is inverted with the plastic cut and folded in to form four rectangles (5 × 10 × 5 cm) to act as baffles or vanes to intercept the beetles. A Trécé or Rescue lure was attached with a plastic thread to the inside of the inverted bottle. The lower bottle was the capture receptacle, had five1 cm diam. holes in the bottom to drain water and was attached with a friction fit to the upper bottle by a 5 × 3.45 cm OD plastic tube.

Trap color

To evaluate the effect of trap color on captures, the upper bottles were painted chrome yellow, green or left unpainted (clear). Three traps of each color, baited with Rescue attractants, were hung on the east edge of a soybean field (20 × 200 m, variety: Jinongda, at the late vegetative stage; 40–50 cm height) adjacent to a common field-corn plot (Var: Xianyu, at early kernel formation stage) on 6 July 2012. Beetles were removed, but only counted and sexed every two continuous rainy or sunny days at ca. 3:00 pm until 20 July. Rainy/cloudy days which reduced beetle activity were rainy/cloudy between 10 and 3 when beetles normally fly on sunny days.

Inhibition or synergism

For evaluation of possible synergism or inhibition between floral lures and SA, nine replicates of Trécé and Rescue traps were hung on 14 July on the east side of the same soybean field above, but were located to the north of the previous test, and only emptied, assessed and sexed every two continuous rainy or sunny days as above from 20 July to 8 August 2012. Trécé traps were baited with their floral lure, SA, floral lure plus SA, or no lure. Rescue traps were baited with the standard Rescue bait of floral lure, Japonilure and the oriental beetle pheromone as noted above.

To further evaluate the attraction of Japonilure to *P. quadriguttata*, Trécé traps with the SA plus floral lure, or the two lures alone, were placed on the north edge of a rape and soybean-mixed field, near a campus forest, and next to a vegetable field. Traps were placed on 16 July

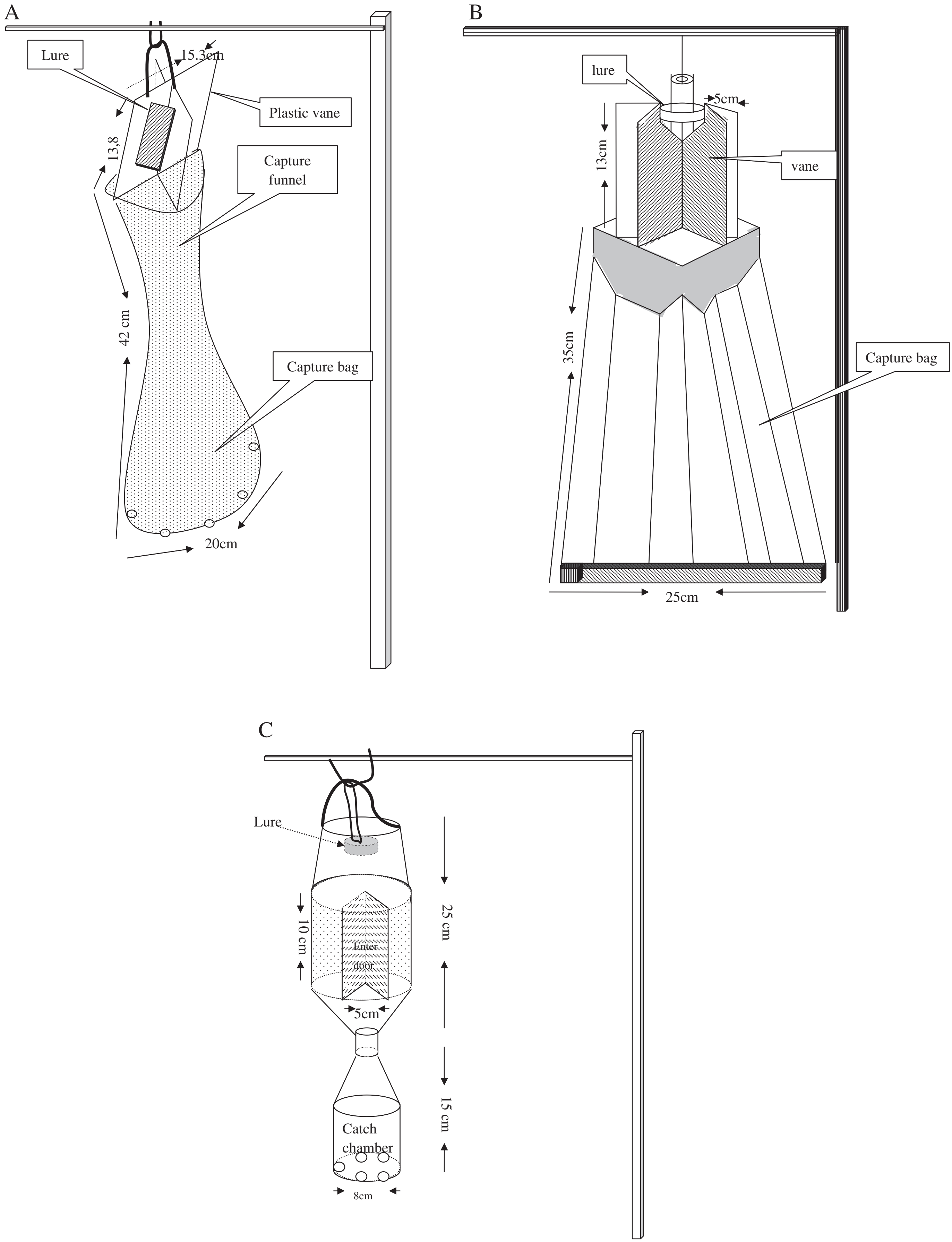

Fig. 1. Traps used in *Popillia quadriguttata* attraction studies: A) Trécé; B) Rescue®; and C) bottle trap.

Table 1
Captures of *Popillia quadriguttata* in bottle and Rescue® traps at Changchun, China. July–August 2012.[a]

Trap	♂ Captures			♀ Captures			Total
	Rainy weather	Sunny weather	Average	Rainy weather	Sunny weather	Average	
Yellow bottle	6.6 ± 1.2a	17.3 ± 2.1a	12.5 ± 3.0a	9.8 ± 1.3a	13.2 ± 2.6a	12.2 ± 1.5a	24.7 ± 2.5a
Rescue	5.6 ± 2.1a	18.4 ± 1.8a	12.6 ± 3.0a	1.8 ± 1.1bc	6.3 ± 2.3b	4.2 ± 2.5b	16.8 ± 2.5ab
Green bottle	3.8 ± 0.9b	11.8 ± 2.2b	8.3 ± 3.4b	3.0 ± 0.6b	7.7 ± 1.6b	5.5 ± 2.8b	13.8 ± 2.3b
Clear bottle	2.4 ± 1.2b	9.6 ± 2.5b	6.5 ± 2.4b	6.0 ± 1.4b	4.5 ± 1.2b	5.8 ± 2.0b	12.3 ± 1.7b
Rescue no lure	0.4 ± 0.2c	2.2 ± 0.6c	1.4 ± 0.3c	0.2 ± 0.3c	1.2 ± 0.2c	0.8 ± 0.3c	2.2 ± 0.2c
$F_{(4,20)}/P_{value}$	3.32/0.05	3.06/0.05	3.82/0.05	3.73/0.05	4.42/0.01	4.52/0.01	4.9/0.01

[a] Mean ± SD. Numbers in a column followed by the same letter are not significantly different, Duncan's multiple range test.

2012 and evaluated every two continuous rainy or sunny days as above until 20 August.

Other insects attracted

The ability of JB traps and lures to catch a diversity of species such as the WSFC was evaluated with Rescue traps and lures placed beside a rape garden (Var: Jufeng 1th, at late vegetative stage with 20–25 leaves) near an apple grove (Var: Guoguang, at early stage fruit of ca. 0.2 cm diam.), and near a vegetable field (cucumber, Var: Jinongda 3th, at early growing stage with fruit 3–5 cm long) on 2 July, and were emptied every two days until 14 July. On14 July, Rescue, Trécé and bottle traps baited with SA plus floral lure, or the two lures alone were placed on the eastern border of a corn field adjacent to organic cabbage. On 28 July, six replicates of the bottle traps baited with SA plus floral lure were placed in the sweet corn field and rape garden again. The catches were counted after being emptied every other day at ca.3:00 pm until 20 August.

Trap layout and data analysis

Each trap contained 5 ml of the floral lure. SA was dispensed as noted above. Traps were placed in a randomized complete block design with 10 m between treatments and at least 25 m between each block. Traps were secured to wooden poles so the upper edge of the funnel was about 75 cm above the ground.

During the two month investigation period, all beetles were taken to the Agricultural Insects Research Laboratory at the Jilin Agricultural University, Changchun, where they were given preliminary identifications and counted. In addition, the sex was determined using the front tibial spur characteristic, which is similar to that of the JB (Fleming, 1972). Trap captures were transformed by log(x + 1) to normalize the data, insect counts were subjected to analysis of variance and means were separated using Duncan's (1955) multiple range test. Since tests were conducted under similar conditions, and had high data homogeneity, replicates from various dates were pooled for an average.

Results

Popillia quadriguttata was initially captured in Rescue traps on 2 July near the rape field — apple grove, and subsequently near the vegetable field. Rescue traps and lures captured an average of 6.23 +/− 0.77 per two day period between 1 and 8 July. Yellow bottle traps captured an average 7.11 +/ −1.8 per two day period from 3 to 11 July.

Trap color

Captures of male beetles showed a uniform trend during both sunny (favorable for beetle activity and flight) or cloudy and rainy (unfavorable) days (Table 1). The yellow bottle and Rescue trap both captured significantly more *P. quadriguttata* than the other three traps. The green and clear bottle traps both caught statistically more beetles than the trap with no lure. The total captures mirrored the male catches (Table 1). The yellow bottle and Rescue traps were superior for attraction of *P. quadriguttata*. Although the yellow bottle trap caught the most beetles, the difference was not significant. Any trap baited with SA captured significantly more beetles than a trap with no lure. The yellow, Rescue, green, and clear traps capture ca. 11.2, 7.6, 6.3, and 5.6 times as many total beetle as the trap with no lure. In comparison with an unpainted trap, those painted yellow caught ca. twice as many beetles, and green traps caught 1.36 times as many beetles. The yellow bottle and Rescue traps were equally attractive (24.7 + 2.5, 16.8 + 2.5), and both were superior to the other three traps in both rainy and sunny weather.

Yellow bottle traps were significantly better than clear traps for females (12.2 ± 1.5, 5.8 ± 2.0), males (12.5 ± 3.0, 6.5 ± 2.4) and total captures (24.7 ± 2.5, 12.3 ± 1.7). The relatively high proportion of beetles captured in the yellow un-baited traps (male: 0.8 ± 0.3; female: 1.4 ± 0.3; total: 2.2 ± 0.2) further indicates an attraction to yellow, or perhaps a slight contamination of the traps by the lures during production, shipping and handling.

As expected, traps containing only Japonilure caught males, but no females. There was no synergism between the floral lure and SA as is found with *P. japonica*, although captures were slightly higher with the combination lure.

These studies covered about three weeks and 7 investigations, capturing ca. 489 beetles. An additional 2 week trial was conducted in late August, but almost nothing was captured then, indicating that *P. quadriguttata* populations were gone by August 30th. Male to female ratios for the first 3 weeks were 2.1:1, 1.4:1 and 1:5.1. This indicates that as with other scarabs, male beetles are probably out and responding to lures before females. Observations and trap data also

Table 2
Popillia quadriguttata captured in Japanese beetle traps baited with phenethyl propionate/eugenol/geraniol 3:7:3 (floral lure = FL) and/or sex attractant (SA) at Changchun, China. July–August 2012.[a]

Traps/Lure	♂ Captures			♀ Captures			Total
	Rainy weather	Sunny weather	Average	Rainy weather	Sunny weather	Average	
Trécé FL&SA	0.6 ± 0.1b	2.2 ± 0.7b	1.6 ± 0.2b	1.8 ± 1.4a	0.3 ± 0.1b	1.3 ± 1.1a	2.9 ± 3.0b
Trécé FL	0.6 ± 0.2b	1.6 ± 0.8b	1.2 ± 0.9b	0.4 ± 0.1b	1.5 ± 0.3a	1.1 ± 0.3a	2.3 ± 0.8b
Trécé SA	4.4 ± 0.9a	13.6 ± 1.2a	10.0 ± 6.4a	0 ± 0b	0 ± 0b	0 ± 0b	10.0 ± 6.4a
Rescue® FL&SA	0.6 ± 0.2b	1.1 ± 0.5b	1.0 ± 0.3b	0.2 ± 0.1b	2.8 ± 0.9a	1.6 ± 0.8a	2.6 ± 0.9b
Trécé no lure	0b	0.3 ± 0.01c	0.1 ± 0.002c	0b	0b	0b	0.1 ± 0.002c
$F_{(4,20)}/P_{value}$	3.14/0.05	3.18/0.05	3.44/0.05	4.48/0.01	4.52/0.01	4.85/0.01	4.67/0.01

[a] Mean ± SD. Numbers in a column followed by the same letter are not significantly different, Duncan's multiple range test.

showed that cool, rainy days greatly decreased captures, and that like the JB, bright sunlight is an important factor for *P. quadriguttata* activity.

Inhibition or synergism

Table 2 shows an inhibition between the floral attractant and SA. Trécé traps with the SA alone captured significantly more male *P. quadriguttata* (10.0 ± 6.4) than traps containing SA plus floral lure (1.6 ± 0.2), floral lure alone (1.2 ± 0.9) and Rescue traps and lures (1.0 ± 1.0). Traps with SA alone caught ca. 7 times as many males as traps with SA plus floral lure. The floral lure, SA plus floral lure, and Rescue lure were equally attractive to male *P. quadriguttata*, indicating the floral lure is inhibiting the activity of the SA, and the oriental beetle pheromone in the Rescue lure has no effect. Given that the SA is not attractive to females, as expected the three traps containing floral lure had about equal attractiveness. The strong attraction of the SA for males resulted in a 4-or 5-fold increase in total captures over the other traps.

On cool, rainy days, reductions in male and female captures were uniformly spread over the season, with an exception for male captures in SA traps (4.4 ± 0.9). This confirmed that Japonilure had a very strong attraction to *P. quadriguttata* males, causing them to fly even under adverse conditions.

JB lure capture diversity

Table 3 shows the attraction of JB SA or floral lure to the white spotted flower chafer, *Colias erate poliographus* (Motschulsky) and *Perris rapae* (Linnaeus). The first WSFC was caught in a Rescue trap on 4 July in a rape field. The combination of the SA and floral lure was similar in attraction to the SA alone for females (11.0 ± 2.0; 10.0 + 3.4), and trapped significantly more male (3.2 ± 1.4; 1.0 ± 0.1) and total WSFC (14.2 + 2.2; 11.0 + 2.7; 1.0 + 0.5) than the floral lure. This indicated an added effect between the SA and floral lure for male and total WSFC. Two butterflies were also trapped, *C. erate* and *Per. rapae*, both of which are agricultural pests. No *C. erate* were attracted to the SA alone, and the SA in combination with floral lure attracted similar numbers of male, female and total *C. erate* as the floral lure alone. While the SA alone attracted an average of one male and female, the SA and floral lure combination attracted 2.3 times as many female *Per. rapae* as the floral lure and 7 times as many females as SA. The trend is reflected in the total catches where the SA and floral lure combination had 13.0 ± 2.2 and floral lure 8.0 ± 0.8. This indicates an unexpected synergistic response to the two lure combination to female *Per. rapae*.

Discussion

Popillia quadriguttata is an important scarab pest of horticultural crops throughout Korea and China (Sang, 1979; Lee et al., 2002). It is a particularly severe pest of golf course turf in Korea, and can be expected to increase in importance in China as more golf courses are built. It will be interesting to follow its progression on the newly built course near Changchun. To examine damage potential, and to allow for early detection, forecasting and control, there is a need to exploit attractants for use in IPM programs.

The attraction of both male and female *P. quadriguttata* to the floral lures, and the strong male attraction to Japonilure are important on several levels. First, the floral lures provide a tool for the detection, monitoring and forecasting of this species in both China and the United States. Second, the strong response of males from a different *Popillia* species to the Japonilure, gives us a possible mechanism to sort out the extremely complicated JB sex pheromone and the need for its high degree of enatomeric purity (Tumlinson et al., 1977). We will explore the possible attraction of the racemic Japonilure to *P. quadriguttata* in future tests. We will also examine the unusual inhibitory effect of the floral lure on the SA. Since there was a similar response to both the Rescue and Trécé lures, the presence of the oriental beetle pheromone in the Rescue lure did not affect attraction. Third, this opens an opportunity to use commercially available lures for possible mass trapping or mating disruption of *P. quadriguttata*. In addition, since rose is not considered a favorite host plant of *P. quadriguttata*, maybe replacement of the geraniol would improve attraction to this scarab. In contrast to what one sees with these lures and JB populations in the U.S., field observations in China indicated that *P. quadriguttata* did not congregate on plants near traps. This phenomenon may not hold with higher population pressure. There was a positive interaction between the lures and yellow traps. Thus commercially available JB traps or yellow bottle traps would work best in field trials. However, since traps with SA alone attracted ca. 7 times as many male beetles as traps containing SA and floral lure, perhaps the two lures should be used separately in the field. These results add to the information from previous studies on *P. quadriguttata* to JB lures. Reed et al. (1991) attracted only males of *P. uchidai* = *P. quadriguttata* in Korea. It is possible that in large populations, attraction to the floral lures would not differ from the control. It is hard to tell what to make of the high trap captures of *P. quadriguttata* with the combination SA and floral lures on Korean golf courses (Lee et al., 2007). No information is available on the sex of beetles captured, but the traps were clearly useful in obtaining information of population dynamics.

This is the first report of trapping WSFC, an economically important sweet corn pest, with a commercial attractant. WSFC is native to China and adults presently cause severe damage to immature sweet corn ears in China and other countries (Chen et al., 2006, 2010; Chen and Zhao, 2008; Kim et al., 2008; Chen and Li, 2011). Although using Malathion in combination with attractive compounds has been relatively successful in suppressing WSFC populations in sweet corn fields (Chen et al., 2010; Chen and Li, 2011), the technique has not be applied on a large scale due to the high cost of materials and labor. The commercialized Japanese beetle lure greatly reduces labor and is more cost-effective, therefore overcoming that limitation of the earlier technique. It is not surprising that the JB lures would attract WSFC in the field, since the two scarabs share similar lure components, and many other Cetoniinae have been attracted to these lures (see Introduction). Chen and Li (2011) found that geraniol and 2-phenethyl propionate elicit an active response from WSFC which were similar to host plant volatiles or

Table 3
Captures of *Potosia brevitaris* (white spotted flower chafer), *Colias erate poliographus* and *Pieris rapae* in Japanese beetle traps baited with phenethyl propionate/eugenol/geraniol 3:7:3 (floral lure) and/or sex attractant (SA) at Changchun, China. July–August 2012.[a]

Lure	*Potosia brevitaris*			*Colias erate poliographus*			*Pieris rapae*		
	♂	♀	Total	♂	♀	Total	♂	♀	Total
SA & floral lure	3.2 ± 1.4a	11.0 ± 2.0a	14.2 ± 2.2a	3.3 ± 1.8a	10.2 ± 1.6a	13.5 ± 2.3a	6.1 ± 0.9a	7.1 ± 1.0a	13.0 ± 2.2a
Floral lure	1.0 ± 0.1b	10.0 ± 3.4a	11.0 ± 2.7b	2.2 ± 2.3a	9.1 ± 1.1a	11.3 ± 1.1a	5.3 ± 0.3a	2.3 ± 0.2b	8.0 ± 0.8b
SA	1.0 ± 0.2b	0 ± 00b	1.0 ± 0.5b	0 ± 0b	0 ± 0b	0 ± 0b	1.0 ± 0b	1.0 ± 0b	2.0 ± 0.1b
No lure	0 ± 0c	0 ± 0c	0 ± 0c	0 ± 0b	0 ± 0b	0 ± 0b	0 ± 0c	0 ± 0c	0 ± 0c
$F_{(4,30)}/P_{value}$	3.01/0.05	4.14/0.01	4.42/0.01	4.25/0.01	4.16/0.01	4.39/0.01	2.92/0.05	2.68/0.05	2.95/0.05

[a] Mean ± SD. Numbers in a column followed by the same letter are not significantly different, Duncan's multiple range test.

food attractants. Those two compounds are the main components of the current standard Japanese beetle lure, phenethyl propionate, eugenol, and geraniol at a ratio of 3:7:3, (Ladd and McGovern, 1980), plus Japonilure (Ladd et al., 1981). It is possible that the geraniol would not be needed for the WSFC, thus further reducing lure costs.

Conclusions

Popillia quadriguttata and *Pro. brevitarsis* are major pest in turf, soybeans and horticultural crops, and in corn fields, respectively, requiring updating of pest control strategy. Further research on improving trapping technique as an alternative to chemical control is demanded now for the benefit of famers and end-consumer as an environmentally friendly control technique. The attraction of the JB lures to *C. erate* and *Per. rape* is interesting and may provide a potential means of monitoring these pests in Chinese fields. Utilization of lures to monitor and control pest species in China is an expanding area of both research and field practice. It will help to reduce the past reliance on chemical insecticides in the agricultural ecosystem there. Increased information about these lures will also allow for the early detection and eradication these Chinese pests from the United States or Europe. Such action will reduce environmental contamination when these pests migrate to new locations.

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