Evaporation Rates of a Five-Component Attractant for the Rose Chafer (Coleoptera: Scarabaeidae)[1]

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Abstract The attractant developed for the rose chafer, *Macrodactylus subspinosus* (F.), is composed of pentanoic acid (valeric acid), hexanoic acid, octyl butanoate (octyl butyrate), *trans*-2-nonen-1-ol and alpha-ionone. Studies were conducted to determine evaporation rates of the five components and evaluate the ability of the attractants to lure beetles at various quantities of attractant over a 3 wk period of adult activity. Pentanoic acid (valeric acid), the compound with the lowest boiling point of the five compounds, was found to decrease from 26% to 7% by gas chromatographic studies. Alpha-ionone, the component with the highest boiling point of the five compounds, increased from 15% to 26%, while the other three compounds increased by 1% to 5%. Field studies demonstrated that lures baited with 5 mL of attractant provided the best results.

Key Words scarab attractant, rose chafer, *Macrodactylus subspinosus*

The rose chafer, *Macrodactylus subspinosus* (F.), is at times a serious pest of the flowers, buds, foliage and fruit of numerous plants (Singerland and Crosby 1922). It is distributed across much of North America east of the Rocky Mountains and is especially abundant in areas of light sandy soil where beetles may appear suddenly in large numbers when host plants begin to blossom (McLeod and Williams 1990).

There are no effective parasites or predators of this insect. Until recently the only means of controlling this pest was with pesticides. However, during the 1980's an attractant for the adult rose chafer was developed (Williams et al. 1990, 1993, 2000). This new rose chafer lure is a blend of compounds that was developed and tested over several years. The lure is a blend of attractants, which are not only individually attractive, but when combined, produce a synergistic effect resulting in a more powerful attractant. The attractant is a mixture of equal parts by volume of the following: two acids, pentanoic (valeric acid) and hexanoic; an ester, octyl butanoate; an alcohol, *trans*-2-nonen-1-ol; and a compound referred to as a rose essence, alpha-ionone. This five-part mixture performs very well as an attractant for both male and female rose chafer and may be used to monitor for the emergence and presence of this pest. It is currently being evaluated as a tool for controlling rose chafer by mass trapping (R. N. W., unpubl. data).

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The newly developed, five-component lure has been successfully tested under field conditions in OH, MI, and NY, and is currently available commercially (Great Lakes IPM, Vestaburg, MI). However, little is known about the longevity of this attractant over time under field conditions. Two separate studies were conducted to determine if the amount of attractant was directly proportional to the number of beetles captured, and to determine if the persistence of the five individual components, measured by evaporation, had an effect on the long-term efficacy of the attractant. The first study examined beetle response to various amounts of attractant under field conditions over a 3 wk period. The second was conducted under laboratory conditions to determine the evaporation rates of the lure components. The purpose of this trial was to determine the composition and potency of attractant required for maximum lure performance.

Materials and Methods

The field experiment was conducted on the lawn and gardens of a 2-ha estate near Castalia, OH. Ornamental shrubs, flowers and vegetables all suffered from the feeding of adult beetles. This estate, located in a sandy area, has had extensive damage from large populations of rose chafers for several years (R. N. W., unpubl. data).

Five different treatments, including an untreated control, were placed in white Catch Can™ Japanese beetle traps (Trece Inc., Salinas, CA) with green metal canisters for collecting and holding the beetles. The treatments consisted of a range of quantities (0.5 mL, 1.0 mL, 2.5 mL, 5.0 mL and the control) of equal parts (by volume) of pentanoic acid and hexanoic acid (Aldrich Chemical Co., Inc., Milwaukee WI); octyl butanoate (Penta Manufacturing, Livingston, NJ); *trans*-2-nonen-1-ol and alpha-ionone (Bedoukian Research Inc., Danbury, CT). Five replicates of each treatment were placed along the eastern border of the yard for a total of 25 traps. Treatments within blocks were re-randomized at each collection. A block was composed of a single replicate of each treatment. Traps were attached to metal rods 1.0 m above the ground and they were spaced 10 m apart.

The traps were checked at 2- to 3-d intervals and the total number of rose chafers in each was recorded for comparison with the other treatments. The adult activity period ranged from 19 June through 5 July 1999. During this time, seven collections were made.

The evaporation study was conducted under laboratory conditions. A Hewlett Packard 5890 gas chromatograph (GC), equipped with a 15 m fused-silica column coated with SBP-5 and a thermal conductivity detector, and a Mettler AL100 scientific balance were used to monitor the test samples for percentage composition and weight loss, respectively. Chemical standards used (listed in order of increasing boiling point) were pentanoic acid, hexanoic acid, *trans*-2-nonenol, octyl butanoate, and alpha-ionone. The lure consisted of 5.00 mL of each component leading to the following composition (percentage by mass, mmoles in 1.00 mL, mmole percentage composition): pentanoic acid (20.8%, 9.19, 28.5%), hexanoic acid (20.6%, 7.98, 24.7%), *trans*-2-nonenol (18.98%, 5.94, 18.4%), octyl butanoate (19.2%, 4.31, 13.4%), and alpha-ionone (20.6%, 4.84, 15.0%).

Evaporation rates were determined as described below. The Poly-Con dispenser (Madan Plastic, Cranford, NJ) used in the traps in the field experiment contains an absorbent disc (GenPore, Reading, PA) that holds a maximum of 5 mL of liquid. To five pre-weighed (A-E) dispensers, 5 mL of attractant (composed of equal volumes of the five compounds listed above) was added and the dispensers immediately reweighed. The weight of each dispenser at room temperature was monitored and recorded every 24 h. A gas chromatogram could not be obtained because the attractant could not be drawn out of the Poly-Con disc inside the dispenser. The evaporation rate was assumed to be close to the actual evaporation rate that would take place in the field. A linear regression was performed to determine the relationship between attractant evaporation and time.

To determine the relative percentages of the five-component lure, gas chromatographic analysis was carried out on samples placed in crucibles, which in turn were placed in a hood to allow evaporation (see below). The temperature within the hood ranged from 20.2°C to 22.0°C (average = 21.1°C, standard deviation = 0.4°C); airflow was 147 CFM. The percentages for each component as detected were converted to actual percentages based on mass by the use of the following gc-TCD sensitivity factors: pentanoic acid, 1.262; hexanoic acid, 1.098; *trans*-2-nonenol, 0.949; octyl butanoate, 0.934; alpha-ionone, 0.741. Retention times were determined under the following conditions. The GC settings were as follows: initial temperature 50°C for 2 min; a rate of 15°/min to 90°C, held for 2 mm; a rate of 6°/min to 150°C, held for 4 min; a rate of 10°/min to 250°C, held for 5 min; column head pressure of 7 psi (50 kPa); overall helium flow, 34-45 ml/min; inlet gauge pressure, 60 psi; detector, 230°C; injection port, 220°C; split injection 1:35.

To obtain enough attractant to take GC measurements, three small crucibles, each containing 5 mL of the attractant, were placed in a hood on a slowly rotating platform to insure equal draft over them. The weight of the crucibles were determined and samples for gas chromatographic analysis were obtained on Monday, Wednesday, and Friday mornings for a period of 27 days. A 5-µl sample from each crucible was placed in 1.0 mL of hexadecane contained in a half-dram (1.8 mL) capped vial for GC analysis, which was carried out the morning of the collection.

Results and Discussion

In the study we determined that the amount of attractant in a dispenser does have an effect on the number of rose chafers collected (Table 1). The control captured the fewest beetles. This was to be expected because no attractant was added to this

Table 1. The effect of the amount of lure on rose chafer attraction

	Mean no. of beetles captured/trap/collection day						
Amount (ml)	1	4	6	8	11	13	15
0.0	21b	17c	9e	8d	10a	1a	1a
0.5	274a	341a	77a	153a	101ab	19ab	2a
1.0	366a	371a	122b	225a	162b	31ab	4a
2.5	443a	655b	250c	381b	277b	61b	9a
5.0	398a	583b	320d	573c	435c	114c	25b

Means followed by the same letter in the same column are not significantly different at the ($P < 0.05$) (LSD).

treatment. Those beetles captured were probably attracted by the white color of the trap tops. White traps were reported by Williams et al. (1990) to be significantly more attractive to rose chafers than all other colors tested. Over all, the number of beetles captured by treatments 1 through 4 increased as the quantity of attractant in the lure increased (Table 1), and this relationship held throughout time.

GC retention times of the five lure components were: pentanoic acid, 4.2 min; hexanoic acid, 5.8 min; *trans*-2-nonen-1-ol, 9.8 min; octyl butanoate, 15.2 min; and alpha-ionone, 15.9 min acid. This elution order corresponds to the increasing boiling points of the five components.

Loss of material from Poly-Con dispensers due to evaporation was 0.08 ± 0.001 g per day (t = −136.9; F = 18751.78, df = 1,118; P < 0.01) (Fig. 1). The rate of evaporation from the crucibles (Fig. 2) was similar to that from Poly-Con dispensers and differed by about 0.1 g per day.

Figure 3 shows the percentage based on mass of each of the five components versus day number. The lack of smoothness in the individual curves is due to the standard deviations in the areas recorded in the GC analyses. Each analysis was replicated at least six times. Still standard deviations ranged from 0.1 to 1.1% for all the samples except for day 13 samples when peaks 1 and 2 (pentanoic and hexanoic acid, respectively) had values of 1.9 and 1.7%, respectively. Even with the lack of smoothness in the curves, the following conclusions can be drawn: (1) pentanoic acid, the compound with the lowest boiling point, evaporated the fastest, declining from 20.8% to 5.6% of what remained in the crucibles over the 27 days of the study; (2) alpha-ionone, the highest boiling of the five components, increased from 20.6% to 35.5%; (3) the percentage of hexanoic acid, the second lowest boiling compound, increased by 1.1%; (4) *trans*-2-nonen-1-ol, the compound with the middle boiling

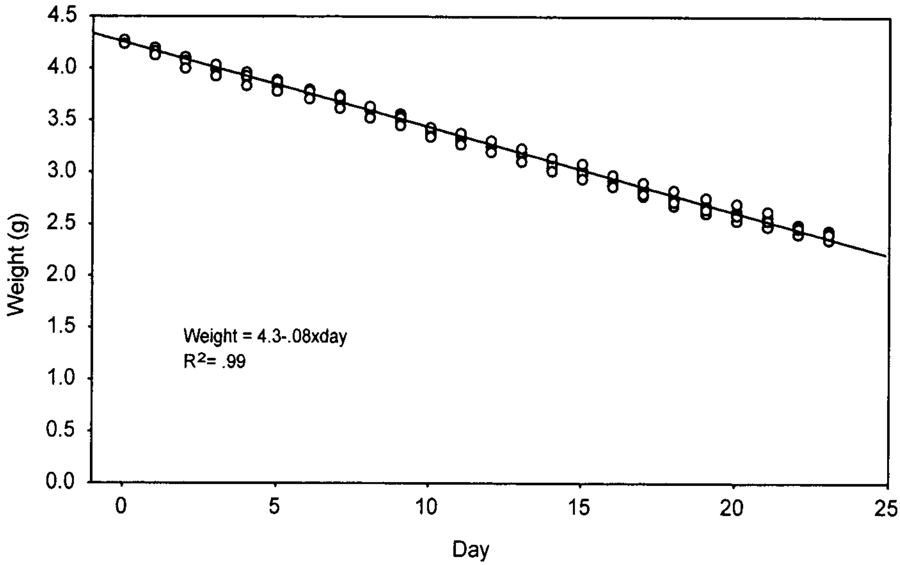

Fig. 1. Weight (g) of Poly-Con dispenser contents over a range of days.

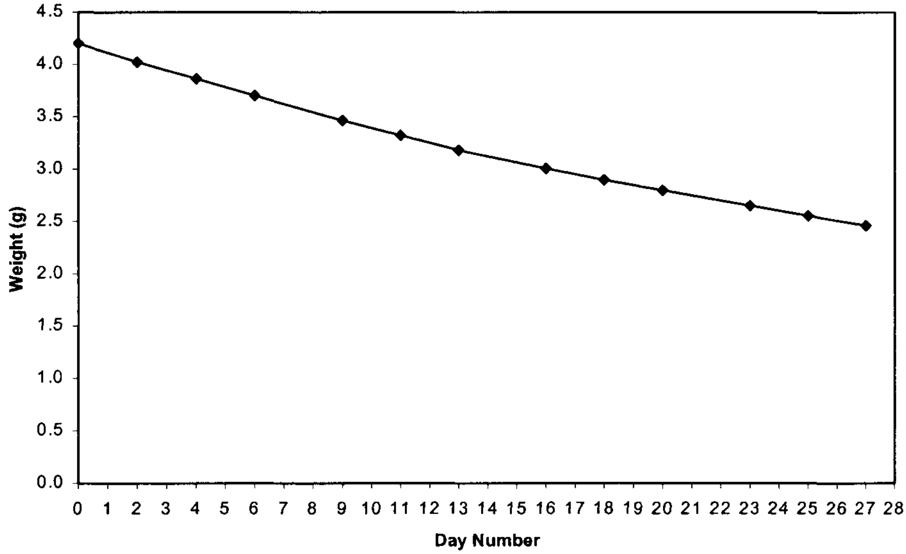

Fig. 2. Average weight of crucible contents over time.

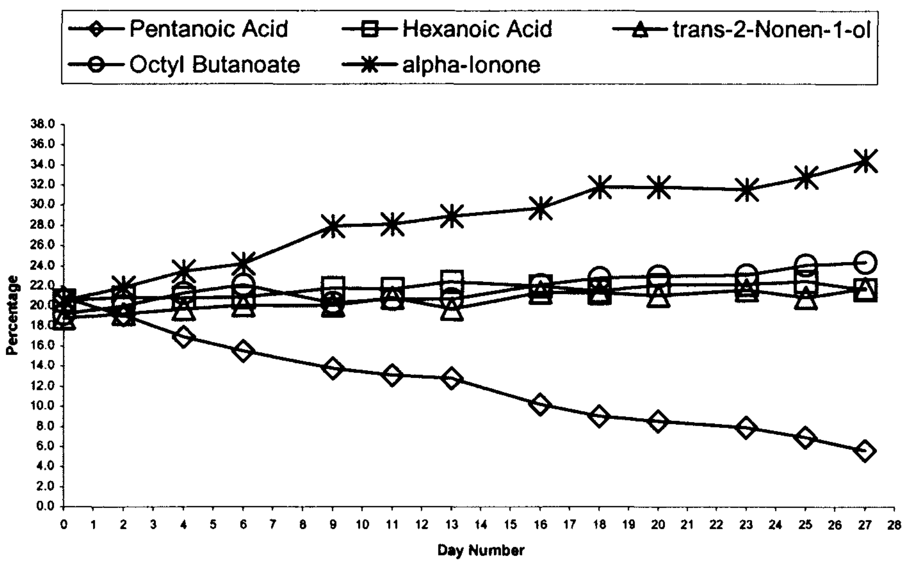

Fig. 3. Percentage of five components over time.

point, increased from 18.8 to 21.8%; (5) octyl butanoate, the fourth highest boiling compound, increased from 19.2% to 24.4%. Those percentage changes match the predictions made on the basis of boiling points. We expected that the relative percentage of pentanoic acid would decrease the most and alpha-ionone would increase the most.

The above data show what the percentage changes were in the crucibles; that is, what remained after a portion of the lure evaporated. Samples for gas chromatographic analysis were taken from the crucibles on Mondays, Wednesdays and Fridays after the crucibles were weighed. The average mass loss (mg/h over a 2- or 3-d period were the following (day number, mass loss/h): 2, 3.7; 4, 3.4; 6, 3.4; 9, 3.3; 11, 2.9; 13, 2.9; 16, 2.4; 18, 2.0; 23, 2.0; 25, 2.0; 27, 1.9. Again this is a reasonable trend since the compound with the lowest boiling point should evaporate fastest and the highest boiling the slowest. Thus, as time goes on, the amount lost per time period should decrease.

Using the GC data coupled with the mass loss data, the mg/h for each component was calculated over that same time period. Because of the variability in the GC data, the values for the individual components must be considered only as general indicators of mass loss, not as absolute numbers. Therefore, we will present the data not on a daily basis but showing the average (mg/h per time period) and the standard deviation (in parentheses) for each compound on a weekly basis (w number in brackets):

Pentanoic acid	[1] 2.1 (0.4), [2] 0.9 (0.4), [3] 0.9 (0.5), [4] 0.6 (0.2);
Hexanoic acid	[1] 0.6 (0.1), [2] 0.4 (0.3), [3] 0.5 (0.4), [4] 0.5 (0.3);
trans-2-nonenol	[1] 0.3 (0.1), [2] 0.7 (0.6), [3] 0.3 (0.5), [4] 0.3 (0.5);
Octyl butanoate	[1] –0.1 (0.3), [2] 0.8 (0.6), [3] 0.1 (0.2), [4] 0.2 (0.2);
Alpha-ionone	[1] –0.2 (0.4), [2] 0.0 (0.9), [3] 0.1 (0.7), [4] 0.2 (0.5).

Again, these are the general trends that we expected. The data for the *trans*-2-nonenol and the octyl butanoate for w 2 are not consistent with the trends. However, both have rather large standard deviations.

That some pentanoic acid is still present after 27 d and that the relative percentages of the other components, except for alpha-ionone, increased modestly indicate that the lure should still possess some ability to attract rose chafers over a 4-wk period. However, the numbers of rose chafers trapped towards the end of the three-week field test fell dramatically. If the large decrease in the percentage of pentanoic acid over 3 wks is related to this observation, perhaps the efficacy of the lure could be improved by starting with a larger relative amount of pentanoic acid.

From the field study the amount of attractant dispensed in the lure appeared to have an effect on the ability of the lure to attract rose chafers. Even though there was no statistical difference in beetles captured between 2.5 mL and 5.0 mL of attractant the first two collection dates, 5.0 mL proved to be more effective over the entire course of the study. Therefore, for maximum lure performance during the short (3-wk) activity period of the rose chafer, 5 mL of attractant is recommended. Any less than this will not maintain maximum lure performance over the entire adult activity period. These findings are based on the current attractant release mechanism (Poly-Con dispenser). Alternative release systems may possibly reduce the amount of attractant required to achieve maximum lure performance over time or the use of more lures may improve performance. However, using the current dispensing system 5 mL of attractant is still viable since the activity of the rose chafers decreases considerably after 3 wks.

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