Journal of Chemical Ecology, Vol. 10, No. 1, 1984

EFFECT OF ALLYL ISOTHIOCYANATE ON FIELD BEHAVIOR OF CRUCIFER-FEEDING FLEA BEETLES (COLEOPTERA: CHRYSOMELIDAE)

C. VINCENT[1] and R.K. STEWART

Department of Entomology, Macdonald Campus of McGill University 21,111 Lakeshore Road, Ste-Anne-de-Bellevue, Quebec, Canada H9X 1C0

(Received September 30, 1982; revised March 9, 1983)

Abstract—When water traps baited with allyl isothiocyanate (AIC)diffusing through polyvinyl chloride (PVC) and rubber membranes were used to monitor four species of crucifer-feeding flea beetle adults in a rutabaga field at L'Assomption, Que. in 1980–1981, differential responses to AIC were observed. *Phyllotreta cruciferae* was more attracted to AIC than *P. striolata*, whereas the behavior of *Psylliodes punctulata* was not affected by the presence of AIC. The traps with the PVC membrane caught significantly more flea beetles than the traps with the rubber membrane in 1980, but caught a similar number in 1981. Sticky traps covered with AIC mixed with Tangletrap® caught significantly more flea beetles than control sticky traps.

Key Words—Mustard oil, allyl isothiocyanate, Coleoptera, Chrysomelidae, flea beetle, beetle, *Phyllotreta, Psylliodes*, crucifer, rutabaga, behavior, isothiocyanate.

INTRODUCTION

Görnitz (1953) observed that extracts of rapeseed were attractive to several crucifer-feeding flea beetle species including *Phyllotreta cruciferae* (Goeze) and *P. striolata* (F.). Later Feeny et al. (1970) demonstrated that both species were attracted by an aqueous solution of 1% allyl isothiocyanate (AIC), one of the isothiocyanates naturally found in crucifers (Kjaer 1960). Mustard oil glucosides, secondary plant chemicals, also function as selective barriers to non-crucifer-feeding insects (Feeny 1977).

[1]Present address: Saint-Jean Research Station, Agriculture Canada, P.O. Box 457, Saint-Jean, Quebec, J3B 6Z8, Canada.

0098-0331/84/0100-0033$03.50/0

Several methods of dispensing AIC have been used. After laboratory trials, Burgess and Wiens (1980) proposed a dispenser model with a rubber membrane allowing slow release of AIC which enhanced capture of flea beetles in boll weevil traps while lowering the risks of chemical burn associated with the manipulation of AIC in the field. Vincent and Stewart (1981) used hollow polyethylene caps as AIC dispensers to monitor crucifer-feeding flea beetle adults. However, these caps released AIC too quickly and had to be refilled monthly. In preliminary tests in our laboratory, a polyvinyl chloride membrane allowed slow diffusion of pure AIC from a vial. Although AIC appears to have an effect on estimates of sex ratio of *P. cruciferae* and *P. striolata* (Wylie 1981), it is not known if it exerts a differential effect on the different species here considered.

We here report the results of a two-year field study. The objectives were (1) to compare a PVC membrane to a rubber membrane as a suitable barrier for slow release of AIC, (2) to measure the effect of AIC on relative abundance and sex ratio of flea beetle adults as estimated using AIC-baited and unbaited water traps, and (3) to measure the effect of AIC mixed with Tangletrap® on the number of captures of flea beetles.

METHODS AND MATERIALS

The studies were conducted at the "Station de la Défense des Cultures," Ministry of Agriculture of Quebec at L'Assomption, Quebec, in 1980 and 1981.

Testing PVC Membrane in the Field. Ten 4-ml vials (No. 3338 A 1 Dr., Fischer Scientific Co.) containing 2 ml of freshly distilled AIC (No. 0322, 50 g, Anachemia Chemicals Ltd., P.O. Box 147, Lachine, Quebec, Canada H8S 4A7) diffusing through a 0.50-mm-thick PVC (Miller Plastics Inc., 10229 Cote de Liesse, Dorval, Quebec, Canada, H9P 1A3) membrane were put into a standard meteorological box (Stephenson screen) 1 m above ground level in the field on June 23, 1981. Release of AIC was measured by weighing the dispensers individually and weekly until September 23, 1981. Temperature and relative humidity fluctuations inside the Stephenson screen were recorded with a thermohygrograph.

Water Traps. Field plots measuring 30 x 30 m (rows 1 m apart, 66,000 plants/hectare) of rutabaga (var. Laurentian) were established on May 20, 1980, and June 1, 1981. Commercial fertilizer was applied, but no pesticides were used, weeding being carried out manually. Eighteen water traps, 15 cm diameter by 10 cm high, were randomly positioned between the rows of rutabaga with the top of the traps at 25 cm from ground level. They were half filled with tap water, and a few drops of detergent were added to reduce surface tension. Three groups (treatments) of six traps (replicates) were positioned in a complete randomized design. The groups were assigned as follows:

Group 1 consisted of 2 ml of freshly distilled AIC (boiling point 151–152°C) in a 5-ml vial with a rubber membrane (No. 06-406-10, Serum Bottle Sleeve type, Fischer Scientific Co.) as described by Burgess and Wiens (1980). The vial, painted black to screen the AIC from the sun and increase AIC evaporation, was suspended by a wire over the center of the trap a few centimeters above the water.

Group 2 consisted of 2 ml of freshly distilled AIC in a 4-ml vial painted black with PVC membrane stretched over a 5-mm hole drilled in the plastic cap of the vial, arranged as previously described.

Group 3 was the control, no AIC and no vial.

The traps were emptied every 3–4 days from establishment of the crop until any movements of flea beetles had stopped in late October. Specimens were sexed, identified as to the species, and counted on the same day when possible.

Sticky Traps. In an adjacent field with the agronomic characteristics described previously, 20 sticky traps were randomly positioned between the rows. The traps consisted of 6 x 6-cm^2 plastic gutter painted white (White gloss No. 514, Valspar Corp.). The four sides were covered with Tangletrap® (The Tanglefoot Co., Grand Rapids, Michigan, 49504) from 5 to 20 cm from ground level. Each trap therefore presented a trapping surface area of 15 x 6 cm on each of the four sides giving a total of 360 cm^2/trap. Two trap types were used: type 1 (control), vertical surface coated with Tangletrap only, and type 2, 10 ml of freshly distilled AIC was thoroughly mixed with 500 ml of Tangletrap before application. This apparently did not change the physical properties of the Tangletrap. Two trapping runs were carried out. The first run of 20 traps (10 AIC baited and 10 with Tangletrap only) was begun on August 18, 1981, and the captures recorded on August 28, 1981. The second run, with the same trap arrangement, was begun on September 4 and the captures recorded on September 14, 1981.

Voucher specimens were deposited at the Biosystematics Research Institute (Ottawa) (lot No. 81-1158) and at the Lyman Entomological Museum and Research Laboratory, Macdonald Campus of McGill University.

RESULTS AND DISCUSSION

The dispensers in the Stephenson screen released AIC constantly from June 23 to September 23, 1981 (Figure 1). The cumulative release was linearly related to time, as indicated by the value of the coefficient of correlation (r = 0.97**), and did not appear to be affected by temperature fluctuations. However, this picture might have been different if the PVC had been exposed to wind, sunshine, and rainfall. Four species, *P. cruciferae*, *P. striolata*, *P. bipustulata* (F.), and *Psylliodes punctulata* Melsh. were recorded (Figure 2).

In both years, the AIC-baited water traps caught more specimens than

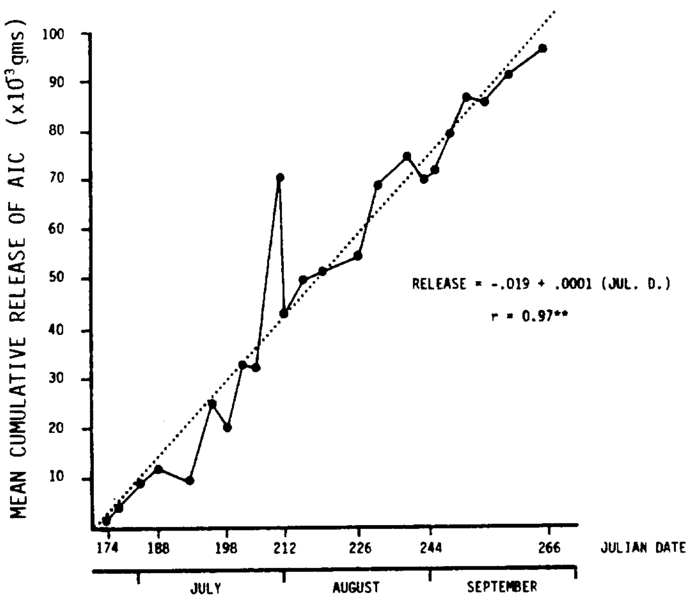

FIG. 1. Mean cumulative release of allyl isothiocyanate through a polyvinyl chloride membrane. Each dot represents an average for 10 dispensers.

the unbaited water traps, 1656 and 1158 against 251 in 1980, and 389 and 386 against 39 in 1981. The dispenser with PVC membrane caught significantly more flea beetles over the two years (χ^2 test, $\alpha = 0.01$), its performance being similar to the rubber membrane in 1981 (χ^2 test, $\alpha = 0.01$). The use of AIC as an attractant affected the estimates of relative abundance of flea beetle species. The control traps indicated that *P. striolata* was more prevalent (61.3% of the total catches in 1980 and 71.8% in 1981), and this agreed with absolute population estimates obtained by D-Vac® in the same fields, where *P. striolata* represented 74 and 79% of flea beetles sampled in 1980 and 1981, respectively (Vincent and Stewart, unpublished data). However, this species comprised only 32% (PVC) and 26% (rubber) of seasonal captures in AIC-baited traps in 1980 and 52% (PVC and rubber) in 1981. *P. cruciferae* was relatively more abundant in AIC-baited than in the control traps. Therefore both species are attracted to AIC, *P. cruciferae* more so than *P. striolata.* This is consistent with the finding that *P. cruciferae* is a more specialized herbivore than *P. striolata* (Hicks and Tahvanainen 1974). The behavior of *Ps. punctulata* was not affected by AIC, the relative abundance estimate being constant in the control and AIC-baited traps. Again, this is consistent with D-Vac estimates taken in this field (Vincent and Stewart, unpublished data).

For both *P. cruciferae* and *P. striolata*, wherever AIC was used, the number of females trapped was significantly higher than the number of males

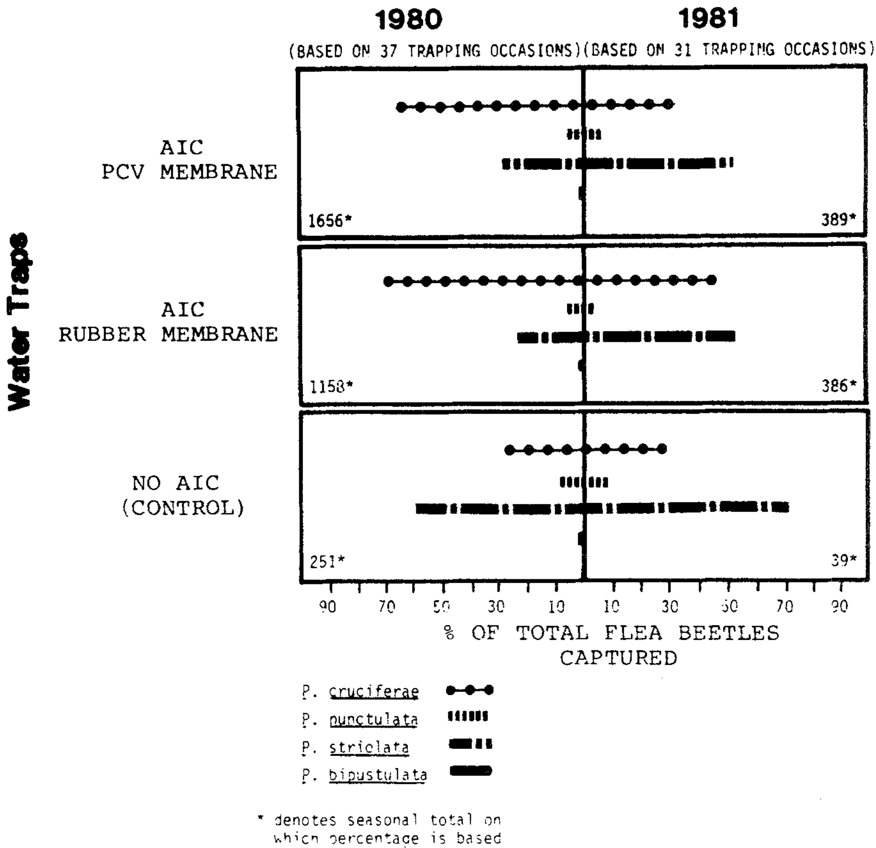

FIG. 2. Proportions of flea beetle species as determined by water traps in rutabaga fields, L'Assomption, 1980–1981.

(Table 1). The observed sex ratio was 1 : 1 when no AIC was used except for *P. striolata* in 1980. This greater attraction for females suggests that AIC might not only be a feeding stimulant as glucosinolates are (Hicks 1974), but also an oviposition stimulant, as Traynier (1965) demonstrated for the cabbage maggot. The observed sex ratio for *Ps. punctulata* was unaffected by the use of AIC. Wylie (1981) observed a higher percentage of female *P. striolata* and *P. cruciferae* in AIC-baited traps.

Sticky traps with AIC captured significantly more (t test, $\alpha = 0.01$) flea beetles than those without AIC. Mean captures were 43.1 per trap (control) and 104.1 per trap (AIC) and 20.2 (control) and 55 (AIC) in the first and second trials, respectively. We suggest that intrafield movement is influenced by AIC and the movements of flea beetles to new host plants may also be affected by mustard oils.

TABLE 1. FLEA BEETLE SEASONAL CAPTURES AND SEX RATIO IN A RUTABAGA FIELD, L'ASSOMPTION, QUÉBEC, 1980–1981.

	Phyllotreta cruciferae			*Psylliodes punctulata*			*Phyllotreta striolata*			*Phyllotreta bipustulata*		
	Male	Female	χ^2	Male	Female	χ^2	Male	Female	χ^2	Male	Female	χ^2
1980												
AIC												
PVC membrane	329	761	171.2**[a]	32	43	1.6NS	169	317	45.0**	1	4	[b]
AIC												
Rubber membrane	232	589	155.2**	32	27	0.4NS	109	167	12.1**	1	4	[b]
No AIC (control)	27	43	3.6NS	8	16	2.6NS	54	101	14.5**	3	4	[b]
1981												
AIC												
PVC membrane	30	93	32.2**	7	11	0.8NS	92	155	16.0**	0	1	[b]
AIC												
Rubber membrane	34	142	66.2**	3	5	[b]	66	136	24.2**	0	1	[b]
No AIC (control)	4	5	[b]	1	1	[b]	9	19	3.5NS	0	0	[b]

[a] Value of χ^2 statistic. Under H_a: No. of females captured greater than number of males. **, significant at 0.01 level.
[b] χ^2 test not performed due to Cochran's restriction.

Acknowledgments—The authors thank Dr. H.G. Wylie, Agriculture Canada, Winnipeg Research Station, for his suggestions on an early draft of the manuscript. Paul Maloney and Jean François Danis are acknowledged for field assistance. Dr. L. Lesage, Biosystematics Research Institute, Ottawa, confirmed the identification of the specimens. This work was supported by a "Conseil des recherches et services agricoles du Québec" grant (C.R.S.A.Q. MCA 78-730).

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