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EVALUATION OF METHIOCARB, ZIRAM, AND METHYL ANTHRANILATE AS BIRD REPELLENTS APPLIED TO DENDROBIUM ORCHIDS

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Hawaiian orchids (*Orchidaceae*) and anthuriums (*Anthurium* spp.) have a combined market value >$12 million (1986 U.S. dollars). Orchids alone account for 13% of cut flowers, 33% of lei flowers, and 62% of flowering potted plants grown and sold in Hawaii (Kefford et al. 1987).

Generally, dendrobium orchids (*Dendrobium* spp.) are grown in shade houses constructed from woven polypropylene screens stretched over a metal frame. While shade houses protect orchids from intense sunlight, they can not be completely sealed to prevent entry by birds. As a result, red-vented bulbuls (*Pycnonotus cafer*) and Japanese white-eyes (*Zosterops japonicus*) damage up to 75% of plants at some plantations. The most intense depredation occurs from January–March and June–September (H. Kaneshiro and C. Mow, Dendrobium Orchid Growers Assoc. of Hawaii, Honolulu, pers. commun., 1991).

Application of nonlethal chemical repellents may protect orchids from bird damage. In cage trials, we tested 3 candidate compounds: methyl anthranilate (MA; Mason et al. 1989), methiocarb (Guarino 1972), and ziram (Schafer et al. 1983). Methyl anthranilate is a human food flavoring offensive to birds because of its taste (Mason et al. 1989). Methiocarb (3,5-dimethyl-4-methylthiophenol methylcarbamate) is a carbamate insecticide that repels birds via learned avoidance (Rogers 1974; i.e., birds become sick after eating treated foods and subsequently avoid them). Ziram (zinc dimethyldithio-carbamate) is a fungicide that also repels birds; the mode of repellency is unknown. Following cage tests, we evaluated methiocarb and ziram in field trials.

MATERIALS AND METHODS

Cage Tests

Experiment 1.—Sixty-four red-vented bulbuls of undetermined sex were mist-netted (Bleitz 1970) at various locations on the island of Oahu during June and July 1990. Sixteen birds were housed in each of 4 outdoor pens (2 × 3 × 3 m) with access to papaya mash, whole peeled bananas, and water.

Seven days after capture, 32 bulbuls were selected randomly and paired according to weight (i.e., the 2 heaviest birds were paired, the 2 next heaviest, and so forth) to reduce any size/food intake bias. Individual pairs were housed in 1 × 1 × 1 m cages. After 3 days,

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the pairs were randomly assigned to 4 treatment groups (n = 4 pairs/group): 1.0% (g pesticide/g papaya mash [g/g]) methyl anthranilate, 1.0% (g/g) ziram, 0.1% (g/g) methiocarb in papaya mash, or control (untreated papaya mash). The treatment period followed immediately.

On each of 3 treatment days, each pair was given a bowl containing 100 g of chemically treated mash or control ration between 0700 and 1200. At the end of the 5 hours, consumption was measured after adjusting for evaporation. Birds then had free access to a maintenance diet of papaya and banana until 1800. To encourage feeding, all pairs were food-deprived between 1800 and 0700 the following day.

Experiment 2.—We replicated Experiment 1 with the remaining 32 unexposed bulbuls using lower chemical concentrations: 0.5% methyl anthranilate, 0.5% ziram, and 0.01% methiocarb in papaya mash. Again, untreated papaya was the control.

Analysis.—The results of Experiment 1 and 2 were combined, and differences among chemical concentrations and day were examined using analysis of variance (ANOVA) with repeated measures over days. The 2 control groups were both included as levels of this factor. Data from the group given 0.1% methiocarb in Experiment 1 were not included in the analysis because 0.1% methiocarb killed 7 of 8 birds in the group. Tukey's Honestly Significant Difference (HSD) test was used to detect significant differences among means (Winer 1962:198).

Field Test

For field tests we selected methiocarb and ziram because both are registered with the U.S. Environmental Protection Agency (EPA) for various applications; methyl anthranilate is not (Thompson 1988). In addition, methyl anthranilate showed adverse effects on plant tissue.

We located 5 sites ranging from 1–2 ha with measurable bird damage. The sites were 7 km apart, and all sites were planted with dendrobium orchids in shade houses. Sites were in similar spike stages of growth. A plant produces a single spike about every 20 days during a 4 month growing season (C. Mow, Dendrobium Orchid Growers Assoc. of Hawaii, Honolulu, pers. commun., 1991). Our testing began at the start of a spiking period.

Two weeks before treatment, all bird control activities and spraying with chemicals similar to methiocarb and ziram were suspended. Two 0.12-ha plots were selected at each site and the corners marked with flagging tape. One plot was assigned randomly as a control and the other as treated.

From 6 days pretreatment until 18 days after treatment, bird numbers by species were recorded in both plots at every site. Observations were made every second day between 0600 and 1100 for 60 minutes; the number of birds/plot was recorded at 5 minute intervals.

On the day of treatment, we recorded the number of undamaged orchid spikes on 100 randomly selected plants within each plot at every site. These plants were marked at the base with coded blue flagging tape and were used in subsequent surveys of bird damage (6, 12, and 18 days after treatment).

After marking plants, we prepared aqueous solutions of methiocarb (mesurol 75% wettable powder, Miles, Inc., Kansas City, Mo.) and ziram (76% wettable granular, Microflo, Modesto, Calif.). Treated plots at 3 sites were sprayed with methiocarb (3.4 kg active ingredient/ha). Treated plots at the 2 remaining sites were sprayed with ziram (7.6 kg active ingredient/ha). Control plots at all sites were sprayed with the carrier solution minus mesurol or ziram. A backpack sprayer (Solo Inc., Raleigh, N.C.) was used to spray plots. The sprayer was cleaned thoroughly after each application.

Prior to treatment, two 20-g samples of each chemical and a 40-ml sample of spray formulation were collected and frozen for subsequent verification of chemical concentrations. In addition, we collected orchid flowers from 2 randomly chosen locations in each plot for residue analysis. Samples were collected 1, 6, 12, and 18 days after treatment. Each sample consisted of 16 flowers and 6 spikes which were frozen and shipped to Morse Laboratories (Sacramento, Calif.) for residue analysis.

Analysis.—The test was started at the beginning of a spiking period, thus we did not have to be concerned about new spikes occurring during the test. However, five plants produced double spikes of which one was removed. Spike damage (%) was calculated for each plot by dividing the number of damaged spikes on each post-treatment date by the number of undamaged spikes counted just prior to chemical applications. Difference in spike damage was calculated by subtracting the damage in the treated plot from the damage in the control plot for each assessment date at each site. We compared chemicals and dates using ANOVA with repeated measures over dates (i.e., 6, 12, 18 days after treatment). In addition, 95% confidence intervals on the average percent difference in control and treated plots were calculated for both methiocarb and ziram. These intervals indicated whether control plots were significantly less damaged than treated plots.

RESULTS

Cage Tests

All 3 repellents produced ≥65% reduction in consumption of papaya mash (Experiment 1: MA reduction = 72%, Ziram reduction = 73%; Experiment 2: MA = 65%, Ziram = 75%, methiocarb = 80%). There were differences among groups ($F = 442.2$; 6, 21 df; $P < 0.01$) and days ($F = 10.2$; 2, 42 df; $P < 0.01$). Posthoc examination of these effects showed that birds in the control groups consumed significantly more ($P < 0.01$) than birds presented with methiocarb (0.01%), ziram (1.0%, 0.5%), or methyl anthranilate (1.0%, 0.5%; Fig. 1). Also, birds given 0.5% methyl anthranilate consumed more than birds presented with 0.01% methiocarb ($P < 0.05$). Overall consumption was higher on Day 1 than on Day 2 or 3 ($P < 0.05$).

Field Test

After 18 days, orchid spikes damaged on methiocarb and ziram treated plots averaged 3.7% and 6.8% respectively compared to 21.7% damage in control plots (Fig. 2). The average difference in spike damage between treated and control plots did not differ between methiocarb (18.7%) and ziram (13.9%; $F = 0.64$; 1, 3 df; $P = 0.48$). There also were no differences among days ($F = 1.45$; 2, 6 df; $P = 0.30$) or a treatment by day interaction ($F = 0.17$; 2, 6 df; $P = 0.84$). Thus, treatment performance did not change significantly over time. Confidence intervals calculated on the mean percent differences (positive differences are loss due to not treating) between treated and control orchid fields were 6.5–30.7% for methiocarb and −4.3–31.9% for ziram.

Individual methiocarb test fields had 23.9%, 12.0%, and 31.3% of the orchid spikes damaged in control plots compared to 1.6%, 1.7%, and 7.8% damaged in treated plots (Fig. 2). For ziram test fields, control plots had 28.6% and 12.8% of the orchid spikes damaged; 11.4% and 2.3% were damaged on the treated plot (Fig. 2). Methiocarb and ziram residues from test fields 1 day post-treatment averaged 59.8 ppm (range = 5.6–102.0 ppm) and 181.5 ppm (range = 137–226 ppm), respectively, and 7.5 ppm (range = 3.4–11.8 ppm) and 58.7 ppm (range = 54.9–62.5 ppm) 18-days post-treatment, respectively (Table 1). Overall, methiocarb and ziram residues declined an average of 87% and 67% over the 18-day post-treatment period.

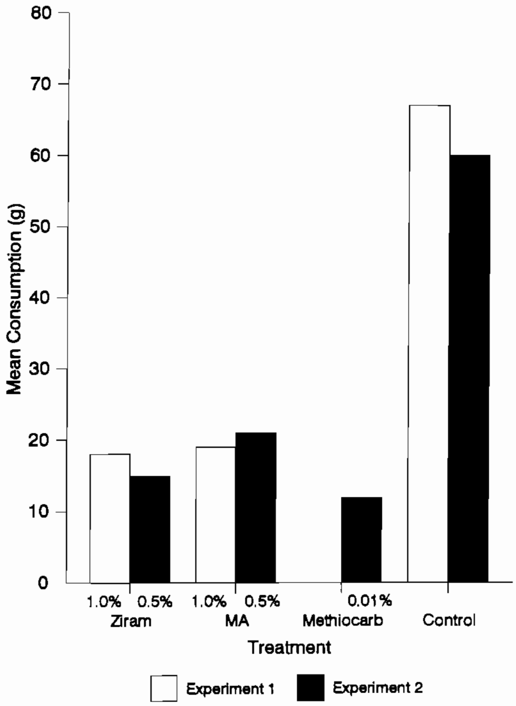

Fig. 1. Mean total consumption by pairs of red-vented bulbuls of papaya mash treated with 0.5% or 1.0% ziram, 0.5% or 1.0% methyl anthranilate (MA), or 0.01% methiocarb for 3-day tests.

Residues on methiocarb-treated orchids varied considerably among post-treatment periods and fields. Because ziram residues were still high (58.7 ppm) 18-days post-treatment, samples from 6 and 12 days post-treatment were not analyzed.

Red-vented bulbuls, Japanese white-eyes, and several other species, including spotted doves (*Streptopelia chinensis*), zebra doves (*Geopelia striata*), white-rumped shamas (*Copsychus malabaricus*), common mynas (*Acridotheres tristis*), northern cardinals (*Cardinalis cardinalis*), and red-crested cardinals (*Paroaria coronata*) were observed in treated and untreated plots. Overall numbers of birds were low and sightings were sporadic. Thus, bird numbers were not statistically evaluated.

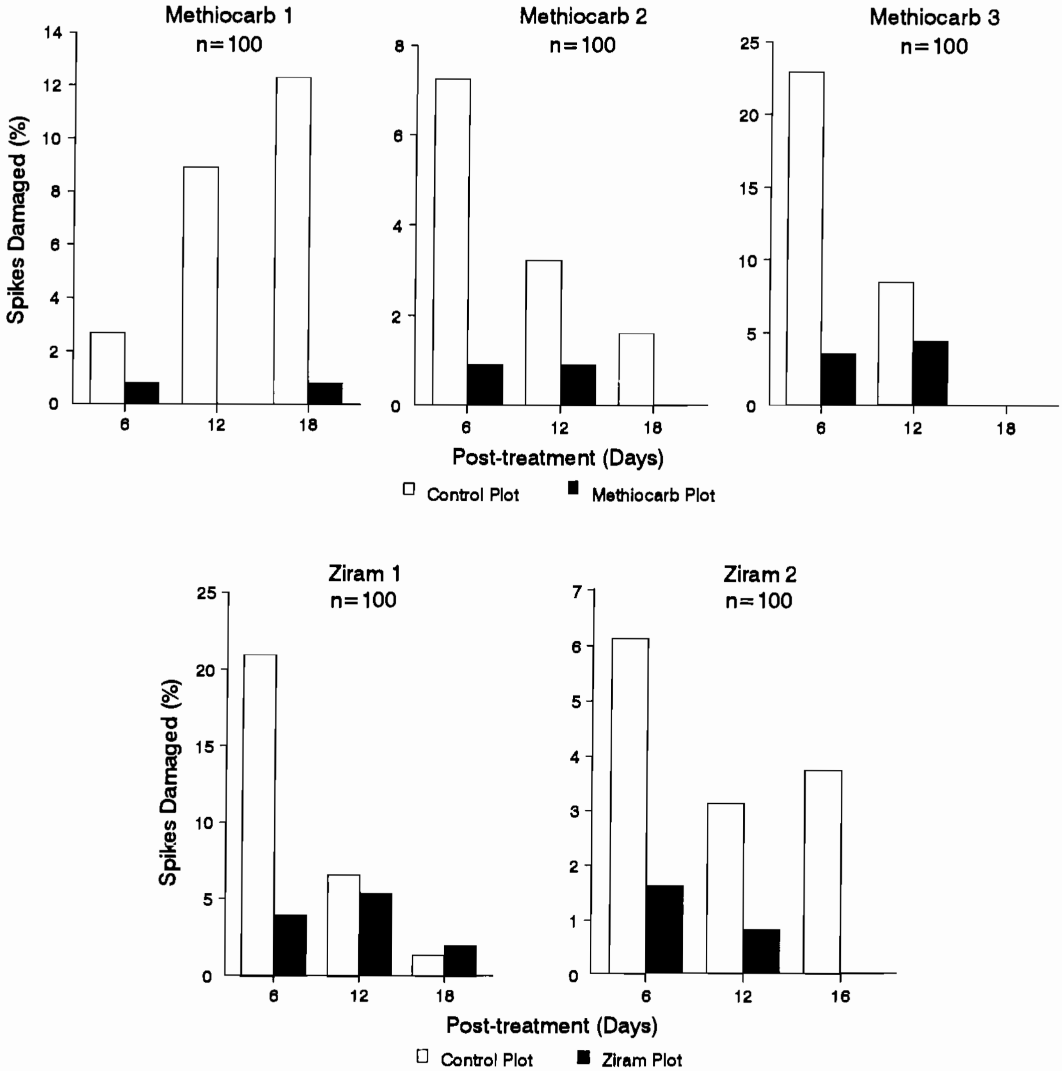

Fig. 2. Orchid spikes damaged by red-vented bulbuls in fields sprayed with methiocarb at 3.4 kg/ha and ziram at 7.6 kg/ha, Oahu, Hawaii, June and July 1990.

DISCUSSION AND MANAGEMENT IMPLICATIONS

In cage tests, 0.01% methiocarb, 1.0% or 0.5% ziram, and 1.0% or 0.5% methyl anthranilate repelled red-vented bulbuls. Among these chemicals and concentrations, 0.01% methiocarb, both concentrations of ziram, and 1.0% methyl anthranilate were equally effective. The low methyl anthranilate concentration (0.5%) was not as effective as 0.01% methiocarb.

In the field test, methiocarb (3.4 kg/ha) reduced damage to dendrobium orchids in shade houses. However, we detected no difference in the protection provided by methiocarb over ziram. The statistical power of our field test was low due to the small number of test sites.

Table 1. Methiocarb and ziram residues (ppm) on dendrobium orchids and formulation analysis (%) for test fields sprayed with methiocarb (75% wettable powder) at 3.4 kg active ingredient/ha or ziram (76% wettable granular) at 7.6 kg active ingredient/ha, respectively, Oahu, Hawaii, June and July 1990.

Site	Field	Post-treatment day (ppm)[a] 1	6	12	18	Formulation[b] concentration (%)
Hudson #1	Control	0.03	0.00	0.02	0.01	0.00
	Methiocarb	102.00	20.20	66.55	3.44	0.20
Hudson #2	Control	0.05	0.15	0.05	0.22	0.00
	Methiocarb	71.81	45.17	42.50	11.80	0.37
Mow	Control	0.08	0.05	0.09	0.05	0.00
	Methiocarb	5.61	11.60	15.50	7.41	0.85
Overall	Control	0.05	0.06	0.05	0.09	0.00
	Methiocarb	59.80	25.60	41.51	7.55	0.47
Kaneshiro	Control	0.72			0.15	0.00
	Ziram	226.00			54.95	1.12
Thomas	Control	35.45			5.84	0.00
	Ziram	137.00			62.50	1.29
Overall	Control	18.08			2.99	0.00
	Ziram	181.50			58.72	1.20

[a] Because residues were still high 18 days post-treatment, analysis of ziram treated orchids was not conducted for days 6 and 12.
[b] Analysis of spray formulations verifies contamination and application rate.

Approximately 3 times as many sites would be necessary to statistically detect the treatment differences observed in our experiment. The lack of a significant difference in the protection provided by methiocarb and ziram should be interpreted in this context. Similarly, small sample sizes resulted in wide 95% confidence intervals and decreased our ability to detect reduction in damage caused by the treatments. The field experiment, however, provided evidence that a large difference in the effectiveness of the 2 chemicals is unlikely.

The variation of residues could be attributed to differences in environmental or cultural practices at each site. In addition, application rates at each site could have varied due to fluctuations in sprayer pressure or spray distance.

Overall, the present findings indicate that any of these 3 chemicals may act as a bird repellent for use on flowering plants. In the short-term, methiocarb and ziram have greater promise than methyl anthranilate for several reasons. First, neither chemical showed evidence of deleterious effects on orchids in the field test. Second, methiocarb is registered as a foliar treatment on ornamental plants for the control of mollusks and ziram is registered as a foliar treatment for flowers (i.e., carnations, marigolds, asters). Third, the effective application rates used in these experiments did not exceed rates already approved for pesticide use. Further, the level of methiocarb applied to flowers was less than half the level of ziram and the cost of methiocarb is $225/ha whereas ziram is $33/ha (1990 U.S. dollars). Although methyl anthranilate has potential utility, it would have to be registered with the EPA before it could be used as an agricultural chemical.

In the long-term, however, methiocarb and ziram may not be the repellents of choice. If methyl anthranilate is registered and practical encapsulation strategies are developed (Cummings et al. 1991), then field testing will be warranted. It is an approved human and animal food flavoring and has very low vertebrate toxicity. For these reasons, methyl anthranilate may be an especially desirable repellent when flowers are sold for use as decorations with foods and beverages and consumption of flower parts might occur.

Because the field test application rates of both methiocarb and ziram were probably higher than needed for effective control, we recommend further testing of these chemicals at lower application rates. Also, we suggest field tests with other flowers (e.g., anthuriums). Finally, we propose field tests from January–March when few alternatives to orchid spikes are available as bird food and growers report that bird damage is most severe. We expect that testing during this period would more completely evaluate repellency effectiveness.

SUMMARY

Red-vented bulbuls and Japanese white-eyes damage dendrobium orchids in the Hawaiian Islands. We tested whether application of the chemical repellents methiocarb, ziram, or methyl anthranilate could reduce this damage. In cage trials, we found that all 3 repellents reduced ($P < 0.05$) consumption of treated papaya mash by bulbuls. In the field, methiocarb reduced ($P < 0.05$) damage to dendrobium orchids; methyl anthranilate was not evaluated.

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LITERATURE CITED

BLEITZ, D. 1970. Mist nets and their use. Inland Bird Banding News. 42:1–14.

CUMMINGS, J. L., J. R. MASON, D. L. OTIS, AND J. F. HEISTERBERG. 1991. Evaluation of dimethyl and methyl anthranilate as a Canada goose repellent on grass. Wildl. Soc. Bull. 19:184–190.

GUARINO, J. L. 1972. Methiocarb, a chemical bird repellent: a review of its effectiveness on crops. Proc. Vertebr. Pest Conf. 5:108–111.

KEFFORD, N. P., K. W. LEONHARDT, T. TANAKA, AND K. G. ROHRBACH. 1987. Orchid industry analysis. Coll. of Tropical Agric. and Human Resour., Univ. of Hawaii Rep. 3. 9pp.

MASON, J. R., M. A. ADAMS, AND L. CLARK. 1989. Anthranilate repellency to starlings: chemical correlates and sensory perception. J. Wildl. Manage. 53: 55–64.

ROGERS, J. G. 1974. Responses of caged red-winged blackbirds to two types of repellents. J. Wildl. Manage. 38:418–423.

SCHAFER, E. W., W. A. BOWLES, AND J. HURLBUT. 1983. The acute oral toxicity, repellency, and hazard potential of 998 chemicals to one or more species of wild and domestic birds. Arch. Environ. Contam. Toxicol. 12:355–382.

THOMPSON, W. T. 1988. Agricultural chemicals. Thompson Publ., Fresno, Calif. 210pp.

WINER, B. J. 1962. Statistical principles in experimental design. McGraw-Hill Book Co., New York, N.Y. 907pp.

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