Proceedings of the Eighth International Conference on Urban Pests
Gabi Müller, Reiner Pospischil and William H Robinson (editors) 2014
Printed by OOK-Press Kft., H-8200 Veszprém, Papái ut 37/a, Hungary

REDUCING PESTICIDE RUNOFF IN URBAN WATERWAYS

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Abstract Treatment strategies focused on reducing the amount of fipronil applied and the amount fipronil and its metabolites detected in the water runoff. Directed applications around the perimeter of the structure, narrow pin-stream applications, and no spray zones reduced the amount of fipronil detected. Alternative formulations such as foam may also have potential in reducing the amounts of fipronil in the water runoff. A standard treatment that avoided the driveway and garage provided satisfactory control and the lowest levels of fipronil in the water runoff.
Key words Fipronil, pyrethroids, Argentine ant.

INTRODUCTION

Ants are a major pest in the urban environment in California and represent 60-85% of pest problems on residential accounts for Pest Management Professionals (PMP). Argentine ants, Linepithema humile (Mayr), accounted for up to 85% of the ants encountered by PMPs (Field et al., 2007). A summary of research conducted from 2003 to 2012 (CASQVA, 2013) reported that the pyrethroid bifenthrin was found in 69% of the sediment samples and 64% of the water samples in California. Fipronil was detected in 39% of the water samples and 19% of the sediment samples. Maximum observed levels were higher than the reported toxicities of fipronil and its degradates. The conventional use of these sprays by PMPs clearly poses a problem and challenge.

Runoff from concrete treated surfaces contained bifenthrin and permethrin even 3 to 7 months after treatment. Water events (irrigation, washing, and rain) to treated concrete surfaces should be avoided since concrete surfaces may act as a reservoir for pesticides (Jiang et al., 2012). A consortium of university, industry and governmental agencies organized the Ant Pest Management Alliance (Ant PMA) and developed procedures that reduced the amount of pyrethroids applied by 75% (CDPR 2010). The lower risk IPM routes provided excellent ant control at costs slightly less than conventional treatments. However, single applications of fipronil were applied in most cases instead of pyrethroids.

The objective of this study was to expand upon the continued the efforts of the Ant PMA and reduce the amount of fipronil applied to control ants. Several different formulations of fipronil and application techniques were applied to residential homes and the amount of fipronil and its metabolites in the water runoff and the efficacy of the treatments were determined.

MATERIALS AND METHODS

Collection of Water Runoff

A technique reported by Greenberg et al. (2010) was used to collect the water runoff at the curb. A custom-made 'U'-shaped Styrofoam dam was enclosed in a thin plastic liner and placed firmly against the sides of the street curb. Once water began to fill the cutout, samples were continuously taken from the center of the pooled water. The samples were transported to the laboratory in ice boxes and stored at 4°C until analysis.

Pesticide Analysis

Pesticides were identified using a procedure outlined by Greenberg et al. (2010). Water samples (1000 ml) were extracted with 40 ml methylene chloride three consecutive times using glass separatory funnels. For analysis of fipronil and its metabolites, the residue was recovered in petroleum ether + acetone (70 + 30 by volume; 1.0 ml) and subjected to a further cleanup. The extract (1.0 ml) was then passed through the conditioned cartridge and eluted with petroleum ether + acetone (70+30 by volume; 10ml) at a flow rate of 0.5 ml min^{-1}. The concentrations of target compounds in the final extracts were analyzed using an Agilent 6890 series GC equipped with a Ni63 microelectron capture detector (ECD; Agilent Technologies, Wilmington, DE). An HP-5MS column (30 m×0.25mm×0.25 µm; Agilent Technologies) was employed for separation. The typical retention times for desulfinyl fipronil, fipronil sulfide, fipronil, and fipronil sulfone under these conditions were 10.7, 12.9, 13.1, 15.2 and 17.8 min, respectively. A preliminary experiment showed that the method detection limits for the analytes were 0.001 µg l^{-1}. The recoveries of spiked analytes were higher than 85% using the above extraction and analysis steps.

Field Treatments

All treatments were applied during July 2010. The standard 0.06% fipronil preparation (Termidor SC, BASF Corp., Grenesboro, NC) was applied using a 19 L backpack sprayer (Birchmeier, Stetten, Switzerland) that had a 1.5 mm Duro mist nozzle. The fan spray was applied around the entire house foundation, approximately 30 cm up and 30 cm out from the house. At the driveway, it was applied to the garage door/driveway interface. Approximately 3.7 liters of spray were applied around each of 5 homes.

In the no spray zone treatment, the 0.06% fipronil was applied similar to the standard treatment, except that the driveway and hardscape areas near the driveway were not treated. About 2.8 liters of spray were applied to each of 5 homes.

The pin stream application of 0.06% fipronil was applied with the same equipment as the standard spray, except the spray was applied in a narrow pin stream. The pin stream was applied about 5 cm up and 5 cm out from the house. About 3.8 liters of spray were applied to each of 5 homes.

An application of dry foam using an aerosol can consisting of 0.65% fipronil (Whitmire Research Labs, St. Louis, MO) was applied to the entire house foundation approximately 5 cm up and 5 cm out from the house. At the driveway it was applied to the garage door/driveway interface. The amount used depended on the size of each house, ranging from 285 to 693 g (an average of 441 g).

An application of wet foam was applied using a Jack Plus Compressed Air Sprayer (NPD Products Ltd., Midhurst, Ontario, Canada). The 3.8 liters of fipronil was mixed with 40 ml of Pro Foam Platinum (Nisus Corp., Rockford, TN). The band of foam was applied 30 cm up and 30 cm out from the house. About 3.8 liters of fipronil plus foam were applied at each of 5 houses.

Monitoring Treatment Efficacy

The methodology used for monitoring Argentine ants and determining the efficacy of treatments has been reported in detail (Klotz et al., 2009). Ten vials of 15 ml 25% sucrose were placed around the house's foundation. Consumption of the sucrose/water over 24 hours was measured converted into the number of ant visits.

RESULTS AND DISCUSSION

Pesticide Runoff

At day 1, the standard spray and the crack and crevice treatment resulted in concentrations of fipronil lethal to mysid shrimp (Figure 1). At day 7 only the crack and crevice treatment provided a concentration in excess 140 PPT. At day 21, all the samples were below 140 PPT. The wash of the driveway with 151 liters of water to simulate a rain event resulted in fipronil concentrations high enough to kill *Ceriodaphnia*. The driveway flush at 56 days showed that the treatment that excluded the driveway had significantly lower runoff than any of the other treatments (Tukey's HSD test, $P < 0.05$ for each pairwise comparison).

Treatment Efficacy

The standard perimeter spray of fipronil provided up to 85% reductions in the number of ants visiting monitoring stations (Table 1). Initially the no spray zone treatment provided outstanding reductions, but the control declined by week 8. The pin stream application around the foundation and across the crack in the driveway in front of the garage door failed to satisfactory control. The wet foam provided about 55% reductions for the entire test period. The dry foam aerosol application initially provided satisfactory control, but the number of ants increased at week 4.

Table 1. The field performance of fipronil treatments against Argentine ants.

		Avg. ant visits per vial (% reduction) at week after treatment			
Treatment	Avg. Pre-count	1	2	4	8
Standard	11,595	3,188 (72.5)	2,883 (75.1)	5,023 (56.7)	2,022 (85.7)
Std. - driveway	16,388	3,621 (77.9)	1,215 (92.6)	4,783 (70.8)	5,924 (63.9)
Pin Stream	7,571	5,456 (27.9)	3,666 (51.6)	801 (89.4)	6,969 (9.3)
Wet Foam	13,152	5,348 (59.3)	6,009 (54.3)	5,534 (57.9)	6,046 (54.0)
Dry Foam	12,432	2,935 (76.4)	3,737 (69.9)	6,308 (49.3)	8,029 (35.4)

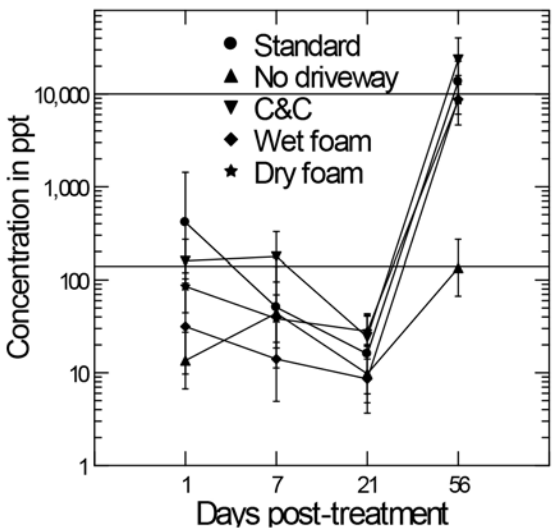

Figure 1. Fipronil runoff. Upper dotted line is Ceriodaphnia EC50 (10,000 PPT); lower dotted line is Mysid shrimp EC50 (140 PPT). Day 56 is the result from a 151 L wash of driveway and garage door.

CONCLUSIONS

The levels of fipronil in all treatments, except the no spray zone, produced levels toxic enough to kill 50% of the *Ceriodaphnia* and well above those necessary to kill all the Mysid shrimp.

The level of ant control decreased with those strategies that avoided the driveway. In the future, alternative treatment strategies that permit the treatment of the driveway and do not contribute to pesticide runoff and water quality issues need to be investigated.

ACKNOWLEDGMENTS

The research has been in part supported by grants from the California Department of Pesticide Regulation and the United States Environmental Protection Agency.

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