Trap-Mulching Argentine Ants

JULES SILVERMAN,[1] CLYDE E. SORENSON, AND MICHAEL G. WALDVOGEL

Department of Entomology North Carolina State University, Raleigh, NC 27695–7613

J. Econ. Entomol. 99(5): 1757–1760 (2006)

ABSTRACT Argentine ant, *Linepithema humile* (Mayr), management is constrained, in large part, by polydomy where nestmates are distributed extensively across urban landscapes, particularly within mulch. Management with trap-mulching is a novel approach derived from trap-cropping where ants are repelled from a broad domain of nest sites to smaller defined areas, which are subsequently treated with insecticide. This concept was field-tested with mulch surrounding ornamental trees replaced with a narrow band of pine (*Pinus* spp.) needle mulch (trap) within a much larger patch of repellent aromatic cedar (*Juniperus* spp.) mulch. After ants reestablished around the trees, the pine needle mulch band was treated with 0.06% fipronil (Termidor). Poor results were obtained when the trap extended from the tree trunk to the edge of the mulched area. When the trap was applied as a circular band around the tree trunk reductions in the number of foraging ants were recorded through 14 d compared with an untreated mulch control, but not for longer periods. Reductions in the number of ant nests within mulch were no different between the trap mulch and any of the other treatments. We conclude that trap-mulching offers limited benefits, and that successful management of Argentine ants will require implementation of complementary or perhaps alternative strategies.

KEY WORDS Argentine ant, trap-mulch, management, insecticide, repellent

Since its introduction to the United States from South America in the late 19th century, the Argentine ant, *Linepithema humile* (Mayr), has become established in numerous urban developments in the southeastern United States and is a serious agricultural and urban pest throughout much of California (Vega and Rust 2001). This invasive ant also has disrupted ecosystems worldwide by directly displacing native ant and other insect fauna (Cole et al. 1992, Holway 1998), with additional indirect costs to organisms at other trophic levels dependent on these depleted and dislocated indigenous species (Bond and Slingsby 1984, Christian 2001).

Argentine ant colonies can reach extremely high population levels around e.g., homes, schools, and hospitals. Management is constrained by many factors, especially landscaping practices using mulch in and around planting beds; mulch provides very suitable conditions for ant nest sites because it retains soil moisture. Because Argentine ant colonies cover large areas (Markin 1968, Holway et al. 2002b) and nests are somewhat protected by organic mulch, high volumes of insecticide are frequently needed to provide control. This approach is generally not cost effective and can be detrimental to the environment. Here, we examine a novel methodology similar to that used in agricultural settings (trap-cropping; Hokkanen 1991) to concentrate ants into preferred nest habitats for subsequent treatment with insecticide. Previously, Meissner and Silverman (2001, 2003) demonstrated that aromatic cedar (*Juniperus* spp.) mulch was highly repellent to Argentine ants, which avoided aromatic cedar mulch as a nesting substrate in favor of any one of several other organic mulches. We test how Argentine ant populations are affected by combining both repellent and nonrepellent organic mulches to concentrate ants and later apply relatively small volumes of pesticide to these infested parcels.

Materials and Methods

Studies were conducted on the grounds of a business complex in Research Triangle Park, NC. Despite ongoing professional pest control services, the Argentine ant population in this office complex was large and continuous, covering ≈100 ha, and it had persisted year-around for at least 10 yr. The field site had numerous "islands" (25 m^2–1 km^2) of mulched ornamental trees containing *L. humile* nests among buildings, parking lots, and walkways. Each tree was mulched with ≈500 cm^2 in diameter by 15 cm in height pine (*Pinus* spp.) needle mulch. Trees used in the experiments were separated by at least 20 m to minimize migration of ants between treatments.

Treatments were assigned equally to mulched ornamental trees (10 replicates per treatment) after estimates of ant population size. All the trees selected had large numbers of ants in the mulch and a foraging trail leading toward the canopy (where aphids and scale insects were generally abundant). Treatment

[1] Corresponding author, e-mail: jules_silverman@ncsu.edu.

0022-0493/06/1757–1760$04.00/0

effects were measured by counting the number of trailing ants on the trees that passed a predetermined point for 1 min before and at various times after treatments were applied. Counts were performed between 0900 and 1200 hours during the pretreatment and all posttreatment assessment periods. Initial forager counts across treatments ranged from 51.4 to 69.1 ($F_{3,\ 39}$ = 0.21; P = 0.88) for experiment 1 and from 139.8 to 153.8, ($F_{3,\ 39}$ = 0.05; P = 0.98) for experiment 2. Treatments (Tables 1 and 2) were as follows. 1) The trap-mulch system involved removal of existing pine needle mulch and replacement (to same depth, 15 cm) with aromatic cedar mulch and fresh pine needle trap-mulch in two configurations, each used in separate experiments conducted at different times: (a, experiment 1), the trap was a strip (20 cm in width) of pine needles extending from the base of the tree to the far edge of the mulch bed; and (b, experiment 2) the trap was a ring (20 cm in width) of pine needles surrounding the base of the tree with cedar mulch completing the mulch bed. The pine needle trap was treated 8 d later with 170 ml of 0.06% fipronil (Termidor SC, BASF, Research Triangle Park, NC) per label directions. Fipronil insecticide was selected because it is registered for residential ant control and because it is relatively nonrepellent (Costa and Rust 1999), thereby improving the chances that ants would nest in the treated trap. 2) Removal of existing pine needle mulch and replacement with aromatic cedar mulch (i.e., no trap mulch, to determine whether the preferred trap mulch was necessary). 3) Removal of existing pine needle mulch and replacement with fresh pine needle mulch, to assess the impact of disturbance on ant activity. 4) Undisturbed control. In the second experiment, a fifth treatment was included whereby fipronil was applied to the entire surface of pine needle-mulched trees to compare the effect of equivalent rates of insecticide applied broadly versus concentrated in the trap.

Before the first experiment, we determined that the band width selected for the trap (20 cm) was sufficient to accommodate the ants that were in the larger pine mulch bed around the tree. The trap was far from being filled with ants to the point that they were forced into the adjacent cedar mulch.

Mulch was examined for the presence of ant nests (pockets with brood) 7 d after all treatments were set in place. This examination was necessary to determine whether ants had reestablished in the replaced mulch before applying insecticide to the trap. The mulch was carefully parted by hand and inspected, and then it was replaced. Ants did not vacate the inspected area when we used this procedure. We determined that ants indeed recolonized all replicates within 1 wk, indicating that any disturbance caused by the removal of ants from the nesting substrate was temporary. Furthermore, in the trap-mulch treatment, all nests found before the application of insecticide were relocated within the trap. Insecticide was applied to the trap 1 d after we inspected for ant nests. In the second experiment, we also measured the impact of each treatment on the number of ant nests within the mulch

Table 1. Effect of trap-mulch applied as a strip from the tree base to the edge of the mulch on Argentine ant worker numbers

Treatment (no.)	Median (range) % reduction in foraging workers at day[a]				
	1	2	7	14	28
Trap-mulch and spray (1a)	96.4 (24.0 to 100)a	55.1 (−12.2 to 100)a	43.7 (−85.1 to 100)ab	96.3 (−142.7 to 100)a	89.9 (−110.7 to 100)a
Cedar (2)	−2.6 (−85.7 to 33.7)b	−44.6 (−143.4 to 42.1)b	−0.8 (−86.0 to 52.4)ab	98.4 (−82.6 to 100)a	84.2 (−54.3 to 100)a
Replacement pine (3)	28.3 (−67.3 to 85.3)ab	70.9 (−158.4 to 95.9)a	67.5 (−95.0 to 100)a	38.9 (−85.7 to 100)a	63.6 (−13.6 to 100)a
Undisturbed pine (4)	−21.7 (−286.7 to 22.5)b	−14.0 (−110.0 to 26.2)ab	−50.0 (−220.0 to 43.0)b	17.4 (−150.0 to 100)a	21.7 (−75.0 to 100)a

[a] Kruskal–Wallis test statistics for day 1 (H = 20.3, P = 0.00), day 2 (H = 16.2, P = 0.001), day 7 (H = 9.91, P = 0.019), day 14 (H = 2.63, P = 0.45), and day 28 (H = 3.16, P = 0.367). Column medians followed by the same letter are not significantly different (P < 0.05, Nemenyi nonparametric multiple comparisons test). Ten replicates were performed for each treatment.

Table 2. Effect of trap-mulch applied as a ring around the tree base on Argentine ant worker numbers

Treatment (no.)	Median (range) % reduction in foraging workers at day[a]					
	1	2	7	14	28	56
Trap-mulch and spray (1b)	91.2 (61.7 to 100)a	96.5 (61.5 to 100)a	62.9 (−400.0 to 96.3)a	50.2 (−477.8 to 95.2)a	33.6 (−2150.0 to 81.5)a	−30.9 (−233.0 to 83.6)a
Cedar (2)	−15.8 (−98.6 to 58.6)b	−47.0 (137.9 to 29.1)b	−8.8 (−29.6 to 58.6)b	−15.4 (−148.1 to 43.3)ab	−19.8 (−196.4 to 46.6)a	−100.7 (−268.6 to 16.2)a
Replacement pine (3)	−49.5 (−201.1 to 52.4)b	−123.1 (−220.9 to 60.2)b	−15.9 (−672.5 to 92.1)b	−74.8 (−372.9 to 77.0)ab	−26.0 (−134.1 to 73.0)a	−71.1 (−828.6 to 75.8)a
Broad spray (4)	94.3 (−17.8 to 100)a	82.5 (−10.3 to 100)a	12.2 (−141.2 to 61.2)ab	−63.4 (−338.1 to 53.8)ab	36.1 (−37.1 to 83.5)a	−104.5 (−489.0 to 24.4)a
Undisturbed pine (5)	−32.5 (−348.4 to 78.3)b	−133.1 (369.4–27.0)b	−77.7 (−292.2 to 37.2)b	−137.7 (−408.8 to 25.6)b	8.3 (−438.4 to 43.8)a	−201.9 (−893.8 to 45.0)a

[a] Kruskal–Wallis test statistics for day 1 ($H = 26.7$, $P = 0.00$), day 2 ($H = 28.9$, $P = 0.00$), day 7 ($H = 10.6$, $P = 0.014$), day 14 ($H = 9.64$, $P = 0.022$), day 28 ($H = 6.64$, $P = 0.084$), and day 56 ($H = 3.77$, $P = 0.288$). Column medians followed by the same letter are not significantly different ($P < 0.05$; Nemenyi nonparametric multiple comparisons test). Ten replicates were performed for each treatment.

before any insecticide was applied and 28 and 56 d later.

Ant forager reductions were analyzed with nonparametric tests: Kruskal–Wallis followed by Nemenyi multiple comparisons tests (Zar 1996). Nest counts were analyzed with analysis of variance (Minitab, Inc. 2000).

Results and Discussion

Reductions in ant foraging activity were minimal when the trap was applied as a strip running from the base of the tree to the edge of the mulch (Table 1, treatment 1a). No differences were evident with this arrangement compared with a pine mulch replacement (Table 1, treatment 3). Although there may have been an impact from this treatment, it could not be adequately measured, because ants trailed from outside the area of the mulched tree across the top of the aromatic cedar and then nested at the base of the tree. Therefore, although ants may have been killed in the insecticide-treated trap, foragers crossing the cedar mulch and trailing on the trees were equally abundant in the treated and untreated replicates. This issue was addressed by conducting a second experiment in which we placed the trap-mulch in a narrow band around the tree (treatment 1b) so that ants would be forced to nest in the trap or cross the surface of the trap to reach the homopteran food source in the tree canopy. We recorded ant reductions with the trap-mulch system through 14 d, relative to the undisturbed pine (Table 2, treatment 5) control, with this modified configuration. Because reduced numbers of foragers were not observed with the cedar mulch-only treatment, trap-mulch forager reductions were most likely due to ant mortality caused by insecticide treatment to the trap rather than by ants being deterred by the cedar. By comparison, an identical insecticide application over the entire mulched bed (i.e., 170 ml covering a broader area; Table 2, treatment 4) reduced ant foragers for only 2 d. Therefore, a focused insecticide application (i.e., same active ingredient [AI] per m^2 applied to smaller area) was beneficial, probably because more insecticide penetrated the mulch and reached areas where the ants resided. However, because we did not record a significant reduction in ant foragers from the trap-mulch treatment after 14 d the benefits obtained from trap-mulching were limited. Furthermore, when we searched mulch for Argentine ant nests, there was no significant difference in the number of nests present at any time for any treatment (28 d: $F_{3, 19} = 2.35$, $P = 0.11$; and 56 d: $F_{3, 19} = 1.08$, $P = 0.38$; Fig. 1). Although not measured, an effect on nest number may have occurred between 0 and 28 d, when forager reductions were recorded in the trap-mulch treatment. Also, in the trap-mulch treatment there was no difference in the number of nests within the trap or cedar mulch at 28 d (trap: 1.3 ± 0.37; cedar: 1.2 ± 0.80; t-test, $n = 5$, $t = 0$, $P = 1.0$) or 56 d (trap: 1.4 ± 0.75; cedar: 1.4 ± 0.25, t-test, $n = 5$, $t = 0$, $P = 1.0$). We were somewhat surprised that a relatively large number of nests were found within the aromatic cedar

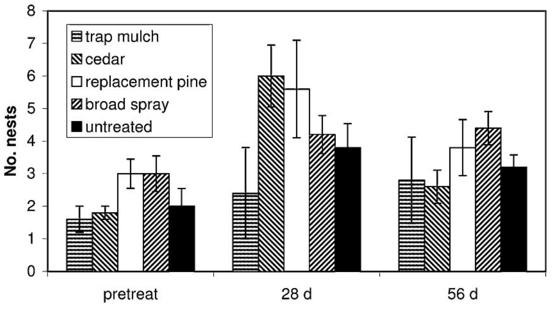

Fig. 1. Effect of treatment on the mean ± SE number of Argentine ant nests located within mulch.

treatment and the cedar portion of the trap-mulch treatment, considering that Meissner and Silverman (2003) reported a significant reduction in Argentine ant nests in cedar mulch through 8 wk. Differential rates of repellent compound loss from the cedar mulch caused by varied rainfall, irrigation patterns, or both may explain the less persistent ant reductions recorded here compared with those of Meissner and Silverman (2003).

Although cedar mulch may not be a persistent repellent to Argentine ants, there may be situations where using a locally restricted high-quality habitat (trap) that is subsequently insecticide-treated can be a viable means to manage this unicolonial pest. Introduced Argentine ant populations generally thrive where habitat has been altered through human activity. For example, California *L. humile* populations are restricted to urban and agricultural landscapes where soil of sufficient moisture content is available (Human et al. 1998, Holway et al. 2002a, Menke and Holway 2006). Consequently, their spread is limited to areas that receive irrigation. By modifying irrigation practices in regions with dry climate such that only the area around desired vegetation is watered, it may be possible to attract Argentine ants to these refugia, which could then be treated with insecticide. We followed the label directions for Termidor (fipronil) and consequently applied a relatively low volume of insecticide to the trap. That population reductions were achieved through 14 d suggests that at least some of the insecticide penetrated the mulch. Mulch penetration with higher volumes of finished product should be greater; therefore, it would be useful to measure the performance of other nonrepellent insecticides registered for higher volume application by using the trap-mulch approach.

Acknowledgments

We thank Adrian Carper, Paul Labadie, and Alan Stephenson for assistance. This work was supported by USDA Grant SRIPM 2004-04620 and the Blanton J. Whitmire Endowment at North Carolina State University.

References Cited

Bond, W., and P. Slingsby. 1984. Collapse of an ant–plant mutualism: the Argentine ant (*Iridomyrmex humilis*) and myrmecochorous protecaeae. Ecology 65: 1031–1037.

Christian, C. E. 2001. Consequences of a biological invasion reveal the importance of mutualism for plant communities. Nature (Lond.) 413: 635–639.

Cole, F. R., A. C. Medeiros, L. L. Loope, and W. W. Zuehlke. 1992. Effects of the Argentine ant on arthropod fauna of Hawaiian high-elevation shrubland. Ecology 73: 1313–1322.

Costa, H. S., and M. K. Rust. 1999. Mortality and foraging rates of Argentine ant (Hymenoptera: Formicidae) colonies exposed to potted plants treated with fipronil. J. Agric. Urban Entomol. 16: 37–48.

Hokkanen, H.M.T. 1991. Trap cropping in pest management. Annu. Rev. Entomol. 36: 119–138.

Holway, D. A. 1998. Effect of Argentine ant invasions on ground-dwelling arthropods in northern California riparian woodlands. Oecologia (Berl.) 116: 252–258.

Holway, D. A., A. V. Suarez, and T. J. Case. 2002a. Role of abiotic factors in governing susceptibility to invasion: a test with Argentine ants. Ecology 83: 1610–1619.

Holway, D. A., L. Lach, A. V. Suarez, N. D. Tsutsui, and T. J. Case. 2002b. The causes and consequences of ant invasions. Annu. Rev. Ecol. Syst. 33: 181–233.

Human, K. G., S. Weiss, B. Sandler, and D. M. Gordon. 1998. Effects of abiotic factors on the distribution and activity of the invasive Argentine ant (Hymenoptera: Formicidae). Environ. Entomol. 27: 822–833.

Markin, G. P. 1968. Nest relationship of the Argentine ant, *Iridomyrmex humilis* (Hymenoptera: Formicidae). J. Kans. Entomol. Soc. 41: 511–516.

Meissner, H. E., and J. Silverman. 2001. Effects of aromatic cedar mulch on the Argentine ant and the odorous house ant (Hymenoptera: Formicidae). J. Econ. Entomol. 94: 1526–1531.

Meissner, H. E., and J. Silverman. 2003. Effect of aromatic cedar mulch on Argentine ant (Hymenoptera: Formicidae) foraging activity and nest establishment. J. Econ. Entomol. 96: 850–855.

Menke, S. B. and D. A. Holway. 2006. Abiotic factors control invasion by ants at the community scale. J. Anim. Ecol. 75: 368–376.

Mintab, Inc. 2000. MINITAB release 13. Minitab, Inc., State College, PA.

Vega, S. J., and M. K. Rust. 2001. The Argentine ant: a significant invasive species in agricultural, urban and natural environments. Sociobiology 37: 3–25.

Zar, J. H. 1996. Biostatistical analysis, 3rd ed. Prentice-Hall, Upper Saddle River, NJ.

Received 16 March 2006; accepted 5 July 2006.