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OUTDOOR BAITING TO CONTROL TURKESTAN COCKROACHES (BLATTODEA: BLATTIDAE)

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Abstract Insecticidal baits are proven effective tactics for domestic cockroach species, but limited information about their use and efficacy exist for outdoor applications targeting peridomestic species. We evaluated three commercial bait products against large populations of Turkestan cockroaches at two public school campuses in California over a one-year period. Baits were applied monthly around buildings and in hardscape elements within self-contained tamper-proof stations at product label rates. Populations were monitored using attractant sticky traps placed overnight once per month adjacent to structures in treatment areas. Populations plummeted at both sites after baiting in June, just prior to mating and ootheca deposition., with 90% fewer cockroaches trapped after one month. Cockroach density also declined significantly in untreated plots, however, suggesting that cockroaches moved from treated areas to untreated areas, producing secondary mortality via cannibalistic scavenging.

Key Words Peridomestic cockroaches, insecticidal bait, foraging range, secondary mortality

INTRODUCTION

Peridomestic cockroaches are those generally considered to live and breed outdoors but that may invade homes and other structures to access food and water resources if they are not excluded (Gondhalekar et al., 2021). Common species, found alongside human habitations throughout the world, include *Periplaneta americana* (L.), other *Periplaneta* spp., *Blatta orientalis* L., and *Shelfordella* (*Blatta*) *lateralis* (Walker). These large insects may have the potential to contaminate food and introduce allergens (Guzman and Vilcinskas, 2020; Pollart et al, 1991): public health threats that are well established for domestic cockroaches, such as *Blattella germanica* (L.) (Brenner et al., 1987). Common pest control strategies aim to exclude or repel them from buildings (Thoms and Robinson, 1987; Gaire and Romero, 2020). Insecticide sprays, however, may not always be effective at keeping cockroaches out (Smith et al, 1997). Additionally, pyrethroid insecticides have been identified as important surface water contaminants (Weston et al., 2009). As a result, regulations (CDPR, 2012) and product label revisions (EPA, 2013) may prohibit or restrict applications made to building perimeters. Insecticide baits have been shown to be highly effective against domestic cockroaches indoors (Nalyanya et al., 2001), even in the presence of competing food resources (Miller and Smith, 2020). Furthermore, cannibalism and cannibalistic scavenging, well documented for many cockroach species, may confer secondary mortality after baiting (Gahlhoff et al., 1999; le Patourel, 2000). Few studies have evaluated the efficacy of outdoor baiting programs for peridomestic cockroaches; granular baits have been broadcast around structures to control *B. orientalis* or *Periplaneta* species (Short et al., 1993; Smith et al., 1997; Carlson et al., 2017).
Increasingly, the most common peridomestic cockroach species in the American Southwest is *S. lateralis*, the Turkestan cockroach, an invasive species considered endemic to central and western Asia as well as northeastern Africa (Gaire and Romero, 2020) that may have been introduced by military equipment returning from installments in its native habitat (Spencer et al., 1979) or, perhaps, by widespread internet sales as food for insectivorous pets (Gaire et al., 2017). Highly adapted to arid environments, they have displaced other peridomestic cockroach species in parts of their introduced range (Kim and Rust, 2013).

In late 2016, we connected with several public school districts battling large populations of Turkestan cockroaches. Perimeter insecticide programs at the sites had failed to reduce populations, structures were being routinely invaded, and stakeholders were concerned about pesticide exposure and community health. We hypothesized that targeted applications of insecticide baits, together with improved monitoring programs and structural exclusion tactics, would provide control at these sensitive sites.

MATERIALS AND METHODS

Two public school sites were included in this study: a high school in Mendocino County (northern California, small town surrounded by forested wildland) and an elementary school in Riverside County (southern California, sprawling suburban development). Campuses were divided into large circular treatment areas (~ 30 m D, ~ 700 m^2, n = 24 in Mendocino, n = 20 in Riverside) which were then assigned to receive one of four treatments: indoxacarb gel bait (Advion Cockroach Gel Bait, 0.6% indoxacarb; Syngenta), clothianidin gel bait (Maxforce Impact Roach Gel Bait, 1.0% clothianidin; Bayer), indoxacarb granular bait (Advion Insect Granule, 0.22% indoxacarb; Syngenta), or no treatment at all (untreated control). All products were applied according to label guidelines; four times at the Mendocino site (once per month during June 2017 – September 2017) and twice (October 2017 and June 2018) at the Riverside site. Higher rates were used when monitoring indicated cockroach populations were high. In accordance with the California Healthy Schools Act (2000), baits were applied in tamper-proof stations (Protecta RTU; Bell Laboratories, Inc.) or in plastic cylinders (DURA 1 in. x 1 in. PVC Slip x Slip Couplings; Home Depot, Inc.) within in-ground utility ports. In addition, both schools implemented exclusion strategies designed to eliminate breeding sites or prevent incursion into structures, including installation of sweeps on exterior doors and filling of gaps and voids in concrete and around doors and windows. Cockroach populations were assessed once monthly using attractant glue traps (LO-Profile Trap; B&G Equipment Co.) placed overnight (2100 h – 600 h) along exterior walls of structures (1 trap per treatment area). Nighttime surveys were conducted to assess localized population densities. Concurrently, school districts tracked complaints and maintained monitoring programs inside buildings.

Data Analysis Using a completely randomized design, four treatments were replicated six times each at the Mendocino site and five times each at the Riverside site. Factors included treatment and observation month, and the response was the number of cockroaches trapped per month, a continuous numerical variable. Means comparisons of the response variable per month and per treatment were conducted using Wilcoxon signed rank tests (Zar, 2010) and JMP Statistical Software (JMP Pro 16, SAS Institute, Inc.).

RESULTS

Initial monitoring indicated a much larger population in Mendocino (14.8 ± 2.9 cockroaches per glue trap, n = 23, June 2017) than in Riverside (1.95 ± 1.00 cockroaches per glue trap, n = 20, October 2017). Therefore, the maximum product label rates were initially used in Mendocino (3 g per bait placement x 4 bait placements per treatment area = 12 g bait per treatment area) while lower label rates were used in Riverside (1 g per bait placement x 4 bait placements per treatment area = 4 g per treatment area).

Mendocino. Within one month, the overall population plummeted (2.38 ± 0.64 cockroaches per glue trap, n = 24, July 2017). This represented an 84% reduction (Figure 1a). Bait application rates were therefore reduced to the lower label rate (1 g per placement, 4 g total per treatment area) for the remainder of the study. A visit to the site in June 2018 indicated that *S. lateralis* populations were still present, albeit at much lower densities than originally measured (2.17 ± 0.72 cockroaches per glue trap, n = 23). Overall treatment differences could not be detected (χ^2 = 2.90, P = 0.41) due to population crashes in untreated areas. No cockroaches were trapped in treated areas during September 2017, but small numbers (0.83 ± 0.40 per glue trap, n = 6) were detected in untreated areas; this was a significant treatment difference (χ^2 = 9.82, P = 0.02). Staff at the site reported that complaints and indoor trap catches declined significantly during the study. Stakeholders in the community, including parents of schoolchildren enrolled at the site and district officials, publicly thanked the project team for the successful program.

Riverside. The first baiting event took place in October 2017. Population densities in June 2018 were unchanged, however (1.75 ± 0.46 cockroaches per glue trap, n = 20), so another application was made. One month later, no cockroaches were trapped, but nighttime visual surveys indicated small populations still existed. In September 2018, trapping detected moderate densities in untreated areas (1.40 ± 0.68 cockroaches per glue trap, n = 5), but this treatment difference was not quite statistically significant (χ^2 = 7.53, P = 0.057). At the end of the season, densities approached zero (0.05 ± 0.05 cockroaches per glue trap, n = 20; one cockroach was trapped within an untreated area), and a nighttime visual survey detected no cockroaches. Overall density declined by 97% between October 2017 and October 2018 (Figure 1b). Staff trapped very few cockroaches within buildings and reported no complaints during the study period.

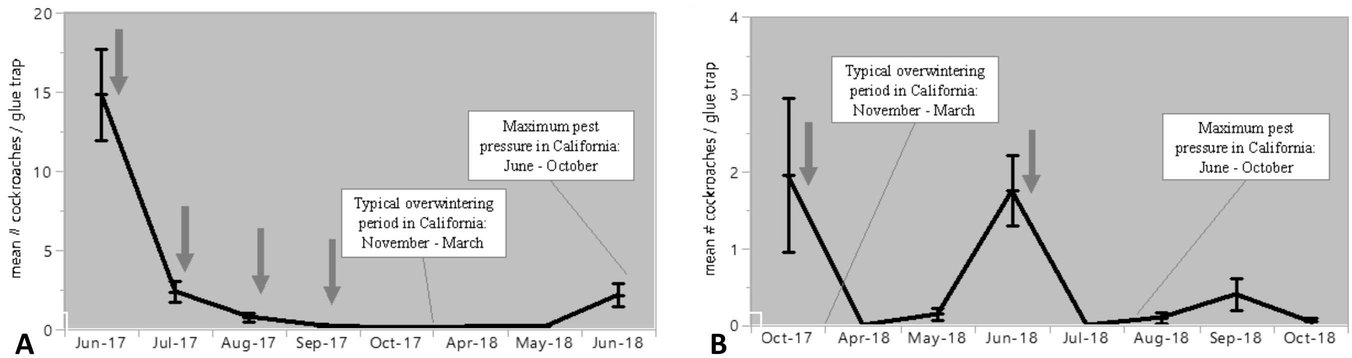

Figure 1. Population density of Turkestan cockroaches, *Shelfordella* (*Blatta*) *lateralis*, at **a)** a public high school in Mendocino County and **b)** a public elementary school in Riverside County (California, USA) during a one-year demonstration of an integrated pest management program that utilized targeted insecticidal bait applications and structural exclusion tactics. Vertical arrows indicate bait application dates. Call-out boxes indicate periods of expected high pest pressure or inactivity due to overwintering.

DISCUSSION

Turkestan cockroach populations at both school campuses declined dramatically during the intervention programs. Evidently, the combination of outdoor bait applications and structural exclusion provided effective control. Peridomestic cockroaches may be especially vulnerable because individual lifespans are greater than one year, eggs (within ootheca) are deposited only during the summer, and there are few overlapping life stages. As an example, many *B. orientalis* adults die in autumn after depositing ootheca during summer months (Gould and Deay, 1941). Observations suggest *S. lateralis* overwinters as nymphs of mixed age that hatched from ootheca deposited during summer months. Control programs targeting nymphs and young adults in late spring or early summer may prevent deposition of ootheca. Such targeted programs disrupt the pest life cycle and may eradicate localized populations. In this study, bait applications in June resulted in rapid and lasting reductions in cockroach density. Initial baiting conducted in October failed to reduce populations, perhaps because ootheca had already been deposited and many hatchling nymphs were able to avoid exposure to baits and successfully overwinter. Populations at our study sites were historically targeted with regular pyrethroid insecticide spray applications to building perimeters. Control failures may have been experienced because sprays killed some cockroaches foraging near structures but did not address harborage and breeding locations found throughout the campuses, ensuring steady pressure from replacement individuals. Furthermore, without the exclusion measures demonstrated, cockroaches were previously able to easily enter classrooms and other indoor spaces.

We were unable to experimentally detect control efficacy of our bait treatments since populations declined significantly in untreated areas as well as treated areas. One explanation for this experimental failure is that our treatment areas were too small, allowing for movement of foraging cockroaches into untreated areas and out of baited areas. Size of our treatment areas (30 m D circles, ~ 700 m^2) was determined by considering previous work that estimated foraging distances of large peridomestic cockroaches. For instance, Fleet et al (1978) reported that marked and recaptured *P. fuliginosa* adults moved less than 10 m on average, and Appel and Rust (1985) estimated foraging ranges of *P. fuliginosa* to be less than 300 m^2. Thoms and Robinson (1987b) reported that *B. orientalis* adults moved, on average, less than 10 m between sightings, though a single observation of 50 m movement was observed. Turkestan cockroaches, which are flightless and lack tarsal arolia, were expected to exhibit dispersal patterns like those observed for *B. orientalis*. It seems likely, however, that foraging ranges were much larger than treatment areas and that cockroaches consuming bait in treated areas may have died in untreated areas, exposing resident cockroaches there to secondary mortality during cannibalistic scavenging events. Cannibalistic scavenging was observed during nighttime surveys, and several insects observed on glue traps appear to have been partially consumed, perhaps by conspecifics. We conclude that outdoor baiting programs have the potential to drastically reduce Turkestan cockroach populations and control significant pest problems over large areas, especially when combined with structural exclusion practices. Such programs represent valuable alternatives to liquid insecticide sprays, which may contribute to environmental contamination issues, insecticide resistance development, and may be ineffective in many instances.

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