TARGETING OVIPOSITION SITES AS A CONTROL STRATEGY FOR POPULATION REDUCTION IN *PERIPLANETA FULIGINOSA* (SERVILLE) (DICTYOPTERA: BLATTIDAE)

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Abstract—A focal point for pest management programs is often limiting the amount of insecticide to the minimum level while still maintaining the maximum benefit for population reduction. With that in mind we conducted a field study in 28 homes to evaluate the efficacy of applying insecticide to habitats identified as potential oviposition sites for the smokybrown cockroach, *Periplaneta fuliginosa* (Serville). We hypothesized that by targeting those sites we could significantly reduce the amount of insecticide applied while selectively reducing the number of reproductive females and newly eclosed nymphs in the population. The habitats were chosen based on laboratory generated data on oviposition site selection in the smokybrown cockroach in which, in decreasing order, peat, wall void and landscape marble chips were differentially preferred by females for deposition of oothecae. Three treatment strategies were evaluated and a control was included in the study. The treatments were exterior, interior/exterior, and interior/exterior coupled with an insect growth regulator (IGR). The insecticides used were microencapsulated chlorpyrifos and fenoxycarb. Trapping was conducted at 1 week pretreatment, and 1,2,4,6,8,10, and 12 weeks post-treatment.

There were no significant differences in population reduction for *P. fuliginosa* between the three treatments investigated, although all did vary significantly from the control. Mean numbers of cockroaches trapped from exterior, interior/exterior, and interior/exterior with IGR treatments were 13.1, 11.6, and 11.1. No smokybrown cockroaches were trapped inside the homes after treatment. Populations in untreated homes were, on the average, four times greater than in the treated homes. As one measure of the success of the control strategy we evaluated the percentage of the population for each treatment that were adult females. In the exterior, interior/exterior, and interior/exterior with IGR the percentages of the trapped population that were adult females were 19.2, 18.5, and 16.8% respectively. These percentages were all significantly less than the untreated control in which 29.7% of the population was female.

These data indicate that insecticide applications to target oviposition sites for smokybrown cockroaches can significantly reduce populations while also reducing the amount of insecticide applied over a standard treatment program. We suggest that effective placement of insecticide to target reduction of reproductive females and eclosing nymphs in a population of smokybrown cockroaches is a successful pest management strategy.

INTRODUCTION

Spot treatments of insecticides are those which are applied in specific areas of a building where a localized pest infestation occurs (Cornwell, 1973). An advantage of spot treatment is reduction in the amount of insecticide used. In the following study, spot treatments of a microencapsulated formulation of chlorpyrifos (Empire, Dow Chemical Co. Midland, MI) were applied to areas of homes where reproductive females of the smokybrown cockroach, *Periplaneta fuliginosa* (Serville) were expected to be harboring.

Research conducted on insecticidal control of cockroaches is frequently conducted in laboratory chemical tests (Cornwell, 1973). However, the chemical chosen is not the only factor to consider. How and where the chemical is applied is also important in effective control. Blackwell (1972) tested the efficacy of chlorpyrifos using a power sprayer on the exterior of homes in Houston, TX. Fleet et al. (1978) reported that the population of smokybrown cockroaches fluctuated from May through November and suggested that timing of insecticide applications to match these fluctuations would increase the efficacy of treatment. Zungoli and Robinson (1982) found that targeting cockroaches (*Blattella germanica* (L.) in their harbourage sites by using crack and crevice treatment was more effective than conventional fan spray application. They reported that the significant difference between treatments was due to the method of application rather than the chemicals they tested.

The hypotheses of this study were: 1) smokybrown cockroach populations could be reduced by spot treatments using a relatively small amount of insecticide, 2) there would be significant

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differences in levels of control between homes receiving only exterior treatments versus homes receiving interior/exterior or interior/exterior treatments supplemented with an insect growth regulator. The areas treated were chosen based on data from laboratory studies on the location of oviposition sites. This strategy was designed to reduce the population by targeting females and newly eclosed nymphs using less chemical than would normally be applied in a standard insecticide treatment using a fan or power spray application.

MATERIALS AND METHODS

Twenty-eight homes in Clemson, S.C. with smokybrown cockroach populations were treated with insecticide to evaluate three treatment regimes. Additionally, seven homes were used as a control group where no treatment was applied. None of these homes had been treated with an insecticide for at least one year prior to this study. The other treatment groups received applications of a microencapsulated formulation of 0.5% (95 ml in 1 l) chlorpyrifos (Empire). Seven homes each received exterior treatments, interior/exterior treatments, and interior/exterior treatments of chlorpyrifos combined with an insect growth regulator, fenoxycarb at a rate of 30 ml/3.79 l (Torus, Maag Agrochemicals Inc. Vero Beach, FL). Populations were monitored every two weeks for twelve weeks.

Identification of co-operators

In May 1991 flyers were distributed door to door in the Clemson area. Residents who responded were interviewed to assess whether or not they had a smokybrown cockroach infestation in their home and whether they would be willing to participate in the study. All homes selected were single family dwellings. Residents were asked to not treat their homes with any insecticides or growth regulators during the study period. During early May, one to two dozen glass jar traps (0.95 l) were placed in several locations throughout prospective homes for one night. These had the inner rim coated with petroleum jelly, and were baited with 25 g of Purina cat chow (Ralston Purina Co. St. Louis, MO. 63164) soaked in 20 ml beer. Homes from which less than 20 cockroaches were trapped were not used for the study. During this time, over 100 flyers were distributed, 68 residents were interviewed, 40 houses were monitored for smokybrown cockroach populations, and of these, 28 houses were chosen for the study based on willingness of residents to participate and numbers of smokybrown cockroaches trapped.

Pre-treatment monitoring

On June 20, 1991 twelve trap jars were placed at each of the 28 homes in the study. Eight jars were placed around the exterior and four were placed in the interior of each home. Traps were placed in locations which had been identified as likely cockroach habitats based on previous trapping. On this and all subsequent trap dates, traps were placed at the same locations between 4:00 and 6:00 PM and picked up the following day between 7:00 and 9:00 AM. On June 21, 1991 trapped cockroaches were counted and released at their site of collection. Data were recorded on number of cockroaches by gender, and immatures were characterized as small, medium or large nymphs. Any unusual information which may have affected the data was also recorded, eg. traps knocked over, dead cockroaches, the presence of rodents or cats or the occurrence of species other than *P. fuliginosa.*

Treatment

Four homes for each test group were treated on June 25, 1991 and three homes for each test group were treated on June 28, 1991. Chemicals were applied with a 3.79 l B & G compressed air sprayer (B & G Equipment Co. Box 130, Plumsteadville, PA. 18949). Two types of tips were used, a crack and crevice tip extension was used for spraying under window and door frames, and into cracks in walls and a B & G multijet tip was used for spraying under mulch and shrubbery and along rafters in attics and basements.

Treatments were applied at volumes lower than label recommendations and amounts used for each home were recorded. The amount applied was only that which was necessary to spot treat areas identified as preferred oviposition sites.

Post Treatment Monitoring

On weeks 1,2,4,6,8,10 and 12 following treatment, all homes were monitored for smokybrown cockroaches in the manner previously described for pre-treatment monitoring. Weeks 1–12 covered the period between July 1, 1991 and September 17, 1991.

Statistical Analysis

The study was conducted as a randomized complete block design. An analysis of variance *F* test, and a *T*-test for least significant differences were performed on the data to test for significant differences between treatment means for dates and type of treatment (Steele and Torrie, 1982).

RESULTS

There was a significant difference in numbers of smokybrown cockroaches trapped between the four treatments ($F=47.89$; $df=3,24$: $P=0.0001$). There was also a significant difference between numbers of smokybrown cockroaches trapped on each of the eight trap dates ($F=3.11$; $df=7,165$: $P=0.0041$), and the treatment/date interaction ($F=5.67$; $df=21,165$: $P=0.0001$). Means for total number of cockroaches trapped in control homes was significantly greater than all other treatments (Table 1).

The pretreatment mean number of smokybrown cockroaches trapped was 35.00, 29.86, 25.57, and 29.14 (S.E. = 3.94) for the control, exterior, interior/exterior, and interior/exterior/Torus 2E treatments, respectively. Pretreatment means for each group were not significantly different. Insecticide treatment means are not significantly different from each other on any given date, yet all insecticide treatment means were significantly different from the control treatment mean on each individual date ($F=5.67$; $df=21,165$: $P=0.0001$) (Figure 1).

The percent of the population that were females differed significantly between treatments across all trapping dates ($F=8.52$; $df=3,24$: $P=0.0005$). The percentages of female smokybrown cockroaches trapped from the total population before treatment was applied were 33.7, 29.5, 38.8, and 34.2% (S.E. = 5.0%) for the control, exterior, interior/exterior and interior/exterior/Torus 2E treatments, respectively. Pretreatment percentages for each group are not significantly different. Percentages after insecticide treatment are not significantly different from each other on any given

Table 1. The mean number of cockroaches trapped for each of four treatments during a twelve week period.

Treatment	Means[1]
Control	56.6[a]
Exterior	13.1[b]
Interior/Exterior	11.6[b]
Interior/Exterior/T2E	11.1[b]

[1] Means followed by different letters are significantly different at $\alpha=0.05$, $df=24$, S.E. = 3.20.

Table 2. The percent of smokybrown cockroach females and immatures trapped for each of four treatments during a twelve week period

	Percent of Population[1]	
Treatment	Females	Immatures
Control	29.7%[a]	48.5%[c]
Exterior	19.2%[b]	40.4%[d]
Interior/Exterior	18.5%[b]	45.7%[c]
Interior/Exterior/T2E	16.8%[b]	50.7%[c]

[1] Means followed by different letters are significantly different at $\alpha=0.05$, $df=24$, S.E. = 3.20

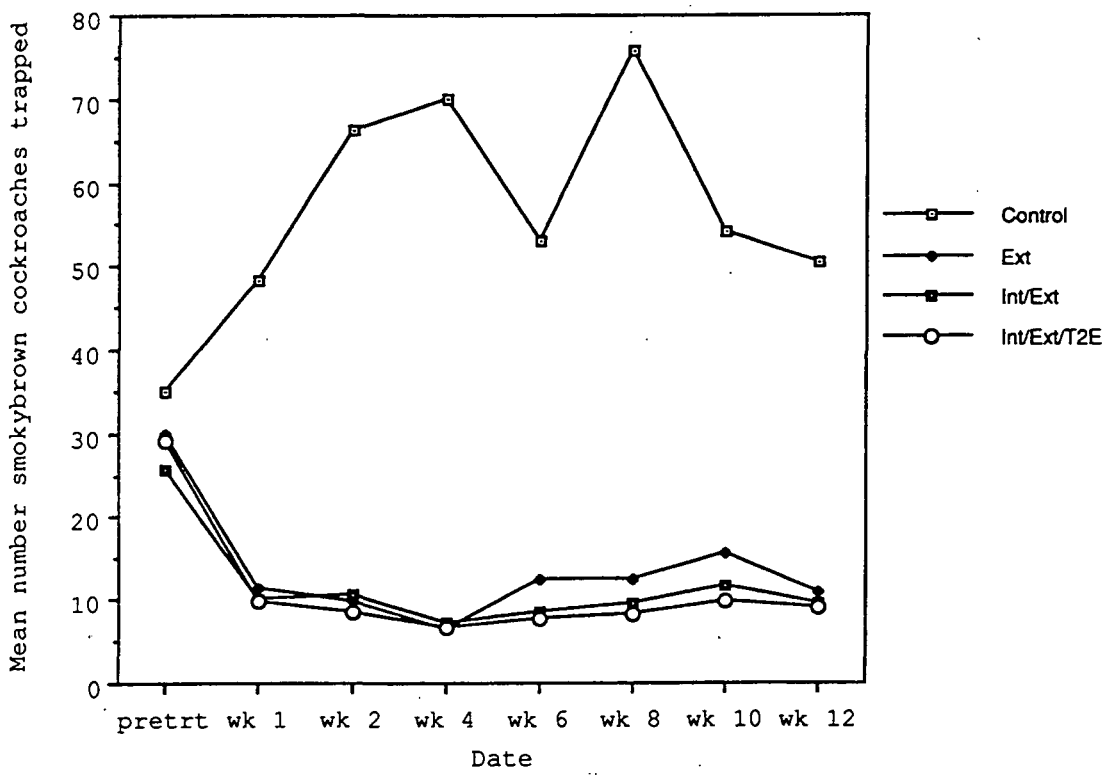

Figure 1. The number of smokybrown cockroaches trapped over a twelve week period under four treatment regimes. SE = 3.94

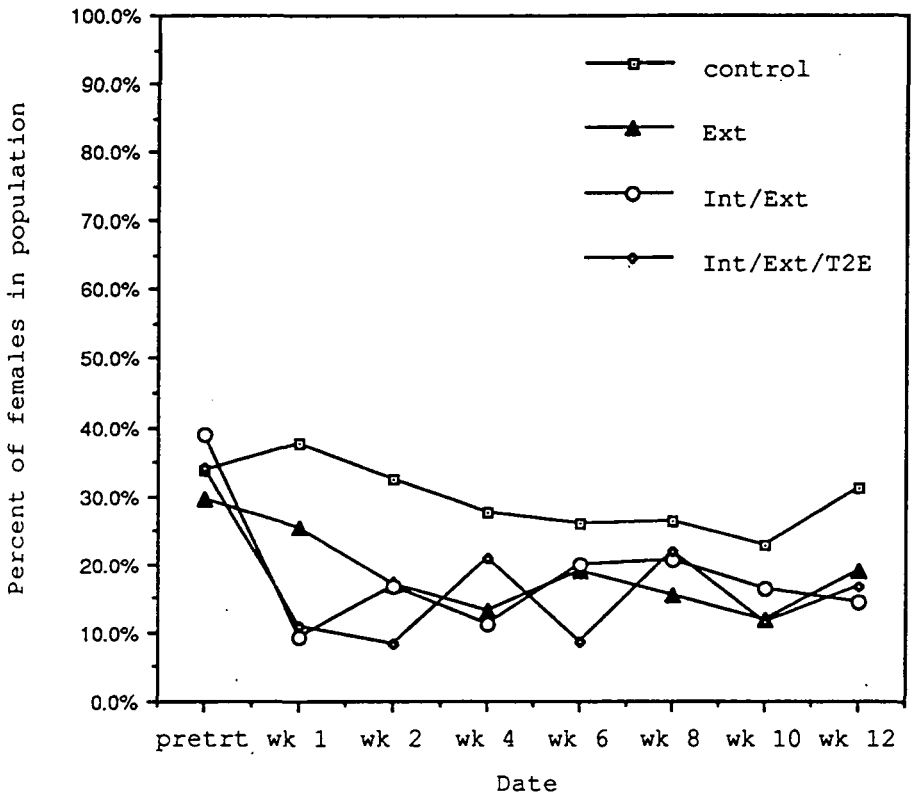

Figure 2. The percent of smokybrown cockroach females in a population under four treatment regimes over twelve weeks.

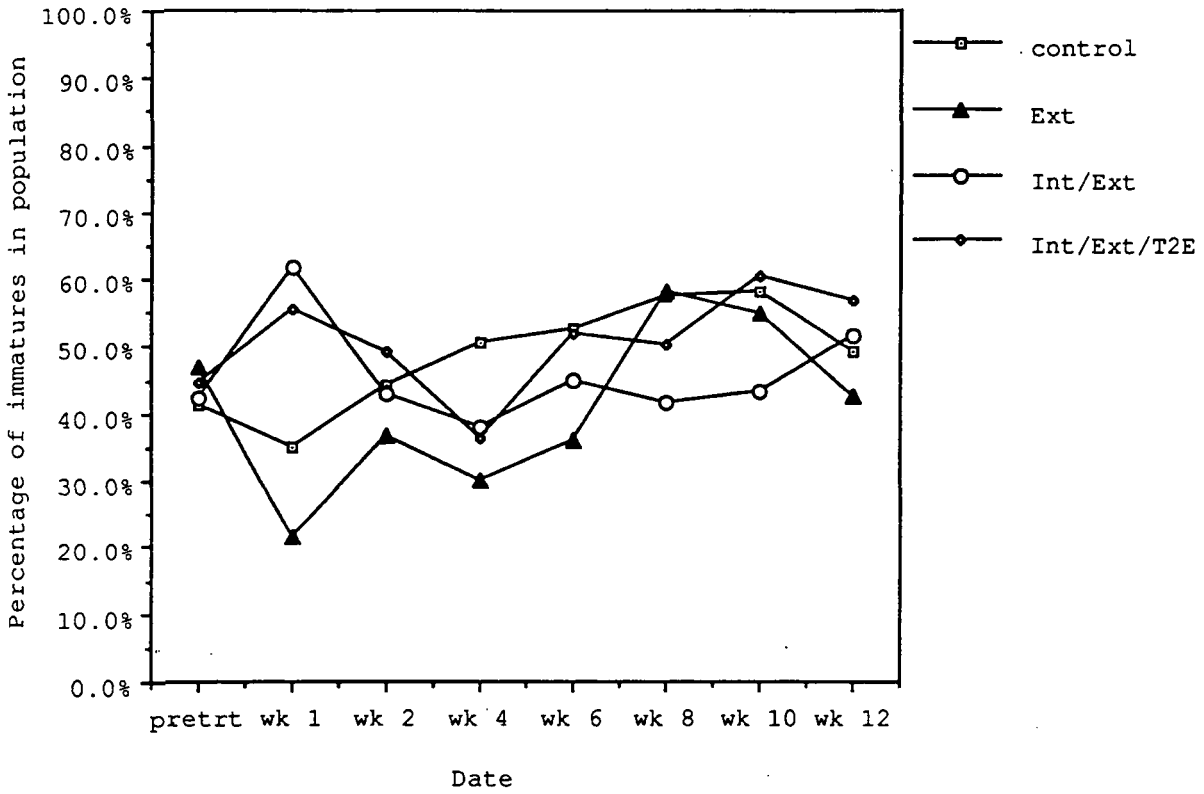

Figure 3. The percentage of immature smokybrown cockroaches in a population under four treatment regimes over twelve weeks.

date, yet all insecticide treatment means are significantly different from the control treatment mean on each individual date ($F = 8.52$; $df = 3,24$: $P = 0.0005$) (Figure 2).

The mean percentage of female smokybrown cockroaches trapped in control homes differed significantly from homes receiving insecticide treatments, but there was no significant difference in the percent of the population which were immatures in treated versus untreated homes (Table 2).

The percent of the population which was composed of immatures, did not vary significantly between the four treatments across all trap dates ($F = 1.51$; $df = 3,24$: $P = 0.2368$). The percentages of immature smokybrown cockroaches trapped from the total population before treatments began were 41.4, 47.0, 42.0, and 44.4% (S.E. = 9.0%) for the control, exterior, interior/exterior, and interior/exterior/Torus 2E treatments, respectively. Pretreatment percentages for each group are not significantly different from each other. Percentages after insecticide treatment means are not significantly different from the control treatment on any given date ($F = 1.51$; $df = 3,24$: $P = 0.2368$) (Figure 3).

The average amount of chemical used in each treatment group was as follows: exterior treatments used an average of 4.5 l of chemical mixture, interior/exterior treatments used an average of 7.6 l of chemical mixture and the interior/exterior/T2E treatments used an average of 7.2 l of chemical mixture. The houses treated range in size from 4800 to 10,500 m^2. The suggested label amount of application for the chlorpyrifos is to cover 20% of the lower wall and floor surface for indoor spot treatments. The outdoor recommendation is to treat a 18 to 30 m band around the structure and foundation up to 1 m high with a course spray of 37.9 l per 3,000 m^2. Re-treatments are recommended after a period of at least 2 weeks.

DISCUSSION

The population size of the control group was significantly different from the treatments. When untreated, smokybrown cockroach populations appeared to be highly variable during the period of

June 20 through September 17, 1991. Control populations increased steadily through the four weeks post treatment trapping and then dropped off at 8 weeks after treatment. This decrease in the control population may be attributed to heavy rain on August 6, 1991 (at 6 weeks) which filled many trap jars with rain and may have prevented smokybrown cockroaches from foraging and entering trap jars on that date. Appel and Rust (1985) reported that smokybrown cockroaches forage less during periods of rainfall. However, Benson (1988) found trap catches of smokybrown cockroaches to be slightly higher on rainy nights. At 8 weeks after treatment, the control population again began to increase and then dropped off slightly at the 10 and 12 week trap dates. This population curve correlates with findings reported by Benson (1988) for smokybrown populations in 1986 and 1987.

There were not significant differences between the exterior and interior/exterior insecticide treatments. The treatment of chlorpyrifos which was applied to the exterior of a structure was as effective as the same chemical applied to the interior and exterior of a structure. Almost twice as much chemical was used in the interior/exterior treatment as in the exterior treatment to achieve the same results. These results may be attributed to the ecology of the smokybrown cockroach. The smokybrown cockroach is an indoor/outdoor pest which moves freely across the boundaries of most structures by entering through attics and other areas which may have unsealed cracks or joints (Cornwell, 1968). These cockroaches do not usually establish an infestation which remains wholly inside a structure, but instead move in and out through the upper levels, spending as much time outside the structure as inside. This habit is one reason why the smokybrown cockroach is so difficult to control. The potential for continuing re-infestation from outdoor reservoirs is great. However, for the same reason, unless an infestation is unusually severe, it may be that spot treating the structure externally is enough to control the population at levels acceptable to the inhabitants.

Spot treatment was effective in reducing the female portion of the population which lead to overall population reduction. Southwood (1978) argued that in long lived species, fecundity is an important factor in demography. Smokybrown cockroaches are a long lived species in which reducing the numbers of reproductive females is a method of reducing fecundity and subsequently reducing the intrinsic rate of increase of the population.

The percentage of immatures in the population experienced a marked increase during the fourth week of trapping, as did the entire population. At this point in the study the insect growth regulator was able to maintain the percent of immatures in the population at below control population numbers although the difference was not statistically significant. During weeks 4 through 10, the percentage of immatures in the control population remained high while the percentage of immatures in the treated population began to increase until the tenth week when there was no significant difference in the percentage of immatures in the treated population when compared with the control and insect growth regulator treatment (Figure 3). The effects of the insect growth regulator were expected to be most pronounced later in the study due to the delayed reaction time of a population to insect growth regulators (Piper and Frankie 1978). However, immature smokybrown cockroaches made up a greater percentage of the population at the end of the study than at the beginning of the study. Note that the label for Torus 2E recommends a second application at 8 weeks after the initial treatment. This is the time of the study where the population which received the insect growth regulators began to increase above the control. A second treatment of Torus 2E was not applied because of the effort to minimize the amount of chemical used in all of the treatments. Spot treatments of insect growth regulators using less than label amounts may not be enough to effectively maintain long term control of the immature segment of smokybrown cockroach populations.

Overall, the spot treatments using less than label amounts of insecticide appeared to be effective. When compared with control populations, the treated populations remained at a relatively constant density. When the control population experienced a surge of growth during the fourth and eighth week of trapping, the treated populations did not respond with a comparable surge.

In summary, the three treatments tested did not vary significantly from each other in effectiveness for controlling smokybrown populations. However, a consistent level of control was maintained for a period of twelve weeks with a single application of insecticide applied at below labeled amounts using spot treatments. In this way, less insecticide was used than in a standard pest control program

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K.B. Wildey and Wm H.Robinson (editors). 1993

which would treat two or three times within a season and an acceptable level of control was maintained.

Of the two classes of the smokybrown cockroach population which were targeted by the spot treatments, the percent of reproductive females in the population were consistently below the percentage found in control populations. The percent of immature smokybrown cockroaches in the population remained below the control population during a population surge at 4 weeks but increased to at or above control populations at 8 weeks, indicating the need for a second application of insect growth regulator at 8 weeks following treatment.

Successfully managing smokybrown cockroach populations may depend more upon using spot treatments targeted at sites where the cockroaches are likely to be found than the amount of chemical applied to and around a structure.

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