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CONTROL OF *CTENOLEPISMA LONGICAUDATA* (ZYGENTOMA: LEPISMATIDAE) USING BAIT

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Abstract The increasing prevalence of the nuisance pest *Ctenolepisma longicaudata* has demanded an assessment of the tools for control and elimination that are available to the pest control industry. A single application of a commercially available cockroach bait containing 1% Clothianidin at a dose rate of 0.1 to 0.2 g/treated m^2 showed a 100% reduction of the visible grey silverfish population and 93% reduction in trap catches after 63 days. This study demonstrates the suitability of the chosen bait matrix and active ingredient. In addition, we identified the need for a thorough and detailed inspection to identify the most promising locations for bait placement. Baiting techniques also differ from cockroach baiting, as many small bait spot are required to be delivered to the preferred hiding places to increase the chances of contact.

Key words Invasive species, Paper fish, bait placement, population control, pest control, public health

INTRODUCTION

The Grey silverfish (*Ctenolepisma longicaudata*, Zygentoma; Lepismatidae ; Escherich 1905) was identified as nuisance pest across Europe in recent years. Depending on geography, this insect is also known under the common name Long-tailed silverfish or Paper fish. Increasing awareness to this pest has led to a rising number of identifications, mostly after 2014 (Nierop and Hakbijl, 2002; Goddard et al., 2016; Kulma et al., 2018; Meineke and Menge, 2014; Schoelitsz and Brooks, 2014). *C. longicaudata* is able to feed on a multitude of diets and is therefore considered omnivorous (Lindsay, 1940, Mallis, 2011), however, they show a preference to starch-containing materials and may attack and damage books, files, pictures and other collectable/stored items. Based on this food preference and their reduced reliance to moist environments (Heeg, 1967a; Heeg, 1967b), *C. longicaudata* has spread not only in domestic dwellings but also in offices, archives, museums and other similar buildings (Querner, 2015). Conventional broad-spectrum residual products like water-based surface sprays cannot be used in those locations. An alternative method to control certain crawling insects is the use of toxicant baits that are readily available to the professional pest control operator, especially against cockroaches and ants (Rupes et al., 2008; Brooks et al., 2008; Tee and Lee, 2014).

Only limited information is currently available on baits targeting the grey silverfish or related species, but anecdotal claims suggested that bait strategies have some degree of effectiveness (personal communications; Sims and Appel, 2012). A first non-quantitative field evaluation using baits against *Lepisma saccharina* (L.) indicated that indeed a baiting strategy with commercial cockroach baits may be effective (Gutsmann, unpublished results). In this study, we investigated in a quantitative field trial whether a Clothianidin bait, labelled for cockroaches, is effective in controlling the Grey / Long-tailed silverfish. An additional and important aspect of the study was to describe and validate an effective bait placement strategy.

MATERIALS AND METHODS

Selection Of Infested Properties. Four suitable residential houses with a long history of Grey silverfish infestation were found for the trial. All four of the test sites were semi-detached houses in the Netherlands in a housing estate where a large number of the residents have had or still have problems caused by the grey silverfish. Species were collected and identified to be *C. longicaudata*. All four test sites were approximately 19 years old consisting of a crawling space, the ground floor and the first floor with a flat roof. They were well-insulated houses with double glazed windows and with central heating throughout. The layout of each of the houses was similar although the total

floor space of each house varied between 112 and 145 $m^{2.}$. The inhabitants of all four houses complained about silverfish on the ground floor, mainly in the living room, the toilet and in the entrance hall. On the first floor, Grey silverfish were occasionally observed in the bathroom and in the toilet. None of the inhabitants observed the pest in the bedrooms. No previous treatment had been performed against Grey silverfish or other arthropod pest within at least a 12-month period before the start of the trial.

Inspections / Activity Monitoring Methods. All test sites were inspected to determine *C. longicaudata* infestation hot spots, and most appropriate treatment points. During the initial inspections 14 days before treatment, the Grey silverfish and signs of their presence (faecal pellets and feeding damage on paper) were found in all of the houses (Figure 1). As expected, the majority of the target insects were well hidden and difficult to find without disturbing them. Several harbourages were identified during the initial inspection and, despite the carefulness, were disturbed so much that during the following observations *C. longicaudata* could not be detected anymore. These locations were therefore excluded from our assessment of population and replaced by locations where insects could be repeatedly counted without disturbing them. As we felt that a reliance on a sole readout method could be a risk in this study, we established a second monitoring system based on traps. Monitoring pots ("pitfall" traps) were placed at appropriate places in the infested test sites. The traps were made using glass containers (5 cm x 5 cm x 3 cm) wrapped with paper tape (Figure 2). *C. longicaudata* were able to climb over the paper tape to fall into the glass containers from which they were unable to escape. Tissue paper was placed in the traps to provide food and harbourage for any silverfish caught. The traps were then monitored during all of the following assessments and the number of Grey silverfish caught were counted and recorded. After counting, the insects were released close to where they had been caught.

Three pre-treatment assessments were made 14 and 7 days prior to treatment, and on the day of treatment (days -14, - 7 and 0). Bait application was performed on day 0 directly after the last pre-treatment assessment. Four post-treatment assessments were conducted at each test site 7, 21, 49 and 63 days after bait application in the same manner as the previously performed assessments.

Treatment Groups. Initially, houses 1, 2 and 3 were treated at day 0 and assessed until the end of the trial at day 63. House 4 acted as untreated control throughout this period. After the 63-day assessment an additional treatment took place in house 4. The counts in house 4 at 49 and 63 days were used as pre-treatment figures for house 4. House 4 was assessed at the exact time intervals as the house 1-3 in the first round of treatments.

Treatment And Bait Placement Strategy. The product used in this trial was Maxforce® Platin, a commercially available cockroach gel containing 1% Clothianidin, manufactured and sold by Bayer AG, Germany. The product had originally a label for the control of *Blattella germanica* (L.), *Periplaneta americana* (Burmeister) and *Blatta orientalis* (L.). Dosing instruction on the label require an effective dose of 0.1 to 0.2 g bait per treated m^2. In contrast to baiting techniques for cockroaches, the bait placement was not done in 1-2 spots per m^2 but bait was divided into many small portions. Spreading the dose into many smaller spots was chosen to accommodate the different food finding behaviours of silverfish in comparison to cockroaches. Treatment areas were behind hollow skirting boards (Figure 3) or under wooden wall panelling or protected by other structures. Rooms without signs of silverfish in any of the pre-assessments were not treated. This resulted in treatment of all of the rooms on the ground floor whereas on the first floor only toilet, bathrooms and the boiler rooms were treated. We frequently observed that target insects found the bait spots very fast and started to feed almost instantaneously (Figure 4).

RESULTS AND DISCUSSION

During the initial activity inspections on days -14, -7 and 0 both methods described above indicated that silverfish were present in relatively large numbers spread over the entire ground floor with the highest population densities found around the trap doors for the crawling space in the entrance hall. On the first floor, silverfish were only observed and/or caught in the toilet, the bathroom and boiler room.

The average number of *C. longicaudata* visually observed in the pre-counts in house 1, 2, 3 and 4 was 63, 79.7, 15 and 19.3 per house, respectively (Figure 5a). The average number of *C. longicaudata* caught in the traps in houses 1, 2, 3 and 4 before bait application was 21, 15, 15.5 and 9.5 per house, respectively (Figure 6a). Seven days after treatment, numbers of live *C. longicaudata* visually observed and caught in the traps were much lower compared to the pre-count inspections. After 21 days very few live *Grey silverfish* were seen during the inspections and inhabitants reported seeing almost no insects in the previous 2 weeks. At 49 days after the treatment, only 2 target pests were observed in

Figure 1. *C. longicaudata* on damaged paper.

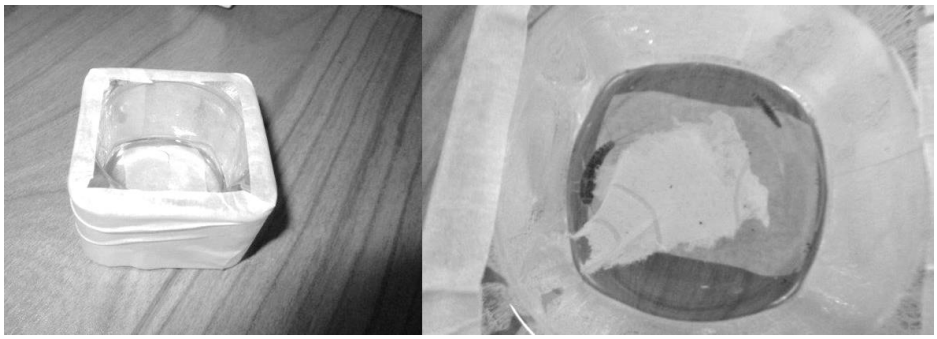

Figure 2. Pit fall traps for trapping live target insects.

Figure 3. Location for bait placement.

Figure 4. .*C. longicaudata* feeding on Clothianidin 1% bait

house 2, the other three houses were visually free of insects. During the last inspection, 63 days after treatment, no living Grey silverfish were found visually resulting in 100% reduction in the number of *C. longicaudata* (Figure 5a).

When looking a trap catches, reduction was still dramatic but not reaching a complete 100% as in the visual detection. In the four treated houses reductions of 90%, 93%, 100% and 95% were recorded in the numbers of Grey silverfish caught in the traps compared to the numbers of *C. longicaudata* caught in the traps before the treatment (Figure 6a). The untreated control showed the opposite trend. Based on visual counts, populations increased to 135% whereas trap catches indicated an increase of 210% compared to pre-treatment levels (Figures 5a and 6a)

To relieve the residents in house 4 (control) from the silverfish infestation, we extended the trial to this house. Pre-counts of this treatment were the last two assessments of the previous trial section. House 4 showed similar control levels as house 1-3: From an average of 25.5 insects before the treatment, we visually detected 6 *C. longicaudata* after 7 days and 1 insect after 21 days. From then on until the end of trial at 63 days, no insects were found, resulting again in 100% reduction (Figure 5b). When using the pit fall trap assessment method, insect numbers were reduced from 18.5 insects before the treatment, to 7, 3, 3 and 1 insects after 7 days, 21, 49 and 63 days respectively (Figure 6b). The corresponded to a 95% reduction from pre-counts at the end of the trial.

The combined population reduction of houses 1-3 and house 4 averaged 100% in using the visual count method. When applying the pit fall trap method an average of 94.2% reduction was achieved. We believe that the different reduction values between readout methods is caused by the fact that the visual assessment was performed in areas where disturbance to *C. longicaudata* was kept to a minimum. These locations with low disturbance may not be the locations with the highest population densities.

CONCLUSION

Maxforce® Platin, a commercial cockroach bait containing 1% Clothianidin was applied using a dose rate of 0.1 to 0.2 g product per m2 treated area. This treatment has successfully reduced the populations of *C. longicaudata* in four houses in the Netherlands. Based on these results a European label extension of Maxforce Platin to the long-tailed silverfish was achieved. Within the 63 day test period 100% reduction was achieved in the number of silverfish observed during the inspections in all four treated houses compared to the average number of silverfish observed during the counts made before the treatment. When using traps as monitoring device, 90%, 93%, 100% and 95% reduction was achieved in the number of *C. longicaudata* compared to the average number of *C. longicaudata* caught in the traps during the counts made before the treatment. This scientific evidence was confirmed by the residents of the treated properties who regularly observed *C. longicaudata* roaming around their houses before treatment whereas by the end of the test period, silverfish were no longer seen.

Successful silverfish control using baits however relies on a few pre-requisites that are important to mention at this stage. Due to the particularities of the silverfish's behaviour, we propose that a bait treatment should be associated with the following instructions: a) Very thorough inspections should be carried out to locate all areas where the Grey silverfish may be hiding. Placement of bait should be implemented as described above and focused to areas where treatment can be carried out safely; b) In areas where target insects have been found and treatment is not possible, a sanitation process should be performed to physically remove as many insects as possible. Furthermore, this sanitation will remove clutter to limit future hiding places. Residents could also be advised to clean regularly under surfaces (like under rugs or vases) where insects have been found and bait cannot be applied. Then bait placement should be carried out as close as possible to these cleaned areas; c) We also believe that the pest control operator should consider a repeat treatment although initial eradication may have been achieved. It is possible that a proportion of the *C. longicaudata* population is hiding in places that are not reachable for treatment or for other measures such as cleaning. These locations may be wall cavities, in floor or roof insulation, behind kitchen units etc. These insect populations could remain in these locations for months and will therefore not come in contact with bait until they migrate searching for new harbourages or driven out by climatic changes between summer and winter. Based on our experience this inspection interval could be 6 months.

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