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ELIMINATION OF PHARAOH'S ANT, *MONOMORIUM PHARAONIS* COLONIES WITH S-METHOPRENE BAITS (HYMENOPTERA: FORMICIDAE)

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Abstract The Pharaoh's ant, *Monomorium pharaonis* (L.) is an important species in the urban environment. This paper discussed the performance of a new bait formulation containing S-methoprene. Discussions are made on various laboratory experiments (in Budapest, Hungary and Penang, Malaysia) and field trials in the Netherlands and Hungary, particularly on the effects of S-methoprene, the acceptance of different bait matrices, the development of the bait station, as well as systematic approach on managing Pharaoh's ant infestation. S-methoprene in two matrices caused a major disruption in the development of ant nests, and also affecting the reproductive capability of queen ants. Field trials demonstrated that 80-90% decrease in ant population after 4-5 weeks, colony elimination of the Pharaoh's ant occurred after 13-15 weeks.
Key Words *Monomorium pharaonis*, colony, queen, bait, S-methoprene, monitoring

INTRODUCTION

The Pharaoh's ant (*Monomorium pharaonis*) has become an important pest ant species in many parts of the world (Lee and Robinson, 2001). In Europe and Hungary in particular, the Pharaoh's ant infestation has increased over the last several years. This species has adapted to live in the urban environment, and has been reported to serve as mechanical vector for pathogenic microorganisms, including *Streptococcus* and *Staphylococcus* sp. (Lee, 2002). Its ability to produce numerous queens within a short period of time, as well as the ability to bud to establish new colonies is remarkable and have made it a very successful pest species. The life-cycle from egg to adult of this species is about 45 days, adult worker ant lives for 60-90 days (Peacock et al., 1955). Colony size of a Pharaoh's ant may vary in size from the few dozen to hundreds of thousands of ants (Eow et al., 2004). The visible part of a nest is the foraging ants that represent about 10 % of the total colony (Adams et al., 1999). Their main food source is proteinaceous material, but they may consume other foods, depending on the state of the colony.

The common approach to controlling this ant species is with insecticide sprays. However, this method is not suitable because the possibility of colony budding, especially with the use of pyrethroid insecticides (Lee et al., 1999). Sprays only target foraging ants, and others survive and colony management is difficult. The target of the control measures must be the colony and the nest itself. The colony's most important members are the queens. They are responsible for reproduction and the life of a colony is dependent and organized around them. The main function of a nest is to serve the queen and defend the eggs and brood. Unfertile queens and brood inhibit development, leave the workers and the foraging ants jobless, and cause the gradual decline of the nest. When this stage is achieved the use of insecticide spraying is effective for eradication of the foraging ants.

Baiting is probably the best control strategy for Pharaoh's ant (Vail et al., 1996; Lee, 2000; Lee, 2002; Lee and Lee, 2002; Lee et al., 2003). Toxicants from many insecticide groups have been used in bait formulations. The first application of an insect growth regulator for ant control was Pharorid (Zoecon Corporation, USA), which contained 4.9 % methoprene and was used as a bait additive. The end-user had to prepare the bait themselves, leaving palatability and stability an open question. In Hungary in 1982 a granulated methoprene formulation (VIODAT 10 PA) was developed with honey and liver additives.

Reported here are the result of laboratory and field trials of the efficacy of an ant bait containing S-methoprene (Henrick et al. 1973) to control Pharaoh's ant.

MATERIALS AND METHODS

Insecticide and Application

Bait stations used were 1) blank T-matrix granules; 2) M-matrix granules, 0.3 % S-methoprene; 3) T-matrix granules, 0.3 % S-methoprene; 4) M-matrix, 0.5% S-methoprene plus T-matrix, 0.5% S-methoprene in one station.

For field evaluation, bait stations were placed vertically and the level of granular bait in the transparent plastic station were marked prior to baiting. After baiting, the remaining amount was marked again and the amount difference was calculated and converted to percentage consumption.

Laboratory evaluation (Malaysia). Healthy colonies of *Monomorium pharaonis* were used. They were subcolonies isolated from several main cultures. Each colony consisted of 300-500 workers, 3-7 queens and 0.3 g of brood, which was estimated to be about 360 brood. The insects were starved for 24 h before experiments. T- or M-bait matrix containing 0.3% S-methoprene was introduced along with colony which was provided with food and water ad libitum in the test arena. T- and M-matrix are dried granules with an average particle size of 0.6-1.0 mm, and are based on sweetened proteinaceous food. At day 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77, 84, 91, 98 and 105 the number of remaining queens, adult workers, and brood were estimated or counted. There were 4 replicates for each bait formulation. Controls were not provided with a bait. Normal food, which was cockroach nymphs, tuna fish, egg yolk and sugar water, was provided throughout the experiment. Bait consumption for each replicate was measured at the end of the experiment, after correcting the moisture gain in each formulation.

Field Evaluations (the Netherlands). In January 2004, 0.3 % S-methoprene in the M-matrix (LO 312, or Biopren BMS) was evaluated in infested urban locations, with permission from College voor de Toelating van Bestrijdingsmiddelen. Three locations were tested: Pretorius, Mercator and Wolff. Pretorius consisted of 2 houses which were treated curatively and two treated preventively; 5 - 7 bait boxes were placed in each house and a couple of stations to the surrounding habitations. Mercator consisted of 22 apartment units. Baiting started February 9, 2003. Eleven units were curatively treated, the remaining were treated preventively. Wolff consisted of 14 residential units. The bait stations were placed on March 10, 2004.

An index of 6 degrees of infestation was used to estimate the Pharaoh's ant infestation rate: 0 = ants cannot be observed in the room; 1 = ants are observed shortly before controls are applied; 2 = a few wandering ants are observed; 3 = a small number of workers are visible, but foraging routes are not visible; 4 = several foraging worker ants are visible, tens of ant workers along foraging routes; 5 = many foraging workers are visible, many workers along two or more foraging routes.

Laboratory evaluation (Hungary). Between May-August 2004, bait stations containing T-, M- and T-plus M-matrix were evaluated at Babolna Bioenvironmental Center. Four queens, approximately 300 workers and different staged brood was placed in 10 x 5 x 5 cm hollow elm wood nests. The ants were acclimatized for 7 days. Sugar, fresh cockroach carcasses, finely-ground dried dog food and water was supplied. Following acclimatization, the different matrixes were placed into the test arena.

Field evaluation (Hungary). In November 2004, field trial was conducted in Northern Budapest's 4th district in a 10-storey-twin-staircased building. A total of 47 tenants participated in the trial, and received a detailed questionnaire together with a short description on the aims and duration of the trials. In apartment block #1, 28 tenants participated; in block #2 there were 14 tenants. The infestation rate in the second staircase on block 2 was low and this may explain why tenants where less interested in participating in the trial. An index of 3 degrees of infestation was used to estimate the Pharaoh's ant infestation rate: 0 = Free of infestation, ants cannot be observed; 1 = Weak infestation, ants are observed rarely; 2 = Semi-infestation, ants observed by the tens, and visible during treatment; 3 = Strong infestation, many foraging ants observed, even around foodstuffs.

Trials began with the placement of blank, monitoring baiting stations. These stations were left for 7 days. Results of the monitoring gave an indication of the most infested area and in some cases it was possible to assume the location of nest. Treatment began by placing 8 bait stations: 4 with T-matrix and 4 stations with M-matrix in pairs next to each other in each flat. The most infested premises were defined by the questionnaires filled by tenants, and of the monitoring results.

RESULTS AND DISCUSSION

Laboratory Evaluations

Malaysia. Visual examination of digital photographs taken over the 15-week experimental period showed a drastic reduction in ant numbers in colonies treated with bait formulations. Results indicated that both 0.3 % S-methoprene bait formulations (M-matrix and T-matrix) performed adequately against laboratory colonies of the Pharaoh's ant over a 15-week post-treatment period (Figures 1-3). A gradual reduction of worker numbers in treated colonies was recorded after 4 weeks post-treatment. Significant difference ($P < 0.05$) in worker numbers treated with T-matrix bait formulation when compared to that of the control colonies was registered (Figure 2). Both bait matrices suppressed the production of queens, when compared to that in untreated colonies (Figure 1). Colonies treated with T-matrix bait formulation showed a significant reduction ($P < 0.05$) than those in control (Figure 2). The queen numbers were still higher than those at the initiation of the experiment at the end of 15 weeks. Bait effects on the brood were generally significant for both formulations, especially after 4 weeks post-treatment (Figure 3). Both formulations nearly achieved brood elimination after 6 weeks post-treatment; however due to the surviving queens in the colony, brood continued to be produced, but at a very low rate. Methoprene in these bait formulations may have only partially suppress brood production in queen. T-matrix bait formulation showed a greater effect on the tested colonies than M-matrix bait formulation.

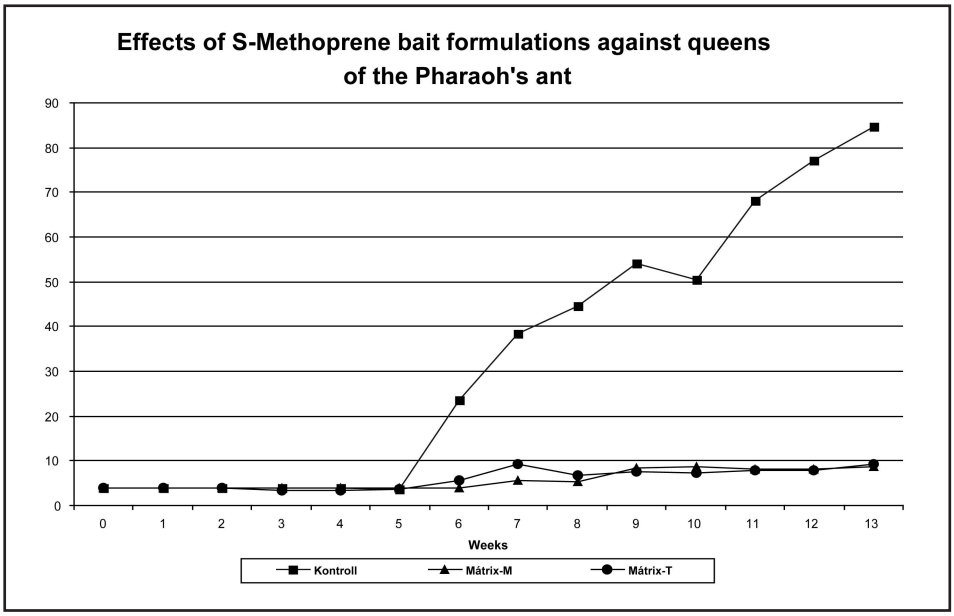


Figure 1. Effects of S-methoprene baits against queens of the Pharaoh's ant.

The bait consumption recorded in this study was low. This may be due to the presence of normal food in the test arena. M-matrix was significantly ($P < 0.05$) preferred by the ants, when compared to the T-matrix. Baits were explored initially for the first few days, since holes in the bait indicated that ants walked through them. No bait was found to be brought back to the nesting dish of each replicate. When the worker ants died, the dead bodies accumulated around the bait dish.

In colonies treated with T-matrix bait formulation unusually large workers occurred (Figure 4). These individuals, referred to here as super workers, were smaller than normal queen, but larger than the normal worker.

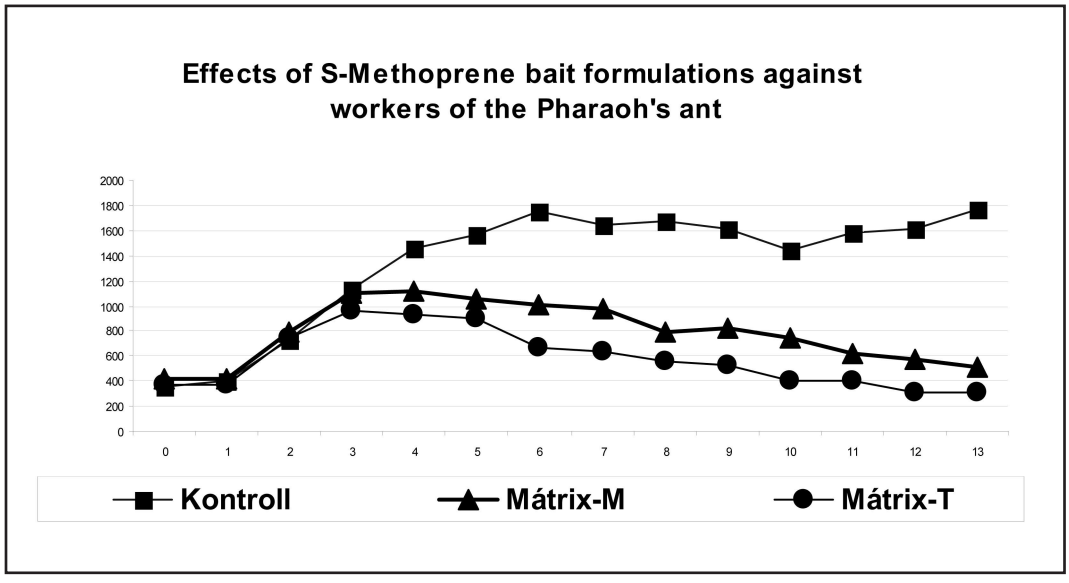


Figure 2. Effects of S-methoprene baits against workers of the Pharaoh's ant.

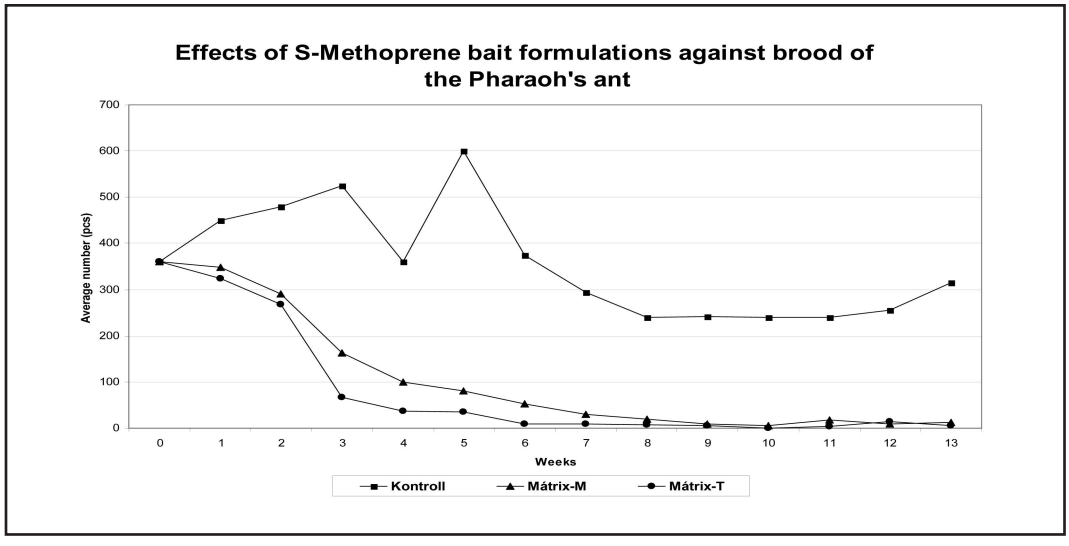


Figure 3. Effects of S-methoprene baits against brood of the Pharaohs' ant.

Field evaluation (Netherlands). Pretorius. In the beginning, infestation has increased due to the strong attraction of the bait. During inspections, bait stations were replaced with the new ones. By the end of March, infestation level has decreased considerably and by early June, no more ants were visible on the site.

Mercator. In spite that tenants have not observed ants at the preventively treated sites, consumption occurred from the baiting stations. On March 31, 2003 no foraging ants were visible in the preventive area, but the curative areas were still infested. On April 7, 2003, the pest was found to be only concentrated at a few curatively treated apartments. On May 12, 2003, there was just one apartment with a few visible foraging ants and finally end of June, all the ants in the Mercator site were no longer visible.

Wolff. All ants were eliminated within a week after treatment. Bait consumption rates varied, and in certain areas at a fairly low rate. However, the bait still proved to be able to solve the ant problem in the tested sites within 12 weeks. The length of treatment depended on the rate of infestation.

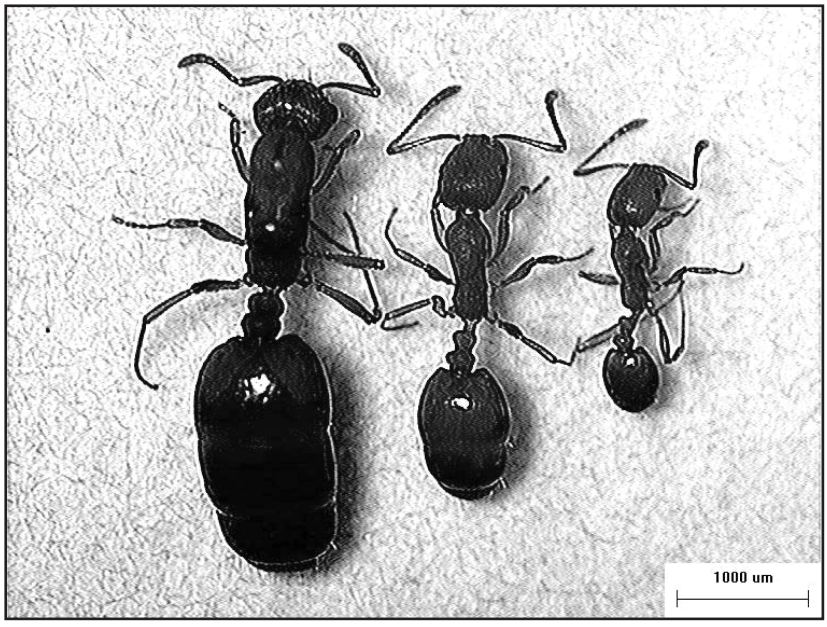


Figure 4. Comparison of the Pharaoh's ant body size; from left to right: queen, super worker and normal worker.

Laboratory evaluation (Hungary). Results indicated that queen number started to decrease after 5 -7 weeks post-treatment (Figure 5). By week 8, queens began to leave their nests and wondered around, and by week 12 all queens had died. In the control arena, queen number increased from 4 to10 by the end of the experiment. Worker numbers decreased after 5 weeks post-treatment, and all workers were eliminated after 15 weeks (Figure 6). The number of workers in the control arena doubled during the experimental period.

Brood stages started to decrease in number at the beginning of week 3 post-treatment (Figure 7). By week 8 post-treatment, there were no more brood left in the test arena. The number of brood in the control arena increased by 50 %. During the experiment there was a gradual disruption in normal colony activity such as decrease in worker foraging activity, and queens that were out foraging. Workers and queens were evidently affected by the effects from S-methoprene.

Field evaluation (Hungary). Table 1 and 2 show the decline in infestation levels in apartment blocks #1 and #2 during the treatment period. In apartment block # 1, higher infestation were found in the higher floors, which may be related to the central heating where higher floors were often much warmer. Apartment block # 2 had a lower infestation and the control of the Pharaoh's ant in this block demonstrated a similar trend as that of the the former one. Until week 11, M-matrix was the preferred bait, but subsequently, T-matrix became the choice of the ants. This could be due to the changes in ant feeding preference (Eow et al., 2005). The parallel use of both M- and T-matrix in a baiting program overcome problems associated with seasonal food preference. By week 13, the infestation has dropped considerably and it was then assumed that complete elimination of the ant infestation will happen after another several weeks.

SUMMARY AND CONCLUSION

Pharaoh ant infestations may be effectively treated by a sequence of 1) pre-treatment monitoring with blank bait stations to determine infestation level and locate possible nesting sites; 2) use of 0.5% S-methoprene either separately or in dual or twin bait stations; 3) replenish the bait whenever required. Post-treatment monitoring with blank bait stations will detect new infestations before colonies become established.

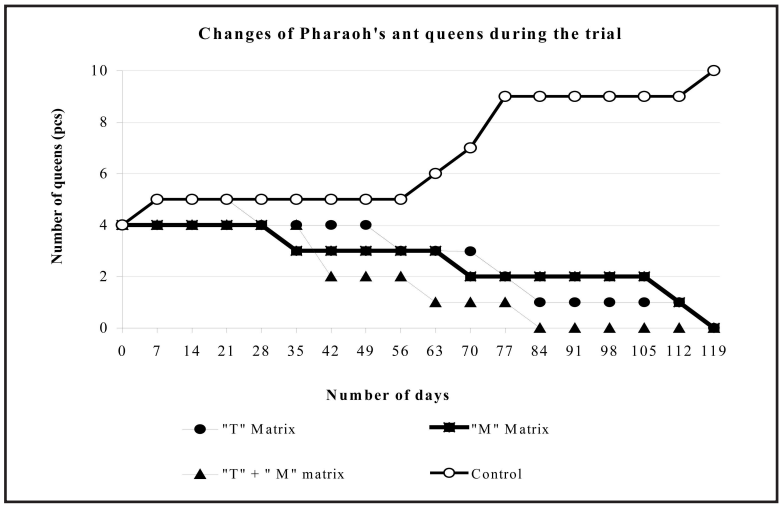


Figure 5. Changes in the Pharaoh's ant queen number after subjected to treated with S-methoprene bait.

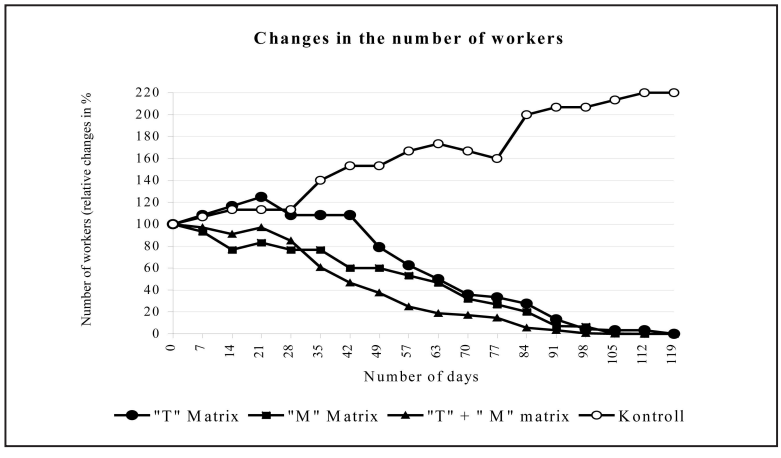


Figure 6. Changes in the Pharaoh's ant worker number after subjected to treatment with S-methoprene baits

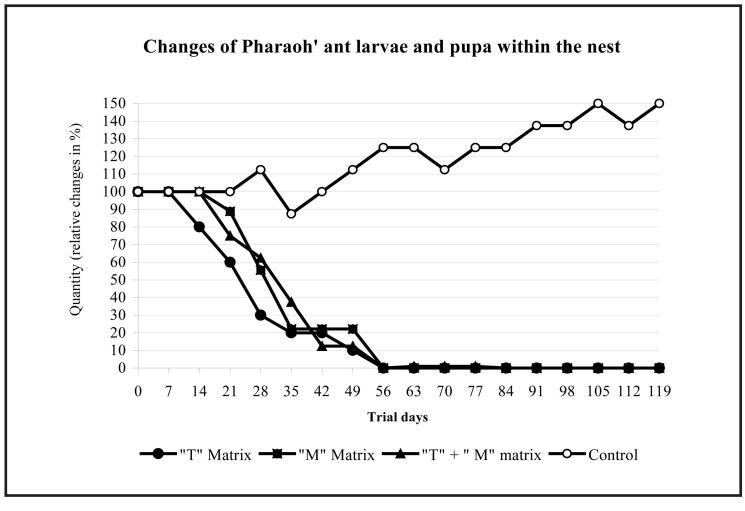


Figure 7. Changes in the Pharaoh's ant brood number after subjected to treatment with S-methoprene baits.

Table 1. Infestation level of Pharaoh's ant in apartment block # 1.

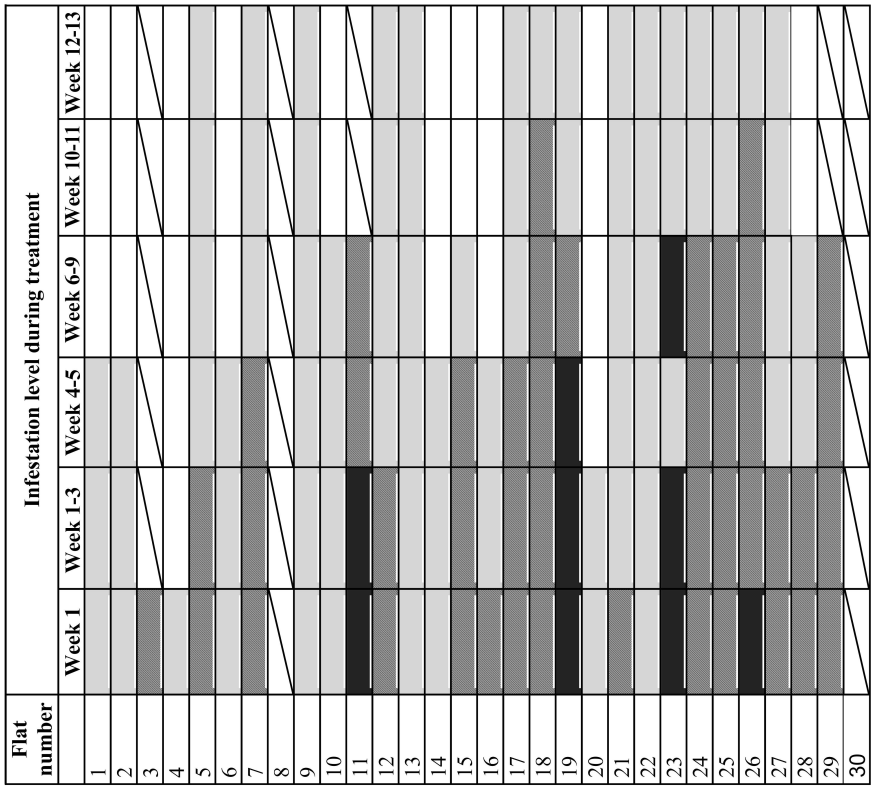
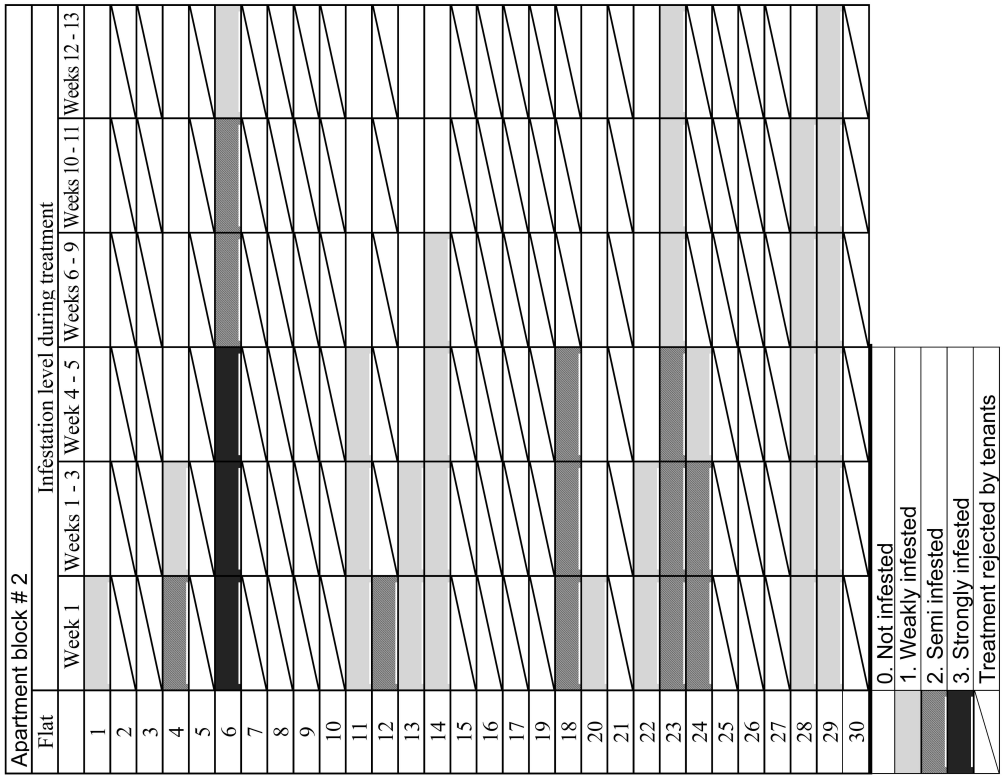


Table 2. Infestation level of the Pharaoh's ant in apartment block # 2.



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