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Research Article

Comparisons between different fire ants control methods in urban environments

Elisa Furtado Fernandes[1], Helba H Santos-Prezoto[1], Raquel Mendonça[1], Mariana Monteiro de Castro[2], Odair Correia Bueno[3] and Fábio Prezoto[1]*

[1]Laboratório de Ecologia Comportamental e Bioacústica (Labec), Departamento de Zoologia, Universidade Federal de Juiz de Fora, MG. Rua José Lourenço Kelmer, s/n, São Pedro, Juiz de Fora, MG 36036-900, Brazil

[2]Faculdade Pitágoras, Avenida Barão do Rio Branco, 2572, Juiz de Fora, MG 36016-311, Brazil

[3]Instituto de Biociências, Centro de Estudos de Insetos Sociais, Universidade Estadual Paulista (UNESP), Avenida 24-A, 1515, Rio Claro, SP 13506-900, Brazil

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***Corresponding author:** Fábio Prezoto, Laboratório de Ecologia Comportamental e Bioacústica (Labec), Departamento de Zoologia, Universidade Federal de Juiz de Fora, MG. Rua José Lourenço Kelmer, s/n, São Pedro, Juiz de Fora, MG 36036-900, Brazil,
E-mail: fabio.prezoto@ufjf.edu.br

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Abstract

Many homemade methods are recommended for the control of fire ants, but the choice of a control method for this ants in the urban environment is necessary in view of the damage they have caused to the environment and human health. Thus, the objective of this work was to compare the efficiency of chemical (liquid insecticide and granular insecticide) and homemade (hot water and detergent water) methods used to control these ants in urban gardens. The study was conducted in the city of Juiz de Fora, MG, Brazil. The treatments were applied only once on *Solenopsis saevissima* colonies: (T1) Hot water, (T2) Water with detergente, (T3) Liquid insecticide and (T4) Granular inseticide. To determine the amount of applied product in T1, T2 and T3 treatments, colonies were selected by linear size and for treatment T4, colonies were classified by volume. the colonies were monitored monthly for four consecutive months (July to October) to evaluate the effectiveness of the control method employed. The treatments presented distinct performances in fire ants control in urban area, being the liquid insecticide the most efficient in eliminating the colonies. With this study we were able to evaluate the impacts caused by each treatment, as well as the pros and cons of using each one of them, and finally, we suggest an efficient fire ants control method with lower cost per colony and less impact on the environment.

Introduction

Ants of the *Solenopis* Westwood, 1840 genus, better known as fire ants, are considered one of the main invasive species in the world, standing out as pests in urban and agricultural environments where they cause serious public health issues, mainly due to accidents with humans. They are also excellent competitors, predators of invertebrates, small vertebrates and even other ant species [1-5]. Given the success of these ants in occupying environments altered by human activity [6-8], several practices have been employed for their control, such as the use of chemicals, baits and biological control [9,10]. However, when analyzing the cost, efficiency, practicality of application and environmental impact, it is observed that there is no consensus on a method, on the contrary, the most varied recommendations for fire ants control multiply by literature and internet.

As with most insects, fire ants control also depends on the application of chemical insecticides [11-13]. Although this method temporarily reduces ants in infested regions, it does not prevent recolonization, as well as being harmful to the environment and humans, causing death or physiological and behavioral damage to non-target insects [14-17].

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Generally, these products promote colony fragmentation and, consequently, increases ant infestations [12,18,19].

Another method employed is the use of toxic attractive baits, usually successful in urban áreas [20] and already reported for fire control [10,21-23]. These baits, usually granular, are carried into the nests by the ants and act at various stages of life, which can cause queen ovary retrogression, reduction in hatching rate, deformities, as well as the death of individuals [13,24-26].

Homemade methods are also indicated to eliminate ants in residences and gardens. Among these methods, the use of hot water and detergent water stands out. Other options like essential oils and vinegar, which repel ants due to their strong odor; Vaseline and calcium carbonate, which create a physical barrier to ant circulation, are also reported, but these methods do not eliminate colonies, which makes their practice inefficient. In the United States, for example, the use of rice grains, corn and soft drinks to eliminate ants are popular, as well as other extremely environmentally dangerous products such as gasoline and diesel [27-31].

Thus, the objective of this work was to compare the use of chemical and homemade methods in the control of fire ants in field experiments, seeking the treatment that presents the lowest risk of contamination to the environment, lower cost per colony and the best control efficacy.

Material and methods

Study area and period

The study was conducted in the city of Juiz de Fora, Minas Gerais, Southeastern Brazil (21° 41'20 '' S 43° 20'40 '' N, 800 m asl), from July to October, 2015. Control of the *Solenopsis saevissima* (Smith, 1855) colonies were carried out in July, which corresponds to the peak of the cold and dry season, the period with the lowest rainfall, being therefore suitable for the experiment to reduce the leaching of the tested products. The species *S. saevissima* was chosen because it is abundant in the study area [8].

Data collection

S. saevissima colonies (n = 95) were previously selected for their size and divided into 4 groups with different single dose treatments:

T1: Hot water: Water was applied over the nests at a temperature of approximately 100 °C (n = 25).

T2: Water with detergent: The neutral detergent was diluted with water at a concentration of 200mL / L and then applied over the nests (n = 23).

T3: Liquid insecticide: The insecticide (K-othrine®) after being diluted with water, 8mL / L (following manufacturer's recommendation) was applied over the nests (n = 23).

T4: Granular insecticide: The bait was deposited on the perimeter of the colony. Each bait measurement corresponds to 30mL. The experimental bait was provided by Dr. Odair Correia Bueno, from the Centro de Estudos de Insetos Sociais (CEIS), Universidade Estadual Paulista – Câmpus Rio Claro, (n = 24).

To determine the amount of applied product in T1, T2 and T3 treatments, colonies were selected by linear size and subsequently classified into small (less than 55cm), medium (56-100cm) and large (bigger than 100cm) (Table 1). For treatment T4, colonies were classified by volume (Table 1), calculated by the ellipsoid formula [6,8,32].

Table 1: Quantity of product applied per treatment (T1, T2, T3, T4) in relation to the size (cm) and volume (m3) of *S. saevissima* murundum, in Juiz de Fora, 2015.

Length of Colonies (cm)	Water Volume (L)	Colony Volume (m3)	Bait Measurement (g)
T1, T2, T3		T4	
Less than 55	2,5	Less than 0,003	30
56-100	4	0,004-0,014	60
Bigger then 101	5	Bigger then 0,015	90

Subsequently, colonies were monitored monthly for four consecutive months (July to October) to evaluate the effectiveness of the control method employed. The activity of the colonies was evaluated using sardines and honey baits, placed separately in 4mL tubes and buried approximately 0.5m from the colony and kept for 24h. Colonies in which baits did not present fire ants after 24h were considered inactive and consequently controlled.

Data analysis

Normal distribution of data was confirmed by the Shapiro-Wilk test. To verify the difference between the applied treatments, the analysis of variance (ANOVA) was used. All analyzes were performed at 5% significance level in the R software (R Development Core Team, 2017 - version 3.4.3).

Results

Control efficacy differed significantly between the four treatments tested ($p = 0.0005$, $F = 16.81$). Liquid insecticide (T3) controlled the largest number of colonies at the end of the experiment (91.3%), followed by hot water (60%), granular insecticide (39.75%) and detergent water (30.44%). (Figure 1).

Regarding the efficacy of treatments during the four months of monitoring, Liquid Insecticide (T3) eliminated the largest amount of colonies immediately after its application, leaving only 2 active colonies at the end of the experiment. Water with detergent (T2), after the first monitoring, eliminated 11 of the 23 colonies treated, but at the end of the experiment, 16 colonies remained active. Treatment 4 (Granular Bait) presented a different response for each month monitored, with previously controlled colonies returning to activity. Thus, at the end of 4 months, of the 25 colonies treated, only 10 were eliminated. Hot water (T1) was the treatment that eliminated the smallest number of colonies soon after its application. Of the 25 colonies treated, only 4 were eliminated. However, at the end of the experiment, this treatment eliminated 15 colonies (Figure 2).

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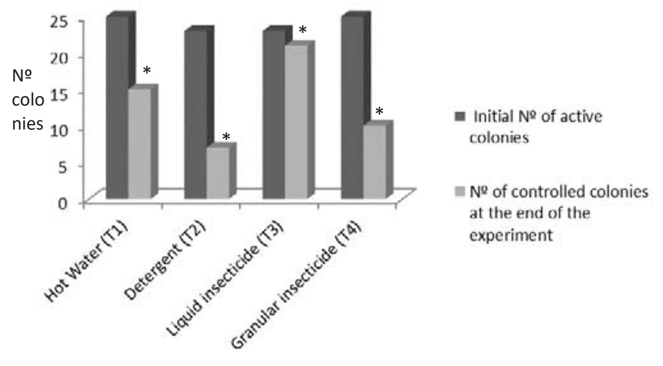

Figure 1: Number of *Solenopsis saevissima* colonies controlled at the end of the experiment, subjected to Hot Water (T1), Detergent (T2), Liquid Insecticide (T3), Granular Insecticide (T4) treatments, in Juiz de Fora, Brazil, 2015. The bars with The symbol * indicates that a significant difference occurred between the colonies at the end of the experiment.

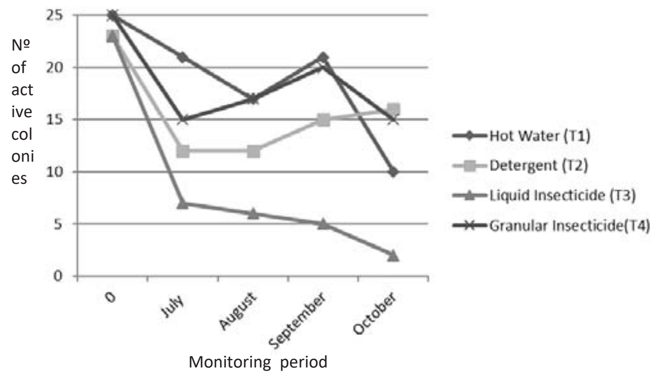

Figure 2: Number of active colonies of *Solenopsis saevissima* over 4 months in Juiz de Fora, Brazil, 2015. Note: "0" (zero) corresponds to the time of treatment application (T1, T2, T3 and T4) .

Discussion

In this study, Liquid Insecticide (T3) was the treatment that proved to be the most efficient in eliminating fire ants colonies, however, it presents high toxicity to the environment.

Liquid insecticides, widely used in urban pest management, in addition to being effective in controlling, must have mechanisms of action that prevent the selection of resistant pest populations, and also a pre-determined residual period preventing it from being exposed to the environment for a long time consequently contaminating the soil, water and neighboring animals [33,34]. In addition, due to risks during handling and product toxicity, Personal Protective Equipment (PPE) such as gloves, spray and masks are required.

Hot water is an effective method for eliminating fire ants colonies, as the internal structure of their nests, with channels and connecting chambers, facilitate the rapid penetration of water inside, and the small size of these ants causes them to heat up and die quickly even in a brief contact with the hot water. In our study, hot water was less efficient in the short term, but in the long term eliminated 60% of treated colonies. Tschinkel and King JR [7], with the use of hot water, managed to eliminate 70% of fire ants colonies in two years of study. This methodology has also been successfully used by Tschinkel and Howard [35] and Adams and Tschinkel [36].

Handling hot water requires caution, as well as the use of personal protective equipment such as gloves and boots because at 100ºC water can cause severe burns. Water with detergent presents low risk of handling, but care should be taken that the detergent does not come into contact with mucous membranes. In the application of granular insecticide, the risk of handling is moderate, requiring the use of gloves not to contaminate the skin.

Water with detergent is a commonly recommended method for eliminating ants in homes and gardens, being applied directly to the colony or sprayed on the ant trail [31]. Its good performance is due to easy application and handling, low cost per colony and little impact on vegetation.

Granular insecticide showed a relatively low efficacy compared to other methods employed in this work, eliminating approximately 39% of fire ants colonies. This low efficacy may be related to the fact that fire workers cannot ingest solid particles above 0.9μm. Only the 4th larval instar is able to digest solid food, and then shares it with the other colony individuals [37,38]. In addition, some authors claim that granular insecticide takes longer to make effect when in the environment, such as Aubuchon, et al. [14], who conducted field and laboratory experiments with baits containing mainly Metoprene and found that the number of colonies was significantly lower after 16 weeks of application, which corresponded to an efficiency of 95% of the product. Adams, et al. [39,40] and Callcott and Collins [41], found a higher mortality of fire ants colonies between 12 and 13 weeks after the use of baits. Fast efficiency baits are more prone to reinfestation by fire ants than those that provide slower initial control, and therefore generally the use of these baits requires multiple applications [42,43].

The results of this study allow us to conclude that the efficiency of a control method is not only based on the amount of colonies that can be eliminated, other criteria such as dangerousness, risk of manipulation and impact on vegetation should also be taken into consideration because applying a product can have short-term and long-term consequences for both the environment and the locals.

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