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Source: Florida Entomologist, 97(2) : 668-673

Published By: Florida Entomological Society

URL: <https://doi.org/10.1653/024.097.0246>

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NESTING OF THE FIRE ANT *SOLENOPSIS SAEVISSIMA* (HYMENOPTERA: FORMICIDAE) IN AN URBAN ENVIRONMENT

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ABSTRACT

Ants of the genus *Solenopsis* are common in urban environments due to their abilities to explore resources and to establish nesting sites, which helps their proliferation and also increases the occurrence of encounters with people and severe stinging. We aimed to increase understanding of this species in urban areas, so this study attempted to answer these questions: Are certain seasons more amenable to the founding of new colonies? Does colony size vary among seasons? What sites are used by these colonies in an urban environment? Observations were carried out every 2 weeks from May 2011 to Apr 2012 in Juiz de Fora, Minas Gerais, southeastern Brazil. For each active colony the site and the dimensions of the nest were registered. We showed that colonies of *Solenopsis saevissima* (Smith, 1855) were present in urban areas during the entire yr, with the highest incidence in the wet season, and nesting sites were associated mainly with vegetation. Because the dry season (Apr–Aug) was the period that had the smallest number of active colonies, this period could be considered the most favorable for area-wide control operations, but an individual mound treatment approach in the dry season should be take into consideration the occurrence of cryptic mounds.

Key Words: colonies, nesting sites, urban pest, climatic variables

RESUMO

Formigas do gênero *Solenopsis* são comuns em ambientes urbanos devido à sua capacidade de explorar recursos e estabelecer locais de nidificação, o que ajuda na sua proliferação e também aumenta a ocorrência de encontros com pessoas e dolorosas ferroadas. Nosso objetivo foi contribuir para maior conhecimento desta espécie em áreas urbanas e tentamos responder às seguintes perguntas: Existe uma época mais propícia para a fundação de novas colônias? O tamanho da colônia varia entre as estações? Quais os locais de nidificação utilizados por estas colônias em ambiente urbano? Observações foram realizadas quinzenalmente de maio de 2011 a abril de 2012, em Juiz de Fora, Sudeste do Brasil. Para cada colônia ativa foram registrados o tipo de local de nidificação e as dimensões do ninho. O estudo demonstrou que as colônias de *Solenopsis saevissima* (Smith, 1855) estavam presentes em áreas urbanas durante todo o ano, com maior incidência na estação chuvosa, e os locais de nidificação estavam principalmente associados à vegetação. Como a estação seca (abril-agosto) foi o período que teve o menor número de colônias ativas, este período pode ser considerado o mais favorável para as operações de controle em toda a área, mas uma abordagem de tratamento dos montes nessa estação deve ser levada em consideração pela ocorrência de montes crípticos.

Palavras Chave: colônias, locais de nidificação, praga urbana, variáveis climáticas

The genus *Solenopsis* Westwood, 1840 is frequently reported in urban areas (Ulloa-Chacon 2003; Pacheco & Vasconcelos 2007; Drees et al. 2012) and has a pest status because fire ant species have a high ability to exploit resources and find nesting sites, resulting in their proliferation. These ants are omnivores, and are attracted to many kinds of food including oily substances;

they recruit a great number of workers when they find food and generally build their nests in open areas, each characterized by a mound of loose soil (Lofgren et al. 1975; Bueno & Campos-Farinha 1999).

Mounds are built in the open areas with a system of interconnected passages (Hölldobler & Wilson 1990; Penick & Tschinkel 2008). The nest size

can vary and the colony's growth is rapid. Laboratory and field studies suggest that colony growth rates are strongly food-limited. In the field, the colonies grow to sizes of about 200,000 workers in 5 to 6 yr (Tschinkel 1988). However, queens can produce up to 500,000 workers in their first year of life (Tschinkel & Porter 1988).

Solenopsis saevissima (Smith, 1855) and *Solenopsis invicta* Buren, 1972 are important to public health because of the severe injury they inflict when many of them severely sting a person (Dress et al. 2012). The effects may range from a localized burn to full allergic reactions. These ants can act as mechanical vectors of pathogenic microorganisms, as well introduce infectious agents through their stings (Funasa 2001; Pinto et al. 2007). *Solenopsis saevissima* is responsible for more than 35% of reported stinging encounters with insects, mostly in urban areas (Fox et al. 2012; Chadee & Maitre 1990). Annual expenses in the USA for fire ant control are estimated to be over US\$ 2.5 billion, and approximately 50% of people living in infested areas are stung at least once per year (Della-Lucia 2003). In Brazil, fire ant attacks on infants in the State of Rio Grande do Sul, on children in the State of Paraná, and on people and damage to crops in the Amazon region have been reported (Chadee & Maitre 1990; Brasil 1993; Oliveira & Campos-Farinha 2005; LBA 2005).

In order to contribute to increased understanding of this species in urban areas, this study attempted to answer the following questions: Are certain seasons more amenable to the founding of new colonies? Does colony size vary among seasons? What sites are used by these colonies in an urban environment?

MATERIALS AND METHODS

This study was conducted at the campus of the Federal University of Juiz de Fora, Minas Gerais, Brazil (S 21° 4' 20" W 43° 20' 40"; 800 m asl), which has a total area of 134.68 ha. The climate is tropical of altitude, type Cwa, according to Köppen's classification (1970), with a dry, cooler season from Apr to Aug and a wet, warmer season from Sep to Mar. Twenty-four surveys were made by two-person teams between 8:00 am and 4:00 pm, at 15-day intervals during one yr, from May 2011 to May 2012.

Surveys consisted of the search for *S. saevissima* active colonies in alleys, gardens, and areas adjacent to the buildings around the campus. The first sampling was considered a preliminary test and the data on the number of new nests found were not used in the analysis. New colonies were those registered at a new location, without considering if they were expansions of other colonies or if they were movements from other colonies.

Daily mean air temperature, relative humidity and rainfall were obtained from the Laboratory of Climatology and Environmental Analysis, EMA/INMET, UFJF, from May 2011 to May 2012. These data were used to calculate the average values of each 15-day period of the survey.

Nest size (length, width and height of the external mound) and location of nest founding sites were obtained. Each nest was labeled with an individual code and specimens were collected from each nest, placed in 70% alcohol and saved for identification by taxonomic keys (Fernández 2003). Identification confirmation was obtained from Dr. Jacques Hubert Charles Delabie, and vouchers were deposited in the CPDC collection (#5700) (CEPEC-CEPLAC, Laboratório de Mirmeccologia).

Nesting sites were classified in 4 categories: grass, mixed vegetation + artificial (side walk border in contact with grass, cement slabs covered with grass, etc.), natural sites (near trunks of palm trees, cut and fallen logs, etc.) and artificial nesting sites (side walk border, sidewalks, cement). The number of nesting sites in each category was compared between wet and dry seasons by a chi squared test.

The chi-squared test was used to compare the numbers of colonies registered for the first time (considered new colonies) in the wet and the dry seasons as well as the total number of colonies found during the study period. The Mann Whitney U-test was used to compare the average number of colonies per survey between seasons and to compare the length, width, height and volume of new nests and total number of nests between seasons. Possible correlations with average temperature, relative humidity, rainfall and the number of colonies and the total number of colonies in the wet and dry season were analyzed using the Spearman's correlation coefficient.

The area and volume of new colonies and of the total colonies surveyed were calculated by the ellipsoid formula (Tschinkel 1993; Macom & Porter 1996; Almeida et al. 2007).

$$A = \pi \frac{\text{length}}{2} \frac{\text{width}}{2}, \text{ where } A = \text{area}$$

$$V = \frac{2}{3} \pi \frac{\text{length}}{2} \frac{\text{width}}{2} \text{ height, where } V = \text{volume}$$

The tests were performed using the freeware academic Statistical Program Bioestat 5.0, at 5% level of significance.

RESULTS

The results showed that colonies of *S. saevissima* were present in urban areas throughout the yr. A total of 585 nest measurements were made during the yr.

In the wet season we found a greater total number of active mounds ($n = 388$) than in the dry season ($n = 197$) ($\chi^2 = 62.36$, $P < 0.0001$) (Fig. 1), as also occurred when considering only the new colonies in the wet ($n = 111$) and dry season ($n = 43$) ($\chi^2 = 30.03$, $P < 0.0001$). When considering the average number of mounds per survey, there was no difference between seasons ($U = 1.3467$, $P = 0.089$).

New active mounds were registered in almost all months, except Aug 2011, 1 survey in Oct 2011 and 1 in Mar 2012 (Fig. 2). From the second to the 24th survey, 154 new mounds were observed; the highest number was found in Dec 2011 and the lowest in Aug 2011. Similarly, to what happened to the total number of colonies, we found a significant difference between the number of new colonies and seasons ($\chi^2 = 30.03$, $P < 0.0001$). When considering the average number of new colonies per collection, there was no significant difference between the number of colonies found in the dry and wet seasons ($U = 0.8819$, $P = 0.1889$).

The number of new colonies per sampling time had a positive and significant correlation with rainfall ($rs = 0.5207$, $P = 0.0108$). In separate analyses, during the dry season there was a negative correlation between the number of new colonies and humidity ($rs = -0.6862$, $P = 0.0412$) and a positive correlation with rainfall ($rs = 0.7755$, $P = 0.0014$). In the wet season the number of new colonies was positively correlated with humidity ($rs = 0.6105$, $P = 0.0204$). The temperature in

the dry season did not correlate with the number of colonies ($rs = 0.2929$, $P = 0.4443$). Wet season temperatures and precipitation also were not correlated with the number of colonies ($rs = -0.1$, $P = 0.6539$ and $rs = 0.2749$, $P = 0.3415$, respectively).

Concerning habitat, grass (or vegetation) was the most used for nesting (61%), followed by the mixed sites (30%), natural sites (7%) and artificial sites (3%).

There were significant differences among nesting sites in the wet and the dry season, i.e., grass ($\chi^2 = 20.357$, $P < 0.0001$), natural sites ($\chi^2 = 25.348$, $P < 0.0001$) and artificial sites ($\chi^2 = 0.0004$, $P = 0.0004$). There was no difference in the preference for nesting in mixed site in both seasons of the year ($\chi^2 = 0.425$, $P = 0.5782$).

There was a significant difference between the lengths of the new nests in the wet and dry seasons ($U = 1.7519$, $P = 0.0399$), as well as between the total number of nests ($U = 4.6757$, $P < 0.0001$). In relation to volume, there was a significant difference between the total nests in the wet and dry seasons ($U = 2.6561$, $P = 0.0040$) (see Table 1).

DISCUSSION

Although we did record new foundations during the dry season, the number of colony foundations in the dry season was significantly lower than in the wet season, despite the average number of mounds between seasons not being significantly different. The uncertainty of the early dry

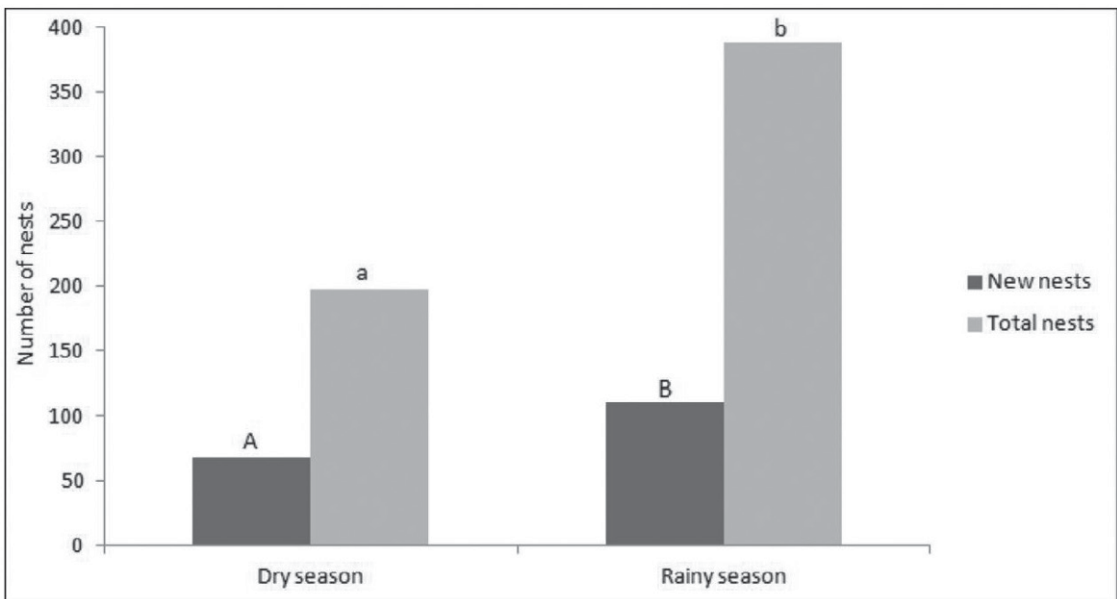


Fig. 1. New and total nests surveyed of *Solenopsis saevissima* in the dry and wet seasons found in collections during one year (May 2011 to May 2012) on the campus of the Federal University of Juiz de Fora (UFJF), Juiz de Fora, Minas Gerais, Brazil. Different letters above members of each pair of bars indicate that the number of nests significantly different.

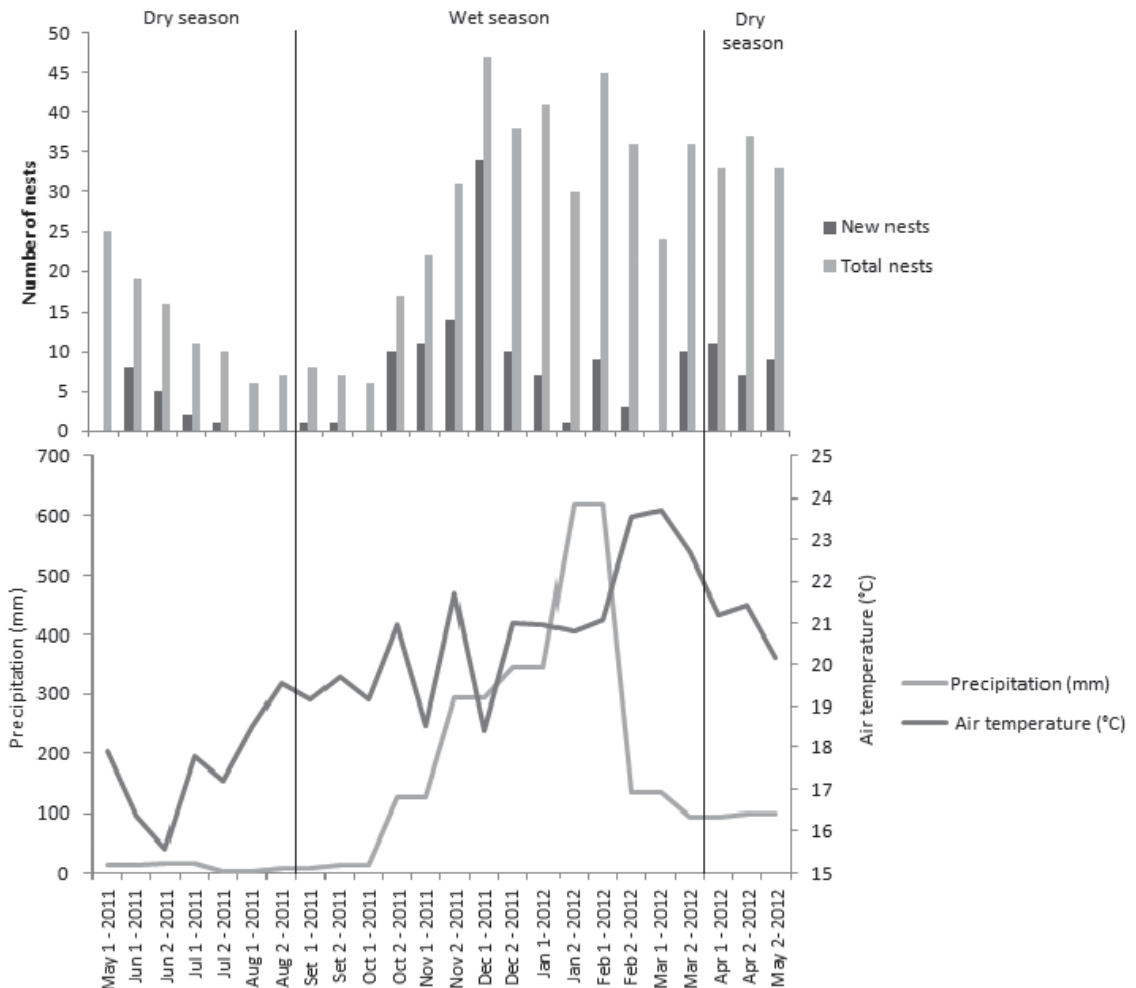


Fig. 2. New and total nests of *Solenopsis saevissima* found in one year of samples on the campus of the Federal University of Juiz de Fora (UFJF) at Juiz de Fora, Minas Gerais, Brazil, and the daily mean air temperature and precipitation.

season, marked by high temperatures and precipitation for the period may contribute to a delay in the decline of the colonies, which occurs only at the end of this season.

Climatic variables seem to have a strong effect on the timing of the founding of new colonies, at least in this urban environment. In our study rainfall was important in the dry season and humidity (variable associated with precipitation) was also important in both seasons, but—interestingly—not temperature. Because the study was conducted during one year only, the association of the colonies with the weather conditions may be linked to a climatic irregularity, which may not be characteristic of the climate of the region.

Temperature is the main factor to influence colony activities and metabolism, although the workers exhibit efficient thermoregulation

(Porter & Tschinkel 1993). Furthermore, temperature affects colony size in *S. invicta* and modifies brood survival and workers longevity (Asano & Cassil 2012). It is of relevance that when humidity, rainfall and temperature are reduced colony foundation and growth are decreased. The ants of this genus are influenced by abiotic factors, which have important effects on the colony activity (Porter & Tschinkel 1993; Dress 1994).

The highest number of new colonies registered during the first survey in Dec was probably due to favorable temperature and rainfall. As to the total rainfall per year, 89% was registered in the first period (Jan through Mar and Oct through Dec) and 11% in the second period (Apr to Jun and Jul to Sep), and these data corroborate the study of Ferreira (2012).

TABLE 1. MEAN LENGTH, WIDTH, HEIGHT AND VOLUME [\pm SD (RANGE)] OF COLONIES OF *SOLENOPSIS SAEVISSIMA* FOUND IN THE DRY AND THE WET SEASON FROM MAY 2011 TO MAY 2012 IN THE URBAN AREA OF JUIZ DE FORA, MINAS GERAIS, BRAZIL.

Dimensions (cm)	New nests		Total nests sampled	
	Dry season (n = 43)	Wet season (n = 111)	Dry season (n = 197)	Wet season (n = 388)
Length	64.8 \pm 65.2 (21.5-219) a	51.3 \pm 23.7 (12-147) b	65.4 \pm 40.3 (12.6-238) A	50.6 \pm 23.6 (12-170) B
Height	26.6 \pm 40.5 (5.4-56.5) a	26.9 \pm 11.9 (7-65) a	29.5 \pm 14.6 (3.8-80.4) A	28.4 \pm 11.6 (7-65) A
Width	7.6 \pm 13.3 (1-19) a	8 \pm 9.8 (2-83) a	8.8 \pm 7.2 (1-52) A	8 \pm 6.3 (0.5-83) A
Volume	7.6 \pm 8.6 (0.1-36.2) a	6.7 \pm 10.8 (0.2-90.3) a	11.7 \pm 22.2 (0.1-212.6) A	7.1 \pm 9.1 (0.1-90.3) B

Means, standard deviations and ranges followed by different letters in the same row differ significantly ($P < 0.05$).

The influence of climatic factors on fire ants colonies has been well documented (Lofgren et al. 1975; Pranschke & Hooper-bùi 2003). Lunz et al. (2009) observed that the economic impact caused by *S. saevissima* to the tree *Schizolobium amazonicum* Huber ex Ducke (Fabales: Fabaceae), is much lower during the dry season (Jun to Nov) than during the wet season (Dec to May) when the tree has many new buds, which favor the ant's occurrence.

We suggest that the predominance of nest founding on grassy lots during the wet season is due to a smaller digging effort by workers as compared that required on artificial and natural sites. Colonies of *S. saevissima* can readily move from one location to another in search for resources as could have occurred in this study. Hays et al. (1982) demonstrated that the lack of food can facilitate relocation of colonies, and that colonies may relocate several times per year to facilitate successful foraging.

The average area of the nests found in this study was similar to that obtained by Macom & Porter (1996) in surveys collected between Feb and Apr 1994 (late winter and early spring) for polygynic colonies of *S. invicta* ($0.11 \pm 0.01 \text{ m}^2$) and smaller than the areas found for monogynic colonies ($0.17 \pm 0.02 \text{ m}^2$) in pastures of Florida. The values in areas of *S. invicta* nests we found were similar to those reported by Almeida et al. (2007) ($0.12 \pm 0.01 \text{ m}^2$), in the State of Rio de Janeiro in different sites of agricultural plantations, between Jun and Jul 2006.

The volume of the colonies (monogynic = 14.7 ± 1.5 and polygynic = $7.6 \pm 1.4 \text{ L}$) found by Macom & Porter (1996) was smaller than the volumes obtained in our study. The differences between these average values may be due to sampling effort, or to differences in soil composition and abiotic factors.

In summary, we showed that there are changes in relation to the choice of nesting sites between

seasons, although colonies of *S. saevissima* are present in urban areas during the entire year. As the final dry season was the period that has the smallest number of active mounds, this period can be considered the most favorable for the area-wide application of control methods, but an individual mound treatment approach in the dry season take into consideration the occurrence of cryptic mounds. Nevertheless, control expenses with labor and insecticides should be lower in the dry season than in the wet season. In addition in the dry season, control substances will probably have lower rates of percolation, and result in less soil and water contamination. The inspection methodology we carried out can be applied to problem areas of infestation of these ants, and if combined with appropriate control practices, can enhance their effectiveness.

ACKNOWLEDGMENTS

The authors thank Jacques Hubert Charles Delabie for collaboration and identification of the ants. We thank Manuel Eduardo dos Santos and Juliane Floriano Lopes Santos for contributions to the manuscript. We are also grateful to the Fundation of Support to Research of the State of Minas Gerais (FAPEMIG), to the Graduate Program in Animal Biology and Behavior and the Graduate Program of Ecology of the Federal University of Juiz de Fora for financial support.

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