**DOI:** 10.5327/Z2176-947820200659

# ASSOCIATED FACTORS WITH ANTS OCCURRENCES IN URBAN SCHOOLS

## FATORES ASSOCIADOS À OCORRÊNCIA DE FORMIGAS EM ESCOLAS URBANAS

*Junir Antônio Lutinski*

Professor from Postgraduate Program in Health Sciences, Universidade Comunitária da Região de Chapecó (Unochapecó) – Chapecó (SC), Brazil.

*Carin Guarda*

Student from Postgraduate Program in Health Sciences, Unochapecó – Chapecó (SC), Brazil.

*Maria Assunta Busato*

Professor from Postgraduate Program in Health Sciences, Unochapecó – Chapecó (SC), Brazil.

**Corresponding author:** Junir Antonio Lutinski. Avenida Senador Attílio Fontana Av., 591-E, Efapi - 89809-000, Chapecó, SC, Brazil. E-mail: junir@unochapeco.edu.br.

**Received on:** 12/24/2019
**Accepted on:** 04/23/2020

## ABSTRACT

Schools consist of environments that offer favorable conditions for nesting by ants. This study aims to identify the factors associated with the occurrence of ants in four environments at schools located in urban areas. Sampling was conducted in kitchens, warehouses, dining rooms, and outdoor areas in twelve schools in four cites in the western region of the State of Santa Catarina, Brazil. For sampling, baits and manual collection were used. The environmental variables were obtained in each environment. Similarity between schools regarding ant composition and abundance was assessed by a Non-metric Multidimensional Scaling. We sampled 1,478 specimens of ants and identified 45 species. Similarities (60%) were observed in the abundance and composition of ant assemblages among schools in small towns (Caxambu do Sul, Guatambu, and Palmitos).The presence of outdoor areas with vegetation and green areas in the surroundings, size of constructed area, and frequency of insect control event contribute to the abundance of these insects in the schools environments. Ants are not recognized as potential vectors of pathogenic microorganisms in schools and are neglected if considered the periodicity of insect control.

**Keywords:** school environment; ants assemblage; infestation; pest control.

## RESUMO

As escolas consistem em ambientes que oferecem condições favoráveis para a colonização por formigas. Este estudo objetiva identificar os fatores associados à ocorrência de formigas em quatro ambientes escolares localizados em áreas urbanas. A amostragem foi realizada em cozinhas, almoxarifados, refeitórios e áreas externas em doze escolas de quatro municípios da região oeste do estado de Santa Catarina, Brasil. Foram utilizadas iscas e coleta manual na amostragem. Variáveis ambientais foram obtidas em cada local. A similaridade entre as amostras quanto à composição e a abundância de formigas foi avaliada por meio de uma escala multidimensional não métrica (*non-metric multidimensional scaling* — NMDS). Foram amostrados 1.478 exemplares de formigas e identificados 45 espécies. Foi observada uma similaridade de 60% na abundância e composição das assembleias de formigas entre escolas de pequenas cidades (Caxambu do Sul, Guatambú e Palmitos). A presença de áreas externas com vegetação e áreas verdes no entorno, o tamanho da área construída e a frequência de eventos de controle de insetos contribuem para a abundância desses insetos nos ambientes escolares. As formigas não são reconhecidas como potenciais vetores de micro-organismos patogênicos nas escolas e são negligenciadas se considerada a periodicidade do controle de insetos.

**Palavras-chave:** ambiente escolar; assembleia de formigas; infestação; controle de pragas.

# INTRODUCTION

Schools have predominantly horizontal constructions with numerous doors and windows for access (BRASIL, 2002; SANTOS; DELLA-LUCIA; DELABIE, 2002; FAGUNDES *et al*., 2015). The structure provides shelter, and the presence of food provides suitable environments for nesting by ants (OLIVEIRA; CAMPOS-FARINHA, 2005; LUTINSKI *et al*., 2014; LUTINSKI *et al*., 2015). In the outdoor environment, the presence of gardens with trees also contributes to nesting by ants. Favorable conditions of temperature and humidity in addition to food resources and nesting sites are offered to ants in school environments (IOP *et al*., 2009; CORIOLANO *et al*., 2014; ESTRADA *et al*., 2014). In a study conducted in 30 urban schools located in ten cities in the western region of the State of Santa Catarina (LUTINSKI *et al*., 2014), the occurrence of 81 ant species was recorded in the outdoor areas (yards and gardens), evidencing the importance of schools for the occurrence of the urban ant fauna. Among the species identified, those that stand out regarding abundance in school environments are *Linepthema humile* (Mayr, 1868), *Monomorium floricola* (Jerdon, 1851), *Nylanderia fulva* (Mayr, 1862), *Wasmannia auropunctata* (Roger, 1863), and species of the genera *Brachymyrmex* Mayr, 1868*, Camponotus* Mayr, 1861, *Crematogaster* Lund, 1831, *Pheidole* Westwood 1840, *Solenopsis* Westwood, 1840 (LUTINSKI *et al*., 2014), all taxa recognized by the potential to colonize urban environments and to become pest in these environments (LISE; GARCIA; LUTINSKI, 2006; CASTRO *et al*., 2015).

Urban areas are characterized as regions of low biological diversity (MCKINNEY, 2002), which facilitates nesting by generalist ant species (MARTINS *et al*., 2011). Due to lower competition and low ecological requirements, these species easily adapt to urban environments and colonize them (OLIVEIRA; CAMPOS-FARINHA, 2005). Habitats altered by human activities are more vulnerable as many predators and competitors are eliminated, creating opportunities for invasive species (CASTRO *et al*., 2015).

The interior of the buildings provides a favorable microclimate for some ant species, since they offer food, water, and shelter (TANAKA; VIGGIANI; PERSON, 2007; CAMPOS, 2011). Food storage and meal preparation environments are more susceptible to invasion (LUTINSKI *et al*., 2015). Foods, especially sugary substances and sources of proteins and oils are used by ants (BUENO; BUENO, 2007). When improperly stored, they allow the access of ants, serve as an attractive, and contribute to their presence in the environment (LUTINSKI *et al*., 2015). When ants manage to access the trash cans, they can also use the waste as food sources.

Biological characteristics of ants as their small size, great mobility in search of food, and generalist diet, favor the exploration of internal environments (OLIVEIRA; CAMPOS-FARINHA, 2005; TANAKA; VIGGIANI; PERSON, 2007). Poorly preserved buildings have cracks in the floor, walls, and ceiling, which provide a warm and suitable environment for the development of their eggs, larvae, and pupae (SILVA; LOECK, 1999).

Conditions including the absence of waste management, lack of adequate storage conditions, food transportation (TANAKA; VIGGIANI; PERSON, 2007), lack of knowledge about the importance of environmental management to restrict shelter and food supply, ignorance of the biological and ecological aspects of ants, and the inadequate environmental management of outdoor areas (BUENO; CAMPOS-FARINHA, 1999) can favor the establishment of ants in schools. Schools environments located in urban areas are complex because of their location, type of building and around biotic characterization. The availability of resources at these sites for ant nesting makes it relevant to investigate the factors associated with the composition, richness, and abundance of these insects. In this context, the present study is aimed to identify the environmental factors associated with the ant assemblages in schools located in urban areas.

# MATERIALS AND METHODS

This study was carried in 12 schools located in urban areas of cities of the western region of Santa Catarina State, Brazil, Chapecó (27º05'48" S; 52º37'07" W), Caxambu do Sul (27º09'17'' S; 52º52'59'' W), Guatambu (27º08'5'' S; 52º47'15'' W), and Palmitos (27º04'20'' S; 53º09'29'' W). In all, six sampled schools are located in the municipality of Chapecó. The other six belong to Guatambu, Caxambu do Sul, and Palmitos, two in each municipality. The schools are characterized by a built area that varies between 677 and 3,000 $m^2$. These measures were obtained in the schools, from the engineering project, during the collections. The outdoor areas range from 125 to 2,955 $m^2$ and the number of trees varied between zero and 80 (Table 1).

## Sampling

Ants were sampled in four school environments: outdoor areas, dining rooms, kitchens, and warehouses. Sampling was conducted in the period between September and October 2016, between 9 and 17 hours. Ants' activities are regulated by climatic factors, especially temperature (HÖLLDOBLER; WILSON, 1990). In the southern region of Brazil, samples taken in seasons with higher temperatures (spring and summer)

**Table 1 – Municipality, geographic coordinates, number of students, built area, external area, and number of trees at schools where the ants were sampled, from September to October 2016.**

| Municipality | School | Coordinates | Number of students | Building area ($m^2$) | Outside area ($m^2$) | Number of trees |
|---|---|---|---|---|---|---|
| Palmitos | 1 | 27º4’14”S; 53º9’32”W | 163 | 2,200 | 180 | 0 |
| | 2 | 27º4’37”S; 53º9’19”W | 345 | 1,500 | 200 | 8 |
| Caxambu do Sul | 3 | 27º9’45”S; 52º52’48”W | 280 | 1,595 | 2,955 | 20 |
| | 4 | 27º9’22”S; 52º52’55”W | 360 | 1,266 | 2,000 | 50 |
| Guatambu | 5 | 27º7’57”S; 52º46’46”W | 320 | 677 | 100 | 10 |
| | 6 | 27º7’55”S; 52º47’14”W | 600 | 3,000 | 7,000 | 50 |
| Chapecó | 7 | 27º5’37”S; 52º37’50”W | 900 | 2,000 | 450 | 30 |
| | 8 | 27º5’33”S; 52º40’27”W | 500 | 695 | 260 | 55 |
| | 9 | 27º5’55”S; 52º40’15”W | 600 | 2,455 | 85 | 25 |
| | 10 | 27º5’27”S; 52º37’30”W | 170 | 800 | 1,000 | 75 |
| | 11 | 27º4’53”S; 52º38’24”W | 243 | 950 | 900 | 80 |
| | 12 | 27º5’40”S; 52º38’45”W | 258 | 850 | 600 | 40 |

allow greater richness and abundance (ROANI *et al.*, 2019). Therefore, these parameters can be maximized with samples obtained under such conditions. The sample period corresponds to spring, characterized by an elevation of the temperatures (up to 20ºC) and by an average monthly rainfall of approximately 250 mm. Two sampling methods were used: baits and manual collection. In each environment, samples with sardine-based (two) and honey-based (two) were used (LUTINSKI *et al.*, 2014), which remained for one hour. In all, eight samples were obtained with sardine baits (~1 g per sample). Also, eight glucose (same product) baits (~1 g per sample) were used at each school. In the indoor environments, baits were placed on the floor, close to the walls, trying to keep as much distance between them as possible. In the outdoor environment, baits were distributed on the ground maintaining a distance of 10 m between them. In the case of small gardens, baits have been distributed in such a way as to mater as far as possible between one and another.

Manual samplings were conducted indoors (kitchen, dining room, warehouse) and in the outdoor area, following a random path in each environment, totaling one hour (SARMIENTO, 2003). The ants were sampled manually with the aid of tweezers and packed in vials (10 mL) containing 70% alcohol and identified. Samples were sent to the Laboratory of Entomology of the Universidade Comunitária da Região de Chapecó (Unochapecó) for sorting and identification.

The identification was made based on identification keys of Gonçalves (1961), Kempf, Klingenberg and Sautter (1964; 1965), Watkins (1976), Della-Lucia (1993), Lattke (1995), Taber (1998), Bueno and Campos-Farinha (1999), and Fernández (2003). The classification followed Bolton (2019) and the sampled specimens were also compared with the specimens deposited in the Entomological Collection of the same university.

## Environmental factors

General information about the school and the environment was collected, as well as the environmental and structural variables of each school environment as described below:

- general information about the school: time of existence (years), size of the constructed area ($m^2$), number of students enrolled, number of meals prepared daily, time since the last disinsection (months), time since last maintenance (months), frequency of gardening services and waste collection;
- school environment: number of residences, number of vacant lots, number of green areas (squares, parks), number of forest fragments, number of trades and industries directly adjacent to schools;
- outdoor area: total area ($m^2$), size of the area covered with vegetation ($m^2$) (grass or other shrub or creeping vegetation), number of trees with breast height perimeter (BHP) greater than 20 cm, number of cracks in sidewalks and walls, number of trash cans, and number of places with food residues;
- indoor environments (kitchen, dining room, and warehouse): total area ($m^2$), number of cracks in the floor, number of cracks in the walls, number of openings (doors and windows), number of open food portions, and number of trash cans.

## Data analysis

Richness was defined as the number of ant species occurring in each of the samples. Abundance was defined based on the number of records of a given species in each bait or hand sample and not on the number of individuals. The number of records minimizes the effect of foraging habits and colony sizes and is more appropriate for ant assemblage studies (ROMERO; JAFFE, 1989). The richness and abundance of ants were presented in a descriptive way for each school. In addition, the ecological diversity indicator (Shannon H') was used to compare these parameters between schools. To present the richness and abundance of ants in each school, a table was constructed with the number of occurrences of the species (Table 2).

A non-metric multidimensional scaling (NMDS) was applied to evaluate and illustrate the similarity between schools regarding the composition and abundance of ants' assemblages (LUTINSKI *et al.*, 2017b). The data



RBCIAMB | v.55 | n.2 | jun 2020 | 192-205 - ISSN 2176-9478

**Table 2 – Sampled assemblages of ants, followed by their respective numbers of occurrences in 12 urban schools, in four cities in the west of the State of Santa Catarina. September and October 2016.**

| Taxon | Palmitos | | Guatambu | | Caxambu do Sul | | Chapecó | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | |
| Subfamily Dolichoderinae | | | | | | | | | | | | | |
| Tribe Leptomyrmecini | | | | | | | | | | | | | |
| *Dorymyrmex brunneus* (Forel, 1908) | 1 | 1 | 1 | 2 | 4 | 3 | 1 | 3 | 2 | 2 | | 1 | 21 |
| *Dorymyrmex* sp. | | 1 | | | | | | | | | | | 1 |
| *Linepithema humile* (Mayr, 1868) | | | | | | | 1 | | | 1 | | 1 | 3 |
| SubfamilyFormicinae | | | | | | | | | | | | | |
| TribeCamponotini | | | | | | | | | | | | | |
| *Camponotus personatus* (Emery, 1894) | | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 2 | | 1 | 10 |
| *Camponotus crassus* (Mayr, 1862) | | | | | | | 2 | 1 | 1 | | | 1 | 5 |
| *Camponotus mus* (Roger, 1863) | | | 1 | 1 | | | | | | 3 | | | 5 |
| *Camponotus rufipes* (Fabricius, 1775) | | | | | | | 1 | 1 | | | | 1 | 3 |
| *Camponotus* sp. 1 | | | | | | | 1 | 1 | | 1 | | | 3 |
| *Camponotus* sp. 2 | | | | | | | 1 | | | | | | 1 |
| Tribe Myrmelachistini | | | | | | | | | | | | | |
| *Brachymyrmex coactus* (Mayr, 1887) | | | | 1 | | | 1 | | | | 1 | | 3 |
| *Brachymyrmex cordemoyi* (Forel, 1895) | | | 1 | | | | | | | | | | 1 |
| *Brachymyrmex* sp. | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 13 |
| Tribe Lasiini | | | | | | | | | | | | | |
| *Nylanderia fulva* (Mayr, 1862) | | | | 1 | | | | | | | 5 | 1 | 7 |
| *Nylanderia* sp. | | | | | | | | | | 1 | | | 1 |
| Subfamily Mirmicinae | | | | | | | | | | | | | |
| Tribe Attini | | | | | | | | | | | | | |
| *Acromyrmex subterraneus* (Forel, 1893) | 1 | | 1 | 1 | 1 | | 1 | 1 | 2 | | | | 8 |
| *Cephalotes pusillus* (Klug, 1824) | | | | | | 1 | | | | | | | 1 |
| *Cyphomyrmex rimosus* (Spinola, 1851) | | | | 1 | | | 1 | 1 | 1 | | | 1 | 5 |
| *Pheidole laevifrons* (Mayr, 1887) | 1 | 1 | 1 | 1 | 4 | 2 | 2 | 3 | 1 | | 1 | 2 | 19 |
| *Pheidole lignicola* (Mayr, 1887) | | | | | | | | | 1 | 1 | 4 | 1 | 7 |
| *Pheidole pubiventris* (Mayr, 1887) | | 2 | 2 | 1 | 3 | 4 | 1 | 2 | 2 | 1 | 2 | 3 | 23 |
| *Pheidole* sp. 1 | | 1 | | | | | | | | | | | 1 |
| *Pheidole* sp. 2 | | | 2 | | 2 | 1 | 2 | | 1 | 2 | | 2 | 7 |
| *Pheidole* sp. 3 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 2 | 1 | 2 | 2 | 14 |

Continue...

**Table 2 – Continuation.**

| Taxon | Palmitos | | Guatambu | | Caxambu do Sul | | Chapecó | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | |
| *Pheidole* sp. 4 | | | | | | | | 2 | | | 1 | 2 | 5 |
| *Pheidole* sp. 5 | | | | | | | | 1 | | | | | 1 |
| *Pheidole* sp. 6 | | | | | | | | | | | | 1 | 1 |
| *Pheidole* sp. 7 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | | | 1 | | 10 |
| *Pheidole* sp. 8 | | | | | | | 1 | | | | | | 1 |
| *Pheidole* sp. 9 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 19 |
| *Wasmannia auropunctata* (Roger, 1863) | | | | | 1 | | | 1 | | | | | 2 |
| *Wasmannia* sp. | | | | | | | | | | | 1 | | 1 |
| Tribe Crematogastrini | | | | | | | | | | | | | |
| *Crematogaster acuta* (Fabricius, 1804) | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | | | 1 | 8 |
| *Crematogaster magnifica* (Satschi, 1925) | | | | | | | 1 | 1 | | 1 | | 1 | 5 |
| *Crematogaster* sp. | | | | | | | | | | | | 1 | 1 |
| Tribe Pogonomyrmex | | | | | | | | | | | | | |
| *Pogonomyrmex naegelii* (Forel, 1878) | 2 | 1 | 2 | 1 | 1 | 1 | | 2 | 2 | 1 | | 1 | 14 |
| Tribe Solenopsidini | | | | | | | | | | | | | |
| *Monomorium floricola* (Jerdon, 1851) | | | 1 | | | 1 | | | | | | | 2 |
| *Monomorium pharaonis* (Linneaus,1758) | | | | 1 | 1 | 1 | 1 | | | | | | 4 |
| *Solenopsis saevissima* (F. Smith, 1855) | | 1 | 1 | 1 | 1 | 1 | 1 | 3 | | 2 | | 1 | 12 |
| *Solenopsis schmalzi* (Forel, 1901) | | | 1 | | | 2 | 1 | 1 | 1 | 1 | | 1 | 8 |
| *Solenopsis* sp. 1 | | | | 1 | | | | | | | | 1 | 2 |
| *Solenopsis* sp. 2 | | 1 | | 2 | 1 | 2 | | | | | | | 6 |
| Subfamily Ponerinae | | | | | | | | | | | | | |
| Tribe Ponerini | | | | | | | | | | | | | |
| *Pachycondyla striata* (F. Smith, 1858) | | | | | | | | | 1 | | | | 1 |
| Subfamily Pseudomyrmecinae | | | | | | | | | | | | | |
| Tribe Pseudomyrmecini | | | | | | | | | | | | | |
| *Pseudomyrmex flavidulus* (F. Smith, 1858) | | | | | | | | | 1 | | | | 1 |
| *Pseudomyrmex gracilis* (Fabricius, 1804) | | | | | | | | 1 | | | | | 1 |
| *Pseudomyrmex termitarius* (F. Smith, 1855) | | | | | | | | 1 | | | | | 1 |
| Richness | 9 | 14 | 17 | 19 | 15 | 17 | 21 | 22 | 16 | 16 | 11 | 23 | |
| Abundance | 10 | 17 | 20 | 23 | 24 | 27 | 25 | 32 | 21 | 23 | 20 | 30 | |
| Shannon (H’) | 2,2 | 2,6 | 2,8 | 2,9 | 2,5 | 2,7 | 2,9 | 3,0 | 2,8 | 2,6 | 2,2 | 3,1 | |

S1: School 1; S2: School 2; S3: School 3; S4: School 4; S5: School 5; S6: School 6; S7: School 7; S8: School 8; S9: School 9; S10: School 10; S11: School 11; S12: School 12.

matrix was previously transformed into Log (x + 1) and Bray-Curtis was used as the association index. The analysis was run with the statistical software Primer 6.1.9 (CLARKE; GORLEY, 2005).

To evaluate the influence of environmental factors on the richness and abundance of ants in schools, correlation analyses were run using the Pearson correlation coefficient. The Shapiro-Wilk test was used to test the normality of the data. These tests were performed using the Past software (HAMMER; HARPER; RYAN, 2001).

### Ethical aspects

Sampling was authorized by ICMBio (Chico Mendes Institute for Biodiversity Conservation), "Authorization for activities with scientific purpose", number 54250-1 of August 6, 2016.

## RESULTS

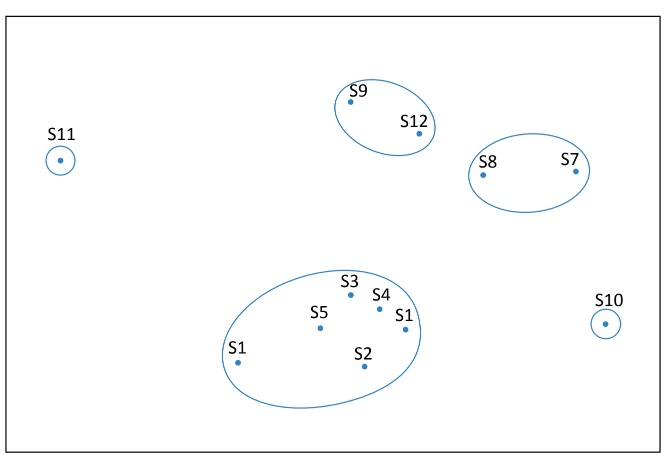
We sampled 1,478 specimens of ants in 283 occurrences. Finally, 45 species were identified. The most abundant genera in the schools was *Pheidole* (n = 108), *Solenopsis* (n = 28), *Camponotus* (n = 27), *Dorymyrmex* (n = 22), and *Brachymyrmex* (n = 17) (Table 2).

In the schools of Chapecó municipality, the genera *Pheidole* (S = 11; n = 59) and *Camponotus* (S = 6; n = 21) presented greater richness and abundance. In other cities, the most abundant genera were *Pheidole* (S = 7; n = 49) and *Solenopsis* (S = 4; n = 15) (Table 2).

In schools S8 and S12, there were the highest values of richness (S = 22), followed by S7 (S = 20). The lowest richness was recorded in schools S1 (S = 9) and S11 (S = 11), followed by schools S5 and S2 (S = 14). The schools with the highest abundances were S8 (n = 29), S12 (n = 27), and S6 (n = 24), while lower values were observed in S3 (n = 18), S2 (n = 10), and S1 (n = 10) (Table 2).

Schools S1, S2, S3, S4, S5, and S6 presented similarity of 60% (Bray-Curtis index) to each other regarding the abundance and composition of ant assemblages, such as S7 and S8, and S9 and S12. The similarity in the composition and abundance of the ant assemblages between the schools indicates homogeneity on beta diversity. S10 and S11 differed from each other as well from the others (Figure 1).

The similarity (Figure 1) between abundance and composition of the ant fauna was 60% when compared the schools in the municipality of Chapecó and those in the other cities, indicating homogeneity among ant assem-



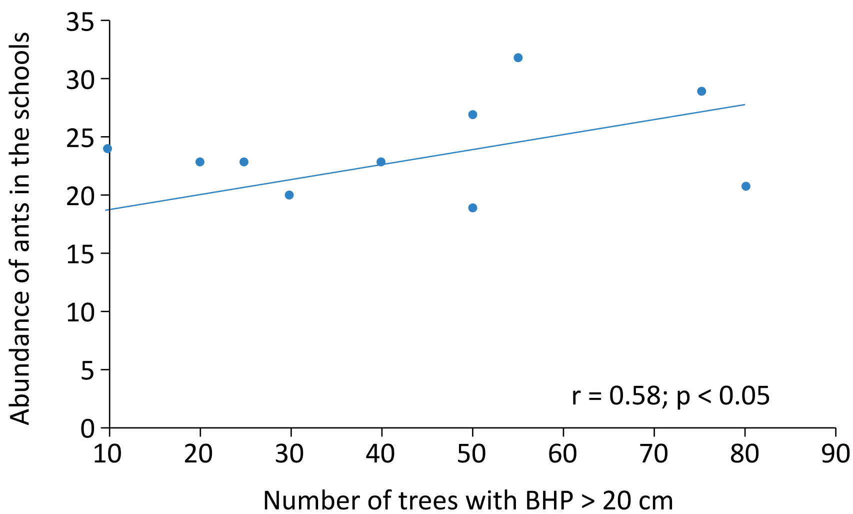

School 1: S1; School 2: S2; School 3: S3; School 4: S4; School 5: S5; School 6: S6; School 7: S7; School 8: S8; School 9: S9; School 10: S10; School 11: S11; School 12: S12.

**Figure 1 – Similarity (Bray-Curtis) between ant assemblages sampled in 12 schools of cities in the western region of the State of Santa Catarina, Brazil. September and October 2016.**

blies in schools in small towns. The number of trees (Figure 2) and the time from the last insect control event (Figure 3) showed a positive correlation with the abundance of ants, while the size of the constructed area (Figure 4) showed a negative correlation. All other variables evaluated did not present a significant correlation.

All the environmental and structural variables evaluated in the school environment and surroundings were analyzed and none of them were correlated with ant richness. The abundance of ants presented a positive correlation ($r = 0.58$, $p < 0.05$) with the number of trees with BHP > 20 cm (Figure 2).

There was a positive correlation between time from the last disinsection and the abundance of ants ($r = 0.72$, $p <0.05$) (Fig. 3).




BHP: breast height perimeter.

**Figure 2 – Correlation between the abundance of ants in 12 schools of cities in the western region of the State of Santa Catarina, Brazil, and the number of trees with BHP greater than 20 cm. September and October 2016.**

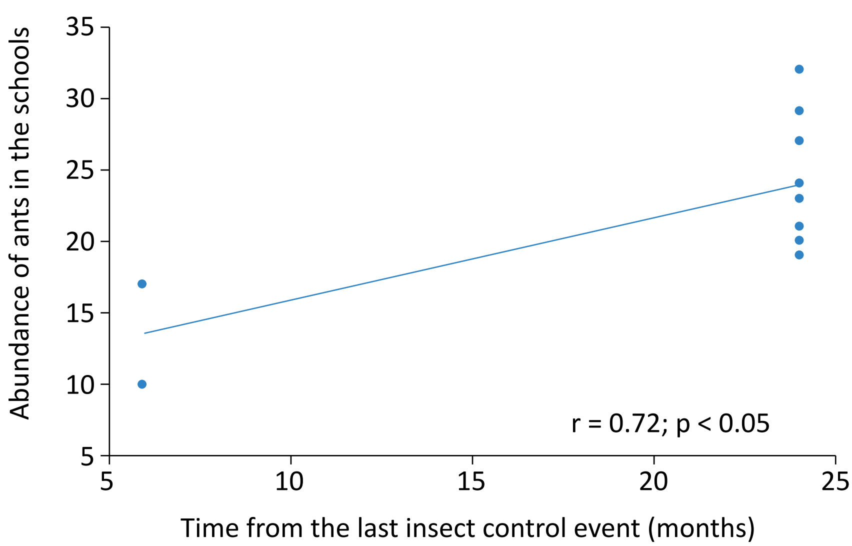



**Figure 3 – Correlation between the abundance of ants in urban schools in the western regionof the State of Santa Catarina, Brazil, and the time from the last insect control event (months). September and October 2016.**



RBCIAMB | v.55 | n.2 | jun 2020 | 192-205 - ISSN 2176-9478

The abundance of ants presented a negative correlation with the constructed area ($m^2$) ($r = -0.59$, $p < 0.05$). The smaller the constructed area of the school ($m^2$), the greater the abundance of ants (Figure 4).

# DISCUSSION

Ant richness found in schools is representative when compared to other studies carried out in urban environments, conducted in the same region (LISE; GARCIA; LUTINSKI, 2006; LUTINSKI *et al*., 2014; SCHWINGEL *et al*., 2016; NEVES *et al*., 2019; ROANI *et al*., 2019). The diversity of ants resembles the results found by Lutinski *et al*. (2014), who investigated the ant fauna in 30 urban school's outer area located in ten cities in the same region. The assemblies regarding the richest and most abundant subfamilies and genders corroborated the Lutinski *et al*. (2014) and Roani *et al*. (2019) findings. In schools of Chapecó municipality (S7-S12), we recorded the highest values of richness and abundance, with emphasis on abundance of species of the genus *Pheidole*, *Solenopsis* and *Camponotus*.

The results indicate the importance of the external school areas as reservoirs for the urban ant fauna. The present study adds information about ant species occurring in school environments, increasing the knowledge about the occurrence of these insects in the western region of the State of Santa Catarina, Brazil (LISE; GARCIA; LUTINSKI, 2006; IOP *et al*., 2009).

The greatest richness and abundance recorded in S8 and S12 can be explained by the presence of outdoor areas formed by lawns and gardens with a large number of trees (n > 50), once the presence of trees was one of the factors positively correlated with the abundance. Another factor that may have contributed to the increase in ant fauna diversity in these schools is their proximity to green areas and forest fragments. Both schools are adjacent to forest fragments. In cities, green areas contribute to conservation, acting as reservoirs for ant species and local diversity maintenance (MARTINS *et al*., 2011; ESTRADA *et al*., 2014). This relationship may explain the occurrence of ants of the genus *Pseudomyrmex* only in these schools. Ants of this genus are considered habitat specialists and their occurrence is associated with the presence of vegetation (MARTINS *et al*., 2011; FEITOSA, 2015). Pseudomirmecine ants are frequently recorded in samples in the southern region of Brazil (LUTINSKI *et al*., 2017a; LUTINSKI *et al*., 2018a; LUTINSKI *et al*., 2018b), including urban environments (NEVES *et al*., 2019; ROANI *et al*., 2019). Ants of this genus forage in vegetation and are predators of small invertebrates (FEITOSA, 2015).

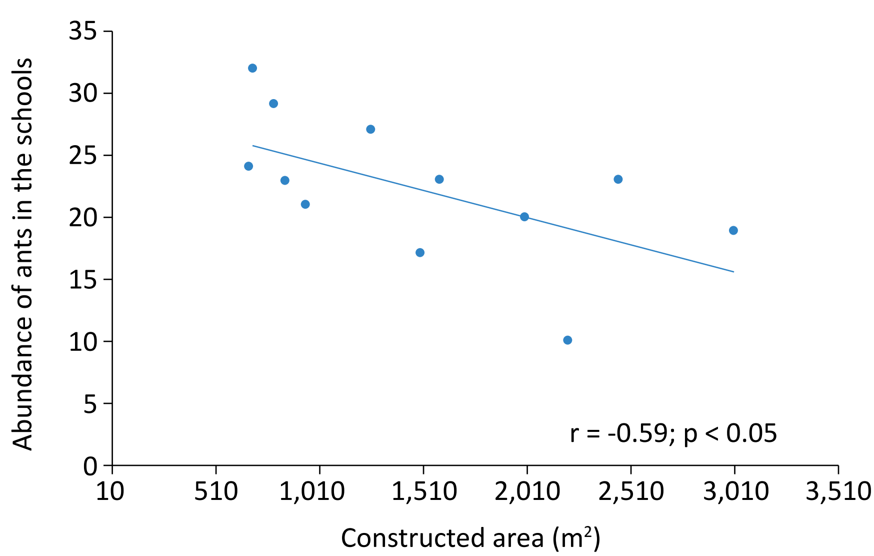



**Figure 4 – Correlation between the abundance of ants in 12 urban schools in the western region of the State of Santa Catarina, Brazil, and the constructed area ($m^2$). September and October 2016.**

The lower richness and abundance found in school S1 may be justified because this school presents conditions such as reduced external area, absence of trees and lawns. The lack of vegetation cover can cause changes in microclimatic conditions, such as temperature, luminosity, humidity, and wind speed in the environment that may influence the local ant fauna (MARTINS *et al*., 2011; LUTINSKI *et al*., 2017a). In this sense, the vegetation present in schools can offer food sources for species that depend on it like leaf-cutting ants (*Acromyrmex*) and shelter for other species, even for those that forage food inside buildings. Vegetated school yards, in this respect, can serve as reservoirs for the mirmecofauna and the associated biodiversity.

The schools belonging to the municipality of Chapecó were distinguished from the schools of the other cities according the abundance and composition of the ant assemblages. It was observed the occurrence of 18 species exclusive to the schools of this municipality, with emphasis on the richness of the genera *Pheidole* and *Camponotus*. These two genera are rich and abundant in samples obtained from the Atlantic Forest Biome (RIZZOTTO *et al*., 2019). They are general ants that use any food source, including sugars, proteins and fat in their diets (FEITOSA, 2015). Together with species of *Brachymyrmex*, *Linepithema*, *Monomorium, Nylanderia*, and *Solenopsis*, they are often recorded in urban environments, including indoor environments (LUTINSKI *et al*., 2017b).

The variation in the abundance and composition of ant assemblages from Chapecó schools and those in the other cities suggests that they are under different environmental and structural conditions. Chapecó is considered a large city (more than 200,000 inhabitants). Its sampled schools have a longer time of existence and are located at different distances of the edge of the city. These factors may explain the difference between the composition and abundance of ants in schools in relation to the other sampled cities, considered small (less than 20,000 inhabitants). The results obtained allow to infer that the parameters of abundance and richness in urban school environments are independent of the city size. They are more influenced by intrinsic aspects related to afforestation, building area, and insecticide exposure.

In the indoor environments, inadequate waste management and lack of care with food storage and transportation (TANAKA; VIGGIANI; PERSON, 2007) favor the establishment of ants (OLIVEIRA; CAMPOS-FARINHA, 2005). In outdoor areas, the presence of buildings and sidewalks (LUTINSKI *et al*., 2014) represent, for some species of the genera *Pheidole*, *Camponotus*, and *Solenopsis*, sites for nesting, contributing to the greater richness and abundance of these genera in these locations (GONÇALVES *et al*., 2011; BACCARO *et al*., 2015; FEITOSA, 2015).

The increase in the availability of ecological niches offered by the presence of trees in the outdoor areas of the schools can contribute to maintain the diversity of ants. The richness of ants is associated with the abundance and the diversity of the vegetation (MARTINS *et al*., 2011; ESTRADA *et al*., 2014). The presence of trees was positively associated with ant abundance in schools. This result corroborates the study of Estrada *et al*. (2014) in squares and urban parks, where these parameters of the mirmecofauna increase with the environment vegetation.

The time since the last insect control event had a positive influence on the abundance of the ants in the evaluated schools. The neglect with respect to pest control can be explained by the fact that ants are little recognized as agents that carry biological contaminants (PEREIRA; UENO, 2013). It is not considered that they feed on other dead animals and that they forage on contaminated environments and thus can transmit pathogenic microorganisms, such as *Escherichia coli* (Escherich, 1885) and *Sthaphylococcus aureus* (Rosenbach, 1884) (MÁXIMO *et al*., 2014), therefore not considering the risks they offer (BUENO; CAMPOS-FARINHA, 1999; PEREIRA; UENO, 2013). Consequently, the presence of ants in the indoor school environments is often ignored and does not awaken the need for regular disinsection (BUENO; CAMPOS-FARINHA, 1999).

In schools with smaller constructed areas ($m^2$), it is expected that the environments will be more homogeneous, which will contribute to the increase in ant abundance, as observed in this study. Generalist species belonging to the genera *Pheidole, Camponotus*, and *Dorymyrmex* have biological and ecological characteristics that favor the exploration of altered environments (SILVESTRE; BRANDÃO; SILVA, 2003) and were the ones that presented the highest number of occurrences in this study.

Ant assemblages occurring in schools differ from one school to another. The conditions of the environment and the surroundings, as proximity to green areas, can influence the ant fauna in schools (ESTRADA *et al*., 2014; LUTINSKI *et al*., 2014). The richness found in the outer areas of the schools shows that these are contributing to maintain the ant diversity in urban areas. Nevertheless, the lack of disinsection in indoor environments deserves attention, as it may favor the presence of these and other insects that may pose a risk to the health of the school community by contaminating food.

Inside buildings, rooms for storage and preparation of meals usually present the highest infestations by ants (LUTINSKI *et al*., 2015) due to the presence of food and residues that can be used as resources by the ants (TANAKA; VIGGIANI; PERSON, 2007; CAMPOS, 2011). However, the observed results were different and the occurrence of ants did not present correlation with these variables.

The presence of cracks and crevices in the walls and floor, which are normally used by ants as shelter and nesting site (SILVA; LOECK, 1999), also did not correlate with the richness or ant abundance. The same was observed for the number of doors and windows that are cited as access to the interior of the buildings (SILVA *et al*., 2005).

## CONCLUSIONS

The composition of ant assemblies in schools located in urban areas does not differ from assemblies sampled in other urban environments. It is composed mainly of tolerant and generalist species.

The richness and abundance of ants increases with the school afforestation and with the time interval between insecticide applications. It decreases as the proportion of building areas increases.

The results add distribution mirmecofauna information in urban environments, for the role of school environments as biodiversity reservoirs and for the management of these environments.

## ACKNOWLEDGMENTS

To the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

## REFERENCES

BACCARO, F. B.; FEITOSA, R. M.; FERNANDEZ, F.; FERNÁNDES, O. M.; IZZO, T.; SOUZA, J. L. P.; SOLAR, R. *Guia para gêneros de formigas no Brasil*. Manaus: INPA, 2015. 388 p.

BOLTON, B. *Synopsis and classification of Formicidae*. Gainesville: Memoirs of the American Entomological Institute, 2019. 370 p.

BRASIL. Ministério da Educação. *Espaços educativos de ensino fundamental:* subsídios para elaboração de projetos e adequação de edificações escolares. Brasília: Fundo de Fortalecimento da Escola, 2002. n. 4, v. 1. 207 p.

BUENO, O. C.; BUENO, F. C. B. Controle de formigas em áreas urbanas. *In*: PINTO, A. S.; ROSSI, M. M.; SALMERON, E. (orgs.). *Manejo de Pragas Urbanas*. Piracicaba: CP2, 2007.

BUENO, O. C.; CAMPOS-FARINHA, A. E. C. As formigas domésticas. *In*: MARICONI, F. A. M. (org.). *Insetos e outros invasores de residências*. Piracicaba: FEALQ, 1999. p. 136-180.

CAMPOS, A. E. C. Formigas causadoras de danos à saúde. *In*: MARCONDES, C. B. (org.). *Entomologia médica e veterinária*. 2. ed. São Paulo: Atheneu, 2011. p. 239-248.

CASTRO, M. M.; PREZOTO, H. H. S.; FERNANDES, E. F.; PREZOTO, F. The ant fauna of hospitals: advancements in public health and research priorities in Brazil. *Revista Brasileira de Entomologia*, Curitiba, v. 59, n. 1, p. 77-83, 2015. http://doi.org/10.1016/j.rbe.2015.02.011

CLARKE, K. R.; GORLEY R. N. *Primer:* Getting started with v. 6. Plymouth routines in multivariate ecological research. PRIMER-E Ltd., 2005. Available at: <http://updates.primer-e.com/primer7/manuals/Getting_started_with_PRIMER_7.pdf>. Accessed on: February 1, 2017.

CORIOLANO, R. E.; ESTRADA, M. A.; SANTOS, N. T.; CAIXEIRO, L. R.; VARGAS, A. B.; ALMEIDA, F. S. Mirmecofauna associada à arborização urbana no município de Três Rios, RJ, Brasil. *Revista Brasileira de Biociências*, v. 12, n. 4, p. 210-214, 2014.

DELLA-LUCIA, T. M. C. *As formigas cortadeiras*. Viçosa: Folha da Mata, 1993. 262 p.

ESTRADA, M. A.; CORIOLANO, R. E.; SANTOS, N. T.; CAIXEIRO, L. R.; VARGAS, A. B.; ALMEIDA, F. S. Influência de Áreas Verdes Urbanas sobre a Mirmecofauna. *Floresta e Ambiente*, Rio de Janeiro, v. 21, n. 2, p. 162-169, 2014. http://dx.doi.org/10.4322/floram.2014.035

FAGUNDES, J. F.; BANDEIRA, G. L.; SIQUEIRA, A. B.; NEIS, F. A.; KONFLANZ, T. L. Arborização e jardinagem na Escola Municipal de Ensino Fundamental Assis Brasil em Palmeira das Missões – RS. *Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental*, v. 19, n. 2, p. 1162-1173, 2015. http://dx.doi.org/105902/2236117015041

FEITOSA, R. M. Formigas do alto Tietê - Parte II. *In*: SUGUITURU, S. S.; MORINI, M. S. C.; FEITOSA, R. M.; SILVA, R. R. (eds.). *Formigas do alto Tietê*. São Paulo: Canal 6, 2015. p. 101-437.

FERNÁNDEZ, F. *Introducción a las hormigas de la región neotropical*. Bogotá: Instituto de Investigación de Recursos, 2003. 398 p.

GONÇALVES, C. R. O Gênero Acromyrmex no Brasil. *Studia Entomology*, v. 4, p. 113-180, 1961.

GONÇALVES, M. G.; LOECK, A. E.; SILVA, E. J. E.; SILVA, W. P.; ROSADO, J. L. O.; BASTOS, C. P.; BASSANI, M. T. Associação entre formigas (Hymenoptera: Formicidae) e bactérias patogênicas em cinco hospitais do município de Pelotas, RS. *Arquivos do Instituto Biológico*, São Paulo, v. 78, n. 2, p. 287-295, 2011.

HAMMER, O.; HARPER, D. A. T.; RYAN, P. D. *Past:* Palaeonthological statistics software package for education and data analysis. Version 1.37. 2001. Available from: <http://palaeo-electronica.org/2001_1/past/issue1_01.htm>. Accessed on: Dec. 10, 2019.

HÖLLDOBLER, B.; WILSON, E. O. *The Ants*. Cambridge: Belknap Press of Harvard University Press, 1990. 732 p.

IOP, S.; CALDART, V. M.; LUTINSKI, J. A.; GARCIA, F. R. M. Formigas urbanas da cidade de Xanxerê, Santa Catarina, Brasil. *Biotemas*, v. 22, n. 2, p. 55-64, 2009. http://doi.org/10.5007/2175-7925.2009v22n2p55

KEMPF, W. W.; KLINGENBERG, C.; SAUTTER, G. A revision of the Neotropical fungus-growing ants of the genus Cyphomyrmex Mayr. Part 1: Group of strigatus Mayr. *Studia Entomology*, v. 7, p. 1-44, 1964. https://doi.org/10.15468/j9k3jk

KEMPF, W. W.; KLINGENBERG, C.; SAUTTER, G. A revision of the Neotropical fungus-growing ants of the genus Cyphomyrmex Mayr. Part II: Group of rimosus (Spinola) (Hym.,Formicidae). *Studia Entomology*, v. 8, p. 161-200, 1965. https://doi.org/10.15468/8xfelz

LATTKE, J. Revision of the ant genus Gnamptogenysin the New World (Hymenoptera: Formicidae). *Journal of Hymenoptera Research*, v. 4, p. 137-193, 1995.

LISE, F.; GARCIA, F. R. M.; LUTINSKI, J. A. Association of ants (Hymenoptera: Formicidae) with bacteria in hospitals in the State of Santa Catarina. *Revista da Sociedade Brasileira de Medicina Tropical*, Uberaba, v. 39, n. 6, p. 523-526, 2006. http://doi.org/10.1590/S0037-86822006000600002

LUTINSKI, J. A.; AHLERT, C. C.; FREITAS, B. R.; TRAUTMANN, M. M.; TANCREDO, S. P.; GARCIA, F. R. M. Ants (Hymenoptera: Formicidae) in hospitals of southern Brazil. *Revista Colombiana de Entomologia*, v. 41, n. 2, p. 235-240, 2015. Available from: <http://www.scielo.org.co/pdf/rcen/v41n2/v41n2a14.pdf>. Accessed on: Dec. 05, 2019.

LUTINSKI, J. A.; GUARDA, C.; LUTINSKI, C. J.; DORNELES, F. E.; PEDROSO, J.; BUSATO, M. A.; GARCIA, F. R. M. Assembleias de formigas (Hymenoptera: Formicidae) respondem ao processo de recuperação de áreas de preservação permanente? *Revista Brasileira de Ciências Ambientais*, n. 50, p. 112-127, 2018a. http://doi.org/10.5327/Z2176-947820180402

LUTINSKI, J. A.; ILHA, C.; LUTINSKI, C. J.; BAUCKE, L.; FILTRO, M.; BUSATO, M. A.; GARCIA, F. R. M. Ant fauna associated with areas under the direct impact of small hydropower plants in the state of Paraná, Brazil. *Revista Brasileira de Ciências Ambientais*, n. 46, p. 2-13, 2017a. http://doi.org/10.5327/Z2176-947820170196

LUTINSKI, J. A.; LUTINSKI, C. J.; BELING, J. F.; BUSATO, M. A.; CORRALO, V. Ant assemblages (Hymenoptera: Formicidae) associated to environments of a rural property in the extreme western region of the state of Santa Catarina, *Revista Brasileira de Ciências Ambientais*, n. 47, p. 12-23, 2018b. http://doi.org/10.5327/Z2176-947820180180

LUTINSKI, J. A.; LUTINSKI, C. J.; LOPES, B. C.; MORAIS, A. B. B. Efeitos microclimáticos e temporais sobre a assembléia de formigas (Hymenoptera: Formicidae) de áreas urbanas do oeste de Santa Catarina. *In*: LUTINSKI, J. A. (org.). *Formigas em ambientes urbanos de Santa Catarina*. Curitiba: CRV, 2017b. 126 p. p. 95-123.

LUTINSKI, J. A.; LUTINSKI, C. J.; LOPES, B. C.; MORAIS, A. B. B. Estrutura da comunidade de formigas (Hymenoptera: Formicidae) em quatro ambientes com diferentes níveis de perturbação antrópica. *Ecología Austral*, Córdoba, v. 24, p. 229-237, 2014. http://www.scielo.org.ar/pdf/ecoaus/v24n2/v24n2a12.pdf

MARTINS, L.; ALMEIDA, F. S.; MAYHÉ-NUNES, A. J.; VARGAS, A. B. Efeito da complexidade estrutural do ambiente sobre as comunidades de formigas (Hymenoptera: Formicidae) no município de Resende, RJ, Brasil. *Revista Brasileira de Biociências*, Porto Alegre, v. 9, n. 2, p. 174-179, 2011.

MÁXIMO, H. J.; FELIZATTI, H. L.; CECCATO, M.; CINTRA-SOCOLOWSKI, P.; BERETTA, A. L. R. Z. Ants as vectors of pathogenic microorganisms in a hospital in São Paulo county, Brazil. *BMC Research Notes*, v. 7, p. 1-5, 2014. http://doi.org/10.1186/1756-0500-7-554

MCKINNEY, M. L. Urbanization, biodiversity, and conservation. *BioScience*, v. 52, n. 10, p. 883-890, 2002. http://doi.org/10.1641/0006-3568(2002)052[0883:UBAC]2.0.CO;2

NEVES, L.; LUTINSKI, J. A.; SABEDOT-BORDIN, S. M.; BUSATO, M. A. Formigas (Hymenoptera: Formicidae) que ocorrem em ambientes de reciclagem do município de Chapecó. *Revista NBC*, v. 9, n. 18, p. 67-82, 2019.

OLIVEIRA, M. F.; CAMPOS-FARINHA, A. E. C. Formigas urbanas do município de Maringá, PR, e suas implicações. *Instituto Biológico*, São Paulo, v. 72, n. 1, p. 33-39, 2005.

PEREIRA, R. S.; UENO, M. O. Presença de bactérias resistentes aos antimicrobianos em formigas de ambiente hospitalar. *Revista Biociências*, Taubaté, v. 19, n. 2, p. 83-87, 2013.

RIZZOTTO, A. M.; ROANI, A. H.; GUARDA, C.; GIOVENARDI, R.; LUTINSKI, J. A. Mirmecofauna em áreas de preservação permanente e plantios florestais no noroeste do Rio Grande do Sul. *Ciência Florestal*, v. 29, n. 3, p. 1227-1240, 2019. https://doi.org/10.5902/1980509836279

ROANI, A. H.; RIZZOTTO, Â. M.; GUARDA, C.; GIOVENARDI, R.; LUTINSKI, J. A. Formigas em ambientes urbanos da região noroeste do Rio Grande do Sul. *Revista Brasileira de Ciências Ambientais*, n. 51, p. 128-140, 2019. https://doi.org/10.5327/Z2176-947820190464

ROMERO, H.; JAFFE, K. A comparison of methods for sampling ants (Hymenoptera: Formicidae) in Savanna. *Biotropica*, Caracas, v. 21, n. 4, p. 348-352, 1989. https://doi.org/10.2307/2388285

SANTOS, M. F. S.; DELLA-LUCIA, T. M. C.; DELABIE, J. H. C. A ocorrência de formigas em hospitais de Viçosa, MG. *Biológico*, v. 64, n. 1, p. 1-122, 2002.

SARMIENTO, M. C. E. Metodologías de captura y estudio de las hormigas. *In*: FERNÁNDEZ, F. (ed.). *Introducción a las hormigas de la región neotropical*. Bogotá: Instituto de Investigación de Recursos, Biológicos Alexander von Humboldt, 2003. p. 201-210.

SCHWINGEL, I.; LUTINSKI, J. A.; QUADROS, S. O.; BUSATO, M. A.; TEO, C. R. P. A. Formigas (Hymenoptera: Formicidae) em centros de saúde da família de Chapecó, SC. *Hygeia*, Uberlândia, v. 12, n. 23, p. 111-121, 2016.

SILVA, E. J. E.; LOECK, A. E. Ocorrência de formigas domiciliares (Hymenoptera: Formicidade) em Pelotas, RS. *Revista Brasileira de Agrociência*, v. 5, n. 3, p. 220-224, 1999.

SILVA, L. T.; PICHARA, N. L.; PEREIRA, M. A.; FIORINI, J. E. Formigas como veículo de patógenos no Hospital Universitário Alzira Velano, em Alfenas - MG. *Revista Médica de Minas Gerais*, v. 15, n. 1, p. 13-16, 2005.

SILVESTRE, R.; BRANDÃO, C. R. F.; SILVA, R. R. Grupos funcionales de hormigas: el caso de los gremios del Cerrado. *In*: FERNÁNDEZ, F. (ed.). Introducción a las hormigas de la región Neotropical. Bogotá: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, 2003. p. 113-148.

TABER, S. W. *The world of the harvester ants*. College Station: Texas A & M University Press, 1998.

TANAKA, A. J. M.; VIGGIANI, A. M. F. S.; PERSON, O. C. Bactérias veiculadas por formigas em ambiente hospitalar. *Arquivos Médicos ABC*, São Paulo, v. 32, n. 2, p. 60-63, 2007.

WATKINS, J. F. *The identification and distribution of New World army ants Dorylinae:* Formicidae). Waco: Markham Press Fund of Baylor University Press, 1976.