Acta Scientiarum. Biological Sciences
ISSN: 1679-9283
eduem@uem.br
Universidade Estadual de Maringá
Brasil

Cantone, Stefano Marco; de Carvalho Campos, Ana Eugênia
Nesting and reproduction of Pachycondyla striata (Formicidae: Ponerinae) in urban areas: an ant that offers risk of accidents
Acta Scientiarum. Biological Sciences, vol. 37, núm. 3, julio-septiembre, 2015, pp. 337-344
Universidade Estadual de Maringá
Maringá, Brasil

Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1679-9283
ISSN on-line: 1807-863X
Doi: 10.4025/actascibiolsci.v37i3.27584

Nesting and reproduction of *Pachycondyla striata* (Formicidae: Ponerinae) in urban areas: an ant that offers risk of accidents

Stefano Marco Cantone and Ana Eugênia de Carvalho Campos*

*Unidade Laboratorial de Referência em Pragas Urbanas, Instituto Biológico, Av. Conselheiro Rodrigues Alves, 1252, 04014-002, São Paulo, São Paulo, Brazil. *Author for correspondence. E-mail: anaefari@biologico.sp.gov.br*

ABSTRACT. It was conducted a research, in urban areas, on the nesting habits and reproductive period of *Pachycondyla striata*, a species of ant that stings painfully. The study was motivated by the frequent reports of accidents in the city of São Paulo. The reports are more common during the reproductive seasons of the species, when the winged females sting the population, since they enter the houses of the people attracted to light. Although anaphylaxis for *P. striata* has not been reported yet, other close species may cause anaphylaxis, which makes important to understand their biology in order to take management and control measures. Fourteen green areas in the city of São Paulo, Brazil, were monitored in the search for the species and their nests that were found in 64.3% of the areas. The nests are located around the trunk base of the trees, between the roots that protrude from the ground, under the rocks and through the cracks and crevices on the sidewalks. The spatial distribution of the nests is random. The reproductive period of *P. striata* was monitored from April 2012 to November 2013, through passive collection and laboratory colony. The nuptial flights occur during the cooler and drier months of the year, between July and September.

Keywords: Ponerinae, biology, reproductive phenology, alate specimens.

Nidificação e reprodução de *Pachycondyla striata* (Hymenoptera: Formicidae) em áreas urbanas: uma espécie de formiga que oferece risco de acidentes

RESUMO. Foi realizada uma pesquisa sobre a nidificação e o período reprodutivo em área urbana de *Pachycondyla striata*, uma espécie de formiga que ferroa dolorosamente. O estudo foi motivado pelos frequentes relatos de acidentes com essa espécie de formiga na cidade de São Paulo. Os relatos são mais comuns nas épocas reprodutivas da espécie, quando fêmeas aladas entram no domicílio, atraídas pela luz. Apesar de não haver registros de choque anafilático com *P. striata,* há com outras espécies poneromorfas, de maneira que se faz necessário conhecer sua biologia para que se tomem medidas de manejo e controle. Quatorze áreas verdes na cidade de São Paulo, Brasil, foram investigadas em busca de ninhos, tendo sido encontrados em 64,3% delas. Os ninhos são distribuídos aleatoriamente e localizam-se em torno da base do tronco de árvores, entre raízes que projetam do solo, sob rochas, bem como em falhas e rachaduras de calçadas. O período reprodutivo foi monitorado de abril de 2012 a novembro de 2013, por meio de coleta passiva e em ninho artificial. Os voos nupciais ocorrem nos meses mais frios e secos do ano, entre julho e setembro.

Palavras-chave: Ponerinae, biologia,fenologia reprodutiva, alados.

Introduction

Among invertebrates, ants are the most species-rich and ecologically dominant animals of all the eusocial insects (HÖLLDOBLER;WILSON, 1990), and under certain circumstances some species may cause negative impacts, from altering an ecosystem by interfering with the mutualistic relationships, to becoming a medical or agricultural problem (HOLWAY et al., 2002).

Pachycondyla striata Fr. Smith is a Ponerinae Neotropical ant species, distributed in South America between the parallels 10°S and 35°S. It is present in Brazil, Bolivia, Paraguay, Uruguay and North Argentina, and colonies have been found since the sea level until 1,300 meters in altitude (MACKAY; MACKAY, 2010). Medeiros and Oliveira (2009) excavated nests, and recorded from five to six interconnected chambers located between 5 and 80 cm beneath the ground surface, with two or eight entrances beneath the leaf litter (from 20 to 80 cm apart from each other), but with the ant traffic occurring only through a single main entrance. Colonies can be polygynous and

monogynous (RODRIGUES et al., 2011). It is considered a generalist predator ant, feeding on insect carcass, fruits, and hunting other arthropods (GIANNOTTI; MACHADO, 1994). The workers and alate reproductive forms are relatively large, from 13.2 to 16.7 mm (KEMPF, 1961).

This species was already registered in Brazil in the Restinga Forest (PASSOS; OLIVEIRA, 2003), in the *Eucalyptus* forests (FONSECA; DIEHL, 2004), in the Atlantic Forest (ROSUMEK et al., 2008; MEDEIROS; OLIVEIRA, 2009), in Cerrado (SOARES et al., 2010) and in the urban area (SILVA-MELO; GIANNOTTI, 2010). Workers and queens are able to sting effectively, due to their predator habits (SILVA-MELO; GIANNOTTI, 2011), and they can be a threat to public health.

Ants do not lose their stings after stinging their prey, and some venoms are neurotoxic, cytolytic, or may even cause both effects (HÖLLDOBLER; WILSON, 1990), including the Ponerinae ants. The efficacy of the sting as a defense weapon of the insects is based on the toxic properties and the pronounced allergenic effect of the secretion produced by the venom gland (ORTIZ; MATHIAS, 2006). Ponerinae ants include over 1,600 species (BOLTON et al., 2006), many of which are well known for their potent sting, which may cause anaphylactic shock. As an example, *Brachyponera chinensis* (Emery) (=*Pachycondyla chinensis*) is an Old World species that was introduced into the New World, that has a painful sting that can induce severe allergic reaction (MACKAY; MACKAY, 2010; GUÉNARD; DUNN, 2010).

Pachycondyla striata may be a threat to human health due to the stings of the workers or alate females. Citizens report the accidents to the health technicians in the Municipality of São Paulo that, in turn, seek information in the research institutes. In this context, this study aimed to register where the *P. striata* nests are located, how their spatial distribution are characterized, and the reproductive period of the species. Such data are expected in order to inform the general public about this species and to be the bases for the management, control, and for the preventive measurements against this Ponerinae ant.

Material and methods

The study was conducted in the city of São Paulo (23°33'S; 46°37'W; 800 m in altitude), located in Southeast Brazil. The city has a humid subtropical climate (Cwa), according to the Köppen classification, characterized by a dry winter and a rainy summer, presenting annual precipitation of 1,376.2 mm and annual average temperatures between 17 and 24ºC (CEPAGRI, 2014). São Paulo is within the Atlantic Forest biome, a world hotspot characterized as a mosaic of plant physiognomies that range from dense, open and mixed rainforests. It is the biggest city of Latin America and one of the five biggest metropolitan areas of the world (IBGE, 2000). The city is almost completely urbanized with many buildings that offer suitable conditions for several synantropic species, including ants (RIBEIRO et al., 2012; PIVA; CAMPOS, 2012).

Survey of *Pachycondyla striata* nests

Fourteen urban green areas in the city were visited in the period from April 2012 to April 2013 (Figure 1) for the search of *P. striata* nests and collections of workers. Depending on the size of the studied area, each area was visited once or twice in the period. One person did the searches for the nests at random, from 10h00 am up to 4h00 pm, uninterruptedly. When workers were seen foraging, they were followed until their return to the nests. They were then collected with forceps and placed into vials in 90% alcohol for further identification, following Kempf (1961) and Mackay and Mackay (2010). All nest locations were described, and the data are shown as being of presence/ absence of nests in the area.

Spatial distribution of nests

The spatial distribution of the nests of *P. striata* was determined in the park of the Instituto Biológico (IB) (Figure 1), a research institute, in October 2013. The evaluated area comprises a coffee crop with 1,500 plants, lawns, gardens with flowers, bushes, trees, palm trees, and buildings that house laboratories, administrative units and a library. The park is not open to public visitors as the other surveyed areas. The gardens, lawns and buildings are surrounded by paved areas in order to allow the traffic of cars and people.

The area was subdivided into 25 blocks of 10 x 36 m in order to facilitate the counting of nests. Every garden, lawn, tree root, rocks and crevices on the paved area were carefully searched for nests, by one person, in each block, which was daily visited for five consecutive days, from 10h00 am to 15h00 pm. When the nests were found, due to the flux of ant workers, their positions were plotted on the map of the park for further evaluation. Only the nests with visual activity of ants were included in this study in order to avoid the inclusion of abandoned nests, or to count different entrances of the same nest, once this species uses only one main entrance for the ant traffic (MEDEIROS; OLIVEIRA, 2009).

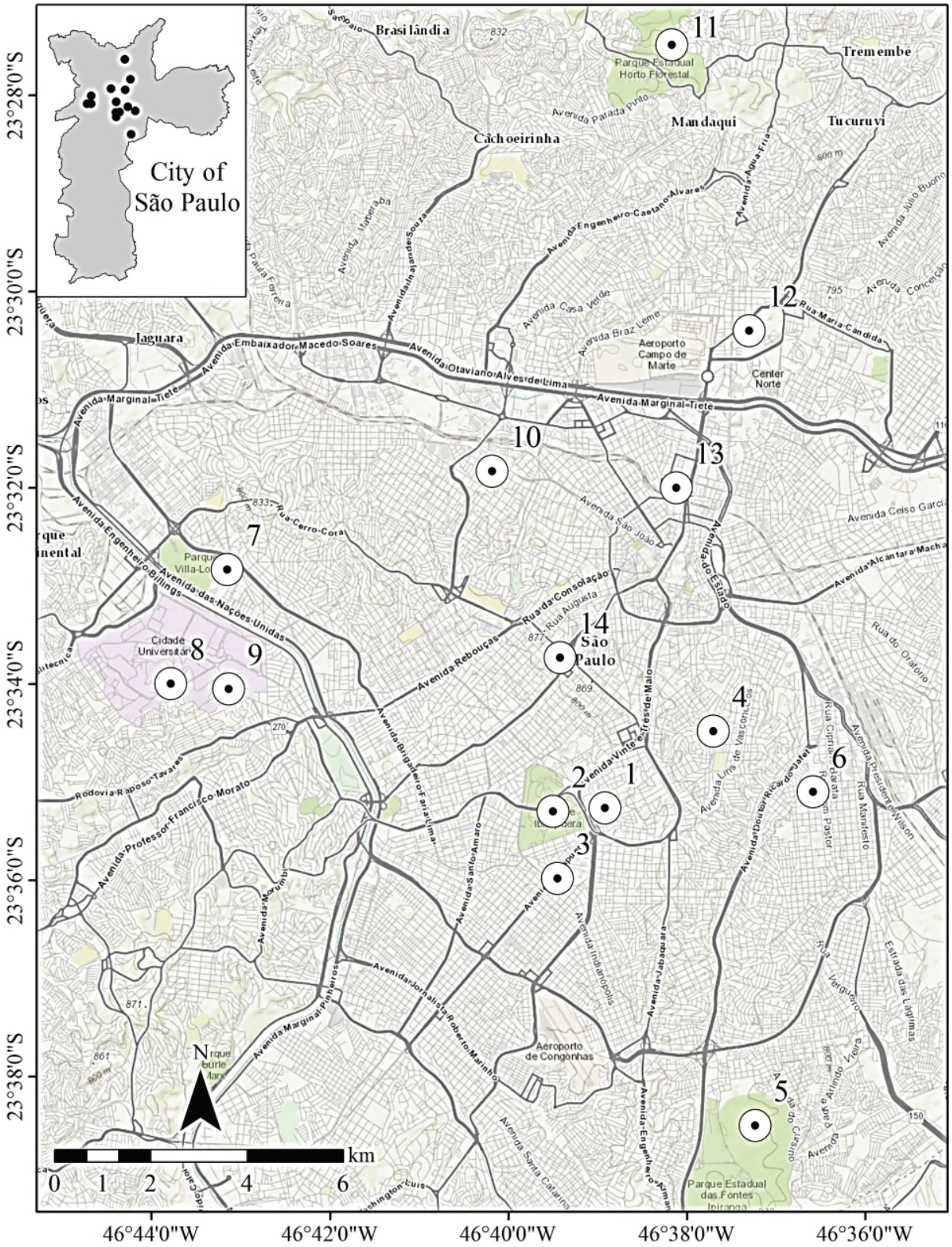

Figure 1. Parks surveyed in the city of São Paulo, for workers and nests of *Pachycondyla striata*. (1) Instituto Biológico, 0.9 ha; (2) Parque Ibirapuera★, 5 ha; (3) Parque das Bicicletas, 0.3 ha; (4) Parque da Aclimação, 0.8 ha; (5) Instituto de Botânica★, 4.0 ha; (6) Parque da Independência★, 3.0 ha; (7) Parque Villa Lobos★, 4.0 ha; (8) Parque Cidade Universitária★, 1.5 ha; (9) Instituto Butantan, 0.5 ha; (10) Parque da Água Branca★, 2.5 ha; (11) Parque Alberto Löefgreen★, 4.0 ha; (12) Parque da Juventude, 1 ha; (13) Parque da Luz★, 3.0 ha; (14) Parque Trianon, 1.0 ha. Parks with an asterisk (★) were visited twice. In hectares: areas monitored in each park.

In order to evaluate the spatial distribution of the nests, it was used the Dispersion Index (I), and to calculate it, the estimated rate of variance (S^2) and the mean number of nests were taken (LUDWIG; REYNOLDS, 1988; KREBS, 1989). For an aggregate distribution $I = S^2/\bar{x} > 1$, for a uniform distribution $I = S^2/\bar{x} < 1$, and for a random distribution $I = S^2/\bar{x} = 1$. In order to test the significance of the value I observed, the chi-square test was used at a 5% significance level.

Reproductive period

Three sites were chosen to study the reproductive period, one park and two buildings. Together, they totaled 19 months of observation.

The chosen park was located at the Instituto Biológico (Figure 1). Two light traps for collecting nocturnal reproductive forms were placed (model Luiz de Queiroz, using 15 W lamps with black light blue bulbs) at a height between two and seven meters from the soil in order to intercept the reproductive forms of *P. striata* in the different heights. One Malaise trap for collecting diurnal alates was also placed near the light traps, on the soil.

The insects captured were removed weekly from the traps from August 2012 to November 2013. The light traps had photoelectric cells to turn them on at sunset and off at sunrise. The insects attracted to the light traps were preserved in 1% formaldehyde solution in the field and taken to the laboratory, where they were thus, placed in 90% ethanol for subsequent sorting and identification. The gender and number of ants were evaluated. The voucher material is stored in the Coleção Entomológica Adolph Hempel (CEAH) of the Instituto Biológico.

In a building (hereinafter referred to as building A), another light trap was placed at a height of 45 meters, on the last floor, which had an open area. The light trap was left there from April 2012 to November 2013. The insects were weekly collected, and the ants were separated from the other taxa for identification. The Building A was chosen for the study due to the several complaints about the Ponerinae alate ants, mainly on the last floors, stinging the employees who worked in the building.

In the other building (hereinafter referred to as building B), the owner of the apartment on the last floor, at 80 meters in height, assumed the commitment of advising the authors of this research when the nuptial flights of the ants are observed in his property. The owner had reported to the Department of Health of the city of São Paulo (at SUVIS, Campo Limpo), on the presence of alate ants flying around and stinging members of his family. According to the biologists from the Department of Health, the complaints occurred annually, from 2010 to 2012, in the drier season, from July to August, when they then requested the assistance of the Instituto Biológico in order to identify the ant species and understand this biological event. The species was *P. striata*.

An artificial rearing from *P. striata* females, recently mated, was also implemented in order to register the exact time of the alate production. Sixty females were collected on August 30, 2012, and were taken alive to the laboratory and placed in two terrariums of 50 x 30 x 40 cm, with 30 females in each terrarium. Ants were provided with soil, water and fed daily with *Tenebrio molitor* Linnaeus (Coleoptera: Tenebrionidae), bee larvae, and blackberries. The ant rearing was observed daily for 12 months to the emergence of workers and reproductive forms.

The Meteorological registers for the study period were obtained at the National Institute of Meteorology – Mirante-Santana (INMET), in São Paulo.

Results and discussion

Survey of *Pachycondyla striata* nests

Workers of *P. striata* forage individually or in pairs on the soil and they were not hard to be found walking among plants and on the paved spaces of the surveyed areas. Tanden running, the habit of two workers walking in pairs is a common behavior in the genus *Pachycondyla*, to lead nestmates to new localities such as the rich sources of food, or new nest sites (TRANIELLO; HÖLLDOBLER, 1984).

Workers and their nests were found in nine of the 14 surveyed green areas, mainly around the base of tree trunks, among their roots that are project from the ground, under the rocks, and in the crevices on the sidewalks. They were never found directly on the lawns and gardens. Medeiros and Oliveira (2009), and Silva-Melo and Giannotti (2010) also reported that the nests were located in shaded areas near the trees of medium and large size, in places with few herbaceous plants on the campus of the State University of São Paulo (UNESP) in the city of Rio Claro, Brazil.

In five parks (35.8%), Parque Trianon, Parque da Independência, Parque da Água Branca, Parque da Luz, and Parque Villa Lobos (Figure 1), neither workers nor nests of this ant species were found. In these monitored green areas, the ground was cleaned weekly in order to have the fallen leaves removed, with the exception of the Parque Trianon where a huge layer of leaf litter was present. The litter layer

hindered the search for nests, but even in the cleanest gardens and lawns, no nests were found. The Parque da Independência, Parque da Água Branca, and the Parque da Luz had the most compacted soils due to the grass and the use of the lawns by users of the park to rest and for outdoor activities, in which may interfere in the establishment of the ant species. In the Parque da Água Branca, several free-range species of birds such as chickens, ducks, and peacocks are found in its area. They scratch the ground all day, which may limit the nesting by *P. striata*. The Parque Villa Lobos was built on a swampy area; the soil is often waterlogged, with accumulation of puddles on the lawns and gardens, so it is clear that the environment is not suitable for the establishment of ants. The most common species in this park was *Solenopsis invicta* Buren, being observed few other ant species. The workers of *Solenopsis* were collected and identified through the mitochondrial gene cytochrome oxidase I (COI) (GUSMÃO et al., 2010).

Spatial distribution of nests

Twenty six nests of *P. striata* were found in the sampled area (0.9 ha) in the park of the Instituto Biológico, most of them were among the tree roots and on the crevices of the sidewalks around the buildings, as were nests found in other areas surveyed in this study. The locations of the nests corroborate the observations made by Silva-Melo and Giannotti (2010) and Medeiros and Oliveira (2009) who reported nests in the shady areas and in close proximity to live trees.

The spatial distribution of the nests was at random ($I = 1.04$, $\chi^2 = 24.96$, d.f. = 24), throughout the area. Based on such distribution, when searching for the nests of *P. striata*, they should be sought in every tree root and crevices on the sidewalks, and around the human constructions. Efforts should be taken in these places so that the soil does not need to be directly investigated.

Reproductive period

The light traps captured 1,348 alates of *P. striata* at the building A (Figure 2). At the park of the Instituto Biológico (IB), the Malaise traps did not capture any ant, and the light traps captured only five specimens, in August 2013. The poor efficiency in capturing the specimens at the IB was due to the time of the nuptial flights, from 10h00 am to 1h00 pm, and to the occurrence of the mating flights at high altitudes. Since the Malaise traps were placed on the ground, they were not efficient in capturing the insects, or the nocturnal flights were not common, which explains the low capture by the light traps. Additionally, as the light trap in the building A was placed in a terrace, at a height of 45 meter, the males and females were gathered in the place during the day and were attracted by the lamp during the night, what explains the efficiency in the capture in this latter case.

In the first year of the study, flight activities occurred in late August/early September, only. In the second year, they occurred from July to September, but peaks occurred in late August/early September, during the winter, the driest and coldest season in southeast Brazil, declining sharply after September 18th and ceasing during the last week of September (Figure 2). According to Wolda (1986; 1992) timing of peaks may vary from year to year.

Males were captured more frequently than females at a ratio of 1.6♂:1♀ (826♂:522♀). It is not possible to infer if the highest number of males captured is an artifice of the light trap design or if the male numbers are indicative of the mating strategies of this species. According to the published records, two types of mating behaviors seem to predominate in ants (HÖLLDOBLER; BARTZ, 1985; HÖLLDOBLER; WILSON, 1990): (i) males that fly in large swarms or are gathered in central places where females can choose among males, and (ii) females that call males. In this latter behavior, flights tend to be asynchronous and may last for many months with occasional males flying out to search for calling females.

The reproductive period varies among the ant species and the geographical regions, and a huge amount of energy is wasted to produce the reproductive forms, males and females (HÖLLDOBLER; WILSON, 1990). The synchronism for producing alate specimens in nearby colonies is essential for the successful reproduction. Such synchronism can be triggered by the abiotic factors such as temperature, rainfall and luminosity (KASPARI et al., 2001).

In the city of Rio Claro, 180 km away from the city of São Paulo, Silva-Melo and Gianotti (2010) registered a maximum of 80 males, when a nest of *P. striata* was excavated. Based on this information, the high number of reproductive forms captured in our study, indicates a synchronization of nuptial flights of several nests in the city of São Paulo in the same period.

In both buildings, A and B, the reproductive forms were observed for consecutive days in the same period in which the alate forms were captured in the light traps, from August to the end of September.

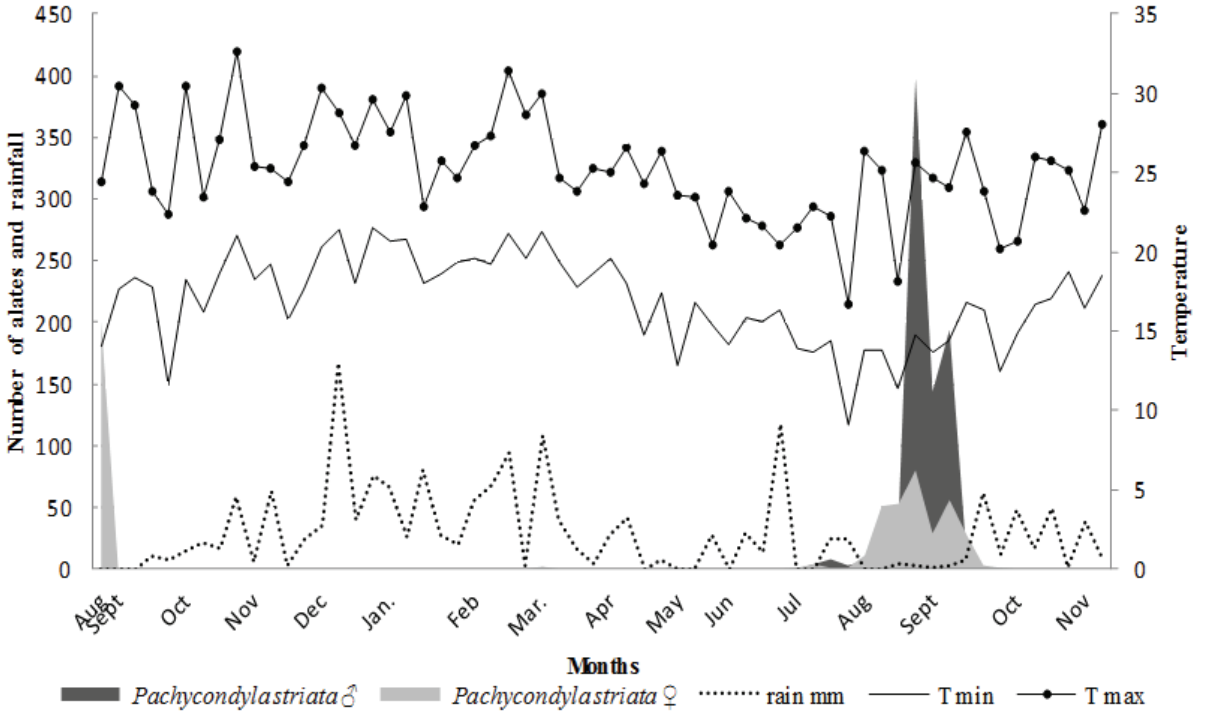

Figure 2. Reproductive period of *Pachycondyla striata* in the city of São Paulo, with data of temperature and rainfall.

In the artificial rearing boxes 45 (75%) females between the captured females died. The 15 remaining females produced only males, in April 2013, but both sexes emerged, from August to September. In the same period, the nuptial flights were recorded in the city of São Paulo. Although we did not measure the workers and alate specimens, they seemed to be as large as reported by Kempf (1961). The first workers emerged in November 2012, three months after the establishment of the artificial rearing.

The alate forms of *P. striata*, already deposited in the CEAH (Table 1), were collected at different altitudes and latitudes in the southeast region of Brazil, as in this study. The data showed that this species is highly synchronous in its nuptial flight time, except in the municipality of Ouro Fino, Minas Gerais State, where the reproductive forms were captured in October. Mackay and Mackay (2010) have also recorded dealate females, that is, females that had already been inseminated in this month in Brazil.

Two different episodes of records of alates were in April and May 2012, and 2013. Four males were captured in the building A and, in the same period, the artificial rearing colony also produced males.

Other surveys should be conducted in the other regions of Brazil in order to determine if the time of reproduction is also similar to those observed in this study.

Table 1. Alate females of *Pachycondyla striata* deposited in the Coleção Entomológica Adolph Hempel (CEAH).

City	Date	Altitude	Latitude	Gender
Petrópolis (RJ)	October, 1920	863 m	22°30'38" S 43°10'43" W	♀ and ♂
Rio de Janeiro (Tijuca)	July, 1926	5 m	22°59'29" S 43°21'08" W	♀
Rio de Janeiro	July, 1928	30 m	22° 54'42" S 43°12'27" W	♀
Ouro Fino (MG)	October, 1928	907 m	22°16'43" S 46°21'56" W	♀ and ♂
São Paulo (Ipiranga)	September, 1931	768 m	23°35'06" S 46°35'55" W	♀

Conclusion

Nests of *Pachycondyla striata* were found in nine from 14 monitored green areas in São Paulo, São Paulo State, located around the base of tree trunks, among their roots, under the rocks, and in crevices on the sidewalks. The spatial distribution of the nests is at random. The nuptial flights occur from July to September, and swarming from 10h00 am to 1h00 pm, at an altitude between 45 and 80 m from the ground. Such data can help to find the nests in order to control the species and on the prevention of flying ants entering the households during the mating periods.

Acknowlegements

The authors acknowledge the scholarship received from CAPES to Stefano Cantone for his Master's studies, and the molecular identification

of *Solenopsis invicta* by Dr. Ricardo Harakava, and also Dr. Eduardo de Masi, from the Department of Health of the city of São Paulo (SUVIS, Campo Limpo), for the discussion on human accidents with *Pachycondyla striata* reported to his institution. We also appreciate the suggestions made by two anonymous referees that improved our manuscript.

References

BOLTON, B.; ALPERT, G.; WARD, P. S.; NASKRECKI, P. **Bolton's catalogue of ants of the world 1758-2005**. Cambridge: Harvard University Press, 2006. CD-ROM.

CEPAGRI-Centro de Pesquisas Meteorológicase Climáticas Aplicadas à Agricultura. **Clima dos municípios paulistas**. Available from: <http://www.cpa.unicamp.br/outras-informacoes/clima_muni_565.html>. Access on: Mar. 17, 2014.

FONSECA, R. C.; DIEHL, E. Riqueza de formigas (Hymenoptera, Formicidae) epigéicas em povoamentos de *Eucalyptus* spp. (Myrtaceae) de diferentes idades no Rio Grande do Sul, Brasil. **Revista Brasileira de Entomologia**, v. 48, n. 1, p. 95-100, 2004.

GIANNOTTI, E.; MACHADO, V. L. L. Notes on the foraging of two species of Ponerinae ants: food resources and daily hunting activities (Hymenoptera, Formicidae). **Bioikos**, v. 6, n. 1-2, p. 7-17, 1994.

GUÉNARD, B.; DUNN, R. R. A new (old), invasive ant in the hardwood forests of eastern North America and its potentially widespread impacts. **PLoS ONE**, v. 5, n. 7, e11614, 2010.

GUSMÃO, F. A.; HARAKAVA, R.; CAMPOS, A. E. C. Fire-Ants of the *Solenopsis saevissima* species-group (Hymenoptera: Formicidae) nesting in parks in the city of São Paulo: identification based on mtDNA sequences and morphological characters. **Sociobiology**, v. 56, n. 2, p. 353-362, 2010.

HÖLLDOBLER, B.; BARTZ, S. H. Sociobiology of reproduction in ants. In: HÖLLDOBLER, B. (Ed.) **Experimental behavioral ecology**. Verlag: Stuttgart, 1985. p. 237-257.

HÖLLDOBLER, B.; WILSON, E. O. **The ants**. Cambridge: The Belknap Press, 1990.

HOLWAY, D. A.; LACH, L.; SUAREZ, A. V.; TSUTSUI, N. D.; CASE, T. J. The causes and consequences of ant invasions. **Annual Review of Ecology Systematics**, v. 33, p. 181-233, 2002.

IBGE-Instituto Brasileiro de Geografia e Estatística. **Censo 2000**. Available from: <http://www.ibge.gov.br/home/estatistica/populacao/default_censo_2000.shtm> Access on: Mar. 17, 2014.

KASPARI, M.; PICKERING, J.; LONGINO, J. T.; WINDSOR, D. The phenology of a Neotropical ant assemblage: evidence for continuous and overlapping reproduction. **Behavioral Ecology and Sociobiology**, v. 50, n. 4, p. 382-390, 2001.

KEMPF, W. W. As formigas do gênero *Pachycondyla* Fr. Smith no Brasil. **Revista Brasileira de Entomologia**, v. 10, n. ?, p. 189-204, 1961.

KREBS, C. J. **Ecological metodology**. New York: Harper and Hall, 1989.

LUDWIG, J. A.; REYNOLDS, J. F. **Statistical ecology**: a primer on methods and computing. New York: John Wiley and Sons, 1988.

MACKAY, W. P.; MACKAY, E. E. **The systematics and biology of the new world ants of the genus *Pachycondyla* (Hymenoptera: Formicidae)**. Lewinston-Queenston-Lampeter: The Edwin Mellen Press, 2010.

MEDEIROS, F. N. S.; OLIVEIRA, P. S. Season-dependent foraging patterns case study of a neotropical forest-dwelling ant (*Pachycondyla striata*; Ponerinae). In: JARAU, S.; HRNCIR, M. **Food exploitation by social insects: ecological, behavioral, and theoretical approaches**. Boca Raton: Taylor and Francis Group, 2009. p. 81-95.

ORTIZ, G.; MATHIAS, M. I. C. Venom gland of *Pachycondyla striata* worker ants (Hymenoptera: Ponerinae). Ultrastructural characterization. **Micron**, v. 37, n. 3, p. 243-248, 2006.

PASSOS, L.; OLIVEIRA, P. S. Interactions between ants, fruits and seeds in a restinga forest in south-eastern Brazil. **Journal of Tropical Ecology**, v. 19, n. 3, p. 261-270, 2003.

PIVA, A.; CAMPOS, A. E. C. Ant community structure (Hymenoptera: Formicidae) in two neighborhoods with different urban profiles in the city of São Paulo, Brazil. **Psyche: A Journal of Entomology**, v. 2012, p. 1-8, 2012.

RIBEIRO, F. M.; SIBINEL, N.; CIOCHETI, G.; CAMPOS, A. E. C. Analysis of ant communities comparing two methods for sampling ants in an urban park in the city of São Paulo, Brazil. **Sociobiology**, v. 59, n. 1, p. 971-984, 2012.

RODRIGUES, M. S.; VILELA, E. F.; AZEVEDO, D. O.; HORA, R. R. Multiple queens in founding colonies of the neotropical ant *Pachycondylastriata* Smith (Formicidae: Ponerinae). **Neotropical Entomology**, v. 40, n. 3, p. 293-299, 2011.

ROSUMEK, F. B.; ULYSSÉA, M. A.; LOPES, B. C.; STEINER, J.; ZILLIKENS, A. Formigas de solo e de bromélias em uma área de Mata Atlântica, Ilha de Santa Catarina, sul do Brasil: Levantamento deespécies e novos registros. **Biotemas**, v. 21, n. 4, p. 81-89, 2008.

SILVA-MELO, A.; GIANNOTTI, E. Nest architecture of *Pachycondyla striata* Fr. Smith, 1858 (Formicidae: Ponerinae). **Insectes Sociaux**, v. 57, n. 1, p. 17-22, 2010.

SILVA-MELO, A.; GIANNOTTI, E. Life expectancy and entropy values for workers of *Pachycondyla striata* (Hymenoptera: Formicidae: Ponerinae). **Sociobiology**, v. 58, n. 1, p. 143-150, 2011.

SOARES, S. A.; ANTONIALLI-JUNIOR, W. F.; LIMA-JUNIOR, S. E. Diversidade de formigas epigéicas

(Hymenoptera, Formicidae) em dois ambientes no Centro-Oeste do Brasil. **Revista Brasileira de Entomologia**, v. 54, n. 1, p. 76-81, 2010.

TRANIELLO, J.; HÖLLDOBLER, B. Chemical communication during tandem running in *Pachycondyla obscuricornis* (Hymenoptera, Formicidae). **Journal of Chemical Ecology**, v. 10, n. 5, p. 783-794, 1984.

WOLDA, H. Nocturnal bee abundance and seasonal bee activity in a Panamanian forest. **Ecology**, v. 67, n. 2, p. 426-433, 1986.

WOLDA, H. Trends in abundance of tropical forest insects. **Oecologia**, v. 89, n. 1, p. 47-52, 1992.

Received on April 28, 2015.
Accepted on July 3, 2015.