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SHORT NOTE

Fluctuation in the richness of social wasps throughout a large construction project

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Abstract

Since some social wasp species are sensitive to environmental changes and can be used as bioindicators, the objective of the present study was to analyze the variation in the fauna of social wasps during the phases: before, during, and after completion, as well as to validate the use of wasps as a tool for monitoring the impacts generated by the implantation of the Botanical Garden of the Federal University of Juiz de Fora. Social wasps were sampled through active searching methods, searching for nests and attractive traps in the years 2011 and 2012 (before the construction), 2013, 2014, and 2016 (during the construction), and 2019 (after the construction and opening of the Botanical Garden). The richness and similarity of the species varied over the years, and it was possible to identify resistant and sensitive species to the impact caused by the implantation of the Botanical Garden. Studies with social wasp fauna conducted over many years in the same area can be an efficient tool in monitoring impacts; in addition, it is necessary to have a partnership between researchers and the management of the enterprises to mitigate the effects caused by guidelines and environmental education.

Habitat change is an immediate consequence of human activities. In the year 2000, in Brazil, the urban population consisted of approximately 138 million people, and in the last decade of the 20th century alone, Brazilian cities increased by 22,718,968 people (Maricato, 2000). Thus, the interest in green areas emerged to mitigate the problems caused by fragmentation, which in the historical context took place from the practice of gardening in Egypt and religious cults in China until they took on the public role of leisure and recreation for the people first time in Greece (Loboda & Angelis, 2005).

In addition to the objective of fun and leisure, a Botanical Garden has a scientific character aimed at preserving and conserving biodiversity with a collection of flora in an orderly, cataloged, and classified manner, with everything duly registered and documented (Portugal, 2012). Although the ultimate goal is interacting with nature through environmental education interventions like any other enterprise, a Botanical Garden generates environmental impacts in its three stages: implementation, operation, and eventual expansion. Such damage can occur to a particular species or a community. It can also cause the modification or even the elimination of the ecological relationships originally existing between plant species, pollinators, and dispersers (Stouffer & Bierregaard Junior, 1995).

The growing number of threatened species and the genetic impoverishment of the remaining populations are the main indicators of ecological degradation (Sánchez, 2015). In turn, insects are declining worldwide in their communities, as shown in the study by Sánchez-Bayo and Wyckhuys (2019), who highlight that more than 40% of species are threatened with extinction worldwide. The authors further state that land use change and landscape fragmentation are certainly the main cause of species decline among Coleoptera, Lepidoptera, and Hymenoptera. Given the ecological importance played by social wasps, the objective of the present study was, therefore, to evaluate the fluctuation of the social wasps' richness during

the phases: before, during, and after the conclusion of the works of Implantation of the Botanical Garden of the Federal University of Juiz de Fora.

The Botanical Garden (21°43'28" S - 43°16'47" W) is 84 ha. It is located on the urban perimeter of Juiz de Fora, southeast of Minas Gerais, Brazil, at 750 m altitude. It has a warm subtropical climate with dry winter and rainy summer (Cwa), according to the Köppen-Geiger classification (Sá-Júnior et al., 2012). The work covered the 20ha area inside the Botanical Garden, referring to the location leading to the building works. Formerly known as "*Sítio Malícia*", it was purchased in 1938 by Pedro Krambeck, where he built his house and started landscaping works with artificial lakes, araucaria boulevards, cedars, and paineiras, gardens, and orchards. Then in 2009, it was purchased by the Federal University of Juiz de Fora to create a Botanical Garden, with the beginning of construction in 2013.

The collections started in 2011, followed by the years 2012 (before the construction), 2013, 2014, and 2016 (during the construction), and 2019 (after the construction and opening of the Botanical Garden). The collections were opportunistically performed using active searching methods, searching for nests and attractive traps, with an average frequency of six campaigns per year (Prezoto et al., 2021). The species were classified as present or absent each year, thus considering only the richness of social wasps in the area. Each nest or individual sighted or collected was registered as the presence of the species for that year. Wasp species were identified using keys proposed by Richards (1978), Hermes and Kohler (2004), Silveira (2008), and Andena et al. (2009). The results of each collection were compared with the following ones using the Jaccard similarity index calculated from the total number of species per survey and generated by the PAST 3.08 program (Hammer et al., 2001).

A total of 38 species were recorded over the six years of study. It was possible to observe that as the vegetation area was removed to build new installations (Fig 1), the local fauna suffered richness loss, and in 2019, at the end of the building works, the richness of wasps was able to return to the site. There were 26 species registered in the area in 2011 before construction started. Richness remained stable until 2013, when construction began. The richness then decreased to eight species in 2014 and remained so until 2016, and that number then rose to 18 species after the opening of the Botanical Garden.

The similarity of the species varied over the years, with it being possible to observe two distinct groups of data influenced by the impact of the work; the years 2011, 2012, and 2013 suffered little or no disturbance due to the construction, and the year 2019 after completion of the construction was grouped. While the second group was represented by the years following the start of the construction (2014 and 2016) (Fig 2).

In analyzing the species by foundation strategy, 53% (n = 8) of the 15 species of the independent foundation were registered during the two years impacted by construction (2014 and 2016), with emphasis on *Mischocyttarus cassununga* (Von. Ihering, 1903) and *Polistes versicolor* (Olivier, 1791) which were present in all years. This is because the most intense phase of the building works was a major removal of vegetation cover, and the richness of social wasps suffered a great fall because wasps used the removed plants for nesting.

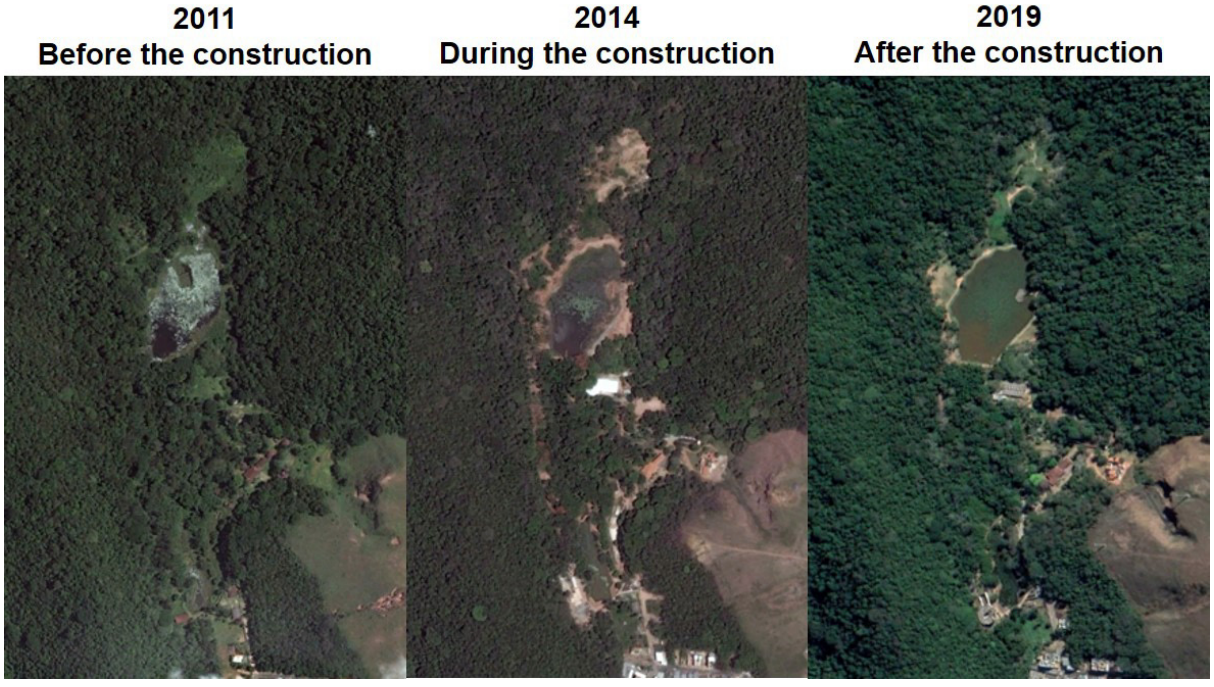

Fig 1. Satellite images of the study area for the years 2011 (before the construction), 2014 (during the construction), and 2019 (after the end of the construction).

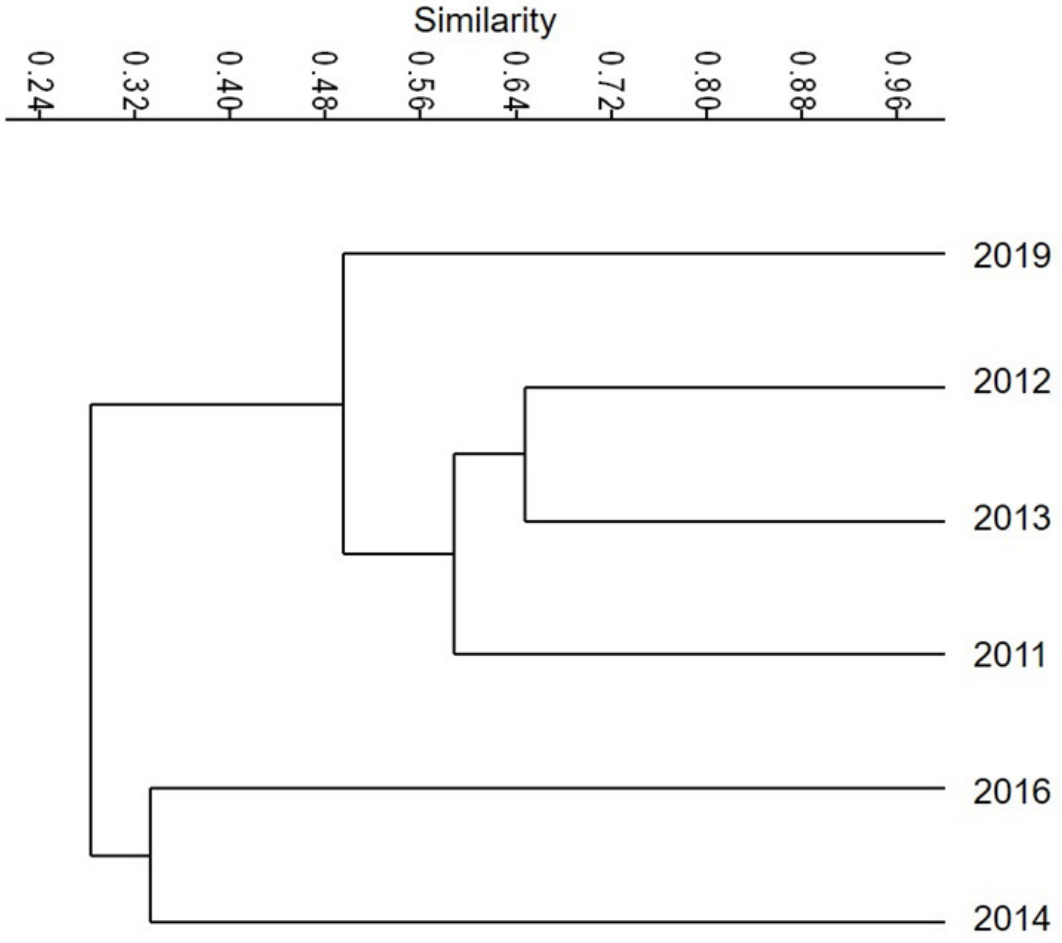

Fig 2. Similarity of the social wasp fauna recorded for seven years at the Botanical Garden of the Federal University of Juiz de Fora in Minas Gerais. The collections started in 2011 and 2012 before the construction, 2013, 2014, and 2016 during the construction, and 2019 after the construction and opening of the Botanical Garden.

Of the 23 species of swarming foundation, only 17% (n = 4) were recorded during those years, and only *Polybia platycephala* (Richards, 1951) appeared in all years. The lower frequency of swarming species registration during this period can be justified by the fact that the colonies of this group are more populous than those of independent foundation and therefore require a greater number of resources which also suffered an impact during the construction and had a drop in its availability. In addition, because they are larger than those with an independent foundation and therefore easier to be observed/found out, and because social wasps have a bad reputation, swarming species end up scaring people and motivating nest removal (Sumner et al., 2018); a fact which was frequently observed during the collection periods where construction and maintenance workers removed the colonies from the building structures.

Identifying resistant and sensitive species to the impact caused by the implantation of the Botanical Garden was possible. *Polybia platycephala*, *M. cassununga,* and *P. versicolor* species were registered in all the study years, corroborating that they are little impacted by anthropogenic disturbances (Alvarenga et al., 2010; Detoni et al., 2018). Moreover, *Apoica pallens* (Fabricius, 1804), *Polybia ignobilis* (Haliday, 1836), *Synoeca cyanea* (Fabricius, 1775), and *Polistes actaeon* Haliday, 1836 were only registered before construction started, and *Polybia sericea* (Olivier, 1791), was not recorded during the three years of construction, then reappearing in the year in which the construction had already been completed, explaining the high sensitivity of these species and indicating that they can be used as bioindicators of environmental impact.

In his work on the environmental impact assessment for the licensing of the Botanical Garden, Portugal (2012) says that actions such as vehicle traffic, use of terrestrial space, and cleaning and maintenance of terrestrial spaces during construction work menace terrestrial fauna. Furthermore, vegetation clearing (either understory or canopy stratum) and mechanical removal of nests for building repairs cause an immediate reduction in the fauna of social wasps. However, the effect is temporary and reversible, returning to balance at the end of activities. For example, landscaping and gardening are considered beneficial since the flora species diversity provides food and shelter, attracting the local fauna again, and these effects are permanent. Even exotic plants commonly used in gardening, such as fan palms [*Coccothrinax barbadensis*

Table 1. Occurrence of social wasps over six years (before construction in red, during construction in blue, and after construction and opening of Botanical Garden in black) at the Botanical Garden of the Federal University of Juiz de Fora in Minas Gerais. Dark bars indicate the occurrence of species in the study year.

Species/Year of occurrence	2011	2012	2013	2014	2016	2019	No. of occurrences
Tribe Epiponini							
Agelaia multipicta (Haliday, 1836)	■	■	■			■	4
Agelaia vicina (Saussure, 1854)	■	■	■			■	4
Apoica pallens (Fabricius, 1804)	■	■	■				3
Brachygastra augusti (Saussure, 1854)		■	■				2
Brachygastra lecheguana (Latreille, 1824)		■	■				2
Parachartergus fraternus (Gribodo, 1892)	■	■	■	■		■	5
Polybia bifasciata (Saussure, 1854)	■	■					2
Polybia chrysothorax (Lichtenstein, 1796)		■	■				2
Polybia fastidiosuscula Saussure, 1854	■	■	■		■	■	5
Polybia ignobilis (Haliday, 1836)	■	■	■				3
Polybia jurinei Saussure, 1854	■	■	■			■	4
Polybia liliácea (Fabricius, 1804)			■				1
Polybia lugubris Ducke, 1905		■				■	2
Polybia occidentalis Olivier, 1791			■				1
Polybia paulista (Ihering, 1896)		■					1
Polybia platycephala Richards, 1951	■	■	■	■	■	■	6
Polybia sericea (Olivier, 1791)	■	■	■			■	4
Polybia scutelaris (White, 1841)	■						1
Polybia striata (Fabricius, 1787)	■	■					2
Protonectarina sylveirae (Saussure, 1854)	■		■				2
Protopolybia exigua (Saussure, 1854)	■	■	■		■	■	5
Protopolybia sedula (Saussure, 1854)	■	■					2
Synoeca cyanea (Fabricius, 1775)	■	■	■				3
Tribe Mischocytarini							
Mischocyttarus araujoi Zikan 1949	■		■	■		■	4
Mischocyttarus socialis (Saussure, 1854)	■	■	■		■	■	5
Mischocyttarus cassununga (Von. Ihering, 1903)	■	■	■	■	■	■	6
Mischocyttarus drewseni Saussure, 1954	■	■	■	■	■	■	6
Mischocyttarus flavosculetatus Zikán, 1935	■			■		■	3
Mischocyttarus iheringi Zikán, 1935			■			■	2
Mischocyttarus rotundicollis (Cameron, 1912)	■	■				■	3
Mischocyttarus sp1		■					1
Mischocyttarus sp2	■	■	■				3
Mischocyttarus wagneri (Buysson, 1908)				■			1
Tribe Polistini							
Polistes actaeon Haliday, 1836	■	■	■				3
Polistes cinerascens Saussure, 1854	■						1
Polistes pacificus pacificus Fabricius 1804		■	■				2
Polistes simillimus Zikán, 1951		■	■		■	■	4
Polistes versicolor (Olivier, 1791)	■	■	■	■	■	■	7
Species richness by collection year	**26**	**29**	**27**	**8**	**8**	**18**	

(Lodd. Ex Mart.) Becc.], and Dracaenas [*Dracaena fragrans* (L.) Ker Gawl.], are often selected by social wasps to nest (Barbosa et al., 2020) and Astrapéia [*Dombeya wallichii* (Lindl.) Baill] and mango (*Mangifera indica* L.) for food (Barbosa et al., 2014; Barbosa et al., 2016).

Just as Portugal (2012) suggests that the fauna of impacted places reestablishes in the long term after an adaptation or selection of local populations following disturbances in their habitat, we observed the return of the social wasp fauna after the end of the construction. The social wasps showed, above all, a high return capacity since, in 2019, four years after the beginning of the building works, we observed 70% (n = 18) of species richness restored on the site. We want to remark that *P. sericea* returned to the site in the last year of the study. It was also possible to observe that species of independent foundation easily adapted to the newly built structures where they were establishing new colonies.

The impact generated by the building work on the local fauna is clear. Therefore, insect conservation experts must work with the administration to mitigate these impacts. Such a goal can be achieved by preventing colonies or animal nests from being destroyed, removing them properly when there is a risk of an accident, promoting an introduction of ornamental plants that not only naturally attract wasps but also other groups of insects and animals, thereby facilitating the return of fauna to the location.

The fluctuation in the richness of social wasps over the years explains the ability of these insects to adapt to the impacts suffered. A social wasp, and fauna survey work, carried out for many years in the same area, can be an efficient tool for monitoring building impacts. Thus, it is suggested that areas where large enterprises will be built undergo a detailed study of the local fauna before, during, and after construction.

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Tatiane T. Maciel – Conceptualization, sampling, investigation, and data curation;
Bruno C. Barbosa – Conceptualization, sampling, investigation, and data curation;
Fábio Prezoto – Conceptualization, investigation, and data curation;
All authors – Writing and revising.

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