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Effects of the COVID-19 pandemic on the number of accidents caused by bee attacks in a historical series from 2010 to 2022

Efeitos da pandemia de COVID-19 no número de acidentes causados por ataques de abelhas numa série histórica de 2010 a 2022

Efectos de la pandemia de COVID-19 en el número de accidentes causados por ataques de abejas en una serie histórica de 2010 a 2022

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Abstract
Introduction: Bees are an essential part of wildlife. However, deforestation, human-caused wildfires, and increasingly frequent agricultural and human activities in forested areas contribute to the occurrence of incidents involving Africanized bees. Aim: This study aimed to describe the epidemiological profile of bee attacks between January 2010 and December 2022, incorporating the pandemic period as an axis of analysis. Methods: Data on incidents involving bees were obtained of the the Health Information System of the Brazilian Ministry of Health from the July to December 2023. Results: The results demonstrated a progressive increase in the number of bee-related incidents during the evaluated period and the impact of measures adopted during the Covid-19 pandemic on the number of bee venom intoxications in Brazil, which decreased during the pandemic years; the seasonality of cases and the distribution of cases by victims' sex; the distribution by age group and the number of cases and deaths, which are higher in the states of Tocantins, Roraima, and Rio Grande do Norte and Roraima and Tocantins, respectively. Conclusions: Despite the pandemic, the data show that incidents involving bees continue to increase steadily, and public policymakers would benefit from implementing measures aimed at improving environmental and health education to reduce the number of bee attacks.
Keywords: Bee venoms; COVID-19; Venomous animals.

Resumo
Introdução: As abelhas são parte essencial da vida selvagem. No entanto, o desmatamento, as queimadas causadas pelo homem e as atividades agrícolas e humanas cada vez mais frequentes em áreas florestais contribuem na ocorrência de incidentes envolvendo abelhas africanizadas. Objetivo: O presente estudo teve por objetivo descrever o perfil epidemiológico de ataques de abelhas entre janeiro de 2010 a dezembro de 2022, incorporando o período

pandêmico como eixo de análise. Métodos: Os dados sobre os incidentes envolvendo abelhas foram obtidos via Sistema de Informação em Saúde do Ministério da Saúde do Brasil de julho a dezembro de 2023. Resultados: Os resultados demonstraram um aumento progressivo do número de incidentes envolvendo abelhas no período avaliado e o impacto das medidas adotadas durante a pandemia de Covid-19 no número de intoxicações por veneno de abelhas no Brasil, que diminuiu durante os anos da pandemia; a sazonalidade dos casos e a distribuição dos casos por sexo das vítimas; a distribuição por faixa etária e o número de casos e óbitos, que são maiores nos estados de Tocantins, Roraima e Rio Grande do Norte e Roraima e Tocantins, respectivamente. Conclusões: Apesar da pandemia, os dados mostram que os incidentes envolvendo abelhas ainda aumentam de forma constante, e os formuladores de políticas públicas fariam bem em realizar medidas que abordem a melhoria da educação ambiental e sanitária para reduzir o número de ataques de abelhas.
Palavras-chave: Venenos de abelhas; COVID-19; Animais venenosos.

Resumen
Introducción: Las abejas son una parte esencial de la vida silvestre. Sin embargo, la deforestación, los incendios provocados por el ser humano y las actividades agrícolas y humanas cada vez más frecuentes en áreas forestales contribuyen a la ocurrencia de incidentes que involucran abejas africanizadas. Objetivo: El presente estudio tuvo como objetivo describir el perfil epidemiológico de los ataques de abejas entre enero de 2010 y diciembre de 2022, incorporando el período pandémico como eje de análisis. Métodos: Los datos sobre los incidentes relacionados con abejas se obtuvieron a través del Sistema de Información en Salud del Ministerio de Salud de Brasil de julio a diciembre de 2023. Resultados: Los resultados demostraron un aumento progresivo en el número de incidentes relacionados con abejas durante el período evaluado y el impacto de las medidas adoptadas durante la pandemia de Covid-19 en el número de intoxicaciones por veneno de abejas en Brasil, que disminuyó durante los años de la pandemia; la estacionalidad de los casos y la distribución de los casos por sexo de las víctimas; la distribución por grupos de edad y el número de casos y muertes, que son mayores en los estados de Tocantins, Roraima y Rio Grande do Norte y Roraima y Tocantins, respectivamente. Conclusiones: A pesar de la pandemia, los datos muestran que los incidentes relacionados con abejas continúan aumentando de manera constante, y los responsables de la formulación de políticas públicas deberían implementar medidas orientadas a mejorar la educación ambiental y sanitaria con el fin de reducir el número de ataques de abejas.
Palabras clave: Venenos de abejas; COVID-19; Animales venenosos.

1. Introduction

Venomous animals are designated as those capable of producing or modifying a substance identified as venom, which also dispose of some way to inoculate said venom into a prey or predator. In Brazil, venomous animals most frequently associated with cases of moderate or severe poisoning include a number of species of snakes, scorpions, spiders, caterpillars and bees (Coordenação Geral de Doenças Transmissíveis, 2016).

According to Ordinance No. 1271 of June 6, 2014 (Ministério da Saúde, 2014), accidents involving these animals must be reported to the Ministry of Health of Brazil and the data summed up from such reports are made available to the general community via a national online platform named DATASUS, assisting policy makers, health professionals and scientists in stablishing and improving public health policies as well as in determining priorities regarding health interventions and assessing their impact (Ministério da Saúde, 2006).

Bees (Hymenoptera: Apoidea) are an important part of wildlife worldwide and not all of them have stingers and/or are venomous. There are more than 20,000 known species of bees in the world; in Brazil, it is estimated about 2,500 species can be found (Associação Brasileira de Estudo das Abelhas, 2020). These insects are major pollinators and are crucial for perpetuation and diversity of plant communities, playing a key role in preserving the ecosystems biomes they are integrated into (Santos & Mendes, 2016).

Africanized bees, *Apis mellifera* L. in particular, fit the definition of "venomous animals", as they possess a stinger in their abdomen alongside a venom sack. These bees originated in Brazil in the 1950s, resulting from the hybridization of exotic subspecies of African bees (*Apis mellifera scutellata*) brought from the African continent in mid-1956 with exotic subspecies of European bees (*Apis mellifera*), which could already be found in Brazilian wildlife at that time (Silva et al., 2019).

The polyhybrid populations of Africanized bees (i.e. *Apis mellifera* L.) have biological characteristics predominantly inherited from African bees, which display more aggressive behavior, higher swarming capacity, greater tolerance to tropical climate and greater resistance to pests and pathogens, making them better suited for beekeeping (Associação Brasileira de Estudo das Abelhas, 2020; Campos & Pereira, 2018; Santos & Mendes, 2016).

Increasing deforestation, larger wildfires, urbanization of rural areas and overall lack of knowledge regarding management of bees pose a threat to such animals, either in their natural environments or during beekeeping, not only compromising their role in wildlife but also increasing the occurrence of accidents involving intoxications due to bee attacks (Pettan-Brewer & Carneiro, 2021; Santos & Mendes, 2016).

According to the scientific literature, this type of intoxication involving accidents with bees has been steadily increasing year after year (Coordenação Geral de Doenças Transmissíveis, 2016; Santos; Mendes, 2016; Silva et al., 2019). According to a study published in 2019 (Silva et al., 2019), 138,674 cases of bee attacks and 410 deaths were recorded in Brazil in the period from 2000 to 2017 and the incidence of these accidents per 100 thousand individuals increased 10.25 times in the period.

Despite the growing body of literature addressing accidents involving bee stings in Brazil, most available studies focus on restricted timeframes or regional analyses, with limited exploration of long-term temporal trends under exceptional public health contexts. In this sense, there remains a scientific gap regarding the behavior of bee attack incidence during large-scale societal disruptions, such as the COVID-19 pandemic (Khan et al., 2020).

Therefore, by analyzing a national historical series spanning from 2010 to 2022, this study offers an original contribution by explicitly incorporating the pandemic period as an axis of analysis, allowing for a more comprehensive understanding of how public health emergencies and mobility restrictions may influence the epidemiology of bee-related accidents in Brazil.

2. Methodology

This investigation is a descriptive quantitative epidemiological study (Toassi & Petry, 2021) which was carried out utilizing the data on bee attacks reported to the Brazilian Health Information System (SINAN), administered by the Ministry of Health of Brazil (Ministério da Saúde, 2023) from the July to December 2023. Data assessed comprised bee attacks reported in the period between January 1, 2010 and December 31, 2022.

The data was gathered from a secondary database, with no access to nominal patient data or any other sort of information which could allow for patient identification, ensuring the study was carried out in compliance with Brazilian ethical standards, according to the Resolution of the National Health Council No. 510, of April 7, 2016 (Castro, 2016).

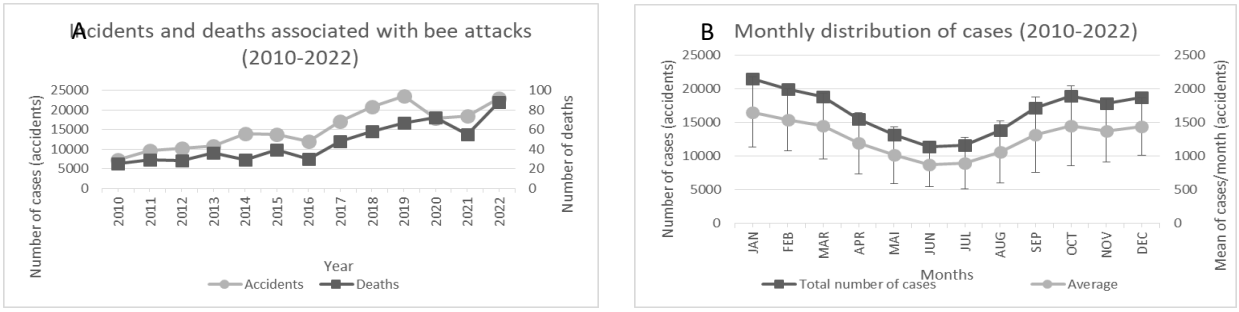
Bee attacks and other similar incidents are reported to Brazilian health management databases through a notification system which makes use of a specific form (roughly translated to “epidemiological investigation form – FIE”) containing a number of variables 3. For this study, the variables assessed and compiled comprise: year and month where the incident occurred, zone of notification, sex, age group, zone of occurrence and evolution of the case.

All variables were analyzed using descriptive statistics and were presented as raw numbers and frequency measures. The incidence of bee attacks was calculated using the number of occurrences in the states divided by the population x 100 thousand inhabitants (Shitsuka et al. 2014), according to the population estimates of the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística, 2023).

3. Results

The data obtained revealed that the number of bee attacks has gradually increased over the period of the study (Figure 1A). For instance, 7,356 cases were reported in 2010, whereas this number increased to 23,587 cases in 2019, this being the year of peak incidence within the analyzed period. Such data reveals a 3-fold increase of bee attacks in 2019 in comparison to 2010. Interestingly, incidence numbers decreased in the following years (17,862 cases in 2020 and 18,470 cases in 2021), but are still higher (up to a 2-fold increase) when compared to the numbers from 2010. Lastly, incidence numbers again increased in 2022 (23,060 cases), reaching levels as high as seen in 2019.

Figure 1. Number of reported cases of bee attacks. A) Accidents and deaths associated with bee attacks (2010-2022) and B) Monthly distribution of cases (2010-2022).

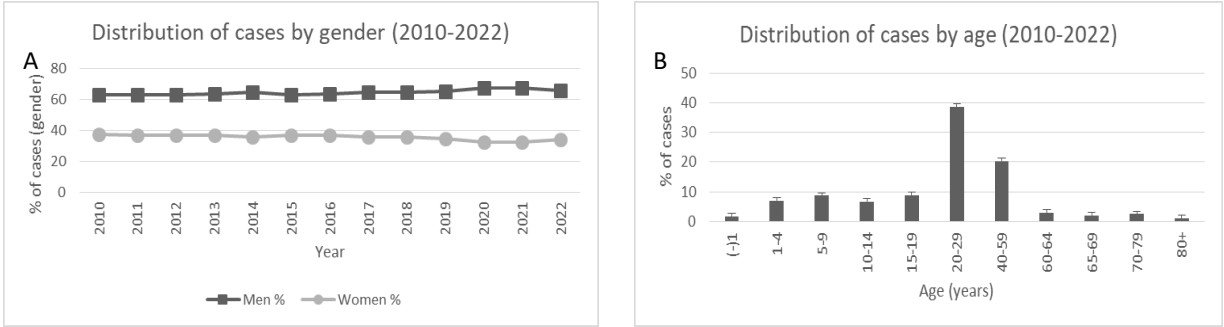


Source: Own elaboration (2023).

By analyzing the monthly distribution of cases over the twelve years assessed in the study, it was possible to observe that the number of cases peaked in the months of January (21,531 cases), February (20,008 cases), March (18,830 cases) and December (18,765 cases), which represent summer season in the south hemisphere. On the other hand, the lowest number of attacks was observed in the months of June (11,403 cases) and July (11,673 cases), which represent winter season (Figure 1B).

Most of the reports on bee attacks showed that victims were mostly male, amounting to 64.5% of cases, while female victims amounted to 35.5% of cases (Figure 2A). Attacks were most prevalent on individuals aged 20-39 (38.6% of cases) and 40-59 (20.3% of cases) years-old (Figure 2B). Remaining cases involved mostly individuals under 20 years old (32.8% of cases); those aged between 10 and 19 years old amounted to a considerable 15.5% of cases. On the other hand, the incidence of bee attacks in individuals older than 60 years was very small (8.2% of cases).

Figure 2. Characterization of reported cases of bee attacks. A) Distribution of cases by gender (2010-2022) and B) Distribution of cases by age (2010-2022).

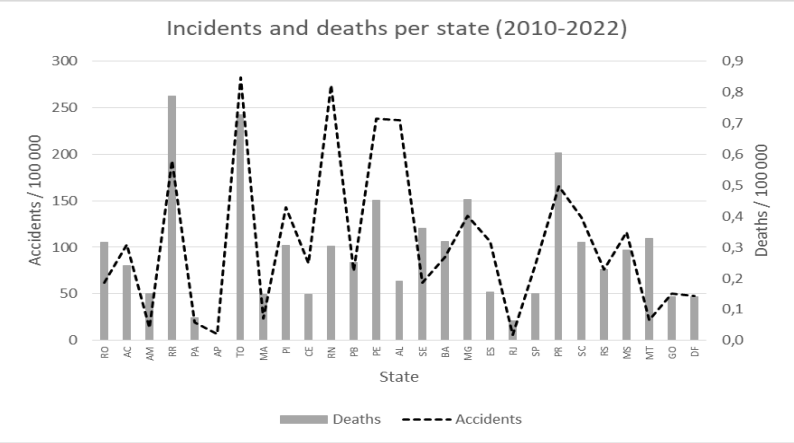


Source: Own elaboration (2023).

As for the regions where most of the reported attacks took place, the states of Tocantins (282.3 cases/100,000

habitants), Rio Grande do Norte (273.9 cases/100,000 habitants), and Roraima (192.9 cases/100,000 habitants) showed the highest prevalence of bee attacks. Regarding number of deaths associated with bee attacks, the states of Roraima (0.8 deaths/100,000 habitants) and Tocantins (0.7 deaths/100,000 habitants) showed the highest numbers among all of the states (Figure 3). The total numbers of reported attacks and deaths for each Brazilian region are shown in the Table 1.

Figure 3. Incidents and deaths per state (2010-2022).



Source: Own elaboration (2023).

Table 1. Total number of cases and deaths associated with bee attacks during the period of 2010 until 2022.

Region	UF	Cases	Deaths
North	**RO**	981	5
	AC	856	2
	AM	552	6
	RR	1228	5
	PA	1598	6
	AP	49	
	TO	4267	11
North-East	**MA**	1622	10
	PI	4679	10
	CE	7308	13
	RN	9048	10
	PB	2970	10
	PE	21537	41
	AL	7394	6
	SE	1371	8
	BA	12637	45

South-East	**MG**	27479	93
	ES	4083	6
	RJ	954	10
	SP	36011	67
South	**PR**	18971	69
	SC	10084	24
	RS	8301	25
Centre-East	**MS**	3204	8
	MT	810	12
	GO	3566	10
	DF	1358	4

Source: Own elaboration (2023).

4. Discussion

Bees play a key role in contributing to the maintenance of different ecosystems, not only pollinating native species of plants, but also regulating the growth and proliferation of invasive plant populations, regenerating fragmented ecosystems and helping to preserve ecological balance. Bees are also economically important for many societies worldwide (Campos & Pereira, 2018; Santos & Mendes, 2016; Silva et al., 2019).

Aiming at expanding honey production, Brazilian researchers in the 1950s started the procedure of hybridizing bees from European and African species, resulting in Africanized bees (*Apis mellifera* L.), which display strong defensive and aggressive behavior (Silva et al., 2019). The hybridization of these species triggered a progressive increase in the number of accidents involving these animals, which have a high capacity to swarm and are more resistant to pests and pathogens (Campos & Pereira, 2018; Santos & Mendes, 2016).

Bee attacks and other apiary incidents (such as involving wasps and other insects of the order Hymenoptera) eventually became recognized as a public health issue in Brazil and the significant increase in the number of reported incidents led public health authorities to adopt measures to monitor and control these events. In 1986, reports of incidents involving venomous animals, including bees, became mandatory by the Brazilian Ministry of Health in 1986 (Terças et al., 2017).

It was only twenty years later in 2006, however, that notification forms were updated to specifically also address incidents involving bees (Terças et al., 2017). This enabled the generation of reliable epidemiological data on bee attacks in Brazil, which have been used to guide researchers and policy makers alike in order to prevent the increasing number of incidents and better assist victims (Kono et al., 2021; Santos & Mendes, 2016; Silva et al., 2019; Souza et al., 2022; Terças et al., 2017). Indeed, as Souza et al. (2022) demonstrated, from 2007 to 2019, the incidence of bee attacks in Brazil increased steadily, corroborating the findings of the present study, which comprised an extended timespan (2010 to 2022).

The historical series of reported cases here described brought to light an unprecedented component. Although in the years 2020 and 2021 the incidence of bee attacks remained alarmingly high (17,862 and 18,470, respectively), the number of incidents during this period was drastically lower in comparison to the numbers from 2019 (23,587). Of note, in the years 2020 and 2021, humanity faced one of the worst health crises in its recent history, the Covid-19 pandemic caused by the SARS-

CoV-2 coronavirus (Khan et al., 2020).

Covid-19 is a highly transmissible disease, and the pandemic has resulted in millions of deaths, impacting the global economy and substantially transforming the daily lives of people worldwide, Brazil not withstanding (Khan et al., 2020). Most importantly in the frame of this study, the Covid-19 pandemic overwhelmed healthcare systems and triggered lockdowns, of which both likely contributed to the decreased numbers of bee attacks reported in the period. This might have been caused both by a failure of health care systems in notifying bee attacks as well as simply less individuals engaging in outdoors activities.

Indeed, in 2022, with the easing of the pandemic and as restrictive measures were gradually lifted, the number of reported cases of bee attacks in 2022 (23,060) returned to the levels seen in 2019 (23,587). Still, it is important to mention that despite the pandemic's impact on various sectors, Brazilian agriculture maintained its production and even experienced some growth, meaning agricultural workers were still at risk of bee attacks (Franco et al., 2019). Even though the Covid-19 pandemic generally reduced the number of bee attacks being reported, the incidence of incidents involving bees was still quite high; the continuity of agricultural activities during the pandemic may have played a key role in contributing to maintaining a high incidence of cases reported.

We also demonstrated that bee attacks happen more often to men than women. Corroborating our findings, Kono et al. (2021) showed a similar trend in their dataset, inferring that such numbers are likely due to a higher prevalence of men working in beekeeping. Additionally, we demonstrated that the age group that most suffers from bee attacks is the one of individuals aged between 20 and 49 years old. According to the Brazilian Institute of Geography and Statistics (IBGE), this age group encompasses the majority of workers in Brazil (Instituto Brasileiro De Geografia e Estatística, 2023).

Environmental changes caused by deforestation, which is vastly present throughout Brazilian territory, can irreparably imbalance local biodiversity and affect bee populations (Franco et al., 2019). Driven by the misguided expansion of agricultural activities, the Northeastern and Northern regions of Brazil and their respective major biomes, the Cerrado and the Amazon biomes, respectively, are the most afflicted by the effects of deforestation and man-caused wildfires (Mapbiomas, 2023). Indeed, the highest numbers of bee attacks in the period assessed are reported in the state of Rio Grande do Norte and Tocantins, both located in the Northeastern and Northern regions of Brazil, respectively. The state of Roraima and Tocantins, both also located in the Northern region, are the ones where deaths caused by bee attacks are the greatest.

Deforestation reduces the availability of habitable areas to bees, which not only results in a decrease in quality and quantity of nectar and pollen available for honey production but also leads to the invasion of urban areas by bees and subsequent increase in number of incidents involving Africanized bees (Santos & Mendes, 2016; Silva et al., 2019).

As a final note, it is worth mentioning that even though the species of bees involved with incidents is not reported in the database assessed in this study, the aggressive behavior displayed by Africanized bees, their widespread distribution, and swarming capacity allow us to safely suggest that such bees are likely the most responsible for attacks in the Brazilian area, as suggested by other authors (Kono et al., 2021; Souza et al., 2022; Terças et al., 2017).

5. Limitations

It is important to acknowledge the limitations inherent to the use of secondary data obtained from the SINAN database. Underreporting of bee attacks is a recognized issue, particularly in remote or rural areas with limited access to healthcare services. Additionally, regional inconsistencies in notification practices and variations in the completeness and accuracy of epidemiological investigation forms may influence the quality of the recorded data. As the system relies on proper case identification and adequate form completion by health professionals, potential information bias cannot be entirely ruled out. Nevertheless, SINAN remains the most comprehensive and reliable nationwide database for monitoring accidents

involving venomous animals in Brazil.

6. Conclusions

The findings shown in this study corroborate the most recent findings described in the scientific literature, evidencing: i) the progressive increase of the number of incidents involving bees in the period assessed (2010 to 2022); ii) the seasonality of cases, which are more frequent in the summer; iii) the distribution of cases by gender of victims, affecting more men than women; iv) the distribution by age group, which is higher among individuals aged 20 to 59 years old; and v) the number of cases and deaths, which are higher in the states of Tocantins, Roraima, and Rio Grande do Norte (cases) and Roraima and Tocantins (deaths).

The data from our study also showed the impact of the measures adopted during the pandemic on the number of bee-related intoxications in Brazil, which decreased during the years of the pandemic. However, despite the pandemic, the circulation of people in forest areas and ongoing agricultural activities contributed to still high number of cases in this period. The presence of Africanized bees in rural and urban areas as result of human activity damaging local ecosystems account for a significant portion of the cases and likely prevented a greater decrease of cases during the pandemic period.

From a public health perspective, the findings of this study reinforce the importance of strengthening epidemiological surveillance of accidents involving venomous animals, particularly bee attacks. Improving the quality and completeness of SINAN notifications, investing in continuous training of health professionals, and integrating environmental surveillance with health information systems are essential measures to enhance data reliability. Moreover, targeted prevention strategies focusing on high-incidence regions, seasonal risk periods, and vulnerable occupational groups may contribute to reducing morbidity and mortality associated with bee attacks in Brazil.

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