Rev. Bras. Saúde Prod. Anim., Salvador, v.25, 01 - 12, 20230031, 2024
http://dx.doi.org/10.1590/S1519-994020230031

Animal Reproduction
Received on: 23/09/2023
Accepted on: 25/01/2024

Mortality of stingless bees on *Spathodea campanulata* Beauv. (Bignoniaceae) flowers

Mortalidade de abelhas sem ferrão nas flores de Spathodea campanulata Beauv. (Bignoniaceae)

CASTAGNINO, Guido Laércio Bragança[1*]
https://orcid.org/0000-0002-6577-0677

MEANA, Aránzazu[1]
https://orcid.org/0000-0002-7599-7226

CUTULI DE SIMÓN, Maria Teresa[2]
https://orcid.org/0000-0001-8037-9994

PINTO, Luís Fernando Batista[1]
https://orcid.org/0000-0002-0831-3293

[1]Universidade Federal da Bahia – UFBA, Escola de Medicina Veterinária e Zootecnia, Av. Milton Santos, 500 - Ondina - CEP 40170-110, Salvador - Bahia – Brasil
[2]Faculty of Veterinary Medicine- UCM, v. Puerta de Hierro, s/n, Moncloa - Aravaca, 28040 Madrid, Espanha
* Mail for correspondence: guidocastagnino@ufba.br

ABSTRACT

Spathodea campanulata Beauv. (Bignoniaceae) is a plant frequently employed in the ornamentation of public squares and gardens, attributed to its rapid growth and showy flowers. However, its use is controversial due to the potentially toxic nectar, which can lead to significant mortality rates among various stingless bee species in Brazil, posing a risk to native biodiversity and disrupting natural ecosystems. The aim of this study was to quantify and identify the species of stingless bees found dead within the flowers of the *Spathodea campanulata* plant. This investigation was conducted at the Ondina Campus of the Federal University of Bahia (UFBA), Brazil. Over a 15-day flowering period, 86 flowers from three specimens of this species were collected. After flower collection, the dead insects found within the flowers were extracted, stored, and identified at the Laboratory of Insect Bionomics, Biogeography, and Systematics (BIOSIS) at UFBA. The analysis revealed that all floral visitors were Hymenoptera insects, with 98.1% identified as bees (*Apidae* and *Meliponini*). In conclusion, *S. campanulata* flowers contain toxic compounds with insecticidal properties, leading to increased mortality among certain *Melipona* bee species. *Melipona scutellaris* and *Apis mellifera* bees are occasional visitors of the *S. campanulata* flowers; hence the lower mortality rates of these species. Given the damage caused by *S. campanulata* on native biodiversity, it is advised to avoid cultivating it in public squares, gardens, or in proximity to bee hives.
Keywords: stingless bee, toxic plant, toxicity, bee mortality

RESUMO

Spathodea campanulata Beauv. (Bignoniaceae) é uma planta frequentemente utilizada na ornamentação de praças públicas e jardins, atribuída ao seu rápido crescimento e flores

Rev. Bras. Saúde Prod. Anim., Salvador, v.25, 01 - 12, 20230031, 2024
http://dx.doi.org/10.1590/S1519-994020230031

vistosas. No entanto, seu uso é controverso devido ao néctar potencialmente tóxico, que pode levar a taxas significativas de mortalidade entre várias espécies de abelhas sem ferrão no Brasil, representando um risco para a biodiversidade nativa e interrompendo os ecossistemas naturais. O objetivo deste estudo foi quantificar e identificar as espécies de abelhas sem ferrão encontradas mortas dentro das flores da planta Spathodea campanulata. Esta investigação foi conduzida no Campus de Ondina da Universidade Federal da Bahia (UFBA), Brasil. Durante um período de floração de 15 dias, foram coletadas 86 flores de três espécimes desta espécie. Após a coleta das flores, os insetos mortos encontrados dentro delas foram extraídos, armazenados e identificados no Laboratório de Bionomia, Biogeografia e Sistemática de Insetos (BIOSIS) da UFBA. A análise revelou que todos os visitantes florais eram insetos Hymenoptera, com 98,1% identificados como abelhas (Apidae e Meliponini). Em conclusão, as flores de S. campanulata contêm compostos tóxicos com propriedades inseticidas, levando a um aumento da mortalidade em certas espécies de abelhas Melipona. As abelhas Melipona scutellaris e Apis mellifera são visitantes ocasionais das flores de S. campanulata; portanto, apresentam taxas de mortalidade mais baixas. Dado o dano causado por S. campanulata na biodiversidade nativa, é aconselhável evitar o seu cultivo em praças públicas, jardins ou próximo a colmeias de abelhas.
Palavras-chave: abelha sem ferrão, planta tóxica, toxicidade, mortalidade de abelhas

INTRODUCTION

The introduction of plant species into novel geographic locales often grants them competitive edges over endemic plants (Daehler, 2023; Mooney et al., 2005). Such advantages manifest when a non-native species, upon introduction to a new habitat, adopts competitive strategies to secure its establishment and proliferation. These strategies may include accelerated growth rates, resistance to predation, and superior efficiency in resource utilization — encompassing nutrients, sunlight, and water — when compared to indigenous plant species (Park et al., 2003).

Nonetheless, the presence of these non-native species can pose significant threats to native biodiversity, potentially disrupting ecological balance (Hierro et al., 2005; Reaser et al., 2007; Kueffer et al., 2010). One notable example is *Spathodea campanulata* Beauv. (Bignoniaceae), popularly known as the African tulip, a secondary forest tree found in tropical forest margins and savannas of Equatorial and Western Africa (Francis, 2000).

Its introduction to landscaping and the ornamentation of public squares and parks worldwide has been so effective that it now proliferates in tropical forests, degraded regions, and abandoned agricultural lands. As per Pouteau et al. (2015), *S. campanulata* has been described as an invasive species across Australia, Brazil, Puerto Rico, and several Pacific islands such as the Cook Islands, Fiji, French Polynesia, Guam, Hawaii, New Caledonia, and Vanuatu.

The encroachment of *S. campanulata* into new territories endangers native biodiversity by inhibiting the development of local species, earning it a highlighted spot in the list of the “100 of the World's Worst Invasive Alien Species” by the Invasive Species Specialist Group (Lowe et al., 2000).

While the timing of introduction of *S. campanulata* to Brazil remains unknown, its adoption was certainly for ornamental purposes, given its flowering at the branch tips that persists for several months in a row.

Rev. Bras. Saúde Prod. Anim., Salvador, v.25, 01 - 12, 20230031, 2024
http://dx.doi.org/10.1590/S1519-994020230031

However, its usage has sparked controversy due to the potential threat it poses to native bee populations, with high mortality rates attributed to its flowers (Nogueira-Neto, 1970). According to Queiroz et al. (2014), these effects may stem from substances found in the buds and inflorescences of the plant.

On the other hand, bees native to the varied biomes of Brazil serve as primary pollinators due to their diverse pollen-gathering behaviors (Silva & Paz, 2012). Their ability to pollinate numerous flower types is crucial for supporting the biodiversity of local flora. Quigley et al. (2019) suggest that highly biodiverse ecosystems reduce natural disasters caused by the introduction of invasive species and human exploitation. This highlights the need to identify the pollinating insects impacted by *S. campanulata*, which may be found in houses, gardens, urban parks, and city squares, to inform urban planning and restrict its cultivation in public areas. Research has explored the impact of *S. campanulata* on the mortality of stingless bees (Nogueira-Neto, 1997; Trigo & Santos, 2000; Noguera, 2014; Queiroz et al., 2014). However, to our knowledge, no studies have specifically examined its effects on the native bees of Bahia, Brazil, despite the known diversity of these species in the state.

Therefore, the objective of this study was to quantify and identify the species of dead stingless bees found within the flowers of the plant species *Spathodea campanulata* Beauv., present on the Federal University of Bahia (UFBA) campus.

MATERIALS AND METHODS

The research was conducted at the Ondina campus of UFBA, located at coordinates 12°59′37″ S and 38°31′13″ W. Flowers of the *S. campanulata* species were collected from three plants (Figure 1) over a 15-day period from August 25 to September 10, 2022, coinciding with the flowering period.

ISSN 1519 9940

Rev. Bras. Saúde Prod. Anim., Salvador, v.25, 01 - 12, 20230031, 2024
http://dx.doi.org/10.1590/S1519-994020230031

Figure 1. Buds and flowers of the *Spathodea campanulata* Beauv. (Bignoniaceae) plant

To ensure no predators could "steal" the floral visitor samples from within the flowers, potentially skewing the results, collections were performed for all flowers found on the ground at 08h00 and 17h00. Immediately afterward, the floral visitor samples were transported to the laboratory for examination. Dead visitors were then removed from the flowers and preserved in 70% alcohol (Carvalho & Vieira, 2001; Garbelotto & Campos, 2014) for later taxonomic classification of species at the Laboratory of Insect Bionomics, Biogeography, and Systematics (BIOSIS) at UFBA.

The floral visitors (Figure 2) were identified and classified by scientific name, genus, and common name. The number of species found in the samples was described in percentage terms.

Rev. Bras. Saúde Prod. Anim., Salvador, v.25, 01 - 12, 20230031, 2024
http://dx.doi.org/10.1590/S1519-994020230031

Figure 2. *Spathodea campanulata* Beauv. (Bignoniaceae) flower with the presence of dead stingless bees

RESULTS AND DISCUSSION

Over the 15-day period, 104 dead floral visitor insects were retrieved, with numbers per flower ranging from 1 to 18 across the 86 *S. campanulata* flowers examined, evidencing a significant occurrence of pollinator mortality (Table 1).

Table 1. Species of pollinating insects found dead within the flowers of *Spathodea campanulata* Beauv. (Bignoniaceae)

Scientific name	Genus	Frequency, %	Common name
Trigona spinipes	Trigona 52	50.0	Abelha irapuá
Partamona helleri	Partamona 25	24.0	Abelha boca de sapo
Nannotrigona estaceicornis	Nannotrigona 9	8.7	Abelha iraí
Tetragonisca angustula	Tetragonisca 7	6.7	Abelha jatai
Apis mellifera. L	Apis 5	4.7	Abelha Apis africanizada
Dialictus opacus	Halictinae 4	3.9	Abelha solitária
Polistes versicolor	Polistes 2	1.9	Marimbondo

The *S. campanulata* flowers proved highly alluring to floral visitors, 98% of which were identified as Hymenoptera insects (Table 1).

This mortality rate aligns with findings by Trigo & Santos (2000), who reported 345 dead insects within 445 *S. campanulata* plants. Their study noted that 97% of these insects were from the tribe Meliponini, predominantly *Scaptotrigona postica*, with the remaining comprising 1.7% Diptera and Hymenoptera from the family Vespidae, 1% from the family Formicidae, and

Rev. Bras. Saúde Prod. Anim., Salvador, v.25, 01 - 12, 20230031, 2024
http://dx.doi.org/10.1590/S1519-994020230031

0.3% Orthoptera. Similarly, Noguera (2014) documented a majority of meliponine bees (71% out of 66 collected insects) dead within the flowers of the African tulip. These findings highlight the particular susceptibility of this bee group to the harmful effects of *S. campanulata*.

Additional research has also documented a large number of insects killed by this plant, predominantly stingless bees. Queiroz et al. (2014) and Nogueira-Neto (1997) reported significant losses among various Meliponini bee species within *S. campanulata* flowers, highlighting *Plebeia droryana* (Friese), *Tetragonisca angustula* (Latreille), *S. postica*, *Trigona spinipes* (Fabricius), and *Friesella schrottkyi* (Friese).

Table 1 reveals that among the 104 dead floral visitors, 50% corresponded to 143 individuals of the genus *Trigona*, specifically, *Trigona spinipes*, commonly known as the Irapuá bee.

Bárbola et al. (2000) describe *T. spinipes* (Fabricius) as a widespread generalist native bee that frequents different types of flowers in search of food, found throughout Latin America. Generalist bees are those which are not very demanding in their choice of plant species for gathering resources like resin, nectar, and pollen (Braga et al., 2012). *Trigona spinipes* colonies are notably populous and possess a very efficient communication system, enabling foraging over extensive distances from their hives (Neves & Viana, 2002). In addition to the fact that it is a generalist bee, it is also noteworthy that the prevalence of *T. spinipes* fatalities in *S. campanulata* flowers may relate to the abundance of colonies of this species situated near the research area. According to Santos et al. (2017), nests of this species are external colonies and are not built within cavities or crevices of trees, rendering them easily identifiable.

The second most frequently encountered floral visitor found dead within the flowers was from the genus *Partamona*, specifically *Partamona helleri* (“boca de sapo”), constituting 24.0% of the total (Table 1). This stingless bee species is known for constructing unique entrance structures to their colonies, facilitating access for foragers, with colonies typically housing 1000 to 3000 individuals (Michener, 2000). Observations in the study area identified numerous *Partamona helleri* colonies established in trees and structures, explaining their presence in the *S. campanulata* flowers.

Other identified species found in smaller numbers were also stingless bees (Table 1): of the genus Nannotrigona, *Nannotrigona testaceicornis* (Irai) at 8.7%; of the genus Tetragonisca, *Tetragonisca angustula* (Jataí) at 6.7%; of the genus *Apis*, Africanized *Apis mellifera* at 4.7%; and of the genus *Halactini*, *Dialictus opacus* (a solitary bee known for collecting mucilaginous substances and essential oils) at 3.9%. It is plausible these bees were attracted to the mucilaginous content within the flower buds of *S. campanulata*.

The *S. campanulata* flower exhibits appeal to a variety of *Melipona* bee species. However, few *Apis* bees (Africanized *Apis mellifera*) were seen flying over these flowers, an observation corroborated by the low number of these bees found dead within the *S. campanulata* flowers. This limited attraction may stem from the floral resources provided by this plant being less appealing to this bee genus. It was noted that a significant portion of this species opted for floral resources from alternative plants or were drawn to soda cans and glasses within the enclosure. Michener (2000) mentioned that *A. mellifera* bees have a diet that includes plants from the most diverse groups to

Rev. Bras. Saúde Prod. Anim., Salvador, v.25, 01 - 12, 20230031, 2024
http://dx.doi.org/10.1590/S1519-994020230031

support their populous and generalist colonies, necessitating substantial resource intake. These colonies are the most numerous in number of individuals among social bee species.

A comparable situation was observed with Uruçu stingless bees (*Melipona scutellaris*), as no dead specimens were discovered within the *S. campanulata* flowers. This observation is particularly notable given the presence of an experimental meliponary housing over 30 *Melipona scutellaris* colonies at the research site. This indicates a tendency of these bees to favor alternative food sources over the flowers of *S. campanulata*.

For both Uruçu stingless bees and *Apis* bees, further investigation is required to determine why *S. campanulata* flowers hold little allure for these species.

The detection of dead *Polistes versicolor* wasps (1.9%) within the *S. campanulata* flowers may suggest opportunistic behavior. Termed “illegitimate visitors” (Genini et al., 2010), these insects exploit floral resources such as water, plant fiber, nectar, and pollen, not for pollination, but to "hunt" insects to feed their young. According to Andrade & Prezoto (2001) and Prezoto et al. (2006), floral visits by wasps are sporadic and primarily driven by their predatory nature.

Historical accounts of bee mortality linked to the toxicity of *S. campanulata* flowers date back to Portugal-Araújo (1963), with subsequent confirmation by researchers such as Nogueira-Neto (1970), Roubik (1989), and Barker (1990). The authors concluded that the toxic effect may be present in the pollen or nectar of the flowers. This aligns with Nogueira-Neto (1997), who also reported the toxic impact of *S. campanulata* inflorescences on other stingless bee species, including *Plebeia droryana*, *Tetragonisca angustula*, *Scaptotrigona postica*, *Trigona spinipes*, and *Friesella schrottky*.

Several theories have been proposed regarding the causes of insect mortality associated with *S. campanulata* flowers. Research conducted by Valter et al. (2020) demonstrated that both flowers and leaves of this species contain substances with antioxidant potential, making them a significant source of antioxidants, irrespective of the geographic location of the plant in Brazil.

Trigo & Santos (2000) indicated that the mucilaginous substances found in the flower buds of *S. campanulata* contain toxic alkaloids, which can be lethal to bees and, in many instances, even to larger animals such as hummingbirds.

Therefore, it can be stated that these secretions serve as a defense mechanism for the plant, leading to the death of bees and other insects. Recent investigations by Alarcón-Noguera & Penieres-Carrillo (2013), Queiroz et al. (2014), and Franco et al. (2015) identified toxic compounds such as terpenes and steroids in the mucilage of the buds and flowers of *S. campanulata*, which can leach into the nectar and exhibit insecticidal properties. Supporting this, Valter et al. (2017) found that the insecticidal efficacy of the *S. campanulata* nectar is attributable to its chemical constituents. These substances, encompassing secondary metabolites and specific protein classes, provide biochemical defense to the plant and impact insect metabolism (Seo et al., 2013; Santos et al., 2017). Distributed throughout the plant, these secondary compounds play a crucial role in warding off herbivore predation (Adler, 2000) and are often detected in the floral nectar, especially in the flower, a portion critical for species reproduction and survival (Levin, 1976).

Ferreyra et al. (2013) and Valter et al. (2017) identified compounds such as peptides from the glycosyl transferase and serine-threonine-protein phosphatase families in the nectar of *S. campanulata*. These enzymes may contribute to the biosynthesis of insecticidal secondary compounds, either directly or indirectly.

The toxic effects on Melipona bee colonies might be an adaptive strategy by the plant to deter bees from utilizing its pollen as a food source, thus preventing pollen collection without achieving pollination (Hargreaves et al., 2009).

In Brazil, the "barbatimão" plants, *Stryphnodendron polyphyllum* and *Stryphnodendron adstringens*, also exhibit insecticidal effects on Apis bees. The disease associated with these effects, known as Brazilian sacbrood (Message & Silva, 1995), is not caused by a pathogen but by a toxin related to tannins found in the "barbatimão" pollen (Santos, 2000). The onset of the disease occurs when nurse bees of the Africanized *Apis mellifera* species feed their larvae with this toxic pollen, poisoning them and thereby interrupting their development to the pupal stage, ultimately resulting in larval mortality.

Symptoms indicative of mortality in bee broods resemble those caused by the Sacbrood Virus (SBV), characterized by the sac-like appearance of dead larvae upon removal from brood cells through the head region, a result of ecdysial fluid accumulation (Carvalho & Message, 2004).

Research by Castagnino et al. (2011) suggests that Africanized *Apis mellifera* bee colonies typically do not have a preference for the pollen of *S. polyphyllum* and *S. adstringens*, resorting to these sources only in the absence of alternative foraging options. Bee brood mortality in such scenarios is attributed to the ingestion of these floral resources. One management strategy to mitigate brood mortality in *A. mellifera* involves providing a pollen substitute via collective feeders approximately 15 days prior to the flowering of "barbatimão", thereby diverting foraging bees from these toxic plants and reducing the consumption of harmful pollen.

In cases where bee mortality is linked to foraging on *S. campanulata* (Bignoniaceae) flowers, it has been identified that Invasive Alien Species contribute to the global decline of pollinating insect populations. Measures to manage and mitigate this impact include the prevention and eradication of such invasive plants (Dainese et al., 2019).

Another alternative is to provide pollinating insects with a diverse array of floral resources throughout the year. This can be achieved by planting trees that provide floral resources to stingless bees, offering them a variety of foraging options and, consequently, minimizing the toxic impact of this plant by reducing their reliance on their pollen.

In summary, *Spathodea campanulata* flowers have been implicated in the mortality of various bee species, notably the stingless bees *Trigona spinipes* (50%) and *Partamona helleri* (24%). Despite the attraction of these flowers to several stingless bee species, other floral resources were available in their environment.

ACKNOWLEDGMENTS

We thank the Complutense University of Madrid for the opportunity to deepen our knowledge of apical pathology and, in particular, Dr. Aránzazu Meana and Dr. María Tereza Cutuli de Simon.

REFERENCES

ADLER, L.S. The ecological significance of toxic nectar. Oikos, v. 91,

n. 3, p. 409-420, 2000. Available at: https://doi.org/10.1034/j.1600-0706.2000.910301.x. Cited: 28 ene. 2023.

ALARCÓN-NOGUERA, R.Y.; PENIERES-CARRILLO, G. In vitro evaluation of African tulip (Spathodea campanulata B.) flowers and leaves extracts on berry borer of coffee (Hypothenemus hampei F.). Revista Tecnología en Marcha, v. 26, n. 3, p. 39-49, 2013. Available at: https://doi.org/10.18845/tm.v26i3.1516. Cited: 28 ene. 2023.

ANDRADE, F.R.; PREZOTO, F. Foraging activity timetable and material collected by polistes ferreri saussure, 1853 (Hymenoptera, vespidae), in different stages of its biological cycle. Revista Brasileira de Zoociências, v. 3, n. 1, p. 117-128, 2001.

BÁRBOLA, I.D.F., LAROCA, S.; ALMEIDA, M.C. Floral resources used by wild bees Hymenoptera, Apoidea in the Floresta Estadual Passa Dois, Lapa, Parana, southern Brazil Utilizacao de recursos florais por abelhas silvestres Hymenoptera, Apoidea da Floresta Estadual Passa Dois Lapa, Parana, Brasil. Revista Brasileira de Entomologia, v. 44, n. 1/2, p. 9-19, 2000.

BARKER, R.J. Poisoning by plants. In: MORSE, R.A.; NOWOGRODZKI, R. (Ed.). Honey bee pests, predators, and diseases. London: Cornell University Press; 1990. p. 306-328.

BRAGA, J.A.; SALES, E.O.; SOARES-NETO, J.; CONDE, M.M., BARTH, O.M.; LORENZON, M.C.A. Floral sources to Tetragonisca angustula (Hymenoptera: Apidae) and their pollen morphology in a Southeastern Brazilian Atlantic Forest. International Journal of Tropical Biology, v. 60, n. 4, p. 1.491-1.501, 2012.

CARVALHO, A.C.P.; MESSAGE, D. A scientific note on the toxic pollen of Stryphnodendron polyphyllum (Fabaceae, Mimosoideae) which causes sacbrood-like symptoms. Apidologie, v. 35, n. 1, p. 89-90, 2004. Available at: https://doi.org/10.1051/apido:2003059. Cited: 28 ene. 2023.

CARVALHO, A.O.R.; VIEIRA, L.G.E. Determinação das condições ótimas para análises de PCR-RAPD em Atta sexdens rubropilosa Forel (Hymenoptera: Formicidae). Neotropical Entomology, v.4, n. 30, p. 593-600, 2001.

CASTAGNINO, G.L.B.; MESSAGE, D.; MARCO JR., P.D. Pollen substitute on the reduction of Apis mellifera L. mortality caused by Brazilian Sac Brood. Ciência Rural, v. 41, p. 1838-1843, 2011. Available at: https://doi.org/10.1590/S0103-84782011001000027.

DAEHLER, C.C. Performance comparisons of co-occurring native and alien invasive plants: implications for conservation and restoration. Annual Review of Ecology, Evolution, and Systematics, v. 34, p. 183-211, 2003. Available at: https://doi.org/10.1146/annurev.ecolsys.34.011802.132403. Cited: 28 ene. 2023.

DAINESE, M.; MARTIN, E.; AIZEN, M.A.; ALBRECHT, M.; BARTOMEUS, I.; BOMMARCO, R. et al. A global synthesis reveals biodiversity-mediated benefits for crop production. Science advances, v. 5, p. 1-13, 2019.

FERREYRA, M.L.F.; RODRIGUEZ, E.; CASAS, M.I.; LABADIE, G.;

GROTEWOLD, E.; CASATI, P. Identification of a bifunctional maize C- and O-glucosyltransferase. Journal of Biological Chemistry, v. 288, n. 44, p. 31678-31688, 2013. Available at: https://doi.org/10.1074/jbc.M113.510040. Cited: 28 ene. 2023.

FRANCIS, J.K. Spathodea campanulata Beauv., Bignoniaceae. In: FRANCIS, J.K.; LOWE, A.C.; TRABANINO, S. Silvics of native and exotic trees of Puerto Rico and the Caribbean Islands. Rio Piedras: USDA Forest Service Technical Report IITF-15, 2000. p. 484-487.

FRANCO, D.P.; GUERREIRO, J.C.; RUIZ, M.G.; SILVA, R.M.G. Evaluation of insecticide potential of Spathodea campanulata (Bignoniaceae) nectar on Sitophilus zeamais (Coleoptera: Curculionidae). Revista Colombiana de Entomología, v. 41, n. 1, p. 63-67, 2015.

GARBELOTTO, T.A.; CAMPOS, L.A. Metodologias de coleta e conservação. In: GARBELOTTO, T.A.; CAMPOS, L.A. Pentatominae do Sul de Santa Catarina [online]. Curitiba: Sociedade Brasileira de Zoologia, 2014. p 77-78.

GENINI J.; MORELLATO, L.P.C.; GUIMARÃES, P.R.; OLESEN, J.M. Cheaters in mutualism networks. Biology letters, v. 6, n. 4, p. 494-497, 2010. Available at: https://doi.org/10.1098/rsbl.2009.1021. Cited: 28 ene. 2023.

HARGREAVES, A.L.; HARDER, L.D.; JOHNSON, S.D. Consumptive emasculation: the ecological and evolutionary consequences of pollen theft. Biological Review. V. 84, p. 259-276, 2009.

HIERRO, J.L.; MARON, J.L.; CALLAWAY, R.M. A biogeographical approach to plant invasions: the importance of studying exotics in their introduced and native range. Journal of ecology, v. 93, n. 1, p. 5-15, 2005. Available at: https://doi.org/10.1111/j.0022-0477.2004.00953.x. Cited: 28 ene. 2023.

KUEFFER, C.; DAEHLER, C.C.; TORRES-SANTANA, C.W.; LAVERGNE, C.; MEYER, J.Y.; OTTO, R. et al. A global comparison of invasive plant species on oceanic islands. Perspectives in Plant Ecology, Evolution and Systematics, v. 12, n. 2, p. 141-165, 2010. Available at: https://doi.org/10.1016/j.ppees.2009.06.002. Cited: 28 ene. 2023.

LEVIN, D.A. The chemical defenses of plants to pathogens and herbivores. Annual review of Ecology and Systematics, v. 7, p. 121-159, 1976. Available at: https://doi.org/10.1146/annurev.es.07.110176.001005. Cited: 28 ene. 2023.

LOWE, S.; BROWNE, M.; BOUDJELAS, S.; DE POORTER, M. 100 of the world's worst invasive alien species: a selection from the global invasive species database. Auckland: Invasive Species Specialist Group, Species Survival Commission - SSC, World Conservation Union – IUCN; 2000.

MESSAGE, D.; BALL, B.; SILVA, I. A serious brood disease affecting Africanized honeybees (Apis mellifera). In: PROC. INT. BEEKEEPING CONGR. 34., 1995. Anais… Bucharest: Apimondia Publ. House, 1995. p. 203.

Rev. Bras. Saúde Prod. Anim., Salvador, v.25, 01 - 12, 20230031, 2024
http://dx.doi.org/10.1590/S1519-994020230031

MICHENER, C.D. The bees of the world. Baltimore. Baltimore: The Jonhs Hopkins University Press, 2000.

MOONEY, H.A.; MACK, R.; MCNEELY, J.A.; MCNEELY, J.A.; NEVILLE, L.E.; SCHEI, P.J. et al. (Eds.). Invasive alien species: a new synthesis. Washington: Island Press, 2005.

NEVES, E.L.D.; VIANA, B.F. As abelhas eussociais (Hymenoptera, Apidae) visitantes florais em um ecossistema de dunas continentais no médio Rio São Francisco, Bahia, Brasil. Revista Brasileira de Entomologia, v. 46, p. 571-578, 2002. Available at: http://dx.doi.org/10.1590/S0085-56262002000400012. Cited: 28 ene. 2023.

NOGUEIRA-NETO, P.A. Criação de abelhas indigenas sem ferrão (Meliponinae). São Paulo: Tecnapis, 1970.

NOGUEIRA-NETO, P.A. Vida e criação das abelhas indígenas sem ferrão. São Paulo: Nogueirapis, 1997.

NOGUERA, R.H.A. Efecto insecticida, repelente y fungistático de extractos de hojas y flores de Llama del bosque (Spathodea campanulata Beauv). 2014. 112f. Tesis (Doctorado en Ciencias Naturales para el Desarrollo con énfasis en Sistemas de Producción agrícola) - Universidad Estatal a Distancia Instituto Tecnológico de Costa Rica Universidad Nacional de Costa Rica Doctorado en Ciencias Naturales para el Desarrollo. Énfasis en Sistemas de Producción Agrícolas, Costa Rica, 2014.

PARK, S.E.; BENJAMIN, L.R.; WATKINSON, A.R. The theory and application of plant competition models: an agronomic perspective. Annals of Botany, v. 92, n. 6, p. 741-748, 2003.

PORTUGAL-ARAUJO, V. O perigo de dispersão da tulipeira do gabão (Spathodea campanulata Beauv). Chácaras e quintais, v. 107, p. 562, 1963.

POUTEAU, R.; MEYER, J.Y.; LARRUE, S. Using range filling rather than prevalence of invasive plant species for management prioritisation: the case of Spathodea campanulata in the Society Islands (South Pacific). Ecological Indicators, v. 54, p. 87-95, 2015.

PREZOTO, F.; SANTOS-PREZOTO, H.H.; MACHADO, V.L.; ZANUNCIO, J.C. Prey captured and used in Polistes versicolor (Olivier) (Hymenoptera: Vespidae) nourishment. Neotropical Entomology, v. 35, p. 707-709, 2006. Available at: https://doi.org/10.1590/S1519-566X2006000500021. Cited: 28 ene. 2023.

QUEIROZ, A.C.M.; CONTRERA, F.A.L.; VENTURIERI, G.C. The effect of toxic nectar and pollen from Spathodea campanulata on the worker survival of Melipona fasciculata Smith and Melipona seminigra Friese, two Amazonian stingless bees (Hymenoptera: Apidae: Meliponini). Sociobiology, v. 61, n. 4, p. 536-540, 2014. Available at: https://doi.org/10.13102/sociobiology.v61i4.536-540. Cited: 28 ene. 2023.

QUIGLEY, T.P.; AMDAM, G.V.; HARWOOD, G.H. Honey bees as bioindicators of changing global agricultural landscapes. Insect Science, v. 35, p.132-137, 2019.

REASER, J.K.; MEYERSON, L.A.; CRONK, Q.; DE POORTER, M.A.J.; ELDREGE, L.G.; GREEN, E.K.M. et al.

Ecological and socioeconomic impacts of invasive alien species in island ecosystems. Environmental Conservation, v. 34, n. 2, p. 98-111, 2007. Available at: https://doi.org/10.1017/S0376892907003815. Cited: 28 ene. 2023.

ROUBIK, D.W. Ecology and Natural History of Tropical Bees. New York: Cambridge University Press, 1989. Available at: https://doi.org/10.1017/CBO9780511574641. Cited: 28 ene. 2023.

SANTOS, M.L.A. Análise dos constituintes químicos do pólen e da inflorescência de Stryphnodendron polyphyllum em relação à cria ensacada brasileira em *Apis mellifera*. 2000. (Dissertação de maestria) - Universidade Federal de Viçosa, Minas Gerais, 2000.

SANTOS, V.H.M.; MINATEL, I.O.; RECO, P.C.; GARCIA, A.; LIMA, G.P.P.; SILVA, R.M.G. Peptide composition, oxidative and insecticidal activities of nectar from flowers of Spathodea campanulata P. Beauv. Industrial Crops and Products, v. 97, p. 211-217, 2017. Available at: https://doi.org/10.1016/j.indcrop.2016.12.025. Cited: 20 sept. 2023.

SEO, P.J.; WIELSCH, N.; KESSLER, D.; SVATOS, A. Park CM, Baldwin IT y Kim SG. Natural variation in floral nectar proteins of two Nicotiana attenuata accessions. BMC Plant Biology, v. 13, n. 1, p. 1-12, 2013. Available at: https://doi.org/10.1186/1471-2229-13-101. Cited: 28 ene. 2023.

SILVA, W.P.; PAZ, J.R.L. Abelhas sem ferrão: muito mais do que uma importância econômica. Natureza Online, v. 10, n. 3, p. 146-152, 2012.

TRIGO, J.R.; SANTOS, W.F. Insect mortality in Spathodea campanulata Beauv. (Bignoniaceae) flowers. Revista Brasileira de Biologia, v. 60, p. 537-538, 2000. Available at: https://doi.org/10.1590/S0034-71082000000300019. Cited: 28 ene. 2023.

VALTER, H.M.; SANTOS, I.O.; MINATEL, G.P.P.; LIMA, R.M.G.S.; CHUNG-YEN, O.C. Antioxidant capacity and phytochemical characterization of Spathodea campanulata growing in different climatic zones in Brazil. Biocatalysis and Agricultural Biotechnology, v. 24, p. 101536, 2020. Available at: https://doi.org/10.1016/j.bcab.2020.101536. Cited: 28 ene. 2023.

VALTER, H.M.; SANTOS, I.O.; MINATEL, P.C.; RECO, A.G.; GIUSEPPINA, P.P.; LIMA, R.M.G.S. Peptide composition, oxidative and insecticidal activities of nectar from flowers of Spathodea campanulata P. Beauv. Industrial Crops and Products, v. 97, p. 211-217, 2017. Available at: https://doi.org/10.1016/j.indcrop.2016.12.025. Cited: 28 ene. 2023.