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Scientific Note

Exotic plant as a new resource: first report of social wasps (Vespidae: Polistinae) foraging on carpel discs of noni fruit (*Morinda citrifolia* L.) in northeast Brazil

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Abstract. Social wasps (Vespidae: Polistinae) are highly adaptable insects that exploit a wide range of locally and seasonally available resources. This study reports the first observation of social wasps foraging on carpel disc of noni fruit (*Morinda citrifolia* L.) in Northeast Brazil, specifically in the Caatinga biome. Noni, a pantropical fruit known for its environmental tolerance and nutritional content, including high water and protein levels. Seven species of social wasps were recorded foraging on noni in the rural area of Patos, Paraíba state, Brazil. These species included *Polybia ignobilis* (Haliday, 1836), *Polybia occidentalis* (Olivier, 1792), *Polybia paulista* (von Ihering, 1896), *Polybia sericea* (Olivier, 1792), *Brachygastra lechiguana* (Latreille, 1824), and *Protonectarina sylveirae* (de Saussure, 1854). Observations revealed that the wasps foraged primarily on the carpel disc of the fruit, engaging in scraping behavior to extract juices and soft tissues. No activity was observed on ripe fruits. The findings highlight the ecological importance of noni fruits as a resource for social wasps, particularly in arid regions as Caatinga biome where such fruits provide essential nutrients.

Keywords: Caatinga biome; cheese fruit; Epiponini; foraging behavior; marimbondos.

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Social wasps are highly adaptable insects that exploit locally and seasonally available resources (Richter 2000; Jeanne & Taylor 2009; Barbosa *et al.* 2014; Brito & Zanella 2022). Their foraging activities serve multiple purposes: gathering protein to nourish their larvae, collecting plant fibers for nest construction, obtaining water for both building and thermoregulation, and acquiring carbohydrates, which serve as an essential energy source for both adults and developing brood (Richter 2000; Carpenter & Marques 2001; Hunt 2007; Prezoto *et al.* 2008; Clemente *et al.* 2012; Barbosa *et al.* 2014). Additionally, these wasps play a crucial role in agriculture as natural predators of pest species, contributing to crop protection (Prezoto *et al.* 2008; Southon *et al.* 2019).

The foraging activities of social wasps play a significant role in maintaining the dynamic ecosystems of the Caatinga biome, a region exclusive to Brazil, spanning about 11% of the country's territory and predominantly located in the Northeast (Silva *et al.* 2017; Vieira Sales *et al.* 2021). known for its seasonally dry tropical forest, this biome is characterized by a unique composition of xerophytic plants, shrubs, and small trees, which are adapted to withstand the semi-arid climate (Brasil 2022; Vieira Sales *et al.* 2021; Dutra Júnior *et al.* 2021). Despite its rich biodiversity and notable levels of species endemism, the Caatinga remains one of Brazil's least explored biomes in scientific research (Leal *et al.* 2005; Costa *et al.* 2022). Furthermore, the biome faces severe challenges, including desertification, habitat loss, and the unsustainable use of its resources, all of which are intensified by ongoing climate change (Smith *et al.* 2015; Silva *et al.* 2019).

In this challenging landscape, the introduction and establishment of exotic plant species can create new ecological interactions (Almeida *et al.* 2015). *Morinda citrifolia* L. (Rubiaceae), commonly known as noni in Brazil, is one such example. Originally native to Southeast Asia (Indonesia) and Australia, noni has a pantropical distribution and thrives across diverse environments, including the Pacific islands (Nelson 2001; McClatchey 2002). This small evergreen tree or shrub, reaching heights of 2 to 10 meters, and the fruits develops from a green infructescence (syncarp) with tubular white flowers into a yellowish-white, fleshy fruit (Dixon *et al.* 1999; Nelson 2001; McClatchey 2002; Janick & Paull 2008; Dar 2009).

Noni demonstrates exceptional environmental tolerance, thriving in saline, acidic, alkaline, and infertile soils, as well as under drought conditions (Dixon *et al.* 1999; Wang *et al.* 2002; Dar 2009; Correia *et al.* 2011). Its fruits are a rich source of water (~90%), protein (~10%), and fiber (Chan-Blanco *et al.* 2006), and it is one of the few fruit trees that produces throughout the year (Dixon *et al.* 1999; Chunhieng *et al.* 2005). The presence of noni in the Caatinga highlights its potential to interact with local fauna, including social wasps, and provides an opportunity to explore its ecological role within this biome.

In Brazil, noni is still relatively poorly unknown, and its cultivation is not carried out on a large scale (Tombolato *et al.* 2005). The exact means by which this plant was introduced to Brazil

are unclear; however, some studies point to its therapeutic property (Saludes *et al.* 2002; Souza *et al.* 2010; Barbosa *et al.* 2017). Despite its adaptation to the Brazilian climate and its widespread commercialization in the Northeast region, the *Agência Nacional de Vigilância Sanitária* (ANVISA) has reported that products containing noni should not be marketed as food until the legal requirements proving its safety (ANVISA 2007; Barbosa *et al.* 2017).

Studies on social wasps' interaction with exotic fruits in Brazil were carried out for example with grapes (Hickel & SchucK 1995) Spanish prune (Prezoto & Braga 2013), mango (Barbosa *et al.* 2014), *Syzygium jambos* (Brügger *et al.* 2017), and Arabica Coffee (Tomazella *et al.* 2018). Furthermore, a variety of insects have been recorded foraging on noni, such as aphids, scales, weevils, leafhoppers and flies (Castro & Montalvão 2019).

The aim of this note is to report, for the first time, the use of *Morinda citrifolia* L. (noni) as a resource by social wasps in the Northeast region of Brazil, highlighting their interactions with this fruit.

The behavioral observation was conducted in a rural area of Patos (Santa Gertrudes district), Paraíba state, Brazil, at Sítio Fechado property (6.97383, -37.40928) in two adult plants about 2.5 meters tall (Figure 1A and B). From June 21 to 24, 2019 the observations were conducted from 08:00 am to 06:00 pm with intervals at least every two hours to check for the presence of the wasps. Behavioral observations were conducted using the *ad libitum* method (Altmann 1974; Del-Claro 2010), allowing for the recording of a wide range of activities actions displayed by the wasps and carefully documented.

For the quantification of total foraging activity, the wasps arriving at the fruits were observed and counted. The photos were taken using a Nikon D3200 DSLR camera equipped with a 50 mm f/1.8 lens and a macro extension tube. To generate a locality map, the geographic coordinates were imported into a free and open-source geographic information system, QUANTUM-GIS v2.18.18. Las Palmas (QGIS Development Team 2016). Additionally, some specimens were collected and pinned to identify using the keys available (Richards 1978; Carpenter & Marques 2001; Andena & Carpenter 2012). The voucher specimens will be deposited in the Entomological Collection Prof. Johann Becker at the Museu de Zoologia da Universidade Estadual de Feira de Santana (MZFS).

A total of 38 specimens were collected, while 130 observations were recorded for behavioral analysis. Seven species of social wasps were recorded in this study. Six belonging to Epiponini *Polybia ignobilis* (Haliday, 1836), *Polybia occidentalis* (Olivier, 1792), *Polybia paulista* (von Ihering, 1896), *Polybia sericea* (Olivier, 1792), *Brachygastra lechiguana* (Latreille, 1824), and *Protonectarina sylveirae* (de Saussure, 1854) (Figure 2A-E), and only one belonging to Polistini, *Polistes canadensis* (Linnaeus, 1758).

The vast majority of specimens observed visiting the fruits during the study were *P. ignobilis* (40), *P. occidentalis* (15), *P. paulista* (five), and *P. sericea* (five). In contrast, *B. lechiguna* (two) and *P. sylveirae* (two) were observed in smaller numbers throughout these days, while *P. canadensis* was recorded only once. The interval with the highest number of specimens foraging occurred between 08:00 am and 10:00 am.

Foraging behavior. During interactions, wasps either landed on nearby leaves and branches before walking to the fruits or landed directly on them, preferring sunlit areas than shaded during foraging. The wasps exclusively foraged on

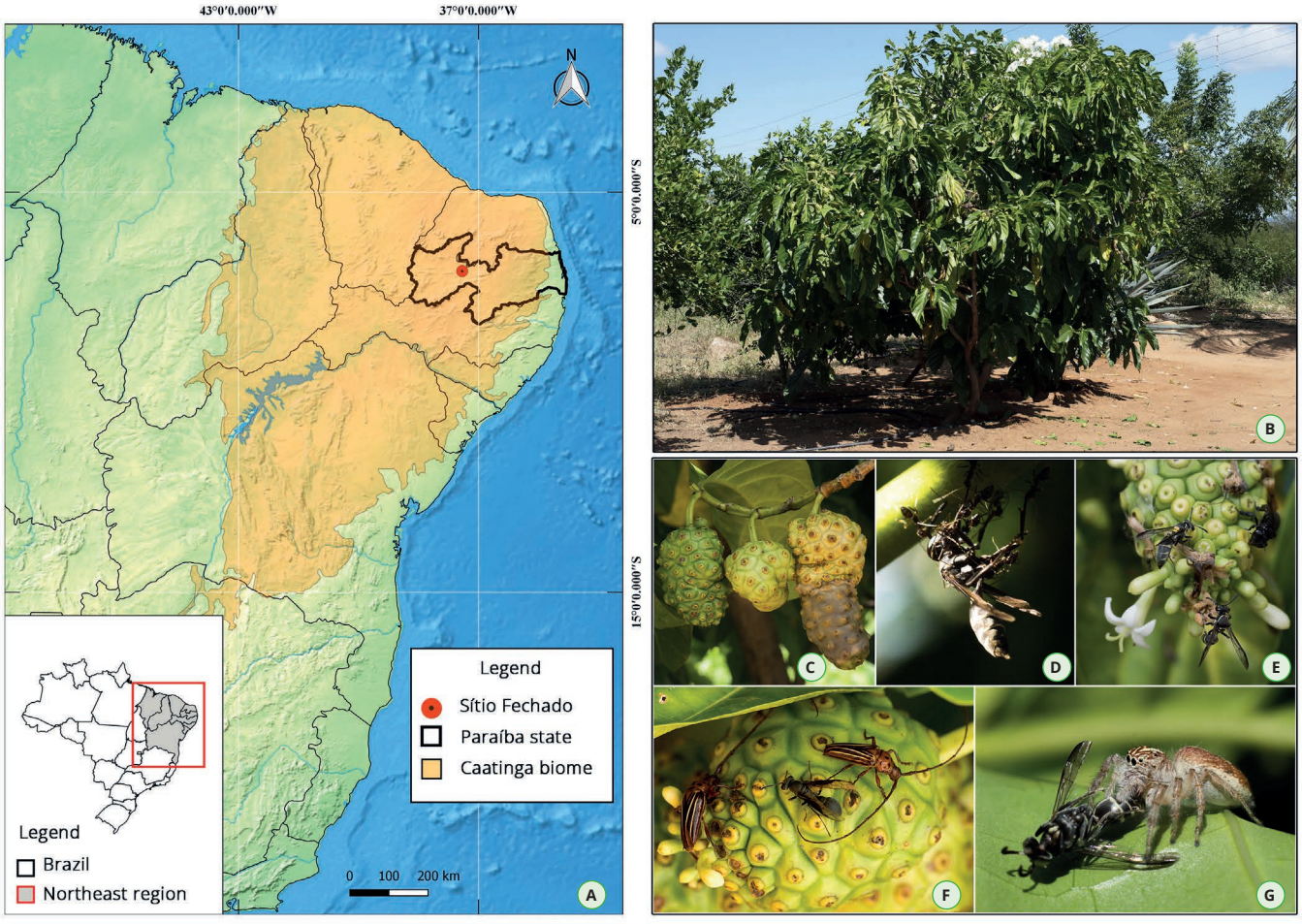

Figure 1. (A) Map of the study area; (B) Noni tree observed in this study; (C) Noni fruit at different stages of ripening; (D) Ants capturing a wasp; (E) Two species of social wasps sharing the resource with a bee; (F) Social wasp sharing the resource with beetles; and (G) Spider capturing a wasp.

the exposed carpel disc, a scar left by the calyx after flower abscission, which forms an "eye-like" structure (Waki *et al.* 2007). Also, some individuals were observed cutting the base of the corolla tube to access this structure (Figure 2B). Then, the wasps positioned themselves on the fruit's surface and engaged in scraping the carpel disk using their powerful mandibles, presumably to extract juices or soft tissues for consumption (Figure 2A, C and E). This behavior typically lasted for approximately 10 to 20 seconds, after which the wasps moved on to explore other carpel discs either on the same fruit or on another. No wasps were observed attempting to make holes to consume other parts of the fruits.

While exploiting the resource, they coexisted with conspecifics as well as stingless bees, beetles (Figures 1E and F), flies,

Figure 2. Species of social wasps foraging on noni in this study: (A) *Polybia sericea*, (B) *Polybia ignobilis*, (C) *Polybia paulista*, (D) *Polybia occidentalis*, (E) *Brachygastra lechiguana*.

and ants (Figure 2B and C). No predatory behavior directly targeting these wasps was observed. However, some wasps were found captured by ants and spiders (Figure 1D and G), suggesting the presence of these predators near the plant may be linked to their potential use of the wasps as prey. These observations point to a network of trophic interactions involving noni, which may serve as a focal resource attracting various organisms, including potential predators. Additionally, some wasps were chased away by bees but quickly returned to forage on another carpel disc.

Interestingly, a similar behavior was observed in Oaxaca, Mexico, obtained through Citizen Science initiatives (https://www.inaturalist.org/observations/73010936), where a specimen of *Parachartergus apicaloides* Willink, 1959, was recorded foraging on noni. This parallel suggests that the use of this fruit as a resource is not geographically restricted, indicating the possibility that other social wasps might also utilize noni in regions where the plant is cultivated.

Notably, no foraging activity was observed on ripe fruits (Figure 1C). This behavior can perhaps be explained by the fact that this fruit, when ripe, exudes a strong "rancid" odor, resembling butyric acid, which gives the fruits their common names in other countries as "cheese fruit" or "vomit fruit" (Dixon *et al.* 1999; Chan-Blanco *et al.* 2005; Dar 2009). On the other hand, further studies are required to determine whether the wasps are indeed repelled by specific chemical compounds, fungi or other pathogens associated with ripeness.

The Caatinga biome in Paraíba state is a region that have a high temperature and a long period of drought (Manoel-Filho 1970; Brito & Zanella 2022). Then, due to these climatic factors and the noni's fruits being rich in water, carbohydrate and protein as cited above, they become a great source for the wasps. Of the 15 Polistinae species recorded by Brito & Zanella (2022) in an area nearby, seven were observed in this study foraging on noni, which demonstrates that these species are indeed utilizing an exotic fruit as an opportunity for a new resource. This number could likely increase if further studies are carried out in this area, as some noni plants are cultivated on other properties in the same region.

In conclusion, given the limited scope of this study, further research in areas with noni cultivation may reveal additional species interactions, contributing to a better understanding of the role of exotic plants in shaping local biodiversity and ecological dynamics.

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MA: Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing and Resources; ELSB: Writing - original draft, Writing - review & editing and Resources.

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CONFLICT OF INTEREST STATEMENT

The author declares that there is no conflict of interest.

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