Notas

First record of microfibers associated with insects in the Amazon: social wasps (Hymenoptera: Vespidae)

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Abstract: The widespread release of synthetic microfibers into the environment poses a growing threat to biodiversity, including insects that interact closely with airborne and surface particles. Social wasps, known for using plant fibers to build their nests, may incorporate these synthetic materials into their colony structures. This study investigated the presence of non-vegetable fibers in the nests and digestive tracts of four social wasp species - *Polybia rejecta (F.)*, *Polybia bistriata (F.)*, *Polybia sericea* (Oliver) and *Polistes canadensis* (L.) - collected from distinct sites in the Amazon region of Brazil. Microscopic analysis revealed non-vegetable fibers, varying in color and measuring 1–16 mm, embedded in both the envelopes and combs of the nests, including structures with larvae. No synthetic fibers were found on the surface of nests or in the gut contents of dissected adult females. These findings represent the first record of synthetic fiber incorporation by insects in natural Amazonian environments. While ingestion was not confirmed in adults, the incorporation of these materials into nest architecture suggests a widespread environmental presence and raises concerns over potential sublethal effects on social wasps. This shows the potential of social wasps as bioindicators for monitoring microplastic pollution in tropical ecosystems.
Keywords: Conservation, Environmental impact, Microplastic, Pollution, Vespidae.
Resumen: La liberación generalizada de microfibras sintéticas en el medio ambiente representa una amenaza creciente para la biodiversidad, incluidos los insectos que interactúan estrechamente con partículas aéreas y superficiales. Las avispas sociales, conocidas por utilizar fibras vegetales en la construcción de sus nidos, pueden incorporar estos materiales sintéticos en la estructura de sus colonias. Este estudio investigó la presencia de fibras no vegetales en los nidos y en los tractos digestivos de cuatro especies de avispas sociales - *Polybia rejecta (F.)*, *Polybia bistriata (F.)*, *Polybia sericea* (Oliver) y *Polistes canadensis* (L.) - recolectadas en distintos sitios de la región amazónica de Brasil. El análisis microscópico reveló

fibras no vegetales, de diversos colores y con tamaños entre 1 y 16 mm, incrustadas tanto en los envoltorios como en los panales de los nidos, incluidas estructuras con larvas. No se encontraron fibras sintéticas en la superficie de los nidos ni en el contenido intestinal de las hembras adultas disecadas. Estos hallazgos representan el primer registro de la incorporación de fibras sintéticas por insectos en ambientes naturales de la Amazonía. Aunque no se confirmó la ingestión en adultos, la presencia de estos materiales en la arquitectura de los nidos sugiere una amplia presencia ambiental y genera preocupación sobre posibles efectos subletales en las avispas sociales. Esto demuestra el potencial de las avispas sociales como bioindicadores para el monitoreo de la contaminación por microplásticos en ecosistemas tropicales.
Palabras clave: Conservación, Contaminación, Impacto ambiental, Microplástico, Vespidae.

Clothing has been part of human history for at least 100,000 years, initially for protection and survival (Backwell et al., 2008; Gilligan, 2010). It later gained social and symbolic meaning, indicating status and identity (Eicher & Roach-Higgins, 1992). Over time, textile advances and cultural shifts, from Ancient Egypt to the Industrial Revolution, made fashion both a social marker and a global phenomenon (Trinkaus & Buzhilova, 2018; Feldman & Junior, 2019).

Despite being indispensable, fabrics release microfibers during washing (Cai et al., 2020), which are carried into natural water bodies, posing risks to aquatic fauna. Synthetic microfibers, also be categorized as microplastics, often derived from polyester and nylon and can be ingested by marine organisms, leading to bioaccumulation and potential disruptions in ecosystems (Napper & Thompson, 2023).

The synthetic fibers can also remain suspended in the atmosphere (Dris et al., 2017; Gasperi et al., 2018) where can adhere to the surfaces of insects, which then act as carriers, retransmitting these fibers into the ecosystem and ultimately to humans through the food chain (Shen et al., 2023). Moreover, synthetic fibers can negatively impact soil fauna in other ways. For instance, ants of the species *Lasiusgrandis* Forel, 1909 and *Monomorium* sp. were found entangled in synthetic fibers on an island in Spain (Luna et al., 2023).

Social wasps, known in Brazil as “marimbondos” or “cabas,” belong to the order Hymenoptera and can be divided into independent and swarming species. Independent species form their colonies with one or a few females and build open nests without a protective envelope. In contrast, swarming species establish their colonies with dozens of females and construct larger nests enclosed by a protective envelope (Wenzel, 2020; Barbosa et al., 2021).

Regardless of the founding strategy, most species use plant fiber to build their nests, which is why they are often referred to as “paper wasps” (Wenzel, 2020; Barbosa et al., 2021). The fiber is collected, mixed with saliva, and gradually deposited on the chosen surface for colony foundation. Consequently, social wasps interact with various types of particles and substances present in the environment, from heavy metals (Urbini et al., 2006) to synthetic fibers, as recorded in this study.

A nest of *Polybia rejecta* (Fabricius, 1798) and another of *Polybiabistriata* (Fabricius, 1804) were collected at Campus II of the National Institute for Amazonian Research (INPA) in Manaus, Brazil (3°05′45.8"S 59°59′22.0"W) in September 2023 and May 2024, respectively. Nests of *Polistescanadensis* (Linnaeus, 1758) were collected in the Ariaú Reserve, Iranduba, Brazil (3º15′16.207"S, 60º13′35.202"W), in October 2023. A nest of *Polybiasericea* (Oliver, 1792) was collected at the Manaus Air Base (BAMN) (3°08′43.5"S - 59°59′32.8"W) on March 20, 2024. All nests were stored in

transparent plastic bags to prevent contamination. To assess the possibility of microplastic ingestion by adults, the guts of 50 adult females of each species were dissected and their contents examined under a microscope, following the methodology proposed by Santos et al. 2021.

The nests were inspected in two stages. First, the entire structures were analyzed under a microscope. Then, to facilitate the sorting of microfibers, the envelope and comb material were separately crushed and examined under a microscope. As no analyses of the material composition were carried out, the fibers found were called non-vegetable fibers, which were defined by colors, different from the standard found in the nests, such as blue, green, and red, and which were insoluble in water.

Non-vegetable fibers measuring between 1 mm and 16 mm, of different colors, were found in fragments from both the envelope material and the combs (Fig. 1), including combs with larvae. No fibers were detected on the surface of the nests, reinforcing the idea that these fibers are processed along with vegetal fibers and used solely in the construction of the nest structure. This is the first record of the interaction between synthetic fibers and insects in a natural environment in the Amazon.

The presence of non-vegetal fibers in the structure of social wasp nests reveals the abundance of this material in the environment, raising significant concern, especially as the reduction in the abundance of social wasps has already been noted in recent years (Sanchez-Bayo & Wyckhuys, 2019). Interaction with these fibers can further impact populations, as occasional ingestion of this material can alter behaviors such as locomotion, reproduction, and foraging (Luna et al., 2023).

No fibers were found in the intestinal contents of the analyzed adult wasps. However, reports indicate that microplastics can cause intestinal blockages and even death, as demonstrated by De Souza et al. (2023). In their study, the authors conducted a laboratory experiment, offering food contaminated with microplastics to larvae of a social wasp species, where they observed larval mortality due to impaired defecation and a lower emergence rate of adults from surviving pupae.

In another group of great ecological and economic importance, such as social bees, particularly *A. mellifera*, laboratory studies have confirmed that the constant ingestion of microplastics by insects is a primary concern (Deng et al., 2021; Wang et al., 2021). Therefore, it is crucial that new research be conducted with a greater diversity of insects, both in the laboratory, testing the impact of different types and sizes of microfibers, and in natural environments. These studies will help us understand the extent of the damage caused and thus take appropriate containment measures, especially in the Amazon region.

Finally, the findings suggest that social wasps can serve as effective bioindicators of synthetic fiber pollution. Their close interaction with the environment, especially through nest construction using local materials, reflects the presence of airborne or surface contaminants. In this context, analyzing wasp nests offers a practical and reliable tool for monitoring microplastic pollution in tropical ecosystems.

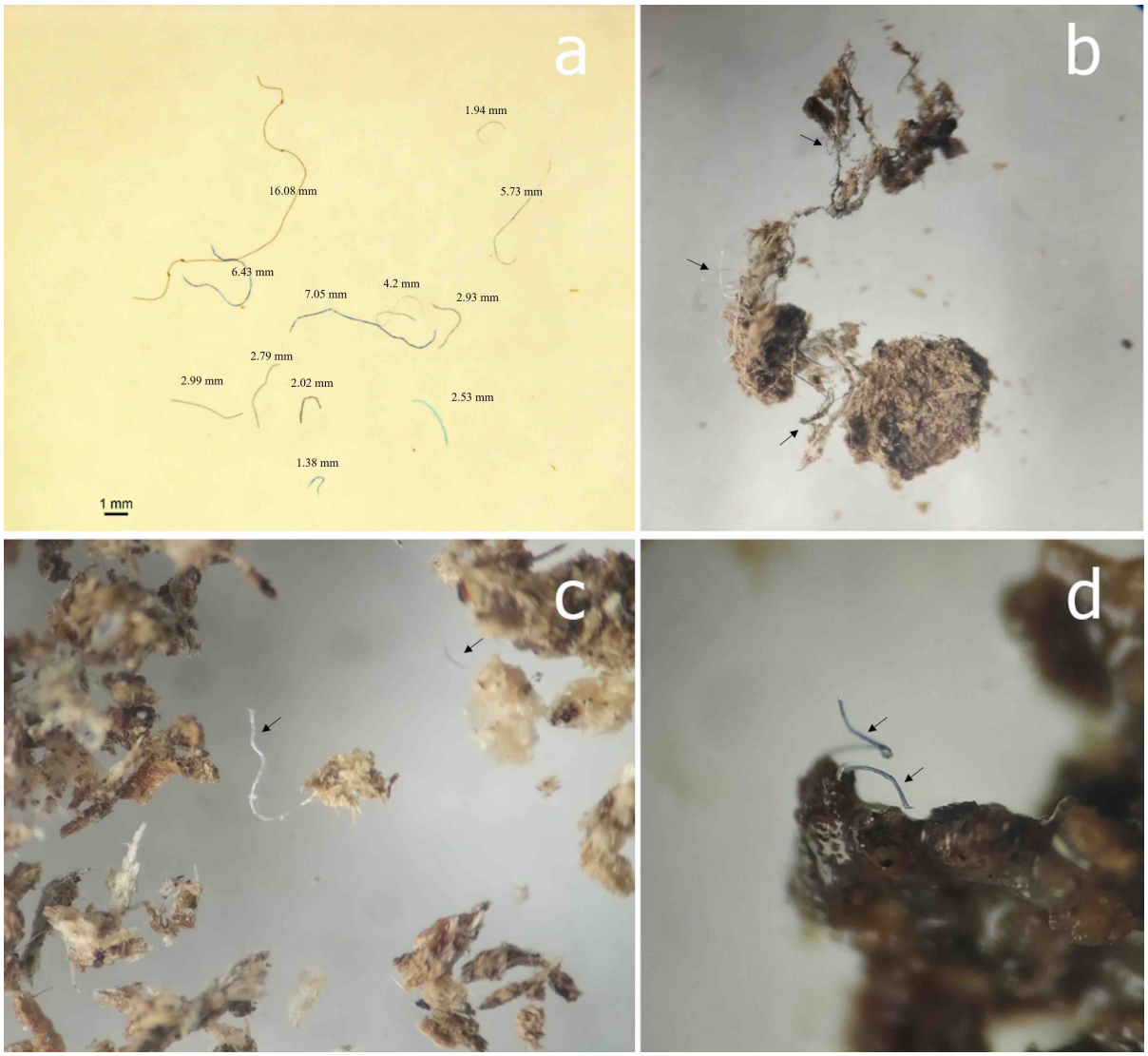

Figure 1.

Samples of microfibers found in wasp nests.

a. Slide with microfibers identified in these material fragments and their length measurements. b. c. and d. Microscope images showing microfibers, highlighted by arrows, entangled in the nest material during sorting. Scale bar= 1 mm.

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Notes

COMPETING INTERESTS

The authors have declared that no competing interests exist.

AUTHORS CONTRIBUTIONS

All authors contributed to the conception and design of the study. TTM and SB were responsible for preparing the materials, collecting data, and conducting the analysis. The initial draft of the manuscript was prepared by TTM, SB, and BCB, followed by revisions and feedback from all authors. All authors read and approved the final manuscript.

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