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RESEARCH ARTICLE

# Anthropoentomophagy in some states of Brazil: an up-to-date review

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**Abstract**

While there are well-documented records of anthropoentomophagy practices among numerous Indigenous Peoples and Local Communities in Brazil, it is likely that its prevalence remains significantly underestimated. This review examines a total of 116 edible insect species in Brazil, identified at the species level, categorized into eight orders: Blattodea, Coleoptera, Diptera, Hymenoptera, Hemiptera, Lepidoptera, Orthoptera, and Psocodea. Hymenoptera was the most represented order, comprising 79 species (68%). Depending on the species, these insects are consumed in both their immature and adult stages, either raw or cooked, ingested whole, in parts, or as by-products. Given Brazil's vast sociobiodiversity, edible insects exhibit substantial potential due to their nutritional richness and abundance, playing a crucial role in Traditional Food Systems while also offering promising prospects as sustainable ingredients for both household cuisine and the food industry.

**Keywords**

edible insects – ethnoentomology – entomophagy – nutrition – use of insects

## 1 Introduction

Anthropoentomophagy, defined as the human consumption of insects, is a historically ancient and geographically widespread practice (Costa Neto and Dunkel, 2016). This dietary habit is often overlooked, although it has deep cultural and ecological significance (Costa Neto and Ramos-Elorduy, 2006). It is particularly common in Africa, Asia, Oceania, and tropical Americas (Mitsuhashi, 2017). Among edible insect groups worldwide, beetles (Coleoptera) are the most consumed, accounting for 31% (n = 659) of the total edible insect species, with their larvae being the primary form consumed. Butterflies and moths (Lepidoptera) were the second most eaten group, representing 18% (n = 362). Bees, wasps and ants (Hymenoptera) make up 14% (n = 321) of edible insect species. Additionally, grasshoppers, crickets and locusts (Orthoptera) contribute to 278 species, while true bugs (Hemiptera) account for 237 species (data based on Jongema, 2017).

In the early 2010s, the Food and Agriculture Organization (FAO) organized a workshop to explore the potential of insect consumption as an alternative to reduce global meat intake and find the demand for alternative protein sources (van Huis *et al.*, 2013; van Huis, 2020). Since then, the number of studies exam-

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ining edible insect consumption has increased significantly, addressing diverse perspectives such as health, nutritional composition, ecological, economic viability, and sociocultural aspects (Brun *et al.*, 2022). Insects are now widely recognized as a nutritious and sustainable food source, with growing engagement from various stakeholders, including consumers, businesses, startups, educational institutions, governments, and other actors within the rapidly expanding insect-based food industry (Fiebelkorn *et al.*, 2020). Media coverage of this sector has also significantly increased in recent years (Mariod, 2020; Mwiinga *et al.*, 2022). Expanding insect consumption and production is encouraged to promote food security and to develop more environmentally efficient forms of animal farming (van Huis and Oonincx, 2017). Recent research (van Huis, 2024) indicates a shift in consumer attitudes driven by increasing awareness of the ecological and nutritional advantages of anthropoentomophagy (Caparros *et al.*, 2024).

A wide range of edible insect species, rich in protein, fat, minerals, vitamins, and dietary fiber, hold significant potential for addressing global food insecurity (Tao and Li, 2018). However, despite the numerous reviews, articles, and books published on entomophagy, this practice remains largely unknown or dismissed by many urban populations in many countries, mainly due to prejudices against the act of consuming insects, or reactions of disgust and disapproval. While insect-based foods offer a promising pathway toward sustainable protein consumption and production, their widespread adoption is contingent on consumer acceptance (Costa Neto and Cheung, 2019; Ranga *et al.*, 2024). Furthermore, the rational exploration and utilization of these resources continue to face resistance, often due to negative perceptions among governments and policymakers.

As insect consumption is a culturally acquired habit that has passed down through generations, traditional communities tend to naturally accept and respect this practice. These communities utilize insects based on their presence, abundance, and availability, often consuming different species on a "seasonal" basis (Ramos-Elorduy, 1990). Anthropoentomophagy is practiced selectively and organoleptically, with practitioners possessing detailed knowledge of when, how, and where to gather entomophagic resources. They also employ diverse methods for preparing and preserving insects, ensuring food availability during periods of scarcity (Ramos-Elorduy, 2010).

Brazil boasts extraordinarily dynamic sociobiodiversity, encompassing one of the highest rates of biological diversity in the world, alongside remarkable cultural diversity. Based on recent estimates, Indigenous Peoples in Brazil comprise 1.7 million individuals (0.83% of the population) and self-identify across 305 distinct ethnic groups (IBGE, 2022). These culturally distinct societies have developed a variety of adaptive strategies to thrive within the diverse ecosystems present across national territories (Diegues and Arruda, 2001). Alongside Indigenous Peoples, Brazil is also home to several traditional Local Communities, such as Afro-Brazilian communities (quilombolas), artisanal coast fishermen, Amazonian riverines, and dry-land pastoralists. According to Diegues and Arruda (2001), documenting the knowledge, practices, and resource use of both indigenous and non-indigenous populations is essential, as these communities undoubtedly hold invaluable wisdom about the biological diversity recognized today.

Ethnographic records of entomophagy in Brazil date back to the 16th century, when early chroniclers documented the practices and people of that time. The use of insects as food in Brazil has been reported since the onset of colonization. In 1542, Cabeza de Vaca (as cited in Noelli, 1993) described the consumption of larvae from *Morpheis smerintha* (Hübner, 1821) (Lepidoptera) by indigenous communities in the state of São Paulo: "(…) in the hollow of these canes, there were some white insects, as thick and long as a finger, which the people roasted to eat, and from them came a lot of fat, sufficient for frying very well; everyone ate them, considering them a very good food (…)." Eighteen years later, José de Anchieta also documented the consumption of these larvae and ants (*Atta* spp.) by inhabitants of São Vicente, São Paulo (Anchieta, 1900). Yves d'Evreux, a French religious and entomologist, noted that in the last quarter of the 16th century, entire villages (referring to settlements in the state of Maranhão) would become deserted during the swarming seasons of "saúvas" (*Atta* spp.), as men, women, and children rushed to hunt these leaf-cutting ants, removing their wings to toast and consume them (Frieiro, 1966).

The number of edible insect species in Brazil is likely to be severely underestimated. In many cases, the records are anecdotal and fail to specify the reference species. Overall, insects remain under-researched by ethnoentomologists (Jara, 1996) and are generally regarded as marginal resources in studies addressing various natural resources (Nonaka, 1996). To address this gap, it is essential for researchers to adopt an interdisciplinary approach that incorporates the values, practices, and knowledge of Indigenous people and local communities.

This study builds upon the foundational work of Costa Neto and Ramos-Elorduy (2006), which provides detailed insights into edible insects in Brazil, focusing on their ethnic, diverse, and significant roles. Leveraging the comprehensive data from this publication, we conducted an extensive literature review on entomophagy in Brazil until 2024, aiming to compile and update information on insect consumption and present a current perspective on this practice.

Our approach encompasses data from a wide range of sources, including articles, monographs, theses, reports, and presentations at national and international roundtables and conferences. The present study addresses the use of insects as human food and delves into the interactions between humans and insects. The data were gathered through fieldwork conducted by various researchers in diverse Indigenous People (see authors cited in Tables 1 and 2). In this study, we have also updated the scientific names of insects to reflect the most current taxonomy.

## 2 Inventory of edible insects

The pioneering work of Costa Neto and Ramos-Elorduy (2006) documented 115 edible insects distributed across 9 orders, 20 families, and 47 genera. Of these, 96 were identified at the species level and 19 at the genus level. In the current inventory, we recorded 140 edible insects, distributed among 8 orders, 24 families, and 68 genera. Of these, 116 were identified at the species level, while 24 were classified at the genus level (Table 1). Additionally, several species are referred to only by their indigenous or local names (Table 2). This represented an increase of 20.8% for species with complete taxonomy (from 96 to 116) and a 26.3% increase for species identified at the genus level (from 19 to 24). In terms of recorded families, the increase was 20% (from 20 to 24).

The order Hymenoptera was the most abundant, representing 89 species (63.5%), followed by Coleoptera with 24 species (17.2%), Blattodea with 9 species (6.4%), Orthoptera with 8 species (5.7%), and Lepidoptera with 6 species (4.3%) (Figure 1). In terms of the number of families per order, Coleoptera included six families, with Chrysomelidae contributing seven species; Lepidoptera ranked second with five families, with Saturniidae accounting for two species; and Hymenoptera had four families, with Apidae contributing 74 species. It is noteworthy that all the recorded species (100%) were terrestrial. These insects are consumed in various life stages, but larvae (91 records) are the most consumed, followed by pupae (56), adult individuals (30), and nymphs (2) (Figure 2). In addition to the body parts of edible insects, wild honeys (98), especially from stingless bees, and pollen (23) are also consumed.

Records of insect consumption exist in 17 of the 27 Brazilian states (66,7%) (Figure 3). The state of Mato Grosso has 55 documented species, followed by Pará (22), Rondônia (20), Amazonas (17), and São Paulo (15) (Figure 4). Could Mato Grosso be a possible center for the spread of insect-eating culture? Could this state benefit from the Pantanal-Cerrado-Amazon ecotones versus high ethnic diversity? At least 11 Indigenous Peoples inhabiting the territory of Mato Grosso have records of edible insects: Bororo, Enawenê Nawê, Kaiabi, Kamaiurá, Kuikuru, Mehinaku, Nambiquara, Paiter Suruí, Tapirapé, Trumai, and Umutina (Table 1). In addition, the Kaiabi, Kamaiurá, Kuikuru, Mehinaku and Trumai, all located in the Parque Indígena do Xingu, share cultural elements. We believe that the state of Mato Grosso stands out due to a greater number of research in anthropology and ethnobiology that were carried out with indigenous populations and their interactions with insects.

Over a span of nearly 20 years, the records of 116 species with complete taxonomy are still below expectations. In this regard, we can attest that the actual number of insect species utilized as food resources is likely to be underestimated. Out of the 305 distinct ethnic groups in Brazil (IBGE, 2022), our review documents the use of insects as food by 44 ethnic groups based on studies primarily conducted by anthropologists, ethnographers, and ethnobiologists. There is a need to expand the sample, including additional Indigenous people. These data in fact reflect a lack of ethnoentomological studies and point to the need for sampling efforts and fieldwork to understand where and who is consuming insects, which species are involved, and all the traditional nuances related to preparation and storage methods. It is also important to investigate the historical use of insects as food, to determine whether it is a declining practice or whether it persists in certain ethnic groups, and to understand sociocultural dynamics and the implications for food security and conservation of biocultural heritage.

Considering Brazil's sociocultural diversity, coupled with its rich biodiversity, there is still much to study regarding the use of insects as food resources. More investment in fieldwork is needed to conduct culturally oriented research to document local knowledge and practices related to edible insects in different regions of the country, both in urban and rural areas. For example,

TABLE 1 Updated list of edible insects consumed in some Brazilian states

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| Orthoptera | Acrididae | *Rhammatocerus* | *schistocercoides* (Rehn, 1906) | Adult, nymph | MT | Nambiquara | Embrapa (2000) |
| | | *Rhammatocerus* | sp. | Nymph | MT | Nambiquara | Setz (1991) |
| | | *Schistocerca* | sp. | Adult | MT | Nambiquara | Setz (1991) |
| | Gryllidae | *Gryllus* | *assimilis* (Fabricius, 1775) | Adult | – | – | Costa Neto (2023) |
| | | *Acheta* | *domesticus* (Linnaeus, 1758) | Adult | – | – | Costa Neto (2023) |
| | Romaleidae | *Titanacris* | *albipes* (De Geer, 1773) | Adult | MT | Nambiquara | Setz (1991) |
| | | *Titanacris* | sp. | Adult | MT | Nambiquara | Setz (1991) |
| | | *Tropidacris* | *collaris* (Stoll, 1813) | Adult | MT | Nambiquara | Setz (1991) |
| Blattodea | Termitidae | *Cornitermes* | sp. | Alate adult, soldier, queen | AM | Desâna | Ribeiro and Kenhíri (1987) |
| | | *Termes* | *flavicolle* (Fabricius, 1793) | Soldier | AM | – | Wallace (1854) |
| | | *Syntermes* | *spinosus* (Latreille, 1804) | Alate soldier | MT | Nambiquara | Setz (1991) |
| | | *Syntermes* | sp. | Adult | AM | Maku | Milton (1984) |
| | | | | | AM | Tariana | Gouveia (2022) |
| | | | | | MT | Enawenê-Nawê | Santos (1995) |
| | | *Nasutitermes* | sp. | Adult | MT | Enawenê-Nawê | Santos (1995) |
| | Blaberidae | *Blaptica* | *dubia* Serville, 1838 | Adult | – | – | Costa Neto (2023) |
| | | *Gromphadorhina* | *portentosa* (Schaum, 1853) | Adult | – | – | Costa Neto (2023) |
| | | *Nauphoeta* | *cinerea* (Olivier, 1789) | Adult | – | – | Costa Neto (2023) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | Blattidae | *Periplaneta* | *americana* (Linnaeus, 1758) | – | SC | Xokleng | Lenko and Papavero (1996) |
| Hemiptera | Membracidae | *Umbonia* | *spinosa* (Fabricius, 1775) | Adult | AM | – | Wallace (1854) |
| Psocodea | Pediculidae | *Pediculus* | *humanus* Linnaeus, 1758 | Adult | MT | Tapirapé | Hitchcock (1962) |
| | | *Pediculus* | sp. | Adult | AM | Maku | Paoletti and Dufour (2005) |
| | | | | | SP | Tupinambá | Staden (2000) |
| Hymenoptera | Argidae | *Dielocerus* | *formosus* (Klug, 1834) | Pupa | RO | Nambiquara | Carrera (1992) |
| | Formicidae | *Atta* | *cephalotes* (Linnaeus, 1758) | Alate adult | PA | Kayapó | Posey (1987b) |
| | | | | | MT | Enawenê-Nawê | Santos (1995) |
| | | *Atta* | *sexdens* (Linnaeus, 1758) | Alate adult | AM | Tukuna | Taunay (1937) |
| | | | | | BA | Tupinambá | Sousa (1971) |
| | | | | | PA | Sateré-Maué, Kayapó | Taunay (1937), Posey (1986) |
| | | | | | MT | Nambiquara | Setz (1991) |
| | | | | | MS | Guarani Ñandéva | Vera *et al.* (2013) |
| | | *Atta* | *laevigata* (Smith, 1858) | Alate adult | MT | Kuikuro, Kamaiurá, | Carvalho (1949, 1951), Setz (1991) |
| | | | | | | Mehinaku, Trumai, Nambiquara | |
| | | *Atta* | *bisphaerica* Forel, 1908 | Alate adult | – | – | Costa Neto and Ramos-Elorduy (2006) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | | *Atta* | *opaciceps* Borgmeier, 1939 | Alate adult | – | – | Costa Neto and Ramos-Elorduy (2006) |
| | | *Atta* | *capiguara* Gonçalves, 1944 | Alate adult | – | – | Costa Neto and Ramos-Elorduy (2006) |
| | | *Atta* | spp. | Alate adult | PA | Kayapó, Mundurucu, Sateré-Maué | Posey (1987b), Santos (1957), Lenko and Papavero (1996) |
| | | | | | AM | Baniwa, Desâna, Macu, Waura, Mehinako, Yudja Juruna, Kamaiura, Kuikuro, Kalapalo, Tariana, Tukano, Tuyuka, Wanana | Giacone (1949), Gouveia (2022), Ribeiro and Kenhíri (1987), Balée (2000), Petiza *et al.* (2013), Lenko and Papavero (1996) |
| | | | | | MT | Umutina | Apodonepa and Barreto (2015) |
| | | | | | SP | – | Rossato (1984) |
| | | | | Alate adult | RO | Suruí | Coimbra Júnior (1984) |
| | | | | Adult | AL | – | Lima (2000) |
| | | | | | CE | – | Alves *et al.* (2015) |
| | | | | | RR | – | Almeida *et al.* (2017) |
| | | | | | PE | – | Almeida *et al.* (2017) |
| | | | | | PB | – | Alencar *et al.* (2012) |
| | Vespidae | *Brachygastra* | *lecheguana* (Latreille, 1804) | Larva, pupa, honey | SP | Guarani M'byá | Rodrigues (2005) |
| | | | | | AM | Desâna, Yanomamo | Costa Neto and Ramos-Elorduy (2006) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | | | | Honey | MT | Enawenê-Nawê, Tapirapé | Costa Neto and Ramos-Elorduy (2006) |
| | | *Brachygastra* | sp. | Honey | PA | Kayapó | Posey (1986) |
| | | *Polybia* | *occidentalis* (Olivier, 1792) | Honey | – | – | Bodenheimer (1951) |
| | | | | Larva, pupa | MT | Nambiquara | Setz (1991) |
| | | *Polybia* | *dimidiata* (Oliver, 1792) | Larva, pupa | MT | Nambiquara | Setz (1991) |
| | | *Pseudopolybia* | *vespiceps* (Saussure, 1863) | Larva, pupa | MT | Nambiquara | Setz (1991) |
| | | *Epipona* | *media* Cooper, 2002 | Larva, pupa | MT | Nambiquara | Setz (1991) |
| | | *Apoica* | *pallens* (Fabricius, 1804) | Larva, pupa | MT | Nambiquara | Setz (1991) |
| | Apidae | *Apis* | *mellifera scutellata* Lepeletier, 1836 | Honey | SP | Guarani M'byá | Rodrigues (2005) |
| | | | | | BA | Pankararé | Costa Neto (1998) |
| | | | | Larva, pupa, honey, pollen | MT | Nambiquara, Umutina | Setz (1991), Apodonepa and Barreto (2015) |
| | | | | | MS | Guarani Ñandéva | Vera *et al.* (2013) |
| | | *Geotrigona* | *mombuca* (Smith, 1863) | Honey | – | – | Crane (1992) |
| | | *Geotrigona* | *mattogrossensis* (Ducke, 1925) | Honey | MT | Enawenê-Nawê | Santos and Sales Júnior (1995) |
| | | *Melipona* | *scutellaris* Latreille, 1811 | Honey | BA | – | Costa Neto (2003) |
| | | *Melipona* | *mandacaia* Smith, 1863 | Honey | BA | – | Costa Neto (2003) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | | *Melipona* | *marginata* Lepeletier, 1836 | Honey | SP | Guarani M'byá | Rodrigues (2005) |
| | | *Melipona* | *fasciata* (Latreille, 2008) | Honey | – | – | Bodenheimer (1951) |
| | | *Melipona* | *crinita* Moure & Kerr, 1950 | Honey | AC | Ashaninka, Jamamadi | Costa Neto and Ramos-Elorduy (2006) |
| | | *Melipona* | *grandis* Guérin-Méneville, 1844 | Larva, pupa, honey | AC | Ashaninka, Jamamadi | Costa Neto and Ramos-Elorduy (2006) |
| | | | | | RO/MT | Paiter Suruí | Molina *et al.* (2023) |
| | | *Melipona* | *schwarzi* Moure, 1963 | Larva, pupa, honey | RO/MT | Paiter Suruí | Molina *et al.* (2023) |
| | | *Melipona* | *rufiventris* Lepeletier, 1836 | Honey | AC | Ashaninka, Jamamadi | Costa Neto and Ramos-Elorduy (2006) |
| | | *Melipona* | *eburnea fuscopilosa* Moure & Kerr, 1950 | Honey | AC | Ashaninka, Jamamadi | Costa Neto and Ramos-Elorduy (2006) |
| | | *Melipona* | *asilvai* Moure, 1971 | Honey | BA | – | Dias (2003) |
| | | *Melipona* | *compressipes* (Fabricius, 1804) | Honey | – | – | Crane (1992) |
| | | | | Honey, pollen | MT | Kaiabi | Ferreira *et al.* (2010) |
| | | *Melipona* | *compressipes fasciculata* Smith, 1854 | Larva, pupa, honey | PA | Kayapó | Posey and Camargo (1985) |
| | | *Melipona* | *melanoventer* Schwarz, 1932 | Pupa, larva, honey | PA | Kayapó | Posey and Camargo (1985) |
| | | *Melipona* | *fulva* Lepeletier, 1836 | Honey | – | – | Crane (1992) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | | *Melipona* | *seminigra abunensis* Cockerell, 1912 | Honey | MT | Enawenê-Nawê | Santos and Sales Júnior (1995) |
| | | *Melipona* | *seminigra merrillae* Cockerell, 1919 | Honey | – | – | Crane (1992) |
| | | *Melipona* | *quadrifasciata* Lepeletier, 1836 | Honey | SP | Guarani M'byá | Rodrigues (2005) |
| | | *Melipona* | *bicolor* Lepeletier, 1836 | Honey | SP | Guarani M'byá | Rodrigues (2005) |
| | | *Melipona* | *bicolor schencki* Gribodo, 1893 | Honey | – | – | Crane (1992) |
| | | *Melipona* | *interrupta* Latreille, 1811 | Larva, pupa, honey, pollen | MT | Nambiquara | Setz (1991) |
| | | | | Larva, pupa, honey | RO | Suruí | Coimbra Júnior (1985) |
| | | *Friesella* | *schrottkyi* (Friese, 1900) | Honey, larva, wax, pupa, pollen | SP | Guarani M'byá | Rodrigues (2005) |
| | | *Frieseomelitta* | *varia* (Lepeletier, 1836) | Honey | MT | Kaiabi | Ferreira *et al.* (2010) |
| | | *Frieseomelitta* | *meadewaldoi* (Cockerell, 1915) | Larva, pupa, honey | RO/MT | Paiter Suruí | Molina *et al.* (2023) |
| | | *Frieseomelitta* | *silvestrii* (Friese, 1902) | Honey | – | – | Crane (1992) |
| | | *Frieseomelitta* | sp. | Honey | AL | – | Costa Neto (1994) |
| | | *Cephalotrigona* | *femorata* (Smith, 1854) | Larva, pupa, honey, pollen | MT | Nambiquara | Setz (1991) |
| | | *Cephalotrigona* | *capitata* (Smith, 1854) | Honey | SP | Guarani M'byá | Rodrigues (2005) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | | | | | BA | – | Costa Neto (2003) |
| | | *Nannotrigona* | *testaceicornis* (Lepeletier, 1836) | Honey | – | – | Bodenheimer (1951) |
| | | *Oxytrigona* | sp.1 | Larva, pupa, honey | PA | Kayapó | Posey (1987b) |
| | | *Oxytrigona* | sp.2 | Larva, pupa, honey | PA | Kayapó | Posey (1987b) |
| | | *Oxytrigona* | sp.3 | Larva, pupa, honey | PA | Kayapó | Posey (1987b) |
| | | *Oxytrigona* | *flaveola* (Friese, 1900) | Honey | MT | Kaiabi | Ferreira *et al.* (2010) |
| | | *Oxytrigona* | *obscura* (Friese, 1900) | Larva, pupa, honey, pollen | MT | Nambiquara | Setz (1991) |
| | | *Oxytrigona* | *tataira* (Smith, 1863) | Larva, pupa, honey | PA | Kayapó | Posey (1987b) |
| | | | | Larva, pupa, honey pollen | MT | Nambiquara | Setz (1991) |
| | | *Paratrigona* | sp. | Larva, pupa, honey | SP | Guarani M'byá | Rodrigues (2005) |
| | | *Partamona* | *cupira* (Smith, 1863) | Honey | AL | – | Costa Neto (1994) |
| | | | | Larva, pupa, honey, pollen | MT | Nambiquara | Setz (1991) |
| | | *Partamona* | *bilineata* (Say, 1837) | Honey | – | – | Bodenheimer (1951) |
| | | *Plebeia* | *mosquito* (Smith, 1863) | Honey | AL | – | Lima (2000) |
| | | *Plebeia* | *emerina* (Friese, 1900) | Honey | – | – | Crane (1992) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | | *Plebeia* | *remota* (Holmberg, 1903) | Honey | – | – | Crane (1992) |
| | | *Plebeia* | spp. | Larva, pupa, honey | SP | Guarani M'byá, Suruí | Rodrigues (2005), Coimbra Júnior (1984) |
| | | | | | RO | | |
| | | *Ptilotrigona* | *lurida* (Smith, 1854) | Larva, pupa, honey | RO/MT | Paiter Suruí | Molina *et al.* (2023) |
| | | *Scaptotrigona* | sp.1 | Larva, pupa, honey | RO | Suruí | Coimbra Júnior (1984) |
| | | *Scaptotrigona* | sp.2 | Honey | MT | Enawenê-Nawê | Santos and Sales Júnior (1995 |
| | | *Scaptotrigona* | *nigrohirta* Moure, 1968 | Larva, pupa | PA | Kayapó | Posey and Camargo (1985) |
| | | | | Larva, pupa, honey, pollen | MT | Nambiquara | Setz (1991) |
| | | *Scaptotrigona* | *polysticta* Moure, 1950 | Larva, pupa, honey | PA | Kayapó | Posey and Camargo (1985) |
| | | | | Larva, pupa, honey | RO/MT | Paiter Suruí | Molina *et al.* (2023) |
| | | | | Larva, pupa, honey, pollen | MT | Nambiquara | Setz (1991) |
| | | *Scaptotrigona* | *xanthotricha* Moure, 1950 | Larva, pupa, honey, pollen | MT | Nambiquara | Setz (1991) |
| | | | | Larva, pupa, honey | RO | Suruí | Coimbra Júnior (1984) |
| | | *Scaptotrigona* | *tubiba* (Smith, 1863) | Honey | AL | – | Costa Neto (1994) |
| | | *Scaptotrigona* | *postica* (Latreille, 1807) | Honey | | | Crane (1992) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | | | | Larva, pupa, honey, pollen | MT | Kaiabi | Ferreira *et al.* (2010) |
| | | *Tetragona* | *clavipes* (Fabricius, 1804) | Honey | – | – | Crane (1992) |
| | | | | Honey | SP | Guarani M'byá | Rodrigues (2005) |
| | | | | Larva, pupa, honey | RO | Suruí | Coimbra Júnior (1984) |
| | | | | Larva, pupa, honey, pollen | MT | Enawenê-Nawê, Kaiabi | Santos and Sales Júnior (1995), Ferreira *et al.* (2010), Coimbra |
| | | *Tetragona* | *dorsalis* (Smith, 1854) | Larva, pupa, honey | RO | Suruí | Júnior (1984) |
| | | *Tetragona* | *truncata* Moure, 1971 | Larva, honey, pollen | MT | Kaiabi | Ferreira *et al.* (2010) |
| | | *Tetragonisca* | *angustula* Latreille, 1811 | Larva, pupa, honey | PA | Kayapó | Posey (1987b) |
| | | | | Larva, pupa, honey, pollen | MT | Enawenê-Nawê, Kaiabi | Santos and Sales Júnior (1995), Ferreira *et al.* (2010) |
| | | | | Honey | MT | Umutina | Apodonepa and Barreto (2015) |
| | | | | Honey | BA | – | Costa Neto (1996) |
| | | | | Larva, pupa, honey | RO/MT | Paiter Suruí | Molina *et al.* (2023) |
| | | | | Larva, pupa, honey, pollen | SP | Guarani M'byá | Rodrigues (2005) |
| | | *Duckeola* | *ghilianii* (Spinola, 1853) | Larva, pupa, honey, pollen | MT | Enawenê-Nawê, Nambiquara | Setz (1991), Santos and Sales Júnior (1995) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | | *Trigona* | *amazonensis* (Ducke, 1916) | Larva, pupa, honey | PA | Kayapó | Posey and Camargo (1985) |
| | | *Trigona* | *hyalinata* (Lepeletier, 1836) | Honey | MT | Enawenê-Nawê | Santos and Sales Júnior (1995) |
| | | *Trigona* | *branneri* Cockerell, 1912 | Larva, pupa, honey | RO | Suruí | Coimbra Júnior (1984) |
| | | | | | MT | Enawenê-Nawê, Nambiquara | Setz (1991), Santos and Sales Júnior (1995) |
| | | *Trigona* | *chanchamayoensis* Schwarz, 1948 | Larva, pupa, honey | PA | Kayapó | Posey (1987b) |
| | | *Trigona* | *silvestrii* Friese, 1902 | Honey | – | – | Crane (1992) |
| | | *Trigona* | *dallatorreana* Friese, 1900 | Larva, pupa | PA | Kayapó | Posey and Camargo (1985) |
| | | | | Larva, pupa, honey, pollen | MT | Enawenê-Nawê, Nambiquara | Setz (1991), Santos and Sales Júnior (1995) |
| | | *Trigona* | *leugogastra* Cockerell, 1914 | Larva, pupa, honey, pollen | MT | Nambiquara | Setz (1991) |
| | | *Trigona* | *cilipes* (Fabricius, 1804) | Larva, pupa, honey, pollen | MT | Enawenê-Nawê, Nambiquara | Setz (1991), Santos and Sales Júnior (1995) |
| | | | | Larva, pupa, honey | PA | Kayapó | Posey (1987) |
| | | *Trigona* | *spinipes* (Fabricius, 1793) | Larva, pupa, honey, pollen | SP | Guarani M'byá, | Rodrigues (2005) |
| | | | | Larva, pupa, honey | PA | Kayapó | Posey (1987b) |
| | | | | Honey | BA | Pankararé | Costa Neto (1998) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | | *Trigona* | *goettei* (Friese, 1900) | Honey | MT | Enawenê-Nawê | Santos and Sales Júnior (1995) |
| | | *Trigona* | *recursa* Smith, 1863 | Honey | – | | Ott (1998) |
| | | *Trigona* | *guianae* Cockerell, 1910 | Honey | – | – | Bodenheimer (1951) |
| | | *Trigona* | *truculenta* Almeida, 1984 | Honey | – | – | Bodenheimer (1951) |
| | | *Trigona* | *hypogea* Silvestri, 1902 | Larva, pupa, honey, pollen | MT | Nambiquara | Setz (1991) |
| | | *Trigona* | *mombuca* Smith, 1863 | Honey | – | – | Crane (1992) |
| | | *Xylocopa* | *muscaria* (Fabricius, 1775) | Honey | – | – | Bodenheimer (1951) |
| | | *Lestrimellitta* | *limao* (Smith, 1863) | Larva, pupa, honey, pollen | MT | Nambiquara | Setz (1991) |
| Coleoptera | Scarabaeidae | *Megasoma* | *anubis* (Chevrolat, 1836) | Larva | – | – | Netolitzky (1920) |
| | | | | Larva | MG | – | Netolitzky (1920) |
| | | *Megasoma* | *actaeon* (Linnaeus, 1758) | Larva, adult | AM | Kayapó | Posey (1987b) |
| | | *Strategus* | sp. | Larva, adult | PA | Kayapó | Posey (1987b) |
| | | *Megaceras* | sp. | Larva | AM | – | Ratcliffe (1990) |
| | | *Dynastes* | *hercules* (Linnaeus, 1758) | Larva | AM | – | Ratcliffe (1990) |
| | | *Geniatosoma* | *nigra* (Ohaus, 1917) | Larva | AM | Tukano | Carrera (1992) |
| | Chrysomelidae | *Pachymerus* | *nucleorum* Fabricius, 1792 | Larva | AL, BA | – | Costa Neto (2003) |
| | | | | | TO | Timbira | Paoletti and Dufour (2005) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | | | | | MA | – | Lima and Freitas (2023) |
| | | | | | PA | Araweté | Viveiros de Castro (1992) |
| | | | | Larva | MS | Guarani Ñandéva | Vera *et al.* (2013) |
| | | *Pachymerus* | *bactris* (Linnaeus, 1763) | Larva | – | – | Brito and Costa Neto (2022) |
| | | *Pachymerus* | *cardo* (Fåhraeus, 1839) | Larva | RO | Suruí | Coimbra Júnior (1984) |
| | | *Pachymerus* | sp. | Larva | BA | – | Costa Neto (2003) |
| | | *Speciomerus* | *ruficornis* (Germar, 1818) | Larva | – | – | Brito and Costa Neto (2022) |
| | | *Caryoborus* | serripes (Sturm, 1826) | Larva | PA | – | Soares (2019) |
| | | *Caryobruchus* | sp. | Larva | RO | Suruí | Coimbra Júnior (1984) |
| | Buprestidae | *Euchroma* | *giganteum* (Linnaeus, 1758) | Larva | PA | Kayapó | Posey (1987b) |
| | Cerambycidae | *Macrodontia* | *cervicornis* (Linnaeus, 1758) | Larva | – | – | Netolitsky (1920) |
| | Curculionidae | *Rhynchophorus* | *palmarum* (Linnaeus, 1758) | Larva | RO | Suruí | Coimbra Júnior and Santos (1993) |
| | | | | Larva | MS | Guarani Ñandéva | Vera and Brand (2012) |
| | | | | | AM | Maku | Milton (1987) |
| | | | | | MT | Bororo | Paoletti and Dufour (2005) |
| | | | | Larva | MT | Umutina | Apodonepa and Barreto (2015) |
| | | | | | SP | Caingua (Guarani) | Paoletti and Dufour (2005) |
| | | *Rhynchophorus* | sp. | Larva | AM | Baniwa | Petiza *et al.* (2013) |
| | | *Cosmopolites* | *sordidus* (Germar, 1824) | Larva | MS | Guarani Ñandéva | Vera and Brand (2012) |

TABLE 1 (Continued)

| Taxonomy data | | | | Entomophagy data | | | Reference |
|---|---|---|---|---|---|---|---|
| Order | Family | Gender | Species | Consumption level | Area | Ethnic groups | |
| | | *Homalinotus* | *validus* (Olivier, 1790) | Larva | RO/MT | Paiter Suruí | Molina *et al.* (2023) |
| | | *Rhinostomus* | *barbirostris* (Fabricius, 1775) | Larva | RO | Suruí | Coimbra Júnior and Santos (1993) |
| | | | | | AC | – | Soares and Lucas (2019) |
| | | | | | MT | Nambiquara | Setz (1991) |
| | | *Metamasius* | sp. | Larva | MS | Guarani Ñandéva | Vera and Brand (2012) |
| | Tenebrionidae | *Ulomoides* | *dermestoides* (Fairmaire, 1893) | Adult | AL, BA | – | Costa Neto (1999) |
| | | *Zophobas* | *morio* (Fabricius, 1776) | Larva | – | – | Costa Neto (2023) |
| | | *Tenebrio* | *molitor* Linnaeus, 1758 | Larva | – | – | Costa Neto (2023) |
| Lepidoptera | Mimallonidae | *Cicinnus* | *callipius* Schaus, 1928 | Larva | | Paiter Suruí | Molina *et al.* (2023) |
| | Notodontidae | *Lusura* | *altrix* Stoll, 1782 | Larva | | Paiter Suruí | Molina *et al.* (2023) |
| | Nymphalidae | *Brassolis* | *sophorae* (Linnaeus, 1758) | Larva | MT | Nambiquara | Setz (1991) |
| | Pyralidae | *Myelobia* | *smerintha* (Hübner, 1821) | Larva | SC | Kaingang | Schorr and Schmitz (1975) |
| | | | | Larva | MS | Guarani Ñandéva | Vera *et al.* (2013) |
| | Saturniidae | *Molippa* | *nibasa* Maassen & Weyding, 1885 | Larva | | Paiter Suruí | Molina *et al.* (2023) |
| | | *Lonomia* | sp. | Larva | AM | Tariana | Gouveia (2022) |
| Diptera | Simuliidae | *Simulium* | *rubrithorax* Lutz, 1909 | Larva | AM | Yanomamo | Shelley and Luna Dias (1989) |

AC, Acre; AL, Alagoas; AM, Amazonas; BA, Bahia; CE, Ceará; PB, Paraíba; MA, Maranhão; MG, Minas Gerais; MS, Mato Grosso do Sul; MT, Mato Grosso; PA, Pará; PE, Pernambuco; RO, Rondônia; RR, Roraima; SC, Santa Catarina; SP, São Paulo; TO, Tocantins.

TABLE 2 Some examples of native names of edible insects recorded in Indigenous ethnic groups of Brazil

| Order | Local name | English name | Stage/used product | Ethnicity | Geographic area | Source |
|---|---|---|---|---|---|---|
| Orthoptera | *Ahato* | Grasshopper | Adult | Waurá, Mehinako | Xingu National Park | Kopp *et al.* (2025) |
| | *Aügügo* | Grasshopper | Adult | Kuikuru, Kalapalo | Xingu National Park | Kopp *et al.* (2025) |
| | *Tzutzu* | Grasshopper | Adult | Yudja | Xingu National Park | Kopp *et al.* (2025) |
| Blattodea | *Maniuara* | Termite | Adult | – | Río Negro | Pereira (1974) |
| | *Heri* | Térmite | Adult | Waurá | Xingu National Park | Kopp *et al.* (2025) |
| | *Exkó* | Termite | Adult | – | Río Negro | Pereira (1974) |
| | *Buxtuá* | Termite | Adult | – | Río Negro | Pereira (1974) |
| | *Ataoro* | Termite | Adult | Enawenê-Nawê | Mato Grosso | Santos (1995) |
| Hemiptera | *Haieru* | Stink beetle | Nymph | Nambiquara | Mato Grosso | Setz (1991) |
| | *Katagu* | Cicada | Adult | Kalapalo, Kuikuro | Xingu National Park | Kopp *et al.* (2025) |
| | *Nukikĩ* | Cicada | Adult | Kamaiurá | Xingu National Park | Kopp *et al.* (2025) |
| Hymenoptera | *Yha* | Leaf-cutter ant | Adult | Uru-eu-wau-wau, Amondawa | Rondônia | Instituto Socioambiental (2025) |
| | *Yaya* | Limon ant | Adult | Waurá | Xingu National Park | Kopp *et al.* (2025) |
| | *Metsukuto* | Ant | Adult | Waurá | Xingu National Park | Kopp *et al.* (2025) |
| | *Kuta* | Ant | Adult | Waurá, Mehinako | Xingu National Park | Kopp *et al.* (2025) |
| | *Iquytáia* | Ant | Adult | – | Amazonas | Pereira (1974) |
| | *Cuqui* | Ant | Adult | – | Uaupés- Caquetá | Lenko and Papavero (1996) |
| | *Nkgoginkgogi* | Honeybee | Honey | Kuikuro, Kalapalo | Xingu National Park | Kopp *et al.* (2025) |
| | *Xuluxulu* | Stingless bee | Honey | Waurá | Xingu National Park | Kopp *et al.* (2025) |
| | *Kraxai* | Stingless bee | Honey | Guarani M'Byá | São Paulo | Rodrigues (2005) |
| | *Kawiju* | Wasp | Larva, pupa | Kamaiurá | Xingu National Park | Kopp *et al.* (2025) |
| Coleoptera | *Tumbu* | Beetle | Larvae | Kaingang | South of Brazil | Schorr and Schmitz (1975) |
| | *Fytogngá* | Beetle | Larvae | Kaingang | Paraná | Baldus (1947) |
| | *Niaingá* | Beetle | Larvae | Kaingang | Paraná | Baldus (1947) |
| | *Feniú* | Beetle | Larvae | Kaingang | Paraná | Baldus (1947) |
| Lepidoptera | *Mongo* | Butterfly | Larva | Xukuru-Kariri | Alagoas | Torres (1984) |
| | *Hototo* | Butterfly | Larva | Kalapalo, Kuikuro | Xingu National Park | Kopp *et al.* (2025) |

TABLE 2 (Continued)

| Order | Local name | English name | Stage/used product | Ethnicity | Geographic area | Source |
|---|---|---|---|---|---|---|
| | *Bali'i* | Butterfly | Larva | Desâna | Mato Grosso | Ribeiro and Kenhíri (1987) |
| | *Alanauhsu* | Butterfly | Larva | Nambiquara | Mato Grosso | Setz (1991) |
| | *Waisenauhsu* | Butterfly | Larva | Nambiquara | Mato Grosso | Setz (1991) |
| | *Unrenauhsu* | Butterfly | Larva | Nambiquara | Mato Grosso | Setz (1991) |
| | *Bá-ti-ya* | Butterfly | Larva, Chrysalis | Tukano | Amazonas | Pereira (1974) |
| | *Waxpó-ya* | Butterfly | Larva, Chrysalis | Tukano | Amazonas | Pereira (1974) |
| | *Me're-pama* | Butterfly | Larva | Tukano | Amazonas | Pereira (1974) |
| | *Me're-kapextoroa* | Butterfly | Larva | Tukano | Amazonas | Pereira (1974) |
| | *Nyxtyá* | Butterfly | Larva | Tukano | Amazonas | Pereira (1974) |
| | *Nextoá* | Butterfly | Larva | Tukano | Amazonas | Pereira (1974) |
| | *Pixkoroa* | Butterfly | Larva | Tukano | Amazonas | Pereira (1974) |
| | *Sitá* | Butterfly | Larva | Tukano | Amazonas | Pereira (1974) |
| | *Mamnye-ey* | Butterfly | Larva | Suruí | Amazonas | Coimbra Júnior (1984) |

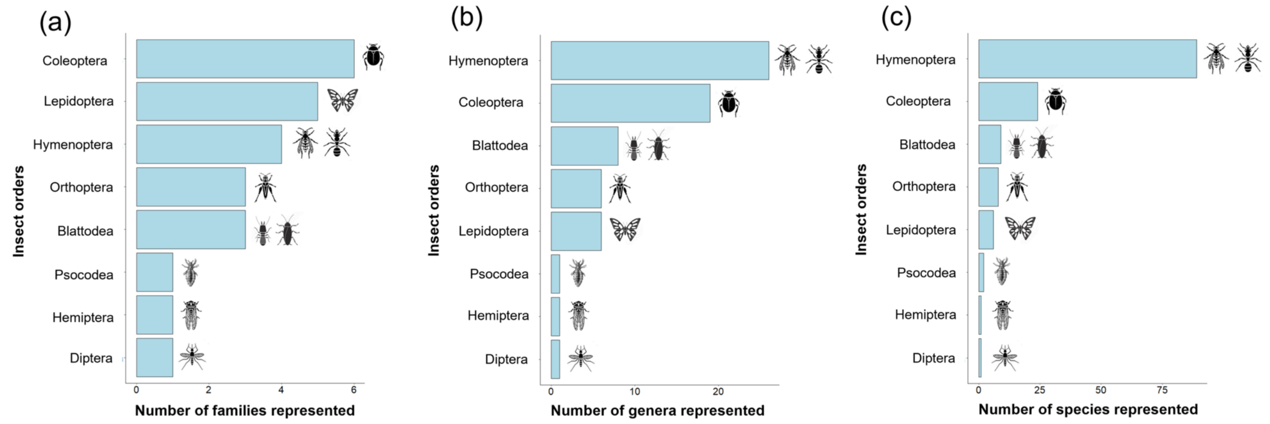


FIGURE 1 Diversity of edible insects in Brazil according to the number of families (a), genera (b) and species (c) registered.

how many species are still used today, when they are used in rituals, festivals, ordeals as well as understanding the methods of collection and consumption. Most of the articles consulted do not provide detailed information on these aspects of food culture. The authors, however, discuss the sociocultural and economic importance of the practice of consuming insects, as they provide people with a diet rich in animal protein.

This study focuses on a systematic review in which many of the referenced authors do not provide detailed information on collection techniques, nor on where and whether the entomological material was properly deposited in scientific collections. Many studies are ethnographic and therefore lack rigor regarding the collection and taxonomic identification of specimens involved in human consumption.

Our study revealed that at least 24 insects need their taxonomic identity to be determined as they were classified only at the genus level. In this sense, there should be an effort by entomologists for a systematic collection and corresponding identification, using morphological and genetic taxonomy. On the other hand, many insects recorded only by their common names, sometimes only in local languages, require scientific taxonomy to be carried out and the specimens be properly registered in scientific collections. In this regard, researchers should include the geographical coordinates of the locations where insect consumption occurs to ensure that the distribution of this information can be accurately rep-

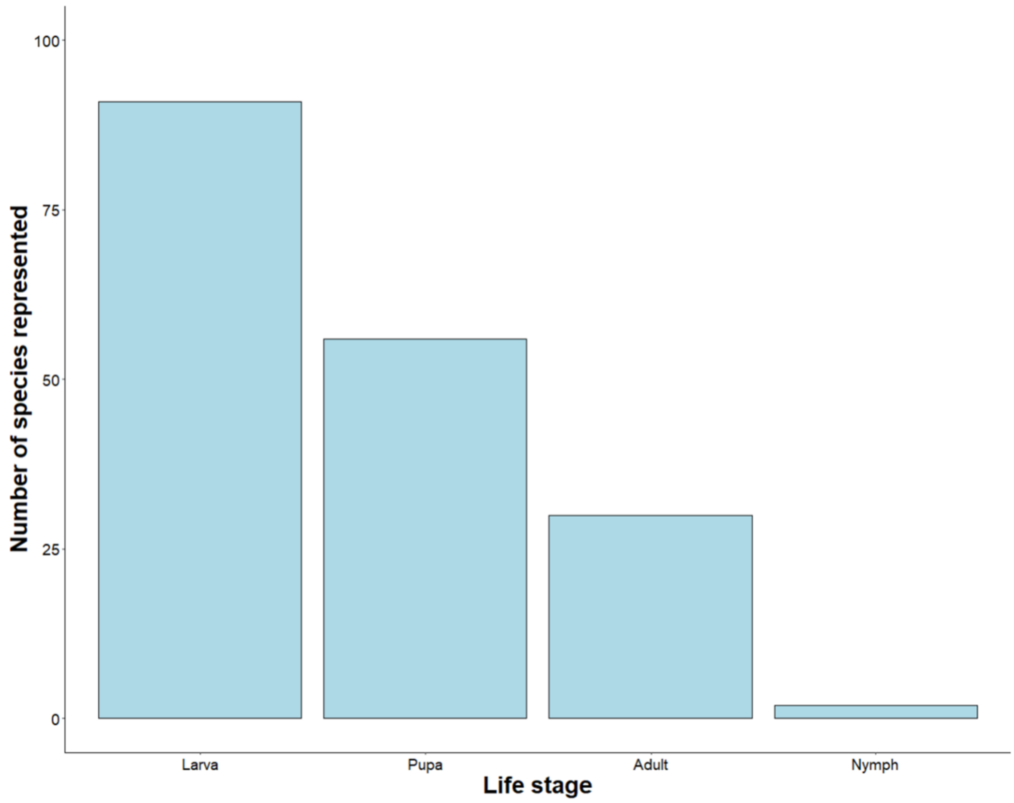


FIGURE 2 Representation of the life stage of the edible species and consumed products.

resented on maps. Furthermore, data on edible insects could be organized regionally by ethnic group, gender, and whether the insects are cultivated or wild-collected, among other factors. It is essential to standardize the oral information provided by interviewees; recording sessions should be conducted to provide evidence if needed, and, when possible, photographic documentation of individuals utilizing edible species should be taken. Additionally, it is important to establish standardized methods for species collection, ensuring that samples are properly labeled with details such as the species' scientific and common names, their origin, and the interviewee's name and ethnic background. Collecting this type of data is vital for enhancing databases at the local, regional, and international levels (Costa Neto, 2016).

Many studies address social perceptions, attitudes, and cultural taboos, but they generally lack detailed empirical data, such as: (1) robust and reliable quantitative data on the amount of insects consumed, the frequency (daily, seasonal, annual), or per person; (2) specific nutritional information for the species consumed in Brazil; with the exception of a few cases (as highlighted by Ramos-Elorduy *et al.* (2006) regarding *Pachymerus nucleorum*), comprehensive data on protein, lipids, vitamins, etc., are lacking; (3) data on the sustainability of harvesting practices: impacts on insect populations, ecosystem resilience, and conservation; (4) detailed methods of collection, production capacity or management (when applicable), as well as sanitary aspects related to food safety; and (5) broad geographic representativeness with larger or region-specific samples, especially from different Brazilian regions.

Regarding the data presented on insect gathering and consumption in Brazil, there are studies focused on social perceptions and preferences. For example, Schardong *et al.* (2019) conducted a survey with 1619 consumers across the five regions of Brazil. They collected data on safety perceptions, preferred form of consumption (flour versus whole insect), gender (women were more reluctant), and educational level (those with more familiarity considered it safer). Their results show that women are more reluctant than men to consume insects. In general, there is a preference for consuming insects in the form of flour. However, those with more familiarity with this type of consumption prefer the whole insect. Most Brazilian consumers have no opinion about the safety of consuming insects; however, consumers with higher levels of education and familiarity consider it safe.

Bisconsin Junior *et al.* (2022) investigated social perceptions among 780 participants from various regions,

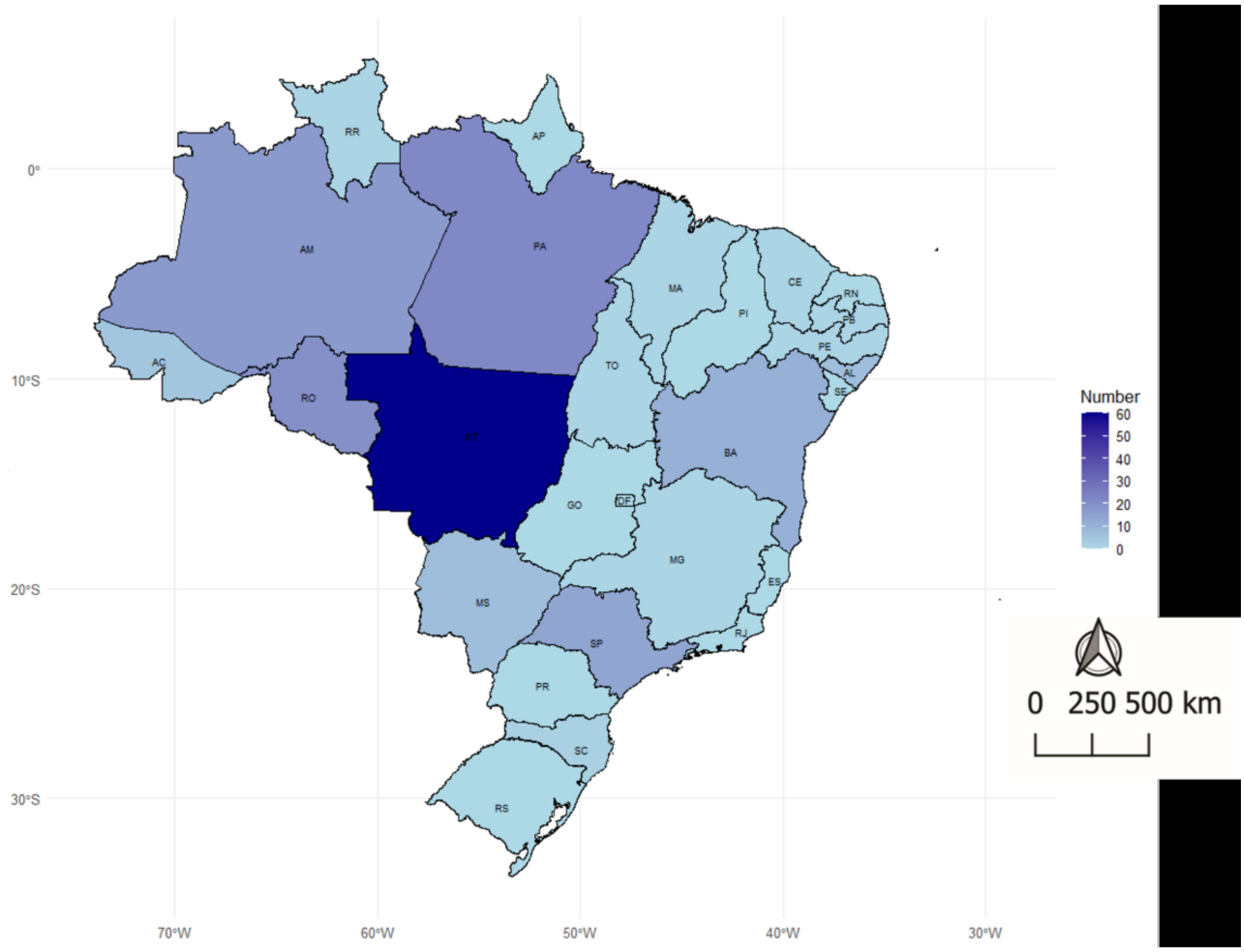


FIGURE 3 Record of insect consumption in some Brazilian states. AC, Acre; AL, Alagoas; AM, Amazonas; BA, Bahia; CE, Ceará; PB, Paraíba; MA, Maranhão; MG, Minas Gerais; MS, Mato Grosso do Sul; MT, Mato Grosso; PA, Pará; PE, Pernambuco; RO, Rondônia; RR, Roraima; SC, Santa Catarina; SP, São Paulo; TO, Tocantins.

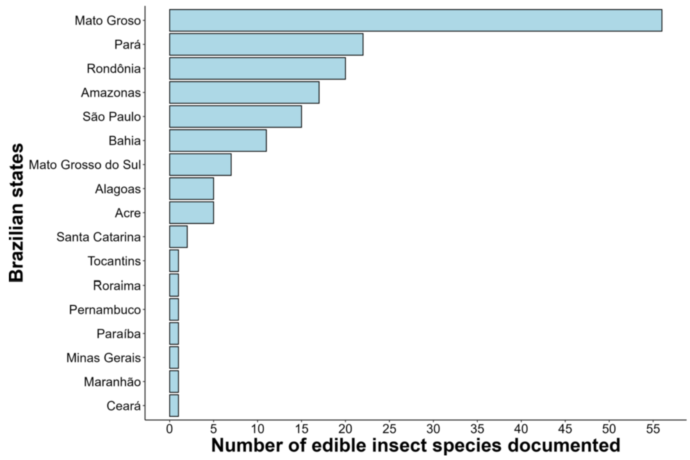


FIGURE 4 Distribution of the number of edible insect species in 17 Brazilian states.

using word association, risk assessment, and open interviews. They identified three consumer profiles: younger, more educated individuals with a lower perception of risk; another group with medium perception; and a third, composed of older women with lower educational levels, who expressed a high level of disgust and fear. The most acceptable species are crickets, grasshoppers, and ants, usually consumed fried or roasted; motivations reported include survival and curiosity.

## 3 Insects used as food resources by ethnic groups in Brazil

This section provides a brief discussion of the consumption of insects across various sociocultural contexts, highlighting some examples of insects significantly utilized in the entomophagy practiced in Brazil. The orders presented follow a phylogenetic taxonomic sequence (Vanin *et al*., 2024).

***Orthoptera* (*grasshoppers and crickets*)**

Grasshoppers hold significant dietary importance for various ethnic groups, particularly the Nambiquara people in the state of Rondônia and the Bakairi people in Mato Grosso. Both nymphs (during the rainy season) and adults (during the dry season) species such as *Rhammatocerus schistocercoides*, *Titanacris albipes*, *Tropidacris collaris*, and *Schistocerca* spp. are collected by the Nambiquara. These grasshoppers form part of their daily diet, which is typically prepared toasted or ground into powder (Setz, 1991; Embrapa, 2000).

The Desâna people along the Rio Negro in Amazonas also consume grasshoppers, preparing them by roasting in clay pots and crushing them with salt and chili or skewering them, much like they do with small fish (Ribeiro and Kenhíri, 1987). Similarly, the Mundurucu people in Pará, studied by ethnologist Hartt in the 19th century, were noted to consume a wide variety of insects, including grasshoppers, weevil larvae, caterpillars, ants, and termites (Santos, 1957). Hartt described their method for collecting grasshoppers, which involved digging holes in the ground to guide the insects into small caves, after which the intestines were removed, and the grasshoppers were consumed either raw or cooked. Additionally, Carvalho (1951) reported that Indigenous people of the Alto Xingu region in Central Brazil eat wasp larvae and grasshoppers. Currently, only two species of crickets – *Gryllus assimilis* (Fabricius, 1775) and *Acheta domesticus* (Linnaeus, 1758) – are widely farmed mainly as feed by companies from São Paulo and Minas Gerais.

***Blattodea* (*cockroaches and termites*)**

The only known report on the traditional use of cockroaches as food in Brazil was published by Schaden (1938 in Lenko and Papavero, 1996). He documented that the Xokleng people of Santa Catarina highly valued consuming cockroaches, likely to belong to the species *Periplaneta americana*. In contrast, three exotic cockroach species are commercially farmed to serve as a protein source for the animal feed industry: *Blaptica dubia*, *Gromphadorhina portentosa* and *Nauphoeta cinerea* (Costa Neto, 2023).

Alfred Russel Wallace (1823–1913), a British naturalist, geographer, anthropologist and biologist. reported the consumption of soldier termites from *Termes flavicolle* in the Upper Amazon (Wallace, 1854). Mill (1982 in Posey, 1986) noted that termites and their mounds contribute to the diet, though not as frequently as one might expect given their abundance. Father Giacone (1949, as cited in Lenko and Papavero, 1996) described the dietary practices of the Maku people living in Amazonas: “When hunting becomes scarce due to drought, or when there are not enough fruits, they almost exclusively feed on insects, saúvas (the reproductive females of the genus *Atta*), termites, lizards, mice, frogs, etc.”.

The Sateré-Maué people in Pará consume toasted, dried termites wrapped in banana leaves (Pereira, 1954 in Lenko and Papavero, 1996). Similarly, Jacob (1974, as cited in Lenko and Papavero, 1996) reported that the Yanomamo of the Uaicá subgroup in Roraima described termite mounds as “good” and noted their nutritional benefits, stating: “Termite houses, those earthen ones, were said to be good. They provided nourishing sustenance for the body, making one feel robust and strong”. The Kayapó people also follow a similar practice (Posey, 1987b).

The Enawenê Nawê people of Mato Grosso utilize various termite species from the genera *Syntermes* and *Nasutitermes* (Santos, 1995). Women primarily collect *Syntermes* species, which are roasted in ceramic dishes before being consumed. Meanwhile, men seek out arboreal nests of *Nasutitermes* spp., using their fingers to trace the insects’ trails and smelling them to determine the edible of the species.

Termites of the genus *Cornitermes* are consumed by the Desâna people (Ribeiro and Kenhíri, 1987). These termites undergo four reproductive flights annually, coinciding with the migrations of the *aracu* fish (*Anostomus brevior*). Interestingly, the authors observed that

FIGURE 5 Roasted termites served to tourists in a Desâna settlement within Manaus city, Amazonas (photo by Ariel Molina, 2019).

while the Tucano people focused on fishing during these migrations, the Desâna prioritized capturing termites. In addition to winged adults, soldiers and the queen are also consumed. Soldiers are eaten either raw or roasted, the ground in a mortar with salt and chili (Figure 5). Furthermore, the Desâna consume two additional termite species, although in these cases, only the winged females are ingested.

Pereira (1974), in discussing the dietary practices of Indigenous communities in the Amazon, highlights the consumption of various edible insects. For example, groups along the Negro River consume a yellow termite species known as *maniuara*, which is eaten either live or roasted. Pereira notes that "maniuara is a mandatory food for young women during the puberty rite". Another termite species, *exkó*, is wingless and consumed either live or roasted, often wrapped in small bundles made from the leaves of sororoca (*Ravenala guianensis* Peterson, Musaceae). Additionally, a third termite species, known as *buxtuá*, is commonly eaten as a snack by Indigenous groups along the Uaupés River.

***Hemiptera: Membracidae* (*treehoppers*)**

Wallace (1854) documented the consumption of the membracid *Umbonia spinosa* in northern Amazonas. However, he did not specify the ethnic group associated with this practice.

***Psocodea* (*lice*)**

The Tapirapé people of Mato Grosso consume lice, but only those taken from someone they hold very dear (Hitchcock, 1962). This entomophagic pratice is also reported among the Maku people (Paoletti and Dufour, 2005).

Wallace (1854), during his travels in northern Amazonas in the 19th century, observed that Indigenous people consumed lice by picking them from a companion's head. Rodrigues (1885) further noted that this practice was widespread among many tribes in the Amazon region. Similarly, Koch-Grunberg (1909, as cited in Bodenheimer, 1951) documented the consumption of lice during his two-years stay with Indigenous communities in northwest Brazil.

***Hymenoptera* (*ants, wasps and bees*)**

Nineteen genera and 66 species of bees have been recorded, which their larvae, pupae, honey, wax, and pollen being consumed. Data is available for 14 ethnic groups, though the socioeconomic and biocultural importance of bees is recognized nationwide, particularly due to the widespread consumption of honey and beekeeping products such as royal jelly. In many households, honey serves as a natural and healthy alternative to refined sugar and synthetic sweeteners.

According to Chagnon (1968), nothing excites the Yanomamo more than discovering a dead tree where bees have built a nest. All activities are immediately halted until they manage to cut down the tree and access the honey. Posey (1987b) highlighted the importance of beekeeping and the significant role of honey and other bee products among the Kayapó people in Pará state. Honey is collected exclusively by men and boys, never by women, and most of it is consumed at the collection site. They cultivate stingless bees not only for their products but also out of fascination with the insects' behavior. Symbolically, the structure of wasp nests from the genus *Polybia* represents the natural model of the Kayapó universe, while beeswax plays a ceremonial role in crafting a traditional headdress style (Posey, 1986). Nine bee species, including *Apis mellifera scutellata*, are semi-domesticated or otherwise manipulated. The larvae and pupae of seven species are consumed as food, including *Tetragonisca angustula*, three species of *Oxytrigona*, *Trigona spinipes* and *Trigona chanchamayoensis*.

Carvalho (1951) observed that honey produced by various stingless bees (Meliponini) is highly valued by the Indigenous people of the High Xingu (Central Brazil). He noted that "similar to their approach with fish, the Indigenous people try to avoid their companions, employing all kinds of subterfuge to sneak into their malocas unseen while carrying their cuías (honey containers)."

Caspar (1956) documented the use of honey and bee larvae by the Tupari people in Rondônia. Roquette-Pinto (1975) highlighted the extensive use of honey and beekeeping practices among the Pareci people in the same region. The native bee *Trigona recursa*, is referred to as "the sorceress" or "vamo-embora" (free translation let's go away), alluding to the feeling of intoxication sensation experiences after consuming its honey (Ott, 1998). The honey produced by *Plebeia mosquito* is flavorful and slightly acidic, but it is always produced in small quantities. In contrast, the honey from *T. spinipes* is scarce, of lower quality, and characterized by an unpleasant taste (Lenko and Papavero, 1996). Among the Guarani M'byá, the honey of *Tetragona clavipes* is not only consumed as food but is also given to one-year-old children orally as a preventive measure against certain injuries (Rodrigues, 2005). Similarly, the honey and wax produced by *T. angustula* are highly valued in Guarani culture. Honey can be consumed either in its pure form or together with the cells, which are chewed to extract their contents. The cells can then either be swallowed or discarded. Additionally, the honey, larvae, and pollen collected from the nests of this stingless bee are consumed to treat digestive issues, such as stomach pains (Rodrigues, 2005).

The Pankararé people, who inhabit the northeastern region of Bahia, maintain a close relationship with "abéias", an ethnocategory encompassing both bees and wasps. The products derived from these insects hold significant importance in their economy, religion, medicine, and diet. The honeys produced by *Apis mellifera scutellata* and native bees of the subfamily Meliponinae serve not only as an energy source but also as nutraceuticals, being traditionally recommended for the treatment of diabetes, bronchitis, oral mycosis, influenza, sore throats, and even impotence. Furthermore, these honeys are utilized as anthelmintics and are believed to act as antidotes for snake bites and bites from rabid dogs (Costa Neto, 1998).

***Argidae* (*sawflies*)**

Ducke (1916, as cited in Carrera, 1992) reported that the pupae of *Dielocerus formosus* were avidly consumed by the Nambiquara people of Rondônia.

***Formicidae* (*ants*)**

Among edible insects, ants are considered the most preferred in tropical regions. Winged individuals, particularly the female leafcutter ants of the genus *Atta*, have long been used as food in Brazil, both in urban and rural areas (Fontes *et al.*, 2018; Silvestre and Sauda Neto, 2020; Costa Neto 2025). The inventory of edible insects in the country records six species of *Atta* consumed by at least 25 Indigenous groups. These ants receive different local names according to the region they inhabit, and as such they are known as "içás", "tanajuras" or "saúvas".

The culinary use of ants is, in fact, a heritage from Indigenous peoples. Gabriel Soares de Sousa, a sugarcane plantation owner in the Recôncavo Baiano (around Salvador in Bahia State), likely provided the first reference to *Atta* as food in Brazil in 1587. He noted:

"There are other ants that the Indians call içás (…). They eat these ants toasted over the fire and celebrate them greatly. And some white men who live among them, as well as mestizos, regard them as a fine dinner and find them tasty" (Sousa, 1971).

In 1658, Willem Piso, a Dutch physician and naturalist who lived in the state of Pernambuco, mentioned the use of *A. cephalotes*, referred to at that time as "tana-ioura" (Piso, 1957). And Wallace (1854) reported that it is the female of *Oecodoma cephalotes* L. (now *A. cephalotes*) that provides Indigenous peoples of the Amazon with a luxurious food source. The edible part of these ants is the abdomen, which is rich and fatty due to the mass of eggs.

The Tukuna, living in the Amazon, appreciate the abdomens of red ants (likely *Atta sexdens* (L., 1758)), which they eat roasted and mixed with cassava flour. The Sateré-Maué prepare a paste made from termites and roasted ants, wrapped in banana leaves (Lenko and Papavero, 1996). Meanwhile, the Enawenê Nawê gather *kutahuno* ants (*A. cephalotes*), which are primarily collected by women, especially young girls (Santos, 1995).

The Tukano and Tuyuka of Amazonas state also consume ants (Giacone, 1949, in Lenko and Papavero, 1996). *Atta* species are still consumed on special occasions, such as during rituals for young women undergoing their second initiation (marking their readiness for motherhood) among the Wanana people in the state of Amazonas. Similarly, young Desâna girls eat roasted ants during their first menstruation (Balée, 2000). Among the Tukano, the father consumes these ants three times a day following the birth of one of his children. Lenko and Papavero (1996) note that, in this case, it is customary for the father to lie in a hammock for three days, adhering to a diet limited to ants and tapioca porridge (cassava flour).

In addition to being consumed as food, *Atta* ants are also ingested for their therapeutic properties. Carl Friedrich Philipp von Martius was a German physician, botanist, anthropologist, and leading researcher who studied Brazil, particularly the Amazon region, from

1817 to 1820. The expedition began in Rio de Janeiro and headed north, passing through São Paulo, Minas Gerais, Goiás, Bahia, Pernambuco, Piauí, and Maranhão. Von Martius (1939), traveling through the interior of Brazil in the 19th century, reported that Indigenous people roast and eat large ants (probably *Atta* spp.) with flour, describing them as a powerful remedy for dyspepsia. In the city of Alter do Chão, near Santarém, in Pará state, ants of the species *Atta sexdens* are crushed and mixed with cassava flour to be consumed as a treatment for chest palpitations (Branch and Silva, 1983). To combat alcoholism, a traditional remedy involves toasting numerous leafcutter ants (*Atta* spp.), reducing them to powder, and adding this powder to the drink of the affected individual (Rossato, 1984). In Teófilo Otoni, Minas Gerais, consuming these ants is believed to aid in the treatment of tuberculosis. In Pernambuco, they are prescribed for sore throats, and it is said that eating ants promotes perfect vision (Lenko and Papavero, 1996).

***Vespidae* (*wasps*)**

The honey produced by certain wasps, particularly *Brachygastra lecheguana*, is readily collected and consumed by indigenous groups and rural communities, although it can sometimes become poisonous or toxic (Costa Neto, 2025). Among the Guarani M'byá living on the outskirts of São Paulo, this wasp honey is consumed of chewing the comb itself, as the honey is thick and difficult to extract from the cells (Rodrigues, 2005).

The larvae and pupae found in wasp nests are also used as food. For instance, the Tapirapé roast the larvae and then remove them from their cells using a small stick. Both men and women consider the larvae to be special treats and typically eat them mixed with cassava flour (Baldus, 1970, in Lenko and Papavero, 1996). Silva (1962, in Lenko and Papavero, 1996) notes that Indigenous people from the Uaupés River region in Amazonas, upon finding a wasp nest, rub their hands in their armpits before approaching it. The scent drives the wasps, allowing them to collect the nest, which serves as a container for the larvae. These are then eaten with the flour. The Desâna (Ribeiro and Kenhíri, 1987), Yanomamo (Lizot, 1977), Nambiquara (Setz, 1991), and Enawenê Nawê (Santos, 1995) also consume wasp larvae and pupae. Depending on the aggressiveness of the species, the use of fire may be necessary.

***Coleoptera* (*weetles*)**

DeFoliart (2004) reported that various species of beetles are known to be used as food sources in Brazil, although their taxonomic identification at the species level remains largely unidentified. Métraux (1963, cited in Schorr and Schmitz, 1975) documented that among the Kaingang people in southern Brazil, "stingless bee honey and the larvae of the tumbu beetle, which are easily found in fallen palm and bamboo trunks, are appreciated foods".

FIGURE 6 Fried *Pachymerus* sp. larvae prepared and served as a traditional dish in a Paiter Suruí village (photo by Ariel Molina, 2018).

Lenko and Papavero (1996) stated that the larvae of Scarabaeidae and Buprestidae beetles might be among the most important insect food sources. The Tukano people highly value the larvae of the beetle *Geniatosoma nigrum* from the subfamily Melolonthinae (Carrera, 1992). According to Chagnon (1968), the Yanomamo in Venezuela and Brazil extract and prepare larvae from Chrysomelidae beetles that infest fallen palm fruits. Viveiros de Castro (1992) noted that the larvae of *Pachymerus nucleorum*, found in babaçu fruits (*Attalea speciosa* Mart.), are an important food source for the Araweté people in Pará. The Paiter Suruí people from the border of Mato Grosso and Rondônia states, Brazil, consume larvae of Chrysomelidae species, specifically *Pachymerus cardo* and *Caryobruchus* spp., collectively referred to as *kadeg*, which are obtained from babaçu fruits. These *kadeg* are roasted in their own fat (Figure 6). After prepared, larvae are highly valued as a dish to be served with roasted corn, popcorn, or mixed with a porridge made from tender corn kernels (Coimbra Júnior, 1984).

Bondar (1928, cited in Lenko and Papavero, 1996) stated that in Bahia and throughout northern Brazil, species of *Pachymerus* are among the most popular insects consumed by Indigenous people and farmers. Rural residents obtain them by breaking open babaçu

(*A. speciosa*), piaçava (*Attalea funifera* Mart.), or licuri (*Syagrus coronata* (Mart.) Becc.) fruits to extract the precious, oil-rich almond. In more than one-third of cases, they find the larvae of *P. nucleorum* instead of the almonds, resulting in a significant loss of their expected income. People believe the larvae are naturally born from fruit, which justifies their consumption. When well-fried, the larvae are a highly sought-after dish among farmers. Since *P. nucleorum* feeds on the endocarp of the fruit, its flavor is delicate and exquisite, imparted by the lipid compounds in its fat, which are transferred and synergized within the insect itself. The larvae can be eaten raw or fried in their own oil and are said to have the flavor of the licuri fruit itself, according to those who have tasted them (Carrera, 1992; Brito and Costa Neto, 2022).

In the state of Pará, "tucumã worm oil", derived from the larvae of beetles that feed on the seeds of the tucumã palm (*Astrocaryum vulgare* Mart.), is used in three main categories: culinary, cosmetic, and medicinal, with a particular emphasis on its therapeutic applications. In culinary contexts, the oil is consumed pure, paired with bread, used for frying eggs and meats, and incorporated into regional dishes like "tapioquinha" (a staple breakfast in Pará, made of slightly damp manioc starch (made of a white powder obtained by decanting grated manioc)) and "caribé" (a liquid food similar to porridge, whose main ingredient is cassava flour). As a cosmetic, it is predominantly reported among older women who use it as a beauty product for hair and skin, valued for its moisturizing properties (Soares, 2019). In traditional medicine, the oil is applied therapeutically for the treatment and cure of 46 diseases and addresses 23 indications of symptoms, signs, abnormal findings, injuries, and consequences of external causes, covering 16 subcategories of body systems within the International Statistical Classification of Diseases (ICD-10) by the World Health Organization (Soares and Lucas, 2019).

Netolitzky (1920) noted that the larvae of *Megasoma anubis* are roasted over glowing coals, and similarly, the larvae of *Macrodontia cervicornis* (Cerambycidae), which inhabit *Bombax* trees (Malvaceae), are roasted in a pot over charcoal. Larvae of beetles found in buriti palms (*Mauritia flexuosa* L. f.) are roasted and consumed by the Tukuna people (Nimuendajú, 1952). Beetle larvae are also eaten by the Desâna (Ribeiro and Kenhíri, 1987). Reitter (1972, cited in Lenko and Papavero, 1996) indicated that some indigenous people consumed the larvae of *Dynastes hercules*, believing that the special powers associated with the size of these beetles (which can reach nearly 150 mm) could be acquired through consumption. Meanwhile, the Yanomamo prepare large larvae, likely from Scarabaeidae family, by cooking or roasting them. It is said that their white, tender flesh has a flavor reminiscent of bacon.

FIGURE 7 Raw *Rhynchophorus palmarum* larvae presented as part of traditional food practices in a Paiter Suruí village (photo by Ariel Molina, 2019).

Among the edible insects of South America, the palm weevil, *Rhynchophorus palmarum*, appears to hold the greatest potential for mass production and trade. This insect has long been 'semi-cultivated' by Indigenous populations in Brazil (Chagnon, 1968). Wallace (1854) discussed the consumption of beetle larvae, which he believed were likely a species of *Calandra* genus (Curculionidae). The Paiter Suruí people also consume the larvae of *R. palmarum* (Figure 7), *Rhinostomus barbirostris*, and *Homalinotus validus* (Molina *et al.*, 2023). To obtain Curculionidae larvae, they cut down preferentially *Jaracatia spinosa* (Aubl) A.DC. (Caricaceae) trees and some palm species (Arecaceae), which are intentionally harvested for immature insects. Curculionidae larvae may be eaten either raw or fried by the Paiter Suruí.

The Guarani Ñandéva of the Pirajuí village in the state of Mato Grosso do Sul use as food the larvae of beetles that infest palm trees, such as "aramanday guasu" (*R. palmarum*) and "aramanday mirĩ" (*Metamasius* sp.) – guasu means 'big' and mirĩ 'small'. In their worldview, these larvae are classified as light food, with no restrictions on consumption. They are considered by the prayers to be clean, healthy food, as they contain fat that is not harmful to health (Vera and Brand, 2012).

Known as peanut beetles, *Ulomoides dermestoides* (Tenebrionidae) (Figure 8) used to be raised in glass jars and fed peanut seeds by people in some cities in Brazil in the 1980s. Adults were consumed whole or pro-

FIGURE 8 *Ulomoides dermestoides* consumed as an energy-boosting snack (photo by Eraldo M. Costa Neto, 2012).

cessed into juices and smoothies, largely due to their food source, peanuts, popularly considered an aphrodisiac (Costa Neto, 1999).

Two other species of Tenebrionidae hold economic importance, as they are traded globally, with companies dedicated to their cultivation and processing for the food industry: *Zophobas morio* and *Tenebrio molitor* (Knežić *et al.*, 2024).

### *Lepidoptera* (*butterflies and moths caterpillars*)

The larvae or caterpillars of various Lepidoptera species have been documented as a food source in Brazil. However, as with most edible insect groups, the taxonomic identities of the species utilized remain largely unknown.

The Xukuru-Kariri people of Alagoas state consume caterpillars known as *mongo*, which are said to have a flavor reminiscent of roasted intestines (Torres, 1984). Saint-Hilaire (1936), visiting several locations in Rio de Janeiro, Espírito Santo, Minas Gerais, Goiás, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul, observed that the natives took great care to remove the cephalic capsule and intestines before consuming the larvae of moths from the family Hepialidae. In contrast, Chagnon (1968) reported that Yanomamo consume certain caterpillar species, likely belonging to the families Phalaenidae and Nymphalidae. These caterpillars are not cleaned but are simply wrapped in leaves, twisted, and roasted over hot coals. They contain significantly less fat than weevil larvae and become dry and crispy during cooking.

The larvae of *Myelobia smerintha* develop within the internodes of taquara (*Bambusa tuldoides* Munro, Poaceae). During his travels in Brazil, Saint-Hilaire consumed these larvae and described their flavor as delicious and creamy (Carrera, 1992). Serrano (1936, as cited in Schorr and Schmitz, 1975) reported that "the current Kaingang, who are the descendants of the Guaianá, eat the larvae of taquara (a kind of bamboo) and prepare a whitish fat from them".

In the Uaupés-Caquetá region of the Colombian Amazon, Father A. Bruzzi, as cited by Pereira (1974), reported that the Tukano people consume Lepidoptera larvae:

"At certain times of the year, numerous larvae about three to four centimeters long appear on the japurá (*Erisma japura* Spruce ex Warm., Vochysiaceae, bati in Tukano) and cunuri plants (*Cunuria spruceana* Baill., Euphorbiaceae, waxpó in Tukano), completely devouring the leaves. These larvae are known as *bá-ti-ya* (the louse of japurá) and *waxpó-ya* (the louse of canuri)".

Additionally, eight larvae are considered edible, all of which are recorded in the Tukano language (see Table 2). When the Indigenous people spot these larvae, they cut down nearby plants to prevent them from migrating to other trees, forcing the larvae to descend the trunk in search of food. Once collected, the larvae are slowly roasted, with such abundance that large baskets can be filled. Similarly, when the larvae are found in their pupal stage, branches laden with these cocoons are cut and roasted. Pupae are a highly valued snack and are also used as bait for fishing.

Ribeiro and Kenhíri (1987) documented the common names of seven caterpillars collected by the Desâna. One particularly valued species, known as "bali'I", is appreciated not only for its excellent flavor but also for its gland, which secretes an enzyme used by the Indigenous people to remove warts. The larvae are typically boiled (after the gland is removed) or roasted, then ground and mixed with salt and dried chilies.

The Paiter Suruí people consume *Lusura altrix* larvae, which they regard as a delicacy, while non-Indigenous harvesters in their territory perceive it solely as a defoliator pest that negatively impacts *Bertholletia excelsa* Bonpl. (Brazil nut tree) yields (Coimbra Junior, 2012). In addition to *L. altrix*, the Paiter Suruí incorporate five other moth caterpillars into their diet, including *Ciccinus callipius*, associated with *Anacardium giganteum* Hanc. ex Engler, and the venomous *Molippa nibasa* (Figure 9) linked to *Hevea brasiliensis* Muell. Arg. (rubber tree). To safely consume *M. nibasa*, they employ a traditional detoxification method, heating the caterpillars in a pan until their poisonous bristles burn, making them safe to eat (Molina *et al.*, 2023).

FIGURE 9 A *Molippa nibasa* caterpillar photographed in the Paiter Suruí territory; its toxic bristles are traditionally neutralized through pan-roasting prior to consumption. (photo by Leonardo Oyaxaká Suruí, 2019).

***Diptera* (*flies and mosquitoes*)**

Shelley and Luna Dias (1989) documented the consumption of larvae of the midge *Simulium rubrithorax*, by the Yanomamo people inhabiting the Serra de Surucucus in the Parima River basin, Amazonas. Similarly, Levi-Strauss (1948, as cited in Hitchcock, 1962) reported that the Nambiquara consume mosquitoes (species and family unspecified) that land on their bodies.

## 4 Insects as human food

Understanding the role insects play in any economic system is crucial, as they are integral of it, even if they represent only a small portion of the available resources (Sutton, 1990). However, for ethnocentric reasons, insects are often disregarded as appropriate in cultures outside of those that traditionally value them. Posey (1987a) highlights the undeniable tendency to overlook or omit the importance of insects in many cultural contexts. He reports that Amerindian cultures possess sophisticated knowledge of insect behavior, which is deeply embedded in their mythology and reflected in practical applications, such as agricultural systems, housing choices, dwelling designs, and various other aspects of daily life adapted to coexist with insects.

Despite their significance, insects are frequently omitted from ethnological literature. When mentioned, they are often referred to only by Indigenous names or generic terms, making it difficult to identify the specific species within the Linnaean classification system. For instance, Chagnon (1968) notes that caterpillars are among the entomophagous resources of the Yanomamo people (Brazil/Venezuela). He also highlights their reliance on weevils, larvae, spiders, and wasps to supplement their diet but does not provide taxonomic identifications for these species. Similarly, Métraux (1963, as cited in DeFoliart, 2004) observes that the Cocama and Omágua, Tupi tribes of the Upper Amazon (Brazil–Peru), collect honey from stingless bees as well as larvae and pupae of ants and palm weevils. However, many such accounts remain anecdotal and lack the detailed taxonomic precision needed for comprehensive understanding.

Several references provide substantial evidence that many insects have historically been, and continue to be, important food sources for Indigenous groups in Brazil. However, demonstrating how insects are incorporated into diets presents significant challenges. As Posey (1976) emphasizes, the use of insects and their products in any quantity requires a sophisticated body of Indigenous knowledge regarding these organisms and their behaviors, which is often revealed through oral traditions that incorporate insects in various ways. For instance, regarding the primary food resources of the Araweté, Viveiros de Castro (1992) highlights honey, for which they have developed a sophisticated classification system encompassing at least 45 specimens of bees and wasps, whether the honey is consumed or not. Additionally, the larvae of *Pachymerus nucleorum* are a notable food resource. Similarly, the Desâna people of Amazonas include edible insects in their economic calendar, as discussed by Ribeiro and Kenhíri (1987). These authors explore the relationship between subsistence activities and the seasonal appearance of specific constellations. Milton (1984) underscores the significance of edible insects for the Maku people, particularly between July and September, when game animals become scarce. During this period, insects, much like fish, are actively collected due to their abundance. Milton observed that the fresh weight of these insects exceeded that of birds and reptiles. Her study identified four insect used as food during the sampling period: two species of larvae (worms), one species of caterpillar, and soldier termites.

Studies on entomophagy in Brazil (Lizot, 1977), Colombia (Ruddle, 1973; Dufour, 1987), Paraguay (Hurtado *et al.*, 1985), and Peru (Denevan, 1971) generally indicate that women and children dedicate more time to foraging for insects than men. Furthermore, insects constitute a larger proportion of the diet for women and children compared to men (MacGrew, 1981). Ratcliffe (1990) emphasizes that entomophagy often plays an integral and complementary role in the diets of Indigenous groups, helping to offset the general deficiency in animal protein. Supporting this, Smith (1996) argues that protein malnutrition has likely never been a significant public health issue on the Amazon. In addition to hunting, the disposal of protein-rich foods, such as insects, certain fungi, and nuts, gathered from tropical forests and secondary vegetation, contributes to sustaining a nutritionally balanced diet.

The collection of insects for food can be attributed to four primary factors: personal taste; dietary restrictions and taboos; traditional customs; and survival needs. Conversely, the determinants of using insects as a human food resource are shaped by four variables: the physical environment; the availability and accessibility of insects, which are influenced by their life cycle, host plants, behavioral adaptations, and overall ecology; the culture's mode of production and subsistence methods; and dietary restrictions, which may be both nutritional and temporal (Miller, 1997). Miller further states that an insect becomes a suitable food resource when it is available in large quantities and can be easily collected. For instance, Owen (1973) highlights that entomophagy is particularly well-developed among cultivators in forest regions of Africa, where protein deficient is common in normal diets. The species consumed tend to be those that are locally or seasonally abundant, including locusts and other orthopterans, which can sometimes reach extraordinary population densities; winged termites, which emerge in large numbers at the onset of the rainy season; and gregarious larvae of lepidopterans, particularly species belonging to the Saturniidae family.

Promoting entomophagy in rural and Indigenous societies, particularly those with a history tradition of insect consumption, can significantly diversify and enhance diets while also providing opportunities to generate income through the sale of insects. Conversely, integrating the large-scale collection of pest insects into biological control programs could reduce reliance on pesticides (Ramos-Elorduy, 2010). Moreover, insect farming for protein production is likely to have a lower farming, which contributes to the destruction of native forests and grasslands (Gullan and Cranston, 2005). However, DeFoliart (1995) notes that, although wild-collected insects are commonly sold in tropical countries, relatively few species possess the characteristics required for domestication and large-scale cultivation. for sale and utilization. Among the exceptions are species raised in "mini livestock" systems, such as the silk moth (*Bombyx mori*), honeybees (*Apis* spp.) which are farmed extensively worldwide, and weevils from the genus *Rhynchophorus*, likely the most widely cultivated non-domesticated insects across Asia, Africa, and Latin America (DeFoliart, 1995). In addition, countless species of stingless bees (Meliponinae) have been cultivated for millennia in various regions, and many other insect species exhibit forms of "proto cultivation" in the wild. These include certain ants, wasps, beetles, cockroaches, and more, suggesting untapped potential for expanding insect farming practices.

In Mexico, Ramos-Elorduy *et al.* (2003) observe that certain insect species are so highly prized for their flavor and prestige that their market has grown substantially. However, this exploitation remains largely unregulated. Insects are sold in various forms and portions not only in numerous restaurants across the capital but also internationally by restaurant owners and companies that package and can them in diverse quantities and styles. This growing demand, however, lacks adherence to established guidelines for the sustainable management and conservation of these species, thereby posing a significant risk to entomofaunal diversity. Additionally, in many cases, these insects are harvested from agricultural fields treated with herbicides, insecticides and fungicides (Calatayud-Vernich *et al.*, 2018; De Paepe *et al.*, 2019).

There has been a significant increase in the edible insect industry in Brazil and worldwide, but only a few species have reached industrial-scale production, much of which is focused on animal feed production (Tomberlin and van Huis, 2020; Barragán-Fonseca *et al.*, 2022). On the other hand, some species are traditionally produced or cultivated as minilivestock to meet local demands. The fact remains that many edible species are still collected directly from nature. This practice can cause the overexploitation of many species, placing them at some level of threat. Ramos-Elorduy *et al.* (2003) propose viable alternatives to address these challenges, emphasizing the need to establish regulations for the sustainable use of insects. Such measures would ensure that rural communities retain access to these vital food and medicinal resources in the future. Wilson (1997) argues that increased knowledge and awareness of a species often foster greater interest in its preservation. In other words, the sustainable utilization of a species can incentivize efforts toward its conservation. As such, research on the use of insects is essential, as it holds significant potential to contribute to the preservation of entomofaunal diversity.

## 5 Health safety on edible insect consumption

When evaluating food resources, their suitability for human consumption must be carefully considered. In the case of insects, it is crucial to acknowledge that many species acquire toxins from their host plants or can produce their own toxins, which can render them inedible (Miller, 1997). Furthermore, individuals with allergies to shrimp or lobster should exercise caution when consuming insects, as shared allergens appear to exist among members of the phylum Arthropoda (Phillips, 1995; Broekman *et al.*, 2016).

As with the consumption of other animals or plant products, eating edible insects may pose various risks to human health, including exposure to chemical and biological contaminants or allergenic substances (Murefu *et al.*, 2019). Blum (1994) explores the toxicity of insects consumed by humans and categorizes toxic insects into two groups: phanerotoxic and cryptotoxic. These insects are venomous and possess a venom apparatus comprising a gland, reservoir, duct, and injection mechanism. This group includes certain insects from the orders Lepidoptera, Hymenoptera, and Hemiptera, whose secretions are delivered via retractable stingers or penetrating mouthparts. The toxins produced by phanerotoxic species are active when injected but become inactive in the gastrointestinal tract. Nevertheless, individuals consuming insects from this group should exercise a minimum level of caution.

Cryptotoxic insects produce toxic secretions that are not exocrine in nature, with toxicity becoming apparent only when ingested. This occurs when the insect is damaged or chewed, allowing the toxin-laden fluid to interact? with the predator's tissues. Cryptotoxic species require greater caution in their selection as potential food sources. For instance, *Paederus* rove beetles produce blistering substances that are released only when the insect is crushed. One such blistering agent is pederin, a non-protein compound that acts as a potent inhibitor of protein synthesis and mitosis (Navarrete-Heredia and Gómez Flores, 2005). Similarly, females of *Lytta vesicatoria* (Coleoptera, Meloidae) store cantharidin in their ovaries and eggs. In this case, toxicity becomes apparent only when the reproductive apparatus encounters the intestinal or oral tissues of an unsuspecting insect-eater.

Examples of insects to be avoided as food include cyanogenic insects (e.g. Lepidoptera from the families Heliconiidae and Nymphalidae), insects producing blistering agents (e.g. moths from the genus *Lonomia*, Saturniidae), and those synthesizing steroid hormones (e.g. *Ilybius fenestratus*, Dysticidae) and corticosteroids (e.g. *Dytiscus marginalis*, Dysticidae), as well as those producing necrotizing alkaloids (e.g. fire ants *Solenopsis* spp., Formicidae) and toluene (e.g. cerambycids from the genus *Syllitus*, Cerambycidae) (Blum, 1994). However, Ramos-Elorduy (2004) reports that several species from Dytiscidae, Saturniidae, and Nymphalidae are consumed in Mexico, suggesting that this classification may not be entirely accurate.

Regarding the odoriferous compounds of pentatomids and other Hemiptera, Blum (1994) notes that these compounds often lead to significant rejection at the oral level, despite their limited intestinal toxicity. However, human populations should recognize the substantial nutritional potential of insects, given their high content of proteins, fats, vitamins, and minerals. When edible insects are harvested systematically and sustainably, they could contribute to alleviating protein deficiency, a persistent issue in many parts of the world. Promoting entomophagy through (re)education initiatives could highlight the nutritional advantages of insects, fostering greater acceptance among consumers.

The microbiological safety of edible insects represents a critical area of research and practical application as these organisms continue to gain popularity. The potential presence of pathogenic microorganisms in edible insects is considerable (Gałęcki and Sokół, 2019). Insects maintain a range of symbiotic interactions with the microbiota, which confer unique survival abilities, including resistance to pathogens and insecticides.

Insects can harbor a wide range of pathogens, including *Escherichia coli*, *Staphylococcus* spp., and *Bacillus* spp. (Gałęcki and Sokół, 2019; Grabowski and Klein, 2017; Grenda *et al.*, 2021), as well as *Listeria monocytogenes* (Gałęcki and Sokół, 2019), with the potential for others yet to be identified. This underscores the importance of implementing strict hygiene practices in production environments intended for human consumption (Gałęcki and Sokół, 2019). Furthermore, the intrinsic microbiota of insects may include harmful bacteria, which could pose significant risks if not adequately managed during processing and storage (Frigerio *et al.*, 2020; Grenda *et al.*, 2021).

The presence of mycotoxins and bacterial toxins further complicates the safety of edible insects (Orkusz, 2021). Research has demonstrated that processing methods and substrates used in insect farming can significantly affect the levels of these contaminants, emphasizing the need for careful selection and rigorous monitoring of production practices.

We also highlight the potential risk of toxin bioaccumulation from symbiotes, which represents another complicated factor in the safety assessment of edible insects. The presence of mycotoxins and bacterial toxins further adds to the complexity of their safety profile (Frigerio *et al.*, 2020; Orkusz, 2021). Processing methods and the substrates used in insect farming can significantly influence the levels of these contaminants, underscoring the need for careful selection and strict monitoring of production practices (Poma *et al.*, 2019). Additionally, the chemical risks associated with the bioaccumulation of pesticides and toxic metals are highly dependent on the insects' diet and habitat (Frigerio *et al.*, 2020).

Allergic reactions represent a critical aspect of the microbiological safety of edible insects. Certain species have been associated with allergic responses in consumers, often exacerbated by cross-reactivity with crustacean allergens (Barre *et al.*, 2021; Orkusz, 2021). For individuals allergic to crustaceans, it is essential to avoid consuming insects as a precautionary measure. The European Food Safety Authority (EFSA) underscores the importance of detecting specific allergens in edible insects to mitigate these risks (Baiano, 2020).

With the development of research and regulatory frameworks aimed at standardizing safety assessments, such initiatives can enhance consumer confidence in insect-based foods (Barre *et al.*, 2021). Therefore, the safety of edible insects encompasses a range of microbiological, chemical, and allergic concerns, all of which must be addressed to ensure both public health and consumer acceptance.

## 6 Concluding remarks

It is essential to conduct bromatological analyses on insect species traditionally consumed in Brazil to determine their chemical composition. This includes establishing profiles for amino acids, fatty acids, mineral salts, and vitamins. Such studies will not only deepen our understanding of the nutritional value of these insects but also support their potential as sustainable food sources in addressing dietary deficiencies. Additionally, these analyses could provide valuable insights for developing guidelines for safe consumption and promote the inclusion of edible insects in more diverse diets.

The Brazilian Association of Edible Insect Breeders (Associação Brasileira dos Criadores de Insetos Alimentícios, ASBRACIA) was established in 2015 to regulate and strengthen the insect breeding and commercialization sector in Brazil. This initiative aligns with global efforts, particularly those highlighted by the Food and Agriculture Organization (FAO) in 2013, which advocated for edible insects as a sustainable protein source and a means of preserving traditional knowledge, thereby contributing to food security. In Brazil, discussions on the topic have been widespread, especially on social media and within academic groups focusing on Entomophagy, Entomology, and Animal Science. These discussions reflect a growing interest in insect breeding, with an increasing number of breeders, consumers, and traders supplying insects for both human and animal consumption. Since its inception, ASBRACIA has regularly organized conferences, bringing together researchers, breeders, and enthusiasts to advance the field. Advancing research in this field will contribute to the preservation of traditional practices while also opening new avenues for improving Food Security and Nutrition.

These practices are an important part of biocultural heritage, but they are at risk due to urbanization, biodiversity loss, and the devaluation of traditional knowledge. Despite their current low appreciation, the traditional use of insects has strategic potential in the following areas: local food security, as they are accessible sources of protein and fat, especially during times of game or fish scarcity; low environmental impact, as insects require few resources and can be collected without significant impact – if managed sustainably; biocultural conservation, as maintaining these practices helps preserve local knowledge, native species, and forest-related ways of life. Therefore, understanding whether these practices are declining or enduring is fundamental for public food policies, intercultural education, and conservation.

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