ABSTRACT
This study aimed to gather information about the role of native stingless bees in protecting biodiversity and preserving the environment, in addition to elucidating the beneficial effects of bioactive compounds in honey in the prevention and treatment of chronic degenerative disorders. It was a qualitative and exploratory bibliographical review, using electronic databases with descriptors combined two by two. Records of 251 species of stingless bees were identified in Brazil, occupying mostly tropical (North and Northeast) and subtropical (South and Southeast) climate regions, they are distributed in 29 genera, with the tribes Frieseomelitta, Nannotrigona, Plebeia, Scaptotrigona, Tetragonisca and Melipona managed for honey production. Native bees are responsible for pollinating about 87% of the world's cultivated plants, resulting in up to 50% more production of seeds and fruits, which ensures genetic diversity and promotes environmental sensitivity. Studies have also identified that meliponine honeys have high levels of phenolic compounds and flavonoids, with antioxidant, antibacterial, antifungal, antiviral and anti-inflammatory activities greater than those present in Apis mellifera honey, and in particular, honey from native Brazilian bees have compounds that are not found in other regions of the world.

KEYWORDS: Bees, Brazilian biodiversity, Honey, Therapeutic food, Antioxidant.
INTRODUCTION
Insects are among the most diverse and successful animals on planet Earth, occurring in various types of environments, and although only about one million species are cataloged, it is estimated that there are about five million species of insects in all over the world. The order Hymenoptera gathers ants, wasps and, mainly, bees, the most diverse group, with around 20,000 species already described, but it is estimated that there are much more than 20,000 species distributed in the world. Brazilian fauna contains, today, 1965 species of bees, according to the records of the of Moure’s Bee Catalog about neotropical species.

Bees are the pollinating agents most adapted to any environmental conditions, living in a system of reciprocal dependence, where plants provide food, especially pollen and nectar to bees, and these, in return, benefit them with the transfer of pollen.

Native stingless bees, also known as meliponines and indigenous bees, are subdivided into two tribes: Meliponini, formed only by the genus Melipona, found exclusively in the Neotropical region (South and Central America and Caribbean Islands) and Trigonini, which groups a large number of genera, distributed more widely (Trigona, Tetragonula, Plebeia, among others). In Brazil, the creation of native stingless bees began among indigenous peoples, and the practice gradually became popular among medium and small producers, especially by subsistence farmers who used the activity to supplement profits.

Meliponini honey has been used for curative purposes, empirically, in the treatment of various diseases by indigenous people and residents of rural areas. Currently, researchers have shown numerous benefits of honey obtained through meliponiculture, classifying it as a functional food, in view of the presence of secondary components with antioxidant and anti-inflammatory activities in its composition.

In this article we present data in the form of a review about the environmental importance and the role of native stingless bees in the preservation of biological diversity, and the physiological and metabolic properties of honey's bioactive compounds in the prevention and treatment of chronic-degenerative disorders.

MATERIAL AND METHODS
This is a bibliographical review of scientific production whose nature is qualititative and exploratory, carried out from searches in electronic databases that had information involving
native Brazilian bees and honey, environmental nature, biodiversity, and chemical and functional characteristics. The following databases were used: Scholar Google, Scientific Electronic Library Online (SciELO), Science Direct and Pub Med, using the following descriptors in Portuguese and English to filter the searches: “stingless bees honey”, “native Brazilian stingless bees”, “environmental preservation”, “biodiversity”, “anti-inflammatory”, “antioxidant”, “antibacterial”, “phenolic compounds”, “pollination”, “phytochemicals indigenous bees” in a combined way two by two.

RESULTS AND DISCUSSION

Stingless bees in Brazil

Considering the biodiversity of bees in general, a group that deserves to be highlighted are the stingless bees, whose components are popularly known as indigenous “stingless” bees, because they have a stunted (remaining) sting, losing the ability to sting.[15] The activities of raising stingless bees have been taking place for a long time in different regions of Brazil by meliponiculturists in traditional communities, especially in the North and Northeast.[26] According to Kerr[28], this activity was already carried out in Latin America before the colonial period. However, literary data suggest that the term Meliponiculture was created in 1953 by the researcher and environmentalist Paulo Nogueira Neto (1953), naming the creation of native stingless bees.[41]

Currently, 251 species of stingless bees are registered in Brazil[13], which occupy, for the most part, tropical (North and Northeast) and subtropical (South and Southeast) climate regions.[52] Such species are distributed in 29 genera, although only those grouped in the genera Frieseomelitta, Nannotrigona, Plebeia, Scaptotrigona, Tetragonisca and Melipona, are managed for honey production, the latter genus representing 65% of the stingless bee species most handled by meliponiculturists.[26,53]

The local distribution of bees throughout the Brazilian territory (Figure 1) is influenced by several biotic and abiotic factors and, consequently, these variables also affect bee products.[61]
Figure 1: Geographic distribution of stingless bee species in the Brazilian states. Sources: SILVA et al.\textsuperscript{[55]}; Camargo.\textsuperscript{[13]}

According to Dantas et al.\textsuperscript{[21]}, in the states of Paraíba and Rio Grande do Norte, the cultivation of Jandaíra (Melipona subnitida), Uruçu Nordestina (Melipona scutellaris), Rajada (Melipona asilvae), Mandaguari (Scaptotrigona sp) and Moça Branca (Frieseomellita sp) bees stand out, and it is a practice transmitted from generations to generations, by mostly rural breeders (64.4%). In the southeastern region of Bahia, close to the municipality of Vitória da Conquista, different species of meliponines are found (Melipona scutellaris, Melipona quadrifasciata and Melipona subnitida), in addition to the species Tetragonisca angustula and Scaptotrigona postica from the Trigonini tribe, characteristics of each type of vegetation, bearing in mind that the region is considered an ecological transition between humid and semi-arid, due to the diversity of the biomes of this region.\textsuperscript{[57]}

In the northeastern mesoregion of Para, the species normally reared are Melipona flavolineata and Melipona fasciculata, popularly known as Uruçu-amarela and Uruçu-cinzenta, respectively. Among stingless bees, uruçus are considered good honey producers, producing between 3L and 6L of honey per year per nest.\textsuperscript{[67]} Its honey is used as a sweetener and food, and, historically, as an adjunct in respiratory treatments, such as colds, coughs, bronchitis, and pneumonia.\textsuperscript{[2]}
In a study conducted by Fernandes et al.\[23\], the most abundant species in the southwest region of the state of Mato Grosso were *Tetragonisca fiebrigi*, *Friseomelitta* spp., *Trigona* spp and *Tetragonisca angustula*, standing out among the 27 species and 14 genera observed in this region. The latter, however, popularly known as “Jataí”, is distributed in almost all of Brazil. In the Northeast, there are records of its occurrence in Alagoas, Bahia, Paraíba, Pernambuco, Sergipe and in other regions in Espírito Santo, Goiás, Mato Grosso do Sul, Minas Gerais, Rio de Janeiro and São Paulo.\[58\]

The genus *Melipona* is larger than the other genera, the bees of this genus are not very defensive, produce honey in greater quantities compared to other species of stingless bees and stand out for their great biodiversity richness.\[19, 58\] They are also distinguished by the ability to extract pollen through the vibration of the flight muscles, a very efficient behavior in pollen collection, both in poricidal and non-poricidal anthers.\[12\] The maximum flight range distances of the genus *Melipona* were established between 1,200m and 2,700m.\[18,30,58\]

It is noted, therefore, that meliponiculture is a relevant activity for numerous indigenous and traditional communities and family farmers in Brazil, in all regions, who depend on it as their main source of income, or even as an additional contribution.\[50\] In addition to their economic importance, native stingless bees are of great importance to humanity and to the maintenance of the terrestrial ecosystem, as they are responsible for most of the pollination of plant species.\[64\]

**Guardians of biodiversity and global food**

Insect-plant interactions are crucial for environmental harmony. The pollination process tends to guarantee this environmental balance, as it is an essential production factor in the development of agricultural crops around the world.\[62\] Pollination is defined as the transmission of pollen grains from the anthers of a flower to the stigma of the same flower or another flower of the same species, with subsequent fertilization.\[48\] Although wind and water are considered pollinating agents, insects, especially bees, carry out the pollination process better.\[4\]

The body covered with feathery hairs and the use of structures for pollen transport, called corbicula and scopae located on the hind legs, make them efficient pollen collectors (Figure 2).\[61\] Furthermore, according to Jarau; Hrncir \[27\] bees can manipulate the floral parts to
reach the nectar and/or pollen available, and in their collection flights they locate the flowers that offer the best rewards, communicating the location of the food source to their nestmates.

Figure 2: Body covered with feathery hairs: (a) Uruçu Amarela (*Melipona rufiventris*) and (b) Mandaguari preta (*Scaptotrigona postica*) – greater efficiency in pollen collection.\[^{61}\]

According to Clarke et al\[^{17}\], electrical forces are involved in pollination. The body of bees, after the flight, carries small positive electrical charges (due to friction with the air), and when approaching the anthers, they induce an irregular distribution of charge in the pollen grain: negative particles that take part in the composition of the pollen are attracted towards the bee and positive particles are repelled in the opposite direction. When attracted towards the body of the bees, the pollen grain touches the hairs that cover the bodies and adheres to them.

According to Toledo-Hernández et al.\[^{66}\] bees are responsible for pollinating about 87% of cultivated plants worldwide, which can result in up to 50% greater production of seeds and fruits (Figure 3), and in the Atlantic Forest 90% of plant species are pollinated by bees. Still, according to the authors, stingless bees were the main pollinators of plants in the American continent before the introduction of honey bees from Europe.

Insect-plant interaction services and pollination are directly associated with various benefits to society, such as agriculture and food production. Several agricultural crops are significantly benefited by pollination by bees, which lead to better fruit quality and higher productivity rates. In Brazil, studies indicate that different bee species are efficient pollinators of crops such as passion fruit (*Passiflora* spp.),\[^{55}\] bell pepper (*Capsicum annuum* L.),\[^{51}\] orange (*Citrus sinensis* L.),\[^{33}\] strawberry (*Fragaria x ananassa* Duch.),\[^{1}\] tomato (*Solanum*
lycopersicon), \(^{59}\) eggplant (Solanum melongena), \(^{43}\) soybean (Glycine max), \(^{24}\) among others.

Figure 3: Examples of stingless bees used to pollinate agricultural crops. a) Melipona fasciculata pollinating eggplant; b) Trigona pallens pollinating pumpkin; c) M. fasciculata pollinating tomato plant; d) M. melanoverter pollinating annatto tree; e) M. flavolineata pollinating hog plum; f) M. fasciculata pollinating sunflower. Source: Venturieri.\(^{68}\)

Pollination carried out by bees is also important for the maintenance and conservation of biodiversity. This is defined as the variety of living organisms from all sources, including terrestrial, marine, and aquatic ecosystems, and the ecological complexes of which they are part. \(^{29, 70}\) Pollination determines the formation of fertile fruits and seeds, which will maintain genetic diversity, ensuring the second, third and more generations. According to Barbosa et al \(^{4}\) fruits born from plants pollinated by meliponines have a higher genetic quality than those that were not pollinated.

In addition, meliponiculture induces an environmental sensitivity regarding the careful and respectful management of ecosystems, which is considered an occupational ethos of self-respect\(^{40}\) linked to beekeeping.
In addition to their direct contribution to the environment through pollination, bees can be important for analyzes of environmental degradation and pollution. According to Silveira [60] bees have contact with plants, soil, water, and air during their flights, and in this way, pollution particles that can be stored in their organism act as bioindicators of environmental pollution, and can be identified through specific analyses, contributing to the quantification of atmospheric pollution rates by the flight locations.

Despite such importance, the population of native stingless bees is disappearing and decreasing in their natural habitats.[7] This is caused by the indiscriminate use of pesticides and insecticides, deforestation and burning, which destroy their natural nests in hollow trees, the predatory action of producers who extract the products leaving colonies on the ground, which are inevitably destroyed by ants; the action of the sawmills, which remove old trees from the forest, which generally have adequate holes to be occupied by new swarms; and they are fought by beekeepers for considering them competitors of A. mellifera.[4,28]

Thus, the absence of bees in the environment leads to a significant decrease in the number of plants and, consequently, in the low production of food and pharmacological products, since they are responsible for supplying the raw material necessary to produce a large part of everything that is consumed. The disappearance of bees can promote the reduction or even loss of biodiversity. In this way, if a bee species were extinct, it would cause a chain extinction, from the plants it pollinates to the animals that feed on these plants (and their parasites) and, consequently, human beings.[16]

**Honey as a functional food**

Honeybees produce honey from the nectar of flowers and/or extrafloral nectaries and saccharin exudates secreted by sap-sucking insects, adding enzymes produced in their hypopharyngeal glands to these collected resources and depositing the product in combs constructed with wax produced by the bees (Apis).[22] Honey produced by native stingless bees, unlike Apis mellifera honey which is deposited in combs, is stored in pots (Figure 4), usually oval and of different sizes according to the species, with honey and pollen stored separately.[45,69]
Figure 4: Cerumen from honey pots in a Taquaruçu nest (*Melipona seminigra* – from Tapajós, Pará, Brazil). Source: Venturieri. [68]

The quantity and quality of these honeys depend on different factors such as the plant source, the climate and soil of the region, the climate at harvest time, the producing stingless species, the physiological state of the colony and the state of maturation of the honey. [68] Honey is rich in sugars, especially fructose and glucose, as well as minerals, enzymes, organic acids, carotenoids and phenolic compounds, the latter components being responsible for its numerous therapeutic properties, used empirically by popular medicine. [36]

Table 1 presents the main studies that identified a variety of bioactive compounds in honey samples from native Brazilian stingless bees, and that evaluated their nutraceutical and medicinal effects potential.

A wide variety of bioactive compounds have been detected in Melipona honey samples. According to Oliveira et al. [44], meliponine honeys have high levels of phenolic compounds such as gallic acid, derived from hydroxybenzoic acid, followed by o-coumaric acid (derived from hydroxycinnamic acid) and vanillic acid, also derived from hydroxybenzoic acid, which stand out mainly due to its antioxidant function, actively acting through its chelating action due to the presence of the hydroxyl group in its composition. In a study carried out by Ávila et al. [3], the results revealed that meliponine honey can reach antioxidant and biological activities up to 45% higher than traditional honey from *Apis mellifera*.

Table 1: Studies with honey from native Brazilian stingless bees.

<table>
<thead>
<tr>
<th>Stingless Bee Honey</th>
<th>Geographic location</th>
<th>Phytochemicals found</th>
<th>Main results</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. scutellaris</em> Latrelle (‘Uruçu’);</td>
<td>State of Bahia and Paraiba</td>
<td>Nineteen phenolic compounds and flavonoids, especial</td>
<td>In vitro antioxidant activity (DPPH)</td>
<td>Moreira et al. [39]</td>
</tr>
<tr>
<td>Cephalotrigona capitata (‘Mombucão’)</td>
<td>epicatechin gallate, myricetin, quercetin and procyanidin A2</td>
<td>(In vitro Anti-inflammatory effects on macrophages RAW264.7 stimulated by LPS and reduction of NOx, TNF-α, IL-6, MCP-1, IL-12p70, INF-γ and IL-10; Increased MCP-1 and IL-10 levels.</td>
<td>Biluca et al. [9]</td>
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<tr>
<td>Meliponinae</td>
<td>State of Santa Catarina (Brazil) (Municipalities São Miguel do Oeste e Santa Rosa de Lina)</td>
<td>Salicylic, p-coumaric acid, aromadendrin, taxifolin, caffeic acid, 4-aminobenzoic, and umbelliferone.</td>
<td>Braghini et al. [11]</td>
<td></td>
</tr>
<tr>
<td><em>M. bicolor</em> species</td>
<td>State of Santa Catarina (Brazil)</td>
<td>P-coumaric, ferulic, chlorogenic acid, aromadendrin, taxifolin</td>
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<td></td>
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<tr>
<td><em>M. bicolor; M. quadrifasciata; M. marginata; Scaptotrigona bipuncata</em></td>
<td>State of Paraná (Brazil)</td>
<td>P-coumaric acid, Ellagic acid, Hesperitin, Querceritin</td>
<td>Ávila et al. [3]</td>
<td></td>
</tr>
<tr>
<td>Jandaíra stingless bees (<em>Melipona subnitida</em> D.)</td>
<td>Semiarid region of northeastern Brazilian</td>
<td>Quercetin, myricetin, 2,4-dihydroxybenzoic acid, kaempferol, rutin and syringic acid</td>
<td>Bezerra et al. [8]</td>
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<tr>
<td><em>M. quadrifasciata</em> (<em>M. q. quadrifasciata</em> and <em>M. q. anthidioides</em>), <em>M. asilvai</em>, <em>M. subnitida</em> and <em>M.</em></td>
<td>Sergipe, Maranhão and Bahia states</td>
<td>P-cummaric acid, gallic acid, Kaempferol, luteolin, apigenin, caffeic acid, naringenin.</td>
<td>Oliveira et al. [45]</td>
<td></td>
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<tr>
<td>Honey Source</td>
<td>Location</td>
<td>Identified Compounds</td>
<td>Activity Studied</td>
<td>Reference</td>
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<tr>
<td><em>M. scutellaris</em>, <em>M. compressipes</em>, <em>M. mandacae</em></td>
<td>Semiarid region of Brazilian northeastern</td>
<td>Trans-cinnamic, p-coumaric, ellagic and ferulic acids; catechin, rutin, hesperetin and chrysin.</td>
<td>In vitro antioxidant activity (DPPH, ABTS, ORAC) and antimicrobial activity.</td>
<td>Souza et al. [63]</td>
</tr>
<tr>
<td><em>M. subitida</em> Ducke (Jandaíra) and <em>M. scutellaris</em> Latreille (Uruçu)</td>
<td></td>
<td>Benzoic acid, Caffeic acid, p-Coumaric acid, Ferulic acid, Methyl syringate, Sinapic acid, Myricetin, Quercetin, Kaempferol</td>
<td>Anti-inflammatory activity by topical application of <em>M. marginata</em> honey extract (1.0 mg) in ear edema (inhibitory effect of 54±5%) induced in mice.</td>
<td>Borsato et al. [10]</td>
</tr>
<tr>
<td><em>M. marginata</em></td>
<td>Parana state (Curitiba)</td>
<td>Gallic acid, 3,4-Dihydroxybenzoic acid, 4-Hydroxybenzoic acid, catechol, cis,trans-Abscisic acid, taxifolin.</td>
<td>In vitro antioxidant activity (ABTS) and antibacterial activity against <em>S. aureus</em>, <em>S. epidermidis</em>, <em>P. aeruginosa</em>, <em>E. coli</em>, <em>C. krusei</em>, <em>C. tropicalis</em> and <em>C. albicans</em></td>
<td>Silva et al. [56]</td>
</tr>
<tr>
<td><em>M. (Michmelia) seminigra merrillae</em></td>
<td>Amazonas state (Brazil) and southern region of Amazonas (Boca do Acre, Pauini and Lábrea)</td>
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</table>

Honey from native Brazilian bees has phenolic compounds with antioxidant activities not found in honey from other regions of the world. Silva et al. [56] identified the presence of catechol for the first time in samples of Brazilian honey, in addition to the flavonoid taxifolin in honey from stingless bees. Taxifolin, according to Zhang et al. [72], has numerous pharmacological properties, including hepatoprotective function, preventing alcoholic hepatic steatosis, inhibiting lipogenesis, and producing a mediator of chronic inflammation, interleukin 1-beta (IL-1β).

In a study by Santos et al. [54], five aliphatic organic acids (malonic, fumaric, glycolic, glutaric and propionic) were also identified for the first time in samples of honey from Brazilian native bees (*Melipona bicolor*, *Scaptotrigona bipunctata*, *Melipona quadrifasciata*, and *Melipona marginata*).

Native stingless bee honeys have also been studied for their antimicrobial activities, and, alternatively, against antibiotic-resistant microorganisms, mainly because they are a natural product. [14] In a study by Mercês et al. [37], honeys produced by *Melipona asilvai*, *Melipona quadrifasciata anthidioides*, Friseomelita doederleinei, Tetragonisca angustula and Plebeia...
sp demonstrated antibacterial action against *Staphylococcus aureus*, and the samples produced by *M. quadrifasciata anthidioides* and *F. doederleini* significantly inhibited the growth of *Escherichia coli*. Honey samples collected from the species *M. bicolor* (guarupu) also showed antibacterial activity in the presence of *E. coli*, in a study conducted by Batiston.[5]

Studies indicate that low water activity, high osmotic pressure, low pH, high content of reducing sugars, the glucose/oxidase system with formation of hydrogen peroxide, high carbon/nitrogen ratio and the presence of numerous bioactive phytochemical compounds and volatile substances are responsible for the antimicrobial properties evidenced in different types of honey.[32,34,35] According to Weston[71], the variation in the antimicrobial action of honeys from different species is due to many factors that affect their chemical composition, including differences in soil and atmospheric conditions, in addition to differences between plant species that contribute to the formation of the products.

Also, according to a study by Bazoni[6], honey produced by native stingless bees has a much more efficient antibacterial activity than honey produced by *Apis mellifera*. Such efficiency, according to Temaru et al.[65], is due to the storage of meliponine honey in cerumen pots, made of wax combined with propolis, which is rich in phytochemical compounds, which contribute to antibacterial, antifungal, and antiviral properties.

**CONSIDERATIONS**

Native stingless bees play an indispensable role in the reconstitution and conservation of tropical forests, in the maintenance of biodiversity, in the production of food and human life, and consequently in the maintenance of life on the planet. In addition to their properties as pollinating agents, honey from native Brazilian bees has been considered as a unique product of Brazilian biodiversity and has demonstrated nutraceutical potential and medicinal effects.

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