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Revisión / Review

Plants and intestinal parasitosis: a review on ethnopharmacological use by the Kantaruré-Batida indigenous community of Brazil

[Plantas y parasitosis intestinal: una revisión sobre el uso etnofarmacológico de la comunidad indígena Kantaruré-Batida de Brasil]

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Abstract: Indigenous knowledge is one of the most notable traditional sources about plants used to treat diseases. Thus, the aim of this study was to describe the botanical features and to investigate the pharmacological properties of plants used by the Kantaruré-Batida community to treat intestinal parasitosis. Botanical characterization was performed based on integrative review and on access to 'Flora do Brasil' platform, whereas plants' pharmacological properties were investigated through systematic review. Among the 21 ethnospecies used, 48% were described as having activity against intestinal parasites. Although 52% had no such activity described, other properties can account for their use, that indicates that further studies are required. Therefore, this review reinforces the importance of valuing indigenous knowledge as tool to guide antiparasitic agent trials.

Keywords: Ethnobotany; Medicinal plants of the Caatinga; Indigenous health; Ethnoparasitology; Bibliometric analysis.

Resumen: El conocimiento indígena es una de las fuentes tradicionales más notables sobre las plantas utilizadas para tratar enfermedades. Por lo tanto, el objetivo de este estudio fue describir las características botánicas e investigar las propiedades farmacológicas de las plantas utilizadas por la comunidad Kantaruré-Batida para tratar la parasitosis intestinal. La caracterización botánica se realizó con base en una revisión integradora y en el acceso a la plataforma "Flora do Brasil", mientras que las propiedades farmacológicas de las plantas se investigaron mediante una revisión sistemática. Entre las 21 etnoespecies utilizadas, se describió que el 48% tenía actividad contra los parásitos intestinales. Aunque el 52% no tenía tal actividad descrita, otras propiedades pueden explicar su uso, lo que indica que se requieren más estudios. Por lo tanto, esta revisión refuerza la importancia de valorar el conocimiento indígena como herramienta para guiar los ensayos de agentes antiparasitarios.

Palabras clave: Etnobotánica; Plantas medicinales de la Caatinga; Salud indígena; Etnoparasitología; Análisis bibliométrico.

INTRODUCTION

Quinine and its many derivatives, such as hydroxychloroquine, are among the drugs that saved more lives in human history. These drugs derived from the ethnobotanical knowledge of indigenous communities living in the Amazon region (Achan *et al.*, 2011; Renslo, 2013; Luciano, 2015; Jomsky & Kerna, 2020). This knowledge was passed on to the church and generated intense commercial activity through more than 100 joint ventures focused on trading this product. The trading process was coordinated by the Dutch pharmaceutical consortium of Cinchona producers, Cinchona Bureau, between the 1920s and 1930s (Van Der Hoogte & Pieters, 2016), and it generated considerable economic power.

Also, the relevance of ethnopharmacology for human health can be unequivocally verified by the discovery of the antimalarial activity of the *Artemisia annua* L. (Sadiq *et al.*, 2014), for which the Chinese researcher Youyou Tu was awarded the Nobel Prize in 2015 (Chen, 2016). Nowadays, the repositioning of antimalarial drugs has revealed the anti-cancer activity of hydroxychloroquine (Amaravadi *et al.*, 2019; Liu *et al.*, 2020) and *Artemisia* L. compounds (Taleghani *et al.*, 2020). Therefore, plants used by native communities can guide the discovery of new compounds potentially employed for treating different disorders (Diehl, 2013; Araújo *et al.*, 2016).

Informations about which and how medicinal species are used by indigenous communities has aroused the interest of the world's scientific community, as observed in studies conducted in China (Chang *et al.*, 2017), Pakistan (Aziz *et al.*, 2018), Nigeria (Taiwo *et al.*, 2018), Madagascar (Riondato *et al.*, 2019), Saudi Arabia (Tounekti *et al.*, 2019), Ethiopia (Abebe & Garedew, 2019), Argentina (Carabajal *et al.*, 2020), Uganda (Anywar *et al.*, 2020), India (Rana *et al.*, 2021), Italy (Mattalia *et al.*, 2021) and Spain (Tardío *et al.*, 2021).

According to the World Health Organization (2020), traditional indigenous medicine results from knowledge, attitudes and practices exercised in therapeutic procedures to cure different diseases, based on individuals' beliefs and experiences. Brazil has the largest number of publications on the subject among Latin American countries. It happens not only due to the number of researchers, but also to the cultural and plant diversity linked to wide edaphic, climatic and geomorphological variations (Rapini *et al.*, 2009; Oliveira *et al.*, 2009; Albuquerque *et al.*, 2013a; Silva *et al.*, 2015a). The relevance of herbal medicine use in the country has led to the development of the National List of Medicinal Plants of Interest to the Unified Health System[a] (Ministry of Health, 2009), which included 71 plant species and estimated that 2,000 species are currently used. The high use rate is mainly attributed to the indigenous culture (Sousa *et al.*, 2008).

Investigations about plants used by native communities in Brazil have revealed promising properties. Oliveira *et al.* (2007), observed mycobactericidal activity in plants deriving from Vanuíre pharmacopoeia (São Paulo State); Moura-Costa *et al.* (2012), reported antifungal, antiviral, leishmanicidal activity and cytotoxic effect of species used by indigenous communities living in Rio das Cobras reserve (Paraná State); Brandelli *et al.* (2013), have explained the action of plants used by Mbyá-Guarani communities (Rio Grande do Sul State) against *Trichomonas vaginalis* Donné 1836; Aquino *et al.* (2017), have partly confirmed the diuretic activity of *Alibertia edulis* (Rich.) A. Rich. ex DC.; and Tirloni *et al.* (2018) reported antioxidant activity and high bioactive compounds extracted from *A. edulis*.

Despite housing 25.5% of the national indigenous population (IBGE, 2010), Northeastern Brazil lacks studies on the knowledge of these communities, mainly about the treatment of infections caused by worms, which comprise major causes of morbidity and mortality associated with socio-sanitary vulnerability (Albuquerque *et al.*, 2007; FUNAI, 2010; Basta *et al.*, 2012; Vasco-dos-Santos *et al.*, 2020). According to Hossain (2018), it is necessary to encourage research about the flora used in traditional systems in order to find new anthelmintics, consequently increasing the scientific interest in ethnopharmacology studies. However, studies conducted in this field in recent years have focused on finding specific properties and on synthesizing new drugs, there has been no record of studies about the flora used in traditional medicine (Yeung *et al.*, 2020).

This study took into consideration the relevance of indigenous knowledge, its demand for research, dissemination and valorization, as well as

[a] Relação Nacional de Plantas Medicinais de Interesse ao SUS – RENISUS.

health issues caused by parasitic diseases. Thus, the aim of the present research was to review the botanical characterization and pharmacological properties of plant species used by the Kantaruré-Batida indigenous community to treat intestinal parasites.

MATERIALS AND METHODS

The Kantaruré-Batida territory is located in Glória County, Bahia State (Figure No. 1). It presents semi-arid climate, low rainfall rates and typical caatinga vegetation. Fishing, hunting and plant extraction, mainly of cassava, corn and beans, are the basis of their subsistence (Santos, 2008; ISA, 2018). Community's use of natural resources has low environmental impact, and it is not restricted to food; it includes the use of over 100 fauna and flora species to treat different diseases (Lima, 2014; Lima *et al.*, 2016).

Plants indicated by the Kantaruré community to treat intestinal parasitosis were previously reported (Vasco-dos-Santos *et al.*, 2018). Botanical characterization was carried out based on integrative review (Whittemore & Knafl, 2005) and on Flora do Brasil platform (BFG, 2020), in order to access taxonomic, anatomical and geographical distribution information. Systematic review (Khan *et al.*, 2003) was performed to investigate plants' pharmacological properties by using the scientific name of each species as descriptors in the Science Direct, PubMed and Google Scholar databases. The first 500 titles of studies published in these databases until 2016, without language limitations, were checked, whenever available. Thus, making a search plan of 1,500 studies per species and 31,500, in total.

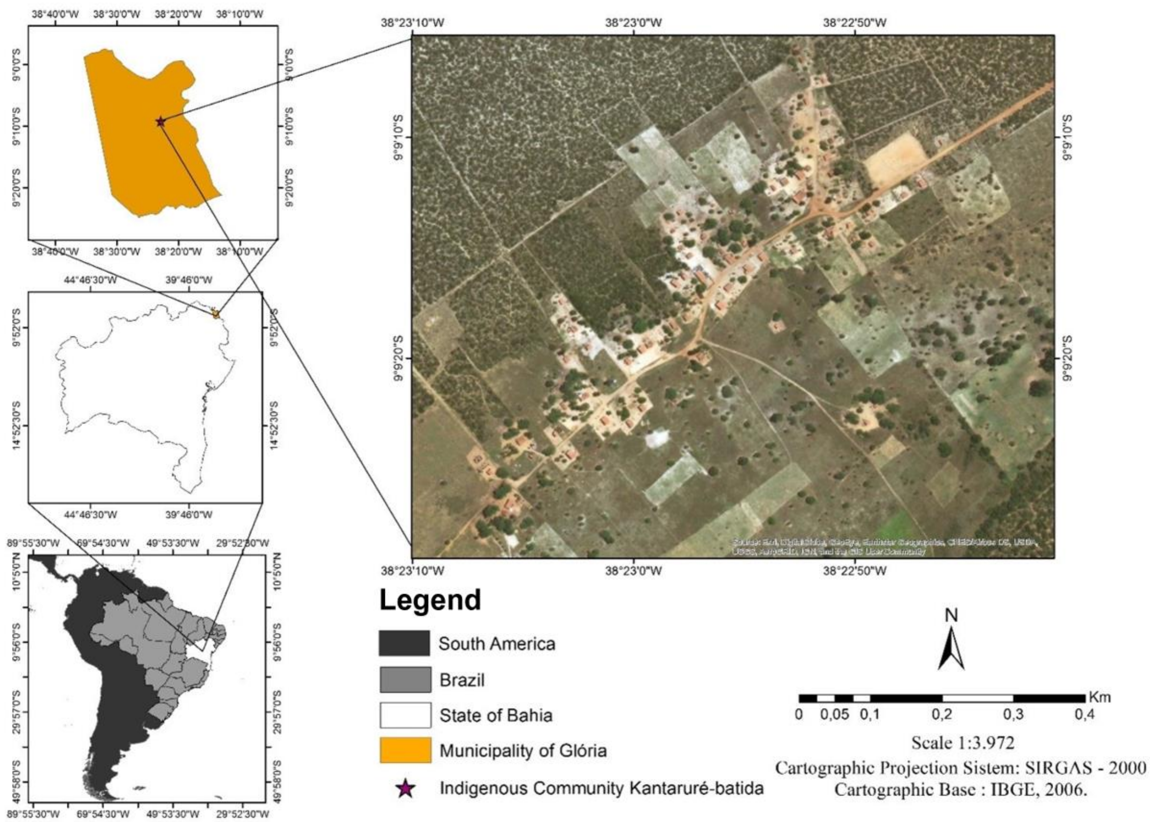

Figure No. 1
Location of the Kantaruré–Batida indigenous community, Bahia State, Brazil

The time frame of systematic review is justified by the period when the ethnobotanical survey was carried out, by taking into consideration that, likewise biotechnological and pharmaceutical advances, the group of plants composing the pharmacopeia of a given culture is always dynamic, as reported in the theory of cultural evolution (Mesoudi, 2007; Araújo *et al.*, 2016). Therefore, the time of access to indigenous and pharmaceutical knowledge was standardized. Selective criterion only comprised studies with significant pharmacological properties. Consequently, other research types, such as physiological and ecological studies were disregarded. The most recent research was taken into consideration whenever similar properties were observed for the same species in different studies, except for the ones about intestinal parasites.

The analysis of the collected information was organized into three categories, namely: I) Botanical characterization; II) Diverse pharmacological properties and III) Activities on intestinal parasites. Data deriving from the first category were compiled in order to optimize and detail plants' description, whereas the second category only took into consideration plants' demonstrated medicinal action. The last category included data extraction process adapted from Sousa *et al.* (2013), it took into consideration the following information: a) plant species/reference; b) used part; c) extract type; d) concentration/dose; e) assay type; f) infected animal/fecal collection and g) tested parasites.

RESULTS

The systematic review strategy adopted in the current study resulted in 334 studies reporting plants pharmacological activity. Among these, 140 were excluded from the sample because they repeated properties for some plant species, except for studies about intestinal parasites. Thus, 194 studies were included in the final analysis (Figure No. 2). The botanical characterization and pharmacological properties observed for each plant are presented below.

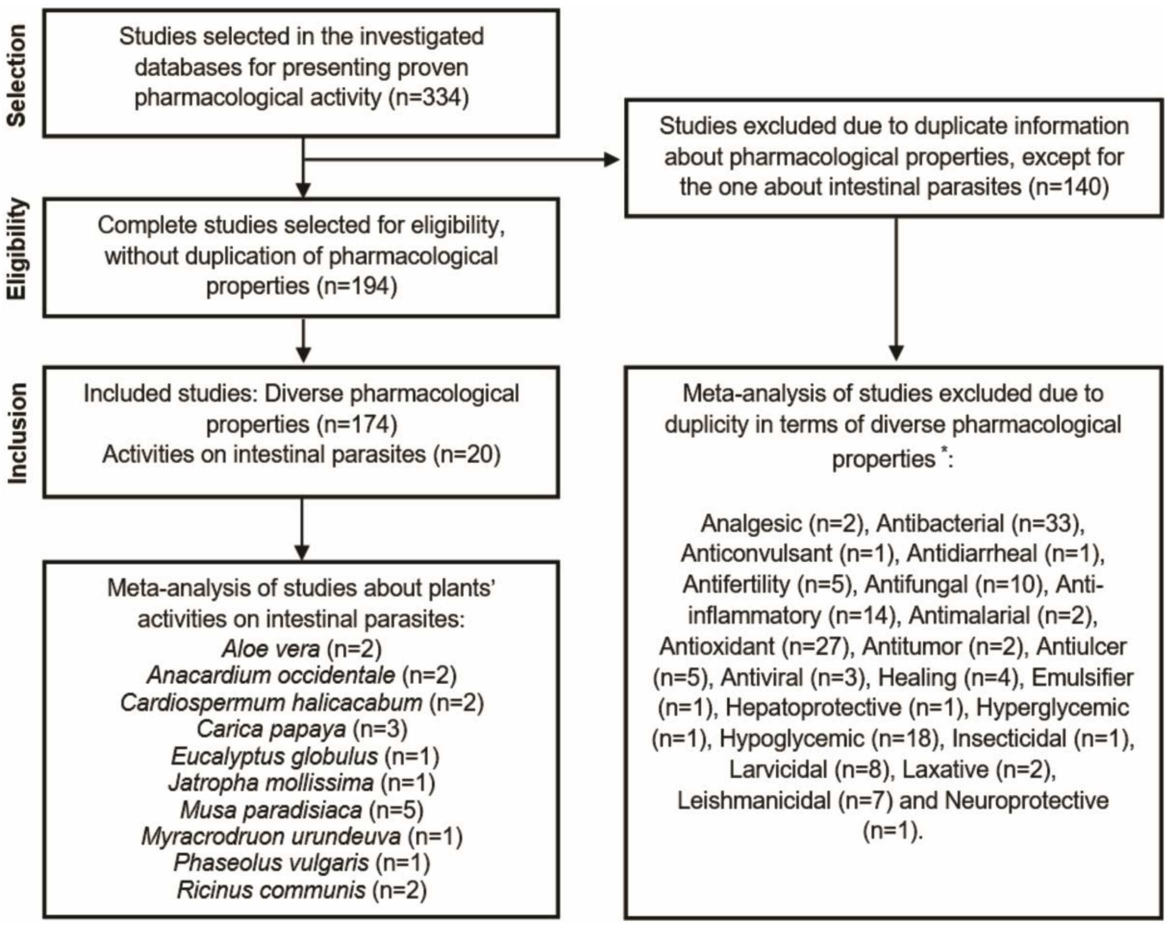

Figure No. 2
Flowchart of systematic review about plants' pharmacological properties used by Kantaruré-Batida indigenous, Bahia State, Brazil. *Quantification based on properties

ALECRIM

Botanical characterization

Lippia thymoides Mart. & Schauer (Verbenaceae) is a shrub species that reaches up to 1.5 m in height. It presents simple, verticillate, membranaceous leaves, oblanceolate-to-spatulate blade with hyphenated venation; helical axillary summit inflorescence, flowers with white-to-orange-yellow corolla and schizocarp fruit. The species is endemic to Brazil; it naturally grows in the Northeastern (Bahia, Pernambuco, Rio Grande do Norte and Sergipe) and Southeastern regions (Minas Gerais), in phytogeographic domains such as Caatinga and Cerrado (Melo *et al.*, 2010a; BFG, 2020).

Diverse pharmacological properties

Antiseptic (Pinto *et al.*, 2013).

Activities on intestinal parasites

Not reported.

ALGODÃO (Figure No. 3B)

Botanical characterization

Gossypium hirsutum L. (Malvaceae) it is a subshrub or shrub that reaches ca. 1.5 m in height. It presents simple, alternate, cartaceous leaves; 3-lobed or partly 5-lobed blade and reticulated venation; overall solitary flowers, yellow corolla and vinaceous base, androphore, as well as capsule fruit with white kapok and blackened seeds. Reported to be originated in both Jamaica and in warm South American regions. The taxon was introduced in Brazil and it can be seen in all five regions of the country in phytogeographic domains such as the Amazon, Caatinga, Cerrado and Atlantic Forest (Watt, 1907; Bayer & Kubitzki, 2003; BFG, 2020).

Diverse pharmacological properties

Larvicidal (Patil *et al.*, 2014).

Activities on intestinal parasites

Not reported.

AMEIXA DO MATO (Figure No. 3C)

Botanical characterization

Ximenia americana L. (Olacaceae) is a shrub or small tree species that reaches 3-4 m in height. It presents zigzag thorny branches; simple, alternate, cartaceous leaves; yellow-white aromatic flowers with curved petals arranged in short, axillary or terminal racemes; and drupe fruits. The species is often found in Africa, India, New Zealand, Central and South America. It can be found in dry and open forests, in rocky and riverside slopes, as well as in coastal forests. The species is native to Brazil; it grows in all five regions in phytogeographic domains such as the Amazon, Caatinga, Cerrado and Atlantic Forest (Sacande & Voutier, 2006; Brasileiro *et al.*, 2008; BFG, 2020).

Diverse pharmacological properties

Antibacterial (Adamu *et al.*, 2005), anticonvulsant (Quintans-Júnior *et al.*, 2002), antifungal (Traoré *et al.*, 2015), anti-inflammatory (Shettar *et al.*, 2015), antineoplastic (Voss *et al.*, 2006), antioxidant (Almeida *et al.*, 2016), antipyretic (Soro *et al.*, 2009) and hepatoprotective (Jayaveera *et al.*, 2009).

Activities on intestinal parasites

Not reported.

AROEIRA

Botanical characterization

Myracrodruon urundeuva Allemão (Anacardiaceae) is a tree species that reaches 5-30 m in height. It presents aromatic, composed, alternate, imparipinnate leaves with 6 to 14 opposite leaflets; light yellow or green female flowers arranged in terminal or axillary panicles and male purple flowers arranged in hanging panicles, persistent sepals; dark-brown drupe fruits with rough surface. The species is native to Brazil and widely distributed in the Northern, Northeastern, Midwestern, Southeastern and Southern regions in phytogeographic domains such as Caatinga, Cerrado, Atlantic Forest, Pampa and Pantanal (Siqueira Filho *et al.*, 2009; BFG, 2020).

Diverse pharmacological properties

Analgesic (Viana *et al.*, 2003), antiadherent (Alves *et al.*, 2009), antibacterial (Jandú *et al.*, 2013), antidiarrheal (Chaves *et al.*, 1998), anti-inflammatory (Machado *et al.*, 2012), antioxidant (Vieira *et al.*, 2015), antiulcer (Carlini *et al.*, 2010), antiviral (Cecílio *et al.*, 2016), insecticidal (Napoleão *et al.*, 2013), larvicidal (Souza *et al.*, 2015), neuroprotective (Calou *et al.*, 2014) and wound healing (Mello *et al.*, 2013).

Activities on intestinal parasites

Anthelmintic (Oliveira *et al.*, 2011).

BABOSA (Figure No. 3D)

Botanical characterization

Aloe vera (L.) Burm.f. (Asparagaceae) is an herbal species that reaches 30-60 cm in height. It presents short and stoloniferous stem; rosette, erect, ensiform and fleshy leaves; central racemose upright inflorescence that reaches 1 to 1.50 m in height; tubular yellowish-white flowers and capsule-type fruits. The species is mainly grown in tropical and subtropical regions worldwide and it likely has its origin in the African Mediterranean region (Dimitri, 1978; Teske & Trentini, 1994). In addition, it grows in anthropic areas of all five regions in Brazil (BFG, 2020).

Diverse pharmacological properties

Anti-acne (Orafidiya *et al.*, 2004), antiasthmatic (Rivas *et al.*, 2004), antibacterial (Dinesh *et al.*, 2015), anticarcinogenic (Saini *et al.*, 2010), anticonvulsant (Rathor *et al.*, 2014), antifungal (Das *et al.*, 2011), anti-inflammatory (El Sayed *et al.*, 2016), antineoplastic (Tabolacci *et al.*, 2015), antioxidant (Haritha *et al.*, 2014), antiseptic (Yun *et al.*, 2009), effective in reducing gastroesophageal reflux symptoms (Panahi *et al.*, 2015), efficient in treating psoriasis (Syed *et al.*, 1996) and oral lichen planu (Choonhakarn *et al.*, 2008), postoperative pain decrease (Eshghi *et al.*, 2010), hepatotoxic (Gbadegesin *et al.*, 2009), immune system improvement (Toliopoulos *et al.*, 2012), larvicidal (Subramaniam *et al.*, 2012), leishmanicidal (Dutta *et al.*, 2007), mosquitocidal (Dinesh *et al.*, 2015), neuroprotective agent in ischemia treatment (Guven *et al.*, 2016), potential to treat diabetes (Haritha *et al.*, 2014), reepithelizer (Atiba *et al.*, 2015) and wound healing (Anjum *et al.*, 2016).

Activities on intestinal parasites

Anticoccidial (El-banna *et al.*, 2013) and anthelmintic (Sprenger, 2015).

BANANA (Figure No. 3E)

Botanical characterization

Musa paradisiaca L. (Musaceae) is a robust herbal species that reaches up to 9 m in height. It presents underground stem; simple, spiral, cartaceous leaves with secondary ribs parallel to the main one and overlapping sheaths forming a pseudostem; cymose inflorescence with proximal female tops and distal male tops, as well as berry-type oblong fruit. It is mainly grown in tropical and subtropical countries worldwide and presents high dietary potential. The species is cultivated and widely distributed in all five Brazilian regions (Imam & Akter, 2011; BFG, 2020).

Diverse pharmacological properties

Antibacterial (Karuppiah & Mustaffa, 2013), antidiarrheal (Yakubu *et al.*, 2015), antifungal (Jawla *et al.*, 2012), antihypertensive (Jaiprakash *et al.*, 2006), antioxidant (Karuppiah & Mustaffa, 2013), antiulcer potential (Goel *et al.*, 2001), antivenom (Borges *et al.*, 2005), hemostatic (Weremfo *et al.*, 2011), hepatoprotective (Nirmala *et al.*, 2012), hypocholesterolemic (Saraswathi & Gnanam, 1997), hypoglycemic (Iroaganachi *et al.*, 2015), it improves breast milk production (Mahmood *et al.*, 2012), and leishmanicidal (Silva *et al.*, 2014).

Activities on intestinal parasites

Anthelmintic (Oliveira *et al.*, 2010; Hussain *et al.*, 2010; Marie-Magdeleine *et al.*, 2010; Hussain *et al.*, 2011; Marie-Magdeleine *et al.*, 2014).

BATATA DE PURGA

Botanical characterization

Operculina macrocarpa (L.) Urb. (Convolvulaceae) is a liana species presenting milky latex; compound, digitized and 5-foliolate leaves; cyme inflorescence; 1-2-flora, white flowers with infundibuliform corolla, pubescent on the mesopetal veins; operculated and globose capsule fruits. The species is native to Brazil and it is widely distributed in the country's Northern, Northeastern, Midwestern and Southeastern regions, in phytogeographic domains such as the Caatinga, Cerrado and Atlantic Forest (Nepomuceno *et al.*, 2016; BFG, 2020).

Diverse pharmacological properties

Antiplatelet (Pierdoná *et al.*, 2014), larvicidal (Paiva *et al.*, 2011) and laxative (Paganotte *et al.*, 2016). It is noteworthy that laxatives may be used in antihelmintic therapy (Futija *et al.*, 2008) and the use of laxatives in the fight against intestinal parasites may date over 5300 years old (Capasso, 1998).

Activities on intestinal parasites

Not reported.

BETERRABA

Botanical characterization

Beta vulgaris L. (Amaranthaceae) is a cultivated herbal species that reaches up to 1.2 m in height (it rarely reaches 2 m in height). It presents basal leaves forming a rosette; small hermaphroditic flowers gathered in dense inflorescences and arranged in glomeruli in groups of one to three (rarely eight) flowers in the armpits of bracts or in the upper half of bractless inflorescences; utricle fruit. The species is native to temperate regions in Europe and Northern Africa; it is one of the main agricultural crops and it accounts for approximately 30% of the world sugar supply. In Brazil, it is grown in the Southeastern and Southern regions of the country and presents likely incidence in the Northern, Northeastern, Midwestern, Southeastern and Southern regions (Lange *et al.*, 1999; Biondo *et al.*, 2014; Kew Science, 2020; BFG, 2020).

Diverse pharmacological properties
Antiacetylcholinesterase (Sacan & Yanardag, 2010), antibacterial (Koochak *et al.*, 2010), anticancer (Kazimierczak *et al.*, 2014), antifungal (Kragh *et al.*, 1995), anti-inflammatory (Jain *et al.*, 2011), antioxidant (Sacan & Yanardag, 2010), anti-radical (Escribano *et al.*, 1998), antiviral (Iglesias *et al.*, 2015), hepatoprotective (Agarwal *et al.*, 2006), hypoglycemic (Yoshikawa *et al.*, 1996) and neuroprotective (Nade *et al.*, 2015).

Activities on intestinal parasites
Not reported.

CAÇATINGA (Figure No. 3F)
Botanical characterization
Croton argyrophyllus Kunth (Euphorbiaceae) is a shrub species that reaches 1-4 m in height. It presents silver-green branches; stellate, lepidote-to-dentate-lepidote trichomes; translucent latex; simple, alternate, cartaceous leaves; monoic terminal inflorescence showing silver-yellow flowers staminated at the apex and pistilized at the base, as well as capsule fruit. It has disjunct distribution in South America (Bolivia, Paraguay, Venezuela and Brazil). The species is native to Brazil and naturally grows in the Northern and Northeastern regions of the country, in phytogeographic domains such as Caatinga and Amazon, mainly in semi-arid environments, in sandy or stony soils with semi-deciduous-to-deciduous vegetation (Carneiro-Torres, 2009; Silva *et al.*, 2010; BFG, 2020).

Diverse pharmacological properties
Anti-inflammatory (Ramos *et al.*, 2013).

Activities on intestinal parasites
Not reported.

CAJUEIRO (Figure No. 3G)
Botanical characterization
Anacardium occidentale L. (Anacardiaceae) is a tree species that reaches 2-15 m in height. It presents simple, whole, alternate, cartaceous-to-subcoriate leaves; obovate, oblong or widely oblong blade; terminal tyrsoid inflorescence; flowers with white or light-green petals presenting red or pink lines in anthesis and dark-red lines after fertilization; piriform drupe fruit; yellow, orange or red fleshy hipocarp. The species is native to Brazil and is widely distributed in virtually all states in the Northern, Northeastern, Midwestern and Southeastern regions of the country, in phytogeographic domains such as the Amazon, Caatinga, Atlantic Forest, Pampa and Pantanal (Silva-Luz, 2011; BFG, 2020).

Diverse pharmacological properties
Aphrodisiac (Mbatchou & Kosoono, 2012), antibacterial (Ajileye *et al.*, 2015), antidiarrheal (Araújo *et al.*, 2015), antifungal (Mahata *et al.*, 2014), anti-inflammatory (Olajide *et al.*, 2013), anti-mutagenic (Barcelos *et al.*, 2007), antioxidant (Encarnação *et al.*, 2016), anti-tumor (Mothé *et al.*, 2008), antiulcerogenic (Konan & Bacchi, 2007), emulsifying (Porto & Cristianini, 2014), gastroprotective (Morais *et al.*, 2010), hypoglycemic (Dionísio *et al.*, 2015), larvicidal (Torres *et al.*, 2015), leishmanicidal (Franca *et al.*, 1993), molluscicidal (Souza *et al.*, 1992), renal function improvement (Tedong *et al.*, 2006) and thrombolytic (Khan *et al.*, 2011).

Activities on intestinal parasites
Anthelmintic (Ademola & Eloff, 2011) and antiprotozoal (Neiva *et al.*, 2014).

CATINGUEIRA PREPREM (Figure No. 3H)
Botanical characterization
Poincianella microphylla (Mart. ex G. Don) L. P. Queiroz (Fabaceae) it is a shrub or small tree species that reaches up to 1.5 m in height. It presents compound, bipinnate, alternate and cartaceous leaves; inflorescence in terminal or axillary raceme up to 6-

cm long; flowers with golden-yellow petals, vexillum petal with reddish spots; and strongly compressed and apiculate oblong-to-oblanceolate fruit. The species is endemic to Brazil; it is typical of and widely distributed in Caatinga environments found in Bahia, Pernambuco and Piauí States (Northeastern region) (Queiroz, 2009; BFG, 2020).

Diverse pharmacological properties
Antibacterial (Silva *et al.*, 2006) and antibiofilm (Silva *et al.*, 2015b).

Activities on intestinal parasites
Not reported.

CHUCAINHO
Botanical characterization
Cardiospermum halicacabum L. (Sapindaceae) it is an herbaceous vine species presenting compound, biternate, 9-foliolate and cartaceous leaves; axillary, spiciform tyrsoid inflorescences with three branches, flowers with white petals presenting yellowish crest at the apex; globose, 3-winged and inflated septifragal capsule fruit. Cosmopolitan species that is widely distributed in the Americas, Africa, South Asia and Oceania. It naturally grows in the Brazilian Northern, Northeastern, Midwestern, Southeastern and Southern regions, in phytogeographic domains such as the Amazon, Caatinga, Cerrado, Atlantic Forest, Pampa and Pantanal (Ferrucci, 2000; Pereira *et al.*, 2016; BFG, 2020).

Diverse pharmacological properties
Analgesic (Muthumani *et al.*, 2010), antibacterial (Jeyadevi *et al.*, 2013), anticonvulsant (Dhayabaran *et al.*, 2012), antidiarrheal (Rao *et al.*, 2006), antifungal (Jeyadevi *et al.*, 2013), anti-inflammatory (Huang *et al.*, 2011), antioxidant (Rupeshkumar *et al.*, 2012), antiplasmodial (Waako *et al.*, 2005), antipyretic (Asha & Pushpangadan, 1999), antispasmodic (Pillai & Vijayamma, 1985), antiulcer (Muthumani *et al.*, 2010), anxiolytic (Kumar *et al.*, 2011), collagenase inhibitor (Ganesan *et al.*, 2011), diuretic (Chandra *et al.*, 2008), hepatoprotective (Rupeshkumar *et al.*, 2012), hypoglycemic (Veeramani *et al.*, 2012), hypolipidemic (Veeramani *et al.*, 2010), hypotensive (Somanadhan *et al.*, 1999), male fertility enhancer (Peiris *et al.*, 2015), potential to treat chronic skin diseases (Jong *et al.*, 2013), repellent (Govindarajan & Sivakumar, 2012) and sedative (Pillai & Vijayamma, 1985).

Activities on intestinal parasites
Anthelmintic (Khunkitti *et al.*, 2000; Boonmars *et al.*, 2005).

EUCALIPTO
Botanical characterization
Eucalyptus globulus Labill. (Myrtaceae) is a forest tree species that reaches 30-55 m in height; it exceptionally exceeds 90 m in height. It presents erect and slender trunk, with branches only in the terminal part, where they form a sparse and irregular canopy at great height. Its leaves are considerably polymorphic. Young individuals present opposite, sessile, oblanceolate 6-to-15 cm long leaves covered by a waxy bluish tegument; they emerge in alternating pairs and give juvenile plants alternifolia features in quadrangular section stems. On the other hand, adult trees present narrow, rectilinear to falciform-shaped, petiolate, 15-to-35 cm long leaves, with grayish green tegument emerging alternately along cylindrical stems; white or cream flowers, either solitary or grouped in up to three individuals; and capsule fruit. The species is native to Australia and Tasmania and it is currently one of the most widely grown trees in production forests. It was introduced in several countries in Europe, South America, Africa and Asia, mainly to produce timber, paper, cellulose and essential oils. It also grows in anthropic areas in all five Brazilian regions (Kirkpatrick, 1974; Jordan *et al.*, 1993; Naithani, 2014; Salehi *et al.*, 2019; BFG, 2020).

Diverse pharmacological properties
Anti-acetylcholinesterase (Aazza *et al.*, 2011), anti-acne (Athikomkulchai *et al.*, 2008), antibacterial (Dezsi *et al.*, 2015), anti-inflammatory (Medeiros *et al.*, 2007), antioxidant (Dezsi *et al.*, 2015), lipid-lowering (Eidi *et al.*, 2009) and potential antiasthma (Ikawati *et al.*, 2001).

Activities on intestinal parasites
Anthelmintic (Macedo *et al.*, 2009).

FEIJÃO DE ARRANCA
Botanical characterization
Phaseolus vulgaris L. (Fabaceae) is a liana species of determined or indeterminate growth. It presents compound, 3-foliolate, alternate and cartaceous

leaves; racemous, axillary and terminal inflorescences; papilionaceous flowers; white, pink or violet petals uniformly distributed throughout the corolla, or corolla with vexillum and wings with different colors or shades; as well as legume fruit presenting two valves joined by two sutures, one dorsal and one ventral. The species is cultivated in Brazil, where it is widely distributed in anthropic areas in all its five regions (Silva & Costa, 2003; BFG, 2020).

Diverse pharmacological properties

Antibacterial (Amarowicz *et al.*, 2008), antidiabetic (Mojica & Mejía, 2016), anti-inflammatory (Monk *et al.*, 2015), antimutagenic, antioxidant (Rocha-Guzmán *et al.*, 2007) and insecticidal (Karbache *et al.*, 2011).

Activities on intestinal parasites

Anthelmintic (Ríos-de Álvarez *et al.*, 2012).

JATOBÁ MANSO

Botanical characterization

Hymenaea courbaril L. (Fabaceae) is a tree species that reaches 6-15 m in height. It presents compound, bifoliolate, alternate, coriaceous, glabrous, predominantly lanceolate-to-oblong leaves with acute and obtuse apex; inflorescence in terminal panicle; flowers with campanulate hypanthium and white petals; legume fruits with dark-brown lenticelous surface. It is widely distributed from Southern Mexico and the Antilles to Southwestern Brazil; the species is mostly represented in forest environments. It is native to Brazil and is widely distributed in the Northern, Northeastern, Midwestern, Southeastern and Southern regions of the country, in phytogeographic domains such as the Amazon, Caatinga, Cerrado, Atlantic Forest and Pantanal (Queiroz, 2009; BFG, 2020).

Diverse pharmacological properties

Antifungal (Costa *et al.*, 2014), anti-inflammatory, antioxidant (Bezerra *et al.*, 2013), antiviral, (Cecílio *et al.*, 2012) and myorelaxant (Bezerra *et al.*, 2013).

Activities on intestinal parasites

Not reported.

MAMÃO (Figure No. 3I)

Botanical characterization

Carica papaya L. (Caricaceae) is a tree species that can reach 6-9 m in height. It presents palm-lobed leaves that emerge from the upper parts of the stem in spiral array, in hollow, succulent petioles; axillary inflorescence with pistillate, staminate or bisexual flowers; fleshy and lightly scented petals; and berry fruit. The species is typically tropical and has likely origin in Central America. It is widely distributed in all states of all five Brazilian regions and in phytogeographic domains such as the Amazon, Caatinga, Cerrado and Atlantic Forest (Paull & Duarte, 2011; Wijaya & Chen, 2013; BFG, 2020).

Diverse pharmacological properties

Abortive (Anuar *et al.*, 2008), action against fish ectoparasite (Ekanem *et al.*, 2004), analgesic (Hasimun *et al.*, 2014), antibacterial (Kokila *et al.*, 2016), anticancer (Li *et al.*, 2012), anti-fertility (Nwaehujor *et al.*, 2014), anti-fungal (Chávez-Quintal *et al.*, 2011), anti-inflammatory (Owoyele *et al.*, 2008), anti-malarial (Tarkang *et al.*, 2014), antioxidant (Galang *et al.*, 2016), antisickling (Oduola *et al.*, 2006), antithrombotic (Zunjar *et al.*, 2016), antiulcerogenic (Oloyede *et al.*, 2015), antiviral (Chinnappan *et al.*, 2016), anxiolytic (Kebebew & Shibeshi, 2013), astringent action (Oloyede, 2005), contraceptive (Lohiya *et al.*, 2005), hepatoprotective (Awodele *et al.*, 2016), hypoglycemic (Juárez-Rojop *et al.*, 2012), molluscicidal (Jaiswal & Singh, 2008), potential to treat allergic diseases (Otsuki *et al.*, 2010), proteolytic (Thomás *et al.*, 2009) and wound healing (Gurung & Škalko-Basnet, 2009).

Activities on intestinal parasites

Anthelmintic (Satrija *et al.*, 1995; Kermanshai *et al.*, 2001; Okeniyi *et al.*, 2007). It is worth highlighting that *C. papaya* compounds obtained from both latex (Moraes *et al.*, 2017) and seeds (Cabral *et al.*, 2019) have anthelmintic activity upon *Strongyloides venezuelensis* Brumpt, 1934 eggs and larvae. The *C. papaya* action on intestinal nematodes is largely due to the worm cuticle disrupture by cysteine proteinases (Levecke *et al.*, 2014; Luoga *et al.*, 2015).

MAMONA (Figure No. 3J)

Botanical characterization

Ricinus communis L. (Euphorbiaceae) is a shrub species that reaches ca. 1.5 m in height. It presents simple, alternate and cartaceous leaves; racemose inflorescence; unisexual flowers: staminate flowers at the base of branches and pistillate flowers at the apex of branches; as well as capsule fruits. The species naturally grows in India, Africa, Europe and Brazil, where it is cultivated and widely distributed in all states of all its five regions, in phytogeographic domains such as the Amazon, Caatinga, Cerrado, Atlantic Forest, Pampa and Pantanal (Linnaeus, 1753; BFG, 2020).

Diverse pharmacological properties
Acaricidal (Ghosh *et al.*, 2013), antiasthmatic (Taur & Patil, 2011), antibacterial (Rampadarath & Puchooa, 2016), antifungal (Naz & Bano, 2012), anti-inflammatory (Ilavarasan *et al.*, 2006), antinociceptive (Taur *et al.*, 2011), antioxidant (Wafa *et al.*, 2014), antitumor (Lin & Liu, 1986), binder (Etzler & Branstrator, 1974), contraceptive (Nath *et al.*, 2013), hypoglycemic (Shokeen *et al.*, 2008), immunomodulatory (Mannoji *et al.*, 1986), insecticidal (Rampadarath *et al.*, 2014), potential to be used in osteoarthritis treatment (Ziaei *et al.*, 2016), as well as in bone and reconstruction processes (Leite & Ramalho, 2008), larvicidal (Rampadarath & Puchooa, 2016), leishmanicidal (Jumba *et al.*, 2015), neuroleptic (Ferraz *et al.*, 1999), neuroprotective (Lee *et al.*, 2012), toxic (Coopman *et al.*, 2009).

Activities on intestinal parasites
Anthelmintic (Zahir *et al.*, 2012; Salles *et al.*, 2014).

MANJERICÃO
Botanical characterization
Ocimum campechianum Mill. (Lamiaceae) is an herbal species that reaches up to 60 cm in height. It presents aromatic, opposite, simple leaves; lax, branched inflorescence with lateral branches smaller than, or equal to, the main branch; whorls with 6 flowers; fruitful chalice with upper lip flowing along the tube and internally-purple, white corolla included in the chalice; uniformly brown nut-type fruit. The species is native to Brazil, where it is widely distributed in all its five regions, in phytogeographic domains such as the Amazon, Caatinga, Cerrado and Atlantic Forest (Albuquerque & Andrade, 1998; BFG, 2020).

Diverse pharmacological properties
Antibacterial (Carović-Stanko *et al.*, 2010), repellent (Benitez *et al*., 2014) and antioxidant (Dzib-Guerra *et al.*, 2016).

Activities on intestinal parasites
Not reported.

PINHÃO BRABO (Figure No. 3L)
Botanical characterization
Jatropha mollissima (Pohl) Baill. (Euphorbiaceae) is a subshrub or shrub species that reaches up to 3 m in height. It presents simple, 5-lobed, alternate and membranaceous leaves; inflorescences in terminal dichasium with unisexual flowers; staminate and pistillate flowers with red petals; as well as tricoca capsule fruit. The species is native to Brazil and is widely distributed in the Northern, Northeastern, Midwestern and Southeastern regions, in phytogeographic domains such as the Amazon, Caatinga and Cerrado (Sátiro & Roque, 2008; BFG, 2020).

Diverse pharmacological properties
Antioxidant (Melo *et al.*, 2010b).

Activities on intestinal parasites
Anthelmintic (Ribeiro *et al.*, 2014).

PITÓ
Botanical characterization
Croton heliotropiifolius Kunth (Euphorbiaceae) is a subshrub or shrub species that reaches 0,7–2,5 m in height. It has simple, alternate and membranaceous leaves presenting the same color at both sides; racemose inflorescence with unisexual flowers, greenish-white staminate and greenish-yellow pistillate flowers; as well as tricoca capsule fruit. The species is widely distributed in the neotropical region. It is native to Brazil and more often observed in the Northeastern region of the country, although it also grows in the Midwestern and Southeastern regions of it, in phytogeographic domains such as the Amazon, Caatinga, Cerrado and Atlantic Forest (Sátiro & Roque, 2008; BFG, 2020).

Diverse pharmacological properties
Antiacetylcholinesterase, antifungal (Queiroz *et al.*, 2014) and insecticidal (Silva *et al.*, 2012).

Activities on intestinal parasites
Not reported.

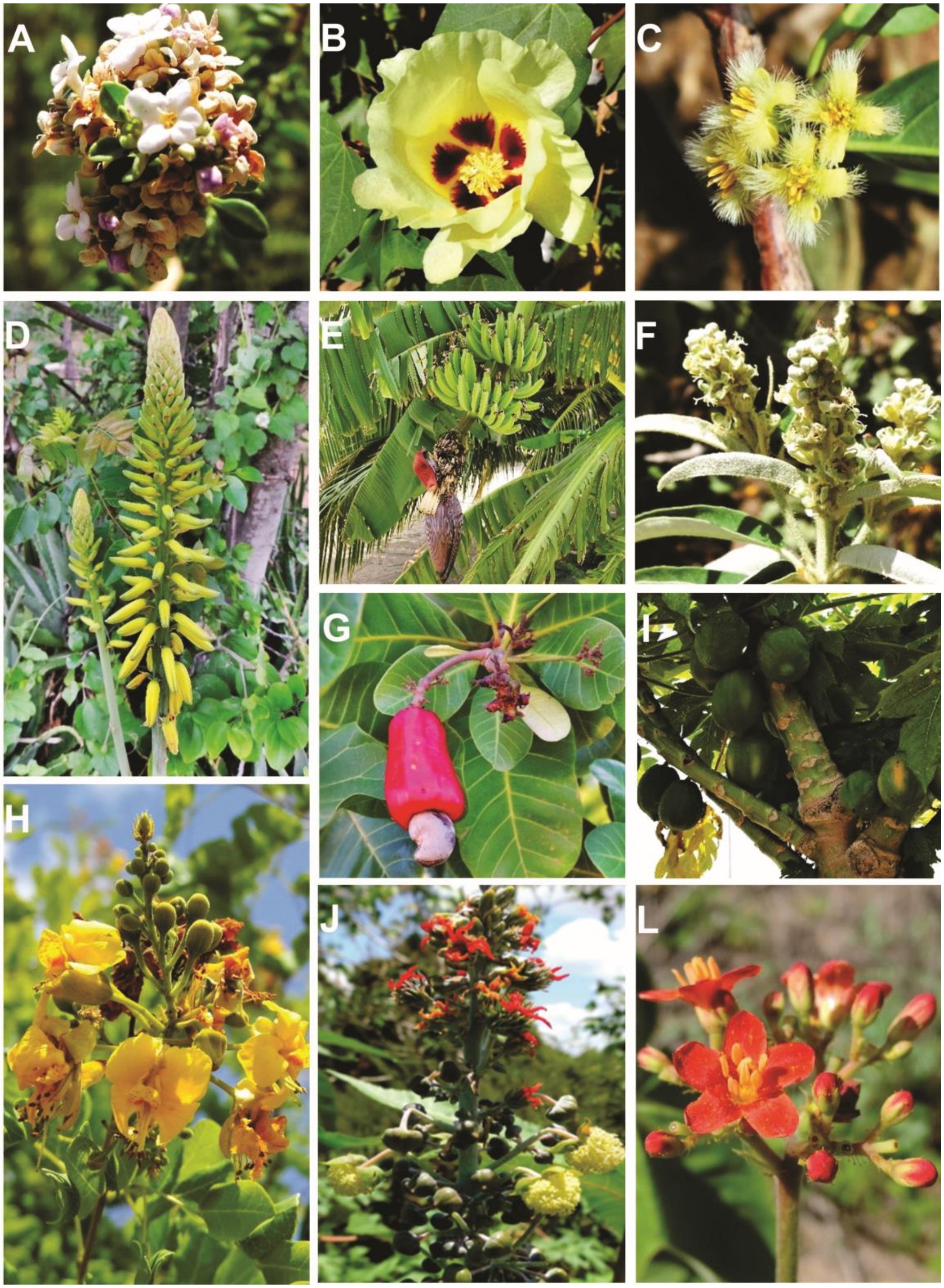

Figure No. 3
Ethnospecies indicated as antiparasitic agents by Kantaruré-Batida indigenous, Bahia State, Brazil. A: *Lippia thymoides*; B: *Gossypium hirsutum*; C: *Ximenia americana*; D: *Aloe vera*; E: *Musa paradisiaca*; F: *Croton argyrophyllus*; G: *Anacardium occidentale*; H: *Poincianella microphylla*; I: *Carica papaya*; J: *Ricinus communis*; L. *Jatropha molissima* (Source: Vasco-dos-Santos DRV, Santos JV)

QUIXABEIRA

Botanical characterization

Sideroxylon obtusifolium (Roem. & Schult.) T.D.Penn. (Sapotaceae) it is a tree species that can reach up to 18 m in height. The apex of its branches are hanging and thorny; it presents simple, coriaceous leaves, either opposite to each other or arranged in a spiral; inflorescence with white or yellow-green or cream, aromatic flower clusters comprising 2-20 flowers; as well as drupe fruit. It is found in some countries in North and South America. The species is native to Brazil, it is widely distributed in the Northern region of the country (Tocantins State), as well as in all states in the Northeastern, Midwestern, Southeastern and Southern regions, in phytogeographic domains such as Caatinga, Cerrado, Atlantic Forest and Pantanal (Silva & Dantas, 2017; BFG, 2020).

Diverse pharmacological properties

Antiandrogenic (Bobach *et al.*, 2014), antibacterial (Aquino *et al.*, 2016), antinociceptive (Araujo-Neto *et al.*, 2010), anti-inflammatory (Leite *et al.*, 2015) and antioxidant (Figueiredo & Lima, 2015).

Activities on intestinal parasites

Not reported.

DISCUSSION

Based on data accessed through the present systematic review, 48% of plants used by Kantaruré indigenous have effect on intestinal parasites, namely: Aroeira (*M. urundeuva*), Babosa (*A. vera*), Banana (*M. paradisiaca*), Cajueiro (*A. occidentale*), Chucainho (*C. halicacabum*), Eucalipto (*E. globulus*), Feijão de arranca (*P. vulgaris*), Mamão (*C. papaya*), Mamona (*R. communis*) and Pinhão brabo (*J. molissima*) (Table No. 1). Studies conducted with Tamang indigenous people living in Rasuwa district, Nepal (Uprety *et al.*, 2010), as well as with residents in Dominica, West Indies (Quinlan *et al.*, 2002), have shown agreement between local knowledge about and pharmacological potential of plants.

Concerning the assay types, 80% were performed *in vitro*, 5% were conducted *in vivo* and 15% of studies performed both types. According to Wink (2012), despite the promising results of tests performed *in vitro*, clinical progress is neglected because parasites mainly affect economically vulnerable populations who cannot afford drugs. Therefore, they are not priority for the pharmaceutical industry. Most articles (85%) presented data about parasites of veterinary interest, mainly about *Haemonchus contortus* (Rudolphi, 1803), which is a gastrointestinal worm accounting for considerable economic damage to global carprinoculture (Silva, 2014). Thus, it is essential emphasizing that some of the human anthelmintic drugs available in the market nowadays derive from veterinary medicine.

Only three of the analyzed studies performed experiments with human parasites, two of them, Boonmars *et al.* (2005) and Neiva *et al.* (2014) were carried out *in vitro*. Boonmars *et al.* (2005) observed *C. halicacabum* extract activity against third-stage *Strongyloides stercoralis* (Bavay, 1876) larvae whereas Neiva *et al.* (2014) recorded giardicidal activity of hydroalcoholic extract of *A. occidentale* leaves. Okeniyi *et al.* (2007) was the only study conducted *in vivo*, whose sample, which comprised 60 parasitized children, was treated with elixir added with *C. papaya* seeds, which was effective against 7 parasites (Table No. 1). Recently, Azadbakht *et al.* (2020) have shown maximum activity of essential oils of *E. globulus* against *Giardia lamblia* Ancey, 1906 and *Entamoeba histolytica* Schaudinn, 1903. However, the aforementioned studies did not explain the active compounds and their respective action mechanisms, which could have been investigated by using electron microscopy to determine cellular and subcellular targets of antiparasitic drugs (Vannier-Santos & De Castro, 2009; Dos Anjos *et al.*, 2016).

Secondary metabolism products such as alkaloids, terpenoids, polysaccharides and peptides, which can promote lesser costly and more effective therapy, are the main plant molecule constituents used to treat worm infections (Bahmani *et al*., 2014; Singh *et al*., 2020). *Artemisia annua* L., which is historically used as dewormer, anti-hemorrhoid and antipyretic drug in China, is a successful example of it (Oriakpono *et al*., 2012). Artemisinin is one of the active agents of this species; this sesquiterpene lactone presenting endoperoxide bond, is isolated from plant leaves (Rehder *et al*., 2002; Taranto *et al*., 2006). Its compounds may also display antiviral activity against the severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2), recently reviewed (Khan *et al*., 2021; Remali & Aizat, 2021). Despite remarkable controversy, other antimalarials such as chloroquine and its derivative hydroxychloroquine are in test for COVID 19 (Million *et al*., 2020; Güner *et al*., 2021) and such activity may be explained at least in part for the autophagy downmodulation (Tang *et al*., 2020; Klionsky *et al*., 2021).

Table No. 1
Antiparasitic activities of species used by Kantaruré-Batida community, Bahia State, Brazil, accessed through systematic review. Note: DNF=Data not found

Plant species/ reference	Used part	Extract type(s)	Concentration/ Dose	Assay type(s)	Infected animal/ Fecal collection	Tested parasite(s)
Aloe vera (L.) Berm.f.						
El-Banna *et al*., 2013	Leaves	Aqueous	100 ppm	*In vivo*	Chickens	*Eimeria acervulina* *E. maxima* *E. necatrix* *E. tenella* *E. brunette*
Sprenger, 2015	Leaves	Aqueous and ethanolic	0.78 to 100 mg/mL	*In vitro*	Eggs from goat feces	*Haemonchus contortus*
Anacardium occidentale L.						
Ademola & Ellof, 2011	Leaves	Liquid (acetone)	0.311 and 1.72 mg/mL	*In vitro*	Eggs from sheep feces	*Haemonchus contortus*
Neiva *et al*., 2014	Leaves	Hydroalcoholic	5 mg/mL	*In vitro*	Axenic strains	*Giardia lamblia*
Cardiospermum halicacabum L.						
Khunkitti *et al*., 2000	Shoot	Aqueous and ethanolic	0, 100, 500,1000 and 2000 µg/mL $^{-1}$	*In vitro*	Peritoneal cavity of birds	*Brugia pahangi*
Boonmars *et al*., 2005	DNF	Hydroalcoholic	2000 µg/mL	*In vitro*	Larvae from dog feces	*Strongyloides stercoralis*
Carica papaya L.						
Satrija *et al*., 1995	Fruits	Aqueous	2, 4, 6 and 8 g/kg of body weight	*In vivo*	Rats	*Heligmosomoides polygyrus*
Kermanshai *et al*., 2001	Seed	Aqueous and oil	10 to 20 µL 0.04 and 0.1 µL	*In vitro*	DNF	*Caenorhabditis elegans*
Okeniyi *et al*., 2007	Seed	Seeds and honey (Placebo)	20 mL	*In vivo*	Humans (Children)	*Ascaris lumbricoides* *Entamoeba histolytica* *Giardia lamblia* *Necator americanus* *Strongyloides stercoralis* *Taenia saginata* *Trichuris trichiura*

Eucalyptus globulus Labill.						
Macedo *et al.*, 2009	DNF	Oil	Different concentrations	*In vitro*	Eggs from sheep feces	*Haemonchus contortus*
Jatropha mollissima (Pohl) Baill.						
Ribeiro *et al.*, 2014	Stem	I Aqueous II Ethanolic	I 1% at concentrations 100, 500 and 1000 µg/mL II 2.5 ml of ethanolic extract 660.80 µg/mL	I *In vivo* II *In vitro*	I Sheep II Eggs from sheep feces	*Haemonchus contortus*
Musa paradisiaca L.						
Oliveira *et al.*, 2010	Leaves and pseudo stems	Aqueous	25, 75 and 150 mg/mL^{-1}	*In vitro*	Eggs from sheep feces	*Haemonchus* spp.
Hussain *et al.*, 2010	Leaves	Aqueous and ethanolic	0.0207 and 0.4813 mg/mL^{-1}	*In vitro*	Eggs from sheep feces	Nematoides
Hussain *et al.*, 2011	Folhas	Aqueous methanolic	I DNF II 100, 50, 25, 12.5, 6.25, 3.12, 1.56, 0.78, 0.39 and 0.19 mg/mL^{-1}	I *In vivo* II *In vitro*	I Sheep II Eggs and adult individuals from sheep feces	*Haemonchus contortus*
Marie-Magdeleine *et al.*, 2010	Stems and leaves	Mixed with food	7000 g/day	*In vivo*	Lamb	*Haemonchus contortus*
Marie-Magdeleine *et al.*, 2014	Stems and leaves	Aqueous, methanolic and/or dichloromethane	2400, 1200, 600 and 300 µg/mL	*In vitro*	Lamb	*Haemonchus contortus*
Myracrodruon urundeuva Allemão						
Oliveira *et al.*, 2011	Leaves and stems	Aqueous and ethanolic	0.31 to 5 mg/mL	*In vitro*	Eggs and larvae from sheep feces	*Haemonchus contortus*
Phaseolus vulgaris L.						
Ríos-de Álvarez *et al.*, 2012	Seeds	Aqueous/ flour	I 2.3 mg of semi-purified PHA lectin per kg of body weight II DNF	I *In vivo* II *In vitro*	I Sheep II Larvae removed from tissue	*Trichostrongylus colubriformis Teladorsagia circumcincta*
Ricinus communis L.						
Zahir *et al.*, 2012	Leaves	Alcoholic	1.0 mL	*In vitro*	Adult individuals collected from the rumen of infected	*Paramphistomum cervi*

					sheep	
Salles *et al.* (2014)	Seeds	Aqueous, NaCl andTris-HCl	DNF	*In vitro*	Eggs from goat feces	*Haemonchus contortus*

Mengarda *et al.* (2020) have tested the antischistosomal activity of piperlongumine *in vivo*. This alkaloid, which is found in *Piper tuberculatum* Jacq. roots, has significantly reduced worm burden and egg production. Furthermore, the study has also shown damage to parasites' integument, based on electron microscopy. Another plant product, curcumin, derived from *Curcuma* sp., was shown to be cytotoxic and antiparasitic, largely due to redox properties, inducing oxidative stress in cancer, protozoal and helmintic models, triggering both autophagy and apoptosis (Haddad *et al.*, 2011; De Paula Aguiar *et al.*, 2016; Araveti & Srivastava, 2019; Gupta *et al.*, 2020). Its action on microtubules of the cytoskeleton in *G. lamblia*, *Plasmodium falciparum* (Wech, 1897), *Trypanosoma cruzi* (Chagas, 1909) and cancer cells, apparently for direct binding to tubulin molecules, was demonstrated by fluorescence spectroscopy and docking *in silico* (Banerjee *et al.*, 2010; Chakrabarti *et al.*, 2013; Sueth-Santiago *et al.*, 2016; Gutiérrez-Gutiérrez *et al.*, 2017). Thus, the development of new tools can lead to the elucidation of the various mechanisms of action of antiparasitic agents.

Other investigations have also reported the effectiveness of active plant compounds against intestinal parasites. Among them, one finds allicin, aspidin, ascaridol, toosendanin and piplartine, which derive from *Allium sativum* L. (Lima *et al.*, 2011), *Dryopteris* spp. (Magalhães *et al.*, 2010), *Chenopodium ambrosoides* L. (Kliks, 1985), *Melia toosendan* Siebold & Zucc. (Zhou, 2014) and *P. tuberculatum* (Moraes *et al.*, 2012), respectively.

Regarding species habit, 23.8% of the investigated species were herbs; 9.5% were lianas; 14.3% subshrubs or shrubs; 14.3% shrubs; 9.5% shrubs or small tree; and 28.7% were average-sized trees. Most plants with antiparasitic potential (Table 1) were trees (40%); they were followed by herbs (30%), as well as by lianas, subshrubs and shrubs (10%, each). This outcome can substantiate the discussion about the ecological appearance hypothesis, since the most apparent plants (trees) have their potential best known and are mostly used likely due to their greater availability (Albuquerque *et al.*, 2013b).

Data collected in the current study do not substantiate the prediction that herbaceous plants are associated with the greater medicinal or cultural importance of a given species since, based on the free list, bush and tree plants such as *P. microphylla* (23%), *C. papaya* (13%) and *M. urundeuva* (10%) were the most cited by Kantaruré (Vasco-dos-Santos *et al.*, 2018). Therefore, seasonality appears to be a better predictor that points towards woody species as the most used plants in the traditional therapeutic arsenal available in caatinga phytogeographic domains, as observed by Almeida *et al.* (2011).

Silva *et al.* (2020) have investigated whether individuals' perception about the taste of plants could influence the selection of medicinal resources; however, they did not find data to substantiate their hypothesis. Thus, apparently, isolated aspects such as plant habit and taste are not good predictors to help better understanding selection mechanisms applied to therapeutic resources. They are likely to be better understood in light of the socio-ecological theory of maximization, according to which, selection processes are linked to cognitive and behavioral strategies adopted in different environmental contexts in order to expand the benefits to, and survival of, human groups (Albuquerque *et al.*, 2019).

Although 52% of the indicated plants do not have reported action in intestinal parasites, it is not possible inferring their ineffectiveness due to lack of standardized and validated antiparasitic tests. In addition, the investigated species have other properties that can help understanding their use, based on their likelihood to enable users' improvement, as reported by Vasco-dos-Santos *et al.* (2019). The need of conducting further research to better understand the properties of indigenous flora was also reported by Baranwal *et al.* (2012) and Raj and Dave (2019), who addressed antiarthritic and antidiabetic medicinal plants, respectively.

Based on the study conducted by Elisabetsky and Posey (1989), who investigated plants used as remedies associated with sexuality and fertility by the Kayapó community, 48% of plant species were also used by other cultures for the same purpose, which indicated their potential effectiveness. Similarly, this aspect can also be applied to Babosa (*A. vera*) and Mamão (*C. papaya*) plants used by the Kantaruré community, which is also used by other indigenous communities in Northeastern Brazil to treat worm infections. *Aloe vera* is used by the Guajajara community (Coutinho *et al.*, 2002), whereas *C. papaya* plant is used by the Funil-ô (Silva, 2003), Tapeba (Morais *et al.*, 2005) and Pataxó communities (Cunha Lima *et al.*, 2012).

Based on data collected by Vasco-dos-Santos *et al.* (2018), the way plants are prepared by indigenous communities likely has implications on traditional therapy. For example, the combined use of banana (*M. paradisiaca*) and garlic (*Alium sativum* L.) can be a strategy adopted to enhance their effect, since both species have antiparasitic properties (Santos *et al.*, 2012; Marie-Magdeleine *et al.*, 2014). Other combinations reported in the literature comprised Batata de purga (*O. macrocarpa*) and Mamão (*C. papaya*); as well as Ameixa (*X. americana*) and Aroeira (*M. urundeuva*). Among them, only *M. urundeuva* and *C. papaya* have information available about their antiparasitic properties (Okeniyi *et al.*, 2007; Oliveira *et al.*, 2011). Therefore, further studies should be conducted about these species, as well as about the risks and benefits generated by their interaction, to test the potential-use hypothesis. After all, some medicinal plants that have potentially toxic substances should be used based on toxicological risks (Veiga Junior *et al.*, 2005).

CONCLUSIONS

Taken together, the current data have confirmed that indigenous ethno-knowledge about medicinal plants plays key role in species selection for pharmacological and phytochemical studies aimed at finding new drugs. They also highlight the importance of conducting research about parasites in traditional communities, mainly in indigenous communities living in Northeastern Brazil. Based on the present literature review, it is possible to assume that some plants have the potential to be investigated as deworming agents, if one takes into consideration the lack of studies performed for this purpose. Among them, one finds Catingueira prepem (*P. microphylla*), Caçatinga (*C. argyrophyllus*), Pitó (*C. heliotropiifolius*) and Alecrim (*L. thymoides*), which stand out as the main species used by Kantaruré-Batida indigenous community.

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