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Amazonian Invertebrates in the Traditional diet of the Paiter Suruí in Southeastern Brazil

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Abstract
The Paiter Suruí people in the southwestern Brazilian Amazon have a complex food system that includes insects and crustaceans. We designed our study to systematize data about the invertebrates they incorporate into their traditional diet. After conducting a review of the literature, we verified and expanded the data through semi-structured interviews with Paiter Suruí volunteers, and traced trends in their consumption of invertebrates. We identified 61 invertebrates, including 58 insects of the orders Coleoptera, Lepidoptera, Hymenoptera, and three crustaceans. While beetle larvae remain a popular choice, consumption of other insects and crustaceans seems to have diminished over time.

Keywords Ethnoecology · Anthropo-entomophagy · Traditional ecological knowledge · Edible insects · Animal-plant relations · Indigenous diets · Paiter Suruí · Matto Grosso · Rondônia · Brazilian Amazon

Introduction

Termed anthropo-entomophagy (Costa-Neto, 2015), consumption of invertebrates has traditionally played an important role in human diets around the world (Sutton, 1995; Defoliart, 1999 Marconi et al., 2002, Maseko et al., 2017, Torres-Vitolas et al., 2019). Insects can be consumed whole, at different stages of their development, or as their parts or products and secretions (such as honey and lacquer), either cooked (boiled, fried, or baked) or ingested raw (Costa-Neto & Ramos-Elorduy, 2006; Miranda Santos, 2011). Although it is rare in urbanized societies, insect consumption is considered a protein-rich option available in human diets and animal feed in many parts of the world (Ramos-Elorduy, 1997; Costa-Neto, 2003; Gullan & Cranston, 2017).

In South America, Indigenous Peoples commonly include insects in their diets (Costa-Neto, 2015) as part of their daily routines, although consumption practices are changing with the rapid transformations entailed in increasing contacts with the surrounding non-indigenous society (Mindlin, 1985; Paoletti et al., 2000; Adams & Piperata, 2014) listed 115 species of invertebrates used as food by Indigenous Peoples in greater Amazonia, while Costa-Neto and Ramos-Elorduy (2006) list 95 species of edible insects used by Indigenous Peoples in Brazil, while allowing that this number may be even higher. The Paiter Suruí, an Indigenous group in the southwestern Brazilian Amazon have traditionally included insects and crustaceans in their diet (Coimbra Jr, 1984; Coimbra, 1985a, 2012). Paiter Suruí culture has been influenced throughout the 52 years since contact by the encroachment of expanding non-Indigenous populations. Our study addresses how their consumption of

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invertebrates is related to their management of their environment and how their use of these resources may have changed over time, as well as the current status of invertebrates in their dietary practices.

In research on edible invertebrates, it is important to understand the context of Indigenous management practices and the habitats and substrates in which the invertebrates develop and are collected (Paoletti et al., 2000). For example, the Guajibo of Venezuelan Amazonia collect larvae of Curculionidae beetles from a range of habitats, including *Attalea maripa* (Aubl.) Mart., *Oenocarpus bataua* Mart., *Mauritia flexuosa* L.f., *Euterpe oleracea* Mart., *Syagrus orinocensis* (Spruce) Burret., and *Bactris gasipaes* Kunth (Cerda et al., 2001). And Jaramillo-Vivanco et al. (2022) highlight the differences in the nutritional and organoleptic characteristics of *Rhynchophorus palmarum* larvae collected from *M. flexuosa*, *B. gasipaes*, and *O. bataua*. The Paiter Suruí collect edible beetle larvae from *Jacaratia spinosa* (Aubl.) A. DC., *Attalea speciosa* (Aubl.) Mart. and *O. bataua*, and edible moth caterpillars from *Bertholletia excelsa* Bonpl., *Castilla ulei* Warb., and *Protium altissimum* Aubl. (Coimbra Jr, 1985b; Coimbra, 2012). Some of these plants are domesticated as their populations are favored by continuous human management (Clement, 1999; Levis et al., 2017). The management of such species can generate persistent changes in landscapes (Levis et al., 2018; Clement et al., 2021), increasing food availability in the long term.

Materials and methods

Study area

We conducted our field study in the Paiter Suruí village of Joaquim (Fig. 1), located in the Sete de Setembro Indigenous Territory (10°42’22” S and 11°24’11” S; 61°32’11” W and 60°42’27” W), an area covered by Ombrophylous Open Forest with a predominance of palms and lianas growing on Red-Yellow Argisols (Ultisols in the American Soil Taxonomy) (RADAMBRASIL, 1978). This Indigenous Territory of 247,000 hectares lies between the states of Rondônia and Mato Grosso, with main access through the municipality of Cacoal (Rondônia), near the BR 364 highway. The Paiter Suruí people were first contacted by non-indigenous society in 1969. Currently, there are about 1,500 Indigenous Paiter Suruí living in 27 villages. Since the beginning of the accelerated colonization of the state of Rondônia between 1960 and 1970, the region has become known for logging, farming, and cattle ranching (Mindlin, 1985), and, more recently, diamond extraction, activities that threaten the forest and the livelihoods of the Indigenous Peoples of the region (Maisonnave, 2017).

Data Collection

In the 1970s, Carlos Everaldo Coimbra Jr. (1984; 1985a; 1985b; 2012) and Betty Mindlin (1985) worked independently with the Paiter Suruí, studying their society (Mindlin, 1985) and their diet (Coimbra Jr, 1984; Coimbra, 1985a,b, 2012). For the specific case of bees, we consulted Bontkes

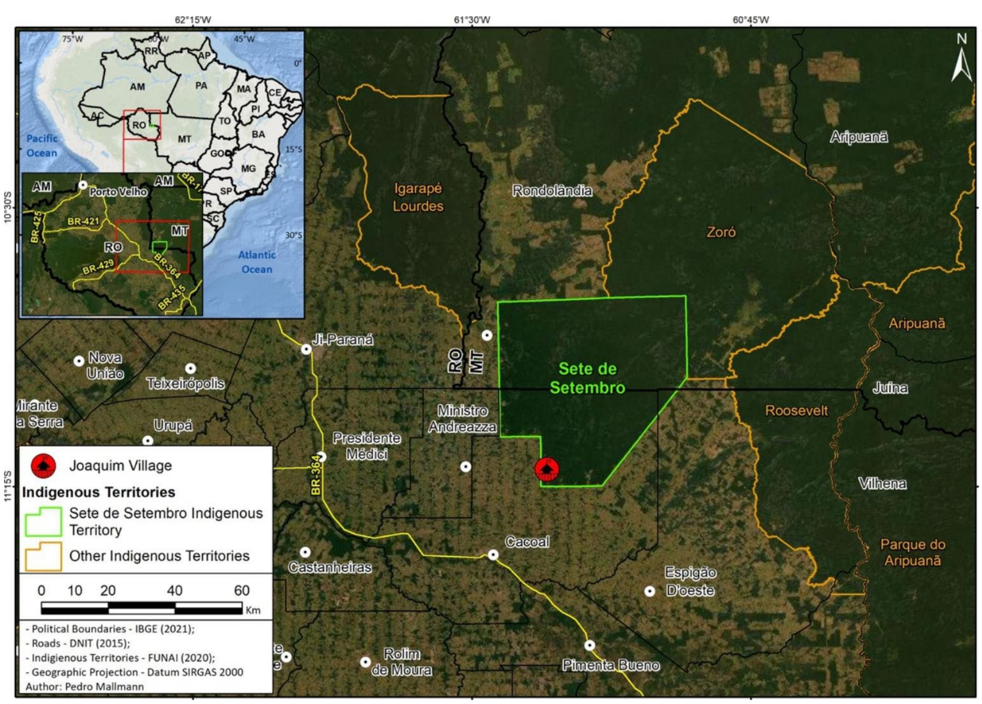

Fig. 1 Joaquim village location in the Sete de Setembro Indigenous Territory

(1978). We systematized these data to design our semi-structured interviews (Alexiades, 1996) in order to both cross-check their accuracy and expand the database.

Officials at FUNAI (the National Indian Foundation of Brazil, a government body that establishes and administers policies regarding Indigenous populations) suggested Joaquim village as a suitable locale to develop our research proposal. After presenting our objectives and methodology to the local village leaders and the community, a group of 12 individuals volunteered to collaborate with our study. We conducted group interviews with all volunteers present in November 2017.[1]

Our volunteer group consisted of adults ranging in age from 18 to 78 (seven men and five women). An elderly couple, born before contact in 1969, agreed to answer questions about differences between past and current food practices. In addition to the collective interview, we arranged guided tours and participant observation (Alexiades, 1996) to collect further data about the invertebrates harvested, their management, and methods of collection (a total of 290 days of participant observation and 15 km traveled over a period of six visits: November 2017, September/October 2018, January/February, April/May, September 2019, and February/March 2020, the last unfortunately interrupted due to the COVID-19 pandemic regulations in Brazil). The planning of all field activities was facilitated by a Paiter Suruí interpreter.

Data Management

We organized our data into two lists; invertebrates and plants associated with the insects. Photographic records of invertebrates observed during fieldwork were identified by the Entomology Laboratory of the National Institute of Amazonian Research (INPA) and the Invertebrate Laboratory of the Federal University of Pará (UFPA); scientific names registered in previous studies were updated according to current standards.

The plant species indicated by volunteers as substrate for larval development were identified in the field from their local Paiter Suruí name referenced in Coimbra Jr (1985b) and by the list of plants in the Sete de Setembro Indigenous Territory ethno-mapping (Cardozo, 2011). The scientific names of the plants follow APG IV 2016 (Tropicos, 2022). The spelling of the Paiter Suruí names of invertebrates and plants was updated following the recommendations of our local interpreter. Invertebrates were considered no longer in use if there was no evidence of their consumption by village residents, and in use when they were observed to be consumed at least once during any of the field visits.

We differentiated degrees of domestication of the plants associated with the insects into incipiently domesticated, semi-domesticated, and domesticated, a classification we based on genetic differences between wild populations and populations that have undergone selection and management (Clement, 1999; Clement et al., 2021). This classification reflects simply domestication of the species, not the source of domestication, i.e., in Paiter Suruí territory or elsewhere in Amazonia.

Results and Discussion

Diversity of Edible Invertebrates used by the Paiter Suruí

We recorded 61 names for invertebrates in use in the Paiter Suruí traditional diet, corresponding to 58 taxa (Table 1). Some of the names in the Paiter Suruí language refer to more than one taxon, including some names for Curculionidae and Chrysomelidae beetles. The insects are from the Coleoptera, Lepidoptera, and Hymenoptera orders, and crustaceans are from the Decapoda order.

Plants Associated with Edible Insects

Beetle larvae (Coleoptera) and moth caterpillars (Lepidoptera) are directly related to the occurrence and management of certain plant species. Seventeen plant species are associated with the insects, of which 11 are domesticated to some degree (Table 2). We recorded 11 new plant names during the collective interview, in addition to the six plant names previously recorded by Coimbra Jr. (1984; 2012). Among the 17 plant species associated with Coleoptera and Lepidoptera, 11 are palms and six are trees from different botanical families (Table 2).

Curculionidae beetle larvae (*mãyõrã*) develop inside substrates of all palms (Arecaceae) and jaracatiá (*Jacaratia spinosa*), and chrysomelidae beetle larvae (*kadeg*) develop inside fruits of babassu (*Attalea speciosa*) and tucumã (*Astrocaryum aculeatum*). Lepidoptera caterpillars are specific to Brazil nut (*Bertholletia excelsa*), caucho (*Castilla ulei)*, breu-manga (*Protium altissimum*), cashew (*Anacardium giganteum*), and rubber (*Hevea brasiliensis*) trees.

We present data on Paiter Suruí management and gathering of these food resources and their preparation and consumption, and on current or lapsed use of invertebrates in their traditional diet in the following sections: Coleoptera (Curculionidae and Chrysomelidae), Lepidoptera,

[1] There was no overlap between our volunteers or our methodology with those of Coimbra Jr. and Mindlin, who conducted their research in other villages.

Table 1 Invertebrates traditionally used in the diet of the Paiter Suruí, Sete de Setembro Indigenous Territory, Rondônia/Mato Grosso, Brazil. Each record includes taxonomic order, species name, Paiter Suruí name, form of consumption, situation of use, and code for reference: (1) Coimbra Jr. (1984); (2) Coimbra Jr. (1985a); (3) Coimbra Jr. (2012); (4) Mindlin (1985); (5) Bontkes (1978) and (6) cited in the collective interview

	Order	Taxon	Paiter Suruí	Form of consumption	Status of use	Cited
Insecta	Coleoptera	*Rhynchophorus palmarum*	Mãyõrã	Raw or cooked larvae	In use	1, 2, 6
		Rhinostomus barbirostris	Mãyõrã	Raw or cooked larvae	In use	1, 2, 6
		Homalinotus validus	Mãyõrã	Raw or cooked larvae	In use	6
		Pachymerus cardo	Kadeg	Fried larvae	In use	1, 2, 4, 6
		Caryobruchus sp.	Kadeg	Fried larvae	In use	1, 2, 4, 6
	Hymenoptera	*Atta* sp.	Moráh-ey	Fried adult	Disuse	2, 6
		Melipona (Melikerria) grandis	Waloya-ey	Larvae, pupae and honey	Disuse	2
		Melipona (Eomelipona) schwarzi	Warwaekuy-ey	Larvae, pupae and honey	Disuse	2, 5
		Scaptotrigona xanthotricha	Yoidíter-ey	Larvae, pupae and honey	Disuse	2, 5
		Nannotrigona sp.	Wakabpe-ey	Larvae, pupae and honey	Disuse	2
		Plebeia sp.	Yape-ey	Larvae, pupae and honey	Disuse	2, 5, 6
		Scaptotrigona polysctica	Yoidmeb-ey	Larvae, pupae and honey	Disuse	2
		Trigona angustula	Waptirir-ey	Larvae, pupae and honey	Disuse	2
		Trigona branneri	Arma-ey	Larvae, pupae and honey	Disuse	2, 5, 6
		Frieseomelitta meadewaldoi	Gosereyb-ey	Larvae, pupae and honey	Disuse	2
		Ptilotrigona lurida	Kirun-ey	Larvae, pupae and honey	Disuse	2, 6
		Meliponini	Gahoub-ey	Larvae, pupae and honey	Disuse	5
		Meliponini	Goberabnor-ey	Larvae, pupae and honey	Disuse	5
		Meliponini	Gohebere-ey	Larvae, pupae and honey	Disuse	5
		Meliponini	Gobetab-ey	Larvae, pupae and honey	Disuse	5
		Meliponini	Gonhub-ey	Larvae, pupae and honey	Disuse	6
		Meliponini	Ikabr-ey	Larvae, pupae and honey	Disuse	6
		Meliponini	Ikorngoser-ey	Larvae, pupae and honey	Disuse	4, 6
		Meliponini	Jíji-ey	Larvae, pupae and honey	Disuse	4, 5
		Meliponini	Kaloy-ey	Larvae, pupae and honey	Disuse	5
		Meliponini	Kerub-ey	Larvae, pupae and honey	Disuse	4
		Meliponini	Lakapóykab-ey	Larvae, pupae and honey	Disuse	4
		Meliponini	Likinhapeposir-ey	Larvae, pupae and honey	Disuse	4, 6
		Meliponini	Mamipokab-ey	Larvae, pupae and honey	Disuse	4, 5
		Meliponini	Maraba-ey	Larvae, pupae and honey	Disuse	5
		Meliponini	Masabpeb-ey	Larvae, pupae and honey	Disuse	4
		Meliponini	Mikab-ey	Larvae, pupae and honey	Disuse	5
		Meliponini	Mober-ey	Larvae, pupae and honey	Disuse	6
		Meliponini	Moberabmo-ey	Larvae, pupae and honey	Disuse	4, 6
		Meliponini	Mosereb-ey	Larvae, pupae and honey	Disuse	6
		Meliponini	Nasoub-ey	Larvae, pupae and honey	Disuse	4, 6
		Meliponini	Palabi-ey	Larvae, pupae and honey	Disuse	5, 6
		Meliponini	Pikãbuxer-ey	Larvae, pupae and honey	Disuse	4
		Meliponini	Píkũr-ey	Larvae, pupae and honey	Disuse	4, 5
		Meliponini	Pirab-ey	Larvae, pupae and honey	Disuse	6
		Meliponini	Soaxereia-ey	Larvae, pupae and honey	Disuse	4
		Meliponini	Wabkiryd-ey	Larvae, pupae and honey	Disuse	5
		Meliponini	Wakixâ-ey	Larvae, pupae and honey	Disuse	5
		Meliponini	Walabi-ey	Larvae, pupae and honey	Disuse	4
		Meliponini	Waloykub-ey	Larvae, pupae and honey	Disuse	4
		Meliponini	Warabe-ey	Larvae, pupae and honey	Disuse	4

Table 1 (continued)

	Order	Taxon	Paiter Suruí	Form of consumption	Status of use	Cited
		Meliponini	Warid-ey	Larvae, pupae and honey	Disuse	5
		Meliponini	Waridob-ey	Larvae, pupae and honey	Disuse	5, 6
		Meliponini	Yoiub-ey	Larvae, pupae and honey	Disuse	4
		Meliponini	Yoid-ey	Larvae, pupae and honey	Disuse	4, 5
		Meliponini	Yoimoi-ey	Larvae, pupae and honey	Disuse	4, 6
		Meliponini	Yokanambe-ey	Larvae, pupae and honey	Disuse	4, 5, 6
		Meliponini	Warir-ey	Larvae, pupae and honey	Disuse	4, 6
	Lepidoptera	*Lusura altrix*	Mãmneg	Roasted caterpillar	In use	2, 3, 6
		Heterocera	Jikibneg	Roasted caterpillar	Disuse	2, 3, 6
		Heterocera	Aberneg	Roasted caterpillar	Disuse	3, 6
		Molippa nibasa	Barneg	Roasted caterpillar	Disuse	6
		Cicinnus callipius	Yokobeab	Roasted caterpillar	Disuse	6
Crustacea	Decapoda	*Macrobrachium carcinus*	Mosaáp	Cooked adults	Disuse	2, 6
		Thrichodactilidae	Gorpã/Gorpã abexacaiá	Cooked adults	Disuse	2, 6
		Fredius sp.	Gorpã/Gorpã sakap	Cooked adults	Disuse	6

N/I: Not Identified.

Table 2 Plants associated with insects consumed by the Surui around Joaquim village, Sete de Setembro Indigenous Territory, Rondônia/Mato Grosso, Brazil. Botanical identification follows Coimbra Jr (1985b), Cardozo (2011) or is our determination. The degree of domestication follows Clement et al. (2021). The plants cited in Coimbra Jr. (1984) and Coimbra Jr. (2012) are indicated in the last column or are identified as New

Paiter Suruí	Portuguese	Taxon	Botanical family	Domestication degree	Associated insect	Cited
Mayor	Tucumã	*Astrocaryum aculeatum* G. Mey.	Arecaceae	Incipient	Kadeg/Mãyõrã	New
Wasam	Inajá	*Attalea maripa* (Aubl.) Mart.	Arecaceae	Incipient	Mãyõrã	New
Tira	Ouricuri	*Attalea* cf. *phalerata* Mart. ex Spreng.	Arecaceae	Incipient	Mãyõrã	New
Pasap	Babassu	*Attalea speciosa* (Aubl.) Mart.	Arecaceae	Incipient	Kadeg/Mãyõrã	1984
Yobar	Pupunha	*Bactris gasipaes* Kunth	Arecaceae	Domesticated	Mãyõrã	New
Bíb	Açaí	*Euterpe oleracea* Mart.	Arecaceae	Incipient	Mãyõrã	New
Wasampara	Paxiúba	*Iriartea deltoidea* Ruiz & Pav.	Arecaceae	N/I	Mãyõrã	New
Yobai	Buriti	*Mauritia flexuosa* L.f.	Arecaceae	Incipient	Mãyõrã	New
Yoitã	Bacaba	*Oenocarpus* cf. *bacaba* Mart.	Arecaceae	Incipient	Mãyõrã	New
Yoí	Patauá	*Oenocarpus bataua* Mart.	Arecaceae	Incipient	Mãyõrã	1984
Para	Sete-pernas	*Socratea exorrhiza* (Mart.) H. Wendl.	Arecaceae	N/I	Mãyõrã	New
Ibôg	Jaracatiá	*Jacaratia spinosa* (Aubl.) A. DC.	Caricaceae	N/I	Mãyõrã	1984
Orixi	Caju-açu	*Anacardium giganteum* Hanc. ex Engler	Anacardiaceae	N/I	Yokobeab	New
Aber	Breu-manga	*Protium altissimum* Aubl.	Burseraceae	N/I	Aberneg	2012
Bar	Seringueira	*Hevea brasiliensis* Muell. Arg.	Euphorbiaceae	Incipient	Barneg	New
Mãm	Castanheira	*Bertholletia excelsa* Bonpl.	Lecythidaceae	Incipient	Mãmneg	2012
Jikib	Caucho	*Castilla ulei* Warb.	Moraceae	N/I	Jikibneg	2012

N/I: Not Informed.

Hymenoptera (Formicidae and Apidae, Meliponini), and Decapoda (Crustacea).

Coleoptera

The Paiter Suruí consume insects from two families of the Coleoptera order: Curculionidae (the largest and most diverse family of beetles) and Chrysomelidae (composed of beetles popularly called "borers"). We confirmed in our field observations and the collective interview that Paiter Suruí distinguish between the larvae of Curculionidae (*mãyõrã*, Fig. 2.a) and those of Chrysomelidae (*kadeg*, Fig. 2.b), but do not distinguish between larvae of different genera within the same entomological family (Coimbra Jr, 1984; Coimbra, 1985a). Curculionidae larvae, mainly of the genus *Rhynchophorus*, called palm weevils, are considered major pests of palm crops worldwide (Gullan & Cranston, 2017; Cartay et al., 2020) because they feed on the seed embryo, as in the case of babassu (Ferreira et al., 2016).

Curculionidae

Coi mbra Jr. (1984) observed that *Rhynchophorus palmarum* larvae develop in the decomposing woody parts of jaracatiá and babassu, and *Rhinostomus barbirostris* larvae in patauá. In our field observations, we found both *R. palmarum* and *Homalinotus validus*, also called *mãyõrã*, which adds another species to their diets and demonstrates taxonomic redundancy, contrary to expectations (Berlin, 2014). The larvae of Curculionidae are gathered from decomposing palm substrates on a regular basis, as well as opportunistically on expeditions into the forest for other purposes, such as hunting (Coimbra Jr, 1985c; Mindlin, 1985: 53). Besides opportunistic gathering, sourcing the larvae of *mãyõrã* is planned by cutting palms and jaracatiá trees for later collection (Coimbra Jr, 1984). These management practices were confirmed during our collective interview.

Our volunteers reported eight palms during the collective interview, some of which had not been recorded by Coimbra Jr. (Table 1). All of these are sometimes managed to obtain Curculionidae larvae. Additionally, they reported that the larvae developed in different types of substrates have recognizably different flavors and aromas, also not recorded by Coimbra Jr.

Larvae management consists in cutting chosen adult jaracatiá trees and palms at their base so that, when they fall to the forest floor, the internal pith can decompose and become substrates for the female beetles to lay their eggs. After about 45 days the outer parts of the jaracatiá and palms are carefully opened to collect the larvae. The Paiter Suruí monitor the entire growth process of the larvae to collect them when they start to pupate, recognized by the sound of the insects' mandibles tearing plant fibers. Our observations and interview responses confirmed that the Paiter Suruí identify the plants with *mãyõrã* larvae by the suffix *teguey* to indicate that larvae development is in progress, which also identifies the origin of the substrate, for example, *Ibôg teguey* are jaracatiá trunks with larvae, as reported by Coimbra Jr. (1984).

During our field observations, only jaracatiá trees were cut to attract the Curculionidae beetles, although gathering of *mãyõrã* larvae also occurred with different palms. The jaracatiá trees were felled with a chainsaw and split lengthwise, leaving the internal wood in contact with the ground. According to our volunteers, this modification of

Fig. 2 Edible beetle larvae consumed as food by the Paiter Suruí: (a) *Rhynchophorus palmarum* larvae (*mãyõrã*) and (b) *Pachymerus cardo* larvae (*kadeg*). (Photos: Ariel Molina, 2019)

the traditional management offers more available substrate for larvae development, thus producing more *mãyõrã* in the same length of time.

The gathering of *mãyõrã* determines the management of jaracatiá trees, but insect collecting may also occur when a fallen trunk is found in the forest. As we observed, this also happens less frequently with palms, which are used opportunistically, but seldom cut specifically for *mãyõrã* production.

According to Coimbra Jr (1984; 1985a), larvae collected from jaracatiá or babassu are only eaten fried, while larvae obtained from patauá can be eaten either raw or fried. Our volunteers and fieldwork observations indicated that *mãyõrã* can be eaten raw or fried regardless of the substrate in which they developed.

Two studies include reports of chemical analysis of *Rhynchophorus palmarum*: Coimbra Jr. (1984) reported a centesimal analysis of larvae collected from jaracatiá (*Jacaratia spinosa*) and partially dried (12.7% humidity): 8.7% protein, 21.1% lipids and 5% ash; and Cerda et al. (2001) reported a centesimal analysis of *R. palmarum* larvae that developed in buriti (*Mauritia flexuosa*) and found 7.3% protein (76% cystine), more than double that of cow's milk (3.1% on average). [2]

Chrysomelidae

We confirmed Coimbra Jr.'s (1984) observation that *kadeg* larvae can be *Pachymerus cardo* or species of the genus *Caryobruchus*, both gathered from babassu fruits (Tables 1 and 2). We were able to add some details to his brief description of *kadeg* gathering. When entering the babassu grove, the Paiter Suruí look for fallen babassu fruits on the ground with small holes indicating perforations by adult insects. Once they have collected a large amount of fruit into a single pile, they break the fruits with rocks or other improvised tools, such as tractor pistons. While both children and adults participate in the search for fruit on the forest floor, the work of breaking the babassu fruit is an exclusively female activity. The insects are carefully removed from inside the broken fruit and stored alive in a container to be prepared in the village. Seeds already in the process of germination are discarded. The whole process of breaking the fruits is performed inside a babassu grove, which may favor this palm since viable or germinating seeds are discarded on site. Furthermore, the removal of these larvae for consumption may favor babassu populations by reducing their parasite loads (see Coimbra Jr., 1984; 1985a and Mindlin 1985: 46; 82; Table 2).

The larvae are prepared for consumption by frying in a pan in their own fat, which melts out during heating and is strained and set aside to be consumed separately from the larvae. On one occasion, we witnessed a small amount of *kadeg* larvae removed from tucumã fruits being cut to make handicrafts.

We witnessed the gathering and consumption of *kadeg* on three occasions, once in the form of snacks (wrapped in babassu straw) for sale alongside industrialized snacks during a local championship soccer match between villages in February 2019 (Fig. 2.b), when even non-indigenous soccer fans also consumed the delicacy. Residents of another Paiter Suruí village offer *kadeg* larvae to visitors as a part of a tourism experience and engage with social media to spread the news. Some residents of Joaquim also mentioned that *kadeg* larvae are more acceptable to non-indigenous people because they have a crunchy and salty taste rather than the slimy texture and strong coconut-like flavor of *mãyõrã* larvae. *Kadeg* larvae can also be kept for a few days in closed containers whereas *mãyõrã* must be immediately consumed, either raw or roasted (see also Araújo et al. 2016).

There is no information in the scientific literature about the nutritional values of *Pachymerus cardo* larvae, but Alves et al. (2016) analyzed the chemical composition of *Pachymerus nucleorum* larvae that used *Acrocomia aculeata* (Jacq.) Lodd. ex Mart. seeds as substrate and found 5.3% protein, 37.9% lipids, antioxidants, and no antinutritional factors. This suggests that the Chrysomelidae larvae obtained from babassu fruits by the Paiter Suruí provide good protein and caloric inputs to their traditional diet, but as in the case of Curculionidae, more research is needed to establish the nutritional value of different species that develop in different palm fruits.

Lepidoptera

Less common than coleopteran larvae, lepidopteran caterpillars are also part of some Indigenous diets (Paoletti et al., 2000). Among the caterpillars consumed, those of the moth species *Lusura altrix* (Notodontidae), known as *mãmneg*, feed on the leaves of the Brazil nut tree (Table 2; Fig. 3.a). According to Coimbra Jr. (2012) and as we also observed (September 2018 and 2019), moth caterpillars are collected preferentially from the stem of the tree during the summer months (July/September), when they occur in large numbers. They are picked by hand off the tree trunk or out of a delicate open cocoon in which they are metamorphizing (Fig. 3.b). The caterpillars are roasted in a pan and after becoming crispy can be eaten alone or together with popcorn or mixed with cornmeal. These caterpillars are

[2] Curculionidae beetle larvae are also greatly enjoyed by the Samaria in Venezuela (Giron et al., 2017) and the Awajún in Peru (Casas Reátegui et al., 2018). Both populations also incorporate other invertebrates in their diets.

Fig. 3 *Lusura altrix* (mãm-neg) caterpillars: (a) ready for consumption, (b) caterpillar pupa laying on a Brazil nut trunk (*Bertollethia excelsa*). (Photos: Ariel Molina, 2019)

regarded as Brazil nut tree pests by non-indigenous extractivist communities in the Amazon, but are considered delicacies by the Surui Paiter (Coimbra Jr, 2012). The removal of the caterpillars from Brazil nut trees for consumption may be directly influencing populations of Brazil nut trees.

Two other caterpillars have similar behaviors and uses to the moth caterpillar, *jikibneg* and *aberneg*; the first is associated with caucho (*Castilla ulei*) and the second with breu-manga (*Protium altissimum*) (Tables 1 and 2). We did not observe the occurrence or consumption of *jikibneg* or *aberneg*. Our volunteers reported another two moth caterpillars, *barneg* (*Molippa nibasa*), found on the rubber tree (*Hevea brasiliensis*), and *yokobeab* (*Cicinnus callipius*), found on the cashew tree (*Anacardium giganteum*), as part of their traditional diet (not mentioned by Coimbra Jr., 2012). Informants reported in the collective interview that, except for the caterpillar that occurs on the cashew tree, the other caterpillars are named after the tree they are associated with (similar to the Curculionidae beetle larvae) and are all collected as they rest on the tree trunks after feeding on the leaves in the crowns and begin the pupal stage. The reason for the name *yokobeab* is that in preparation to pupate, they make a cocoon and wrap themselves in the cashew leaf. They then detach it so that they fall to the forest floor; thus their name in Paiter Suruí is related to the cocoon itself and not the cashew tree (*orixi*). We verified the occurrence of *barneg* and *yokobeab* caterpillars during fieldwork, but since they were in small numbers, sufficient for identification but insufficient to provide a meal, our volunteers did not prepare any for consumption. During the collective interview, we were told that the occurrence of Lepidoptera caterpillars in great quantity is a seasonal and random event that cannot be predicted, which may explain why we did not observe the consumption of caterpillars other than *Lusura altrix*.

Hymenoptera

The Hymenoptera used as food by the Paiter Suruí are from two families: Formicidae, with only one representative (*Atta* sp.), and Apidae, which includes 48 stingless bees (subfamily Meliponini) (Table 1). The insects of the order Hymenoptera presented here do not have specific relationships with plant species.

Formicidae

According to Coimbra Jr. (1985a), the ants recorded as consumed by the Surui (*mohra*) *Atta* sp. are collected at the beginning of the rainy season (September/October) at the first signs of flight during their mating season. Winged adults are collected in plantations and open areas, where their nests are found and marked, and can be eaten raw or fried. Although some Indigenous groups prefer only the abdomen of the adult insect, most consume the whole insect except for the wings, as described by our volunteers in Joaquim village. Ants of the genus *Atta*, popularly called *içás* or *tanajuras*, are traditionally known in national Brazilian cuisine (Fontes et al., 2018), but we did not observe their occurrence on any occasion during our fieldwork and our volunteers reported that they have not consumed *mohra* ants for some years now. We also learned that the landscapes around the village have undergone significant changes since the contact in 1969, and that currently there is even the use of pesticides for agricultural activities. These changes in environment and their local agricultural practices, coupled with a sharp decline in insect diversity and abundance witnessed worldwide (Goulson, 2019), may have contributed to the current scarcity of *mohra* ants for the Paiter Suruí.

Although our interviewees do not currently incorporate ants in their diet, as in the past, *Atta cephalotes* is used as food by the Awajún in Peru (Casas Reátegui et al., 2018) and *Atta laevigata* is consumed by the Samaria in Venezuela (Giron et al., 2017). Since even non-indigenous people occasionally consume *Atta* species, this use appears to be widespread.

Apidae, Meliponini

Forty-two stingless bee names are recorded in the literature (Coimbra Jr, 1985a; Mindlin, 1985; Bontkes, 1978). Our interviewees did not recognize all these names, but during the collective interview we obtained five new names (Table 1). They are consumed raw in the form of larvae or pupae.

According to Mindlin (1985: 54; 64), the Paiter Suruí highly appreciate honey from stingless bees consumed pure or in preparations. From October on, when the rainy season begins, there is great excitement in the search for honey, an outing very much associated with amorous encounters (ibib.:54). Although honey, pupae, and bee larvae were used regularly, the Paiter Suruí are not bee-keepers and will sometimes fell entire trees to obtain them (Coimbra Jr, 1985a; Mindlin,1985: 54, and confirmed by our volunteers). During our field observations, a young indigenous man who had some hives of stingless bees (*arma-ey – Trigona branneri*) near his residence informed us that he had learned this practice from settlers from the areas surrounding Sete de Setembro Indigenous Territory. Our volunteers reported collecting and consuming honey during their walks in the forest, but we did not have an opportunity to observe this. This suggests that despite the great diversity of stingless bees and the traditional ecological knowledge of the Paiter Suruí, honey is perhaps used less frequently than observed in earlier studies. However, beehives are found on certain tree trunks, both living or dead, in Paiter Suruí territory. Stingless bees preferentially seek tree hollows or natural recesses to build their nests, as cavities provide protection from predators and weather (Cortopassi-Laurino, 2009; Mesquita et al., 2017), but are not known to be associated with specific plant species.

Crustacea, Decapoda

Despite the great diversity of edible insects in the traditional diet of Indigenous Peoples in Amazonia, there are few references to the use of crustaceans. Although less common than insects, crustaceans are also part of the traditional diet of the Paiter Suruí, including the *gorpã* crabs (Thrichodactilidae) and the *mosaap* shrimp (*Macrobrachyum carcinus*) (Coimbra Jr, 1985a). However, we did not observe the consumption of crustaceans and our volunteers reported that they had not consumed any for some years. They confirmed the presence of *mosaap* shrimp, but elaborated on the distinction between crabs that live in mud (*gorpã*) and those, which are larger, that inhabit the rivers (*gorpã abexacaiá*), and noted that both are edible. We did not observe any specimens of the river crab during our fieldwork, but we found a specimen of the *gorpã* crab of the genus *Fredius* (Pseudothepulsidae) in the vicinity of the village.[3]

Concluding Remarks

The consumption of invertebrates remains an important part of the Paiter Suruí diet. In the past a greater diversity of invertebrates were consumed, but we were able to identify a number during our fieldwork that remain valued and enjoyed as food. Beetle larvae (Curculionidae and Chrysomelidae) continue to be managed and consumed frequently, and we witnessed consumption of *Lusura altrix* moth caterpillars, but our volunteers reported that consumption of other invertebrates has decreased over recent decades.

This decrease in consumption of traditional foods may be related to changes in eating patterns following Paiter Suruí contact with non-indigenous society (Port Lourenço et al., 2008). The Covid-19 pandemic severely affected Paiter Suruí communities, who lost some of their elders (Maisonnave, 2021), and this loss may directly impact their traditional knowledge and modify their social structures as a whole. Both these factors could limit the ability of the Paiter Suruí to continue using these traditional food resources.

Further, since insect consumption is directly related to the management of certain plants, the abundance of these species in the forest may be positively influenced by the removal of insects that harm their reproduction. We observed that the Paiter Suruí have improved their management with the use of new technological tools that became available only after contact in 1969, and have consequently increased the efficacy of their landscape management to improve production of their favored invertebrates and in the process enabled the

[3] Magalhães et al. (2006) identified five crustaceans consumed by the Yanomami in Brazilian Amazonia, with four crabs (Pseudothepulsidae and Thrichodactilidae) and the pitu shrimp (*M. carcinus*).

plant species on which they depend to flourish, highlighting the interactions between plants, insects, and humans.

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Data Availability The authors declare that data supporting the findings of this study are available within the article.

Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

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