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Indigenous agriculture at the beginning of the twenty-first century: the Guaraní Mbyás minority conserves ethnoknowledge and agrobiodiversity within the remnants of the Brazilian Atlantic Forest

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Abstract Swidden agricultural practices reflect a great deal of Indigenous and traditional ethnobotanical knowledge; however, such system and livelihoods are in decline worldwide and tend to disappear. This study aimed to survey the main characteristics of land use and agrobiodiversity of the swidden culture practiced by the Guaraní, in *Serra do Mar* (São Paulo state, Southeast Brazil). We likewise studied the socioeconomic and cultural characteristics of the Guaraní, focusing specifically on their ethnobotanical knowledge, to help conserve traditional agricultural practices in the deep tropics. A total of eighteen ethnobotanical surveys were carried out on 18 production units (10 × 10 m) in the cultivation phase after combustion took place. All species of agricultural use were indicated by the smallholders and identified to species level. Semi-structured interviews based on the design and diagnosis method World Agroforestry Centre (ICRAF) were carried out in either Portuguese or the native language with 48 smallholders in the village. Main topics discussed were the history of each sampled plot, socio-economic aspects of the production units, aspects of agricultural management to characterize the level of intensification, and forms of managing vegetation and criteria for making decisions about the maintenance of wild species in the agricultural plots. The ethnobotanical survey showed 65 varieties of plants for agricultural use, totaling 39 species, they are used for cultural-ritualistic, ecological, food, economic, medicinal, and ornamental aspects. Main crops found were corn (*Zea mays*), potato (*Solanum tuberosum*) and peanut (*Arachis hypogaea*). Fire is vital for Guarani's agricultural practices. Fields are small and occupy just 0.25% of the indigenous land. The Guaraní's traditional agroforest systems are independent of external inputs and are important for conservation of seeds and agrobiodiversity. There are three factors that maintain the dynamics of Guarani's agricultural systems, namely: religiosity, the network of kinships and the existence of legal owned territories. Swidden and slash and mulch systems are part of the maintenance of the cultural autonomy of the Guaraní, providing them with a way to obtain financial and food resources directly

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and indirectly from the biome in a sustainable way. Hence, protecting this ethnoecology guarantees the cultural, physical, and social existence of the Guaraní and likewise helps to conserve the remnants of the Atlantic Forest hotspot.

Keywords Atlantic forest · Biodiversity · Ethnobotany · Floristic survey · Native cultivars · Traditional agriculture

Introduction

Traditional forms of rural life with different cultural backgrounds guard worldwide sophisticated and often resilient agricultural production systems (Leonel 2000). For instance, traditional agricultural systems, as defined by Altieri et al. (2012), protect the use of cropping systems based on the lunar calendar or other complex astrological practices, traditional soil management practices like *terra preta* (Indian black earth; Woods et al. 2009) and crop diversification schemes based on principles of forest succession (i.e., swidden agriculture or slash and mulching practices; Leonel 2000). Swidden systems were practiced since the Neolithic period (10.000 – 4.500 BCE) when human populations replaced hunter-gatherer regimes with a more sedentary lifestyle (Harris et al., 1997). Swidden systems are still today integrated in livelihood activities of rural populations (Oliveira 2008) and occupy approximately 21% of tropical forest worldwide and feed about 500 million people (Pedroso-Junior et al. 2009).

Knowledge of the swidden cycle is kept alive by traditional populations that inhabit the deep tropical forests and practice swidden agriculture (Mazoyer and Roudart 2010). Swidden systems are cyclical agricultural practices that are characterized by the clearing of vegetation, use of fire, rotational use of agricultural lands and conclude with a fallow time that exceeds the cultivation time (Sanchez 1977; Thurston 1997). It is known that under conditions of low demographics and availability of large territories for cultivation, swidden systems can be a sustainable form of agriculture in tropical forests (Ribeiro Filho et al. 2013).

When talking about swidden agriculture we are dealing with an ironic dualistic paradigm. There is, on the one hand, the romanticized idealization that the relationship of traditional populations with nature is harmonious and equitable, linked to the myth of the "good savage"; and, on the other hand, the idea that these populations are vital agents in the destruction of natural areas (Altieri and Masera, 1993; Diegues 2000). In Brazil, swidden agriculture is mainly practiced in the Amazon and Atlantic Forest by indigenous populations, riverside dwellers, and *quilombolas* (inhabitants of shelters in the forest which were in the past the residence of escaped slaves; Ladeira and Azanha 1986; Posey 2003). The idea that smallholder farmers are vital agents in the destruction of natural areas (by practicing e.g., swidden agriculture) ends up favoring actions to complicate the livelihoods of vulnerable and isolated people that practice the swidden cycle. For example, the creation of red-tape and other complex bureaucratic procedures (to let smallholders obtain permits for swidden agriculture) or the continued implementation of protected areas, threatens both the swidden lifestyle and the culture of people who practice it (Christo 2009; Ribeiro Filho et al. 2013). Furthermore, swidden agriculture is often referred to as "backward" and related to factors of environmental hazards when not practiced moderately (Sušnik 1982; Leonel 2000).

Recent studies have shown positive results in the analysis of swidden systems and found that such agricultural systems can generate ecosystem services and contribute to the conservation of biodiversity (Labrière et al. 2015). When practiced at low intensity—return to the same area after 15 years or more—swidden agriculture can maintain soil properties related to chemical soil fertility (Visscher et al. 2021), increases soil P availability (Lawrence and Schlesinger 2001), soil organic matter and belowground carbon pools (Bruun et al. 2009) as well as other favorable changes in soil fertility (Nakano and Miyauchi 1996) which might be due to the direct influence of fire and/or by the plants during the fallow period. Thus, if practiced under conditions of low demography and controlled fire uses, swidden systems can be sustainable agricultural systems in the tropics. It is therefore important to stress that swidden agriculture (as practiced by smallholder farmers) is often unfairly compared with other large scale intensive farming systems within Brazil. For example, such swidden practices are in common conversation often being compared with serious problems caused by the large-scale deforestation of Brazilian Amazon Forest

to introduce transgenic soybean production for the livestock industry.

Ethnobotanic knowledge, based on traditional and indigenous knowledge, as defined by Berkes (2017), offers a tool to help conserve tropical forest and customs of its inhabitants. For instance, traditional knowledge of plant varieties (i.e. seed selection, propagation, collection and storage, cultural values and uses of species) can boost the development of balanced agriculture practices in the tropics (Thurston 1997; Posey 2003). Hence, documentation of ethnoknowledge can greatly contribute to a sustainable environmental shift (Plotkin 1995; Altieri 2002). Identifying ethno-varities (landraces) and their functions is an important step in understanding the traditional knowledge on ecosystems, as well as the quality of this interrelation, both in environmental and social terms (Begossi et al. 2002). Unfortunately, the gathering of such knowledge is still scarce. Hence, there is an urgent need to advance in this understanding. There are few studies available that talk about ethnoknowledge of the Guaraní Mbyás (Guaraní(s)), a vulnerable ethnic minority who inhabit the Atlantic Forest of Southeast Brazil, depend on swidden agriculture in their daily life (Felipim 2001).

In this study, we sought to fill these knowledge gaps and contribute to the gathering of ethnoknowledge and the role of traditional populations that lives in the Atlantic Forest, through the characterization of the Guaraní Mbyá's swidden system. Its better understanding can contribute both to the strengthening of indigenous populations and to the development and improvement of similar land use systems. Hence, we aimed to (I) characterize the Guaraní Mbyá's swidden system; (II) promote the conservation of ethnoknowledge and protect the cultural heritage of the Guaraní people; and (III) explore the benefits of ethnoknowledge for the conservation of the Atlantic Forest.

Materials and methods

Site description

The Rio Branco Indigenous Land (here after 'RBIL') is positioned in Itanhaém municipality, São Paulo state, Southeast Brazil (under central coordinates ca. 24°01′13″S, 46°41′36″W), within the biome of the Atlantic Forest (Fig. 1). The land is located near the coast at a height of approximately 100 m above sea level (m abs), occupying approximately 2856 hectares (Funai 2010). This is 150 m away from the east bank of the Branco River. Surrounding cities are accessible by dirt roads.

The average temperature of the last 15 years is around 22 °C and precipitation is well distributed throughout the year, with an average of 1700 mm per year. Nonetheless, most rain falls relatively from January to April (Ladeira and Azanha 1986). The climate in the area is subtropical humid with no defined dry season (Af according with Köppen-Geiger classification system). Main soil types of the RBIL are (dystrophic red-yellow) Podzols and (dystrophic-alic) Cambisols both with a moderate A horizon (Lepsch et al. 1988). The landscape of this zone is a plain between the sea and the rocky formation. Within the RBIL occurs the alluvial, lowland and montane ombrophyllous dense forests (IBGE 2012), formations with soils that can contain more clay minerals, on average approx. 38% (Oliveira 2008). The RBIL is composed of an agricultural mosaic inside a matrix with native vegetation belonging to the Atlantic Forest (Felipim 2001). A varied mosaic of secondary forests emerges from the swidden agriculture practiced by the indigenous Guaraní community.

The villagers of RBIL include mainly descends from the Guaraní Mbyá ethnic minority, counting eighteen families (approx. 105 inhabitants). Their main activities involve subsistence agriculture, planting mostly different varieties of bean (*Phaseolus vulgaris* L.), cassava (*Manihot esculenta* Crantz), maize (*Zea mays* L.), potato (*Solanum tuberosum* L.), sweet potato (*Ipomoea batatas* (L.) Lam.) and medicinal plants (anti-spasmodic; anti-ophidic; for childbirth). Other activities involve the sale of handcraft products in the city nearby or to visitors that come to the village (Ladeira and Azanha 1986; Noelli 1999). Inside the village there are currently projects initiated by the National Indian Foundation (FUNAI) to strengthen their ethnobotanic knowledge and therewith the diversity of traditional seeds and agroecosystems.

The Guaraní Mbyá minority in Rio Branco

The Guaraní people of Brazil are classified into three major groups: Mbyá, Nhandeva or Ñandeva and Kaiowá. The differences that led to the ethnographic distinction are mainly marked by language, customs, ritual practices, and occupation of territory (Ladeira

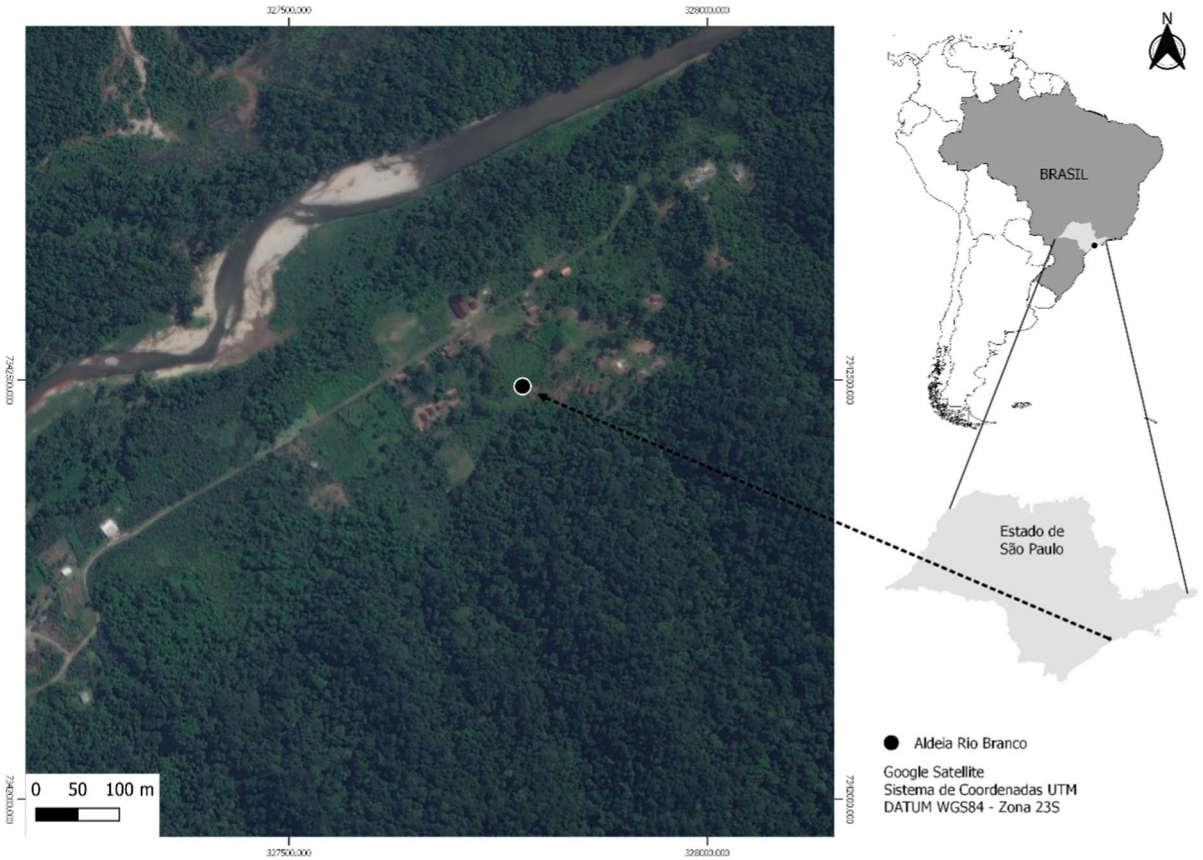

Fig. 1 Geographical location of the Guaraní Mbyá village in the Rio Banco Indigenous Land, Itanhaém, São Paulo state, Southeast Brazil

1992). There belong many individuals to the Guaraní minority and their territorial space covers several countries in South America. In Brazil, in 2008, the population counted 51,000 individuals, among the Kaiowá 31,000, Ñandeva 13,000 and Mbyá 7,000. There is not a more recent demographic count of the Guaraní in Brazil (Funai 2010).

The Guaraní ethnic groups are present in Argentina, Paraguay, Uruguay, and Brazil. This a result of many large group migrations across the territory (Cadogan 1952). This diaspora has its roots in religious, subsistence and historical explanations (Cadogan 1952; Vietta 1992). The last migration waves of the Guaraní occurred between 1800 and early 1900, in which they moved from eastern Paraguay to the Misiones region in Argentina to the southern and southeastern coast of Brazil. The settlements found in these regions are linked to the Guaraní diaspora (Litaiff 2008).

According to Ladeira (1992), the march to the east occurred due to the search for the "*land without fears*" (*yuy-marã-ey*), led by religious leaders (*ñanderú*). This mythical element determined the migration routes taken by the Guaraní in the last century (Litaiff 2008). Ladeira (1992) described the relationship the Guaraní have with their territory as transcendental, hence their relationship with the land and maintenance of their territories is fundamental. There is an important expression among the Guaraní: "Without *tekoá* (custom) there is no *teko* (the place where we live according to our customs)", showing that their ethnic identity is closely linked with territoriality.

The need for demarcation of the RBIL began in the 1960s and 1970s. At this stage, due to growing real estate speculation, the Guaraní territory began to suffer systematic threats from despoilers, invaders, and squatters, leading the Guaraní people to request

its 'official' territory demarcation, which was ratified by Decree 94.224 on April 14 in 1987 (Brasil 1987). Since the demarcation, the sociocultural dynamics of the village has undergone numerous changes. In the end three villages were built following the floods caused by waterspouts, a natural hazard common in the region due to the channeling of tributaries and springs from the *Serra do Mar* Mountain range. In sum, the need for demarcation raised from pressures exerted by the surrounding society and loss of territory by the Guaraní. Despite these stressors the Guaraní managed to preserve their towns, customs, culture and ethnoknowledge (Ladeira and Azanha 1986).

Characterization of the agricultural system

The design and diagnosis method for land use systems (D&D) from the world agroforestry center (ICRAF) was adopted and applied to assess agroforestry practices of the Guaraní ethnic group. We specifically adopted a version of the D&D manual that was tailor made as a teaching guide to assess traditional land-uses in Embu, Kenya, Africa (Beniest, et al. 1996). Beniest et al. explain that to accurate characterize a traditional agricultural system it is necessary to use a holistic approach and thus study biophysical and socio-economic conditions of an area together.

The D&D method works in four phases and was applied in a similar way within this study (Raintree and Torres 1986). The method starts with a so called 'pre-diagnostic' phase, at this stage we explored the agricultural technologies of the Guaraní community and how they managed their agricultural lands. Then followed the 'diagnostic' phase where we explored the problems and obstacles the Guaraní community faces in their contemporary agricultural system. We then continued with the 'design and planning' phase where the newly documented knowledge was analyzed to discover how to improve and/ or protect their current agricultural system. In this study we mainly focused on the first two phases of the D&D method to meet our objective to characterize the Guaraní Mbyá's swidden system and promote its conservation.

Forty-eight semi-structured interviews were carried out with residents of the RBIL, comprising about 45% of the total inhabitants. We needed the help of language interpreters, since not all informants spoke Portuguese. In the interviews, we asked questions about the history of each field, socio-economic aspects of the production units, aspects of agricultural management to characterize the level of intensification, and forms of managing vegetation and criteria for making decisions about the maintenance of wild species in the agricultural plots. All interviews were recorded in audio format with the authorization of the participants. The interviews were transcribed in a summarized form and integrated in the analysis through descriptions and comparisons with literature.

We were authorized by the Brazilian State Agency to work with indigenous ethnic groups and enter territories managed by FUNAI (S1). The necessary documents were presented on forehand to the ethics committee, such documents include information related to the research subject, a free and informed consent form from the village and families and an authorization term for the use of photographic images.

Ethno-botanical survey of swidden agricultural plots in-use

Participative floristic surveys were carried out with traditional smallholder farmers (n = 34) on agricultural plots, derived after felling, drying and combustion of the former vegetation. Hence, all agricultural plots were in the cultivation phase. Eighteen plots of 10 m × 10 m were established in agricultural fields belonging to four different families from the RBIL. The plants recorded in the plots were identified at the lowest taxonomic level possible, by two of the authors (LMF and GMM). When identification in the field was not possible, (sterile) specimens were collected for further identification at the HRCB Herbarium of São Paulo State University (UNESP). The taxonomic nomenclature of the native plants were corresponding with the 'Flora e Funga do Brasil' (2022) database; and the exotics with 'Plants of the World Online' (POWO; 2022). Additionally, during the interviews with the smallholders participating in the research, we described their popular and indigenous names, and uses (i.e. home consumption, ritual-cultural, medicinal, ornamental, ecological, commercial). The following parameters for agrobiodiversity were studied: botanical family, genus, species, ethnicity, scientific name of the species and native indigenous name. All data, both floristic and sociocultural, were descriptively analyzed with the help of the calculation of means, standard deviation, range, and percentages.

Results

The forty-eight respondents belonged to four big family groups with 2, 7, 8 or 16 members, respectively. From the 48 respondents, 34 individuals were smallholder farmers (70%). Fourteen smallholders were female (41%) and 20 individuals were male (60%). The average age of the interviewed smallholders was 30.8 years, where women had an average age equivalent to 28.7 years and men 32.5 years. The great majority (56%) of the individuals interviewed were younger than 30 years, hence the population pattern indicated higher birth rates than mortality indicating population growth.

Within the community two distinct traditional land-use systems were identified, eight swidden systems (here after 'SS') and ten slash and mulch systems (here after 'SMS'). Production plots had an average size of 3.900 m^2, and approx. 79.4% of the agricultural land was dedicated to subsistence farming, comprising about five hectares. The products obtained from the remaining area were used for commerce. SS and SMS plots managed by the Guaraní people are typically polycultures with a variety of fruit trees, legumes, and other annuals crops (Table 1 and 2). Main agricultural crops present in the production plots were Guaraní corn (*Avaxi ete* i- *Zea mays* L.) containing many phenotypic varieties, followed by Potato (*Jety—Solanum tuberosum* L. Lam. and *Ipomoea batatas* L. Lam.) beans (*Kumanda—Phaseolus vulgaris* L.), cassava (*Manji'o—Manihot esculenta* Crantz), banana (*Paková—Musa* x *paradisiaca* L.), peanuts (*Manduvi—Arachis hypogaea* L.), perennial citrus (*Narã—Citrus* sp. L.) and heart of palm (*Jejy—Euterpe* spp.).

The ethnobotanical survey recorded thirty-nine species and sixty-five agricultural varieties, belonging to twenty-three families. The richest families were Arecaceae (four species; ca. 10% of total), Fabaceae, Rutaceae and Myrtaceae (three species each; 8%), Bromeliaceae, Convolvulaceae, Cucurbitaceae, Malvaceae, Poaceae, Solanaceae, and Zingiberaceae (two species each; 5%), and all other families containing a single species (Table 2 & 3, Fig. 2).

The species and varieties had multiple functions and were for example used for rituals (cultural), fauna attraction (ecological), home consumption (food), sale (economic), medicinal use and ornamental aspects as indicated in Table 2. From all the identified species only hearth of palm (*Bactris gasipaes* Kunth) was sold, tobacco was mainly used for ritual practices within the village. Other species such as corn (*Zea mays* L.), potato (*Solanum tuberosum* L. Lam.), peanut (*Arachis hypogaea* L.) and sorghum (*Sorghum bicolor* (L.) Moench), and their varieties were described as sacred since they are commonly used in religious practices. Historically they have been used in common ritual procedures such as in baptisms or prayers within the community (Table 3).

Discussion

Both SS and SMS, as practices within the RBIL, are customary agroforestry systems typically used by traditional populations in the tropics and widely recorded in literature (Cairns 2007). In the Guaraní culture, these agroforestry systems have multiple functions, they provide food, capital, ritual practices, and construction materials. However, in this case the agroforestry systems also are a vital element in the conservation of local agrobiodiversity. The Guaraní maintain local agrobiodiversity through continuous cultivation of landraces of common species such as corn, bean, cassava, and potato. Seeds are typically being traded with neighboring villages which guarantees the maintenance of landraces in the area. SS and SMS plots managed by the Guaraní people are typically polycultures with a variety of fruit tree, legumes, and other annuals crops, sustaining this system as a maintainer of (agro-)biodiversity.

Establishment and maintenance of Guaranís' production systems

To establish SS and SMS the smallholders first need to select an area, measuring from 0.12 to 1.5 hectares. The selected area is typically close to the dwellings of the indigenous people, on a flat terrain with a moist clayey soil (Fig. 3). The terrain can also be chosen by the type of vegetation that predominates on it. The areas can be *capoeirões* (secondary forests) called *kaagui karapeí* (low forest) in the Guaraní language or even spaces of primitive native forest. The indigenous preference is for the use of *capoeirões*, as it facilitates subsequent management. In the felling phase the indigenous people gradually work on managing the local vegetation. With the help of hoes,

Table 1 Management information from crops recorded in the Rio Banco Indigenous Land, Itanhaém, São Paulo state, Southeast Brazil

Family group	Field size (ha)	Main crop in polyculture	Other crops in polyculture	Years field in cultivation phase (years)	Agroforestry system	Main management technique	Secondary management
1	0.2	Cassava	Beans, Banana, Peanuts, Guaraní Corn	6	Swidden	Fire	Selective Weeding
1	0.12	Jussara	none	7	Swidden	Fire	Selective Weeding
1	0.12	Banana	Saffron, Ginger	3	Swidden	Fire	Selective Weeding
1	0.5	Jussara	Pupunha	12	Swidden	Fire	Lunar based planting, weeding and harvest of crop
1	0.5	Guaraní Corn	Potato, Beans, Tobacco	5	Swidden	Fire	Selective Weeding
2	1.5	Guaraní Corn	Beans, Cassava, Potato	3	Swidden	Fire	Lunar based planting, weeding and harvest of crop
2	0.75	Guaraní Corn	none	2	Swidden	Fire	Green Fertilization
3	1.5	Guaraní Corn	Potato, B-zucchini, Beans, Corn, Guaraní Corn, Cane G, Fru (3)	3.5	Swidden	Fire	Selective Weeding
3	0.12	Potatoes	Potato,Pineapple, Cassava, Banana, Citrus Corn G	2	Slash and Mulch	Selective Weeding	Lunar based planting, weeding and harvest of crop
3	0.2	Fruit	Citrus, Medicinal, Loggers	4	Slash and Mulch	Pruning and mulching	Selective Weeding
3	0.18	Jussara	Açai berry	7	Slash and Mulch	Area selection	Lunar based planting, weeding and harvest of crop
3	0.15	Jussara	Pupunha	7	Slash and Mulch	Area selection	Selective Weeding
4	0.15	Banana	Jussara	1.5	Slash and Mulch	Pruning and mulching	Selective Weeding
4	0.1	Banana	Guaraní Corn, Cassava	2.5	Slash and Mulch	Pruning and mulching	Selective Weeding
4	0.1	Guaraní Corn	Jussara, Banana, Tobacco	2.5	Slash and Mulch	Pruning and mulching	Selective Weeding
4	0.3	Fruit	Citrus, Potato, Cassava, Beans, Cupuaçu, Angico	5	Slash and Mulch	Pruning and mulching	Green Fertilization

Table 1 (continued)

Family group	Field size (ha)	Main crop in polyculture	Other crops in polyculture	Years field in cultivation phase (years)	Agroforestry system	Main management technique	Secondary management
4	0.3	Fruit	Cupuaçu, Lima, Lemon, Guava, Jussara	6	Slash and Mulch	Pruning and mulching	Green Fertilization
4	0.35	Jussara	Banana	3	Slash and Mulch	Pruning and mulching	Selective Weeding

machetes and axes they cut down and pile up the vegetation, so that it dries and can be burned more easily (SS) or left to rot (SMS). The size of the area to be used is like to that found in other studies in the Atlantic Forest. The average size of the areas found show values ranging from 0.06 ha in Vila do Aventureiro (RJ; Oliveira et al., 1994; Adams 2000), to 4.86 ha in Quilombo do Mandira in Cananeia (SP; Sales and Moreira 1994; Adams 2000).

When entering the areas, the farmers select in the felling of the trees. Some species such as Ingá (*Inga* sp.), heart of palm (*Euterpe* spp.) and some fruit trees are not cut down, as they provide resources such as wood and food, are attractive to seed dispersing fauna and are a guarantee of permanent soil coverage—something desirable to farmers for maintaining constant fertility and humidity in the place.

The management and preparation of the area lasts between one to three months, and is generally carried out between June and August, as these are the winter months in which the low rainfall in the period allows the vegetation to dry more efficiently. Burning is then carried out at the end of August. This can be done all at once or in parts, with the fire being used in a controlled manner, preferably on dry and breezy days which facilitates dispersion and burning efficiency. After this phase, planting is carried out, which can be continuous or spaced out in time, depending on the species cultivated. In September and February, the most intensive planting is carried out in the village, as this is the period to plant sacred corn (*Avexi etei*) and when the baptism ritual takes place (*Nhemongarai*) in which individuals receive their adult name. Religious practices, such as the tradition of planting sacred corn, but also the baptism ritual that takes place in the planting phase marks the importance of religious aspects that are integrated within the swidden cycle and help maintain it. In another way, in the SMS, the plant material is left to rot on the ground and its activities can be started later, since it is not desired to dry the material. Planting is carried out by organizing the plant material and planting it in the gaps.

The plot is cultivated for about three consecutive years in average (Table 1). When the production plot becomes infertile to the point of not sustaining the planting of cassava, the need for fallow arises. Cassava is therefore an indicator of soil infertility. The fallow period lasts from three to twelve years with an average of 7.6 years, at which time the area can be managed for the use of woody species in traditional construction or the use of medicinal plants. This time is similar to that of some more isolated communities with traditional management of the Brazilian and Peruvian Amazon biomes or even in the rainforests of Mexico and Central America and other Atlantic Forest communities. For instance, fallow fields with an average time of two to fifteen years were found in Arroyo Negro, El Refugio and Nicolas Brabo in the Yucatan peninsula in Mexico (Lawrence and Foster 2002), from 2 to 5 years on the banks of the Purus River in the Peruvian Amazon (Gálvez 2016), from 8 to 10 years in the Juréia-Itatins Ecological Station (Costa 1991; Adams 2000), from 15 years in São Sebastião Island (França 1954), from 10 to 15 years in Despraiado (Vitae Civilis 1995; Adams 2000) and from 3 to 10 years in Vila do Aventureiro (Oliveira et al. 1994; Adams 2000).

Conservation of agrobiodiversity within Guaraní culture

All main local varieties of traditional crops, also named native cultivars, in the Guaraní Mbyas culture, are for the exclusive use of the indigenous community as they are seen as sacred in their culture. According to Guaranític beliefs, every Guaraní

Table 2 Crops and their functional traits in the Rio Banco Indigenous Land, Itanhaém, São Paulo state, Southeast Brazil

Family	Species	Guaraní name*	Common name	Function**	Varieties
Anacardiaceae	*Mangifera indica* L	Unnamed	Manga	F	1
Arecaceae	*Bactris gasipaes* Kunth	*Jejy Coffee*	Pupunha	F/ Rc	1
Arecaceae	*Euterpe edulis* Mart	*Jejy Guapytã*	Jussara	F	1
Arecaceae	*Euterpe oleracea* Mart	*Jejy pindó*	Açai berry	F/Ec	1
Arecaceae	*Syagrus romanzoffiana* (Cham.) Glassman	*Pindó*	Jerivá	Ec	1
Bromeliaceae	*Ananas comosus* (L.) Merril	*Nana*	Pineapple	F	1
Bromeliaceae	Unidentified	Not registered[a]	Bromeliad	S/O	1
Caricaceae	*Carica papaya* L	Unnamed	Papaya	F/Ec	1
Convolvulaceae	*Ipomoea batatas* (L.) Lam	*Jejy Ju*	Guaraní Potato	F/Rc	2
Cucurbitaceae	*Citrullus lanatus* (Thunb.) Matsum. & Nakai	*Xanjau*	Watermelon	F	1
Cucurbitaceae	*Cucumis melo* L	*Merô*	Melon	F	1
Euphorbiaceae	*Manihot esculenta* Crantz	*Manji'o*	Cassava	F	2
Fabaceae	*Arachis hypogaea* L	*Manduvi*	Peanut	F/Rc	3
Fabaceae	*Inga sessilis* (Vell.) Mart	*Inga*	Ingá	Ec/Rc	1
Fabaceae	*Phaseolus vulgaris* L	*Kumanda*	Bean	F	3
Lauraceae	*Persea americana* Mill	Unnamed[b]	Avocado	F/Ec	1
Malpighiaceae	*Malpighia glabra* L	Not registered[a]	Acerola	F	1
Malvaceae	*Theobroma cacao* L	*Cocoa*	Cocoa	F/Ec	1
Malvaceae	*Theobroma grandiflorum* (Willd. ex Spreng.) K.Schum	Unnamed[b]	Cupuaçu	F/Ec	1
Moraceae	*Artocarpus heterophyllus* Lam	Not registered[a]	Jaca	F	1
Musaceae	*Musa*×*paradisiaca* L	*Pacova*	Banana	F	1
Myrtaceae	*Eugenia uniflora* L	Not registered[a]	Pitanga	F	1
Myrtaceae	*Plinia cauliflora* (Mart.) Kausel	Not registered[a]	Jabuticaba	F	1
Myrtaceae	*Psidium cattleyanum* Sabine	Not registered[a]	Araça	F/Ec	1
Myrtaceae	*Psidium guajava* L	*Guaiava*	Guaba	F	1
Orchidaceae	Unidentified	Not registered[a]	Orchid	S/O	1
Passifloraceae	*Passiflora edulis* Sims	*Maraca-á*	Passion fruit	F	2
Poaceae	*Sorghum bicolor* (L.) Moench	*Takua-re-ê*	Guaraní Cane	F	1
Poaceae	*Zea mays L*	*Avaxi*	Corn	F/ Rc	12
Rosaceae	*Rubus* sp.	*Ju'a*	Mulberry	F	1
Rutaceae	*Citrus*×*aurantium* L	*Narã*	Mexirica	F	1
Rutaceae	*Citrus limon* (L.) Osbeck	*Narã*	Lemon	F	3
Rutaceae	*Citrus sinensis* (L.) Osbeck	*Narã*	Orange	S/O	3
Sapotaceae	*Pouteria caimito* (Ruiz & Pav.) Radlk	Not registered[a]	Abiu	F/Ec	1
Solanaceae	*Nicotiana* sp.	*Petã*	Tobacco	Rc	2
Solanaceae	*Solanum lycopersicum* L	Not registered[a]	Tomato	F	2
Solanaceae	*Solanum tuberosum* L. Lam	*Jety*	Potato	F	3
Zingiberaceae	*Crocus sativus* L	*Papara-a*	Saffron	F	1
Zingiberaceae	*Zingiber officinale* Roscoe	Not registered[b]	Ginger	F/Med	1

*a = the name was not mentioned by the farmer, b = there is no name in the Guaraní language

**F = Food, Rc = Ritualistic/cultural, S/O = Sale/ornamental, Med = Medicinal, Ec = Ecological

Table 3 Description of native cultivars found in the Rio Banco Indigenous Land, Itanhaém, São Paulo state, Southeast Brazil

Variety (Guaraní Name)	Scientific Name	Description
Avaxi Dju puku	*Zea Mays*	Large ear corn with yellow seeds
Avaxi etei	*Zea Mays*	Large ear corn with multicolored (red and dark) seeds
Avaxi pani	*Zea Mays*	Dwarf corn with small ear and multicolored (white and dark) seeds
Avaxi xin	*Zea Mays*	Corn with albino seeds
Avaxi Pará	*Zea Mays*	Medium ear corn with multicolored (red and white) seeds
Avaxi para-guaxu	*Zea Mays*	Giant ear corn with multicolored (red and white) seeds
Avaxi Pytã	*Zea Mays*	Medium ear corn with red seeds
Avaxi Dju	*Zea Mays*	Medium ear corn with light yellow seeds
Avaxi pororó	*Zea Mays*	Called popcorn corn, medium sized cob with dark yellow seed
Avaxi ü	*Zea Mays*	Medium ear corn with dark seeds
Avaxi hovy	*Zea Mays*	Medium ear corn with blue seeds
Avaxi tupã	*Zea Mays*	Called common corn, large ear corn with yellow seed
Djety petã	*Solanum tuberosum*	White endosperm with a dark reddish skin
Djety kara ‘ü	*Solanum tuberosum*	Dark endosperm and reddish skin
Djety manji’o	*Solanum tuberosum*	Called cassava potato, with an appearance like the cassava root with withe endosperm
Djety andaí	*Solanum tuberosum*	Called “pumpkin potato”—orange endosperm with a pumpkin-like flavor and orange reddish skin
Djety ropé	*Solanum tuberosum*	Whitish endosperm with dark skin
Djety d’ju	*Solanum tuberosum*	Yellow dark colored endosperm with bluish rind
Manduvi pytã guasu	*Arachis hypogaea*	Large, red-colored beans
Manduvi jukexï guasu	*Arachis hypogaea*	Large red and white grains
Manduvi mirïm	*Arachis hypogaea*	Small and white grains
Manduvi ü	*Arachis hypogaea*	Medium grains of dark color and sweet taste
Manduvi d’ju	*Arachis hypogaea*	Brown colored medium grains
Takua re’ mirim	Unidentified	Dark sorghum with small stalks and medium size

family must have some *Avaxi etei* seed kept in their homes, and those who use these seeds during cultivation believe that they are supported by *Nhanderu* (demiurge of the Guaraní Mbyá cosmogony). This force that supports them (*Nhanderu Tupã*) designated the lands and their domains for them to live and cultivate sacred foods, as their legitimate users. In this sense, agriculture is one of the most important cultural activities for the Mbyás.

Overall, the agrobiodiversity observed within the RBIL is highly diverse and corresponds with numbers of similar studies, like in territories managed by the Kayapós (in the Amazon biome) or other Mbyás territories within the Atlantic Forest (Posey 1985; Ladeira 1992). For instance, Ladeira and Azanha (1986) recorded a variety of agrobiodiversity in the Guaraní fields, with 24 varieties of cassava, twenty-one of sweet potatoes, sixteen of beans, nine of yams, seven of peanuts, four of pumpkin and several other crops such as banana, passion fruit (*Passiflora edulis* Sims), araçá (*Psidium cattleianum* Sabine) and others unidentified. Anderson and Posey (1987) recorded 50 different native cultivars among the Amazon Kayapos, among them, mainly, different types of cassava, yam and taioba (*Xanthosoma sagittifolium* Schott). Felipim (2001) described 24 varieties of agricultural botanical species among the Guaraní Mbyá of Cananéia, mainly being maize, sweet potato, peanut, bean and sorghum varieties.

In this study, despite a wide variety of crops observed, only one cassava variety was found in use. According to Peroni and Hanazaki (2002) there are several factors affecting the loss of varieties and reduction of the genetic variability of cultivars.

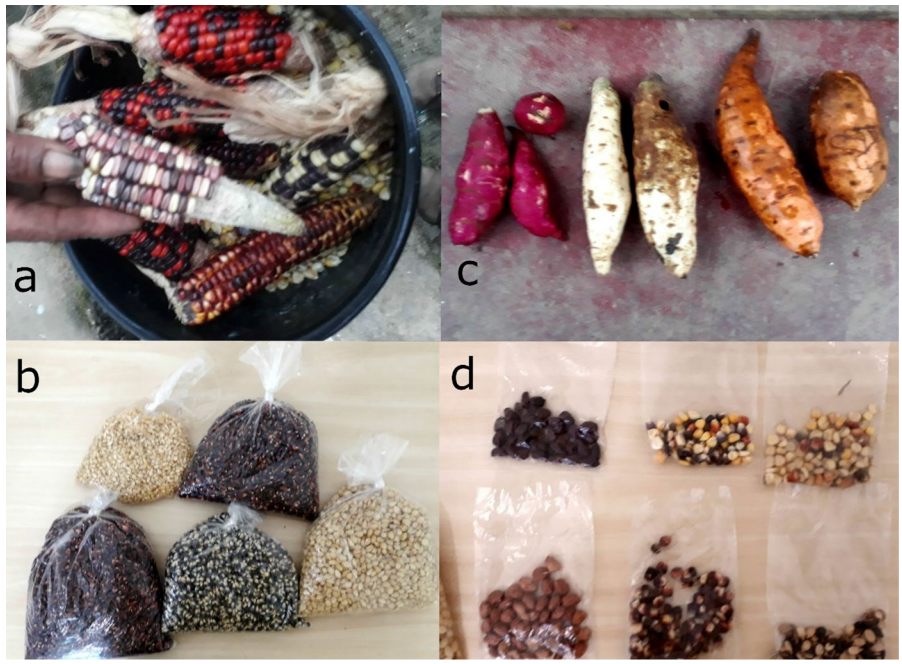

Fig. 2 Native cultivars representatives produced in the Rio Banco Indigenous Land, Itanhaém, São Paulo state, Southeast Brazil. **a** Guarani corn (avaxi etei,); **b** Guarani corn seed (avaxi etei); **c** Sweet potatoes (djety dju); **d** Peanut seeds (manduvi) and Guarani corn (Photos:Lucas Mazzero Fernandes)

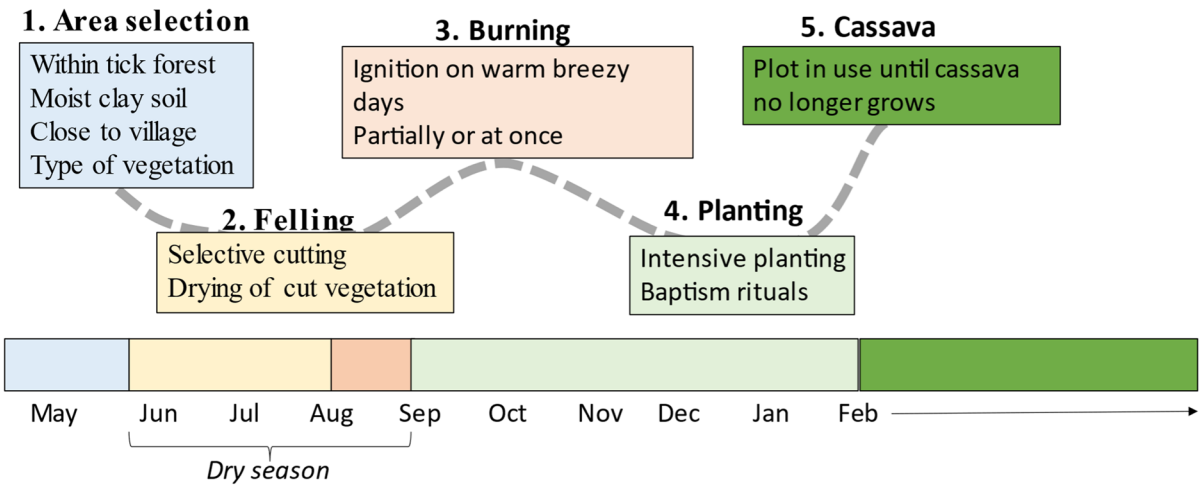

Fig. 3 Graphical model showing the establishment of the swidden production system as practiced within the The Rio Branco Indigenous Land. Colours indicate when each phase takes place within the year a smallholder may decide to take a fallow plot back in use, while the grey dotted line indicates that all phases are successive

Among the main ones are *i.* the little involvement of young people in agriculture, which leads to the loss of skills in cultivation, *ii.* the reduction of exchanges between neighbors, which reflects the loss of the network and the isolation of these communities, *iii.* restrictions of environmental laws, *iv.* tourism, *v.* rural exodus and, *v.* changes in livelihoods.

Some agricultural crops, those of sacred plants and foods (Guaraní corn, Guaraní potato), cannot be sold to non-indigenous society, but are included in the PNAE (National School Feeding Program) and PAA (Governmental Food Acquisition Program). These programs guarantee the purchase of the harvest of these species, allocating it to school lunches at

the indigenous school. Hence, such programs ensure the maintenance of the Guaraní Mbyás cultural habits and the flow of their agricultural production while safeguarding agrobiodiversity. The role of traditional societies in maintaining varieties and genetic diversity has only been recognized very recently, as in the Nagoya Protocol which directly addresses access to such resources and the sharing of their benefits (Nagoya Protocol 2011) although international treaties targeting the intellectual property of varieties have been dealt with since the 1960's (UPOV 1961).

Traditional agricultural systems are reservoirs of native cultivars, and their existence is a crucial factor for the continuity of the genetic heritage of these species. In the Guaraní view, agriculture is not only a productive or labor activity, but also one of the cultural axes of its society and the relationships of individuals. As food is sacred, the act of doing agriculture is a way of connecting with divinity. In this way, the society of the Guaraní Mbyás is the guardian of an important part of the biodiversity of agricultural cultures.

Conclusion

There are three factors that maintain the dynamics of Mbyás agricultural systems, namely: religiosity, the network of kinships and the existence of legal owned territories. Religiosity maintains some native cultivars as part of the sociocultural structure. For example, the baptism ritual, but also the planting of sacred corn is interwoven with the the swidden cycle as practiced by the Guaraní. The kinship network guarantees the exchange of seeds and management techniques, while acknowledged property of lands maintains the physical and cultural existence of the Guaraní Mbyás. The Guaraní Mbyá conserve seed reservoirs for varieties of various plant species and in situ germplasm banks. Therefore, they are important in the role of conservation and preservation of these agricultural native cultivars. It is still inferred that the Atlantic Forest is crucial in the maintenance of Mbyá livelihoods, so the presence of the Guaraní and indigenous lands in *Serra do Mar* is an important factor for its preservation. Both SS and SMS are part of the maintenance of the cultural autonomy of the Guaraní Mbyás, providing them with a way to obtain financial and food resources directly and indirectly. This is because their agroecosystems are independent of external inputs. What guarantees this independence is the ethnoknowledge presented within their agricultural practices (use of fire, pruning, green manure, selection of agricultural areas). In this way, preserving this ethnoknowledge is to guarantee the cultural, physical, and social existence of the Mbyás and to maintain the conservation of the Atlantic Forest hotspot.

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Declarations

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

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