Species selection criteria for firewood. Preferred species and classification categories in two local communities in eastern Misiones, Argentina

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Research

Abstract

Background: Human populations develop locally-based knowledge about the species used as firewood through the use of natural resources, and by experimenting with cultural guidelines and transmitting their experiencies. In the selection and use of firewood this knowledge is mainly based on the igneous properties of each species. This study was carried out in rural settlements and indigenous populations of the province of Misiones, Argentina. We surveyed combustion properties and local categories of firewood classification. We analyzed the most relevant characteristics of the firewood obtained from different species and the multiple applications assigned to it according to local criteria. We recorded the origin of the species used as fuel and their selection criteria, the vernacular nomenclature and the descriptor elements of the firewood qualities. Based on them we identified classification categories.

Methods: The information was obtained through semi-structured interviews, free lists and participant observation.

Results: Through Principal Component Analysis, we established groups of species associated with combustion properties or attributes and identified the emerging criteria that associate them. There were 21 species preferred, most of them native. Differences were observed in the frequency of firewood collection by the two groups, with more frequent activity among the indigenous. In both groups, wood usually comes from dry, medium to large individuals. They both select, use and prefer species whose main attributes as firewood are duration of the embers, intensity of the flames and low emission of smoke.

Conclusions: The tudy of classification system provides key information and broadens knowledge of the semantic corpus involved in their perception and practices.

Keywords: Ethnobotany; Cultural knowledge; Settlers; Indigenous; Combustion properties

Background

The relationship between biological and cultural wealth can be explored through the ethnobotany approach. Its interests include knowledge, uses and management of resources and the complex interactions of local communities with their environment (Caballero & Cortés 2001). Unravelling knowledge about natural resources through categories of use is a challenge for science, since traditional societies host a repertoire of local, collective, and holistic knowledge traversed by the practices, beliefs and vision of the groups employing them for material satisfaction (Zamudio & Hilgert 2015). Classification systems include categories that contain or group characteristics that identify the qualities studied through different criteria (Arenas & Martínez 2012, Kujawska *et al*. 2017, Toledo & Barrera Bassols 2009). These categories are part of the basis of local classification systems, whose analysis often reveal how people recognize and interact with the environment (Lima *et al*. 2020). They also model selection and extraction practices (Albuquerque *et al*. 2018, Morales *et al*. 2017a) and at the same time allow to identify preferred species over others (Jiménez-Escobar 2021, Martínez 2015, Ramos *et al*. 2008a).

The use of plants as fuel in rural communities is one of the main energy sources for domestic activities (Cardoso *et al*. 2012a, Ghilardi *et al*. 2007, Martínez 2015, Ramos *et al*. 2008a). The strategies for using these resources vary according to the environment and vegetation characteristics, their availability and accessibility, the preferences of users (Marconetto 2008) and even factors associated with the type of combustion devices used in each culture (Jiménez-Escobar & Martínez 2019). That is, it is not the mere presence of species that defines their use, on the contrary, it is the differential assessment of species made by different populations. Likewise, the diversity and intensity of use of each plant species are shaped by its properties and qualities and the specific uses they are given (Cardoso *et al*. 2015, Doumecq *et al*. 2020, Jiménez-Escobar 2021, Martínez 2015, Walters 2005).

Studies on the use of plants as firewood are recorded in various regions of the world, including Africa (Abbot & Lawore 1999, Tabuti *et al*. 2003), Asia (Kataki & Konwer 2002, Walters 2005), and the Americas (Da Silva *et al*. 2018, Díaz *et al*. 2020, Marquez-Reynoso *et al*. 2017; Nascimento *et al*. 2019, Sá e Silva *et al*. 2008, Valderrama & Linares 2008), highlighting the contributions of Mexico and Brazil (Doumecq *et al*. 2020). In Argentina, the use of firewood for domestic purposes at the family level has been addressed, both for indigenous and creole communities, residents of regions with urban, peri-urban and rural areas of arid and semi-arid environments, in the northwest, northeast, centre, center-east, and south of the country (Cardoso *et al*. 2012a, 2012b, 2015, Doumecq 2015, Doumecq *et al*. 2020, Fernández 2017, Jiménez-Escobar & Martínez 2019, Martínez 2015, Morales *et al*. 2017a, 2017b, Otegui 2016, Richeri *et al*. 2013). Among them, Martínez (2015) analyzed local perceptions and practices related to firewood quality through local categories and preference criteria, while Márquez Reynoso *et al*. (2017) identified that the consumption of preferred firewood and its relation to dendroenergetic properties is given by several characteristics related to the quality of the flames and the embers obtained. Stampella *et al*. (2016) identified the validity of firewood as a heat source.

Misiones province is populated by descendants of native communities, Creoles, and settlers who arrived in the region along the last century (Gallero & Krautstofl 2010, Poujade 1995). It presents a dispersed and mostly rural settlement pattern (Belastegui 2006, Schiavoni 2008). Different strategies for appropriating the environment associated with cultural and environmental factors are observed (Furlan *et al.* 2015).

The limited information on the use of firewood and the criteria adopted by the people since selecting woody species highlights the need to address this kind of research. In this context, from an ethnobotanical perspective, this study compares the use of firewood between Guaraní residents and settlers living in nearby rural areas whit a similar landscape matrix and with access to the same plant resources. Our hypothesis is that cultural aspects mediate firewood selection, we intend to find out the criteria of species selection, classification and management of wood material partially shared among them.

Materials and Methods

Study area

Our study area is located in the municipalities of San Pedro (department San Pedro) and El Soberbio (department Guarani), east of the province of Misiones, Argentina (Figure 1). Phytogeographically the zoneea belongs to the Paranaense Forest region (Cabrera 1976). It is characterized by a subtropical climate without a dry season, with average temperatures of 24°C; and annual rainfall ranging from 1,600 mm to 2,200 mm (Gran Atlas de Misiones 2015, Pereyra 2012).

Study population

The population is rural, consisting of two cultural groups: settlers (Bartolomé 1975, Ferrero 2005, Furlan *et al*. 2015), mainly of Brazilian German origin who arrived in the province at different times of the colonization process (García 2004, Kujawska *et al*. 2017, Zouvi 2008); and guaranies who mostly belong to the Mbya Guarani partiality, with presence in the area dating to about 1,200 years ago Before the Present approximately (Noelli 2004, Poujade 1995, Stampella 2015).

The economy of settlers is associated with diversified family agriculture sustained in their plots with perennial and annual plantations, cattle raising, and livestock breeding (poultry, pigs and fish in ponds) intended for self-consumption and sale in regional markets. The Guarani people retain much of their traditional subsistence practices, such as slash-and-burn agriculture, harvesting, hunting and fishing for most of the year within large areas of the forest they currently inhabit (Araujo *et al*. 2021, Cebolla Badie 2013, Keller 2008).

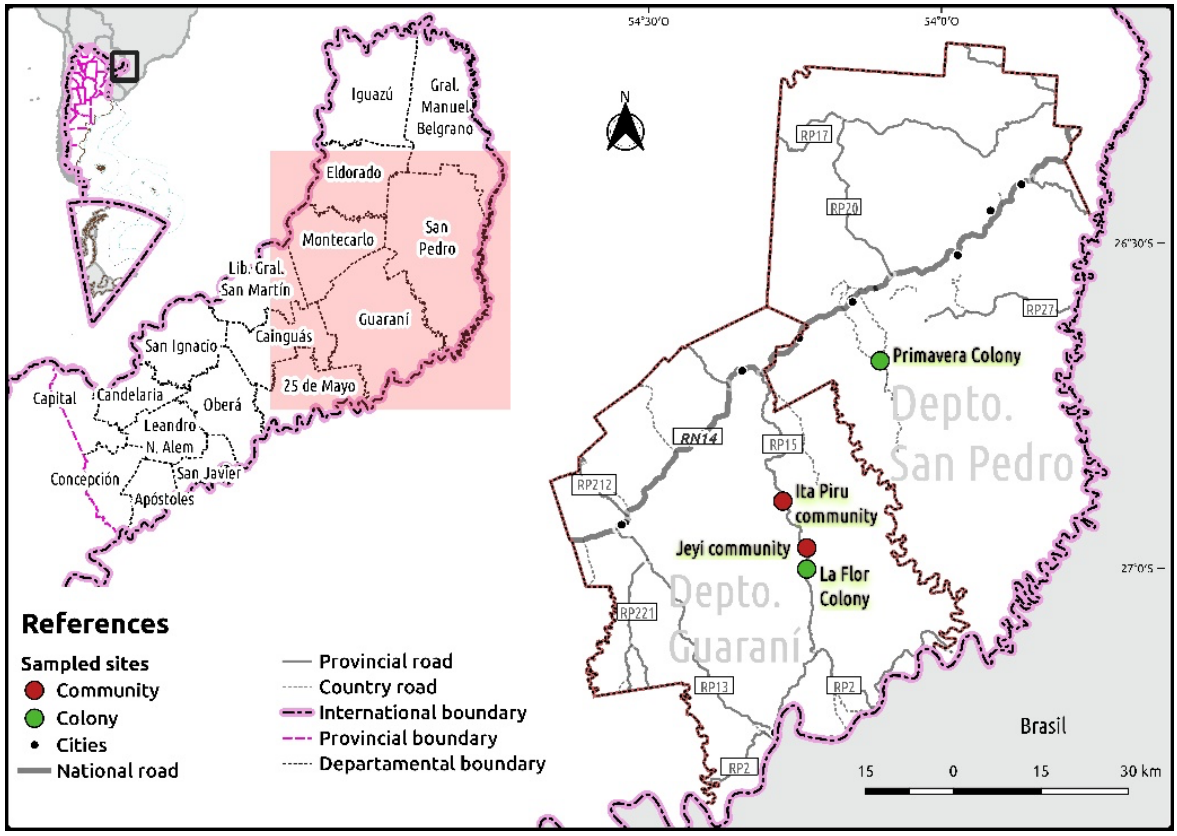


Figure 1. Study area visited in red circles.

Fieldwork

This study involved field trips between 2019 and 2022; during the COVID-19 pandemic, we followed the provincial protocol, performed open-air meetings and used a particular vehicle for the trips.

The sampling unit was the Domestic Unit (DU) we selected using the snowball technique (Alexiades & Sheldon 1996, Bernard 2000). In total, 55 people were interviewed, 30 settlers (5 women and 25 men) and 25 Guarani (3 women and 22 men), aged 18 to 100 years, with an average age of 46.6 years. We interviewed one person per DU. Each DU was visited 2 to 5 times. We exposed the objectives and scope of the study to the inhabitants interested in participating and prior informed consent was required before the interviews (ISE 2016).

The information was obtained through semi-structured interviews and a free list (Albuquerque *et al.* 2010); in the next step, in the interviews, species identified as preferred were recorded, and the qualities that defined them were requested.
We analyzed the classification system based on the uses, preferences and combustion properties assigned to firewood species. Also, we asked about the size of the firewood and when the different species are used (i.e. at the beginning for ignition, to keep lit, or to stoke the fire). In addition, participant observation and guided walks were performed with those interviewed by the collection areas to identify the species (Albuquerque *et al.* 2014, Guber 2004).

Samples of the plants were collected to compare them with the herbarium material deposited at the Instituto de Botánica del Nordeste (Corrientes, Argentina). SACKSER, M.G. and KELLER, H.A. identified the species taxonomically.

Data analysis

For the botanical nomenclature and the biogeographic origin of the species, the database of the Catalogue of Vascular Plants of the Southern Cone was consulted (http://www.darwin.edu.ar). The richness of species and botanical families was estimated based on the total number of species mentioned in each interview in both cultural groups (Jiménez-Escobar *et al*. 2021, Morales *et al*. 2017a, 2017b).

Selection criteria were identified through the analysis of interviews, field records, and observations during collecting activities. In addition, the Value of Preference (VP) was calculated, considering the frequency of citations of each preferred species by the total number of informants and expressed as a percentage (Doumecq *et al.* 2023, Ramos *et al.* 2008a). To analyze the desirable characteristics of firewood, we observed the conditioning and collection, the strategies for ignition and maintenance of the fire in the combustion devices and the characteristics of the combustion of the different logs in each device. We also measured the length, width, thickness and diameter of the pieces of firewood mentioned (species) to determine the type of firewood used at each moment of the fire in the devices mentioned. To identify the classification categories of the species, we analyzed the vernacular terms related to the properties or attributes characterizing them and the local categories mentioned by the interviewees. Through the Principal Component Analysis (PCA), groups of combustible species were established according to their properties and the local categories assigned by the users of the two cultural groups. For this analysis, all species with two or more attributes assigned to the local categories were included (Jiménez-Escobar 2021).

Results

Firewood species and selection criteria

Seventy species belonging to 59 genera and 28 botanical families (Table 1) were found to be used as firewood by settlers, while the Guarani used 65 species belonging to 55 genera and 25 botanical families (Table 1). Regarding biogeographic origin, many native species in the Paranaense Forest region (81.4% and 93.8%) were recorded compared to exotic ones (18.6% and 6.2%) by settlers and Guarani, respectively. Of all the species recorded (in both cultural groups), 84.9% are native. At the same time, the rest are exotic, come from plantations or adventitious specimens, and are resources for combustible and non-fuel uses.

The settlers declared that firewood is the primary source of calorific energy (and use liquefied petroleum gas on specific occasions), and the Guarani mentioned that it is the only source of calorific energy. In addition, all respondents indicated that they collect and use firewood from peri-domestic spaces within their plots or those assigned within communities. Among the settlers, 48.4% of those interviewed collect firewood once a month, 42% every four months and only 9.6% mentioned they collect firewood once or twice a year. 82.2% of the Guarani collect firewood daily, and the rest do it every other day.

The type of firewood and the uses allocated were directly related to preparation and cooking food in pots with wood stoves, brick and clay ovens, roast grills and on the ashes of a stove on the ground (51%); heating with different devices in cold weather (salamander, firewood stove, brazier, water heating tank or firewood heater, firewood stove, stove (9%), fire ignition and production (21%), fire use at religious events (5%) and fire for other uses, like heating forges for metal work, melting pitch for repairing shed roofs, sealing holes in wine barrels, Cooking for pets (pigs) and heating water to slaughter poultry (poultry and pigs), extract citronella essence, coal production, keep the fire burning (15%).

Table 1 shows the species used as fuel and local categories identified of differentiation: easy cutting firewood (during conditioning), hard firewood, soft firewood, white firewood, heartwood (**cerne**), heavy firewood (firewood is heavy to lift), light firewood (firewood low weight), good firewood, bad firewood, regular firewood, not categorized (firewood mentioned without specifying a particular category and specific use). Religious uses were identified: the sacred fire in the temple, cooking of sacred animal **kochi** or **pecarí labiado** (*Tayassu pecari*), dehydration of the **yerba mate** leaves (*Ilex paraguariensis*) by brief exposure to intense fire **sapecado** to be used in celebrations.

Table 1. List of firewood species used as fuel by both cultural groups. Uses and classification categories.

Scientific name Botanical family (Herbarium number according to collector)	Local name: Settlers, (guaraníes)	Origin	Habito	Cultural group	Cooking and preparation of food							Heating and combustion device						Ignition and production of fire				Religious use			Utility/Functional use				Local categories
					a	b	c	d	e	f	g	h	i	j	k	l	m	n	ñ	o	p	q	r	s	t	u	v	w	
Achatocarpus praecox Griseb. var. *praecox* (ACHATOCARPACEAE) (KELLER, H.A. 5408)	**(yvyra ina)**	N	Tr	G		*			*																				Nc
Actinostemon concolor (Spreng.) Müll. Arg. (EUPHORBIACEAE) (KELLER, H.A. 1296)	**laranjeira, (yvyra ũ)**	N	Tr	Se, G	*	*	*	*	*		*								*		*				*		*	*	Go, Ha, Nc, Re
Albizia niopoides (Spruce ex Benth.) Burkart (FABACEAE) (SACKSER, M.G. 1)	**anchico blanco, (ychapy'y)**	N	Sh	Se, G	*	*			*		*																		Ba, Nc
Allophylus edulis (A. St.-Hil. A. Juss. & Cambess.) Hieron. ex Niederl. (SAPINDACEAE) (KELLER, H.A. 6323)	**cocu, (guãkũ)**	N	Sh	Se, G	*	*			*										*						*			*	Nc, Re
Aloysia virgata (Ruiz & Pav.) Pers. var. *virgata* (VERBENACEAE) (KELLER, H.A. 11500)	**(yvyra rei)**	N	Sh	G		*			*										*						*				Nc
Annona neosalicifolia H. Rainer (ANNONACEAE) (KELLER, H.A. 10395)	**araticu, (arachiku)**	N	Sh	Se, G	*	*			*											*							*		Re
Apuleia leiocarpa (Vogel) J.F. Macbr. (FABACEAE) (KELLER, H.A. 13626)	**grapia, (yvyra pere)**	N	Tr	Se, G	*	*		*	*	*	*					*	*	*	*	*	*	*			*	*	*		Ba, Go, Ha, Nc, Re, So
Araucaria angustifolia (Bertol.) Kuntze (ARAUCARIACEAE) (SACKSER, M.G. 33)	**pino Paraná**	N	Tr	Se															*										Go
Aspidosperma australe Müll. Arg. (APOCYNACEAE) (KELLER, H.A. 311)	**guatambu amarillo, (guayrapaju)**	N	Tr	Se, G	*	*	*	*	*	*	*					*	*	*	*	*	*	*			*		*	*	Ba, Ec, Go, Ha, Li, Re, So

Ateleia glazeoveana Baill. (FABACEAE) (SACKSER, M.G. 26)	**timbó blanco, (yvyra ponge)**	N	Tr	Se, G	*	*			*							*	*		*						*				Go
Baccharis dracunculifolia DC. ssp. *dracunculifolia* (ASTERACEAE) (KELLER, H.A. 12078)	**chirca**	N	Sh	Se																								*	Ba
Balfourodendron riedelianum (Engl.) Engl. (RUTACEAE) (KELLER, H.A. 7726)	**guatambú blanco, (yvyra ñechĩ)**	N	Tr	Se, G	*	*	*	*	*	*	*					*	*	*	*	*	*	*	*		*		*	*	Ec, Go, Ha, Li, Nc, Re, So, Wh
Bastardiopsis densiflora (Hook. & Arn.) Hassl. (MALVACEAE) (SACKSER, M.G. 15)	**loro blanco, (mandyjura)**	N	Tr	Se, G	*	*			*										*						*				Go, Nc
Bauhinia forficata Link ssp. *pruinosa* (Vogel) Fortunato & Wunderlin (FABACEAE) (KELLER, H.A. 3327)	**(gueipo)**	N	Tr	G		*			*									*	*	*					*				Nc
Schnella microstachya Raddi (FABACEAE) (SACKSER, M.G. 32)	**isipó, escalera de mono, (ychypo pe)**	N	Sh	Se, G																								*	Ba, Nc
Cabralea canjerana (Vell.) Mart. (MELIACEAE) (KELLER, H.A. 1886)	**cancharana, (yvyra ruvicha)**	N	Tr	Se, G	*	*			*		*			*		*	*		*			*			*		*		Ba, Nc, Re, Wh
Camellia sinensis (L.) Kuntze (THEACEAE) (SACKSER, M.G. 8)	**té**	E	Sh	Se	*	*			*									*											Nc
Campomanesia xanthocarpa O. Berg (MYRTACEAE) (SACKSER, M.G. 20)	**guabirá, (guabira)**	N	Tr	Se, G	*	*	*	*	*	*	*								*	*	*	*			*				Ba, Ec, Go, He, Nc, Re
Casearia decandra Jacq. (SALICACEAE) (KELLER, H.A. 4312)	**guazatunga**	N	Sh	Se	*	*		*	*												*							*	He, Re
Cedrela fissilis Vell. (MELIACEAE) (KELLER, H.A. 13046)	**cedro, (y'ary)**	N	Tr	G		*			*											*									Nc, Re
Chrysophyllum gonocarpum (Mart. & Eichler) Engl. (SAPOTACEAE) (SACKSER, M.G. 2)	**aguay, (aguai)**	N	Tr	Se, G	*	*			*									*		*					*				Go, Nc
Chrysophyllum marginatum (Hook. & Arn.) Radlk. ssp. *marginatum* (SAPOTACEAE) (KELLER, H.A. 12200)	**basuriña, (ka'i rainga)**	N	Tr	Se, G	*	*	*	*	*		*								*	*	*				*			*	Ec, Go, Nc, Re, So

Chusquea ramosissima Lindm. (POACEAE) (KELLER, H.A. 5466)	**(takuarembo)**	N	Cl	G		*											*		*									So
Citrus reticulata, Blanco (RUTACEAE) (SACKSER, M.G. 4)	**mandarina, (mandarina)**	E	Tr	Se, G	*	*	*	*	*	*	*							*	*	*	*				*				Go, Ha, Nc, Re, Wh
Citrus sinensis, Osbeck (RUTACEAE) (SACKSER, M.G. 9)	**naranja**	E	Tr	Se	*	*	*	*	*		*								*	*	*				*				Go, Nc, Re
Citrus x limón (L.) Burm. F. (RUTACEAE) (SACKSER, M.G. 18)	**limón**	E	Tr	Se		*	*		*		*								*	*					*				Go
Cordia americana (L.) Gottschling & J. S. Mill. (BORAGINACEAE) (SACKSER, M.G. 5)	**guayubira, (guajayvi)**	N	Tr	Se, G	*	*	*	*	*	*	*		*	*		*	*		*	*	*	*	*	*	*	*	*	*	Ba, Ec, Go, Ha, He, Hw, Nc, Re
Cordia trichotoma (Vell.) Arráb. ex Steud. (BORAGINACEAE) (KELLER, H.A. 3999)	**loro negro, (apyterevy)**	N	Tr	Se, G	*	*		*	*	*	*					*	*	*	*		*	*			*				Go, Nc, Re
Cupania vernalis Cambess. (SAPINDACEAE) (SACKSER, M.G. 7)	**camboatá colorado, (yvata'y)**	N	Tr	Se, G	*	*	*	*	*	*	*				*	*	*	*	*	*	*	*	*		*		*	*	Ec, Go, Ha, Re, Nc
Diatenopteryx sorbifolia Radlk. (SAPINDACEAE) (KELLER, H.A. 2824)	**María preta, (yvyra porã)**	N	Tr	Se, G	*	*	*	*	*	*	*					*	*		*	*	*	*	*		*	*	*	*	Go, Ha, He, Nc, Re
Enterolobium contortisiliquum (Vell.) Morong (FABACEAE) (SACKSER, M.G. 30)	**(chimbo´y)**	N	Tr	G		*			*																				Nc
Eriobotrya japonica (Thunb.) Lindl. (ROSACEAE) (SACKSER, M.G. 12)	**níspero**	E	Sh	Se	*	*		*	*		*									*	*					*			Ha
Eucalyptus grandis W. Hill ex Maiden (MYRTACEAE) (SACKSER, M.G. 3)	**eucalipto, (eucaplipto)**	E	Tr	Se, G	*	*	*	*	*		*		*					*	*	*					*		*	*	Ec, Go, Ha, Li, Nc, Re, So, Wh
Eugenia involucrata DC. (MYRTACEAE) (KELLER, H.A. 12260)	**(yvyra jepiro)**	N	Tr	G		*			*										*						*				Nc
Eugenia pungens O. Berg (MYRTACEAE) (SACKSER, M.G. 14)	**guaviyu**	N	Tr	Se	*	*			*		*								*						*		*		Nc, Re

Eugenia uniflora L. (MYRTACEAE) (SACKSER, M.G. 23)	**(ñangapiri, yva viju)**	N	Sh	G		*			*		*					*	*		*						*				Go
Handroanthus albus (Cham.) Mattos (BIGNONIACEAE) (KELLER, H.A. 1229)	**lapacho amarillo, (isapui para)**	N	Tr	Se, G	*	*		*	*										*		*				*				Go, Hw
Handroanthus heptaphyllus (Vell.) Mattos (BIGNONIACEAE) (KELLER, H.A. 2210)	**lapacho negro, (tajy)**	N	Tr	Se, G	*	*		*	*	*	*					*	*		*	*	*	*	*		*				Go, Ha, He, Hw, Re
Helietta apiculata Benth. (RUTACEAE) (KELLER, H.A. 5104)	**canela de venado, (yvyra ovy)**	N	Tr	Se, G	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*		*	*	Ec, Go, Ha, He, Nc
Eugenia pyriformis Cambess. var. *pyriformis* (MYRTACEAE) (SACKSER, M.G. 31)	**ubajay**	N	Tr	Se	*	*			*																				Ba, Go
Holocalyx balansae Micheli (FABACEAE) (KELLER, H.A. 318)	**alecrín, (yvyra pepe)**	N	Tr	Se, G	*	*	*	*	*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	Ba, Ec, Go, Ha, He, Hw, Li, Nc
Hovenia dulcis Thunb. (RHAMNACEAE) (KELLER, H.A. 3370)	**hovenia, (hovenia)**	E	Tr	Se, G	*	*	*	*	*		*		*			*	*	*	*	*					*		*	*	Go, Nc, Re, So, Wh
Ilex paraguariensis A. St.-Hil. (AQUIFOLIACEAE) (SACKSER, M.G. 17)	**yerba mate, (ka´a)**	N	Sh	Se, G	*	*	*	*	*		*							*	*	*					*				Go, Li, Nc, Re, So
Inga marginata Willd. (FABACEAE) (KELLER, H.A. 243)	**(inga)**	N	Tr	G		*			*	*								*	*	*		*			*	*			Nc, Re
Jacaranda micrantha Cham. (BIGNONIACEAE) (SACKSER, M.G. 28)	**caroba, (para para'i)**	N	Tr	Se, G	*	*			*																				Nc
Leucaena leucocephala (Lam.) de Wit ssp. *glabrata* (Rose) Zárate (FABACEAE) (KELLER, H.A. 5902)	**leucaena**	E	Sh	Se	*	*			*		*								*	*					*				Re, So
Dahlstedtia muehlbergiana (Hassl.) M.J. Silva & A.M.G. Azevedo (FABACEAE) (SACKSER, M.G. 25)	**rabo amarillo, (yvyra kachĩ guachu)**	N	Tr	Se, G	*	*			*										*	*					*				Ba, Nc

Luehea divaricata Mart. (MALVACEAE) (KELLER, H.A. 3470)	**sota caballo, (ychongy)**	N	Tr	Se, G	*	*			*		*								*						*				Li, Nc, Re
Machaerium paraguariense Hassl (FABACEAE) (KELLER, H.A. 3060)	**breyo cáscara lisa, (ychapy'y guachu)**	N	Tr	Se, G	*	*	*	*	*		*								*	*	*				*				Ec, Go, Ha, Nc
Machaerium stipitatum (DC.) Vogel (FABACEAE) (KELLER, H.A. 8925)	**breyo betudo, (chapy'i mirĩ)**	N	Tr	Se, G	*	*		*	*									*	*		*				*				Ec, Go, Li, Nc
Maclura tinctoria (L.) Steud. ssp. *tinctoria* (MORACEAE) (KELLER, H.A. 247)	**mora amarilla, (tata jyva)**	N	Tr	Se, G	*	*		*	*																			*	Go, Ha, He
Matayba elaeagnoides Radlk. (SAPINDACEAE) (SACKSER, M.G. 21)	**camboata blanco, (yvata'y kuña)**	N	Tr	Se, G	*	*			*																				Nc
Melia azedarach L. (MELIACEAE) (KELLER, H.A. 10719)	**paraíso, (paraiso)**	E	Tr	Se, G	*	*	*	*	*		*							*	*	*					*		*		Ba, Go, Li, Nc, Re, So
Muellera campestris (Mart. ex Benth.) M.J. Silva & A.M.G. Azevedo (FABACEAE) (KELLER, H.A. 7742)	**rabo de bugio, (yvyra kachĩ)**	N	Tr	Se, G	*	*	*	*	*	*	*					*	*		*	*	*	*			*			*	Ba, Go, Ha, He, Nc, Re
Myrocarpus frondosus Allemão (FABACEAE) (KELLER, H.A. 6002)	**incienso, (yvyra paje)**	N	Tr	Se, G	*	*		*	*	*	*					*	*		*	*	*	*	*		*		*		Ec, Go, Ha, He, Hw, Nc, Re
Myrsine balansae (Mez) Otegui (PRIMULACEAE) (SACKSER, M.G. 22)	**(aperea ka´a)**	N	Tr	G		*		*	*	*						*	*			*	*								Go
Nectandra lanceolata Nees & Mart. (LAURACEAE) (KELLER, H.A. 7544)	**(canela palta), (aju'y jo'a)**	N	Tr	Se, G	*	*	*	*	*		*								*	*	*				*				Ba, Go, Nc, Re
Nectandra angustifolia (Schrad.) Nees & Mart. (LAURACEAE) (KELLER, H.A. 10635)	**laurel negro, canela preta, fidida, catinguda, (aju'y ũ)**	N	Tr	Se, G	*	*			*		*								*	*					*				Ba, Go, Nc, Re
Ocotea diospyrifolia (Meisn.) Mez (LAURACEAE) (SACKSER, M.G. 6)	**laurel ayuí, (aju'y)**	N	Tr	Se, G	*	*	*		*	*	*					*	*	*	*	*		*			*	*			Ba, Go, Nc, Re

Ocotea puberula (Rich.) Nees (LAURACEAE) (KELLER, H.A. 8733)	**laurel guaica, (aju'y chi)**	N	Tr	Se, G	*	*			*	*	*					*	*	*	*	*		*			*				Ec, Go, Nc, Re
Parapiptadenia rigida (Benth.) Brenan (FABACEAE) (KELLER, H.A. 3447)	**anchico colorado, (kurupay)**	N	Tr	Se, G	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	Ec, Go, Ha, He, Hw, Li
Peltophorum dubium (Spreng.) Taub. (FABACEAE) (SACKSER, M.G. 10)	**cañafístola, (yvyra pytã)**	N	Tr	Se, G	*	*		*	*	*						*	*	*	*	*	*	*	*		*				Go, Li, Nc, Re
Persea americana Mill. (LAURACEAE) (KELLER, H.A. 2398)	**Palta**	N	Tr	Se	*	*			*																				Re
Merostachys claussenii Munro (POACEAE) (KELLER, H.A. 3306)	**(takua, takuapi)**	N	Cl	G		*												*		*									So
Pilocarpus pennatifolius Lem. (RUTACEAE) (KELLER, H.A. 3405)	**yaguarundi, (yvyra petái)**	N	Sh	Se, G	*	*	*	*	*												*							*	Re
Pinus taeda L. (PINACEAE) (SACKSER, M.G. 19)	**pino**	E	Tr	Se	*	*			*		*								*	*					*				Ba, Re
Plinia cauliflora (Mart.) Kausel (MYRTACEAE) (SACKSER, M.G. 24)	**yaboticaba, (iguapuru)**	N	Tr	Se, G	*	*			*																				Ha
Plinia rivularis (Cambess.) Rotman (MYRTACEAE) (KELLER, H.A. 5899)	**baporoiti, (guaporaity)**	N	Tr	Se, G	*	*	*		*	*									*	*		*			*				Ha, Li, Nc
Handroanthus pulcherrimus (Sandwith) S. Grose (BIGNONIACEAE) (KELLER, H.A. 9148)	**lapachillo**	N	Tr	Se	*	*			*																				Go, Ha
Prunus brasiliensis (Cham. & Schltdl.) D. Dietr. (ROSACEAE) (KELLER, H.A. 3381)	**persiguero**	N	Tr	Se																								*	Ba
Prunus persica (L.) Batsch var. *persica* (ROSACEAE) (KELLER, H.A. 2126)	**durazno**	E	Sh	Se	*	*			*																				Re
Quercus robur L. (FAGACEAE) (SACKSER, M.G. 11)	**quercus, roble común**	E	Tr	Se																									Nc
Ruprechtia laxiflora Meisn. (POLYGONACEAE) (KELLER, H.A. 7668)	**marmelero, (juky pitãngy)**	N	Tr	Se, G	*	*			*										*						*				Nc

Sebastiania commersoniana (Baill.) L.B. Sm. & Downs (EUPHORBIACEAE) (KELLER, H.A. 10089)	**blanquillo**	N	Sh	Se	*	*			*																				Nc
Solanum granulosum-leprosum Dunal (SOLANACEAE) (KELLER, H.A. 4773)	**fumo bravo, (ka'a chingy)**	N	Sh	Se, G	*	*			*									*		*							*	*	Ba, Ec, Li, Nc, Re, So
Sorocea bomplandii (Baill.) W. C. Burger, Lanj. & Wess. Boer (MORACEAE) (SACKSER, M.G. 27)	**(ñandyta)**	N	Tr	G		*			*																				Nc
Styrax leprosus Hook. & Arn. (STYRACACEAE) (KELLER, H.A. 13495)	**carne de vaca**	N	Tr	Se	*	*		*	*				*			*	*				*								Ba, Go
Symplocos uniflora (Pohl) Benth. (SYMPLOCACEAE) (SACKSER, M.G. 29)	**(yvyra vevui)**	N	Tr	G														*											Ec
Trema micrantha (L.) Blume (CANNABACEAE) (KELLER, H.A. 3349)	**palo pólvora, (kurunjy'ũ)**	N	Sh	Se, G	*	*			*																		*	*	Ba, Go
Trichilia catigua A. Juss. (MELIACEAE) (KELLER, H.A. 3468)	**catiguá, (kachygua)**	N	Tr	Se, G	*	*		*	*		*								*						*		*		Ec, Go, Nc
Trichilia claussenii C. DC. (MELIACEAE) (KELLER, H.A. 6488)	**(yvyra chanto)**	N	Tr	G		*		*	*	*	*					*	*		*	*	*	*	*		*				Go, Ha, Nc
Trichilia elegans A. Juss. (MELIACEAE) (KELLER, H.A. 3446)	**(kachygua mirĩ)**	N	Tr	G		*			*																				Nc
Vernicia fordii (Hemsl.) Airy Shaw (EUPHORBIACEAE) (KELLER, H.A. 4293)	**Tung**	E	Tr	Se	*	*	*		*										*	*					*				Nc
Vitex megapotamica (Spreng.) Moldenke (LAMIACEAE) (SACKSER, M.G. 16)	**tarumá, (taruma)**	N	Tr	Se, G	*	*		*	*										*		*				*				Ba, Ha, He, Re
Zanthoxylum rhoifolium Lam. (RUTACEAE) (SACKSER, M.G. 13)	**mamica de cadela**	N	Tr	Se																					*			*	Re

References: Biogeographic origin: N: Native, E: Exotic. Habit: Tr: Tree, Sh: Shrub, Cl: Climber; CG: Cultural Group, Se: Settlers, G: Guaranies; Everyday uses and combustion devices: a) Firewood stove, b) Stove on the soil, c) Clay oven, d) Roast, e) Flame for cooking, f) Ashes for roasting, g) Cooking for pets (pigs) and heating water to slaughter poultry (poultry and pigs), h) salamander, i) firewood stove, j) brazier, k) thermotank/firewood stove, l) firewood stove, m) stove, n) fire starter, ñ) keep the fire burning, o) flame production, p) charcoal production, q) sacred fire, r) cooking of sacred animal **kochi** or **pecarí labiado** (*Tayassu pecari*), s) **sapecado** of **yerba mate** leaves (*Ilex paraguariensis*) to be used in religious celebrations, t) mix or combine with other firewood, u) rest pots/pots/pan/grills, v) extract essence, w) charcoal production. Local categories: Local categories: Ec: Easy crack, Ha: Hard, So: Soft, Wh: White, Hw: Heartwood, He: Heavy, Li: Light, Go: Good, Ba: Bad, Re: Regular, Nc: Not categorized (firewood was mentioned without specifying a particular category or specific use). (CTES) - Herbario Del Instituto de Botánica del Nordeste, Corrientes; KELLER, H.A. –Keller Héctor Alejandro; SACKSER, M.G. –Sackser Mario Gabriel.

In general, when the Guarani collect firewood, they choose native species, referring to them as *"the place where they live, where there is much forest"* (**yvyra rekoa**, S.CH., 40 años; **yvyra rekoa ka'aguy guachu**, C.B., 73 años; **ka'aguy guachu**, A.C., 86 años). Although the use assigned to each species varies, both the Guarani and the settlers stated that, given the prolonged time of combustion and the heat potential: *"We seek wood from the forest,* **ka'aguy***, all that is fallen"* (S.S., 30, Guarani); *"you have to see a wood of the forest as* **anchico colorado** (*Parapiptadenia rigida*), **María preta** (*Diatenopteryx sorbifolia*), **alecrín** (*Holocalix balansae*), *these things there do give fire"*, "*It is usually used for everything, all kinds of food, all kinds of roast you want to make, all kinds of events; it is good firewood"* (R.S., 48, settler); "*the* **canela de venado** (*Helietta apiculata*), *that gives you the burning ember, the* **alecrín** *more and the* **María preta** *also; you throw it in the fire, you have the ember burning half a day on"* (C.B., 72, settler). Another outstanding selection criterion was that most of the collected species were trees.

The settlers commonly use trees of medium to large size. First, they take advantage of the trunk and then the branches (thick and thin), while the Guarani use trees of different sizes, but first, they use thin and thick branches and then the trunk until they run out of firewood. In addition, settlers cut the woody material into smaller parts than the size of firewood used by the Guarani (Table 2). This difference is usually due to the combustion devices used in each case; when using wood stoves or some particular device, the firewood must be arranged to fit in them, unlike in open stoves.

Table 2. Size classification for both cultural groups.

N°	Cultural group	Types of firewood	Measures (m)
1	Se	**Splinter** or **Cabaquiño**	L: ≤ 0.3; D: ≤ 0.01
	G	**Aviyui**: very small branches.	L: ≤ 0.5; D: ≤ 0.05
2	Se	**Cambito the yerba mate**: fine branches.	L: ≤ 0.3; D: ≤ 0.05
3	Se	Fine woodland: small pieces.	L: ≤ 0.3; D: 0,01 a 0.05
	G	**Jape'a Akangue I**: small branches.	L: V; D: 0.005 a 0.05
4	Se	Thick woodland: small and medium pieces.	L: ≤ 0.3; D: 0.05 a 0.08
	G	**Jape'a Akangue**: small and medium branches.	L: V; D: 0.005 a 0.1
5	Se	**Lasca** or small firewood: firewood cracked with an axe to start the fire in the wood stove.	L: 0.20 a 0.25; W: 0.02 a 0.05; T: ≤ 0.07
	G	**Jape'a Ray Kue'i**: cut pieces of the stem or trunk with axe.	L: 0.2 a 1; W: 0.05 a 0.1; T: 0.02 a 0.07
6	Se	**Taquito** or **Lasca** (small firewood): firewood cracked with axe.	L: 0.25 a 0.30; W: 0.05 a 0.08; T: ≤ 0.08
7	Se	**Taquito** or **Lasca** (large firewood): cracked firewood with axe for heating devices.	L: 0.25 a 0.40; W: 0.08 a 0.1; T: 0.08 a 0.1
	G	**Jape'a Ra'y Kue**: cut pieces of the stem or trunk with axe.	L: 0.5 a 1; W: 0.1 a 0.15; T: 0.07 a 0.12
8	Se	**Gajada** (for clay oven, stove, stove): firewood from branches of plants cracked with axe.	L: 0.60 a 1.50; A: 0.1 a 0.15; T: 0.1 a 0,15
9	Se	**Gajada** (for clay oven, stove, stove): firewood of branches cut with chainsaw.	L: 0.60 a 1.50; D: ≤ 0.1
10	Se	**Tora** or **Taco**: firewood cut with chainsaw.	L: 20 a 40; D: V
11	Se	**Tora**: firewood cut with chainsaw.	L: ≤ 1; D: > 0,3
	G	**Jape'a Tuicha** or **Guachu**: firewood of thick branches, stem or trunk, blight.	L: ≥1; D: 0.25 a 0.5
12	Se	**Tizón**: firewood cut with chainsaw.	L: 1 a 1.5; D: ≤ 0.3
	G	**Jape'a Ichyrã**: firewood of thick branches, stem or trunk, blight.	L: 0.6 a 1.2; D: >0.5
13	Se	Roots.	L: V; D: V
	G	**Apo kue**: obtained from dried roots.	L: V; D: V

References: Se: Settlers; G: Guaranies; m: metro; L: length; W: width; T: thickness; D: diameter; v: variable measure; ≤: less or equal; >: greater; ≥: greater or equal.

The settlers generally use firewood stoves, salamanders, water heaters, and devices with a small entrance and a burner; these openings are approximately 25 cm wide and tall. Similar cases are the firewood stove for heating and the brick and clay oven to prepare homemade bread. In contrast, Mbya Guarani families do not have special combustion devices; they

traditionally use stoves on the ground for all activities. To start combustion quickly and effectively (Guarani: **okái pya'e**), both cultural groups reported that the woody material must be dry or dead (Guarani: **jape'a pirukue**). Thin, dry branches ignite the fire; then larger pieces are added to maintain combustion (branches of larger diameter and pieces of wood cut with a machete, axe or chainsaw). The different forms of conditioning and the firewood size receive particular names depending on their dimensions (Table 2).

The settlers often use parts of plants of *Ilex paraguariensis*, *Helietta apiculata*, *Eucalyptus grandis*, *Melia azedarach*, *Balfourodendron riedelianum*, *Camellia sinensis*, *Chrysophyllum gonocarpum* or this purpose. In contrast, the Guarani generally use species such as *Solanum granulosum-leprosum*, *Trema micrantha*, *Trichilia claussenii*, *Balfourodendron riedelianum*, *Merostachys claussenii, Chusquea ramosissima*, *Holocalix balansae*, *Ocotea diospyrifolia*, *Ocotea puberula*, *Nectandra angustifolia* to light the fire or fan the flames from a firebrand in the ashes.

Further, they always stressed that it is essential for firewood to have good combustion, with many flames and strong embers that last in time, that is, that do not extinguish quickly. Following, we transcribed part of the interviews of the collaborators whose testimony reflects the above: Guarani: "*The firewood is burned next to the patio, it will never be extinguished, if it is a good fire it is always going to be burning for the next day*" (S.S., 30 years); "*that we use more because it gives more embers, good embers, and it burns well too, that is why we use more*" (F.B., 31 years); **tataendy porã**, **tataendy guachu**, **haku porã** - beautiful fire, big flame, very hot- (R.O., 60 years). Settlers: "*Gives a nice flame, burns a nice one, that being dry is a luxury to cook, quick to light, you see, lights fast*" (S.G., 53 years).

Preferred species

Of the combustible species registered for both cultural groups, 21 were named as preferred (Table 3). The settlers mentioned 12 species, and the Guarani mentioned 17 species. In turn, 4 and 9 species were registered exclusively for settlers and Guarani, respectively. It is also important to note that although the two groups share species, the value of estimated importance (VP %) differs from one to the other, and among the Guarani, all the species considered as important are native (Table 3).

The reasons justifying the choice of preferred species correspond with their combustion properties, such as high calorific value, production of hot and long-lasting embers, prolonged combustion of the fire, clean and intense flame, and ashes that maintain heat. These attributes are related to specific uses whose desirable characteristics may stand out for different applications.

Among the firewood preferred by the settlers, the main one is Helietta apiculata, which used different fires in combustion devices for different purposes. It stands out because it generates flame and hot, durable embers and is smoke-free "clean". It is used to roast meat charqui, cook food in pots, roast homemade bread in brick and clay ovens, and heat the house in winter. Recognize that it is a species of rapid growth present in the area.

In addition, it is considered, along with the *Holocalix balansae* and *Parapiptadenia rigida*, as one of the best combustible species. Adjectives or qualities for these species are good, hard, solid and beautiful. Some of the stories describing it are: *"that* **canela de venado** *goes for everything"* (J.J., 33 years); *"that is almost the same, almost better than the* ***a*****nchico colorado** *still pufff...,* **canela de venado** *and* ***a*****nchico colorado** *and* ***a*****lecrín** *are first of all hardwood and calories, that* **canela de venado** *has super calories, super good, hardwood; the embers are strong when you burn the wood again when you move the embers man, good puff ember… That is the ember to cast iron"* (V.D.O., 57 years).

For the Guarani, the preferred species of firewood is *Holocalix balansae* (**yvyra pepe**); it is used in stoves for a wide variety of cooking and food preparation, heating, religious and utility uses. Its value is based on the fact that it is a wood that ignites without difficulties, maintains prolonged combustion, generates embers with high heat value, and practically does not generate smoke. In turn, users highlight that it produces good quality clean ashes and maintains the temperature to cook their culture's traditional *"typical"* foods. Also, the thick trunks of this species, along with *Parapiptadenia rigida* (**kurupay**), are used as firebrands to keep the fire burning for several hours and to rest kitchen utensils such as pots, kettles and pans while using them. Along with *Trichilia claussenii* (**yvyra chanto**) it is used to make a sacred fire called **tataendy** during thunderstorms to divert lightning from the community to large native forest blocks called **ka aguy guachu**. We transcribe a fragment: *"that is used more out there is needed at some point for roast or something else, that is excellent firewood; if you need to make roast it has that ember"* (E.S., 49 years); *"the best wood is* **yvyra pepe** *and* ***k*****urupay**, *those are the two best, they last longer too; it has embers and very hot"* (S.R., 44 years); **yvyra chanto** *uses when the storm comes so that lightning*

does not fall so that it goes in the big forest" (S.S., 30 years); *"that wood of* ***kurupay*** *is also from ancient times, it is the favorite of the grandparents", "as* **jape'a** *-firewood- is the preferred in the* **opy** *-temple-, mostly in the winter as now because it heats more, it also gives many embers, it is easier... light"* (M.F., 26 years).

Classification categories associated with firewood properties used by inhabitants

Analyzing vernacular terms and participant observation, we identified classification categories associated with combustion properties and woody resources' physical characteristics (local categories). Twenty (20) categories were registered for the two cultural groups. In the Main PCA, we grouped the combustible species from these categories (Figure 2 A, B, C, D). In all cases, more than 65 % of the variability found in the classification and grouping of species is explained by the first two components. In Figure 2 A, the most outstanding properties cited by settlers are related to rapid ignition, flame production, charcoal production and prolonged (or slow) combustion. All these variables are the quality attributes that users recognize and describe in the firewood species according to their behaviour during the combustion process in their devices. They also mentioned that some wood species **tira chispa** (sizzle) during combustion.

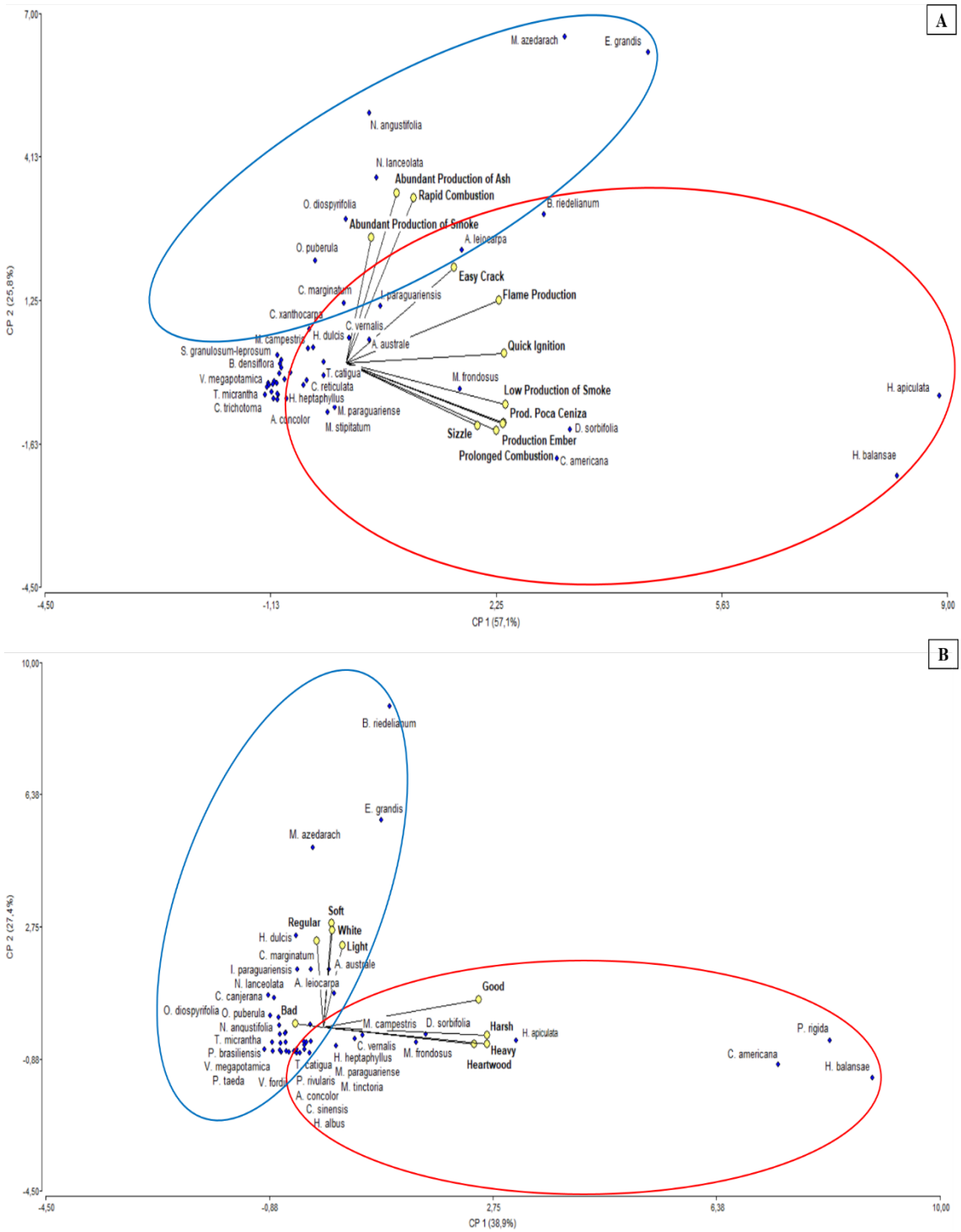
Within these categories, we grouped firewood that meets the positive qualities and is used in the DU to cook foods that require extended periods of cooking and grilled or flame-roasted meats; among them are *Helietta apiculata*, *Holocalix balansae* and *Cordia americana* (red circle). In the opposite categories (blue circle) are included the species used to prepare family food in wood stoves by mixing with other woody species of good quality, usually for cooking on stove and embers for poultry (pigs) and to heat water to slaughter livestock (poultry and pigs). On the other hand, all the combustible species that are not associated with the properties mentioned above or are close to the axis do not present significant differences because the interviewees did not cite them, or they do not attribute discordant properties to them.

Table 3. Preferred combustible species mentioned by the interviewees.

Settlers			**Guarani**		
Scientific name **Botanical family**	**Origin**	**VP (%)**	**Scientific name** **Botanical family**	**Origin**	**VP (%)**
Helietta apiculata	N	36.67	*Holocalyx balansae*	N	52.00
Parapiptadenia rigida	N	33.33	*Diatenopteryx sorbifolia*	N	32.00
Holocalyx balansae	N	30.00	*Parapiptadenia rigida*	N	28.00
Cordia americana	N	10.00	*Cordia americana*	N	24.00
Aspidosperma australe	N	6.67	*Helietta apiculata*	N	24.00
Eucalyptus grandis	E	6.67	*Machaerium paraguariense*	N	20.00
Balfourodendron riedelianum	N	6.67	*Vitex megapotamica*	N	16.00
Muellera campestris	N	3.33	*Trichilia claussenii*	N	16.00
Myrocarpus frondosus	N	3.33	*Balfourodendron riedelianum*	N	16.00
Cupania vernalis	N	3.33	*Handroanthus heptaphyllus*	N	12.00
Diatenopteryx sorbifolia	N	3.33	*Ocotea diospyrifolia*	N	12.00
Trichilia catigua	N	3.33	*Ocotea puberula*	N	8.00
			Cupania vernalis	N	8.00
			Aspidosperma australe	N	4.00
			Apuleia leiocarpa	N	4.00
			Trema micrantha	N	4.00
			Matayba elaeagnoides	N	4.00

References: Biogeographic origin: N: Native, E: Exotic. VP (%): Value of Preference of the species.

The classification based on physical characteristics (Figure 2 B) is related to the group of good, hard, and heavy firewood (*Parapiptadenia rigida*, *Holocalix balansae*, *Helietta apiculata*, as opposed to bad (*Vitex megapotamica*, *Cabralea canjerana*, *Pinus taeda*), and regular, soft, white and light firewood (*Melia azedarach*, *Balfourodendron riedelianum*, *Eucalyptus grandis*). Among these local categories, respondents recognized and specified the properties that characterize or distinguish woody species from each other.



In Figure 2 C, the properties that Guarani constantly highlight are related to the production of embers, prolonged combustion, flame production, rapid ignition, good quality, ash production, low smoke emission and easy cracking (red circle); and in the opposite direction are located rapid combustion and emission of much smoke (blue circle). They also mentioned the **piriri** (sizzle) that produce some firewood. In general, the species mentioned are associated with intrinsic properties that define the quality of firewood, such as the production of flame, embers, and ash to meet the requirements of domestic use. The main species included were *Holocalix balansae*, *Parapiptadenia rigida*, *Helietta apiculata* and *Trichilia claussenii*. On the other hand, species that generate much smoke and combust quickly are used in smaller quantities and certain parts of them, such as thin branches or small dry pieces (Guarani: **jape'a pirukue**) for specific uses such as starting a fire. This shows that associated harmful properties are considered valuable to satisfy other functions. Finally, species with unclear classifications are further away from the central axis categories.

In the classification defined by local categories (Figure 2 D), the terms hardwood and softwood firewood are the ones that best explain the attributes specified by the Guarani to identify the characteristics of the species used as fuel. Among the positive qualities, we recognized the terms hardwood, good and heavy, which include *Holocalix balansae*, *Parapiptadenia rigida*, *Diatenopteryx sorbifolia*, *Apuleia leiocarpa* and *Trichilia claussenii.*

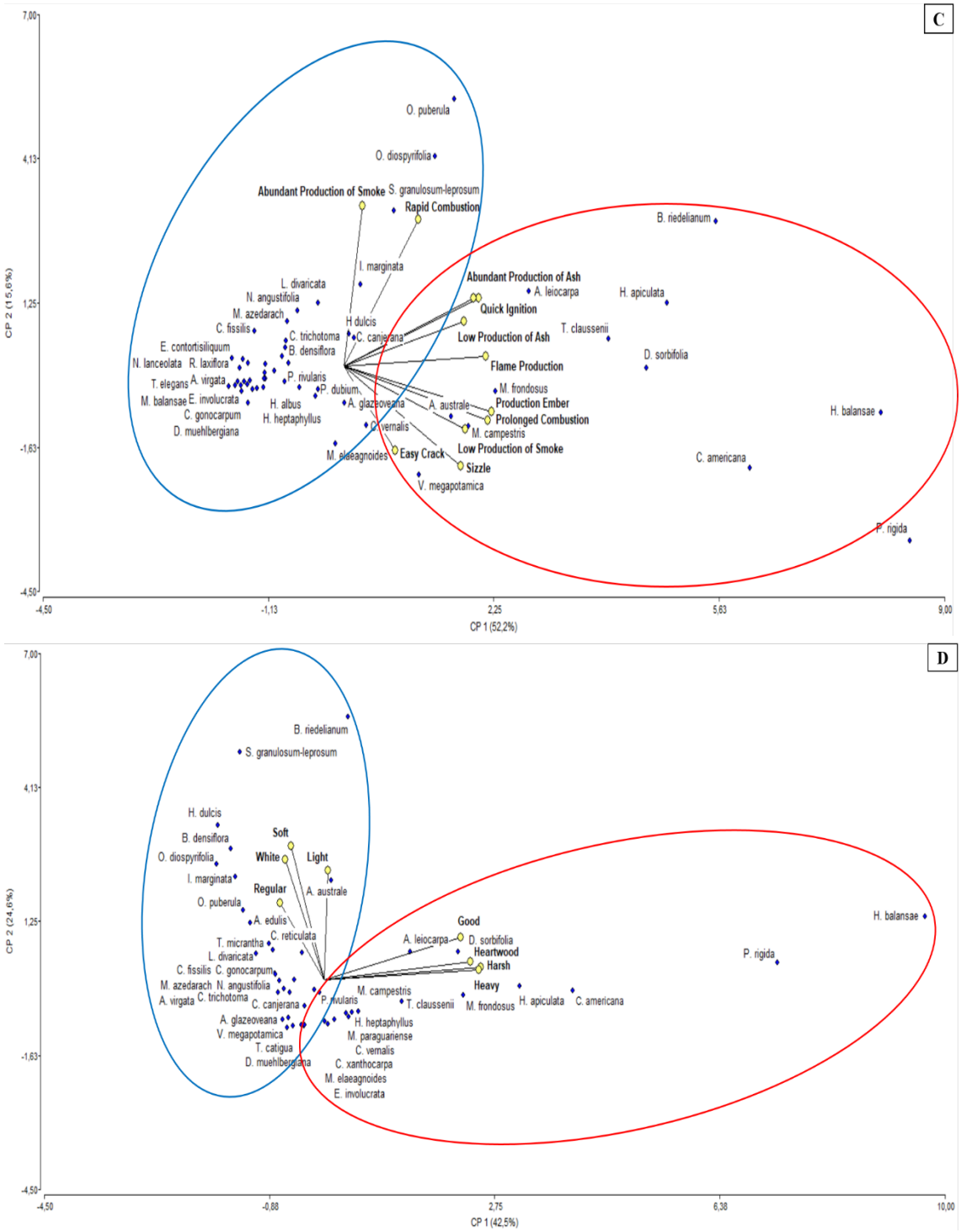


Figure 2. Bi plot of the PCA for the association of combustible species according to the properties of firewood and the local categories assigned by the users of the two cultural groups.

References: A and B: Settlers, C and D: Guarani. Variables Studied: Firewood properties: Ember Production, Prolonged combustion, Quick ignition, Flame production, Abundant production of smoke, Rapid combustion, Abundant production of ash, Sizzle (Settlers they call **tira chispa**, **revienta**, or **estrala**; and Guaranies: they call **piriri**), Low production of smoke, Low

production of ash, Easy crack; Local categories: Hard, Soft, White, Heartwood, Heavy, Light, Good, Bad, Regular (Yellow dot and bold font). Scientific name of the species (Blue dot).

Vernacular terms referring to soft, regular, light, and white firewood are associated with less desirable qualities, but species with these characteristics are commonly used because they meet different needs. Villagers stated that they constantly use these logs for cooking food in pots, heating water to drink mate, **sapecado** of **yerba mate** (dry and toast the leaves of *Ilex paraguariensis*) and giving light. They mentioned *Balfourodendron riedelianum*, *Aspidosperma australe*, *Ocotea diospyrifolia*, *Ocotea puberula*, *Luehea divaricata*, *Solanum granulosum-leprosum*, *Chrysophyllum gonocarpum*, among others.

Discussion

Both cultural groups classify firewood species by recognizing and describing characteristics grouped into categories related to the intrinsic qualities of wood and specific uses. According to our hypothesis, each cultural group differs in their preferences on the firewood to be used according to their perception of the quality of the available resources, their value and differential use of heat for each specific requirement (Table 3).

In the studied area, both cultural groups have developed a classification system that allows recognizing and interpreting the firewood characteristics of interest according to the specific uses and qualities recognized: fast ignition, good combustion, prolonged combustion, abundant flame and smoke-free, production of durable embers, high calorific value and generation of ashes that maintain temperature (Figure 2 A, B, C, D). Sometimes, woods with high hardness, good and heavy (elements valued highly positively), at the same time emit sparks during combustion (a quality indicated as undesirable), which results in the particular ordering of the qualities above (Figures 2 A and 2 C).

In general, the same attributes have been mentioned similarly by people of other cultural belonging in other regions (Jiménez-Escobar 2021, Kataki & Konwer 2002, Kituyi *et al.* 2001). Features like abundance, availability and aroma of species as local categories reported in the literature (Cardoso *et al.* 2015, Cruz *et al.* 2020, Doumecq *et al.* 2023, Jiménez-Escobar 2021, Jiménez-Escobar & Martínez 2019), they were not cited as selection or evaluation criteria for firewood in our study area.

As described by Fernández (2017) and Jiménez-Escobar (2021), the most significant number of uses of firewood are concentrated in cooking and food preparation and the ignition and production of fires in combustion devices; it is also identified that users prefer to select species with high calorific value, that generate embers, flames, and light quickly. Local categories define this species as good, hard, heavy, soft, and light. These attributes were also considered in rural communities of Chaco Seco, Pampa and Patagonia linked to food preparation and cooking; the selection of some firewood to improve the flavours of traditional foods (Doumecq *et al.* 2023) was not cited in our regions.

This study identifies that the type of use influences both extraction and consumption of firewood in each case and by the attributes recognized by each cultural group (biological aspects, intrinsic properties, or biophysical characteristics of each species). The settlers generally use firewood from shrubs and arboreal species of medium to large size, stating that when they reach maturity, they are harder, denser, and heavier and provide good firewood for combustion. Similar situations have been reported in other regions, where large native trees are chosen for the same application (Bhatt & Tomar 2002, Cardoso *et al.* 2015, Martínez 2015). Among the Guarani, we observed less selective use of the dimensions of the individuals to be employed, as was indicated in other latitudes where the dimension of the plants was not a modeller criterion (Martínez 2015, Ramos *et al.* 2008a). Although the general characteristics of the species linked to the size of the specimens used have been explored previously, the detailed understanding of this aspect remains a pending topic in the current literature.

The fact pointed out by the settlers about choosing dry material during the collection, or collecting freshly cut wood of species considered valuable and waiting until it is adequately dried, coincides with the reports in northeastern Brazil, western Dominican Republic, and central Malawi, where was indicated that they use and prefer dry wood (Abbot & Lawore 1999, May 2013, Ramos *et al.* 2008a). On the other hand, the Guarani combine dry and green firewood in the stove since the green resource supports the rest of the cooking utensils and keeps them burning longer; similar management was reported in Patagonia, Argentina (Cardoso *et al.* 2013). This could be associated with a saving strategy as firewood transportation from the collection area to the DU is carried on shoulders in small quantities limited by weight or as a strategy to take advantage of woody plants that have fallen due to bad weather. Also, the Guarani reported that good and dry wood splits easily, which reduces physical effort and facilitates transportation in smaller and lighter pieces (Table 2).

On the other hand, to light and produce fire, they choose pieces of wood of different shapes and sizes that are recognised and collected from different parts of the plant and waste from other activities (Table 2). This process involves the usual choice of thin branches, fragments splinters of the foliage of plants, pieces of cut wood, and dry logs, and it is interesting to note that, in the case of settlers used residues from the harvest of **yerba mate** (*Ilex paraguariensis).* Thus, the knowledge is not limited to a specific range of species but covers a set of physical characteristics of firewood that are directly linked to the efficiency of combustion and the purpose pursued. In this sense, previous investigations, such as those carried out by Cardoso *et al.* (2015) and Doumecq *et al.* (2023), have pointed out that the woody materials used to start the fire are often low-quality components within the general repertoire but that are used and become relevant when they can generate good combustion with thicker pieces of wood.

Both cultural groups highlighted good combustion (understood as the production and duration of flame and embers) as the selection criteria. The same factors were reported in other studies (Jiménez-Escobar & Martínez 2019, Kituyi *et al.* 2001, Tabuti *et al.* 2003).

In addition, hard and heavy species meet these energetic conditions that are constantly required, which coincides with that detailed by Ramos *et al.* (2008b). In the same way, Marquez-Reynoso *et al.* (2017) explained that species are chosen for their heat release during combustion and that these desirable attributes are always considered positive. The Guarani match these descriptions but added that good combustion also involves producing good quality ashes to cook their typical meals, which requires a refined knowledge and a combination of hard and soft firewood to generate warm and clean ashes to keep the temperature and not contaminate the food with intense flavours or unwanted odours.

The mixture of firewood is also reported in different regions to improve the fire's quality and duration and optimise the material's combustion; it is also considered a strategy to reduce pressure on specific groups of plants used as firewood (Morales *et al.* 2017a). This practice is shared among the settlers; they usually mix exotic species, incorporated in peri-domestic plantations and windbreaks, and harvested in their plots to provide wood as raw material in various applications, including as a source of heat (Morales *et al.* 2017a). So, exotic species with similar biophysical properties can cover part of the demand for native species (Jiménez-Escobar *et al.* 2021).

In future studies in the region, it will be interesting to evaluate whether incorporating exotic species can be a diversification strategy to enrich the set beyond the native species already used or to complement scarcity due to changes in land use (Albuquerque 2006). Users carried out plantations modelled by their cultural features (Martínez & Manzano García 2019).

Regarding preferred species, users highlighted a small group of the species mentioned and used firewood for their attributes on energy quality (intrinsic properties). The most outstanding are the heat they generate, the production of long-lasting embers and the generation of clean flames without smoke. These attributes are related to combustion, in which perceptions and cultural preferences are essential for both the settlers and the Guarani.

Several authors have addressed this issue in different regions and agreed that the preferred species are defined by their thermal qualities and their perceived attributes and that the condition of the same species may vary from one cultural group to the other. For example, Tabuti *et al.* (2003) have reported that preferred species have to burn without smoke, produce good embers and spark-free flame; Ramos *et al.* (2008a) cited species preferred for their combustion properties based on strong embers and durable flames; Cardoso *et al.* (2012a) found that wood hardness and duration of the embers are the most important attributes to define the preferred species in a Mapuche community in northern Patagonia. In the present studies, we observed similar perception differences, for example: for the settlers, Helietta apiculata is the most preferred species for firewood for its energy quality, while for the Guarani, it appears in the fifth position, mainly associated with the good flame and little smoke (Table 3).

In the same way, Bhatt & Tomar (2002), Jiménez-Escobar & Martínez (2019), and Marquez-Reynoso *et al*. (2017) agreed that preferred species are associated with duration of flame and embers and the high calorific value they release during combustion. Further, Cardoso *et al*. (2015) and Morales *et al*. (2017a), in agreement with what is observed at present, described that besides assessing energy characteristics, preference also depends on ritual or cultural perceptions attributed to firewood species.

Conclusion

Firewood harvesting practices are guided by cultural attributes emphasizing physical characteristics such as wood quality and good combustion. In addition, the Guarani state that in certain situations, the selection is also guided by other cultural factors related to the way of cooking typical foods in their culture (species that generate hot ashes or maintain heat and do not contaminate cooked food). Both cultural groups use and prefer native species as firewood. However, settlers also use exotic species because they value their qualities, particularly those associated with clean flame generation and rapid growth.

It was also detected that there is a group of preferred species among all the firewood used for the settlers and the Guarani. These species are defined by cultural attributes that characterize woody species as good fuel according to their physical properties or desirable qualities. Within this set of attributes, we detected that preferences vary according to their cultural profile and specific applications.

Finally, through local terminology and categories, we identified and delimited the grouping categories according to firewood's physical properties, considering traditional knowledge and practices. This classification plays a key role in interpreting woody species' qualitative (combustion) characteristics because it contains several distinctive and culturally significant elements.

Declarations

List of abbreviations: Se – Settlers; G – Guaranies; DU – Domestic Unit; VP – Value of Preference; PCA – Principal Component Analysis; N - Native; E - Exotic; MGS - Mario Gabriel Sackser; NH - Norma Hilgert; HK – Héctor Keller.

Ethics statement / Prior Informed Consent: Argentina national legislation does not require prior approval by a research ethics committee to conduct ethno-biological studies. This research was carried out with the authorization of the provincial agency (Provision 011/19, to Dr. Norma I. Hilgert), Directorate of Biodiversity of the Ministry of Ecology and Renewable Natural Resources, MEyRNR, file Nº 9910-00058/12. Prior to the interviews, we obtained written informed consent from each participant.

Consent for publications: The interview data were transcribed in quotation marks and italics; in parentheses the initials of the name and surname, and the ages of the interviewees were indicated.

Conflicts of Interest: The authors declare that there are no conflicts of interest in this article.

Data Availability statement: The figures and tables supporting the results of this study are included in the article, and the original data sets are available from the first author upon request.

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Author's contribution: MGS, NH and HK designed the study. MGS did the fieldwork, analyzed and interpreted the data and prepared the initial version of the manuscript. MGS and HK identified the species. NH and HK guided and reviewed the drafting of the work. All authors read and approved the final manuscript.

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