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Dynamics of the botanical knowledge of the Laklãnõ-Xokleng indigenous people in Southern Brazil

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ABSTRACT

We analyzed the botanical knowledge of the Laklãnõ-Xokleng people in the Ibirama Laklãnõ Indigenous Territory. They are the last remnant of this ethnicity living in a unitary socio-political organization. The objective was to investigate the dynamics, distribution and transmission of botanical information. We interviewed 112 people in two villages about known and used plants. Data were collected through structured socioeconomic questionnaires, free lists and walk-in-the-woods tours. Data were analyzed using descriptive statistics and metrics of social network analysis. Of the 314 plants mentioned in the interviews, 77 % were currently used, 15 % were used in the past, and 8 % were known but never used. Men cited more plants than women. We found no correlation between the distribution of knowledge and age, but there was a relationship between families that valued Laklãnõ-Xokleng culture and individual knowledge. Transmission of knowledge about plants used medicinally and for handicrafts occurs mainly between generations and during childhood. Transmission networks emphasize the central position of elders as knowledge transmitters for their families. Different network topologies reflect particular dynamics in the medicinal and handicraft use of plants. External and internal pressures have caused changes in the transmission of the botanical knowledge of the Laklãnõ-Xokleng.

Keywords: cultural transmission, indigenous people, knowledge distribution, Laklãnõ, plant knowledge dynamics, social network analysis, Xokleng

Introduction

Interfaces between people and the environment are mediated by the complex interactions of human minds, culture, plant knowledge, practice, and choice (Müller-Schwarze 2006). Indigenous people can have alternative knowledge and perspectives based on their practices of managing natural resources (Berkes *et al*. 2000) and based on their own worldview and beliefs. Their adaptation to a given environment, built through generations and based on practical experience, results in the accumulation of unique knowledge about the importance of different species in an ecosystem (Gadgil *et al*. 1993).

Numerous authors have highlighted these relations in studies with indigenous groups in the Neotropics. For example, Hames (1980) observed hunting rotation among the Ye'kuana in Venezuela, and Colchester (1997) described that the Sanema, Yanomami of northern South America, space out their groups to minimize the impact on their environment. Paniagua-Zambrana *et al*. (2014) investigated the influence of socioeconomic factors on traditional knowledge about palms in the Amazon, Andes, and Chocó regions of northwestern

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South America, and Atran *et al*. (2002) studied how social, economic, demographic, and ecological factors influence environmental management and maintenance within distinct groups living in northern Guatemala. In Brazil, Balée (1994) studied the Ka'apor and recorded the enrichment of plant biodiversity in secondary forests due to human activity and ritualistic regulation of hunting. Posey (1985) observed that the Kayapó adopt a rotational system of planting that enriches the forest with species useful for food. More recently, Ribeiro *et al*. (2014) showed that the management of Brazil nut trees among the Kayapó influenced the dispersion of the species in the Amazon. However, only a few ethnobiological studies exist about the non-Amazonian indigenous peoples of Brazil. For example, Haverroth (2007) investigated the use, names, and classification of plants among the Kaingang, especially those considered medicinal, Oliveira (2009) recorded the relationships among the cosmovision, agriculture, spirituality, and cures of the Guarani, and Albuquerque *et al*. (2011) registered the influence of age and gender on Fulni-ô knowledge about medicinal plants.

Academia has shifted from a static view of traditional knowledge to a dynamic one (Aswani *et al*.2018). Gómez-Baggethun *et al*. (2013) analyzed case studies worldwide and found pockets of Traditional Ecological Knowledge (TEK) suggesting hybridization of traditional knowledge with new knowledge and technologies creating new knowledge systems. Earlier studies show that the economic and social pressures from globalization have resulted in changes in local livelihoods and, consequently, in adaptations of traditional knowledge and livelihood strategies due to new pressures, identities, and health and school systems (Pilgrim & Pretty 2010; Wyndham 2010; Paniagua-Zambrana *et al*. 2014). Thus, it is important to understand the dynamics of transformation, incorporation, perpetuation, and loss of indigenous knowledge (Reyes-Garcia *et al*. 2013).

Behind management practices and traditional knowledge lie social mechanisms of adaptation, which provide the generation, accumulation, and transmission of knowledge (Berkes *et al*. 2000). Cultural transmission plays an important role in traditional knowledge (Berkes *et al*. 2000). It is a social mechanism in which the culture's technological knowledge, behavior patterns, and cosmological beliefs are communicated and acquired (Hewlett & Cavalli-Sforza 1986). Knowledge transmission is conducted through everyday practices, such as learning by doing, helping adults with daily tasks, participating, observing and copying adults, interacting with the natural environment within a cultural context, developing abilities required for practical actions (Wyndham 2010; Zarger 2011), and by oral transmission (Berkes *et al*. 2000). In this sense, Cavalli-Sforza *et al*. (1982) indicate three main paths for the transmission of knowledge: vertical between generations related by kinship, horizontal within the same generation, and oblique between individuals of different generations without kinship relation.

Identifying patterns in the distribution of knowledge is the first step to comprehending knowledge transmission (Hopkins & Stepp 2012; Gaoue *et al*. 2017). Knowledge is not uniformly distributed in a community. Different sociodemographic factors correlate with this distribution, such as age, sex, formal education, kinship, place of residence, level of integration, and market economy (Reyes-Garcia *et al*. 2013). Formal education through schools, for example, may become a negative driver when not considering the use of local resources, knowledge, and culture (Cruz-Garcia 2006). However, other authors point to successful initiatives to integrate knowledge and local culture into school subjects, such as the use of local language, exploratory and outdoor activities to identify and collect plants, and flexible timetables, so that students can participate in culturally relevant activities outside of school (Cruz-Garcia 2006; Wyndham 2010; Zarger 2011).

In addition to socioeconomic issues and institutional constraints, other dimensions of knowledge affect the way people learn to manage environmental resources. For example, in the case of the Itza' Maya of Guatemala, the belief in supernatural beings that regulate reciprocity in the relationships among humans, plants, and animals influences the way they manage their environment (Atran *et al*. 2002).

A second step to understanding change in knowledge transmission throughout time is to relate such distribution to characteristics of the members of a given community (Hopkins & Stepp 2012). Recent studies have begun to use social network analysis to explore the exchange of home garden products and related knowledge (Díaz-Reviriego *et al*. 2016). This kind of analysis provides new insights about how knowledge flows through social relations, focusing on the structure of social networks, the position of nodes in relation to their centrality, and the distribution of knowledge (Hopkins 2011; Reyes-Garcia *et al*. 2013). Associating attributes, such as age and gender, with relational variables, such as network centrality measures, gives us more information to understand the variation and transmission of knowledge (Hopkins 2011). Network analysis is useful to investigate this second step, helping in the visualization of different members of a community and how they interact.

In this article, we use social networks to explain the paths of the transmission of knowledge about plants among an indigenous group from southern Brazil. Thus, the objective of this work is to analyze dynamic features in the distribution and transmission of plant use knowledge among the Laklãnõ-Xokleng, Amerindians belonging to the Jê linguistic family with a population of about 2,000 people inhabiting an indigenous territory in the Atlantic Forest. This is the last remnant of this ethnicity that still lives in a unitary sociopolitical organization. Therefore, registering and valuing their unique knowledge is highly relevant. Unlike indigenous peoples from tropical rainforests, such as the Amazon, most indigenous ethnic groups in southern Brazil live in small indigenous territories close to urban centers and small forest fragments, with populations that have become dramatically reduced since European colonization.

Materials and methods

Study area: The Laklãnõ-Xokleng and their territory

Prior to European colonization in southern Brazil, the Laklãnõ-Xokleng inhabited an area between the coast and the highlands (25ºS - 30ºS) that includes parts of the current Brazilian states of Paraná, Santa Catarina and Rio Grande do Sul (Santos 1973). European colonization in the region began in the late 1800s, and during this time conflicts increased between different indigenous groups and with newcomers. The Laklãnõ-Xokleng territory was gradually occupied, and the group became restricted to forested mountainous regions in Santa Catarina State (Santos 1973). In 1908, brutal colonization events were internationally reported, resulting in the foundation of the Service of Indian Protection (Serviço de Proteção ao Índio or SPI) in 1910, which incorporated a policy of creating posts of attraction for indigenous people. After establishing contact in these posts of attraction, indigenous people were confined to a circumscribed area, allowing colonizers to occupy the remaining areas (Pereira 2004). In 1914, the Platê River Post was created (Santos 1973; Urban 1978). This established contact with a population of about 300 to 400 people (Henry 1964), from which present-day Laklãnõ-Xokleng, who live in the Ibirama Laklãnõ Indigenous Territory, are descendants. In 1965 the post was officially demarcated as an indigenous territory.

Before contact, the Laklãnõ-Xokleng had been facing a series of changes, shifting from a semi-nomadic habit typical of Jê people (Urban 1978), where they lived part of the year in villages cultivating food and then divided into smaller groups to spend time hunting and collecting, to a nomadic habit, where they lived exclusively as hunter-gatherers (Henry 1964). After 1914, changes in Laklãnõ-Xokleng livelihoods increased. It is estimated that, from that date on, two-thirds of the population died due to diseases contracted from colonizers, reducing their population to only 106 individuals by 1932 (Henry 1964).

Changes that followed the establishment of the post and indigenous territory, and the inability to access and use extensive areas, resulted in livelihoods that were more dependent on cultivated food crops and orchards in the Platê and Itajaí do Norte river valleys, with influenced eating habits (Pereira 2004). Due to the epidemics that killed two-thirds of the Laklãnõ-Xokleng population, rituals were abolished, and these circumstances contributed to changes in values, beliefs and customs (Pereira 2014; Santos 1973).

The construction of a road inside the indigenous area in the 1950s encouraged natural resource exploitation to supply the outside market, mainly for juçara heart of palm (*Euterpe edulis* Mart.) and native timber, which reached its peak in the 1980s (Namen 1994). Another strong impact on the Laklãnõ-Xokleng livelihood was the construction of the Barragem Norte Dam, which started in 1976 with the objective of preventing floods in the major cities in the lower and middle Itajaí River Valley (Namen 1994). The dam took about 16 years to complete and contributed to an increased rate of inter-ethnic marriages and the arrival of the evangelical Christian religion and conventional schooling, which impacted the Laklãnõ-Xokleng culture and language. The first flood resulting from the construction of Barragem Norte Dam happened in 1979 and inundated agricultural areas, orchards and residences near the rivers. Several families lost their crops and houses and were forced to move to higher ground, mostly mountain slopes, and split into smaller settlements, which resulted in increased internal disputes and discontinuity of traditional cultural practices (Pereira 2004).

Currently, the Laklãnõ-Xokleng Indigenous Territory (IT) is 14 thousand hectares; in August 2003 the Brazilian Ministry of Justice granted an extension to make the territory approximately 37 thousand hectares, but this decision remains in litigation. The IT is located within the municipalities of José Boiteux, Doutor Pedrinho, Itaiópolis, and Vitor Meireles (Fig. 1), in the Atlantic Forest. The multiethnic population at Ibirama-Laklãnõ IT totals 2088 people (SIASI 2013); most are Laklãnõ-Xokleng, but there are also Guarani, Kaingang and non-indigenous families. In 2013 they were distributed in eight villages: Barragem, Sede, Pavão, Palmeirinha, Figueira, Coqueiro, Toldo, and Bugio. The research took place in two villages with distinct climates, vegetation and historical characteristics. Bugio village is at 900 m elevation, in a transitional zone between mixed and dense rainforest (ombrophile forest), while Sede village sits in the valley between the Hercílio and Platê rivers, 300m above sea level, in a region of dense rainforest. Sede is the older settlement, located in the area where contact was made in 1914. Bugio, on the other hand, is a village settled after the floods caused by the Barragem Norte Dam in 1979.

Data collection

Before research began, we obtained consent and authorization from the indigenous leaders and authorization from the National Indian Foundation (Fundação Nacional do Índio [FUNAI]) and the Institute of National Historical and Artistic Heritage (Instituto do Patrimônio Histórico e Artístico Nacional [IPHAN]) in order to access Laklãnõ-Xokleng traditional knowledge. We also received authorization from the Ethics Committee for Research with Human Beings at the Federal University of Santa Catarina in Florianópolis, Brazil.

Field activities were conducted for eight weeks between 2012 and 2013. For data collection and analysis, we used qualitative and quantitative approaches, as recommended by Amorozo (2010). Interviews were carried out with all adults

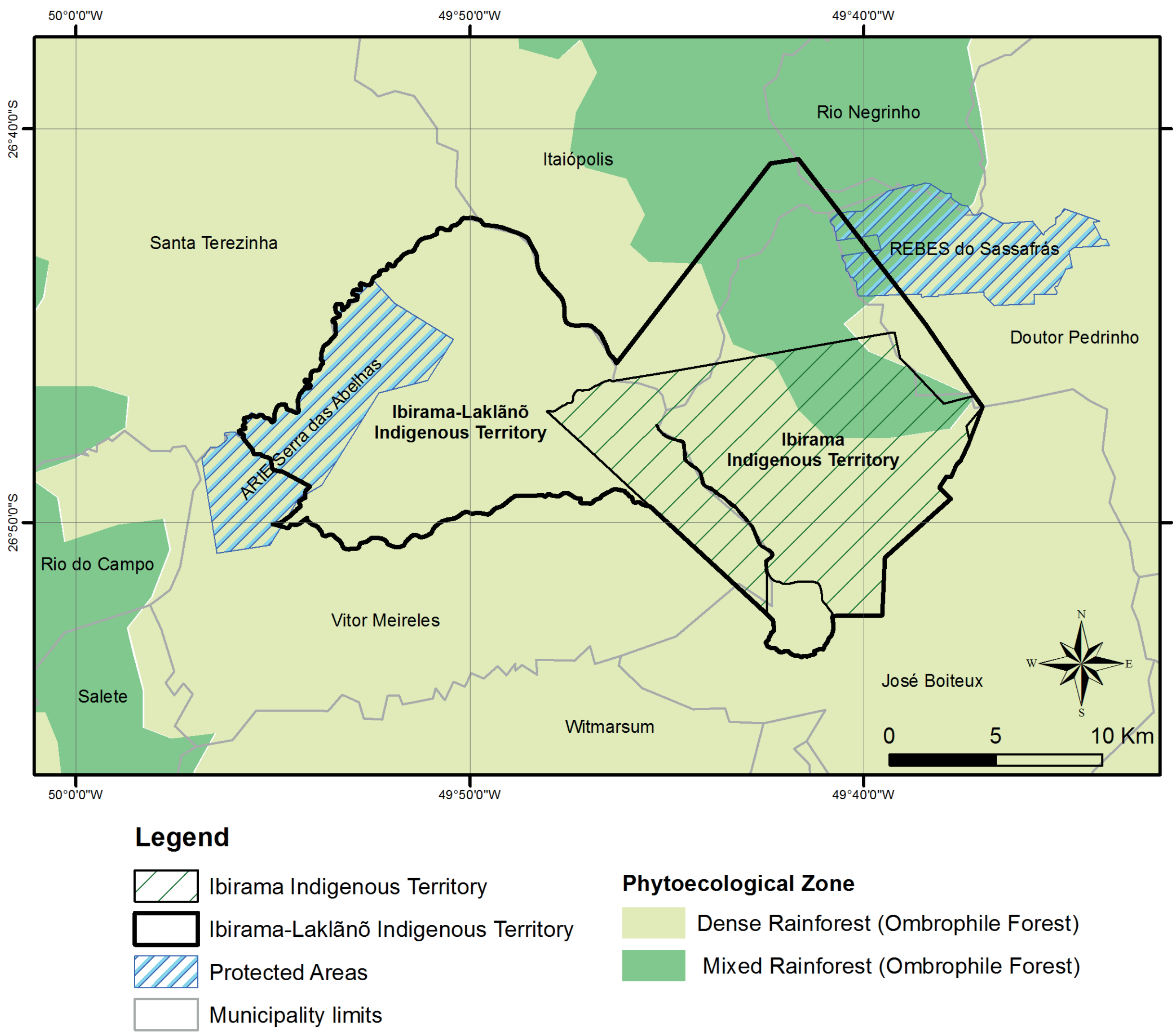

Figure 1. Ibirama Indigenous Territory and Ibirama-Laklãnõ Indigenous Territory (elaborated from cartographic database: Indigenous Territories - FUNAI, Municipality limits - IBGE, protected areas – MMA, and Klein's vegetation map available at: https://sites.google.com/view/iffportal/produtos/mapas.

who agreed to participate (112 people: 43 in Sede village and 69 in Bugio). In both villages, the percentage of female interviewees (58 %) was higher than male interviewees (42%). The average age of the interviewees was 45 years in Sede and 42 years in Bugio.

We used two structured questionnaires (Bernard 2006) with semi-open questions that were pretested with a small group of interviewees. Two researchers went to every house in the two villages, conducting interviews with each resident separately. The researcher read the question and registered the answers. The Portuguese language was used in the interviews as all of the interviewees were fluent in it. The first questionnaire was about socioeconomic characteristics and was applied to family units. We defined the family unit as a nuclear family living in a house consisting of a husband and/or wife, children, and sometimes grandparents and grandchildren.

The second questionnaire consisted of free-listing plants and was applied to all residents over 18 years old who were willing to participate. Interviewees were encouraged to cite all known and used plants and were asked about each cited plant: uses; part used; where they were found; if they were cultivated or spontaneous; how the plants were processed; if they knew the Laklãnõ-Xokleng name for that plant; and from whom, and when they learned about it. For each plant cited, interviewees were asked if the plant was only known (and not used) or if it was actually used, in the present or past. We assumed that there would be limitations to this method, mainly related to the remote memory of elder people, and to the cases of individual learning by her/his own experience rather than by following a model. For example, for some plants there may have been inaccuracy in recalling from whom and when they first learned about it. The free-listing technique was based on the procedures used by Atran *et al.* (2002) and Hopkins (2011), measuring expertise among individuals was based on Hopkins & Stepp (2012), and recording when and where interviewees had begun to use wild plants, who had taught them, and where and how they had been taught was based on Lozada *et al.* (2006).

Plants cited during free-listing were collected on guided tours (Albuquerque *et al.* 2010) with some of the interviewees around their houses or on forest trails. We followed the Angiosperm Phylogeny Group (APG) III system for botanical identification, and vouchers (collector numbers 1 to 172) were deposited in the herbaria FLOR (UFSC, Florianópolis) and EAFM (IFE, Manaus).

Data analysis

We combined qualitative data with quantitative analysis to build a more comprehensive scenario about the plant knowledge dynamics. Plant uses were a priori classified into nine different use categories adapted from Poderoso *et al.* (2012): food, medicinal purposes, handicrafts, building, utensils and tools, firewood, symbolical use, ornamentation, and other uses. For some analyses, in order to add more detail concerning the knowledge about plants, we established three subcategories of knowledge: (1) the person heard about the plant, but never used it (knowledge only); otherwise, the person heard about the plant and used that plant, and this use would either be (2) present (when it was part of his or her everyday life) or (3) past (when the person had used the plant in the past, but did not use it any longer). Ladio & Lozada (2004) emphasized the importance of separating knowledge from use because this allows the comprehension of possible drivers associated with the erosion of knowledge.

We analyzed the distribution of knowledge about plants according to gender by comparing the means of plants cited by each group (men and women), for each use category, using the Mann-Whitney U test. To analyze the knowledge distribution according to age, we verified whether there was a correlation between citation frequency and age, using the nonparametric Spearman correlation coefficient with $\alpha = 0.05$. We used BioEstat 3.0 (Ayres *et al*. 2003) for these analyses.

We selected the two categories of use (medicinal purposes and handicrafts) with a higher number of citations to analyze knowledge transmission. We excluded the category food plants due the uniformity in learning: the use of most food plants occurred during childhood. We considered the following stages of life when people learned about plants: childhood (0 to 11 years old), youth (12 to 28 years old), and adulthood (29 years old and above). We used metrics from a social network analysis to better visualize and, consequently, comprehend the dynamics of information flux. Information about "with whom, and when each plant was learned" was analyzed through sociograms using an ego-centered network without alter connections, which means the networks were focused on the individual node, and not on trying to comprise the network as a whole (Souza & Quandt 2008); therefore, connections between alters (secondary links) were not considered. Also, network limits were not established beforehand.

The characterization of network components using centrality measures provides detailed information on the role of each node in the network (Abay *et al*. 2011).We calculated betweenness centrality in order to understand the importance of different actors in the network dynamics (Marteleto 2001). Betweenness measures indicate how much an actor functions as a bridge facilitating information flux on a determined network. We also employed degree centrality, which measures the number of people with whom a person is directly connected (Díaz-Reviriego *et al*. 2016). Using directed graphs, in which links are not reciprocal but have a specific direction (Hopkins 2011), we calculated the in- and out-degree of the nodes; in our case, in-degree is information received, and out-degree is information transmitted. We calculated the network density measure by dividing the number of existing links by the number of possible links (Díaz-Reviriego *et al*. 2016). Sociograms and calculations of network centrality and density were performed using Pajek 32 3.15 (Mrvar & Batagelj 1996).

Results

A total of 2,186 citations regarding the use and knowledge of 314 plants were registered, of which 277 species were collected and identified, including those used for food (35 %), medicinal purposes (29 %), handicrafts (13 %), building (10 %), tools/utilities (6 %), firewood (3 %), symbolical use (1 %), ornamentation, and other uses (3 %). More than half of the cited plants are spontaneous (59 %), and 41 % are cultivated. Most citations referred to knowledge and present use (77 %), while knowledge and past use (15 %) and only knowledge (8 %) were less cited. The proportion of known and used plants differed for each category of use (Fig. 2).

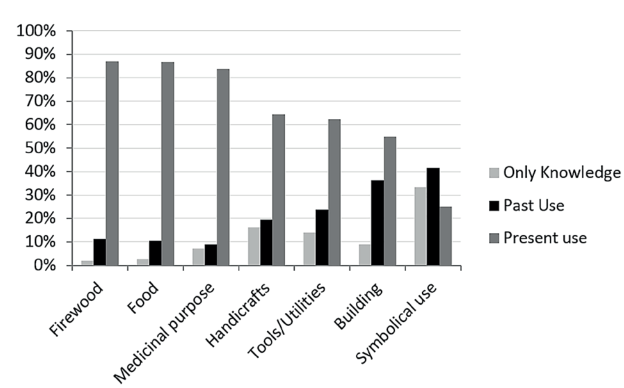

Figure 2. Plant use citations among different categories (n = 2009 citations of plant use in 112 interviews) in the Bugio and Sede villages, Ibirama-Laklãnõ Indigenous Territory.

Categories such as firewood, food, and medicinal purposes were more predominant in present use, and the categories utensils and tools, building, and symbolical use had the lowest present use. Plants cited as "only known" were mainly within the categories of handicrafts (28 %) and medicinal purposes (26 %), followed by food (13 %) and building (12 %). Some examples are the following: palm leaves (Arecaceae, various species) to cover shelters; *caeté* (Marantaceae) and *taquara* (Bambusoideae, various species) to cook food inside and to make baskets; *mamãozinho do mato* (*Jacaratia spinosa*) to eat; and *urtiga-brava* (*Urera baccifera*) to make blankets.

For 135 cited plants, a Laklãnõ-Xokleng name was not recorded. Some of these were plants introduced after contact and perhaps had never been given a Laklãnõ-Xokleng name, for example, *batata-salsa* (*Arracacia xanthorrhiza*), *pontaliv* (*Achillea millefolium*) and *eucalipto* (*Eucalyptus* sp.). It is also possible that the Laklãnõ-Xokleng names of some plants have been forgotten. Of the 135 plants, 37 % are exotic, and 63 % are native species. The Laklãnõ-Xokleng might have used some of the latter, and the lack of designations in native language may reflect a vocabulary loss regarding plant names, or the recent incorporation of some native species into the Laklãnõ-Xokleng ethnobotanical repertoire.

In contrast, we observed that the use of many plants has been perpetuated in the Laklãnõ- Xokleng culture. Some of the plants appear in ancient records of microbotanical remains found at the Bonin archaeological site, a Jê site located in Urubici, dated to approximately 600 BP (Corteletti 2012), such as corn (*Zea mays*), pumpkin (*Cucurbita* sp.), manioc (*Manihot* sp.), beans (*Phaseolus* sp.), and yam (*Dioscorea* sp.). Other species appear in the Henry (1964) records of plants used by the Laklãnõ-Xokleng, such as cedar (*Cedrela fissilis*), *sassafrás* (*Ocotea odorifera*), *Philodendron bipinnatifidum*, queen palm or coco palm (*Syagrus romanzoffiana*), araucaria (*Araucaria angustifolia*), and *mamão-do-mato* (*Jacaratia spinosa*).

Changes in the way plants are used were also registered. For example, some plants have had their uses and meanings transformed over time, such as *sassafrás* or ***tutol*** (*Ocotea odorifera*), which had a symbolic use of protection in the supernatural realm and was used in burial and cremation rituals (Henry 1964). Currently, it has been cited for its medicinal use for treating flu symptoms. In this case, the introduction of Christianity transformed the Laklãnõ-Xokleng perception of spiritual threats.

Nevertheless, *sassafrás* maintains its importance, since its use was adapted to a new threat: diseases brought by the whites. According to the interviewees, *xaxim* or ***gig*** and ***lavekutxug*** (*Dicksonia sellowiana*) were used in the past for making ***Mõg***, a fermented beverage used in rituals. Today, ***Mõg*** is associated with rituals by some, while others convey a more contemporary meaning associated with celebrations of Brazilian Indian Day. Guiné or ***zunh*** (*Petiveria alliacea*) was used to treat snake bites in the past. Currently, it is still known for treating snake bites and was also cited as a snake repellent. Numerous objects previously considered everyday tools/utilities are still made today with the objective of selling them as handicrafts, which has transformed manufacturing techniques. Bows and arrows, for example, which were as tall as a man, are currently made as miniatures that are approximately 40 cm long.

Knowledge dynamics are also associated with the incorporation of practices and values of other cultures. Necklace making was cited by some interviewees as an ability learned from the Guarani who have resided in the Indigenous Territory (IT) since 1950 (Namen 1994). According to some interviewees, interaction with the Kaingang has also influenced the use of leaves for food.

On average, men cited more plants than women did. The mean plant citation was 19.96 for men and 14.95 for women, and this difference is significant (Mann-Whitney p=0.01). The higher citation of plants by men occurred especially for three categories of use related to timber (tools/utilities p=0.001, building p=0.000 and firewood p=0.002), showing that men knew more plants for those purposes than women did.

There was no correlation between plant citation frequencies and interviewee age (Spearman p= 0.125). Seven interviewees cited a higher number of plants, and their ages varied from 26 to 74 years. All of them came from families that used and valued such knowledge.

Most of the cited plants for handicrafts (63 %) were learned during childhood, mainly from the father (23 %), mother (19 %), grandfather (18 %), and grandmother (10 %). Medicinal plants cited (53 %) were also learned during childhood (Tab. 1). The most important knowledge transmitters cited were the mother (26 %), father (14 %), grandmother (14 %), and grandfather (9 %). In the Laklãnõ-Xokleng culture, grandparents have a fundamental role in raising children. This can be seen in Laklãnõ-Xokleng language, which uses the word ***jõ*** for both mother and grandmother and ***jug*** for both father and grandfather.

Table 1. Synthesis of information about when and with whom interviewees learned about plants of artisanal and medicinal uses.

	Artisanal plant use %	Medicinal plant use %
When they learned?		
Child (0-11)	63	53
Adult (29 on)	26	33
Young (12–28)	11	14
	n = 202 citations	n = 470 citations
With whom they learned?		
Father	23	14
Mother	19	26
Grandfather	18	9
Grandmother	10	14
Husband	8	1
Wife	1	1
Others	20	35
	n = 239 citations	n= 616 citations

Although we did not find any difference in relation to gender regarding knowledge distribution of medicinal plants and plants used for handicrafts, there was a difference in transmission of such knowledge: plants used for handicrafts are learned mainly from men (41 %), fathers (23 %), and grandfathers (18 %), and medicinal plants are learned mainly from women (40 %), mothers (26 %), and grandmothers (14 %).

Two sociograms (Figs. 3, 4) illustrate knowledge transmission about plants used for handicrafts and medicines, respectively. Enumerated vertices, or nodes, represent individuals, and arrows, or links, represent information transmission from one individual to another. Nodes were distinguished according to gender (men are represented by squares and women by circles) and village of residence (red nodes for Bugio Village and yellow nodes for Sede Village). White nodes were used when we did not have information about residence, since a considerable number of individuals mentioned were deceased. Arrow thickness increased according to the number of plants taught to others.

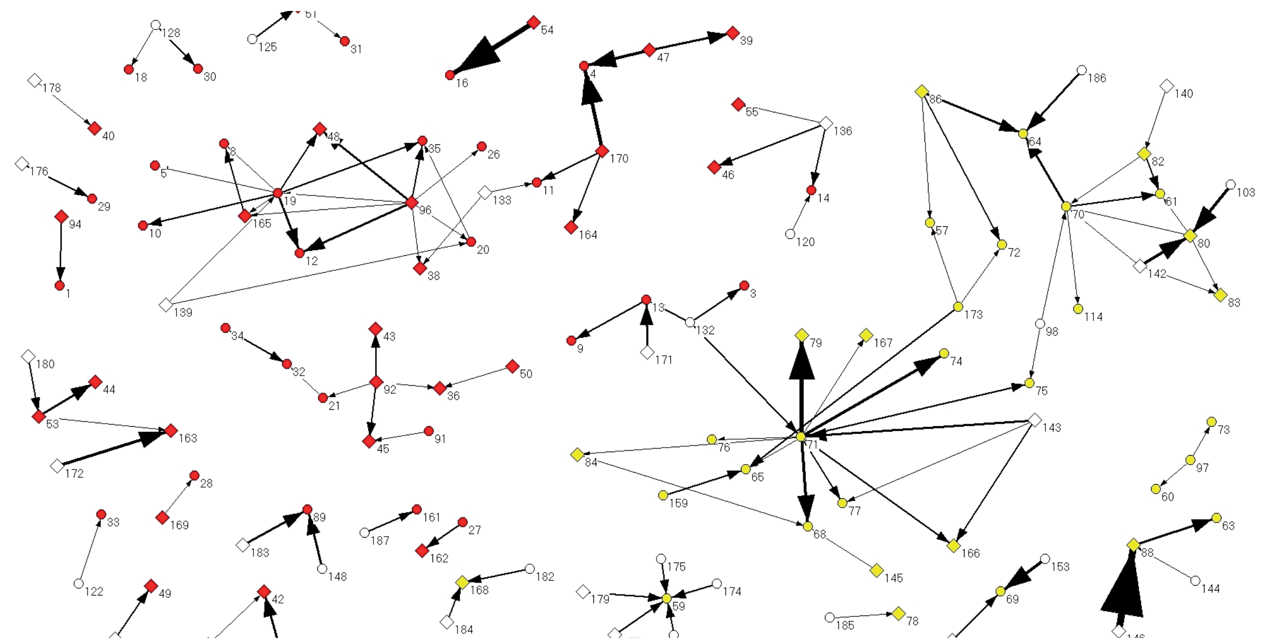

Figure 3. Sociogram - Knowledge Transmission Network of plants used for handicrafts (125 vertices and 247 transmitted information citations).

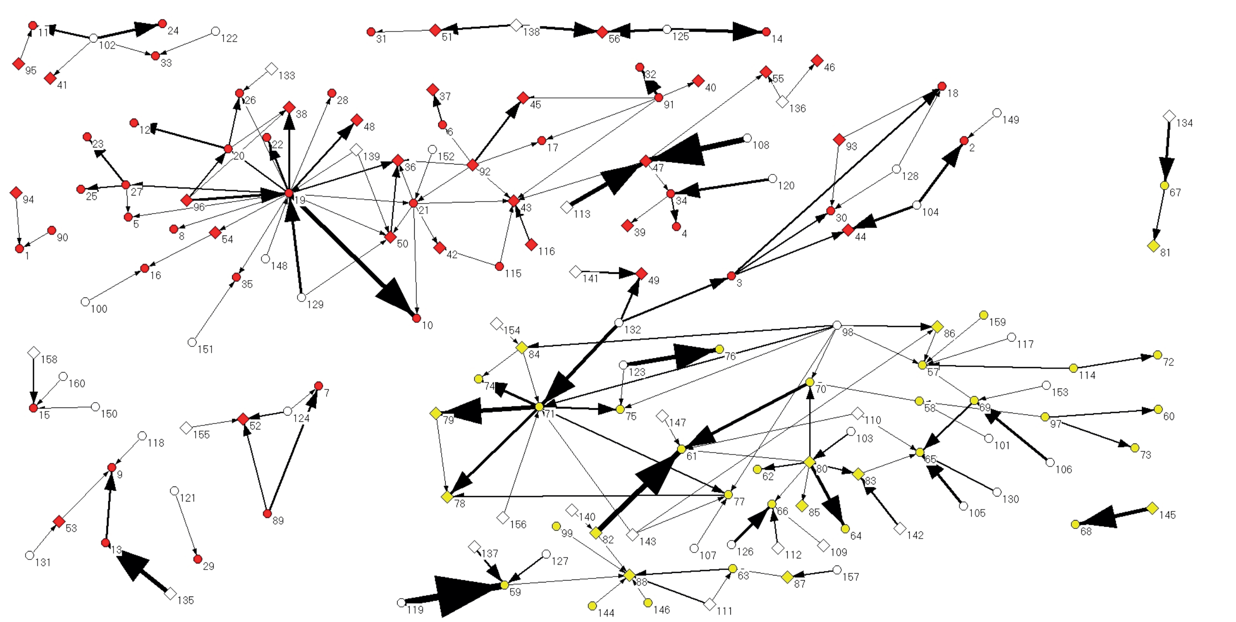

Figure 4. Sociogram - Knowledge Transmission Network of plants used for medicines (160 vertices and 429 transmitted information citations).

The transmission of information was quantified by counting the number of links that left each node. These outgoing links, out-degree, represented the number of people to whom an individual had transmitted information; the number of plant citations consisted of the amount of information transmitted (Tabs. 2 and 3, respectively). Some individuals stood out because they had more arrows leaving them, out-degree, compared to other nodes. We defined transmission cores as nodes that had four or more out-degree links. In the sociogram of plants used for handicrafts (Fig. 3, Tab. 2), there were four transmission cores: I-19, I-96, I-92, and I-71. We detected the presence of eight transmission cores with four or more out-degree links in the sociogram of the knowledge transmission network of plants with medicinal use (Fig. 4, Tab. 3): I-19, I-98, I-80, I- 92, I-21, I-71, I-91, and I-102. Three of the eight cores were repeated in both networks: I-19, I-92, and I-71. I-19 and I-71 were midwives who are 78 and 74 years old, respectively. I-92 was an 80-year-old man, who is currently an evangelical pastor but had worked with agriculture and timber harvesting in the past. These social roles were probably responsible for the central position in transmission of knowledge of these elders in both networks.

Table 2. Synthesis of information related to the knowledge transmission network of handicraft plants: number of outgoing links (out-degree), number of information transmission citations, number of total free-listed citations, and betweenness centrality regarding individuals with two or more links. *Individuals that did not participate in free listing.

Individual[1]	#out-degree	#transmitted information	#free-listed plant citations	Betweenness Centrality
I-71	10	25	36	0.001143
I-96	8	15	*	0.000000
I-19	7	12	18	0.000571
I-92	4	7	7	0.000000
I-170	3	12	*	0.000000
I-70	3	7	15	0.000889
I-142	3	6	24	0.000000
I-143	3	6	*	0.000000
I-173	3	5	12	0.000000
I-136	3	5	23	0.000000
I-80	3	4	45	0.000317
I-86	3	6	19	0.000000
I-47	2	9	24	0.000000
I-128	2	5	36	0.000000
I-53	2	4	23	0.000127
I-82	2	3	21	0.000254
I-133	2	2	*	0.000000
I-98	2	2	25	0.000000
I-97	2	2	*	0.000000
I-139	2	2	*	0.000000

[1] beyond the 20 listed individuals, there are an additional 48 individuals with only 1 link, transmitting 1 to 10 pieces of information. The number of nodes surpasses the actual number of links in the network (125) because it comprises nodes from both transmission networks (i.e., handicraft and medicinal).

Table 3. Synthesis of information related to the knowledge transmission network of medicinal plants: number of outgoing links (out-degree), number of information transmission citations, number of total free-listed citations and betweenness centrality regarding individuals with two or more links. *Individuals that did not participate in free listing.

Individual[1]	#out-degree	#transmitted information	# free-listed plant citations	Betweenness Centrality
I-19	15	33	18	0.003095
I-98	7	14	*	0
I-80	7	15	45	0.000318
I-92	6	10	7	0
I-21	5	5	23	0.000717
I-71	5	24	36	0.003095
I-91	5	11	*	0
I-102	4	10	*	0
I-3	3	8	14	0.000279
I-97	3	5	*	0
I-47	3	3	24	0.000398
I-20	3	6	12	0.000219
I-128	3	4	*	0
I-96	3	7	*	0
I-27	3	7	10	0.000398
I-132	3	14	*	0
I-143	3	4	*	0
I-89	2	7	9	0
I-110	2	2	*	0
I-69	2	5	29	0.000159
I-114	2	4	5	0
I-93	2	2	*	0
I-136	2	3	*	0
I-111	2	5	*	0
I-138	2	8	*	0
I-139	2	2	*	0
I-82	2	9	21	0.00008
I-124	2	5	*	0
I-125	2	9	*	0
I-104	2	10	*	0
I-115	2	2	*	0
I-129	2	8	*	0
I-34	2	3	17	0.000318

[1] beyond the 33 listed vertices, there are an additional 67 individuals with only 1 link, transmitting 1 to 13 pieces of information (n = 100 information transmitting vertices).

In the sociogram of knowledge transmission about plants used for handicrafts (Fig. 3), there were two larger networks of interlinked nodes. One contained only individuals belonging to Sede Village or were undetermined, and another contained individuals belonging to Bugio Village or were undetermined. There were also 22 isolated groups that did not connect to the larger subgroups, which shows this network was highly fragmented, and there were no bridging links between residents of both villages, even though there were large families with members living in each village. The only tie between both villages was represented by I-32, an elderly woman, who transmitted information to her grandchildren and was living at the time in both Sede and Bugio villages.

This was a low-density network (0.00363179 existing links per total of potential links in the network); most vertices had few links, and transmission cores did not connect to one another (except for I-19 and I-96). Knowledge transmission worked more as an irradiation around a few cores than as a flux among different nodes. Betweenness centrality (Tab. 2) revealed that only 12 out of 127 network vertices had the capacity to intermediate, both receiving and transmitting information. Betweenness capacity was not only related to the number of links an individual developed, but also to his or her position in the network (Marteleto 2001). From the four transmission cores, I-71 and I-19 showed the first and third highest degree centrality, respectively, while I-96, totaling nine outgoing (out-degree) links, and I-92, totaling four out-degree links, presented no betweenness capacity. Therefore, I-71 and I-19 were fundamental for knowledge transmission of plants used for handicrafts, since they had a higher out-degree and also held a network position that guaranteed the flux of information transmission.

In the medicinal plant knowledge transmission sociogram (Fig. 4), there are two larger networks related to both villages and 11 isolated groups, presenting a lower fragmentation. Similar to the network of handicraft plant knowledge transmission, there was no transmission between people from both villages, and the only connection between both was through I-32. Based on this, we deduced that the division of the IT into numerous villages, triggered by the construction of Barragem Norte Dam, could have caused ruptures in knowledge transmission, especially due to the geographical isolation of families. These ruptures likely generated consequences not only on individual knowledge, but also on each community's knowledge.

The knowledge transmission network for medicinal plants was more imbricate than the handicraft plants' network. There were more connections between nodes, and more individuals displayed information centrality, totaling 28 nodes with betweenness centrality (Tab. 2); therefore, there was more information flux. Although low, the calculated density for the medicinal plants' network (0.00886719 existing links per total of potential links in the network) was higher than the density found for the handicraft plants' network. This may be related to the fact that there were more citations for medicinal plants (n = 429 transmitted information; handicraft plants' network n = 247). However, there was also an observable structural difference when the networks were compared. The handicraft plants' network had more nodes than links, or more people than transmissions (Tab. 4), while the medicinal plants' network had more links than nodes, or more transmissions than people. Another helpful measure to illustrate increased network activity, independent of sample size, was the percentage of nodes that transmitted information: 53.5 % in the handicraft plants' network and 62.5 % in the medicinal plants' network (Tab. 3).

Table 4. Synthesis of information about knowledge transmission networks for handicraft and medicinal plant use.

	Handicraft	Medicinal
Citations for information transmission	247	429
links	117	180
Citations/links	2.11	2.38
Network density	0.00363179	0.00886719
Nodes	125	160
Nodes that transmit information – frequency	68	100
Nodes that transmit information – percentage	53.5%	62.5%
Transmission cores	4	8
Reception cores	7	22
Isolated groups from main networks	22	11

We considered a reception core a person who had three or more incoming links (in-degree). Hence, there were seven reception cores in the handicraft plants sociogram (I-59, I-70, I-35, I-61, I-64, I-65, and I-68) and 22 in the medicinal plant sociogram (I-88, I-43, I-57, I-61, I-65, I-66, I-71, I-19, I-36, I-50, I-77, I-22, I-15, I-21, I-26, I-38, I-52, I-55, I-59, I- 63, I-70, and I-78). As for transmission of knowledge over time, it is possible that these individuals with higher in-degree will become potential information transmitters in the future and, thus, become key to the perpetuation of knowledge transmission in the long run.

Four reception cores were common to both networks: I-61, I-65, I-59, and I-70. These nodes represented women who came from families that practiced and valued the Laklãnõ-Xokleng culture, reinforcing the importance of family for knowledge distribution, as discussed earlier. It is interesting to note that there was no reciprocity in which transmission and reception occurred between two people. This points to the fact that knowledge transmission occurs mostly in a one-way.

Discussion

The two steps proposed by Hopkins & Stepp (2012) to investigate knowledge dynamics were analyzed through the transmission and distribution of knowledge. Most citations of plants refer to present use (77 %), while past use (15 %) and only knowledge (8 %) were less cited. This indicates a close relation between the Laklãnõ-Xokleng people and their plant resources. Miranda *et al.* (2011) found that of 813 plant citations, 82 % corresponded to plants effectively used by traditional Caiçaras on Cardoso Island, a slightly smaller percentage in relation to the value found among the Laklãnõ-Xokleng in the present study, when considering both present and past uses.

The categories that are most predominant in present use are those related to essential activities in the routines of people, such as food and health. For example, timber is used in ovens to cook food and heat houses. Plants used for tools/utilities, building and with symbolic use had the lowest uses in current livelihoods. With the introduction of industrialized goods, many artisanal tools and utilities stopped being produced. The loss of interest in traditional knowledge about plants due to access to industrial products was also reported in northwestern South America in a study about the influence of socioeconomic factors on traditional knowledge (Paniagua-Zambrana *et al.* 2014). For symbolic uses, there were only a few repeated citations by more than one interviewee, revealing how fragmented and dispersed this knowledge is. The knowledge about plants for symbolic uses is particularly vulnerable to changes in livelihoods that resulted from discontinuation of rituals and adoption of outside religions.

Citations of past uses mainly refer to uses during childhood that were not incorporated into the everyday lives of the interviewees, such as wild fruit consumption, use of plants from remote forests, agricultural crops and timber. The fact that newer generations have not incorporated these plants is related to changes in personal habits throughout their lives, in the case of wild fruit consumption, or changes in the community's livelihood, such as a decrease in cultivation areas caused by the dam construction, and legal restrictions for timber harvesting.

Plants cited as "only known" are mainly in the handicraft and medicinal categories, followed by food and building, and are related to changes that occurred a long time ago. Some of the changes in livelihoods that can be related to the fact that these plants are only known are the construction of cement houses, the introduction of public health systems and industrialized medicine, the fact that some plants are no longer easily found and the introduction of industrialized utilities. Some changes were partial and others were definitive. For example, although farming activities in the valleys were impaired by the dam, farming is still practiced in other places. In contrast, since the cement houses were built, nobody currently lives in huts. Müller-Schwarze (2006) also registered the same example of permanent changes occurring in the way villagers in Panama use and know plants, such as abandoning the use of adobe and wooden houses.

Knowledge transmission about plants among the Laklãnõ-Xokleng is oral. Therefore, according to Toledo & Barrera-Bassols (2010), memory is an important intellectual resource in this process. For example, 3 % of free-listed citations revealed that interviewees did not know the plant name, but recalled its use, sometimes with detailed descriptions about plant processing and instructions of use in the case of medicinal plants.

The fact that it was not possible to record a Laklãnõ-Xokleng name for 135 cited plants could be related to Portuguese gradually replacing the Laklãnõ-Xokleng language. According to Gakran (1999), the number of Laklãnõ-Xokleng speakers has decreased, especially among children, since many of them grew up speaking Portuguese. Thus, words referring to elements that are not part of everyday life may be gradually lost. Moreover, the change from a semi-nomadic to a sedentary habit might be influencing knowledge loss. Settling in the IT reduced the range of the Laklãnõ-Xokleng landscape and, consequently, resulted in less intense contact with previously used plants that might not occur in the current IT. All of the described examples show how the dynamics of knowledge are influenced by socioeconomic factors, as noted by Wyndham (2010) and Paniagua-Zambrana *et al.* (2014). However, knowledge dynamics about plants also point to different processes of simple loss or forgetfulness. Many of the cited plants have been recorded as present in the Laklãnõ-Xokleng culture for a long time, which is evidence that use and knowledge of plants are perpetuated generation by generation over hundreds of years.

Similar results were found by Müller-Schwarze (2006). In a study of a Panamanian village, she describes that although the village has increased access to manufactured goods, the villagers still use their plant knowledge. The author describes a model of selective survival of plant knowledge where younger generations choose the plants they will retain and the new knowledge they will incorporate for their survival. Aswani *et al.* (2018), in a global review, point out that 15% of the studies recorded persistence of knowledge when traditional practices are maintained and hybrid knowledge is being produced due to outside influences.

We also observed changes in knowledge with the incorporation of novelties from other ethnic groups, including learning necklace making from the Guarani and the use of leaves for food from the Kaingang, who also share the IT. The process of change in knowledge resulting from the influence of another culture was also observed with the Kaingang in the Xapecó IT (Haverroth 2007), resulting on a syncretism in which values are constantly re-elaborated by this indigenous group. In northwestern South America, knowledge of African Americans was similar with the indigenous groups, which could reflect the long history of contact among these groups that favored exchanging knowledge (Paniagua-Zambrana *et al.* 2014).

When European colonizers arrived in Brazil they did not know the local flora and might have learned a lot about plants from indigenous peoples. On the other hand, they might have contributed to the Laklãnõ-Xokleng ethnobotanical repertoire with new uses of native and exotic plants. In a study about knowledge and use of plants with farmers descended from German and Italian colonizers in the municipality of Ibirama, adjacent to the IT, Poderoso *et al.* (2012) identified 223 plants, of which more than a half (128) are also present in the Laklãnõ-Xokleng ethnobotanical repertoire. Considering that about 39 % of the species registered by Poderoso *et al.* (2012) and 36% of the species in the present work are idiosyncratic, it is worth noting the concordance between species found in both investigations. This reinforces the matter of exchange, and, on the other hand, raises curiosity about which plants have been used by the Laklãnõ-Xokleng since the pre-contact period and which species were incorporated into their culture after contact. According to Albuquerque (2006), the incorporation of exotics can enrich or diversify rather than erode a culture.

Men cited more plants than women, especially for uses related to timber (tools/utilities, building and firewood). Poderoso *et al*. (2012) found similar results among farmers in the surroundings of Ibirama-Laklãnõ IT; the richness cited was higher for men, which is connected to higher knowledge about timber resources. The literature shows that different particularities of the livelihood of each group influence in the distribution of the knowledge and use of the plants between genders. In several cases, men presented a higher familiarity with plants used for handicrafts, house building, canoes and other purposes related to timber (Hanazaki *et al*. 2000; Miranda *et al*. 2011), or with species that are physically harder to harvest (Paniagua-Zambrana *et al*. 2014), while women had a higher familiarity with medicinal herbs (Miranda *et al*. 2011). In other situations, there were no differences in knowledge among men and women, although they conducted different tasks in daily life (Lozada *et al*. 2006).

The dynamics of the distribution of knowledge also reflect historical changes since contact. In the 1940s, Henry (1964) observed that Laklãnõ-Xokleng women were responsible for preparing the shelters where they slept, gathering firewood, cooking, making ceramic pots, weaving blankets and baby carriers (strips used to carry the babies), and carrying utensils, babies, and coals from one camp to another. Men hunted, made bows and arrows, spears and fringes, and collected honey and pine nuts. They also made fires and wove baskets that the women used to carry things, and often helped the women carry objects and babies, prepare shelters, and cook (Henry 1964). Nowadays, both men and women participate in most activities related to plant use and both are involved in food production (farming), making handicrafts, and using medicinal plants. Although women play an important role in the preparation of home remedies, men help by collecting plants in the forest. Only logging is restricted to the male universe. This current labor division is very similar to those of non-indigenous small farmers in the region (Poderoso *et al*. 2012).

A correlation between plant citation frequencies and interviewee age was not found. Seven interviewees cited a higher number of plants and they varied from 26 to 74 years old. All of them come from families that used and valued such knowledge. Likewise, Wyndham (2010) did not find any correlation between knowledge and age among Rarámuri children and adolescents (5 to 18 years old) in Mexico, but found people who knew more, independent of their age. Although analyzing a wide array of social factors (e.g., type of school and bilingualism) to verify whether they were significant to predict levels of plant knowledge, Wyndham (2010) concluded that these factors were not determinant and that individual variability in knowledge was more related to interest and personal history, which were influenced mainly by the way a family practiced and valued their culture. Paniagua-Zambrana *et al*. (2014) also did not find a correlation between knowledge and age and suggest that more knowledge could be related as individual attitude and curiosity about the environment.

Transmission within the Laklãnõ-Xokleng was found to be essentially vertical (Cavalli-Sforza *et al*. 1982). Most interviewees had learned about food plants and medicinal plants during childhood from their families, and women, especially mothers and grandmothers, were responsible for the majority of knowledge transmission. Soldati *et al*. (2015) also observed that knowledge about medicinal plants was transmitted mostly vertically and by mothers, in a study on knowledge transmission about medicinal plants in southeast Brazil. Similar results were obtained for rural and mestizo communities in Patagonia (Lozada *et al*. 2006). Vertical knowledge transmission, which occurs primarily within families, between generations and during childhood, is highly conservative (Lozada *et al*. 2006) and leads to a higher information heterogeneity in a population, according to Cavalli-Sforza *et al*. (1982).

Regarding the medicinal use of plants, there was a smaller concentration of this knowledge during childhood, and an increase in learning this information during other phases of life (youth and adulthood). Ethnographic research with a wide diversity of cultures suggests that humans acquire extensive ecological knowledge during childhood and continue to refine this knowledge and learn more during their lifetime (Cruz-Garcia 2006). Perhaps, this is more intense with medicinal plants than with those used for handicrafts. The first consists of a more specific type of knowledge; when children observe preparations, they do not necessarily learn preparation. Some interviewees mentioned that they had contact with the use of medicinal plants during childhood but had to relearn this knowledge when they became adults.

Moreover, making handicrafts is a common and everyday activity that requires and allows for more experience and participation than processing medicinal plants, which occurs less frequently. This indicates the importance of "doing" in the learning process and transmission of knowledge described by many authors (Cruz-Garcia 2006; Lozada *et al*. 2006; Wyndham 2010). Resource use depends on knowledge about the resource and the ability to use it. "Learning by doing" connects knowledge to practical know-how, resulting in the development of certain abilities and techniques.

Although we found no relation between knowledge distribution and age, the ethnographic data analysis on transmission cores reveals transmission related to family, people of advanced age as cores, and their relatives as nodes: children, grandchildren, in-laws, nephews, etc.Thus, through combining these two analyses, distribution and transmission, we can observe that the central position of elders in knowledge transmission is more related to their central role in families, as parents and grandparents, than to the quantity of knowledge.

From the nine transmission cores, only two were among the seven more important people in relation to the number of free-listed plants cited (of those who cited 30 or more plants). Therefore, as there was no clear relationship found between the central position of these individuals in knowledge transmission and the amount of knowledge registered, this can be interpreted in two complementary ways. First, the central position for information transmission is strongly linked to the fact that these people are grandparents and have taught to a greater circle of children and grandchildren. This is coherent with the transmission pattern observed (i.e., within the family and among generations). Second, we can understand that this result indicates limitations in measuring knowledge using the number of cited plants from the free-listing exercise. During the interviews, it became clear that some participants, in spite of not citing a great number of plants, had deep and expert knowledge. That some did not cite as many plants may be related to personal reasons, such as available time at the moment of the interview, willingness or unwillingness to participate, and being comfortable with the interviewers and methodology employed. The free-listing exercises with elders could have been exhausting for them, due to the repetitive questions about each plant cited. Moreover, age factors can also be regarded as important obstacles (e.g., hearing impairment and memory loss).

In both networks, knowledge transmission resembled more an irradiation within a family than a flux throughout the web. Henry (1964) emphasized the importance of family in the social organization of the Laklãnõ-Xokleng, describing that shamans acted solely within their extended family and, in general, among close relatives. In spite of not being presently organized into extended families (groups of approximately 50 to 300 individuals, who hunted and travelled together), it was still possible to observe the importance of close family ties in social organization. Díaz-Reviriego *et al*. (2016) also found that the exchange of knowledge among the Tsimane', in Bolivia, was embedded within networks based on kinship.

Low density, reciprocity, and betweenness were also found by Hopkins (2011), who investigated herbal remedy competence among Yucatec Maya, and by Díaz-Reviriego *et al*. (2016), who analyzed the influence of social organization on exchange and presence of medicinal plants in Tsimane' Amazonian home gardens. Fragmentation into subgroups can be related to the low network density, but does not fully explain it. Vertical transmission can also explain the observed fragmentation of the networks. Another associated factor can be the physical distance among subjects (Reyes-Garcia *et al*. 2013); in our study, physical distance might also explain the fact that we found no transmission between the villages. According to Bodin & Crona (2009), network structure influences knowledge transmission processes. In this case, subgroups are important in the generation and transmission of tacit knowledge, which is knowledge that is implied and usually unspoken (Bodin & Crona 2009). However, according to the same authors, the constant influx of information from various actors can hinder development of expert knowledge. Therefore, the presence of subgroups favors the development of knowledge by allowing increased interaction between kin, and also contributes to the development of knowledge diversity by allowing knowledge to develop in different subgroups (Bodin & Crona 2009). Extremely high network densities may also result in an increase in knowledge homogenization (Bodin & Crona 2009).

Among the Laklãnõ-Xokleng, we observed that some medicinal plants highly cited by some families were not mentioned by others, suggesting the development of knowledge diversity favored by subgroups and by the conservative feature of vertical transmission. The low reciprocity found in this and other studies cited above can also be attributed to vertical transmission. Even though betweenness centrality was low when looking at degree centrality (in- and out-degree), we noticed, as did Díaz-Reviriego *et al*. (2016), that the networks were asymmetric and hierarchic, showing that some people had more connections than others.

One surprising finding was the difference between the two networks (medicinal purposes and handicrafts), showing that transmission within a community may be different depending on the subject of knowledge. Higher dynamism in the flow of information within the medicinal plants' network may reflect the variability of medicinal plants used, as well as illnesses that may arise. Each new illness requires more communication, since there is a need to find information about plants for the treatment. Soldati *et al*. (2015) observed that illness was an important stimulus for learning, and similar processes might be occurring here. On the other hand, knowledge about handicraft plants is more stable, since there is only a small number of predetermined objects that are generally made. Today, craftsmanship does not require innovation because it involves commitment to maintaining tradition and produces objects as similar as possible to the ones made by their ancestors. In our study, there was also a higher percentage of learning citations with non-family members for medicinal plants (35 %) compared to handicraft plants (20 %), pointing to an expansion of learning about medicinal plant use from people outside the family unit.

We did not find a correlation between centrality and knowledge, as other authors observed (Calvet- Mir *et al*. 2012; Reyes-Garcia *et al*. 2013; Díaz- Reviriego *et al*. 2016). On the one hand, these authors investigated seed or plant exchange associated with knowledge transmission to study social networks, and not only knowledge transmission. As a first thought, this difference could be because measuring knowledge alone is more subjective than inferring about knowledge transmission through plant resource exchange. On the other hand, Hopkins (2011) used only knowledge to build a network of medicinal plants among Yucatec-Maya, in Mexico, and found the same correlation between centrality and knowledge. There is also another possibility: since research using social networks to understand knowledge transmission is recent, further studies might show different results, and specific situations of each study may influence networks, in the same way we found differences between medicinal and handicrafts networks.

During field activities, it was possible to witness episodes of knowledge transmission that were not necessarily related to plants used but to values and Laklãnõ-Xokleng worldviews. This type of transmission is more difficult to measure, but it is the essence that brings sense and defines how the Laklãnõ-Xokleng relate to their environment. A contextualized learning process also influences the ethical relation with the environment attributed to many indigenous and non-indigenous groups that live closely with nature. Worldviews, which include religious beliefs and ethics, structure observation that produces knowledge (Berkes *et al*. 2000). For different societies, norms and institutions emerge from their knowledge, beliefs and distinct worldviews (Pilgrim & Pretty 2010). Although there is great diversity in existing cultures, many societies develop norms and taboos that guide the respectful treatment of nature and determine their environmental ethics (Pilgrim & Pretty 2010).

Conclusion

By observing knowledge transmission as the intermediation process for the perpetuation, loss, transformation, incorporation and distribution of knowledge within the population, we found that these processes are vertical and centered in the family, mainly between generations, and that most learning occurs during childhood. Network analysis greatly contributed to better visualizing various transmission features. When analyzing quantitative data together with qualitative data ("who is receiving," "who is transmitting," and "individuals' characteristics"), some individuals were considered significant as information transmitters and others as receptors.

Network analysis also resulted in a better comprehension of transmission processes in the network structure, emphasizing subgroups that favor knowledge development and its heterogeneity. It was also possible to note the disconnection between people from different villages and reflect that this fact may bring consequences to knowledge in the community as a whole. Moreover, network analysis allowed for a deepened comprehension about differences in transmission patterns between medicinal plants and plants used for handicrafts.

Analyses on the distribution of knowledge within the population, whether in relation to gender or age, clearly depict the influence of the drastic and diverse changes in the livelihoods of the Laklãnõ-Xokleng and their adaptation processes. Another fundamental factor that seems to determine the distribution of knowledge is the attitude of certain families and individuals in valuing their own culture. Therefore, it is possible to note two antagonistic elements acting over culture and knowledge: the influence of the dominant society; and Laklãnõ-Xokleng resistance, in the sense of valuing and maintaining their culture and knowledge. Finally, it is fundamental to think about school as a driver of change for indigenous knowledge. The influence of formal schooling on indigenous knowledge is a topic that requires an in-depth analysis and was not the primary focus of this study.

School can be considered detrimental for bringing in outside values and taking precious parent-child time for learning during daily activities. On the other hand, school plays an important role in indigenous communities. In order to participate in decision-making processes, indigenous peoples must know how to speak, read, and write in Portuguese. They must learn about their rights in order to claim them. Hence, learning about the outside culture is a defense and survival strategy.

During this research we noted that indigenous schools in Laklãnõ IT play a central role in the community's dynamics, and understanding networks of knowledge related to plants can indicate directions for how this knowledge can be embedded into indigenous schools. In the past, local culture was not significantly considered. Today, however, school staff is composed of indigenous teachers, directors and workers that are engaged in integrating indigenous culture into curricula, through Laklãnõ-Xokleng art and language classes, and also inviting elders to share their wisdom and knowledge through practical experiences such as collecting honey, medicinal and handicrafts plants, teaching handicrafts, and telling stories. Such a growing interest from the Laklãnõ-Xokleng about cultural appreciation can be regarded as a positive driver for changes that affect knowledge transmission in the Ibirama-Laklãnõ IT and may move the balance in the opposite direction.

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