Acta Botanica Brasilica - 33(2): 232-240. April-June 2019.
doi: 10.1590/0102-33062018abb0310

Market integration does not affect traditional ecological knowledge but contributes additional pressure on plant resources

Temóteo Luiz Lima da Silva[1], Juliana Loureiro de Almeida Campos[1], Ângelo Giuseppe Chaves Alves[2] and Ulysses Paulino Albuquerque[1]*

Received: September 13, 2018
Accepted: February 18, 2019

ABSTRACT

Market integration can affect the manner in which individuals learn about and use natural resources. The present study explores the influence of market integration on the traditional ecological knowledge (TEK) and use of natural resources in handicraft production among the Fulni-ô indigenous people of Northeast Brazil. We collect data from 67 artisans about their traditional and non-traditional handicrafts, which are mainly produced for external trade demand (our proxy for market integration). Data regarding the distribution of knowledge among different segments of the population, according to socioeconomic variables, and the comparison of plant biomass used for traditional and non-traditional handicrafts, reveals that integration does not affect the distribution of TEK but leads to a higher consumption of native plant resources, which can negatively affect the populations of the species used. The present findings indicate a future scenario of the replacement of TEK with knowledge that yields higher economic returns. The most experienced artisans have greater traditional ecological knowledge of traditional handicrafts and can play a fundamental role in maintaining traditional knowledge in the context of market integration. Finally, temporal evaluation studies in particular are needed to better understand changes in knowledge derived from market integration.

Keywords: biodiversity conservation, cultural changes, handicrafts, Indians, local ecological knowledge, market participation

Introduction

Changes in traditional knowledge have been the focus of ethnobotanical studies and are typically associated with access to formal education (Reyes-García *et al.* 2013), modernization processes (Benz *et al.* 2000), and, more commonly, market integration (Reyes-García *et al.* 2007). As an effect of modernization, indigenous populations are more prone to enter the market via different economic activities, but this process can influence their well-being, traditional ecological knowledge (TEK), and the use of natural resources (Godoy *et al.* 2005).

Market integration can be understood as all activities that generate goods and services for trade with individuals from outside the community (Gross *et al.* 1979). This integration can change the manner in which people use forest resources, leading to specialization in the production of goods directed by market demand and that yield greater economic advantage (Godoy *et al.* 1998; Vadez *et al.* 2004; Morsello *et al.* 2014). Furthermore, it can intensify the use of natural resources, resulting in their overexploitation (Ruiz-Pérez *et al.* 2004).

There is strong evidence that market integration can promote changes to TEK (Ahmed *et al.* 2010; Gómez-

1 Laboratório de Ecologia e Evolução de Sistemas Socioecológicos, Departamento de Botânica, Universidade Federal de Pernambuco, 50670-9011, Recife, PE, Brazil
2 Departamento de Biologia, Área de Ecologia, Universidade Federal Rural de Pernambuco, 52171-900, Recife, PE, Brazil

* Corresponding author: upa677@hotmail.com

Baggethun *et al.* 2010). Some researchers argue that this process can lead to the replacement of TEK with a non-traditional knowledge (Lu 2007; Olson 2013). However, other researchers have shown that integration can promote the maintenance of TEK, especially when populations enter markets through an activity that involves the use of natural resources (Guest 2002; Reyes-García *et al.* 2007). In a context of strong market integration, people can adopt new forms of knowledge, arriving at a hybrid knowledge that is adapted to new socioeconomic or ecologic conditions (Gómez-Baggethun *et al.* 2013). The dynamic and adaptive nature of traditional ecological knowledge thus favors the accommodation of new knowledge by the traditional knowledge system, being an important element for adaptation to environmental and socioeconomic changes (see Reyes-García *et al.* 2014). However, this integration does not seem to affect a group homogeneously, and it can be shaped by socioeconomic variables (Guest 2002; Gómez-Baggethun *et al.* 2010).

Therefore, we seek to contribute to the understanding of the effects of market integration on traditional ecological knowledge and use of natural resources by studying the traditional and non-traditional handicraft production scenario among the Fulni-ô indigenous people of Northeast Brazil. In this indigenous group, handicraft production is culturally and economically important, and it has been influenced by external market demand, which is observed by the number of non-traditional handicrafts that have been incorporated into the culture and that are produced for sale (e.g. bow and arrow, indigenous headdress, blowguns, and spears). Using the richness of knowledge of non-traditional handicrafts as a proxy for market integration, we seek to gather evidence to test the following hypotheses: i) Socioeconomic factors can predict knowledge of traditional and non-traditional handicrafts. If this hypothesis is correct, then we expect knowledge of traditional and non-traditional handicrafts to concentrate in different segments of the population. ii) The production of non-traditional handicrafts promotes greater consumption of plant resources. If our hypothesis is correct, then we expect to find a greater plant biomass used for production of non-traditional compared to traditional handicrafts. Additionally, we seek to examine the relation between the annual income obtained with the production of handicrafts and the consumption of vegetal biomass for this production. We expect that the biomass used for non-traditional handicrafts will better explain the annual income of artisans than the biomass used for traditional handicrafts.

Materials and methods

Study site

The study was conducted at the Fulni-ô Indigenous Territory, located in the municipality of Águas Belas, Pernambuco, approximately 315 km from the state capital of Recife, Northeast Brazil (Fig. 1). The municipality encompasses an area of approximately 886 km² and has a population of 40,566 inhabitants (CONDEPE/FIDEM 2015). Located in the Agreste pernambucano micro-region, Águas Belas is part of the Ipanema River Basin and has a semi-arid climate, hot and wet, with a mean annual temperature of 25 °C and a mean annual rainfall of 600 mm. The Fulni-ô indigenous territory covers approximately 11,500 hectares and is located in a typical caatinga vegetation. According to data from the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística – IBGE 2010), the indigenous population includes 3,675 people who are distributed between two distinct settlement: the *Sede* settlement, which houses most of the families and is located 500 m away from the urban center of Águas Belas; and the *Xixiakhla* settlement, which is inhabited by about 100 people who choose to live close to native vegetation and far from contact with the urban center.

The Fulni-ô are one of the seven indigenous groups found in the state of Pernambuco (Instituto Socioambiental 2007), and they are the only group to maintain their native language, *yaathê* (meaning "our speech"), which is spoken daily among members of the community, especially among the elders (Albuquerque *et al.* 2011a). The Fulni-ô annual calendar is marked by the Ouricuri Ritual, which occurs from September to November, when the population establishes itself at the Ouricuri settlement. This settlement is located in the Ouricuri woods, which is the main collection site of plant resources by the community (Albuquerque *et al.* 2011b). The woods and the Ouricuri settlement are considered sacred, and only Fulni-ô people can walk through this site during the ritual period.

The Fulni-ô handicrafts

Ouricuri palm (*Syagrus coronata* Mart. (Becc.)) is the sacred plant for the Fulni-ô people. Pinto (1956) highlights ouricuri palm as a cultural complex due to their great importance for the production of handicrafts, in addition to being used in the feeding and making of clothes and ornaments used during the sacred ritual of ouricuri. According to Campos (2011), the broom produced with the leaves of ouricuri palm were the main handicraft sold in the fairs of the city of Águas Belas.

Among the Fulni-ô, handicrafts are produced throughout the entire year, with greater demand in April due to the celebration of "Indian Day" in Brazil. Many artisans are typically organized in groups and travel in caravans through the large capital cities of Brazil to present cultural performances and to sell their handicrafts throughout the entire month. Therefore, from February to March, resource collection and handicraft production are intensified.

Artisans currently produce their culture's traditional handicrafts, which typically have household, ornamental,

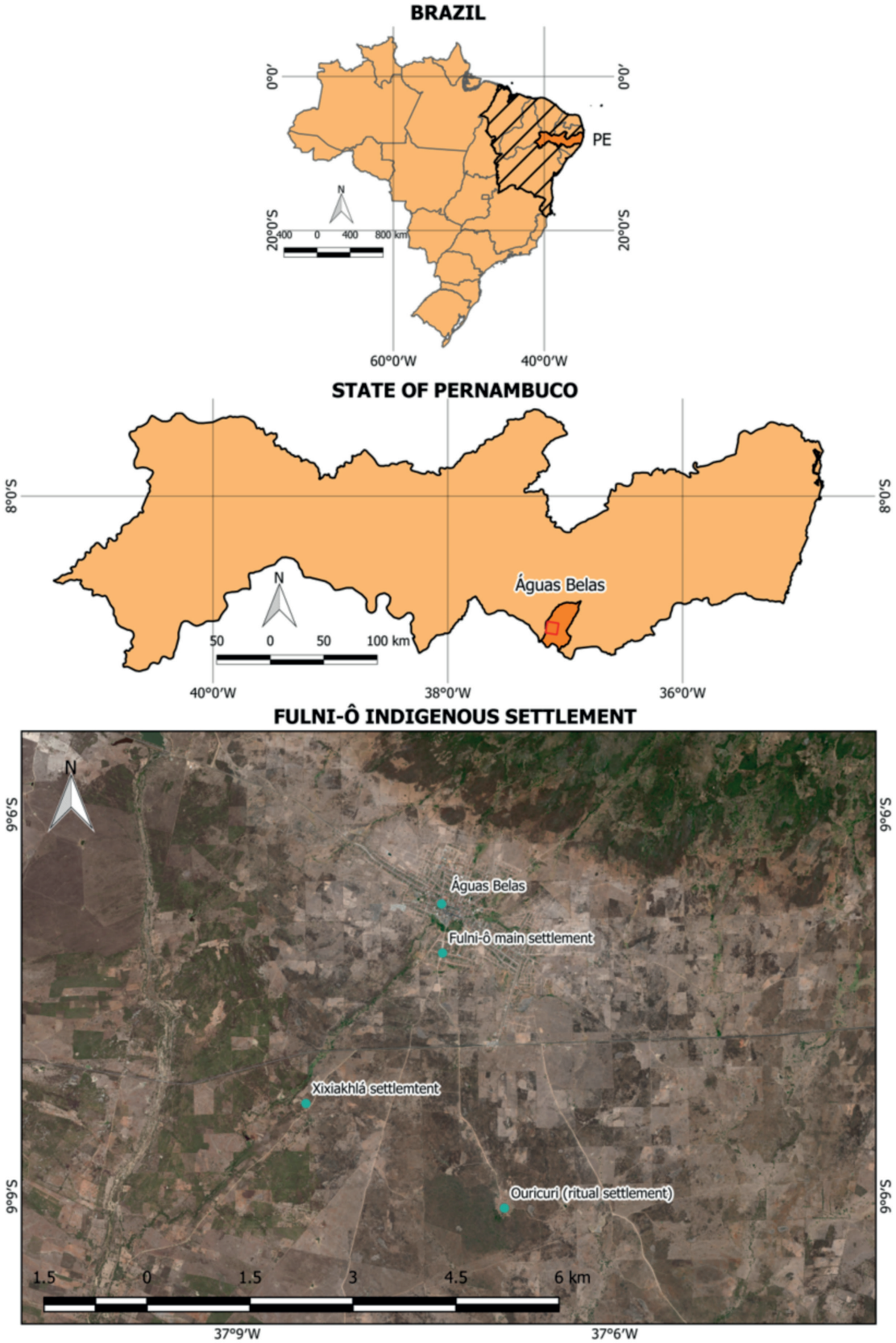

Figure 1. Localization of the municipality of Águas Belas (Pernambuco, northeast of Brazil) and the Fulni-ô Indigenous Territory and its three settlements: *Sede* settlement, *Xixiakhlá* settlement and *Ouricuri* settlement (ritual settlement) (from Campos 2017).

recreational, and/or magical-religious utility, in addition to handicrafts that are non-traditional, products that were not always present in the culture and which are produced for commercialization. Traditional handicrafts that are marketed include the *maracá* (Fig. 2A) (a musical instrument used in dances and rituals), which is produced from gourds (*Curcubita sp.*), and the *xanduca* (Fig. 2B) (a smoking pipe commonly used by adult people), which is produced from the stem of the *angico* (*Anadenanthera colubrina* var. *cebil* (Griseb.) Altschul). Traditional handicrafts include those produced from the leaves of the Ouricuri palm (*S. coronata)*, such as mats, baskets, bags, brooms (Fig. 2C) and rugs (Fig. 2D).

Non-traditional handicrafts include items that have mainly economic value to the Fulni-ô, such as the bow and arrow (Fig. 3A), hatchets (Fig. 3B), blowguns, necklace (Fig. 3C) and spears, which are produced from wood resources originating from local vegetation, mainly to be sold during the caravans in April. These caravans began in the late 1990s and are important for the integration to the market and for the diversification of the production of handicrafts, since in these occasions the Fulni-ô learn to produce handicrafts with other indigenous people and acquire more showy materials such as seeds and feathers of birds from Amazon. Non-traditional handicrafts, such as the bow and arrow and the indigenous headdress, are also used as ornaments during cultural presentations and dances during the caravans.

The village's proximity to the urban center of the city of Águas Belas favors the inclusion of the Fulni-ô in non-indigenous society. The Fulni-ô hold public and political offices and enroll in higher education. The production of handicrafts, the holding of offices in the main village's state school, subsistence activities, and the leasing of lands are some of the main sources of income of the indigenous population. The production of handicrafts is perhaps the best proxy for market integration because this activity has cultural importance and provides economic returns and especially because non-traditional products were added to this practice for integration in the market.

Data collection

The first contact with the community was made in the company of researchers from the Laboratory of Ecology and Evolution of Social-Ecological Systems (Laboratório de Ecologia e Evolução de Sistemas Socioecológicos - LEA) of the Federal University of Pernambuco (Universidade Federal de Pernambuco - UFPE) who were conducting ecological and ethnobotanical studies in the village. In February 2014, we had a meeting with the indigenous leaders (locally known as *pajé* and *cacique*) to explain the objectives of the study and to receive local authorization and consent. The data for the study were collected under the project "Ecology

Figure 2. Traditional handicrafts of Fulni-ô group. **A.** maracá, **B.** xanduca, **C.** broom and, **D.** rug. (photos by Juliana L. A. Campos).

and sustainability of ouricuri (*Syagrus coronata* (Mart.)) extraction by Fulni-ô Indians on Northeast Brazil: support for species management and conservation plan," which was approved by the National Research Ethics Commission (CAAE 24211014.0.0000.5207) and the National Indian Foundation (Authorization n. 04/AAEP/PRES/2015).

Five visits were made (seven days per visit) to the community during February and August 2014 to establish *rapport*. Local data were collected from January to May 2015. From September to November, it is impossible to perform activities in the community, given that all Fulni-ô are secluded in their sacred ritual. We identified all Fulni-ô artisans who currently produce handicrafts from local native plant resources using the snowball sampling technique, which consists of asking one participant to indicate other participant until names repeat, indicating that the sample is saturated (see the description in Albuquerque *et al.* 2014). The first participant was identified with the aid of a Fulni-ô representative with a degree in biology and holds prestige in the community and teaches at the local elementary school. He also guided us in the selection of bilingual assistants to accompany us during house visits. The snowball is a non-probabilistic and intentional sampling technique, allowing generalizations only on the studied group and not on the population (Albuquerque *et al.* 2014). A total of 67 artisans participated in the study, and another seven refused to participate for different reasons.

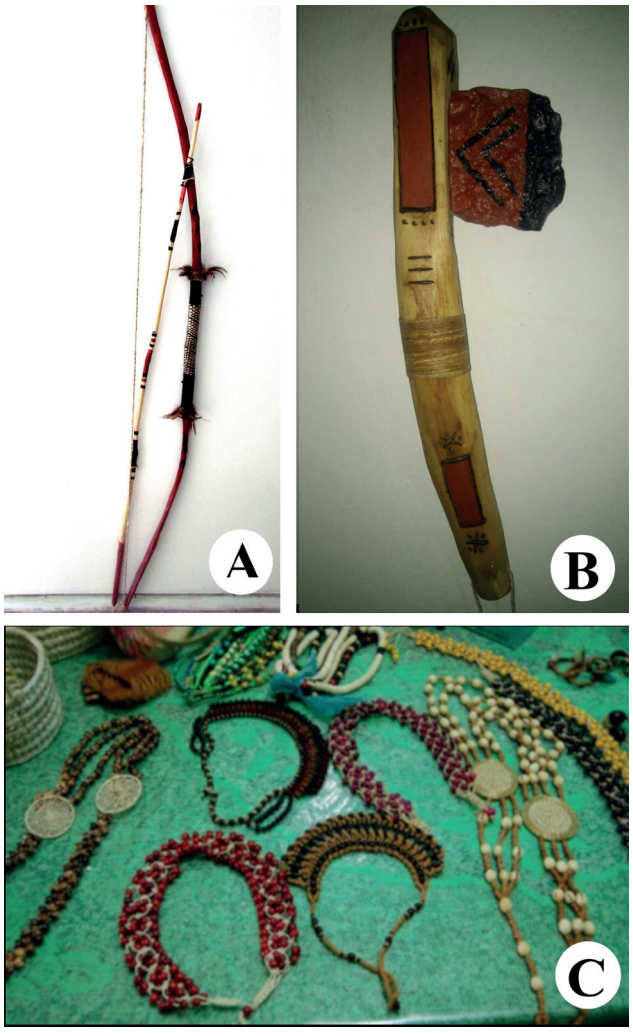

Figure 3. Non-traditional handicrafts of Fulni-ô group, produced mainly for commercialization. **A.** bow and arrow; **B.** hatchet; **C.** different types of necklace. (Photos A e B: Temóteo L. L. Silva; Photo C: Juliana L. A. Campos).

The identified artisans were invited to share information about their knowledge and use of plants in handicraft production. The information was accessed in three stages, not necessarily simultaneously. During the first stage, we recorded the socioeconomic profile of the participants and their TEK to answer our first question. We conducted structured interviews to trace their socioeconomic profile with the following information: age, educational level, the number of persons in the family, the number of family members who are involved in the production of handicrafts, the yearly income from the production of handicrafts and the time of experience with the activity. We used the free-listing technique to access TEK of the plants used for the production of handicrafts (see Albuquerque *et al.* 2014. First, we asked which plants were known as being useful for the production of handicrafts, and then, we asked which handicrafts are produced from these plants.

During the second stage, we recorded information regarding the use of plant biomass in the production of handicrafts using the *in situ* inventory technique (see Ramos *et al.* 2014) to answer our second question. The artisans themselves identified the handicrafts and plants used in the production of each item. Because handicraft production is a traditional activity of the Fulni-ô culture in which few plant species are used, the accuracy of identifications was ensured. For every identified plant, we recorded the number of pieces produced and the plant biomass consumed.

Biomass was measured with a digital hand scale limited to between 0.1 g and 50 kg with 0.1 g precision. Handicrafts made of more than two plants were disassembled, and each plant's biomass was measured. In the case of *imburana de cambão* (*Commiphora leptophloeos* (Mart.) J.B.Gillett), which is used exclusively in the production of hatchets (a non-traditional handicraft), in association with pieces of rock, our biomass measurement was underestimated, given that it was impossible to disassemble some of the pieces to be weighed. The biomass of seeds, which are typically used in the production of necklaces and earrings, was not measured because these handicrafts consist of seeds of different species, especially exotic species that are acquired by trading with indigenous peoples of other regions during caravans and fairs. Our plant biomass consumption analysis is therefore centered on wood, leaves, and fruits.

Inventories were made during March 2015, the period of greatest production of handicrafts, considering that, in the first week of April, the Fulni-ô leave in caravans for the large capital cities. In this stage of the study, the sample

size decreased, with 11 artisans refusing to participate and 19 either not having handicrafts or being unavailable during the attempted visits. The final sample size of the *in situ* inventory was 37 artisans. During the third stage, we attempted to distinguish between traditional and non-traditional handicrafts because we assume that knowledge of non-traditional handicrafts is the result of the market integration. In possession of the list of handicrafts noted in the interviews, we recruited three traditional knowledge holders from the village to classify together the handicrafts into traditional and non-traditional. These knowledge holders were appointed by local leaders and were recognized as having broad knowledge of the traditions of Fulni-ô culture. Furthermore, all knowledge holders had been artisans when young and thus were able to distinguish between traditional artifacts (which were always present in the culture) and non-traditional handicrafts (which started to be produced recently).

We conducted a guided tour (see Silva *et al.* 2014) in the sites of plant collection with three participants of the research to collect plants for taxonomic identification. The species sampled were identified by their local names and taxonomically identified and incorporated into the collection of the herbarium Dárdano de Andrade Lima, at the Instituto Agronômico de Pernambuco (IPA) (Tab. S1 in supplementary material). Species acquired with other indigenous groups (e.g. seeds) and those that did not have reproductive organs at the moment of the guided tour were identified through the Flora of Brazil database (floradobrasil.jbrj.gov.br), using the search by the vernacular name and the geographical distribution to guide the identification. We also consulted previous studies carried out in the Fulni-ô Territory, such as Souza *et al.* (2017) and Albuquerque *et al.* (2011a).

Data analysis

In our knowledge measurements, we assumed information agreement to characterize the local handicrafts. Therefore, information on plants and handicrafts with no agreement among the artisans was excluded from the analysis, considering only the mentions from at least three individuals. We adopted this criterion to analyze only culturally validated information, avoiding idiosyncratic information biases.

We used a general linear model (GLM) to test the first hypothesis and determine the effect of market integration on TEK. We performed the analyses using the Poisson model to correct standard errors. This analysis allowed us to determine the variations in the TEK in different segments of the society. We used the socioeconomic profile characteristics of the participants as independent variables. The predictors were the length of experience with the activity, educational level, yearly income from selling handicrafts, family size, and number of family members involved in the activity. The dependent variables were the richness of knowledge of traditional and non-traditional handicrafts, totaling two different models. We selected the models based on the Akaike Information Criterion (AIC). The best model was chosen from the lowest AIC value.

We performed the Wilcoxon test to analyze the second hypothesis and determine whether there were differences in vegetal biomass consumption between traditional and non-traditional handicrafts. We chose a paired test to decrease the effects of internal variations in both groups. We performed a multiple regression to test whether a relation exists between the annual income obtained with the production of handicrafts and the consumption of vegetal biomass to produce traditional and non-traditional handicraft. We used the measures of vegetal biomass consumed for traditional and non-traditional handicrafts as independent variables and the annual income of handicraft production as the dependent variable. The analyses were performed using the software R, version 3.2.3 (R Core Team 2010).

Results

The descriptive data and the reported species and biomass measurements to produce handicrafts can be found in Table S2 in supplementary material. We recorded in this study 40 plant species used in the production of handicrafts. The most cited plants were *Syagrus coronata*, *Anadenanthera colubrina*, *Capparis flexuosa* and *Coutarea hexandra*. Some of these species are used only in the manufacture of traditional handicrafts, such as *S. coronata* used to produce baskets, bags, and brooms; *A. colubrina* is used to produce *xanduca*; *Curcubita* sp. and *Crescentia cujete* is used to produce *maracá* and cantel (a type of water bottle). Most of the registered species are used to produce non-traditional handicrafts, such as *C. flexuosa* is used to produce the type of showy *xanduca* and the bow and arrow; *C. hexandra* used almost exclusively to produce bow and arrow; *Guadua* sp. used to produce blowgun and *Erythrina velutina* used to produce necklace and earring.

We also register a diversity of 40 Fulni-ô handicrafts. Among the traditional ones, the most produced are *xanduca*, broom and *maracá*. Among the non-traditional, the most produced are the whistle, the blowgun and the bow and arrow, the latter is the one that presented the greatest consumption of vegetal biomass among all the artifacts produced (ca. 233 kg).

According to our first model, occupation influences TEK of non-traditional handicrafts (Tab. 1). This finding indicates that artisans who have other professional occupations and do not dedicate themselves exclusively to produce handicrafts have more knowledge of non-traditional handicrafts. In the second model, the length of experience with the activity is the only predictive variable for the number of known traditional handicrafts, and more experienced artisans hold more knowledge of traditional handicrafts than less experienced artisans (Tab. 1).

Regarding the second hypothesis, we find that the biomass demand for non-traditional handicrafts (= 3322.91; ± = 4306.1; *m* = 2000) is higher than that for traditional handicrafts (= 2773.22; ± = 7991.32; *m* = 910) (Z = 3.5302; p = 0.0002).

The consumption of vegetal biomass for the production of non-traditional handicrafts is the best predictor of the annual income derived from the artisanal activity, indicating that this extraction plant resource is driving the economic returns of the activity (Tab. 2).

Discussion

Knowledge of non-traditional handicrafts is explained by the occupation of the artisan; that is, artisans who divide their time between the production of handicrafts and other activities know more non-traditional handicraft. It may be more advantageous for artisans who cannot be fully dedicated to the production of handicrafts to accumulate knowledge about non-traditional handicraft, especially in this scenario in which this knowledge can help to supplement income.

Knowledge of traditional handicrafts is explained only by the time of experience with the activity, indicating that a more experienced artisan can be a reservoir of knowledge about the material culture of Fulni-ô. This result may indicate that more experienced artisans had more time to accumulate knowledge of traditional handicrafts, as evidenced by Campos *et al.* (2018), in relation to the Fulni-ô harvesters' knowledge of less harmful forms of the *S. coronata* harvest. We could expect that market integration would cause changes in TEK (Godoy *et al.* 1998; Lu 2007; Gómez-Baggethun *et al.* 2010), leading to the replacement of TEK about traditional handicrafts with non-traditional handicrafts. The coexistence of TEK about traditional and non-traditional handicrafts among artisans reflects the ability of TEK to persist in the face of the social and economic changes caused by market integration. Therefore, our findings support the view that market integration does not necessarily cause the loss of TEK (Guest 2002; Reyes-García *et al.* 2007).

Other studies have found coexistence between traditional and non-traditional knowledge as a result of the processes that generate cultural changes (Giovannini *et al.* 2011; Reyes-García *et al.* 2014). Among the Fulni-ô Indians, this hybrid knowledge allows artisans to maintain traits of their material culture and simultaneously earn greater economic returns. The persistence of the knowledge of traditional handicraft may be related to the symbolic and cultural value of these items for the Fulni-ô, who have historically struggled to maintain their traditions, especially by more experienced artisans, as our findings show.

However, as much as it represents cultural resistance, it is possible that TEK about traditional handicrafts is less advantageous in the scenario in which producing non-traditional handicrafts provide greater economic returns, as our findings show. Studies show that individuals with higher traditional ecological knowledge of natural resources can supplement their income with the extractivism of these resources (Byg & Balslev 2001a; b; Campos *et al.* 2015). For example, in a study conducted in Northeast Brazil, Campos *et al.* (2015) found that extractivists who had more TEK about the babassu palm (*Attalea speciosa*) achieved better financial conditions by selling products made from this plant. Accordingly, based on our market integration scenario, it is likely that, in the future, the artisans who participate in this activity will prioritize knowledge of non-traditional handicrafts that provide greater economic returns.

Thus, by possessing greater TEK, more experienced artisans can play a fundamental role in maintaining this knowledge in the context of market integration. Some

Table 1. Summary of the generalized linear model for the effect of the socioeconomic variables on the knowledge of traditional and non-traditional handicrafts of Fulni-ô artisans, Northeast Brazil.

Response variables	Significant variables selected by lowest AIC value	Estimate	Z value	P value
Richness of knowledge of traditional handicrafts	Educational level	0.020854	1.808	0.070611
	Family size	0.043208	1.684	0.092116
	Time of experience with activity	0.014855	3.688	0.000226
	Initial AIC: 500.18 Lowest AIC: 496.57			
Richness of knowledge of non-traditional handicrafts	Time of experience with activity	0.003766	0.978	0.3280
	Occupation	0.171583	1.982	0.0475
	Initial AIC: 432.27 Lowest AIC: 426.61			

Table 2. Summary of the generalized linear model for the effect of consumption of vegetal biomass to produce traditional and non-traditional handicrafts on the annual income by Fulni-ô artisans, Northeast Brazil.

Response variables	Significant variables selected by lowest AIC value	Estimate	Z value	P value
Annual income of handicraft production	Vegetal biomass consumed for non-traditional handicraft	1.514e-01	8.282	0.00015
	Initial AIC: 628.44 Lowest AIC: 626.48			

researchers believe that innovations in a culture (new ideas, practices, or objects) are initially adopted by younger individuals, with the elders subsequently adopting them (Rogers 2003; Gilles *et al.* 2013). Considering that changes in knowledge are the result of dynamic processes (Reyes-García *et al.* 2014), our results may indicate that in future stages of market integration, younger Fulni-ô artisans will tend to favor non-traditional handicrafts, which can lead to a loss of traditional ecological knowledge (see Gómez-Baggethun & Reyes-Garcia 2013; Reyes-García *et al.* 2014). Similarly, we can reasonably assume that in the early stages of market integration, traditional handicrafts were locally prioritized.

Evidence from Ruiz-Pèrez *et al.* (2004) shows that changes in the production strategies and the use of natural resources during the integration process occur in a continuum, extending from the use of resources for subsistence purposes in low degrees of integration to specialization in the production of goods that provide economic advantages in high degrees of integration. We suggest that the changes that the market integration process causes in the TEK of Fulni-ô artisans also occur in a continuum, with the high degree of integration stages being the scenario that is conducive to observing the loss of TEK. Accordingly, disagreements in the literature regarding the effects of market integration could be the result of conducting occasional studies that portray a static moment of this process. Our results do not allow us to assess the dynamics of this process. Thus, we emphasize the need for temporal evaluation studies that assess how changes occur over intervals of time, as highlighted by Hopkins *et al.* (2015).

Our results also indicate that the production of non-traditional handicrafts demands greater amounts of plant biomass compared to traditional handicrafts. These findings suggest that market integration affects the use of natural resources, leading to specialization in the consumption of resources driven by market demands (Godoy *et al.* 1998; Sierra *et al.* 1999; Rudel *et al.* 2002). In addition, the income achieved through this activity is related to the consumption of biomass for non-traditional handicrafts. The traditional handicrafts of Fulni-ô culture do not have the same commercial appeal as items that reflect the image of the "Indian" for society. Therefore, the demand for non-traditional items, such as bows and arrows, hatchets, and indigenous headdresses, drives the patterns of production and the consumption of plant biomass.

Furthermore, our study records high biomass values for some species (Tab. S2 in supplementary material), especially for non-traditional handicrafts, indicating an intensification and overexploitation of natural resources (Ruiz-Pérez *et al.* 2004; Morsello *et al.* 2014). These results have some implications for conservation. Many of the plant species used for the production of handicrafts have other local uses for the Fulni-ô (Albuquerque *et al.* 2011a; b; c; Soldati & Albuquerque 2012), especially the extraction of bark for medicinal purposes, such as *Myracrodruon urundeuva* and *Mimosa tenuiflora*, which also have associated timber uses in the studied region (Souza *et al.* 2017). Versatility in the use of species is common in seasonal dry forests (Albuquerque 2006; Albuquerque *et al.* 2008). Therefore, the extraction of these species for use in other categories can increase damage at the levels of the individual and the population.

Additionally, the demand for biomass for non-traditional handicrafts is related to the use of wood resources, which represents a use that is more harmful to plant populations (Medeiros *et al.* 2011); it is mainly focused on two plant species (*Capparis flexuosa* and *Coutarea hexandra*). Albuquerque *et al.* (2011b) have already recorded low relative densities for *C. flexuosa* in Fulni-ô territory, indicating that the high consumption of biomass observed may represent a threat to local plant populations.

Considering TEK about traditional and non-traditional types of handicrafts, the process of integration into a market economy does not necessary cause the loss of traditional knowledge. However, it is possible that future generations will prioritize non-traditional handicrafts due to the economic returns that it affords, which could cause the loss of traditional knowledge about traditional handicrafts.

Market integration affects the uses of plant resources, causing specialization in the production of items that meet market demand. In our scenario, this process causes additional pressure on these resources and can have negative effects on the populations of the species used.

Finally, performing biomass consumption measurements in a single event for each participant is a limitation of our study. Although the measurements were performed during the time of greatest production of handicrafts, it is possible that, at the time of the interview, some individuals had not finished, or even started, their production. Therefore, the biomass consumption for the production of handicrafts by the Fulni-ô may be underestimated. For future studies that use the *in situ* inventory technique, we recommend the triangulation of methods that provide dynamic consumption measurements, such as the use of semi-structured interviews to record the rate of replenishment of the resources used or the performance of several measurements over a given interval of time.

Acknowledgements

We thank the Fulni-ô people, especially the artisans who contributed by sharing their traditional knowledge. We also thank members of the Laboratory of Ecology and Evolution of Social-ecological Systems of the Federal University of Pernambuco (LEA - UFPE). We thank Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the productivity grant awarded to UPA. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

References

Ahmed S, Stepp JR, Toleno RAJ, Peters CM. 2010. Increased market integration, value, and ecological knowledge of tea agroforests in the Akha Highlands of Southwest China. Ecology and Society 15: 1-18.

Albuquerque UP. 2006. Re-examining hypotheses concerning the use and knowledge of medicinal plants: a study in the Caatinga vegetation of NE Brazil. Journal of Ethnobiology and Ethnomedicine 2: 30. doi: 10.1186/1746-4269-2-30

Albuquerque UP, Araújo TAS, Ramos MA, *et al.* 2008. How ethnobotany can aid biodiversity conservation: reflections on investigations in the semi-arid region of NE Brazil. Biodiversity and Conservation 18: 127-150.

Albuquerque UP, Soldati GT, Sieber SS, Medeiros PM, Sá JC, Souza LC. 2011a. Rapid ethnobotanical diagnosis of the Fulni-ô Indigenous lands (NE Brazil): floristic survey and local conservation priorities for medicinal plants. Environment, Development and Sustainability 13: 277-292.

Albuquerque UP, Soldati GT, Sieber SS, Neto EMDFL, Sá JC, Souza LC. 2011c. Use and extraction of medicinal plants by the Fulni-ô indians in northeastern Brazil - implications for local conservation. Sitientibus Série Ciências Biológicas 11: 309-320.

Albuquerque UP, Soldati GT, Sieber SS, Ramos MA, Sá JC, Souza LC. 2011b. The use of plants in the medical system of the Fulni-ô people (NE Brazil): a perspective on age and gender. Journal of Ethnopharmacology 133: 866-73.

Albuquerque UP, Lucena RFP, Lins Neto EM. 2014. Selection of Research Participants. In: Albuquerque UP, Cunha LVFC, Lucena RFP, Alves RRN. (eds.) Methods and techniques in ethnobiology and ethnoecology. New York, Humana Press. p. 1-13.

Benz BF, Cevallos EJ, Santana MF, Rosales J. 2000. Losing knowledge about plant use in the Sierra de Manantlan Biosphere Reserve, Mexico. Economic Botany 54: 183-191.

Byg A, Balslev H. 2001a. Diversity and use of palms in Zahamena, eastern Madagascar. Biodiversity and Conservation 10: 951-970.

Byg A, Balslev H. 2001b. Traditional knowledge of *Dypsis Fibrosa* (Arecaceae) in Eastern Madagascar. Economic Botany 55: 263-275.

Campos CS. 2011. Aspectos da organização econômica nas relações de pressão e estratégias de sobrevivência. In: Schröder P. (ed.) Cultura, identidade e território no Nordeste Indígena: Os Fulni-ô. Recife, Editora Universitária da UFPE. p. 143-164.

Campos JLA. 2017. Ecologia e sustentabilidade do extrativismo do ouricuri (*Syagrus coronata* (Mart.) Becc.) pelos índios Fulni-ô no Nordeste do Brasil em um cenário de mudanças ambientais e culturais. PhD Thesis, Universidade Federal Rural de Pernambuco, Recife.

Campos JLA, Araújo EL, Gaoue OG, Albuquerque UP. 2018. How can local representations of changes of the availability in natural resources assist in targeting conservation? Science of the Total Environment 628: 642-649.

Campos JLA, Silva TLL, Albuquerque UP, Peroni N, Araújo EL. 2015. Knowledge, use, and management of the babassu palm (*Attalea speciosa* Mart. ex Spreng) in the Araripe Region (Northeastern Brazil). Economic Botany 69: 240-250.

CONDEPE/FIDEM. 2015. Perfil Municipal: Águas Belas. http://www.bde.pe.gov.br/estruturacaogeral/PerfilMunicipios.aspx. 25 Feb. 2019.

Gilles JL, Thomas JL, Valdivia C, Yucra ES. 2013. Laggards or leaders: Conservers of traditional agricultural knowledge in Bolivia. Rural Sociology 78: 51-74.

Giovannini P, Reyes-García V, Waldstein A, Heinrich M. 2011. Do pharmaceuticals displace local knowledge and use of medicinal plants? Estimates from a cross-sectional study in a rural indigenous community, Mexico. Social Science & Medicine 72: 928-936.

Godoy R, Brokaw N, Wilkie D, *et al.* 1998. Of trade and cognition: Markets and the loss of folk knowledge among the Tawahka Indians of the Honduran rain forest. Journal of Anthropological Research 54: 219-233

Godoy R, Reyes-García V, Byron E, Leonard WR, Vadez V. 2005. The effect of market economies on the well-being of indigenous peoples and on their use of renewable natural resources. Annual Review of Anthropology 34: 121-138.

Gómez-Baggethun E, Corbera E, Reyes-Garcia V. 2013. Traditional ecological knowledge and global environmental change: Research findings and policy implications. Ecology and Society 18: 721-729.

Gómez-Baggethun E, Mingorría S, Reyes-García V, Calvet V, Montes C. 2010. Traditional ecological knowledge trends in the transition to a market economy: empirical study in the Doñana Natural Areas. Conservation Biology 24: 721-729.

Gross DR, Eiten G, Flowers NM, Leoi FM, Ritter ML, Werner DW. 1979. Ecology and acculturation among native peoples of central Brazil. Science 206: 1043-1050.

Guest G. 2002. Market integration and the distribution of ecological knowledge within an Ecuadorian fishing community. Journal of Ecological Anthropology 6: 38-49

Hopkins AL, Stepp JR, McCarty C, Gordon JS. 2015. Herbal remedy knowledge acquisition and transmission among the Yucatec Maya in Tabi, Mexico: a cross-sectional study. Journal of Ethnobiology and Ethnomedicine 11:33. doi: 10.1186/s13002-015-0022-6

IBGE – Instituto Brasileiro de Geografia e Estatística. 2010. Os indígenas no censo demográfico 2010. Primeiras considerações com base no quesito cor ou raça. https://ww2.ibge.gov.br/indigenas/indigena_censo2010.pdf. 25 Feb. 2019.

Instituto Socioambiental. 2007. Fulni-ô. https://pib.socioambiental.org/pt/Povo:Fulni-ô. 25 Feb. 2019.

Lu F. 2007. Integration into the market among indigenous peoples: A cross-cultural perspective from the Ecuadorian Amazon Integration into the Market among Indigenous Peoples. Current Anthropology 48: 593-602.

Medeiros PM, Almeida ALS, Silva TC, Albuquerque UP. 2011. Pressure indicators of wood resource use in an Atlantic forest area, northeastern Brazil. Environmental Management 47: 410-424.

Morsello C, Delgado JADS, Fonseca-Morello T, Brites AD. 2014. Does trading non-timber forest products drive specialization in products gathered for consumption? Evidence from the Brazilian Amazon. Ecological Economics 100: 140-149.

Olson EA. 2013. Anthropology and traditional ecological knowledge: a summary of quantitative approaches to traditional knowledge, market participation, and conservation. Culture, Agriculture, Food and Environment 35: 140-151.

Pinto E. 1956. Etnologia brasileira (Fulni-ô - os últimos Tapuias). São Paulo, Editora Nacional.

R Core Team (2010). R: A language and environment for statistical computing. Vienna, R Foundation for Statistical Computing. https://www.R-project.org/.

Ramos MA, Medeiros PM, Albuquerque UP. 2014. Methods and techniques applied to ethnobotanical studies of timber resources. In: Albuquerque UP, Cunha LVFC, Lucena RFP, Alves RRN. (eds.) Methods and techniques in ethnobiology and ethnoecology. New York, Humana Press. p. 349-365.

Reyes-García V, Aceituno-Mata L, Calvet-Mir L, *et al.* 2014. Resilience of traditional knowledge systems: The case of agricultural knowledge in home gardens of the Iberian Peninsula. Global Environmental Change 24: 223-231.

Reyes-García V, Guèze M, Luz AC, *et al.* 2013. Evidence of traditional knowledge loss among a contemporary indigenous society. Evolution and Human Behavior 34: 249-257.

Reyes-García V, Vadez V, Huanca T, Leonard WR, McDade T. 2007. Economic development and local ecological knowledge: A deadlock? Quantitative research from a Native Amazonian society. Human Ecology l 35: 371-377.

Rogers EM. 2003. Diffusion of Innovations. 5th. edn. New York, Free Press.

Rudel TK, Bates D, Machinguiashi R. 2002. Ecologically noble Amerindians? Cattle ranching and cash cropping among Shuar and colonists in Ecuador. Latin American Research Review 37: 144-159

Ruiz-Pérez M, Belcher B, Achdiawan R, *et al.* 2004. Markets drive the specialization strategies of forest peoples. Ecology and Society 9: 1-35

Sierra R, Rodriguez F, Loses E. 1999. Forest resource use change during early market integration in tropical rain forests: the Huaorani of upper Amazonia. Ecological Economics 30: 107-119.

Silva TC, Cruz MP, Araújo TAS, Schwarz, ML, Albuquerque UP. 2014. Methods in research of environmental perception. In: Albuquerque UP, Cunha LVFC, Lucena RFP, Alves RRN. (eds.) Methods and techniques in ethnobiology and ethnoecology. New York, Humana Press. p. 99-109.

Soldati GT, Albuquerque UP. 2012. Ethnobotany in intermedical spaces: The case of the Fulni-ô indians (Northeastern Brazil). Evidence-Based Complementary and Alternative Medicine 2012: 648469. doi: 10.1155/2012/648469

Souza AS, Albuquerque UP, Nascimento ALB, *et al.* 2017. Temporal evaluation of the Conservation Priority Index for medicinal plants. Acta Botanica Brasilica 31: 169-179.

Vadez V, Reyes-Garcia V, Godoy RA, *et al.* 2004. Brief communication: Does integration to the market threaten agricultural diversity? panel and cross-sectional data from a horticultural-foraging society in the Bolivian Amazon. Human Ecology 32: 635-646.