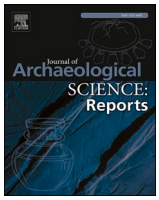
Journal of Archaeological Science: Reports 50 (2023) 104089

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep



Conducting use-wear analysis and experimental research in South Brazil: Legal challenges and possibilities

Felipe Do Nascimento Rodrigues *

Centre for the Archaeology of the Americas, Department of Archaeology, University of Exeter, Laver Building, 23 North Park Road, EX4 4QE Exeter, Devon, United Kingdom

ARTICLE INFO

Keywords:
Experimental archaeology
Contact materials
Environmental preservation
Legislation

ABSTRACT

Environment concerns have been high on the agenda worldwide and recently archaeology has been establishing itself as a powerful discipline to explore people-environment relationships. Despite countless positive outcomes, a series of environment-related challenges faced by archaeologists remain unaddressed.

This paper approaches such challenges through the lens of experimental archaeology: how can use-wear analysis and experimental research be carried out while adhering to environmental legislation? A case study of use-wear analysis research - aiming to better understand the uses of different lithic raw materials by Southern Jê people in southern Brazil during pre-colonial times - is presented to stimulate discussion. For this research, eight different plant species native to the Atlantic Forest – a critically endangered biome that is closely related to the Southern Jê – were used in 32 historically informed and actualistic experiments.

The legal challenges faced in light of the state of the Atlantic Forest and its legal protection, which affected the acquisition of contact materials, are discussed, as are the methods that were used to tackle these challenges. It is demonstrated that collaborating with responsible institutions is an effective way of overcoming the acquisition challenge while also aligning with environmental preservation interests and encouraging the use of native contact materials for experimental use-wear research. Based on the experiences gained during this research, a best practice recommendation is made, proposing that experimental archaeology adopt an environment-led approach, in which contact materials are an equally important component of the experimental design. This study serves as a reference for future research in Brazil and elsewhere where similar challenges may occur.

1. Introduction

This work addresses the challenges of conducting use-wear analysis and experimental archaeology with contextually relevant contact materials in Brazil while helping to preserve native fauna and flora by adhering to environmental preservation guidelines and legislation. This issue first arises when considering the need to conduct experiments in as contextually accurate a way as possible (Mathieu 2002, 8), thus implicating on the use of contextually relevant contact materials. In the meantime, this work was also influenced by calls to strengthen experimental research integrity through the Singapore Statement on Research Integrity (Comis 2021).

A wealth of literary information was acquired about the different uses of stone tools by indigenous groups in Brazil, particularly the Southern Jê for this work. This, however, contrasts radically with the current 'restrictions' to use native contact materials, as that implies in acquiring samples of native fauna and flora, which in many cases, are at risk of extinction and are therefore, protected by law.

This work presents the challenges of acquiring native contact materials while conducting a use-wear analysis project aimed to understand lithic raw material suitabilities in Southern Jê archaeological contexts. Although intrinsically related to a use-wear study, the discussion presented here focuses on the acquisition challenges – the experiments described in this paper (section 1.2) are limited for contextualisation purposes, and their results are intended to be published in a separate, future publication. The challenges identified are 1) the acquisition of contact materials themselves, 2) the quantity of material that can be acquired and 3) the state of the acquired material. Although the overarching theme of this paper is applicable throughout the world, this paper focuses on the southern region of the Atlantic Forest biome, in Brazil.

By identifying and discussing these challenges, this paper contributes

* Address: Department of Archaeology, University of Exeter, Laver Building, 23 North Park Road, EX4 4QE Exeter, Devon, United Kingdom.
E-mail address: fd274@exeter.ac.uk.

https://doi.org/10.1016/j.jasrep.2023.104089
Received 27 January 2022; Received in revised form 19 May 2023; Accepted 17 June 2023
Available online 2 July 2023

to the development of use-wear analysis and experimental archaeology in Brazil, and elsewhere by highlighting alternative sources of native contact material, which do not rely directly on the suppression of native flora and fauna (e.g., cutting of native trees). Given the endangered status of the Atlantic Forest Biome and the many flora and fauna species inhabiting it, the aim of this study is to foster the use of sustainable contact material sources - being either native or non-native.

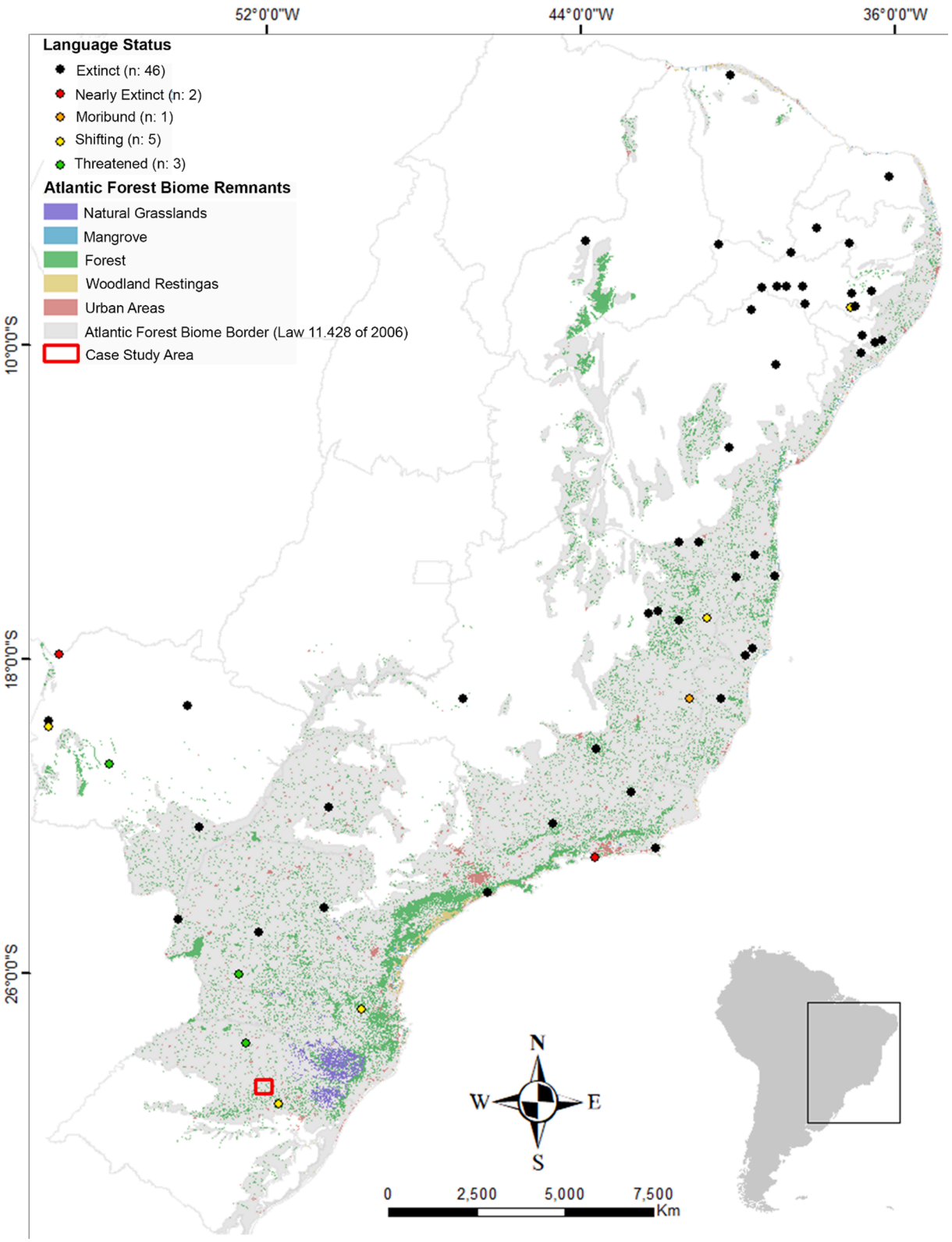


Fig. 1. Map displaying the current preservation status of the Atlantic Forest Biomes and languages associated with it in the present territory of Brazil. Note that the expanse of the language is not limited to where the point is located on the map. Linguistic data has been collected from Glottolog (Hammarström et al. 2021) and biome remnants data has been collected from Fundação SOS Mata Atlântica (2020). (Map by author).

1.1. State of the Atlantic Forest

The Atlantic Forest is the second largest biodiversity concentration in the Americas, and it spams through three countries: Brazil, Paraguay, and Argentina (Fundação Vida Silvestre Argentina and WWF 2017: 15). Its diversity is as large as its size, with a total of fifteen ecoregions spanning through its total expanse of 1,345,300 km^2 (see Fundação Vida Silvestre Argentina and WWF 2017 for further discussions on its total expanse).

Currently, the Atlantic Forest is in a critically endangered state and has been listed by Olson and Dinerstein (2002) as one of the global 200 priority ecoregions for conservation. Recent research by the SOS Mata Atlântica Foundation and Brazil's National Institute for Space Research (INPE) has identified that 15.2% of the Atlantic Forest is left in comparison to the established biome borders (Fundação SOS Mata Atlântica, Instituto Nacional de Pesquisas Espaciais, 2020:58; Fundação SOS Mata Atlântica, Instituto Nacional de Pesquisas Espaciais, 2021: 70). As of the latest report, this figure presents even starker results, with a drastic increase of 66% on the deforestation rate compared to the previous analysis period, totalling 21.642 ha of destruction in the years of 2020–2021 (Fundação SOS Mata Atlântica and Instituto Nacional de Pesquisas Espaciais 2022:38).

This increase in destruction is also happening in other biomes, such as the Amazon rainforest, where the latest figures also point to an increase in deforestation since the last period of analysis (Instituto Nacional de Pesquisas Espaciais, 2022). Such destruction was downplayed by the previous government, whose land grabbing rhetoric fuelled an increase in illegal activities such as deforestation, mining, and the invasion of indigenous lands, particularly in the Amazon region. The latter was also the subject of a harmful nationalistic rhetoric that acknowledged the economic wealth of the region and did very little to nothing to stop its destruction, thus creating a conflict with several existing laws that were put in place to protect endangered biomes, (the latter are detailed on the results section).

This impact, caused by a destructive colonial history and worsened by contemporary politics, affects not only the native flora and fauna, but also the native people who have lived near the Biome. This is further evidenced by the acute loss of languages near the Atlantic Forest Biome (see Fig. 1). Extensive historiography detailing colonial expansions, wars against indigenous peoples, forced national integration, and its many consequences supplements the documentation of these losses (D'Angelis 1984; Henry 1964; Ribeiro 1996; Santos 1973; 1978; 1997; Souza 2015; Veiga 2006).

Due to the extensive damage to the Atlantic Rainforest biome, awareness for its preservation has been growing in the last decades in South America. Governments, institutions, and individuals have been working together in preservation efforts. There are too many to be listed here, but the work of NGO's, such as the SOS Mata Atlântica Foundation in Brazil, the Vida Silvestre Argentina Foundation in Argentina, and the World Wildlife Foundation operating throughout the continent, have been key to support and lead preservation efforts. In addition to these, the work of government agencies, such as the Mata Atlântica em Pé – 'Atlantic Forest standing' a multi-state collaborative operation led by the Public Prosecutor's office, and the creation of a wide legislative corpus has provided the backbone for preservation efforts. This is manifest in many forms: from establishing legal procedures that legitimise the creation of preservation units, to delimiting the protection of biomes and detailing sanctions against agents who act in ways harmful to the environment. This legislative corpus is a focal point of this paper, where its impact on the acquisition of contact materials is further discussed in Section 3.1.

With the governmental change after the 2022 elections, the current government has started to revitalise environmental policies and take actions to reduce and prevent further environmental depredation throughout the country. This is reflected by a series of recent changes ranging from increased financial support - such as the reported environment ministry budget increase (Prizibisczki 2023) and the return of the Amazonia Fund (Ministério do Meio Ambiente e Mudança do Clima – MMA., 2023a) – to the revitalization of the National Council of Traditional People and Communities (Brasil 2023: 11) and the establishment of the Prevention and Control of Deforestation Program at a national level (Ministério do Meio Ambiente e Mudança do Clima – MMA, 2023b). Hopefully, these initiatives will have a positive impact on the preservation and restauration of native forests across the country, particularly the Atlantic Rainforest.

1.2. Experiments conducted

It is within this context of loss of nature and cultures that experimental archaeology in Brazil finds itself. It has great unexplored potential to achieve an in-depth understanding of the techniques and technologies long lost (with exception of the few records available). However, to achieve such understanding, detailed and accurate experiments, using relevant contact materials (i.e., native flora and fauna) are essential, albeit difficult due to the current legislation protecting native flora and fauna. Such challenges have been encountered before by archaeologists conducting experiments in Brazil and was dealt with by using non-native material proxies of wood (Fernandes 2020: 128) and deer antlers (Moreno de Sousa, 2019: 6). Until now, however, this challenge has not been directly addressed.

The starting point of this work stems from the difficulties experienced in acquiring contact materials for experiments as part of the project 'Many Rocks Many Functions?' The project seeks to better understand the underrepresented lithic industry of Southern Jê groups in South Brazil (see Fig. 1) by conducting a multifaceted approach to lithic tools in Southern Jê archaeological contexts. Such approaches are composed of geological cartography and petrography to identify the raw materials and their possible sources on the region, technological analysis of archaeological assemblages and experimental/use-wear research to better understand the different rocks during use.

To do so, a set of historically informed and task-oriented experiments was designed, and variables such as edge and contact angles, movement and activity duration were recorded. Following the experimental activities, use-wear analysis was conducted on the experimental tools with an optical light microscope to record wear patterns formed (such as striations and polish). The data generated by the experiments and the use-wear analysis is not displayed here, as it will be discussed in a separate, future publication focusing more in depth on the experiments and the use-wear accrual. This was done to keep the paper focused and to emphasise the significance of contact material acquisition within the context of the special issue 'The Other in Use Wear,' which focuses on the role of contact materials in use-wear analysis.

The production process of Uy (Kaingang for bows) using native contact materials (see Table 1) was an inspiration for some of the wood working tasks conducted. The objective of the experiments was to record the formation of use-wear on different raw materials widely found on the archaeological record: chert, a range of basic and acidic volcanic rocks, and quartz. The use-wear and material data (e.g., hardness, elasticity, and plasticity) were then compared with the objective of understanding if different rock types were being selected and used for distinctive tasks.

The tasks guiding the experiments consisted of a range of plant working activities: from the extraction of fibres to different wood working activities, such as, debarking, scraping, sawing, and cutting (Fig. 2). In total, seven different plant species were utilised, namely: *Allophylus edulis, Annona sylvatica*, *Bambusoideae.*, *Bromelia balansae, Inga* sp., *Peltophorum dubium*, and *Patagonula americana.* Although every effort was made to be as accurate as possible in terms of both tasks and materials, some of the contact materials detailed in historical sources (e.g., Embaúva leaves and Jacutinga grease, described on Table 1) could not be acquired.

Table 1
The production process of a bow by Southern Jê craftspeople that inspired the tasks conducted during the experimental research. The entire process was pieced together from different historical sources, as there was not a single description encompassing the full process. (Table by author).

Artefact/ Activity	Raw Material	Method of Production	References
***Uy* (Bows)**	-Pau d'arco -– Ipê Rosa and Ipê Amarelo (*Tabebuia impetiginosa*); *(Tabebuia ihrysantha); (Handroanthus albus)*. -Guajuvira (*Patagonula americana*) -Cabriuva (*Myrocarpus frondosus)*	-Wrought the bow stave into shape by rubbing it (parallel to the fibres direction) with coarse grained sandstone followed by a second stage using a finer grained sandstone. -Finished the polishing process with a flint or chalcedony flake until as smooth as possible. -Cut and polish the notches on the ends for the bow string. -Final polish with dry leaves of Embaúva (*Cecropia*) -Heat the wood with a low heat fire and rub it with jacutinga grease (*Aburria jacutinga)*.	Mabilde in Serrano 1939 (18); Mota 2008 (118) Métraux 1946 (459) Ploetz and Métraux 1930 (159) Henry 1964 (166)

2. Methods

To gain a better understanding of current environmental legislation and its implications for the practise of experimental archaeology, a bibliographic review was conducted. To do so, a variety of online sources were consulted, including Brazil's online legislation portal, the National Institute for Space Research (INPE-BR), and the SOS Mata Atlântica Foundation. In addition, contemporary and historical literature on experimental archaeology, ethnography, science centre directories, and environmental reports were reviewed.

The data collected was processed using Microsoft Excel and Esri's ArcMa***p 10.5.1. The experiment photographs were edited in GIMP (version 2.10.10) using the post-processing guidelines outlined in the Small Objects and Photography Protocol (Cerasoni and Do Nascimento Rodrigues, 2021).

Based on historical descriptions of Southern Jê peoples using or reporting on the use of stone tools, the experiments were historically informed and task-oriented (see example in Table 1). To achieve this, an extensive review of historical literature (namely: historical reports and ethnographic accounts) was conducted, focusing on recording the descriptions of tasks, production of artefacts and processes. The tasks were carried out on native contact materials collected at the Lajeado Botanical Garden, under the supervision of Mr. Ivônio Steiner, one of the gardeners. The plants were identified during the collection under the supervision of Mr. Steiner, but two species were not fully identified (*Bambusoideae*. and *Inga* sp.). Despite best efforts, the *Bambusoideae*. samples were not the native species described in historical sources, which was later discovered to be *Guadua tagoara*.

3. Results

The results of this work were organised into three main areas: 1) The relevant environment legislation, its interpretations, and influences on archaeological experiments; 2) The challenges for the acquisition of contact materials; 3) Tackling the challenges and collaborative research with relevant institutions.

3.1. Protection of fauna and flora – legislation and its interpretations

Currently, the environment in Brazil is protected by an extensive set of laws and administrative acts covering the establishment of preservation units, the protection of several biomes, and legal sanctions against trespassers. The focus of this section lies on two main laws[1]: 9.605/1998 and 11.428/2006, as they are directly relevant to what interactions with native flora and fauna are allowed and define and delimit the Atlantic Forest Biome. Additional supporting documentation is brought into the discussion when relevant.

Law 9.605 of 1998 lays out criminal and administrative sanctions derived from conducts and activities harmful to the environment (Brasil 1998). Its focus is on defining what harmful activities consist of, as well as mitigating and aggravating factors to the activities and exceptions. Additionally, it also lays out the procedures that take place after the apprehension of the product (e.g., fauna and flora victims of the illegal action).

For the scope of this paper, the relevant aspects of the law encompass the illegality of killing, stalking, hunting, catching, and using wild specimens of native or migrating fauna without authorization from competent authorities. Additionally, whoever tries to sell, export, acquire, keep, use, or transport eggs, larvae, or other wild specimens of native or migrating fauna, as well as products and objects originating from it without authorization, is also committing a criminal offence (Brasil 1998: Chapter 5, section 1 Art.29). Regarding flora, the crimes against it are composed of cutting trees in preserved forests without permission, causing direct damage to conservation units, destroying or damaging forests under permanent preservation, destroying or damaging primary or secondary vegetation in advanced or intermediate stage of regeneration from the Atlantic Forest Biome and lastly, destroying or damaging ornamental plants located in public or private spaces (Brasil 1998: Chapter 5, section 2, Art. 38, 38-A, 39, 40, 49).

Finally, of particular interest for this discussion is the definition of how to proceed after an infraction is discovered. Apprehended live fauna is to be released back to its natural habitat, or if not possible, taken to a zoo, foundation, or similar entities to be kept safe and taken care of. In the case of all other products, be they faunal or floral, they are to be evaluated and donated to scientific, hospitals, penal institutions, charities, cultural and educational institutions and/or destroyed (Brasil 1998: Chapter 3, Art. 25, § 1st, § 2nd, § 3rd). This last section is further supported by law 13.052 of 2014 (Brasil 2014), where it is laid out that living fauna is to be primarily returned to its original habitat and detailed by the Normative Instruction nº 19 of 2014 (Ibama 2014).

Law 11.428 of 2006 delimits the Atlantic Forest Biome and the diverse ecosystems that compose it, as established by the Brazilian Institute of Geography and Statistics (IBGE), with its full extent being visible in Fig. 1. It also defines that the coverage of the law is only applicable to the remnants of native vegetation on primary and secondary initial, intermediate, and advanced stages of regeneration (Brasil 2006: Chapter 1, Art. 2). To do so, it lays out that the protection and the use of the Atlantic Forest Biome needs to ensure the maintenance and recovery of biodiversity, fauna, and water regimes while stimulating research and transmission of sustainable management practices as well as raising public awareness of the necessity to recover and maintain the ecosystem (Brasil 2006: Chapter 2, Art. 6, 7.).

Similarly, of particular interest for this discussion are some permissions to cut and supress primary and secondary vegetation in intermediate and advanced stages of regeneration. This is allowed in case it is necessary for the realization of constructions, projects or public utility activities, scientific research, and preservation practices, upon an environmental impact study to be conducted prior to the activities (Brasil

[1] Individual sections of law codes were identified using the legal text structure: Chapter, Sections, Articles (Art.) and Paragraphs (§), with occasional mentions of items (roman numerals) and indents (letters of the alphabet).

Fig. 2. Five experiments conducted with different contact materials: A) Smoothening the surface of *Peltophorum dubium,* B) Smoothening the surface of *Allophylus edulis* C) Sawing the node of *Bambusa* sp., D) Debarking *Patagonula americana*, E) Extracting fibers from *Bromelia balansae*. (Photographs by author).

2014: Title 3, Chapter 1, Art. 20, Chapter 2, Art. 21, Chapter 3, Art. 23). Additionally, the eventual exploration of native flora species for non-commercial purposes by traditional populations or small-scale agricultural producers, does not require regulation from competent authorities (Brasil 2006: Title 2, Art. 9).

To complement both laws discussed above, it is highly recommended that the administrative acts 443, 444 and 445 of 2014 (Ministério do Meio Ambiente – MMA., 2014a; Ministério do Meio Ambiente – MMA., 2014b; Ministério do Meio Ambiente – MMA., 2014c) are consulted as they list which species of flora, fauna, fishes, and aquatic invertebrates are threatened with extinction.

Overall, current environmental legislation is broad and detailed, but there are opportunities to obtain native flora and fauna as contact materials for experiments. There are three major possibilities: Firstly, requesting permission from the relevant authorities to interact directly with the fauna and flora; secondly, engaging with cultural and scientific institutions that work to preserve and regenerate the environment throughout Brazil and are direct recipients of specimens, products, and by products apprehended by environmental authorities; and thirdly, collaborating with native traditional populations if the project is of interest to them and they can assist in the acquisition of specimens.

3.2. *Contact material acquisition – collaborating with institutions*

In this section, the acquisition of contact materials is discussed. Here, the second possibility mentioned above, collaborating with institutions is discussed in detail and focus is given to the flora, as due to preservation efforts in place, the legal restriction, and its more perishable nature, animal material is harder to come by.

The acquisition of contact material for this experiment was only possible due to collaboration with two local institutions in the state of Rio Grande do Sul: The Science Museum at the Universidade do Vale do Taquari (Univates) and the Botanical Garden of Lajeado. The plant specimens (detailed in Section 1.2) were in mixed conditions: ranging from fresh to aged, as some were harvested on the collection day while others were collected from the trimming pile. The Science Museum receives animal specimens from various sources, mainly roadkill accidents and/or legal apprehensions (as discussed in Section 3.1) which are used for the taxidermy collection. When approached, the institution was open to collaboration and offered a specimen of *Leopardus pardalis,* but due to time constraints, it was not possible to utilise it.

This example shows that it is possible to acquire relevant contact material for experiments when collaborating with institutions. The main challenge is timing, as in many cases the nature of the contact materials is perishable, and the conditions and policies of storage may vary

throughout institutions and regions.

To foster the development of experimental archaeology in Brazil, it is necessary to facilitate contact with institutions across the country. To do so, a database is under construction (building upon the ABCMC, 2015 catalogue - see appendix 1) and so far, 72 institutions have been listed, covering a wide range of biomes, flora, fauna, and research interests. The database includes the type of institution (e.g., zoo, botanical garden, museum, ecological park), their area of interest, their location, and their contact information to better guide current and future experimental practitioners.

Although this case study only worked with flora (as stated above), the challenge of acquiring fauna remains extremely relevant for this study (as evidenced by the use of *Aburria jacutinga* grease in the bow making process - detailed in Table 1), as well as for future experimental studies in the region, emphasising the importance in discussing the acquisition of both fauna and flora materials.

4. Discussion

The intricacies of the legal system and how to navigate it to acquire contact materials has been demonstrated in the previous section, but what are the implications to the practice of use wear analysis and experimental archaeology? This section discusses two main aspects that are influenced by the challenges of contact material acquisition: 1) the practical impact on experiments and 2) possible theoretical changes on the framework of experimental archaeology. Finally, it culminates by proposing a recommendation(s) of best practice to respond to these challenges.

4.1. Practical impact on experiments

Three main issues with direct implication to experiments were identified. The first two are the contact material acquisition, and the limited quantity of specimens that can be obtained. These have a direct effect on experiments, as when conducted under these circumstances, experiments may face comparability and replicability issues due to the low number of trials and repetitions. This is a recurrent issue in experimental archaeology and use wear analysis (Marreiros et al., 2020a: 2), which in this case stems from the original limited access to contact materials.

Despite arguing for a sustainable approach to native contact materials, the use of alternative contact materials is also commonplace in use-wear studies and can be extremely helpful in answering different questions. In these cases, using materials of similar properties to the native materials (such as using a non-native hardwood as a proxy material for a native hardwood species) can be extremely useful while at the same time not belonging to the same taxonomic species. However, ultimately, the use of contact materials (native or not) needs to be informed choices based on different sets of evidence, from ethnography (Xhauflair et al. 2020) and historical reports (this study, Kononenko et al. 2015) to residue (Fullagar et al. 2015), palaeo diet (Bello-Alonso et al. 2019; Bello-Alonso et al., 2020) and environmental studies (Walton 2018).The third issue is regarding the state of the materials acquired. This can result in severe variability of the samples acquired. In ideal cases, the material may be freshly acquired (as freshly cut branches of *Patagonula americana*) while in other cases it may have been exposed to weathering on the trimming pile for an unknown period before acquisition, which may result in significant material alterations, such as drying and/or rotting. Unfortunately, this is a variable that needs be considered and the best way to deal with it is to bring it into the early stages of experimental design.

This would ideally happen by making sure that the experimenter is aware of the limitations faced, and how they directly affect their experimental design. At the current stage, the safest and most reliable way of dealing with this from an experimental design perspective is to conduct first generation experiments, aiming to identify major variables such as raw material suitabilities and tool efficiency. Additionally, these experiments also provide increased contextual awareness which can lead to optimising planning, costs, and timing of future activities (Marreiros et al 2020b: 484). This paper, for instance, can be argued to be a prime example of the latter beneficial results of first-generation experiments.

4.2. Theoretical changes?

Here, possible theoretical implications to experiments are raised in the form of questions and ponderations for future practices of experimental archaeology. It is not hoped to provide definitive answers, but questions that lead future practitioners to reflect on their own contexts and ultimately make informed decisions.

The first question raised is: how can one ally quantitative validity (see Marreiros et al., 2020a) with environment preservation in experimental archaeology? A clear answer is not possible, but within the context of this paper, it is possible to do so by shifting the experimental framework, to ask questions which do not rely solely on quantification for its validity. The other possibility is to engage directly with possible contact material sources in the early stages of experiment design and establish a collaborative experimental programme that may result in the acquisition of the necessary number of samples.

The second question relates to engaging with the environmental preservation efforts in place and take a stance: How can we turn experimental archaeology practice to be environment led? Heeding the (much needed) current calls for standardization of experiments (Marreiros et al. 2020a, 2020b), it is both logical and necessary to adopt such an approach. Here it is argued that by being aware of the need to standardize processes, and the need to preserve the environment that different populations have been interacting with, we must accept that our experiment protocols need to adapt to this changing reality.

It is strongly believed that by adopting an environment led practice of experimental archaeology, we can ask questions that are relevant to understanding past problems, whilst also acknowledging our present reality and the future implications of our research. Additionally, by taking such an approach, the challenges discussed here will be met at an earlier stage during the experimental design and tackled appropriately. An environment led practice also contributes to narrowing the Cartesian gap between nature and culture, as in these cases both concepts are intertwined and inseparable.

4.3. Recommendation(s) of best practice

Based on the experiences obtained during the presented case study as well as research into other possible challenges related to material acquisition for archaeological experiments, a recommendation of best practice is proposed. This is not a fixed step by step process, but a flexible set of criteria to be considered by experimental practitioners who might find themselves in similar situations.

First and foremost, researchers should always be aware of the contexts they are working with. In the presented case study, that meant being aware of the biome's state of preservation, environmental legislation, and the technology/technique and/or materials trying to be understood. The consultation of resources such as the database provided (appendix 1) and the relevant legislation (see section 3.1) is highly recommended. While some resources are applicable on a national scale (e.g., laws), some are regional and require detailed scrutiny (e.g., lists of endangered species, and regional administrative acts).

Secondly, researchers should ensure that the questions and the experimental design are informed by the identified issues (described in section 1), thus promoting critical reflection at the early stages of research development and the identification of possible acquisition issues.

Thirdly, researchers should engage with a collaborative framework to experimental archaeology, as working together with people and

institutions can prove beneficial for all parties involved. Collaboration has the potential to tackle material acquisition issues, better understand techniques/ technologies and materials as well as bring attention to environmental preservation efforts.

This third issue is particularly important when working directly with indigenous communities. Although it was not the case of the research presented here, collaborating with indigenous communities can be challenging but extremely beneficial for all parties involved (Nicholas et al. 2011: 25-26). This approach, despite being a possibility to acquire contact materials, cannot be treated just as such.

For this to take place, however, close, and clear dialogues must be established between archaeologists and indigenous people where the interests of both sides must be aligned (Silva 2015: 146). The only way of achieving that is when there is community involvement since the onset of the research design all the way through interpretation and publication of the results (Nicholas et al. 2011, Silva 2015; Cabral 2016).

Previous works of collaborative archaeology with Indigenous Peoples in Brazil (Green et al. 2003, Silva 2002, 2015, Cabral 2016) provide an extremely diverse picture, where there is no 'one way' of conducting collaborative research with communities in their lands. Additionally, the interaction between archaeologists and Indigenous populations in Brazil is increasingly harder, given the economic pressures on their territories (Silva 2002:184), particularly worsened by the recent stances of the Brazilian government (as exposed on section 1.1).

On a global picture, this call is also recently exposed by Clark and Horning (2019) when they acknowledge that 'the authors here do not all agree on the specifics of practice or the right steps to take in overcoming challenges and dealing with ethical and practical dilemmas' (2019: 349). Hence, it is of extreme importance that future use-wear studies be aware of these challenges, be honest and open about their intentions and, - echoing the words of Clark and Horning (2019): 36 – 'be ready to walk away from a project'.

To use-wear research, one of the advantages of collaborating with Indigenous people is not only the creation of diverse wear traces, but also acquiring and recording a collection of traditional knowledge, skills, techniques, and processes of working different materials (see the works of Xhauflair, et al. 2017; 2020 with the Pala'wan in the Philippines as exemplary studies).

For future studies, interested in understanding past processes, skills, artefacts and their uses, collaborative engagements (given that this engagement is of interest to all parties involved) with indigenous people may be a possibility of creating 'a knowledge that is grounded in the principles of archaeological science as well as indigenous knowledge' (Green et al., 2003: 393).Lastly, researchers should conduct experiments in a responsible and accountable manner, with detailed accounts of material acquisition, thus promoting conditions that foster their repeatability and comparability.

5. Conclusion

This paper has discussed how contact materials have taken centre stage in use wear analysis and experimental research. Contact materials have moved from a supporting role to the understanding of a main research question (stone tool focused on this case) to an equally important role in the experimental design. It has been shown that while an initial clash arises when trying to conduct contextually accurate experiments with limited access to contact materials, this challenge can be dealt with through establishing thriving relationships between the experimental archaeology praxis and the preservation of native flora and fauna.

This discussion is seen as a key element in the development of a responsible practice of experimental archaeology, bringing it to standards with the Singapore Statement on Research Integrity (Comis 2021). By bringing awareness to the legislation and its implications, it aims to assist future experiments to tackle similar challenges from the beginning of the research development, thus contributing to their replicability, comparability, and reproducibility in contexts where contact material access is more limited.

Finally, the discussion of the challenges and limitations encountered during this case study, the creation of a database containing an extensive and growing list of institutions for potential collaboration, and the writing of a recommendation(s) of best practice can all serve as a reference for future works in experimental archaeology and use-wear analysis, both in Brazil and elsewhere where similar challenges may exist.

CRediT authorship contribution statement

Felipe Do Nascimento Rodrigues: Conceptualization, Investigation, Methodology, Visualization, Funding acquisition, Project administration, Writing – original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The Data used is available online on the website of different institutions. These have been referenced on the paper when relevant.

Acknowledgments

This work was supported by the University of Exeter College of Humanities International PhD Studentship. I would like to thank Dr. Neli Machado for hosting me at the Univates Sciences Museum, Dr. Marina Dalzochio for liaising with the Botanical Garden of Lajeado, Ms. Edith Ester Zago de Mello for granting permission to collect contact materials at the Botanical Garden and Mr. Ivônio Steiner for supervising the collection of the materials. I would like to thank Professors Linda Hurcombe and Jose Iriarte for their support and insightful comments. I would also like to thank Dóra Szabó and Wouter Bonhof for the discussions, comments and language help that improved this paper. I also would like to thank the two anonymous reviewers, whose comments greatly improved this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2023.104089.

References

Bello-Alonso, P., Rios-Garaizar, J., Panera, J., Pérez-González, A., Rubio-Jara, S., Rojas-Mendoza, R., Domínguez-Rodrigo, M., Baquedano, E., Santonja, M., 2019. A use-wear interpretation of the most common raw materials from the Olduvai Gorge: Naibor Soit quartzite. Quat. Int. 526, 169–192.

Bello-Alonso, P., Rios-Garaizar, J., Panera, J., Martín-Perea, D.M., Rubio-Jara, S., Pérez-González, A., Rojas-Mendoza, R., Domínguez-Rodrigo, M., Baquedano, E., Santonja, M., 2020. Experimental approaches to the development of use-wear traces on volcanic rocks: basalts. Archaeol. Anthropol. Sci. 12 (7) https://doi.org/10.1007/s12520-020-01058-6.

Brasil, 1998. Lei n° 9.605, de 12 de Fevereiro de 1998. Dispõe sobre as sanções penais e administrativas derivadas de condutas e atividades lesivas ao meio ambiente e dá outras providências. *Diário Oficial da União.* Brasília, DF. Available at: http://www.planalto.gov.br/ccivil_03/leis/L9605.htm. Accessed on: 22/10/19.

Brasil, 2006. Lei n° 11.428, de 22 de Dezembro de 2006. Dispõe sobre a utilização e proteção da vegetação nativa do Bioma Mata Atlântica, e dá outras providências. *Diário Oficial da União.* Brasília, DF. Available at: https://www.planalto.gov.br/ccivil_03/_ato2004-2006/2006/lei/l11428.htm. Accessed on: 01/12/2021.

Brasil, 2014. Lei n° 13.052, de 8 de Dezembro de 2014. Altera o art. 25 da Lei n° 9.605, de 12 de fevereiro de 1998, que dispõe sobre as sanções penais e administrativas derivadas de condutas e atividades lesivas ao meio ambiente e dá outras providências, para determinar que animais apreendidos sejam libertados prioritariamente em seu habitat e estabelecer condições necessárias ao bem-estar

desses animais. *Diário Oficial da União*. Brasília, DF. Available at: http://www.planalto.gov.br/ccivil_03/_Ato2011-2014/2014/Lei/L13052.htm#art2. Accessed on: 01/12/2021.

Brasil, 2023. Decreto n° 11.841, de 6 de Abril de 2023. Altera o Decreto n° 8.750, de 9 de maio de 2016, que institui o Conselho Nacional dos Povos e Comunidades Tradicionais. *Diário Oficial da União* 67-B. Brasília, DF. Available at:https://pesquisa.in.gov.br/imprensa/jsp/visualiza/index.jsp?data=06/04/2023&jornal=601&pagina=11. Accessed on: 02/05/2023.

Associação Brasileira de Centros e Museus de Ciência. 2015. *Centros e Museus de Ciência do Brasil 2015*. UFRJ. FCC. Casa da Ciência, Fiocruz. Museu da Vida. Rio De Janeiro.

Cabral, M.P., 2016. Entre Passado e Presente: Arqueologia e Coletivos Humanos na Amazônia. Teoria e Sociedade 24, 76–91.

Cerasoni, J.N., Do Nascimento Rodrigues, F., 2021. Small Object and Artefact Photography – 'SOAP' Protocol. Protocols.io. DOI: dx.doi.org/10.17504/protocols.io.buz8nx9w. Accessed on: 10/11/2021.

Clark, B. J. Horning, A. 2019. Introduction to a global dialogue on collaborative archaeology. *Archaeologies: Journal of the World Archaeological Congress* 15. 343-351. https://doi.org/10.1007/s11759-019-09373-8.

Comis, L., 2021. Ethics and Experimental Archaeology. The Singapore Statement for Research Integrity and Possible Applications. Experimental Archaeology Conference 12. Available at: https://www.youtube.com/watch?v=-dSFIcChvg4&t=3s. Accessed on: 30/11/2021.

D'Angelis, W.R., 1984. Toldo Chimbangue. História e luta Kaingang em Santa Catarina. Xanxerê. Conselho Indigenista Missionário (CIMI) Regional Sul.

Fernandes, H.L.A., 2020. Síntese dos Estudos Tecnológicos e Macrotraceológicos em Lâminas de Machado Lascadas de um Grupo Ceramista Horticultor do Brasil. *Revista del Museo de Antropología* 13: 121-134. DOI: http://doi.org/10.31048/1852.4826.v13.n1.23820.

Fullagar, R., Hayes, E., Stephenson, B., Field, J., Matheson, C., Stern, N., Fitzsimmons, K., 2015. Evidence for Pleistocene seed grinding at Lake Mungo, south-eastern Australia. Archaeol. Ocean. 50, 3–19.

Fundação SOS Mata Atlântica, Instituto Nacional de Pesquisas Espaciais, 2020. *Atlas dos Remanescentes Florestais da Mata Atlântica Período 2018-2019*. Technical Report. São Paulo. Available at: http://mapas.sosma.org.br/. Accessed on: 09/08/2021.

Fundação SOS Mata Atlântica, Instituto Nacional de Pesquisas Espaciais, 2021. *Atlas dos Remanescentes Florestais da Mata Atlântica Período 2019-2020*. Technical Report. São Paulo. Available at: https://cms.sosma.org.br/wp-content/uploads/2021/05/SOSMA_Atlas-da-Mata-Atlantica_2019-2020.pdf. Accessed on: 21/10/2021.

Fundação SOS Mata Atlântica, Instituto Nacional de Pesquisas Espaciais, 2022. *Atlas dos Remanescentes Florestais da Mata Atlântica Período 2020-2021*. Technical Report. São Paulo. Available at: https://cms.sosma.org.br/wp-content/uploads/2022/05/Sosma-Atlas-2022-1.pdf.

Fundação Vida Silvestre Argentina, WWF, 2017. Condição da Floresta Atlântica: Três Países, 148 milhões de pessoas, uma das florestas mais ricas da Terra. Report. Puerto Iguazu. Available at: https://wwfbr.awsassets.panda.org/downloads/pub_estadodamataatlantica_web_25maio17.pdf. Accessed on: 09/08/2021.

Green, L.F., Green, D.R., Góes Neves, E., 2003. Indigenous knowledge and archaeological science: the challenges of public archaeology in the Reserva Uaçá. J. Soc. Archaeol. 3, 366–398. https://doi.org/10.1177/14696053030033005.

Hammarström, H., Forkel, R., Haspelmath, M., Bank, S., 2021. Glottolog 4.4. Leipzig: Max Planck Institute for Evolutionary Anthropology. Available at: http://glottolog.org. Accessed on: 22/11/2021. DOI: https://doi.org/10.5281/zenodo.4761960.

Henry, J., 1964. Jungle People, a Kaingáng tribe of the Highlands of Brazil. Vintage Books, New York.

Ibama, 2014. Instrução Normativa Ibama nº 19, de 19 de Dezembro de 2014. Diário Oficial da União Seção 01, p.98. Brasília, DF. Available at: https://www.icmbio.gov.br/cepsul/legislacao/instrucao-normativa/430-2014.html. Accessed on: 03/12/2021.

Instituto Nacional de Pesquisas Espaciais (INPE), 2022. Monitoramento do Desmatamento da Floresta Amazônica Brasileira por Satélite. Available at: http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes. Access on: 10/09/2022.

Kononenko, N., Torrence, R., White, P., 2015. Unexpected uses for obsidian: experimental replication and use-wear/residue analysis of chopping tools. J. Archaeol. Sci. 54, 254–269. https://doi.org/10.1016/j.jas.2014.11.010.

Marreiros, J., Pereira, T., Iovita, R., 2020a. Controlled experiments in lithic technology and function. Archaeol. Anthropol. Sci. 12, 110. https://doi.org/10.1007/s12520-020-01059-5.

Marreiros, J., Calandra, I., Gneisinger, W., Paixão, E., Pedergnana, A., Schunk, L., 2020b. Rethinking use-wear analysis and experimentation as applied to the study of past hominin tool use. J. Paleolithic Archaeol. 3, 475–502. https://doi.org/10.1007/s41982-020-00058-1.

Mathieu, J.R., 2002. Introduction – Experimental Archaeology: Replicating Past objects, behaviors, and processes. In: Mathieu, J. R. (Ed.) Experimental Archaeology Replicating past objects, behaviors, and processes. BAR International Series 1035. 1-11.

Métraux, A., 1946. The Caingang. In: Steward, J. H. (Ed.) Handbook of South American Indians Vol. 1. Washington. Government Printing Office. 445-475.

Ministério do Meio Ambiente – MMA, 2014a. Portaria n° 443, de 17 de Dezembro de 2014. *Diário Oficial da União*, 18/12/2014, Seção 1, p. 110-121. Available at: http://www.icmbio.gov.br/cepsul/legislacao/portaria/427-2014.html. . Accessed on: 20/11/2019.

Ministério do Meio Ambiente – MMA. 2014b. Portaria n° 444, de 17 de Dezembro de 2014. *Diário Oficial da União*, 18/12/2014, Seção 1, p. 12. Available at: http://www.icmbio.gov.br/cepsul/legislacao/portaria/427-2014.html. Accessed on: 20/11/2019.

Ministério do Meio Ambiente – MMA. 2014c. Portaria n° 445, de 17 de Dezembro de 2014. *Diário Oficial da União*, 18/12/2014, Seção 1, p. 126. Available at: http://www.icmbio.gov.br/cepsul/legislacao/portaria/427-2014.html. Accessed on: 20/11/2019.

Ministério do Meio Ambiente e Mudança do Clima – MMA, 2023b. Nova estratégia de combate ao desmatamento reúne 19 ministérios. ASCOM MMA. Published on: 09/02/2023. Available at: https://www.gov.br/mma/pt-br/assuntos/noticias/nova-estrategia-de-combate-ao-desmatamento-reune-19-ministerios. Accessed on: 01/05/2023.

Ministério do Meio Ambiente e Mudança do Clima – MMA, 2023a. *Fundo Amazônia volta e aprova prioridade para Yanomamis*. ASCOM MMA. Published on 16/02/2023. Available at: https://www.gov.br/mma/pt-br/assuntos/noticias/fundo-amazonia-volta-e-aprova-prioridade-para-yanomamis. Accessed on: 01/05/2023.

Moreno de Sousa, J.C., 2019. Bringing Experimental Lithic Technology to Paleoamerican Brazilian Archaeology: Replication studies on the Rioclarense and Garivaldinense industries. EXARC J 3. https://exarc.net/ark:/88735/10440.

Mota, L.T., 2008. As guerras dos índios Kaingang: A História Épica dos Índios Kaingang no Paraná (1796-1924). 2 ed. Maringá. Editora da Universidade Estadual de Maringá (EDUEM).

Nicholas, G.P., Roberts, A., Schaepe, D.M., et al., 2011. A consideration of theory, principles and practice in collaborative archaeology. Archaeological Review from Cambridge 26, 11–30.

Olson, D.M., Dinerstein, E., 2002. The global 200: priority ecoregions for global conservation. Ann. Mo. Bot. Gard. 89 (2), 199–224.

Ploetz, H., Métraux, A., 1930. The material civilization and social and religious life of the Ze Indians of Southern and Eastern Brazil. Unpublished English Translation of: Ploetz, H. Métraux, A. 1930. La civilisation matérielle et la vie sociale et religieuse des indiens Žè du Brésil meridional et oriental. Revista del Instituto de Etnología de la Universidad Nacional de Tucumán I. Tucumán. 107-238. Available at: http://www.etnolinguistica.org/biblio:ploetz-metraux-1930-material. Accessed on: 10/10/2019.

Prizibisczki, C., 2023. Orçamento do MMA tem recomposição de meio bilhão e retorna aos valores pré-Bolsonaro. *O Eco*. Published on: 17/01/2023. Available at: https://oeco.org.br/reportagens/orcamento-do-mma-tem-recomposicao-de-meio-bilhao-e-retorna-aos-valores-pre-bolsonaro/. Accessed on: 01/05/2023.

Ribeiro, D., 1996. Os Índios e a Civilização: A Integração das populações índigenas no Brasil Moderno. São Paulo. Companhia das Letras.

Santos, S.C., 1973. Índios e Brancos no Sul do Brasil: A Dramática Experiência dos Xokleng. Florianópolis. Edeine.

Santos, S.C., 1978. O Homem Índio Sobrevivente do Sul: Antropologia Visual. Porto Alegre. Garatuja.

Santos, S.C., 1997. Os Índios Xokleng: Mémoria Visual. Florianópolis. Ed. Da UFSC; Ed. Da UNIVALI.

Serrano, A., 1939. Los Kaingangs de Rio Grande do Sul a mediados del siglo XIX. Según un manuscrito inédito del tenient coronel Alfonso Mabilde. Revista del Instituto de Antropología de la Universidad Nacional de Tucumán 2, 13–35.

Silva, F.A., 2002. Mito e Arqueologia: A interpretação dos Asurini do Xingu sobre os vestígios arqueológicos encontrados no Parque Indígena Kuatinemu – Pará. Horizontes Arqueológicos 18. 175 -187.

Silva, F.A., 2015. Arqueologia Colaborativa com os Asurini do Xingu: Um relato sobre a pesquisa no igarapé Piranhaquara, T. I Koatinemo. Revista de Antropologia 58. 143-172.

Souza, A.A., 2015. Armas Pólvora e Chumbo: A Expansão Luso-Brasileira e os Índios do Planalto Meridional. Guarapuava. Editora UFPR; Editora UNICENTRO.

Veiga, J., 2006. Aspectos Fundamentais da Cultura Kaingang. Campinas. Editora Curt Nimuendajú.

Walton, D.P., 2018. An experimental program for obsidian use-wear analysis in central Mexican archaeology. J. Archaeol. Method Theory 26, 895–942. https://doi.org/10.1007/s10816-018-9398-7.

Xhauflair, H., Revel, N., Vitales, T.J., Callado, J.R., Tandang, D., Gaillard, C., Forestier, H., Dizon, E., Pawlik, A., 2017. What plants might potentially have been used in the forests of prehistoric Southeast Asia? An insight from the resources used nowadays by local communities in the forested highlands of Palawan Island. Quat. Int. 448, 169–189.

Xhauflair, H., Pawlik, A., Jago-on, S., Vitales, T., Callado, J.R., Tandang, D., Palconit, T., Manipon, D., Gaillard, C., Theodoropoulou, A., Revel, N., Forestier, H., 2020. Plant Processing experiments and use-wear analysis of Tabon Cave artefacts question the intentional character of denticulates in prehistoric Southeast Asia. J. Archaeol. Sci. Rep. 32, 102334.