PaleoAmerica

A journal of early human migration and dispersal

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ypal20

Confirmation of Starchy Plant Processing in Lagoa Santa by Paleoindian People: Results of Microrremain and Use-Wear Analysis at Lapa Grande de Taquaraçu

Rodrigo Angeles Flores, Maria Ester Venezia, Astolfo Gomes de Mello Araujo & Gregório Ceccantini

To cite this article: Rodrigo Angeles Flores, Maria Ester Venezia, Astolfo Gomes de Mello Araujo & Gregório Ceccantini (2023) Confirmation of Starchy Plant Processing in Lagoa Santa by Paleoindian People: Results of Microrremain and Use-Wear Analysis at Lapa Grande de Taquaraçu, PaleoAmerica, 9:1, 7-24, DOI: 10.1080/20555563.2023.2174828

To link to this article: https://doi.org/10.1080/20555563.2023.2174828

Published online: 28 Feb 2023.

PALEOAMERICA
2023, VOL. 9, NO. 1, 7–24
https://doi.org/10.1080/20555563.2023.2174828

Center for the Study of the First Americans
Texas A&M University

Routledge
Taylor & Francis Group

RESEARCH REPORT

Check for updates

Confirmation of Starchy Plant Processing in Lagoa Santa by Paleoindian People: Results of Microrremain and Use-Wear Analysis at Lapa Grande de Taquaraçu

Rodrigo Angeles Flores[a], Maria Ester Venezia[b], Astolfo Gomes de Mello Araujo[c], and Gregório Ceccantini[d]

[a]Museu de Arqueologia e Etnologia, Universidade de São Paulo (MAE-USP), São Paulo, Brazil; [b]Department of Sociology and Anthropology, Fordham University, Bronx, NY, USA; [c]Museu de Arqueologia e Etnologia, Universidade de São Paulo (MAE-USP), São Paulo, Brazil; [d]Instituto de Biociências, Universidade de São Paulo (IB-USP), São Paulo, Brazil

ABSTRACT
For decades, the importance of tuberous plants in central Brazil's Paleoindian subsistence models has been indirectly inferred through dental and lithic analysis. However, little direct evidence about the consumption of this type of plant has been produced. In this report, we present some of the earliest evidence for starchy plant processing in the area. To do so, starch-grain and use-wear analyses were applied to lithics from the Lapa Grande de Taquaraçu site. This is a small limestone rock shelter located in an area bordering the Lagoa Santa micro-region (Minas Gerais State, Brazil), occupied from ca. 11,500 to 1000 calendar years ago. The presence of starch grains in almost every lithic artifact analyzed, together with use-wear marks, suggest their use in the processing of tuberous plants and, indirectly, the consumption of this type of vegetable resource among Paleoindian groups. Moreover, morphological modifications shown in some of the starch grains might indicate cooking or fermentation.

ARTICLE HISTORY
Received 20 June 2022
Accepted 26 January 2023

KEYWORDS
Starch; Paleoindians; Lapa Grande de Taquaraçu; Lagoa Santa; use-wear

1. Introduction and background

1.1. Lagoa Santa

Lagoa Santa is a protected natural park area (APA, according to its Portuguese acronym) located in the southeastern region of Brazil, 46 km from Belo Horizonte, the capital city of the Minas Gerais State (Figure 1; Araujo and de Oliveira 2010).

The predominant biome in the area is the Cerrado (Brazilian savannah), which includes various types of vegetation including *campo limpo*, *campo sujo*, *cerrado sensu stricto*, *cerradão*, and *mata ciliar*. Nevertheless, forest-type physiognomies such as *floresta estacional semidecidual* and *mata ciliar* from the Mata Atlântica biome are also present, because Lagoa Santa is located in an area of ecotonal contact between these two biomes (Freire 2011).

Cerrado's dry environment combined with little arboreal vegetation in the savannah's phytofisionomies makes natural fires easy to occur. The Cerrado vegetation has adapted to these fires in different ways: some trees have developed hard and thick bark and sinuous and suberous trunks (Castro Souza et al. 2018, 12); some grasses form a kind of "tunic" with old or dead leaves that protect their germinated part from moisture loss and fire (Edwards 1956; Rawitscher 1948); sometimes plants form several underground storage systems such as rhizomes, bulbs, and tubers, and some of these systems develop a bark, such as lignotubers and xilopodia (Apezzato-Da-Glória and Estelita 2000). As a result, the biomass below the surface is very vast, reaching up to 71% of the total phytomass (vegetation above + vegetation below the surface) (De Castro and Kauffman 1998, 264).

The karstic nature of this region makes it susceptible to hydric dissolution processes, which have resulted in the formation of numerous sinks, sinkholes, caves, and rock shelters. Paleoindian[1] groups who populated this region 12,000 years ago knew how to take advantage of these geological formations, and today Lagoa Santa is considered one of the richest regions of archaeological sites in southeastern and central Brazil.

The first researcher to popularize this region *vis-à-vis* its scientific importance was Peter Wilheim Lund, a Danish naturalist who arrived at Lagoa Santa during the nineteenth century. His explorations in almost 200 caves led him to propose the coexistence between humans and extinct megafauna, something new for that time. Various researchers followed Lund, mostly to test his conclusions regarding human antiquity, but it was only in the middle of the twentieth century that a proper archaeological excavation took place in the area with the works of the North American-Brazilian mission, formed by Wesly Hurt, Castro-Faria, Paulo

CONTACT Rodrigo Angeles Flores rodrigo.angelesfl@gmail.com

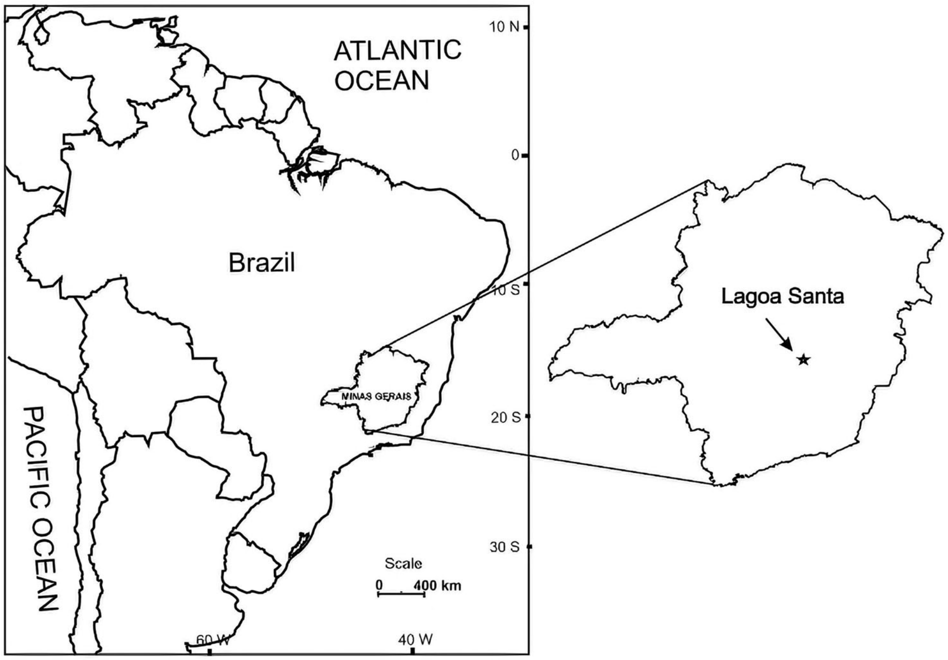

Figure 1 Location of the Lagoa Santa area (from Araujo, Neves, and Kipnis 2012).

Couto, and Oldeman Blasi (Hurt and Blasi 1969). These excavations brought out the first absolute date for the region (9700 ^{14}C yr BP or 11,200 cal yr BP) at the Cerca Grande site (Araujo, Neves, and Kipnis 2012, 534). Years later, the French Mission, led by Annette Lamming-Emperaire and with the participation of André Prous (Lamming-Emperaire et al. 1975), excavated at the Cerca Grande, Lapa das Boleiras, Lapa do Chapéu, and Lapa Vermelha IV sites. At the last, a skeleton named first Hominid-1 and then later *Luzia* by Neves et al. (1999) was found.[2]

It was not until the year 2000 that excavations started again in the region, with a long-term paleoanthropological project directed by Walter A. Neves. That project continued the excavations in Lapa das Boleiras, Cerca Grande IV, and Lapa do Santo, excavated during earlier projects, as well as some never-before-excavated open-air sites (Sumidouro-Coquerinho) and a rock shelter (Araujo, Neves, and Kipnis 2012). The materials discussed in this article come from the last of these sites, Lapa Grande de Taquaraçu.

1.2. Plant consumption amongst Paleoindians

Subsistence amongst Paleoindians is something that has been discussed since the onset of studies about these groups. Traditionally, they were portrayed as hunters specialized in megafauna, and meat consumption was assumed to be the principal component of their diet. The cause of this portrait was that, prior to the development of direct-dating techniques, a site was considered Paleoindian if a great quantity of extinct megafaunal remains were associated with human artifacts, especially projectile points. This led to the situation in which other archaeological materials potentially indicating another type of diet were not taken into account (Kornfeld 2007). The influence of this model was palpable in the popularity of the overkill hypothesis (Martin 1973), which puts humans as the principal cause for the extinction of megafauna in the Americas. According to this model, plants would have a more important role in the diet after the extinction of these animals. Nevertheless, archaeozoological studies have demonstrated a more diverse diet that includes small- to medium-sized animals at Clovis sites (Collins 2007), even at sites where the consumption of megafauna is evident (Ferring 2001; Kornfeld 2007; Yesner 2007). Archaeological findings like ground stones and nets for hunting sheep in Paleoindian sites have also helped to shift the conception of Paleoindian diet as a diverse one (Kornfeld 2007).

Archaeobotanical studies have also played an active role in this interpretation, providing direct evidence for plant consumption in Paleoindian sites (Homsey, Walker, and Hollenbach 2010; McDonough et al. 2022), especially starch-grain analysis (Acosta Ochoa 2010; Piperno and Dillehay 2008). Starch grains can survive in stone-tool cracks, where they seem to be protected from the usual degrading agents like enzymes, bacteria, moist fluctuation, temperature, or pH (Haslam 2004, 1726). This fact has resulted in archaeological findings related to plant consumption and processing from thousands of years ago. Van-Peer and colleagues (2003), for example, reported starch grains and phytoliths recovered from ~200,000-year-old lithic artifacts, and Loy and colleagues (1992) analyzed and identified starch gains from artifacts presumed to date to 28,000 years ago.

1.3. Starchy plant consumption amongst Paleoindian groups in central Brazil

For central Brazil, Kipnis (1998) characterized the people of this region until 3500 cal yr BP as egalitarian gatherers, subsisting on small-sized animals and plants, using an expedient lithic technology to manufacture wooden instruments. According to the model, settlers of this region during the Pleistocene/Holocene transition confronted a scarcity of high-ranked food items such as large animals, and to overcome this problem, they employed a generalized gathering and opportunistic hunting strategy, with the inclusion of several low-ranked resource types, including a diversity of plants (Kipnis 2002). Thus, the subsistence of these people was centered around plant collecting (Kipnis 2002, 418).

New ways for inferring plant consumption amongst Paleoindians in central Brazil arrived with the studies of Turner and Machado (1983), which noted that the number of cavities amongst the people of the Corondó site in Rio de Janeiro, dated between 4700 and 3200 cal yr BP, was higher than expected for hunter-gatherer societies, which led them to propose a tuber-rich diet. Returning to central Brazil, Neves and Cornero (1997) arrived at the same conclusion when they noticed a high number of cavities in teeth amongst skeletons from the Santana do Riacho site at Minas Gerais. In an article derived from the same research, Cornero and colleagues (1999) also suggested a more important role in plant collection than hunting regarding Paleoindian subsistence. Indirectly complementing these studies, Wesolowski (2007) observed that the relationship between cavities and starchy-plant consumption was not as linear as previously thought and that the eating of this kind of food would not necessarily produce cavities. However, starch grains were still a factor that could worsen a cavity injury. More direct evidence arrived with Prous and colleagues (2012), when they analyzed grinding stones related to funerary contexts at the Caixa d'Agua site (6400-5000 cal yr BP), north of the Lagoa Santa area, finding starch grains during the process.

1.4. Starchy plant consumption in Lagoa Santa

In Lagoa Santa, research has made diverse inferences regarding the area's Paleoindian diet based on tooth maladies and tooth wear, most of them viewing plant consumption as the reason for those dental modifications (e.g., Da Gloria and Oliveira 2016). However, it was the above-mentioned study from Neves and Cornero (1997) that had the greatest influence in creating the model of the Lagoa Santa Paleoindians as starchy-plant consumers, leading to subsequent research regarding this model. More direct evidence came with the work of Hermenegildo (2009), who analyzed carbon and nitrogen isotopes in collagen samples from Lagoa Santa and Valle de Piauí skeletons, characterizing an omnivorous diet with a strong tendency towards plant consumption as well as primary consumers.

Archaeobotanical macro-remains studies in the region have seemed to agree with this premise. Nakamura and colleagues (Nakamura, Melo Junior, and Ceccantini 2010) analyzed the macro-remains from the Lapa das Boleiras site, identifying *Syagrus flexuosa* (Arecaceae) seeds as the dominant taxon. Other identified species included *Hymenea* sp. (Fabaceae) and *Annona crassifora* (Annonaceae). The authors inferred that the sugar content in the fruits of these species could explain the cavities found on the skeletal remains of the area. Angeles Flores (2015) also report Arecaceae seeds and possibly *Hymenea* sp. charred remains at Lapa Grande de Taquaraçu, but they were unable to reach similar conclusions due to the lack of identifications in the study.

More recently, studies from Da Gloria and Larsen (2014, 2017) proposed hormonal differences (since more cavities are present amongst female individuals), as well as fruit and honey consumption as alternative explanations for the cavities found in Lagoa Santa skeletons. However, even with these alternatives exposed, these authors suggested a diet consisting of a combination of fruits and tuberous plants to explain the high prevalence of cavities.

In her PhD dissertation, Ortega (2019) analyzed phytoliths and starch grains from 21 lithics and 4 sediment samples from within as well outside the site. The fact that modified starch grains were not found was interpreted as evidence of raw amilaceous plant processing. She identified phytoliths belonged to Poaceae subfamilies: Aristidoideae, Bambusoideae, Chloridoideae, Panicoideae, and Cyperaceae; as well as Arecaceae and the Zingiberales and Eudicot orders. Starch-grain morphotypes were similar to Araceae, Arecaceae, Poaceae, and Convulvaceae. Some of the starch grains seemed to be from domesticated plants like *Zea mays*, *Ipomoea batatas*, or *Capsicum* sp.; however, a local reference study is necessary to securely affirm this.

1.5. Use-wear analysis

Few analyses have been carried out regarding the lithic artifacts in Lagoa Santa (Moreno de Sousa 2014;

Moreno de Sousa, de, and Araujo 2018; Prous, Moura, and Lima 1991), and even fewer have implemented use-wear analysis (Alonso 1991, 2008; Alonso and Mansur 1986/1990.; Pugliese 2007). Alonso and Mansur (1986/1990) started traceological analysis based on stone tools from the Santana do Riacho site. The former research was conducted using experimental archaeology and by analyzing quartz archaeological artifacts under magnification up to 500×. This work was continued by Alonso (1991; 2008). The authors related type of edges and microwear traces with types of use and processed materials. Pugliese (2007) carried out an important experiment to distinguish post-depositional from anthropic traces, analyzing quartz flakes at Lagoa Santa archaeological sites under low magnification (up to 20×). He found that post-depositional processes produce non-patterned and discontinuous micro-wear traces, especially in lithics with sharp edges; while anthropic use produces continuous and patterned traces. The same author suggested the use of these lithics as processing plant resources, mentioning that micro-remains studies would be necessary to sustain this possibility.

In sum, what we have for central Brazil, as well as for the Lagoa Santa area in particular, is that the use of starchy plants has always been inferred as something important in Paleoindian subsistence. This would not be rare, because most of the biomass in Cerrado biomes is underground (De Castro and Kauffman 1998), which is probably translated in the great quantity of starchy plants (tubers) available for consumption, as well as the variety of tree fruits found aboveground (Medeiros 2011). There has been more direct evidence recently by means of the analysis of micro-remains, however, until now these studies have not been related to a proper use-wear analysis.

2. Lapa Grande de Taquaraçu archaeological site

Lapa Grande de Taquaraçu, also known also as Lapa do Niactor (da Silva 2016), is a limestone rock shelter approximately 30 m long × 9 m wide and located next to the Taquaraçu River, a tributary of the Rio das Velhas, in the municipality of Taquaraçu de Minas, Minas Gerais State. It is located about 20 km east of Lagoa Santa (Figures 2 and 3).

The site was studied by a team led by AGMA between 2003 and 2008. Several 1 × 1 m units were excavated

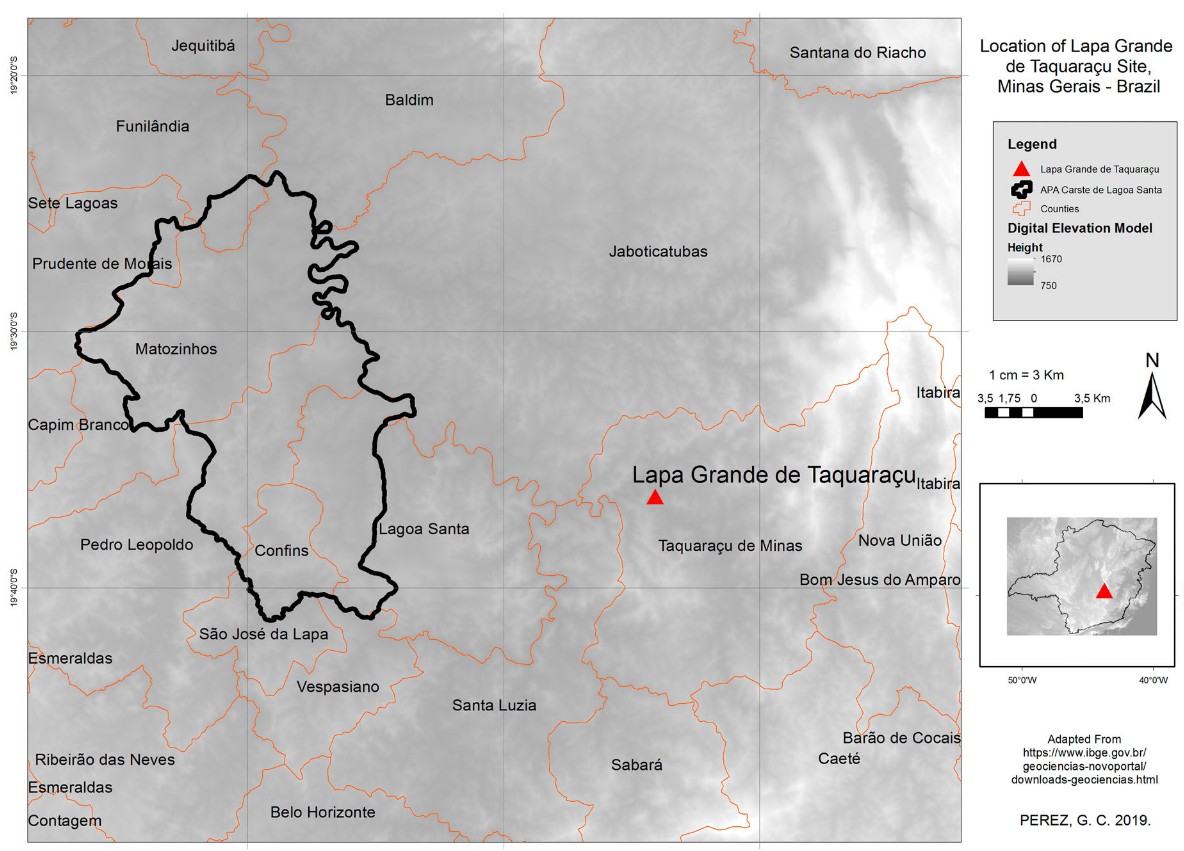

Figure 2 Location of Lapa Grande de Taquaraçu archaeological site (red triangle) with respect to the APA of Lagoa Santa (irregular form). Map by Glauco Constantino Perez, 2019.

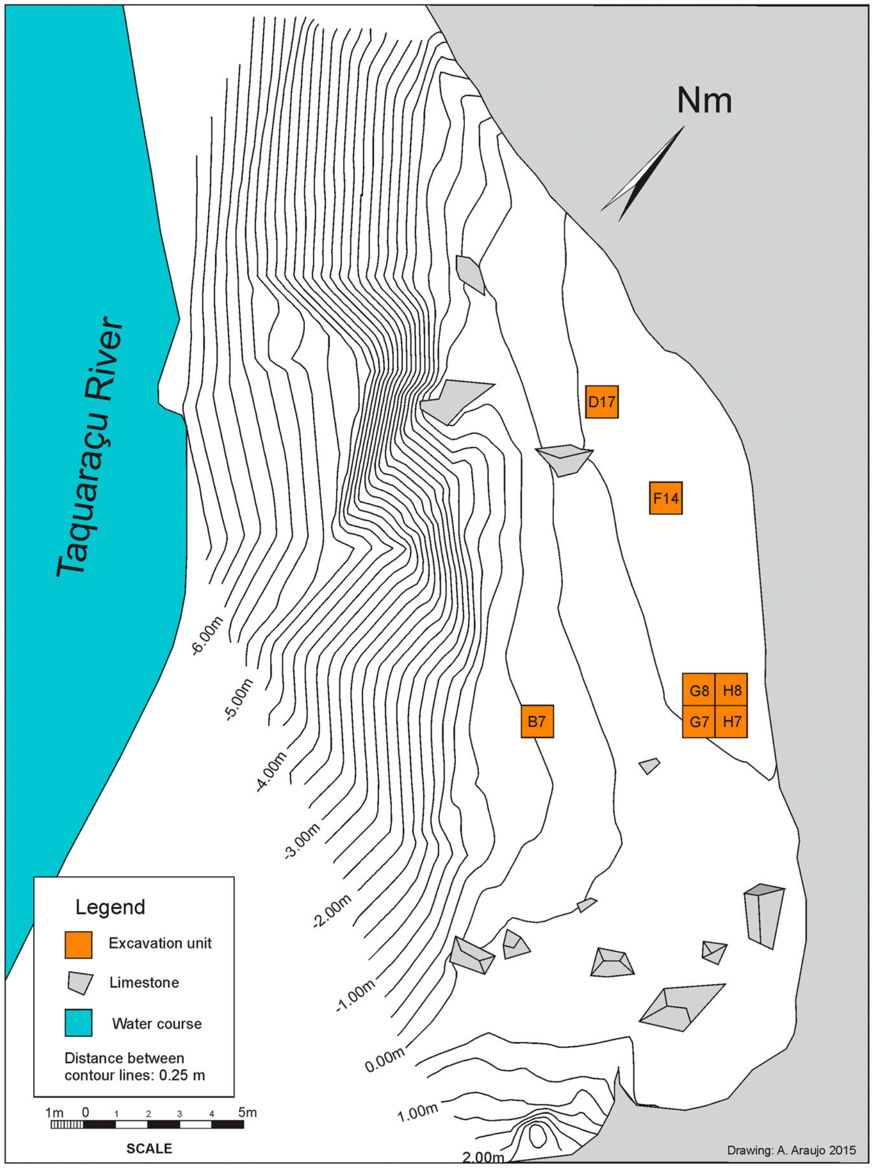

Figure 3 Topographic map showing the location of the excavation units at Lapa Grande de Taquaraçu Rock shelter (Nm, magnetic north). Drawing by Astolfo Araujo, 2015.

using a mixed strategy following both artificial levels and minimum stratigraphic units called "facies."

During the excavations, an 80-cm thick archaeological layer was defined. This layer is composed mainly of well-stratified, anthropogenic sediments (mainly wood ash), with a small geogenic contribution (Araujo, de, and Piló 2017; Tudela et al. 2020, 77), containing a large quantity of lithic, plant, and animal remains, including two human skeletons. Pottery fragments were also found, but in a small amount and only at the surface. The lithic material is mainly composed of hyaline quartz flakes and splinters, with some flint occurring in the lower levels, showing the typical characteristics of the Lagoa Santa industry. An exception is a plano-convex lithic artifact, known colloquially as a "limace," found between the limestone blocks at the bottom of one of the units (H8). This artifact is the only one found in an excavated context in Lagoa Santa (Angeles Flores et al. 2016).

The samples recovered for dating indicated an occupation between 11,481 ± 145 cal yr BP and 1075 ± 81 cal yr BP, with a hiatus between 8977 ± 93 and 1075 ± 81 cal yr BP (Table 1; Figure 4). This hiatus is marked by the complete absence of anthropogenic sediment accumulation, a process already observed at other sites in the Lagoa Santa area (Araujo et al. 2008; Araujo, de, and Piló 2017; Araujo, Neves, and Kipnis 2012; Araújo et al. 2005).

Table 1 Calibrated dates from Lapa Grande de Taquaraçu using the calibration curve CalPal2020 INTCAL 2020 (Danzeglocke, Jöris, and Weninger 2007).

Sample number	Lab number	Level	Facies	^{14}C age (^{14}C yr BP)	Calibrated age (cal yr BP)
TQ 421	Beta 216528	1	2	1160 ± 60	1075 ± 81
TQ 417	Beta 216527	1	3	8080 ± 40	8977 ± 93
TQ 402	Beta 183576	E Profile	X	8230 ± 50	9196 ± 92
TQ 430	Beta 216529	3	9	8310 ± 40	9322 ± 80
TQ 441	Beta 216530	4	11	8730 ± 40	9704 ± 102
TQ 404	Beta 183577	E Profile	X	8730 ± 50	9717 ± 115
TQ 454	Beta 216531	5	11	8910 ± 40	10,043 ± 101
TQ 459	Beta 216532	6	X	9040 ± 40	10,210 ± 27
TQ 297	Beta 216526	7	X	9540 ± 90	10,886 ± 170
TQ 268	Beta 183575	8	X	9550 ± 60	10,903 ± 144
5	Beta 216525	6	X	9620 ± 40	10,974 ± 137
TQ 536	Beta 242714	9	19	9990 ± 60	11,481 ± 145
TQ 544	Beta 242715	10	20	9900 ± 60	11,358 ± 103

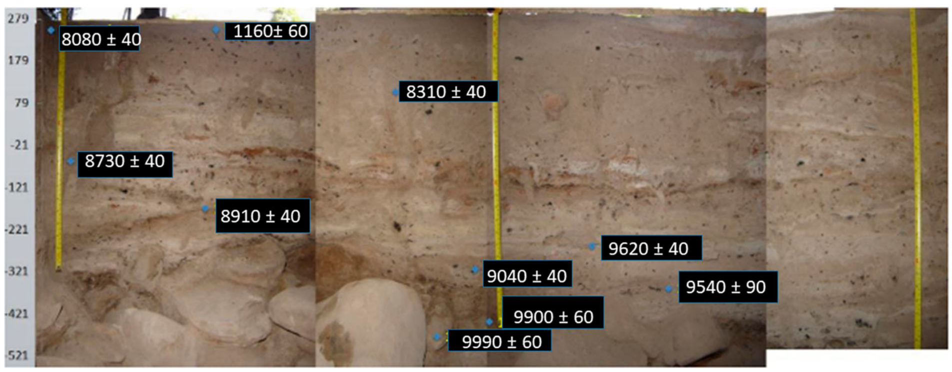

Figure 4 West profile of units G7 and G8 showing the approximate locations of the samples with non-calibrated dates, according to the X, Y, and Z location of the charcoal samples. The photography is modified from Chim (2018, figure 17).

3. Methods

To address whether plant resources were processed by the ancient occupants of Lapa Grande de Taquaraçu, we conducted a starch-grain analysis of a sample of lithic artifacts as well as the associated sediments, and completed use-wear analysis of a sample of the artifacts.

3.1. Starch-grain analysis of lithic artifacts

Ten non-washed archaeological lithic artifacts excavated from Unit G7 were selected (9 flakes and a limestone block). An eleventh artifact, from Unit H8, the above-mentioned "limace," was also included in the analysis (Figure 5; Table 2).

To recover starch grains from the artifacts, a protocol based on the method known as step-wise was created, consisting of recovering various layers of sediment from the lithic tool. The protocols described in Pagán-Jiménez and Oliver (2008), Cascon (2009, 2010), and Pagán-Jiménez (2011) were taken as a base. Most of the analyses were performed at the Laboratory of Plant Anatomy of the Institute of Biosciences (University of São Paulo, Brazil); additional equipment, such as an ultrasonic bath and a centrifuge, were provided by the Laboratories of Cell Biology and Plant Physiology, respectively.

3.1.1. Low-magnification microscopy

With the aim of looking for concentrations of biological material, lithics were placed under a Nikon Eclipse E200 microscope equipped with dark field and examined at low magnifications (4×, 10× objectives and a 10× eyepiece).

3.1.2. Micro-remains analysis

After the general low-magnification survey, sediment on the artifacts was brushed off with a new, unused disposable toothbrush. A different toothbrush was used for every artifact, and the sediment was stored in a clean, new Falcom flask. This operation was repeated with a toothbrush soaked in distilled water. The sediment that resulted from this wet brushing was discarded, because it was considered to have a mixture of remains associated and not associated with the use of the artifact. In this way, each lithic artifact was apparently cleaned of

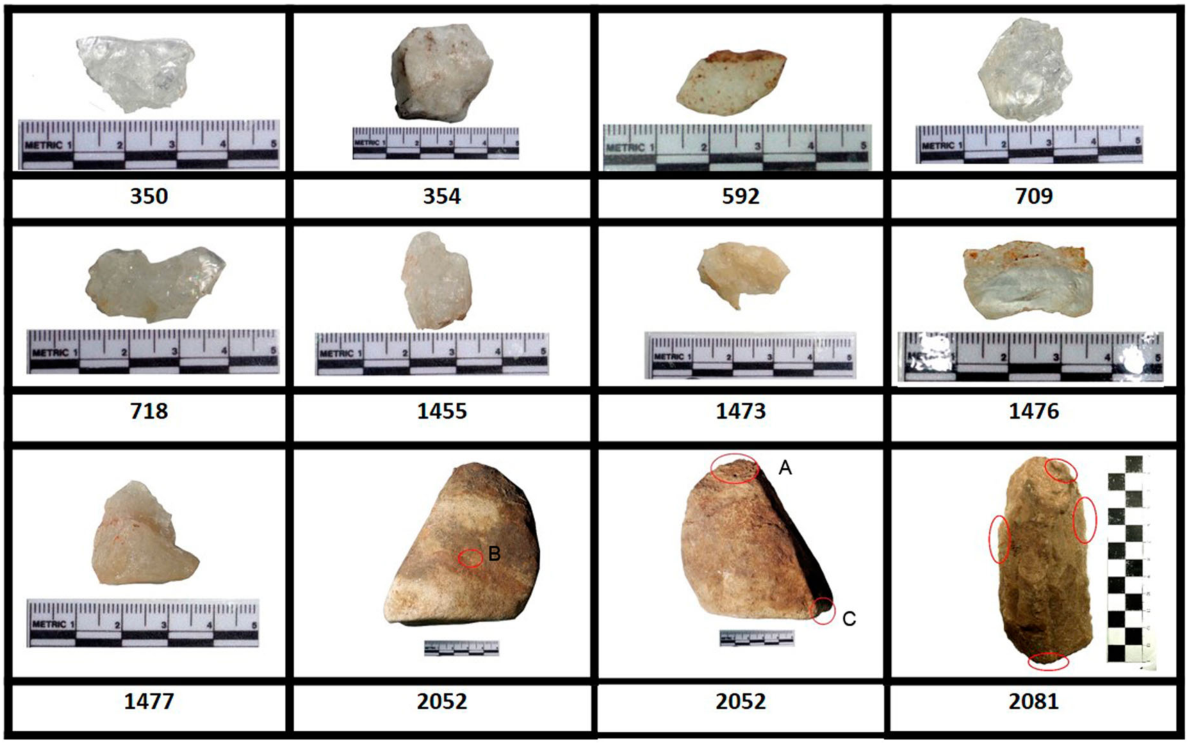

Figure 5 Artifacts analyzed in this study. The parts analyzed in pieces 2052 and 2081 are identified with red circles.

all sediment, but a small amount was left in microcracks. To recover that sediment (under the supposition that this would be most related to the use of the artifact) the artifact was submerged in a 45-mL Falcom flask, then this flask was immersed in an ultrasonic bath for 10 min, and the resulting pellet was then stored in a clean new Falcom flask. This process resulted in two different samples of sediment: one coming from the dry brushing (sediment I), and the other from the ultrasonic bath (sediment II).

For the recovery and separation of starch grains from the sediments, each sample was mixed with a cesium chloride (CsCl) solution with a 1.8 g/cm^3 specific gravity, stirred for 30 s, and then centrifuged at 2500 rpm for 12–15 min. By doing this, the starch grains with a specific gravity of less than 1.8 g/cm^3 floated on the supernatant (A). Even so, the resulting sediment (B) was analyzed because it could contain starch grains with a specific gravity greater than 1.8 g/cm^3. After this, A and B were poured into a 2 mL Eppendorf flask, adding 0.5 or 1 mL of distilled water, shaken for 10–15 s, so as to eliminate all the CsCl crystals that could be formed, and then placed back into the centrifuge for 20–25 min at 3200 rpm. The centrifugation was repeated twice more with less water each time. After this step, one drop of the resulting solution was poured onto a slide, covered with a sterile Petri dish, and then a drop of glycerol was added. Immediately after this procedure a coverslip was placed on top and sealed with nail polish.

Slides were analyzed under a Leica DMLB microscope with polarized filters. Each starch grain and other biological material encountered was photographed with a Leica DFC310FX camera, as well as described and measured with Image J free software (Rasband 1997).

To minimize contamination by modern starch, the plastic and glass materials used were immersed in a Dimethyl Sulfoxide (DMSO) solution for 8 h and then washed with Millipore-filtered water. The DMSO is a standard solvent used in plant storage laboratories for

Table 2 Calibrated dates from the sediments associated with the artifacts analyzed, using the calibration curve CalPal2020_INTCAL2020 (Danzeglocke, Jöris, and Weninger 2007). The date for artifact 2081 is an estimate due to the fact that it was found at the bottom of the neighbor H8 unit.

Artifact	Level	Facies	Calibrated date of associated sediment (cal yr BP)
350	1	3	8977 ± 93
354	1	3	8977 ± 93
592	3	9	9322 ± 80
709	4	11	9704 ± 102
718	4	11	9704 ± 102
1455	6	19	11,481 ± 145
1473	6	19	11,481 ± 145
1476	6	19	11,481 ± 145
1477	9	19	11,481 ± 145
2052	9	19	11,481 ± 145
2081	9	7	>11,481 ± 145

the elimination of starch. The area of work was cleaned daily with ethanol (ETOH), and only non-powdered plastic gloves were used. Following recommendations of past research (Crowther 2014; Laurence 2011) for detecting possible starch grains present in the air, "traps" made with Petri dishes were filled with distilled water and left in different laboratory areas that were used for the starch analysis for 12 days. In addition, the used solutions were routinely analyzed for the presence of starch grains.

3.1.3. Artifacts 2052 and 2081

Two of the artifacts (2052 and 2081) followed a special protocol. The protocol for the latter can be consulted in Angeles Flores et al. (2016). Briefly, sediment for the former was recovered distinctively in proximal (A), distal (C), and middle (B) areas (Figure 5); the last area is a little circular depression which made us think that the artifact could have been used as an anvil. After dry and wet brushing, the proximal and the distal parts were put in an ultrasonic bath and the sediment was stored for analysis. The middle part did not follow this step, but a little bit of the sediment was scraped off with a sterilized needle and stored for analysis. After doing this, some concretions were noted in the distal part of the artifact (Figure 6). We suspected that some starch grains might have been trapped below these concretions; so, to destroy the concretions, this part of the artifact was submerged in a 10% hydrochloric acid solution (HCl) for two minutes. After this, the artifact was placed under running water, preventing the acid from destroying the piece. An equal volume of 20% baking-soda solution ($NaHCO_3$) was added to neutralize the HCl solution. The resulting sediment was stored for analysis.

3.2. Use-wear analysis

The use-wear analysis was conducted by observing the appearance of the supposed working edge(s) in comparison with other parts of the tool, consulting published results of experimental analysis in quartz, such as Pugliese (2007), Taipale (2012), and Knutsson (2015).

To obtain that data, the pieces 350, 354, 592, 709, 718, 1455, 1473, 1476, and 1477 were analyzed using a Leitz Wetzlar stereoscope 12.5×, as well as a Dino-Lite digital microscope AM2111 (up to 230× magnification). During lithic analysis, micro-wear, polishing, scratches, etc., were considered as use traces (Morais 1987).

4. Results

Starch grains were found in all analyzed lithic artifacts. Amongst the 11 pieces analyzed, 301 starch grains were recovered as well as 78 miscellaneous elements (possible phytoliths, vessel elements, and other cells or cell parts). Starch grains were registered based on the characteristics described in Pagán-Jiménez (2011) and the International Code for Starch Nomenclature (ICSN 2011).

The starch grains were classified mainly following the criteria of form (circular, triangular, squared, etc.), and secondly other characteristics (lamella, border, hilum position, hilum form, etc.). In this way, starch grains were organized into 16 types named from A to P (Figure 7).

Starch grains were found in Sediment II as well as Sediment I. The C, I, L, and N types were found in Sediment II exclusively, while types E, F, H, K, and P were found exclusively in Sediment I. The rest of the types were found indistinctively in either sediment. Some of the starch grains were so modified that it was impossible to assign them a proper shape, so they were classified as "undetermined" (Table 3).

Regarding "exotic" pieces, starch grains were observed in Sediment II in the proximal part, Sediment I in the distal part, and in Sediment II in the central part of the 2052 piece. No starch grains were found after the HCl treatment. Results for the piece 2081 can be consulted in Angeles Flores (2015) and Angeles Flores et al. (2016).

Figure 6 Image showing part of the 2052 piece before (left) and after (right) HCl treatment.

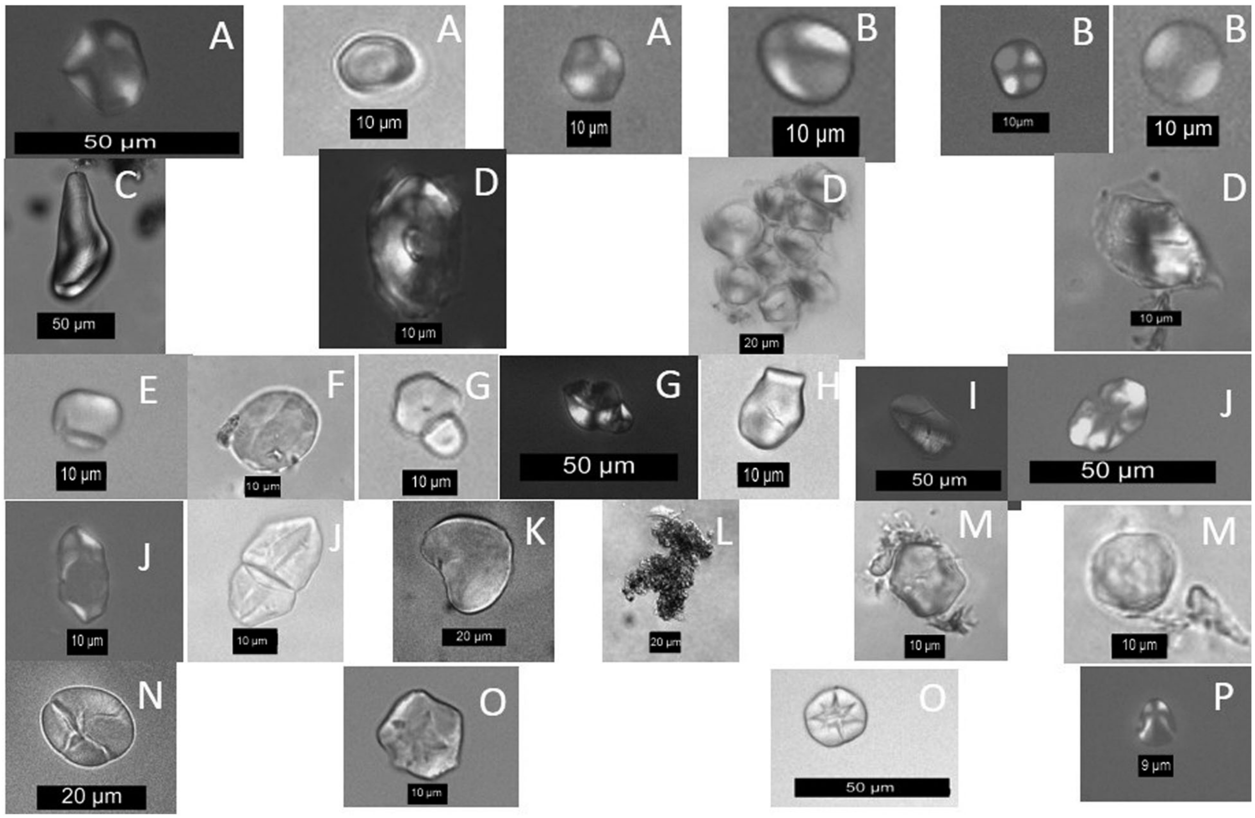

Figure 7 Examples of the different categories used to classify starch grains identified in the analysis.

Table 3 Starch grain types associated with sediments and lithics (Und = undefined).

		Lithic number											
		350	354	592	709	718	1455	1473	1476	1477	2052	2081	Total
	Type	73	1	1	3	1	4	29	3	6	11	54	186
Sediment II	A	16	1	1	1		1	12	2	4	4	3	45
	B	27					1	9		1	4	4	46
	C									1			1
	D	17											17
	G							1			3	1	5
	I				1								1
	J	2										2	4
	L											42	42
	M	5					2	6	1			1	15
	N	1											1
	Und.*	2						1					3
	O	3			1	1						1	6
	Total	350	354	592	709	718	1455	1473	1476	1477	2052	2081	Total
	Type	30	1	1	1	17	17	26	2	8	3	9	115
Sediment I	A	13	1	1		5	3	11			3	3	40
	B	5			1	4	7	5	1	8		4	35
	D					1	1						2
	E							1					1
	F						1						1
	G						1					1	2
	H	1						1					2
	J	4											4
	K											1	1
	M	5				5	4	8	1				23
	O	1				2							3
	P	1											1
	Total	103	2	2	4	18	21	55	5	14	14	63	301

4.1. Modified starch grains

Modified (damaged) starch grains were detected in practically every sediment associated with the analyzed lithics. Generally speaking, nearly a third (103) of the starch grains were damaged in some way.

4.2. Use-wear analysis

Only three lithic pieces presented use-wear traces. The main characteristics of the traces found in the lithic artifacts are described in Table 4.

Based on Table 4, it is possible to notice that the use marks on the lithics correspond to abrasion, and that the trace forms are not always the same. Artifact 350 (Figure 8) presents rectilinear micro-fragmentation on its edge, where the active angle of 36 degrees creates a natural cutting edge. In artifact 709, discontinuous micro-wear traces are present on its 43-degree rectilinear active edge (Figure 9). In artifact 592 (Figure 10), the active edge presents an angle of 60 degrees, conferring to it even more resistance compared to artifacts 350 and 709; however, it probably was not used to cut, but to scrape, as observed by Alonso (2008).

Table 4 Use-wear traces present in the lithics.

Lithic	Raw material	Use-wear marks	Form	Active edge angle (°)	Type of use
350	Hyaline quartz	Yes	Rectilinear	36	Abrasion
354	Milky quartz	No	-		-
592	Milky quartz	Yes	Irregular	60	Abrasion
709	Hyaline quartz	Yes	Rectilinear	43/62*	Abrasion
718	Hyaline quartz	No	–	31	–
1455	Hyaline quartz	No	–	–	–
1473	Milky quartz	No	–	–	–
1476	Hyaline quartz	No	–	–	–
1477	Milky quartz	No	–	–	–

*first number = active edge 1; second number = active edge 2.

5. Discussion

The botanical micro-remains found in the lithics are still under analysis; however, these remains plus the use-wear traces identified give us a clearer idea regarding their use. The implications and limitations of these findings are described in the following sections.

5.1. Use of the stone tools

The lack of use-wear marks on most of the lithics where starch grains were recovered could be explained by various reasons:

(1) It is possible that some of the starch preserved in the soil could have been attached to the surface of the lithics by processes unrelated to their use. This could be due to the decomposition of vegetables near the lithics (Barton and Matthews 2006, 88; Williamson 2006); by the dumping of artifacts in activity areas (Barton, Torrence, and Fullagar 1998); or by the handling of lithics with starchy hands (Barton 2006).

(2) Quartz is a very hard material. According to the Mohs scale, quartz is in the 7th degree (Klein and Dutrow 2012, 56–57). These data suggest that quartz is resistant to scratches and presents low tenacity or flexibility. Quartz also has a vitreous

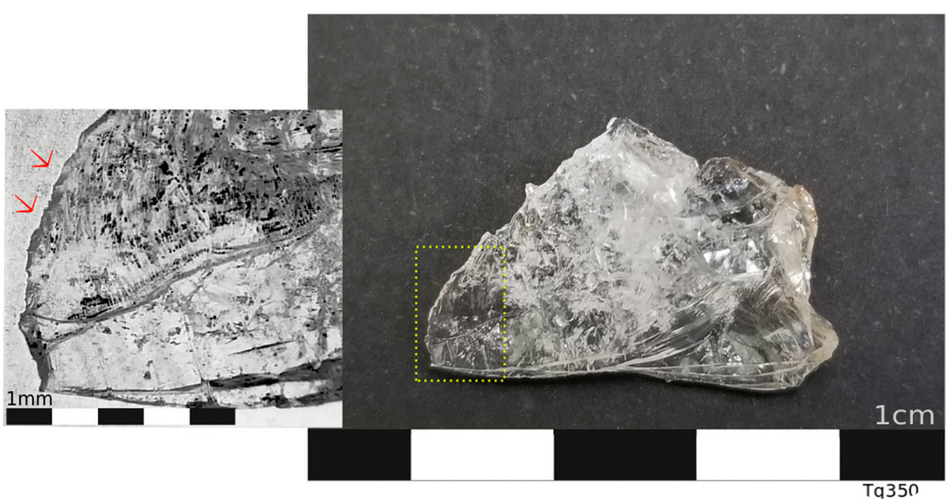

Figure 8 Trace marks on artifact 350.

Figure 9 Trace marks on artifact 709.

luster, can be transparent (hyaline quartz) or translucent (milky quartz), and presents conchoidal fracture (Dana 1960, 564–565). That type of fracture results in a smooth, rounded surface resembling the shape of a scallop shell, giving the mineral discrete characteristics in its internal face after flaking (Prous 1986/1990.). Therefore, it is easy to create a cutting tool by flaking quartz, but it is hard to observe traces on that mineral (Prous 1986/1990).

Taking this into account, it is possible that the marks of use were simply not visible with the microscope used, or that the starchy plants processed by the lithics were not hard enough to make any kind of marks. Regarding this, Knutsson (2015) and Taipale (2012) observed that, because of hardness characteristics of quartz, some tools made of it are not affected when used to scrape fresh wood, for instance, so it would not be rare that

Figure 10 Trace marks on artifact 592.

the processing of a starchy plant did not leave a mark.

Regarding the artifacts that presented visible marks we can affirm the following:

(1) Compared with the anthropic characteristics of use traces defined by Pugliese (2007), Taipale (2012) and Knutsson (2015), it is probable that the artifact 350, which presents a thin edge with rectilinear micro-fragmentation, was used in longitudinal or transversal movements to cut wet plant or dry hide or even to whittle dry wood.
(2) Flake Tq709 presents discontinuous traces that are consistent with what Pugliese (2007) and Taipale (2012) describe as post-depositional traces. Quartz's low tenacity could contribute to the emergence of natural micro-wear traces on the edge of lithic artifacts during post-depositional processes and/or archaeological fieldwork or storage. One of those traces is striations very similar to the striations caused by the friction of quartz grain (from tool micro-fragmentation) or another particle on the edge during tool use. While anthropic striations are linear (regular, irregular, or discontinuous), post-depositional striations tend to present a more random distribution and orientation (Taipale 2012). Also, during fieldwork or when stored, lithics can suffer accidental micro-wear traces. Knutsson et al. (2015) highlight the fact that thin edges can be damaged more easily by mechanical or chemical processes than sturdier edges, and worn areas are more vulnerable to post-depositional impacts (mechanical or chemical) than unworn ones. Nevertheless, we do not think that this is the case regarding flake Tq709 because at Lapa Grande de Taquaraçu, as in the Lagoa Santa region, the sediment is mostly easily removable wood ash (Araujo et al. 2008; Araujo, de, and Piló 2017), which seems unlikely to leave damage on a quartz surface. Moreover, during excavation, each piece was plotted and stored in individual plastic bags to avoid damage. In addition, this tool presents a 43-degree edge that provides it with more resistance to breakage forming a cutting edge with less fragmentation than artifact 350, which again, makes it difficult to form non-anthropic marks. Therefore, discontinuous traces can be formed on a more resistant edge by cutting soft and humid materials.
(3) Tq592 has no sharp edge, but its micro-wear traces are similar to what Taipale (2012) and Knutsson et al. (2015) attributed to human activity for scraping bones with transversal movements.

Taking this into account, the presence of starch grains in all of the lithics studied suggests a general use for processing starchy plants; we can affirm this with more certainty in the lithic flakes that presented marks of use. We can also make this affirmation regarding piece 2081 (Angeles Flores et al. 2016), which, although a use-wear study was not carried out on it, the presence of starch grains in the active parts of the piece, associated with the presence of raphides, reaffirm its use to process tuberous plants. The same cannot be said, however, for piece 2052, which presented starch grains in the sediment I and II on the parts analyzed. A use-wear study is required to complement this analysis.

Regarding the starch grains found in the sediments associated with the artifacts, it is not clear in this study if sediment "I" was representative of background starch grains or is a mixture of both background and use-related grains. Analyses of sediments not related to the artifacts might be needed to distinguish them.

5.2. Cooking?

The modifications of some of the starch grains might indicate some kind of grinding. For example, the damage presented in the grains shown in Figure 10 (E), as well as the central fissure in Figure 6(D) are consistent with what Babot (2003) identified as damage by milling. The star-shaped fissure presented in type O (Figure 6) might also indicate grinding (Dickau 2017, personal communication) or pounding on raw material (compare with Pearsall 2016, figure 6.3). Other starch grains, like the one in Figure 10(C) presented an extinction cross with a very wide center. This feature has been reported in cooked starch (Henry, Hudson, and Piperno 2009, figure 1). Gelatinized grains shown in Figure 11 (A–B) were also present, which might indicate heat damage in an aqueous ambient.

Modifications in the starch grains suggest a variety of processes used on the starchy plants, although it is difficult to pinpoint the exact process used, since various modifications overlap (Babot 2003). Nevertheless, the identification of a tuberous plant in the record strongly suggests a complex, multi-step process, because it is generally needed for the consumption of tuberous plants (Beck 2006). For example, the presence of raphides in some aroids (Sakai and Hanson 1974) and the toxicity in the bitter manioc (McKey et al. 2010) make their consumption impossible without these kinds of processes.

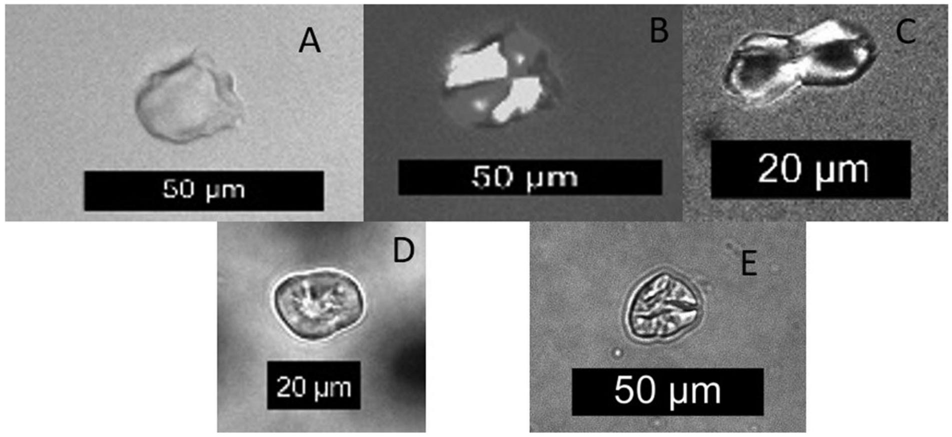

Figure 11 Some examples of modification in starch grains.

5.3. Some tentative identifications on starch grains

As mentioned above, the starch-grain analysis is still being done, but it is possible to have some preliminary identifications.

Type C is represented by a single starch grain found in the sediment II of artifact 1477. Taking into account form, type, lamination, hilum position, and size, Type C is almost identical to a non-domesticated *Dioscorea,* collected in Ecuador by Pagán-Jiménez (2015, 67) (Figure 12). Therefore, it is almost certain that this grain corresponds to this genus. This is important because artifact 1477 is associated with a facies dated to 11,477 ± 133 cal yr BP, which places this find thousands of years before the *Dioscorea* grains found in Xihuatoxtla (8990-8610 cal yr BP; Piperno et al. 2009), Agua Dulce (~7000 cal yr BP; Piperno 2000), and El Jazmín (8493-8313 cal yr BP; Piperno 2011, S458), the earliest finds of *Dioscorea* in an archaeological context in the Americas.

Regarding Type J, Dr. Jennifer Watling (personal communication, 2017) pointed out that some of the grains were similar to those seen by her in *Arecaceae* seeds. This would not be rare, considering that a great quantity was found in all levels of occupation at the site (Angeles Flores 2015).

Type D, found in Sediment I as well as Sediment II, stands out by its characteristic maltese cross in "Y" form, or in a longitudinal line; an open hilum, which turns into a longitudinal fissure when rotated; and a

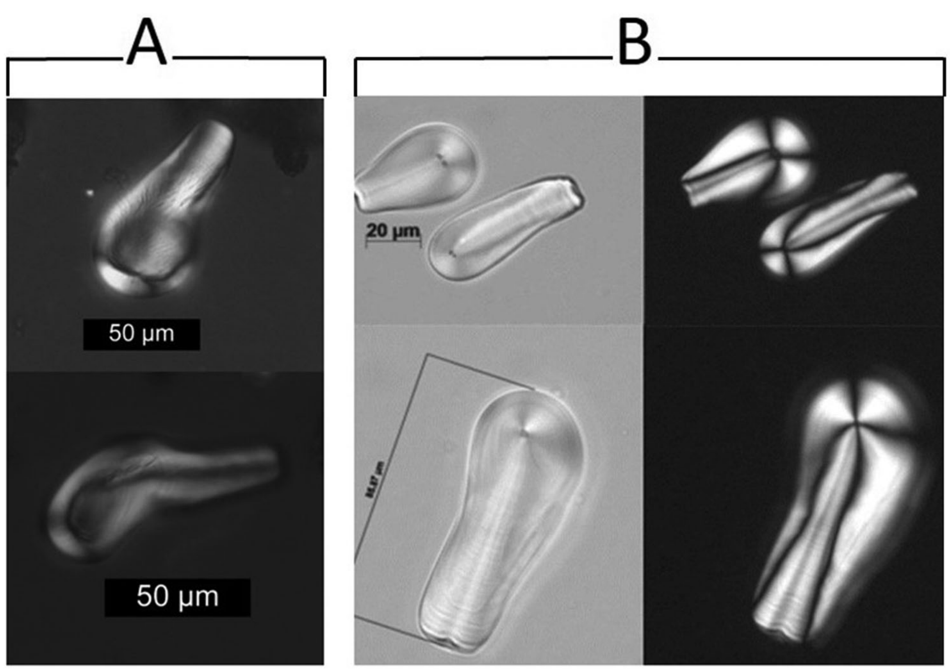

Figure 12 A, Type C starch grain from this study; B, *Dioscorea* registered by Pagán-Jiménez (2015).

thick border and viscous-like layer surrounding it. These characteristics have not been found in the literature consulted. Pagan-Jiménez (personal communication, 2017) has pointed out that this type might not be a starch grain at all. We consider this possibility, as well as the likelihood that, taking Brazil's biodiversity into account, this might be a new type of starch grain or some not well-studied modification.

Taking their form, size (16 × 13 μm), bumps in the surface, a double border, and the irregular form of the extinction cross's arms into account, some of the Type M grains seem similar to those of *Zea mays* and *Prosopis* (Giovannetti et al. 2008). However, this comparison is problematic because *Prosopis* has not been registered in Lagoa Santa's Cerrado either in studies of the present vegetation (Freire 2011) or in paleo-vegetation studies of the same area (Raczka 2013). Also, the arrival of *Zea mays* in Lagoa Santa is registered thousands of years later (Hermenegildo 2009; Shock et al. 2013), and corn starch grains are a very common modern contaminant, be it in the laboratory (Crowther 2014; Laurence 2011) or during excavation itself (Mercader et al. 2017). To clarify these questions (i.e., presence of *Zea mays* or *Prosopis*, species of *Dioscorea* found in the site, and specific processes of starchy plants for consumption), a reference study is being formed with several wild and cultivated *Dioscorea* and *Arecaceae* species as we write this article. We hope to have some results in the near future.

6. Conclusions

Unlike much of the Lagoa Santa archaeological sites, Lapa Grande de Taquaraçu had the advantage of being situated near a perennial water source, which translated into a variety of fluvial, animal, and plant resources at the disposition of Paleoindian groups. The plant resources were probably coming from the Mata Ciliar and Cerrado biomes. Because few starch grains from these environments have been characterized, we cannot affirm this with certainty, but what we can assert positively is that among these resources, starchy plants, and tuberous ones in particular, were present.

The presence of starch grains on all of the lithics studied as well as the use-wear marks visible on some of them, together provide direct evidence of the processing of starchy materials, including tuberous plants, from the area.

Some of the modifications in starch-grain morphology suggest grinding or exposure to high temperatures which might indicate cooking. If that proves true, it would mean that the people of Lagoa Santa knew a variety of plant types and processes needed for their consumption. This happened since the area was initially occupied, and before the use of any ceramic pottery.

Taking all of the above into account, this study agrees with the models constructed by previous investigations (Da Gloria and Neves 2014; Kipnis 2002; Neves and Cornero 1997) regarding the importance of plant consumption amongst Paleoindians in the region, providing some of the earliest evidence of starchy plant processing (including possibly cooking) in Lagoa Santa.

Notes

1. In this paper, we refer to Paleoindians as the people living during the late Pleistocene and early Holocene in the Americas.
2. This skeleton, buried 12 m deep, attracted a lot of attention, first, because of its antiquity 11,400–16,400 cal yr BP dated from charcoal, which was later confirmed by luminescence in the related sediments (Feathers et al. 2010); and second, because of the form of the skull, which craniometrical analysis characterized as closer to modern Austromelanesian populations than Asian people. This was also found to be true for other skulls found at Lagoa Santa (Bernardo 2007; Neves et al. 2003, 2004; Neves and Hubbe 2005; Neves, Hubbe, and Piló 2007; Neves and Pucciarelli 1991). However, not all scientist agree with this, and Seguchi and colleagues suggest an affinity with Jomon populations (Seguchi et al. 2011).

Acknowledgements

We would like to thank Dr. Pagán-Jimenez, Dr. Ruth Dickau, and Dr. Jennifer Waitling for their help regarding the identification of some of the starch grains. However, any mistake that could be found about these identifications is exclusively ours. We also want to thank Dr. Glauco Constantino Perez for his contribution on creating a map indicating Lapa de Taquaraçu's location. Likewise, we would like to thank all the people from the following laboratories: Plant Anatomy, Plant Physiology, Cell Biology, and Laboratory for Human Evolutionary Studies (LEEH) from the Institute of Biosciences, University of São Paulo, Brazil for their kindly allowing us to use their facilities, materials and advice, without which the present study would not have been possible. RAF was granted a scholarship by CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico, process: 160904/2011-0) during his Master's degree course and diverse scholarships by CAPES (Coordenação de aperfeiçoamento de pessoal de nível superior, Social Demand Scholarship, PhD Scholarship and PhD "Sandwich" Overseas scholarship process: 88881.188612/2018-01) during his PhD. MAEFM was the recipient of a CNPq scholarship (process: 142167/2015-0). CNPq also sponsored AGMA by means of an academic productivity fellowship (process: 300339/2008-9) and GC (process: 309805/2011-02). The excavation was also funded by FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo - "São Paulo Research Foundation," a research grant (projeto tematico, process 99/00670-7) under the coordination of Professor Walter Alves Neves, to whom we owe the opportunity of building our data..

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by CAPES; CNPQ [grant number 160904/2011-0; 142167/2015-0; 300339/2008-9; 309805/2011-02]; São Paulo Research Foundation (FAPESP) [grant number 99/00670-7].

Notes on contributors

Rodrigo Angeles Flores has a PhD in Archaeology. His interests include archaeobotany, Peloindian occupations of Brazil, Mesoamerican archeology and he has published on these subjects.

Maria Ester Venezia is Adjunct Professor of Anthropology. Her interests include anthropology, oceanography, lithic technology and Brazilian archaeology.

Astolfo Gomes de Mello Araujo is Associate Professor of Archaeology. His interests include geoarchaeology and Paleoindian occupation of Brazil and he has published widely on these subjects.

Gregório Ceccantini is Associate Professor of Botany. His interests include wood anatomy, dendrochronology, archaeobotany and he has published widely on these subjects.

References

Acosta Ochoa, G. 2010. "Late-Pleistocene/Early-Holocene Tropical Foragers of Chiapas, Mexico: Recent Studies." *Current Research in the Pleistocene* 27: 1–4.

Alonso, M. 1991. "Análise funcional de microtraceologia." *Arquivos do Museu de História Natural, Universidade Federal de Minas Gerais* 12: 275–284.

Alonso, M. 2008. *Estudo traceológico de instrumentos líticos do Brasil Central*. Belo Horizonte: Universidade Federal de Minas Gerais.

Alonso, M., and M. E. Mansur. 1986/1990. "Estudo traceológico de instrumentos em quartzo e em quartzito de Santana do Riacho (MG)." *Arquivos do Museu de História Natural, Universidade Federal de Minas Gerais* XI: 173–194.

Angeles Flores, R. 2015. "Uso de recursos vegetais em Lapa Grande de Taquraçu: Evidências macro e microscópicas." Dissertação de mestrado, Universidade de São Paulo, São Paulo, Brazil.

Angeles Flores, R., J. C. M. de Sousa, A. G. de Mello Araujo, and G. Ceccantini. 2016. "Before Lagoa Santa: Micro-Remain and Technological Analysis in a Lithic Artifact from the Itaparica Industry." *Journal of Lithic Studies* 3 (1): 6–29. doi:10.2218/jls.v3i1.1423.

Apezzato-Da-Glória, B., and M. E. M. Estelita. 2000. "The Developmental Anatomy of the Subterranean System in Mandevilla Illustris (Vell.) Woodson and M. velutina (Mart. ex Stadelm.) Woodson (Apocynaceae)." *Revista Brasileira de Botânica* 23 (1): 27–35. doi:10.1590/s0100-84042000000100003.

Araujo, A. G., M. de, et al. 2008. "Lapa das Boleiras Rockshelter: Stratigraphy and Formation Processes at a Paleoamerican Site in Central Brazil." *Journal of Archaeological Science* 35: 3186–3202. doi:10.1016/j.jas.2008.07.007

Araujo, A. G., M. de, and L. B. Piló. 2017. ""Towards the Development of a Tropical Geoarchaeology: Lagoa Santa as an Emblematic Case Study." In *Archaeological and Paleontological Research in Lagoa Santa: The Quest for the First Americans*, edited by P. J. T. da Gloria, W. A. Neves, and M. Hubbe, 373–391. Springer.

Araujo, A. G. M., and E. C. de Oliveira. 2010. "Capítulo 1: A Lapa das Boleiras: Inserção ambiental, histórico das pesquisas e caraterização do sítio." In *Lapa das Boleiras, Um Sítio Paleoíndio do Carste de Lagoa Santa, MG, Brasil*, edited by A. G. de M. Araujo and W. A. Neves, 14–23. Annablume: FAPESP.

Araujo, A. G., W. A. Neves, and R. Kipnis. 2012. "Lagoa Santa Revisited: An Overview of the Chronology, Subsistence, and Material Culture of Paleoindian Sites in Eastern Central Brazil." *Latin American Antiquity* 23: 533–550. doi:10.7183/1045-6635.23.4.533.

Araújo, A. G. M., W. A. Neves, L. B. Piló, and J. P. Atui. 2005. "Holocene Dryness and Human Occupation in Brazil During the 'Archaic Gap'." *Quaternary Research* 64: 298–307. doi:10.1016/j.yqres.2005.08.002.

Babot, M. D. P. 2003. "Starch Grain Damage as an Indicator of Food Processing." In *Phytolith and Starch Research in the Australian-Pacific Asian Regions: The State of the Art*, edited by D. M. Hart and L. A. Wallis, 69–81. Canberra: Pandanus Books.

Barton, H. 2006. "Testing for Contamination on Tool Edges (Box 9.7.)." In *Ancient Starch Research*, edited by R. Torrence and H. Barton, 192–193. Walnut Creek, CA: Left Coast Press.

Barton, H., and P. J. Matthews. 2006. "Taphonomy." In *Ancient Starch Research*, edited by R. Torrence and H. Barton, 75–94. Walnut Creek, CA: Left Coast Press. 2006.

Barton, H., R. Torrence, and R. Fullagar. 1998. "Clues to Stone Tool Function re-Examined: Comparing Starch Grain Frequencies on Used and Unused Obsidian Artefacts." *Journal of Archaeological Science* 25: 1231–1238. doi:10.1006/jasc.1998.0300

Beck, W. 2006. "Box 4.1 Australian Aboriginal Food-Processing Technology." In *Ancient Starch Research*, edited by R. Torrence and H. Barton, 55–56. Walnut Creek, CA: Left Coast Press.

Bernardo, D. V. 2007. *Afinidades morfológicas intra e extra-continentais dos paleoíndios de Lagoa Santa : uma nova abordagem*. São Paulo: Universidade de São Paulo.

Cascon, L. M. 2009. *Pequenas Grandes Permanências: métodos e técnicas para a construção de coleções de referencia e extração de grãos de amido e outros microvestígios de diversos contextos*. Rio de Janeiro: Universidade Federal do Rio de Janeiro.

Cascon, L. M. 2010. "Alimentação na floresta tropical: Um estudo de caso no sítio Hatahara, Amazônia Central, com base em microvestígios botânicos." Dissertaçao de mestrado, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil.

Castro Souza, V., T. Bevilacqua Flores, G. Dalla Colleta, and R. L. Gayoso Coelho. 2018. *Guia das plantas do Cerrado*. Piracicaba, São Paulo: Taxon Brasil.

Chim, E. N. 2018. “Zooarqueologia da Lapa Grande de Taquaraçu.” Dissertação de mestrado, Universidade de São Paulo, São Paulo, Brazil.
Collins, M. B. 2007. “Discerning Clovis subsistence from stone artifacts and site distributions on the Southern Plains Periphery.” In *Foragers of the Terminal Pleistocene in North America*, edited by R. B. Walker and B. N. Driskell, 59–87. Lincoln and London: University of Nebraska Press.
Cornero, S., W. A. Neves, and A. Prous. 1999. “Prevalencia de caries en una muestra de la poblacion de Santana do Riacho I, o El Mito del Paleoindio Cazador.” *Revista Argentina de Antropología Biológica* 2: 301–306.
Crowther, A., et al. 2014. “Documenting Contamination in Ancient Starch Laboratories.” *Journal of Archaeological Science* 49: 90–104. doi:10.1016/j.jas.2014.04.023
Da Gloria, P., and C. S. Larsen. 2014. “Oral Health of the Paleoamericans of Lagoa Santa, Central Brazil.” *American Journal of Physical Anthropology* 154: 11–26. doi:10.1002/ajpa.22467
Da Gloria, P., and C. S. Larsen. 2017. “Subsisting at the Pleistocene/Holocene Boundary in the New World: A View from the Paleoamerican Mouths of Central Brazil.” *PaleoAmerica* 3: 101–121. doi:10.1080/20555563.2016.1270697.
Da Gloria, P. J. T., and W. A. Neves. 2014. “Hábitos alimentares dos paleoamericanos de Lagoa Santa.” *Scientific American Brasil* 141 (February): 76–79.
Da Gloria, P. J. T., and R. E. Oliveira. 2016. “História das pesquisas sobre saúde e estilo de vida em Lagoa Santa.” In *Lagoa Santa: História das pesquisas arqueológicas e paleontológicas*, edited by P. J. T. da Gloria, W. A. Neves, and M. Hubbe, 275–298. Annablume: FAPESP.
Dana, J. D. 1960. *Manual de mineralogía: tratado moderno para la enseñanza en universidades y escuelas especiales y para guía de ingenieros de minas y geólogos*. 2nd edition. Barcelona: Editorial. Reverté S.A.
Danzeglocke, U., O. Jöris, and B. Weninger. 2007. Calpal Online. http://www.calpal-online.de/index.html.
da Silva, L. V. 2016. “Fogueiras ancestrais: identificação de cinzas vegetais através dos cristais de oxalato de cálcio.” *MG-Biota* 8 (4): 56–60.
De Castro, E. A., and J. B. Kauffman. 1998. “Ecosystem Structure in the Brazilian Cerrado: A Vegetation Gradient of Aboveground Biomass, Root Mass and Consumption by Fire.” *Journal of Tropical Ecology* 14 (3): 263–283. doi:10.1017/S0266467498000212
Edwards, M. R.. 1956. “Alguns Dispositivos para Proteção de Plantas Contra a Seca e o Fogo.” *Boletim da Faculdade de Filosofia, Ciências e Letras, Universidade de São Paulo. Botânica* 13: 35–68. doi:10.11606/issn.2318-5988.v13i0p35-69..
Feathers, J., R. Kipnis, L. Piló, M. Arroyo-Kalin, and D. Coblentz. 2010. “How old is Luzia? Luminescence Dating and Stratigraphic Integrity at Lapa Vermelha, Lagoa Santa, Brazil.” *Geoarchaeology* 25 (4): 395–436. doi:10.1002/gea.20316.
Ferring, C. R. 2001. *The Archaeology and Paleoecology of the Aubrey Clovis Site (41DN479) Denton County, Texas*. Denton County, TX: Center for Environental Archaeology, Department of Geography, University of North Texas.
Freire, G. D. Q. 2011. “Madeiras fósseis holocenicas de Riberao da Mata: anatomia ecológica, relaçoes florísticas e interpretaçao paleombiental da regiao arqueologica de Lagoa Santa, MG.” Tése de doutorado, Universidade de Sao Paulo, São Paulo, Brazil.
Giovannetti, M. A., V. S. Lema, C. G. Bartoli, and A. Capparelli. 2008. “Starch Grain Characterization of Prosopis Chilensis (Mol.) Stuntz and P. Flexuosa DC, and the Analysis of Their Archaeological Remains in Andean South America.” *Journal of Archaeological Science* 35: 2973–2985. doi:10.1016/j.jas.2008.06.009.
Haslam, M. 2004. “The Decomposition of Starch Grains in Soils: Implications for Archaeological Residue Analyses.” *Journal of Archaeological Science* 31 (12): 1715–1734. doi:10.1016/j.jas.2004.05.006.
Henry, A. G., H. F. Hudson, and D. R. Piperno. 2009. “Changes in Starch Grain Morphologies from Cooking.” *Journal of Archaeological Science* 36 (3): 915–922. doi:10.1016/j.jas.2008.11.008.
Hermenegildo, T. 2009. “Reconstituição da dieta e dos padrões de subsistência das populações pré-históricas de caçadores-coletores do Brasil Central através da ecologia isotópica.” Dissertação de mestrado, Escola Superior de Agricultura “Luiz de Queiroz”, Piracicaba.
Homsey, L. K., R. B. Walker, and K. D. Hollenbach. 2010. “What’s for Dinner? Investigating Food-processing Technologies at Dust Cave, Alabama.” *Southeastern Archaeology* 29 (1): 182–196. doi:10.1179/sea.2010.29.1.012
Hurt, W. R., and O. Blasi. 1969. “O projeto arqueológico ‘Lagoa Santa’ – Minas Gerais, Brasil.” *Arquivos do Museu Paranaense Nova Série* 4: 60.
ICSN. 2011. *The International Code for Starch Nomenclature*. http://fossilfarm.org/ICSN/Code.html; accessed 1 October 2022.
Kipnis, R. 1998. “Early Hunter-Gatherers in the Americas: Perspectives from Central Brazil.” *Antiquity* 72: 581–592. doi:10.1017/S0003598X00087019
Kipnis, R. 2002. “Foraging Societies of Eastern Central Brazil: An Evolutionary Ecological Study of Subsistence Strategies During the Terminal Pleistocene and Early/Middle Holocene.” PhD diss., Ann Arbor, USA: University of Michigan.
Klein, C., and B. Dutrow. 2012. *Manual de ciencias dos minerais*. 23rd ed. Porto Alegre, Brasil: Bookman.
Knutsson, H., K. Knutsson, N. Taipale, M. Tallavaara, and K. Darmark 2015. “How Shattered Flakes Were Used: Micro-wear Analysis of Quartz Flake Fragments.” *Journal of Archaeological Science: Reports* 2: 517–531. doi:10.1016/j.jasrep.2015.04.008.
Kornfeld, M. 2007. “Are Paleoindians of the Great Plains and Rockies Subsistence Specialists?” In *Foragers of the Terminal Pleistocene in North America*, edited by R. B. Walker and B. N. Driskell, 32–58. Lincoln: University of Nebraska Press.
Lamming-Emperaire, A., A. Prous, A. V. Moraes, and M. Beltrao. 1975. *Grottes et abris de la region de Lagoa Santa, premier rapport de la mission archéologique franco-brésilienne de Lagoa Santa*. Paris: Cahiers d’Archéologie de Amerique do Sud 1.
Laurence, A. R., et al. 2011. “Airborne Starch Granules as a Potential Contamination Source at Archaeological Sites.”

Journal of Ethnobiology 31 (2): 213–232. doi:10.2993/0278-0771-31.2.213.

Loy, T. H., S. Matthews, and S. Wickler. 1992. "Direct Evidence for Human Use of Plants 28,000 Years Ago: Starch Residues on Stone Artefacts from the Northern Solomon Islands." *Antiquity* 66: 898–912. doi:10.1017/S0003598X00044811.

Martin, P. S. 1973. "The Discovery of America." *Science* 179: 969–974. doi:10.1126/science.179.4077.969

McDonough, K. N., J. L. Kennedy, R. L. Rosencrance, J. A. Holcomb, and D. L. Jenkins. 2022. Expanding Paleoindian Diet Breadth: Paleoethnobotany of Connley Cave 5, Oregon, USA." *American Antiquity* 87: 303–332. doi:10.1017/aaq.2021.141.

McKey, D., T. R. Cavagnaro, J. Cliff, and R. Gleadow. 2010. "Chemical Ecology in Coupled Human and Natural Systems: People, Manioc, Multitrophic Interactions and Global Change." *Chemoecology* 20: 109–133. doi:10.1007/s00049-010-0047-1.

Medeiros, J.D.D. 2011. *Guia de campo: vegetação do Cerrado, 500 espécies.* Brasília: Ministério de Meio Ambiente (MMA).

Mercader, J., M. Abtosway, E. Baquedano, R. W. Bird, F. Díez-Martín, M. Domínguez-Rodrigo, J. Favreau, et al. 2017. "Starch Contamination Landscapes in Field Archaeology: Olduvai Gorge, Tanzania." *Boreas* 46: 1–17. doi:10.1111/bor.12241.

Morais, J. L. A. 1987. "A propósito do estudo das indústrias líticas." *Revista do Museu Paulista* 32: 155–184.

Moreno de Sousa, J. C. 2014. *Cognição e cultura no mundo material : Os Itaparicas, os Umbus e os "Lagoassantenses".* São Paulo: Universidade de São Paulo.

Moreno de Sousa, J. C., A. G. de, and M. Araujo. 2018. "Microliths and Polished Stone Tools During the Pleistocene-Holocene Transition and Early Holocene in South America: The Lagoa Santa Lithic Industry." *PaleoAmerica* 4: 219–238. doi:10.1080/20555563.2018.1531350

Nakamura, C., J. C. F. Melo Junior, and G. Ceccantini. 2010. "Macro-restos vegetais: uma abordagem paleoetnobotânica e paleoambiental." In *Lapa das Boleiras, um sítio paleoíndio do Carste de Lagoa Santa, MG, Brasil*, edited by A. G. M. Araujo and W. A. Neves, 164–190. 1st ed. Sao Paulo: Annablume, FAPESP.

Neves, W. A., A. Prous R. González-José, R. Kipnis and J. Powell. 2003. "Early Holocene Human Skeletal Remains from Santana do Riacho, Brazil: Implications for the Settlement of the New World." *Journal of Human Evolution* 45: 19–42. doi:10.1016/S0047-2484(03)00081-2

Neves, W., and S. Cornero. 1997. "What Did South American Paleoindians Eat?" *Current Research in Pleistocene* 14: 93–97.

Neves, W., R. González-José, M. Hubbe, R. Kipnis, A. Araujo, and O. Blasi. 2004. "Early Holocene Human Skeletal Remains from Cerca Grande, Lagoa Santa, Central Brazil, and the Origins of the First Americans, Lagoa Santa, central Brazil, and the Origins of the First Americans." *World Archaeology* 36: 479–501. doi:10.1080/0043824042000303665.

Neves, W. A., and M. Hubbe. 2005. "Cranial Morphology of Early Americans from Lagoa Santa, Brazil: Implications for the Settlement of the New World." *Proceedings of the National Academy of Sciences* 102: 18309–18314. doi:10.1073/pnas.0507185102.

Neves, W. A., M. Hubbe, and L. B. Piló. 2007. "Early Holocene Human Skeletal Remains from Sumidouro Cave, Lagoa Santa, Brazil: History of Discoveries, Geological and Chronological Context, and Comparative Cranial Morphology." *Journal of Human Evolution* 52: 16–30. doi:10.1016/j.jhevol.2006.07.012.

Neves, W.A., J. F. PowellA. ProusE. G. Ozolins and M. Blum. 1999. "Lapa Vermelha IV Hominid 1: Morphological Affinities of the Earliest Known American." *Genetics and Molecular Biology* 22: 461–469. doi:10.1590/S1415-47571999000400001

Neves, W. A., and H. M. Pucciarelli. 1991. "Morphological Affinities of the First Americans: An Exploratory Analysis Based on Early South American Human Remains." *Journal of Human Evolution* 21: 261–273. doi:10.1016/0047-2484(91)90107-7

Ortega, D. D. 2019. "Microvestígios em artefatos líticos do sítio Lapa do Santo (Lagoa Santa, Minas Gerais)." Dissertação de mestrado, Universidade de São Paulo, São Paulo.

Pagán-Jiménez, J. R. 2011. *Useful Plants Identified through Ancient Starch Grains Recovered from Ceramic and Lithic Artefacts, the Chemin Saint–Louis Site, French Guiana (M. van den Bel, Ed.) DOM, Guyane, Saint-Laurent-du-Maroni Chemin Saint Louis, Rapport d'Operation, Fouille Archéologique.* Vol. 2. Institute national de recherches archéologiques préventives (INRAP).

Pagán-Jiménez, J. R. 2015. *Almidones: Guía de material comparativo modernos del Ecuador para los estudios paleoetnobotánicos en el Neotrópico*. Quito, Ecuador: Aspha Ediciones.

Pagán-Jiménez, J. R., and J. R. Oliver. 2008. "Starch Residues on Lithic Artifacts from two Contrasting Contexts in Northwestern Puerto Rico: Los Muertos Cave and Vega de Nelo Vargas Farmstead." In *Crossing the Borders: New Methods and Techniques in the Study of Archaeological Materials from the Caribbean*, edited by C. L. Hofman, M. L. P. Hoogland, and A. O. Van Gin, 137–158. Tuscaloosa: The University of Alabama Press.

Pearsall, D. M. 2016. *Paleoethnobotany: A Handbook of Procedures.* 3rd ed. London and New York: Routledge.

Piperno, D. R., et al. 2000. "Starch Grains Reveal Early Root Crop Horticulture in the Panamanian Tropical Forest." *Nature* 407: 894–897. doi:10.1038/35038055

Piperno, D. R. 2011. "The Origins of Plant Cultivation and Domestication in the New World Tropics." *Current Anthropology* 52: S453–S470. doi:10.1086/659998.

Piperno, D. R., and T. D. Dillehay. 2008. "Starch Grains on Human Teeth Reveal Early Broad Crop Diet in Northern Peru." *Proceedings of the National Academy of Sciences* 105: 19622–19627. doi:10.1073/pnas.0808752105.

Piperno, D. R., A. J. Ranere, I. Holst, J. Iriarte, and R. Dickau. 2009. "Starch Grain and Phytolith Evidence for Early Ninth Millennium B.P. Maize from the Central Balsas River Valley, Mexico." *Proceedings of the National Academy of Sciences* 106: 5019–5024. doi:10.1073/pnas.0812525106.

Prous, A. 1986/1990. "Os artefatos líticos, elementos descritivos classificatórios." *Arquivos do Museu de História Natural Universidade Federal de Minas Gerais* 11: 1–90.

Prous, A., F. Freitas, L. A. Cruz Souza, M. Rodet, S. O. G. Rocha, and G. S. Pádua 2012. "Amidos Pré-Históricos em mós do sítio Arqueológico Caixa D'água, de Buritizeiro/ Mg: abordagem Arqueobotânica no Cemitério do Holoceno Médio." *Anais do 2º Seminário de Pós-Graduação em Ciência e Conservação - História da Arte Técnica* 2 (1): 186–192.
Prous, A., M. T. T. Moura, and M. A. Lima. 1991. "Industria lítica de Santana do Riacho." *Arquivos do Museu de História Natural da Universidade Federal de Minas Gerais* XII: 187–295.
Pugliese, F. A. 2007. *Os líticos de Lagoa Santa: Um estudo sobre organização tecnológica de caçadores-coletores do Brasil Central*. São Paulo: Universidade de São Paulo.
Raczka, M. F., et al. 2013. "Two Paleoecological Histories Spanning the Period of Human Settlement in Southeastern Brazil." *Journal of Quaternary Science* 28: 144–151. doi:10.1002/jqs.2597
Rasband, W. S. 1997. *Image J*. Bethesda, Maryland, USA U.S. National Institutes of Health. http://imagej.nih.gov/ij/.
Rawitscher, F. 1948. "The Water Economy of the Vegetation of the 'Campos Cerrados' in Southern Brazil." *Journal of Ecology* 36 (2): 237–268.
Sakai, W. S., and M. Hanson. 1974. "Mature Raphid and Raphid Idioblast Structure in Plants of the Edible Aroid Genera Colocasia, Alocasia, and Xanthosoma." *Annals of Botany* 38: 739–748. doi:10.1093/oxfordjournals.aob.a084862.
Seguchi, N., A. McKEOWN, R. Schmidt, H. Umeda, and C. L. Brace. 2011. "An Alternative View of the Peopling of South America: Lagoa Santa in Craniometric Perspective." *Anthropological Science* 119: 21–38. doi:10.1537/ase.090921.
Shock, M. P., R. Kipnis, L. Bueno, and F. M. Silva. 2013. "A Chronology of the Introduction of Domesticated Plants in Central Brazil." *Tipití: Journal of the Society for the Anthropology of Lowland South America* 11 (2): 52–59.
Taipale, N. 2012. *Micro vs. Macro: A Microwear Analysis of Quartz Artefacts from Two Finnish Late Mesolithic Assemblages with Comments on the Earlier Macrowear Results, Wear Preservation and Tool Blank Selection*. Uppsala: Uppsala University.
Tudela, D. R. G., A. G. M. Araujo, S. H. Tatumi, J. C. R. Mittani, and C. S. Munita. 2020. "Preliminary Evidence of Prehistoric Human Activity by Chemical Analysis of Sediments from Lapa Grande de Taquaraçu Archaeological Site Using INAA." *Journal of Radioanalytical and Nuclear Chemistry* 325 (3): 725–736. doi:10.1007/s10967-020-07217-2.
Turner, C. G., and L. M. Machado. 1983. "A new Dental Wear Pattern and Evidence for High Carbohydrate Consumption in a Brazilian Archaic Skeletal Population." *American Journal of Physical Anthropology* 61: 125–130. doi:10.1002/ajpa.1330610113
Van Peer, P., et al. 2003. "The Early to Middle Stone Age Transition and the Emergence of Modern Human Behaviour at Site 8-B-11, Sai Island, Sudan." *Journal of Human Evolution* 45: 187–193. doi:10.1016/S0047-2484(03)00103-9
Wesolowski, V. 2007. *Caries, desgaste, cálculos dentários e micro-resíduos da dieta entre grupos pré-históricos do litoral norte de Santa Catarina: É possível comer amido e não ter cárie?* Escola Nacional de Saúde Pública Sergio Arouca/ FIOCRUZ.
Williamson, B. 2006. "Investigation on Potential Contamination on Stone Tools (Box.5.4)." In *Ancient Starch Research*, edited by R. Torrence and H. Barton, 89–90. Walnut Creek, CA: Left Coast Press.
Yesner, D. R. 2007. "Faunal Extinction, Hunter-Gatherer Foraging Strategies, and Subsistence Diversity among Eastern Beringian Paleoindians." In *Foragers of the Terminal Pleistocene in North America*, edited by R. B. Walker and B. N. Driskell, 15–31. Lincoln and London: University of Nebraska Press.