SHORT LITHIC REDUCTION IN THE ITAPEVA ROCKSHELTER, SÃO PAULO, BRAZIL

REDUCCIÓN LÍTICA CORTA EN EL REFUGIO ITAPEVA, SÃO PAULO, BRASIL

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Keywords

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Statistical methods
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Abstract

The Itapeva Shelter is located to the southeast of São Paulo, Brazil. Initially, the lithic industry was identified as what is known as lithic expediency within North American literature. To test this hypothesis, the physical attributes of the raw materials and the technical attributes of the archeological material were cross referenced with the aim of creating clusters, and Student's t-test and Multi-dimensional Scaling (cMDS) were used to statistically verify whether there were organized reduction sequences within the industry. The conclusion is that there are debitage processes that are detectable through statistical analysis, which are not short, random knapping sequences. This suggests that refined statistical tests are capable of detecting the standardized reduction that connects a series of knapping methods in raw materials of variable quality, with no drop in technical execution in the middle and recent Holocene based on random knapping.

Palabras clave

Refugio Itapeva
Métodos estadísticos
Expeditividad lítica
Tecnología
Análisis

Resumen

El Refugio Itapeva está ubicado al sureste de São Paulo, Brasil. Inicialmente, la industria lítica fue identificada como lo que se conoce como expeditividad lítica dentro de la literatura norteamericana. Para probar esta hipótesis se cruzaron atributos físicos de las materias primas y atributos técnicos del material arqueológico con el objetivo de crear clusters y verificar estadísticamente mediante pruebas T de Student y cMDS si existían secuencias de reducción organizadas dentro de la industria. La conclusión es que existen procesos de talla que pueden ser detectados mediante análisis estadística, no considerándose secuencias de talla cortos y aleatorios, sugiriendo que pruebas estadísticas refinadas son capaces de detectar la reducción estandarizada que vincula una serie de métodos de talla en materias primas de calidad variable, sin caída en la ejecución técnica en el Holoceno medio y reciente basado en talla aleatorio.

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Introduction

The Furnas Formation outcrops in the states of Paraná and São Paulo over a surface area of 4,290 km², being delimited to the east by the Devonian Escarpment, which is an erosion scarp of approximately 250 km long (Bigarella *et al.* 1966). The escarpment face is defined by an abrupt rock wall that reaches up to 120 meters. The foot of the escarpment has slopes of between 25° and 40° that are formed by pediment ramps and talus deposits (Souza and Souza 2000). The Devonian only appears about 5 km SW of Itapeva, in the Taquari-Guaçu River canyon, being precisely where the Itapeva Shelter is located (Figure 1). It occupies a large erosion trough covered with sandy-silt sediments from the Tubarão group (Petri and Fulfaro 1967: 56).

Internally, the Itapeva Shelter is located on a wall of the Furnas Formation, which is 20 m high with an inclination of around 20˚, where a block fell from the wall and became a large boulder blocking the shelter and forming a central hall open at both ends, with measurements varying between 4 m and 7 m wide (Aytai 1970) (Figure 2).

The first information on the existence of the Itapeva Shelter was reported by Tristão de Alencar Araripe (1887). He describes how in the court's trade newspaper, it can be read that Mr. Domingos Jaguaribe Filho receives a communication from Dr. Orville Derbi mentioning a place full of treasures buried with the remains of a priest to whom riches taken to an Indian residence are attributed. The place was a shelter sought by the Indians as a resting

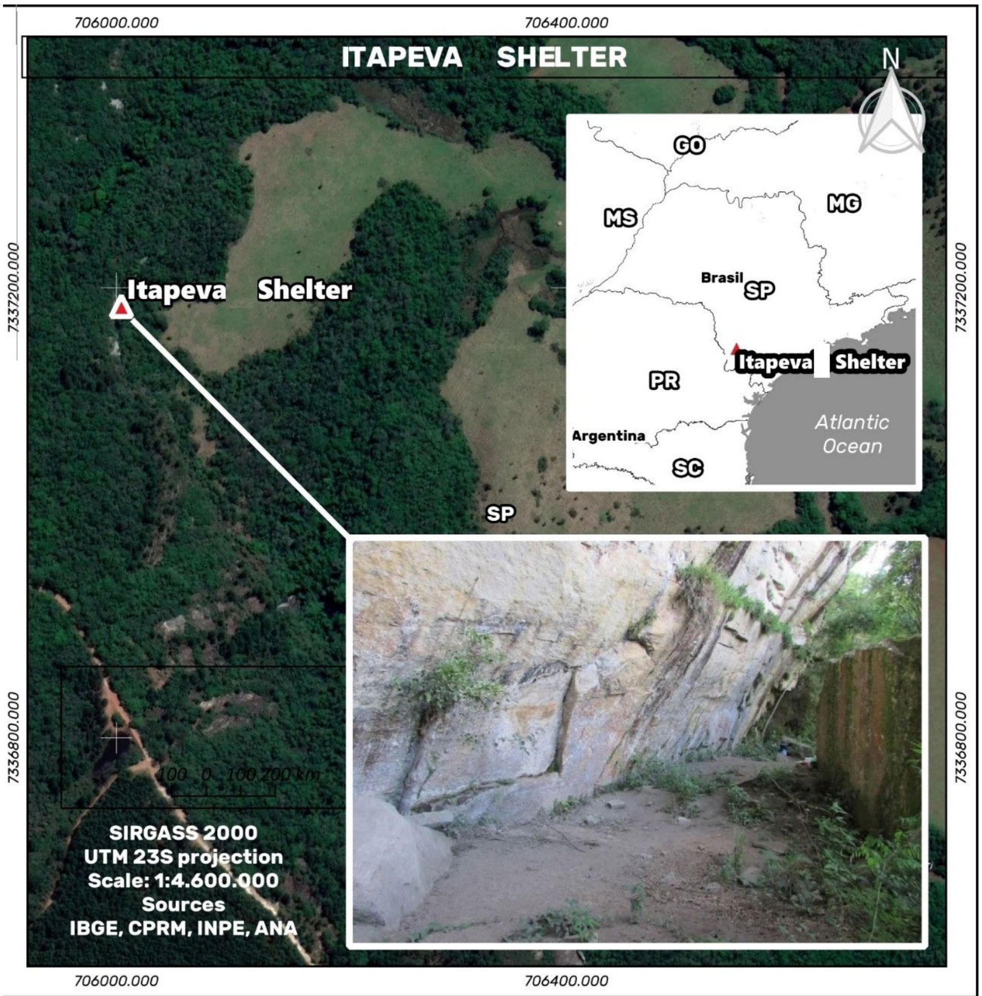


Figure 1. Location of the Itapeva Shelter.

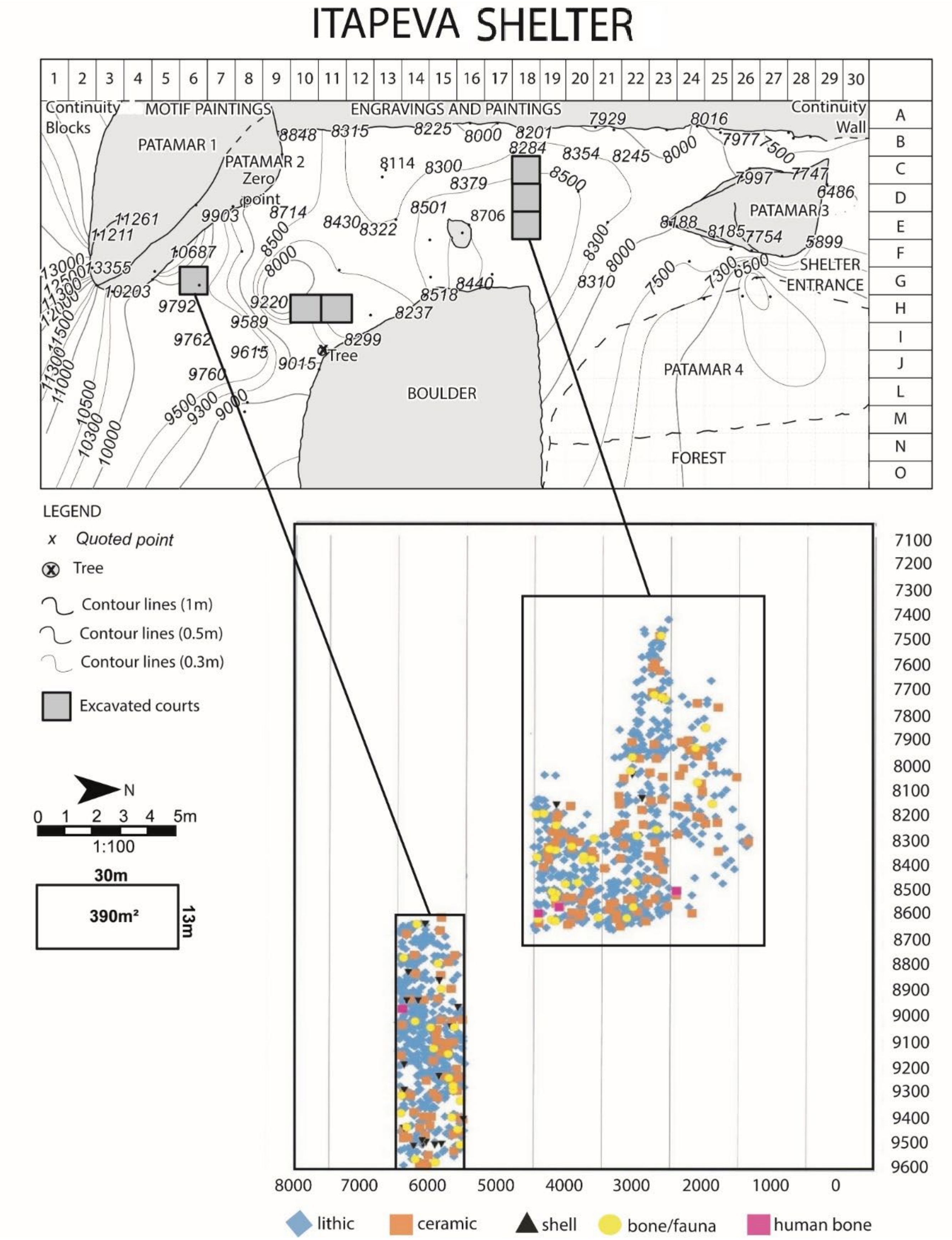


Figure 2. Excavation sketch and material distribution in excavation units.

place for their dead. On the wall of this shelter there are figures engraved in the stone, painted with black and red paint, which include a human figure with feathers adorning the head and neck (Araripe 1887: 231-232).

During the year 1970, Dr. Desidério Aytai focused his attention on describing the rock wall. Its description is classificatory, including techniques performed in grooves of different depth and width, partially painted in different colors, with designs painted in red directly on the natural surface of the rocks (Aytai 1970: 31).

The findings in archeological soil in 1970 from two excavation units (Figure 2) yielded predominantly lithic flakes and ceramic fragments very similar to those found in excavations carried out today (2016, 2017, within the scope of the CNPq Project - Process 408248/2016-5 Itararé-Taquara Archeology in the extreme south of SP: Investigation of chronocultural relationships between rock shelters, underground structures, and earth mounds in the Itapeva region).

Starting in July 2016, a series of excavations began in consecutive stages to open 1 m^2 excavation units. The initial objective was to reach the maximum depth, collect the material culture, and carry out radiocarbon dating. Between 2000 and 5000 meters, three contiguous excavation units were opened, forming a small trench (Figure 2), while in the southern sector, another excavation unit was opened at meter 6000, where there is a sandstone plateau above which there are paintings. applied directly to the rock support.

In total, five field stages were carried out, four concentrated in the shelter for archeological purposes and one outside to collect soil micromorphology samples. The shelter does not have a homogeneous base and its depth was tested at one meter intervals.

The first stage opened excavation units C18 and D18. Excavation unit C18 is the closest to the rock wall. From its initial levels, there is a series of loose, flat sandstone blocks located in the NW quadrant that needed to be constantly supported to preserve the stratigraphy. Excavation unit D18 is adjacent to C18 and consists of 13 artificial stratigraphic levels of 10 cm, tapered due to sandstone blocks in the NE/SE quadrant. It is formed by 6 archeological facies. Excavation unit E18 is adjacent to unit D18, and the same type of material was recovered, as it presents the same archeological facies as unit D18. Unit G6 is made up of 12 stratigraphic levels and is located in the southern sector of the site. It presents 15 archeological facies and the same type of archeological material found in the northern sector.

The Shelter's chronological framework presents a sequence of discontinuous dates. At the bedrock level, the dates are older while the subsequent dates are more recent, presenting an occupation gap as can be seen in Table 1.

Context of the research area

Archaeologists still treat archeological sites and material culture as contact agents. It was within the Pronapian bias that the Alto Taquari was studied during the 2000s (Araújo 2001), although attempts at interdisciplinarity had been adopted by previous authors (Morais 1999-2000). Studies carried out since the 1960s on the Itararé River brought new archeological traditions, described by Igor Chmyz, and many archeological sites have been classified up to the bordes of São Paulo (Chmyz *et al*. 2008).

The Itapeva Shelter dialogues with the archeological contexts of Upper Paranapanema, northeastern Paraná, and the work carried out along the border with Argentina. The Paraná River basin was occupied by human groups in pre-colonial times that spread from Amazonia to the lower Paraná River delta in Buenos Aires

Quadrant	Level	Sample	CRA	Date cal AP	Date cal AD/AP	CI 95% SE AP	CI 95% AD/ AP
D18	2	BETA 432530	640 +- 30	560	1,390 AD	575, 540	1,375,1,410
D18	4	BETA 432531	860 +-30	730	1,220 AD	770,675	1,180, 1,775
D18	7	BETA 432532	860 +- 30	730	1,220 AD	770,675	1,280, 1,775
D18	13	BETA 432533	1,470 +-30	1.310	640 AD	1,365, 1,295	585, 655
D18	14	BETA 432434	4,770 +-30	5,510	3,620 AD	5,585, 5,505	3,663, 3,555

Table 1. Chart of dates established using charcoal, AMS. Beta Analytics Inc, 2016. References: CRA = Conventional Radiocarbon Age; AP = Before the Present (Before 1950); AD = Anno Domini; CI = Confidence Interval; SE = Standard Error.

(Brochado 1984; Loponte and Acosta 2003–2005; Noelli 2008).

Information from southeast São Paulo, as well as that from northeast Paraná, mainly from the upper Paranapanema valley and the Itararé River, enable the conclusion (Araújo 2001, 2007) that the eastern half of São Paulo and Paraná were the main access points to southern Brazil for the groups considered Jê.

In the state of São Paulo, it can be verified that there is greater spacing in the distance between the sites up to the upper Paranapanema in situations of different waves and directions, the relationship of interethnic contacts being modified to maintain variations in the distances between ethnic groups. An expansion line appears to be developing from the Paranapanema River or it may be a social modification in the relationship between human groups (Souza and Rizzi 2023).

This interpolation of sites becomes practically fused on the border between Paraná and São Paulo, and this area can be considered a space of fusions where communication between groups is intense or no longer differentiated, given the proximity of the sites. As such, it can be verified that forms of contact are diluted, and new relationships are formed based on distinct spatial organizations (Souza and Rizzi 2023).

It is stated that a unified trajectory is not maintained between Paraná and São Paulo, such that there appears to be a rupture in the border between these two states and a reconstruction of contacts in Upper Paranapanema (Souza and Rizzi 2023).

Due to these circumstances, it is possible that the mobility pattern is affected and expansion fronts are spatially differentiated due to exchange networks of different natures that could be indigenous or assimilated.

Another perspective is that opposing groups are meeting in this area, and this would denote a well-established border line. Therefore, a possible hypothesis is that groups clashed in the upper Taquari area.

In the Itapeva region, within the São Paulo plateau, it can be seen that the relationships between technological complexes occur in specific, well-defined locations. Clearly, in the area covered, the relationship is one of isolation and accentuated circumscription in specific locations, and it appears that these groups have repelled each other over time.

It is noted that, although the sites have material culture distributed throughout the state, they do not maintain contact according to points established in the vicinity. As such, the unaffiliated lithic sites contained in an extensive territorial strip draw attention to the fact that much needs to be done in terms of prospecting and laboratory analyses to identify and connect human groups with the surrounding spatial areas.

The contested lithic expediency - Informal artifacts as site documents

Discussions on the manufacture of lithic artifacts with low technological implementation are not new in the Brazilian scenario, and a hypothesis was created that there is a transformation in the technological standard of production, culminating in a process of apparent technical simplification that would have started to occur around 9000/ 8000 BP (Bueno 2007; Lourdeau 2010; Schmitz 1981,1987).

There would have been a decrease in the application of normative techniques to lithic materials from older phases. This decrease would be detectable by the shortening of the operative chains and the presence of apparent randomness in the use of knapping debris, with new sources of raw materials for the production of objects (Fogaça 1997: 74-77).

However, observations of Brazilian lithic industries from the middle and recent Holocene period point towards a type of artefactual repertoire that is constant, long-lasting, and standardized in time and space, albeit also classified as simple, incomprehensible, or lacking expression of the skill of artisan producers (Parry and Kelly 1987).

Therefore, the first thing to do is think about the term expediency and how this term was interpreted in relation to lithic artefactual repertoires. A starting point is the etymology of the word expediency itself. Etymologically, it means the situation of things or people at a given time; particularity; accident that accompanies a fact or a situation or a means to resolve a difficulty, an artifice employed (Houaiss and Villar 2009: 858).

However, when we look at informal artifacts contextually, we notice that a small transformation of the original form of the support was not related to an immediate use; it is marked by environmental conditions, poor quality of the raw material, or a decline in skill due to a decline in mobility.

One hypothesis is that it would be related to material aspects due to activities carried out within the site, whose existence of a mental model of production is implied in the technique applied to the lithic material, even when little transformed. Taking advantage of a splinter, rubbing it, beating it, transforming it into a nib, or producing touches that slightly modify the morphology of scraps refers to a pre-existing mental model.

If the observation of these artifacts is maintained in a network of actions, the flakes used refer to the search for shape, size and thickness coming from stages of significant operative chains. This is not because they were made for the needs of the moment, but because they are structured in a social web that does not seek to reach the peak of lithic performance because lithics are being used for other functions within the site.

Rocks are the main indicators of human influence when thinking about maintaining the territory and searching for the extraction zones of the populations that handled them. The way in which they are present at the archeological site, in contrast to the knapping characteristics, is what enables reflections on archeological remains and, in this sense, informal lithics are maintained in a production chain of integrated actions and the focus is not only on their characteristic reduction techniques.

The concept of lithic expediency arises from the discussion established between (Bordes 1961, 1975; Bordes and Sonneville Bordes 1970; Loiseau 2014) and (Binford 1966, 1976, 1979, 1982, 1983). The disagreement concerns the interpretation of lithic artefactual assemblages. While François Bordes suggested that assemblages of lithic artefacts were signatures of cultural traditions, Lewis Binford argued that these assemblages varied independently of the geological horizons identified as cultural traditions.

During the 1970s, this discussion led Lewis Binford to develop the concept of curation and expediency based on the opposition between these categories. The concept of lithic expediency is the notion of having a passive instrument produced to perform a task, despite not having been designed for that purpose.

However, a technical argument that disagrees with this hypothesis is that formalized tools may be less effective and more expensive in preparing a technical action, depending on the task to be performed (Parry and Kelly 1987).

Another technical argument against the hypothesis of simplicity of technical procedures is offered by Vaquero and Ramagnoli (2017), who state that expeditious technology is based on the morphology of the nucleus and that different reduction methods determine morphological variability according to the many patterns of cores involved.

Other perspectives are corroborated by ethnographic data linked to a series of actions carried out on materials considered expedient in different places around the world. Factors such as the availability of alternative resources for the manufacture of lithic tools, such as wood and bamboo, would explain the persistence of expedient, previously lithic, technologies in different Asian regions (Lycett and Norton 2010; Mijares 2001).

In North America, Crabtree (1968, 1972, 1973) reiterated that, although a nucleus is an interesting object of study for archeologists, it was never of real importance in the manufacture of tools for the original groups. Despite this researcher's calls for experimental archeology, an approach based on the precepts of Lewis Binford prevailed in the USA, and a significant number of works were carried out considering only the curation of lithic artifacts (Andrefsky 2008; Bamforth 1986; Dibble 1981, 1995; Nash 1996; Nelson 1992; Odell 2001; Shott 1996).

In Andean America, Gero (1983) noted many useful tools among the artefactual repertoires, emphasizing that their formats were not determined by deliberate processes, but were preferably conditioned by the structure of the raw material and that classifications such as "discoidal" and "triangular", for example, made no sense to its producers.

In Brazil, research that addresses lithic expeditions in the South and Southeast occurs with the fruition of ethnographic and technical studies that remain little explored, with the exception of some studies carried out by (Laming-Emperaire *et al.* 1978; Merencio 2014; Miller Jr 1979, 2009).

In this case, each author presented a specific objective when observing and/or studying the lithic production relationship. For Laming-Emperaire (1978), the indigenous people produced tools that the researcher classified according to the French typology based on the 1960s, considering the production stage presented by the indigenous people as short, while waiting for the demonstration of a longer production sequence.

Tom O. Miller Jr. (1979, 2009) observed that the Xetá indigenous people referred to the reduction stages only with the expression "breaking stones" in the search for specific products. This observation is in line with other observations made around the world when original groups are questioned about expedient lithic production or when informal artefactual assemblages are analyzed (Douglass 2010; Fogaça *et al.* 1997; Parry 2008; Prous and Alonso 2010b; Viana 2007; Viana *et al.* 2014; Vaquero and Rogmanoli 2017).

Tom O. Miller made an important contribution by recognizing the neglect of instruments that are not made from flakes, meaning that entire prehistoric complexes are not recognized as artifacts, and he also described at least three techniques used in the creation of lithic repertoires considered expedient.

This issue was addressed in a more updated version by Merencio (2014) in which the author characterizes the technological system of the Laming-Emperaire subcollection of the Xetá lithic deposited at Museu de Arqueologia e Etnologia da Universidade Federal do Paraná-MAE-UFPR (Museum of Archeology and Ethnology of the Federal University of Paraná). The studies are based on material reduction sequences collected by Laming-Emperaire in 1961. The highlight is that the classified types started to be related specifically to the lithics of the Proto-Jê and Tupiguarani ceramic groups, being supported by the operative chain concept.

Materials and methods

Experimental archeology is a key research component for gaining insights into the human past and interpreting lithic artefactual repositories to understand the archeological record (Andrefsky 2013; Bordes and Crabtree 1969; Crabtree 1969, 1972, 1973; Prous *et al.* 2002, 2010a). Nevertheless, experimentalism should be used to support the recognition of knapping stigmas contained in lithic assemblages and not as a guide on how work was carried out in the past.

It is through preliminary knowledge of the marks observed that the technique used is recognized. The identification of direct percussion shows that there is preparation in carrying out the action, while indirect percussion shows that the object is considerably modified through an intermediate tool placed where the detachment will take place, with or without preliminary preparations regarding the length and curvature of the piece. Finally, retouch assesses whether the work is very precise and delicate, while at the same time reducing the risk of fracture in the piece. These observations were made by comparing studies of the lower, middle, and upper Paranapanema (Faccio 1998; Kashimoto 1992; Mendes 2014; Moraes 1977; Morais 1979; Vialou 1980).

Using this methodology, the Itapeva region and its surrounding areas (Figure 3) were geologically mapped according to rock type and the structural behavior of the rocks. Rocks were then collected from around the Itapeva Shelter (figure 4) with the aim of establishing relationships between the existing material and that observed in the lithic archeological material.

The rocks of the Itapeva region

Around the Itapeva Shelter the lithology basically consists of sedimentary rocks, such as shale, diamictite (C2P1i) and sandstones (D1f), and pelitic rocks with a high degree of chemical weathering. The metamorphic rocks were classified as phyllite (NP3it), metaarenitic quartz (NP3it), Archean meta-sandstone, schist, metapelitic rock (NP3ab), dolomite metalimestone, and calciphylite (NP3ic). In adjacent municipalities, such as Nova Campina and Ribeirão Branco, practically only igneous and metamorphic rocks are found, among which biotite gneiss (NP3p_gamma 1t) and migmatite (PPAmm) stand out. Towards the middle Paranapanema, in the municipalities of Itaberá, Coronel Macedo, and Taquarituba, in addition to sedimentary rocks, there is the presence of basalt (K1_delta_sg), and clayey siltstone (P3t); in Itaí, there is mudstone, shale, and siltstone (P23 sa); while in the municipalities of Tejupá and Piraju, in the middle Paranapanema, sandstone and basalt (K1_delta_sg) stand out, as illustrated in (Figure 3).

Sandstone, quartzite, quartz, siltstone, and mafic rocks were collected at distances of up to 764 meters from the shelter at an average altitude of 700 meters (Figure 4). These raw materials were collected at the Museu de Arqueologia e Etnologia da Universidade de São Paulo (Museum of Archeology and Ethnology of the University of São Paulo) and knapped to test the direct and indirect percussion techniques and applied retouch.

A total of 3,168 pieces were identified, table 2, and the distribution of raw materials can be seen in Table 1. It is noted that the largest representation of the sample is formed by silexite, which does not appear to be part of the geological configuration of the research area (Figure 3). All other raw materials are part of the geological composition of the research area.

Raw Material	Quantity	Percentage
Silexite	1648	52%
Quartz	639	20%
Iron oxide	418	13%
Silicified sandstone	230	7%
Mafic rock	118	4%
Quartzite	64	2%
Argilite	29	1%
Siltite	12	1%
Schist	10	1%
Total	3168	100%

Table 2. Identification of the raw material present in the archeological material.

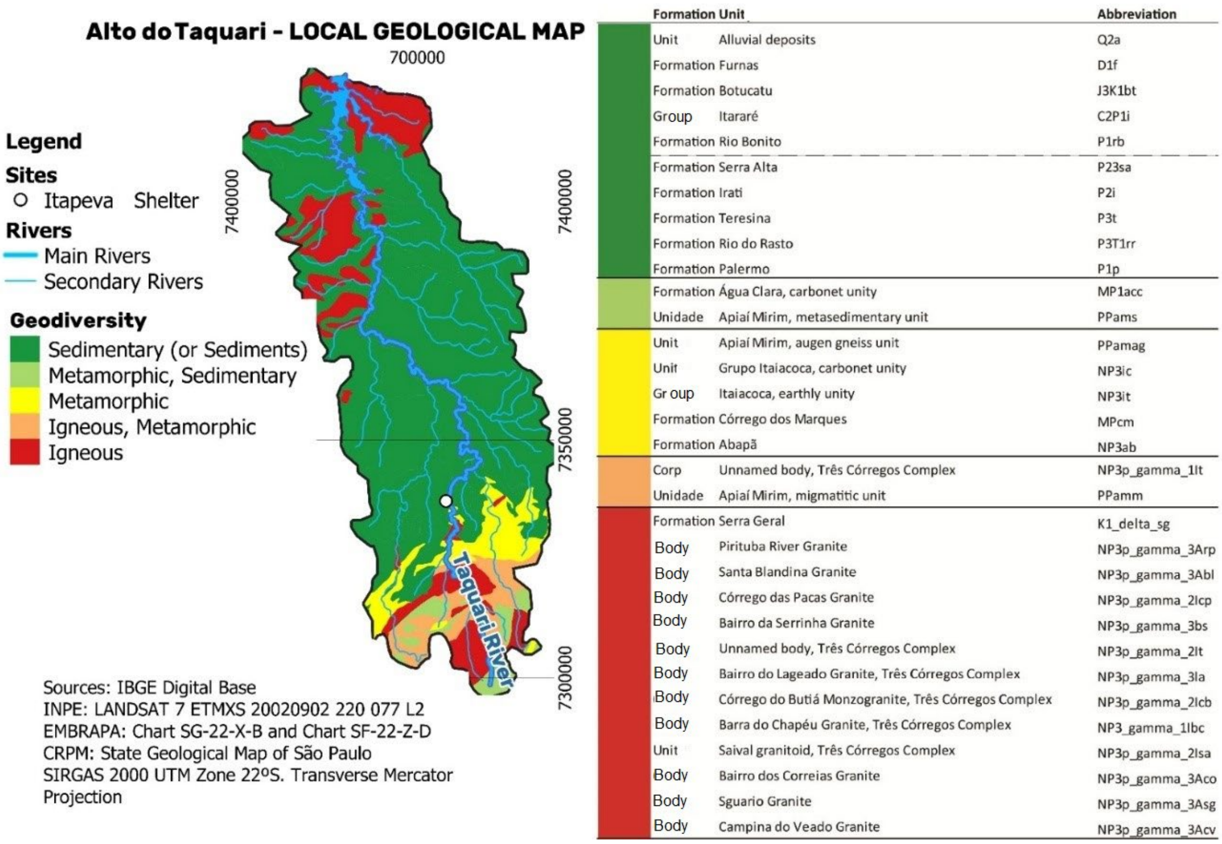
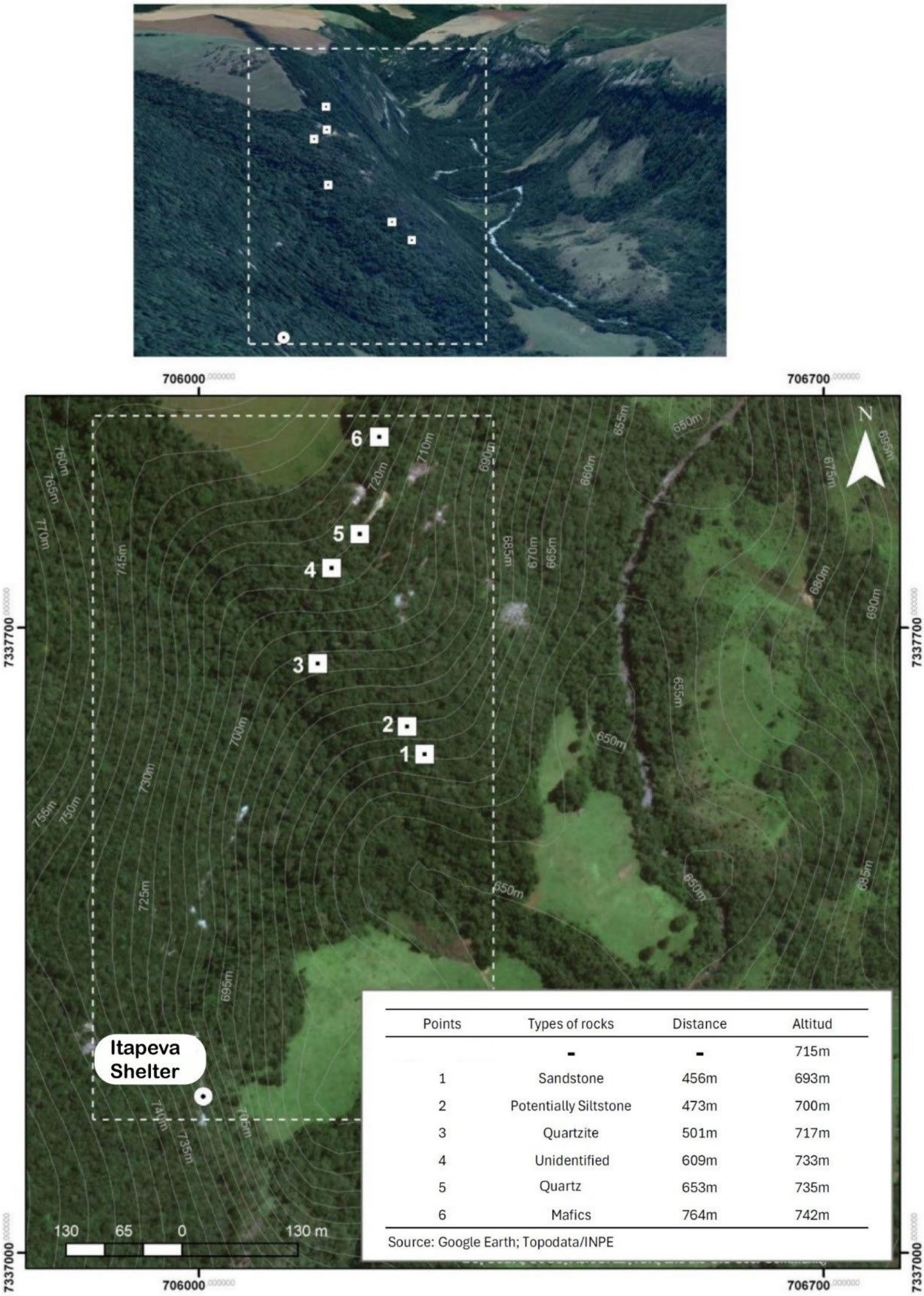


Figure 3. Geological map of the Itapeva region and surrounding areas.



Points	Types of rocks	Distance	Altitud
	-	-	715m
1	Sandstone	456m	693m
2	Potentially Siltstone	473m	700m
3	Quartzite	501m	717m
4	Unidentified	609m	733m
5	Quartz	653m	735m
6	Mafics	764m	742m

Source: Google Earth; Topodata/INPE

Figure 4. Areas prospected for collecting lithic material for experimentation.

The raw materials were classified according to their compaction, granulation, and homogeneity. These characteristics were selected because they are important to debitage performance and can be observed throughout the collection.

Attributes of raw material analysis

1. Compaction - Aggregation between grains, using a visual and tactile scale, ranging from very crumbly grains to total cement cohesion or characteristics that a rock can store in its interstices.
2. Granulation - Determines the size of the particles that make up a rock and which can be difficult to visualize, especially if the rock is chemically cemented. Therefore, the observation was made according to the level of porosity.
3. Homogeneity - Homogeneity can be characterized by the segregation of alternating and discontinuous crusts and veins, with varying color and thickness.

To test the hypothesis that through statistical treatment it is possible to find specific methods of lithic reduction in a collection with short sequences, it was necessary to correlate the raw materials and the reduction techniques used in the rocks. In this regard, the selected and described analysis attributes come from experimental knapping and laboratory observations of the collected lithic remains. A total of 11 technical attributes were listed and described according to the observation of this relationship.

1. Simple cortical flake - Expresses the presence of cortex on the surface, its positioning, and the size of the flake. It is noted that in many pieces there is no cortex, these flakes being very small.
2. Core preparation flake - Flakes derived from intermediate reduction phases were considered based on the knapped supports, the knapping methods, and the percussion techniques employed with the potential for the detachment of a flake that follows an action.
3. Artifact modeling flake - Classified as a flake that sculpts the lithic support, regardless of the size of the flake or artifact in the finishing phase.
4. Artifact retouch flake - Flakes that are generally very small, thin, with straight and curved shapes and have a knapping platform.
5. Fragmented flake in the proximal portion - Flake that has lost the knapping platform. As we did not carry out reassembly, care was taken to make sure it was not derived from the same flake.
6. Fragmented flake in the distal portion - Splinter with a preserved distal portion and identifiable stigmas that define it as a splinter, such as the shape of its termination, curvature, and percussion waves. As we did not carry out reassembly, care was taken to check whether it was derived from the same flake.
7. Indeterminate Fragment - Fragment that does not present evidence of human transformative action but is found within the archeological site and can serve as support, or that presents human transformative action derived from a production sequence and can serve as support both due to size and action to be developed that requires little transformation.
8. Transformed fragment - By retouch, which could be an artifact, abrasion marks or scratches.
9. Artifact or artifact fragment - Transformative action on the support that refers to a mental project carried out in the rock, regardless of the quantity and types of actions carried out.
10. Bipolar flake on anvil - Consists of quadrangular and rounded flakes with two knapping platforms where compression of the piece can be observed.
11. Nucleus or fragment of nucleus - A nucleus was defined as an object that has a percussion plane with negative features, it also involves descriptive characteristics according to the number of strokes, rotation, and profile.

In addition to the nominal categorization of the archeological material, 2,012 pieces were measured according to the variables of length, width, and thickness in their maximum dimension, regardless of whether they were broken or whole. These variables were useful not only for statistical treatment, but to show that these are very small pieces, originating from debitage practices. Table 3 shows the average length, width, and thickness and Figure 5 illustrates the size of the debitage of the silexite and quartz collection.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Standard deviation
length	2012	3	127	19.06	12.668
width	2012	2	139	16.41	9.785
thickness	2012	1	125	6.43	6.694
Valid N (list)	2012				

Table 3. Descriptive statistics of the measurements taken.

Clusters

The lithic sets for cluster analysis were formed based on the observation of the analysis attributes of the raw materials. The technical categories were inserted within these sets. Due to the large number of lithic sets formed according to the raw material, which totaled 47 sets, it was decided to create an optimal number of clusters, carrying out an analysis that considered the lowest variability obtained internally, using R software - version 3.5. 0 and R Studio - version 1.1.453.

The literature indicates that it would be more efficient to obtain results using hierarchical clustering methods, in which each item is considered as an individual group (Kaushik and Mathur 2014; Stanisopoulos and Rigby 2007; Steinbach *et al*. 2000). Merging these groups would produce a final optimal cluster number. Therefore, the Euclidean distance

Figure 5. Knapping analyzed in chert and quartz.

was used with the database evaluated at equal distances. This means evaluating each set of objects without considering that one attribute is more relevant than another (Linden 2009). For analysis, the "ward.D" method was used, as it seeks the minimum standard deviation between the data of each group and establishes the isolation between its internal and external components (Dutra *et al.* 2004).

T-test (Student)

The first statistical test of technological characterization carried out after the establishment of the raw material clusters was the observation between length, width, and thickness. The length, width, and thickness measurements of the samples showed little variability (Table 3), such that a trivial regression model proved to be inefficient in dealing with the problem, requiring an advanced regression model. Variations in width were considered that included heavy tails, and values that reached the minimum and maximum limits. Therefore, the analysis focused on how much the width of the parts in each cluster class contributes to the length and thickness, then the distance between the estimated clusters was calculated. To carry out this analysis, the mean values of each group, the difference, the confidence interval, and the p-value were calculated. Therefore, starting from a base of 19.06 mm, which is the mean observed for all parts in the estimated construction and proportionally, each millimeter of extra width and thickness contributes to 0.31 mm of length and 1 cm of width contributes to 3.1 cm of length.

Multidimensional scaling MDS-based diagram

The third statistical test carried out for technological distinction was applied with the interest of verifying whether there were knapping chains with sequential steps, since in the collection there seemed to be only one or a few knapping steps. Multidimensional Scaling (MDS) analysis was performed on the clusters based on the classification of technical attributes and measurements of length, width, and thickness of all parts (Table 2). MDS aims to produce maps similar to cluster data, based on distance matrices (Garcia 2015), which are created to find the set of coordinates that adequately represents the observed neighborhood with the best fit and appropriate value.

The analyzed artifacts

Formal and informal artifacts were analyzed. The aim was to verify whether the implemented technical action was compatible with the observed technical analysis attributes and to focus on the artifacts considered informal. Describing an artifact is not an easy task, it depends not only on the recognition skills of the techniques applied, but on guided questions. The questions addressed refer to the compatibility of techniques applied to formal artifacts and the residues found at the site in order to know whether they were made there and to observe the informal artifacts and infer their technical procedures.

Results

Frequency data from the lithic industry point to an even distribution among certain classes of flaking, such as simple cortical flakes, core preparation flakes, artifact modeling flakes, and artifact retouch flakes. A large part of the sample is made up of indeterminate fragments, which, depending on the size and shape, may mean that the raw material is being used as a support for the production of informal artifacts, with the other categories having a lower incidence, such that bipolar reduction, the production of formal artifacts and the presence of a nucleus is discrete. However, from the frequency distribution alone, shown in Table 4, it is not possible to know the factors that generate this behavior.

Class	Number of pieces	%
Simple cortical flake	548	16
Core preparation flake	643	20
Artifact modeling flake	359	12
Artifact retouch flake	509	16
Fragmented flake in the proximal portion	137	5
Fragmented flake in the distal portion	156	6
Indeterminate fragment	412	13
Fragment transformed by retouch, abrasion, or breakage	179	5
Artifact or fragmented artifact	158	5
Bipolar knapping on anvil	37	1
Core or core fragment	30	1
Total	3168	100

Table 4. Frequency of analysis classes.

Building Clusters

Figure 6 shows the formation of four clusters whose variability is low, such that more than four clusters would offer little advantage in discriminating the attributes listed. The dendrogram presents four groups clearly defined by rectangles according to the choice of the Ward D method and by the distance matrix according to the mean of the attributes (Table 5).

From this analysis it is concluded that most of the technical processes carried out are contained in clusters two and four because they contain the largest number of raw materials with attributes associated with each other. There is probably no technological analysis class with greater relevance in clusters one and three, as they contain the smallest number of parts with common characteristics.

Cluster two has almost all analysis classes and can only mean one large cluster, followed by cluster four with the same technical characteristics. Clusters one and three present characteristics from all analysis classes and are always in smaller proportions among the knapping categories. The fact that all analysis categories are contained in just two groups may mean that the quality of the raw material is not as relevant when choosing the reduction method.

Clustering

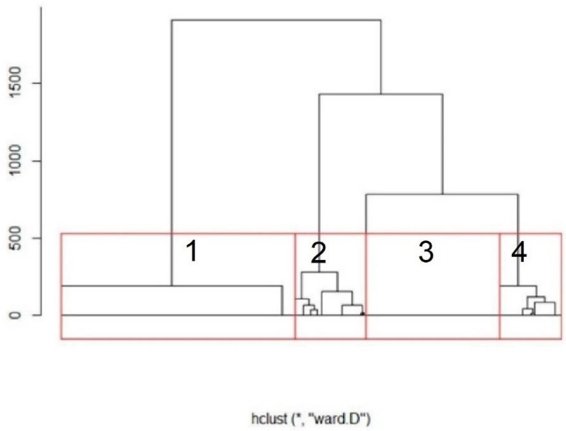


Figure 6. Dendrogram for the classification of rocks into four groups.

	1	2	3	4	5	6	7	8	9
2	1,0354131								
3	2,1279229	2,0890110							
4	1,1938581	1,3111032	1,1849997						
5	0,7934920	1,5204385	1,9232177	1,4161417					
6	1,7128957	1,5821256	0,6699620	0,6286076	1,7614108				
7	1,5763108	1,9067385	0,8989725	1,1241731	1,1364686	1,0746468			
8	0,9495333	1,6012145	1,7322219	1,3460346	0,2352037	1,6320248	0,9148517		
9	1,4313736	1,4403428	0,9642408	0,2648440	1,5786037	0,3757757	1,0885388	1,4789426	
10	0,5121354	0,9329692	2,0701925	0,9603034	1,2289036	1,5332192	1,7120533	1,3272929	1,2114041

Table 5. Cluster analysis matrix.

T-Test (Student)

The regression model verified whether there is a statistically significant difference between the clusters for the technical analytical classes, these being class 10 - Bipolar flakes on anvil, class 2 - Core preparation flakes, class 3 - Artifact modeling flakes, and class 4 - Artifact retouch flakes.

The bipolar flakes in cluster four show lower means in terms of length versus width, which could mean a reduction in small supports. All other analysis categories show that the length versus width relationship better isolates the categories that aim to extract flakes using a support with the characteristic of seeking a symmetrical relationship between length and width.

Otherwise, an important correlation was found in artifact modeling flakes, confirming thickness as a discriminating factor that may signify a different reduction method than industry flaking processes.

Length versus width proves to be the most relevant factor for bipolar flakes, core preparation flakes, and artifact retouch flakes, while width versus thickness is the most important variable for observing artifact modeling flakes. The effect of thickness is verified from the moment that length and width have no effect.

The results indicate that there are two confirmed knapping methods: bipolar knapping and core reduction as already seen in the descriptive/combinatorial analysis. The first method is isolated according to larger sizes. The core preparation flakes were able to be isolated in different clusters according to the positive size estimate, albeit with unequal distribution in the 4 clusters formed. Artifact modeling flakes cannot be isolated in all clusters according to the relationship between length and width, probably because this is not the discriminating factor for modeling flakes, thickness is. Then artifact retouch flakes are very close together and cannot be distinguished.

mm	Estimate	Standard error	t value	P value
Base length	19.06	0.36	35.37	<0.0001
Width	1.60	0.02	12.90	<0.0001
Cluster 1, Class 10	3.39	0.92	3.70	0.0002
Cluster1, Class 2	7.30	0.77	9.52	<0.0001
Cluster 1, Class 3	-1.14	0.77	-1.49	0.1375
Cluster 1, Class 4	-5.83	1.06	-5.52	<0.0001
Cluster 2, Class 10	-0.44	0.77	-0.57	0.5706
Cluster 2, Class 2	1.50	0.35	4.26	<0.0001
Cluster2, Class 3	0.35	0.35	1.00	0.3186
Cluster 2, Class 4	-4.59	0.24	-18.90	<0.0001
Cluster3, Class 10	2.76	0.88	3.15	0.0017
Cluster3, Class 2	5.74	0.52	11.04	<0.0001
Cluster3, Class 3	0.78	0.52	1.48	0.1385
Cluster3, Class 4	-4.64	0.60	-7.73	<0.0001
Cluster 4, Class 10	-2.09	0.45	-4.69	<0.0001
Cluster 4, Class 2	2.71	0.41	6.59	<0.0001
Cluster 4, Class 3	-0.66	0.40	-1.63	0.1017
Cluster 4, Class 4	-5.11	0.33	-15.36	<0.0001

Table 6. Estimates of base length, width and effects of thickness and flaking classes, material cluster, standard error, T-test value, and P-value of the regression model. The values in bold for p-value are the results with a significance level lower than 0.05%, stipulated for the normal distribution test that validates the hypothesis.

cMDS Analysis

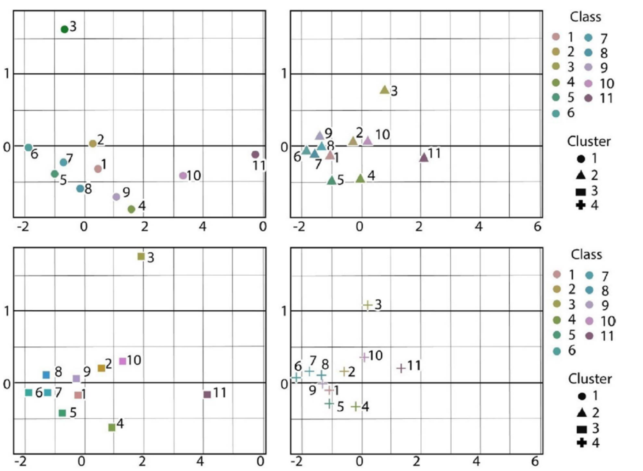


Figure 7. MDS – Projection in two-dimensional space of the multidimensional scale (cMDS) of the 11 classes of analysis.

As can be seen in Figure 7, in cluster one, the artifact modeling flakes are well isolated in the third band, confirming the hypothesis that this is a different knapping stage, while the core preparation flakes are isolated in the second band, which may mean that there is little continuity between successive knapping steps. Bipolar flakes and cores are isolated in the first band on the right, which may mean that a different reduction method is being used and that the cores are not necessarily related to the other flakes. The flakes with breaks in their distal portion are closer to the core preparation flakes, which may indicate knapping accidents, while the flakes with breaks in their proximal portion are closer to simple cortical flakes, which may indicate initial accidents in knapping. Indeterminate fragments, modified fragments, and artifacts show opposite behavior in relation to the other clusters, as they are larger and may be related to the type of support used. The retouch flakes are in the final range, immediately opposite the artifact modeling flakes, indicating that this action is not necessarily a different reduction method.

In cluster two, Figure 7, no technical analysis category is present in band three; however, artifact modeling flakes are isolated in band two in relation to the other analysis categories and artifact retouch flakes remain isolated in band one, in opposition, such that they cannot be confused. Bipolar flakes are closer to core preparation flakes. The nuclei are a little more isolated on the left, which may indicate that they do not participate in this circuit. In band one, simple cortical flakes, indeterminate fragments, modified fragments, and fragmented flakes in their distal portion are very close to artifacts, which may mean that a technical action to construct artifacts is associated with problems related to their own technical action or to raw material quality. Nevertheless, some patterns continue to be observed, such as the presence of artifact modeling flakes and artifact retouch flakes at opposite poles.

In cluster three, Figure 7, the artifact modeling flakes remain isolated in band three and in the opposite position to the artifact retouch flakes. Band two contains modified fragments and artifacts close to each other, which may mean the use of supports from these fragments to manufacture informal artifacts. Fragments and flakes with the distal portion fragmented belong to band one, but close to band two, which could mean knapping errors or that fragments from reduction steps are being manufactured. The cores are distant and allocated in band one, which may mean they are not linked to the identified reduction methods.

In cluster four, Figure 7, the artifact modeling flakes are isolated in the third band, close to the limit of band two, which may mean a certain correlation with other knapping methods. This cluster presents grouped categories, composed of fragmented flakes in the distal portions, indeterminate fragments, and modified fragments, which may mean that this type of material is used for the manufacture of informal artifacts. The formal artifacts are on the boundary between bands two and one, while the core preparation flakes are more centered in band two and distant from the bipolar flakes, which may indicate that different reduction methods are manufactured with the same type of material. The cores appear in this range a short distance from the other analysis categories for the first time, which may indicate correlations between these cores and the knapping methods carried out at the site. Band one contains simple cortical flakes, close to band two and the cluster of fragments, which may mean that these flakes can also be used as support for the manufacture of informal artifacts. This cluster is different from the others because although some distance patterns continue to recur, such as slivers of artifact modeling as opposed to slivers of artifact retouch, almost all analysis classes are contained in band two, including cores, such that several reduction steps may be running from one core.

Formal artifacts - Artifact 1

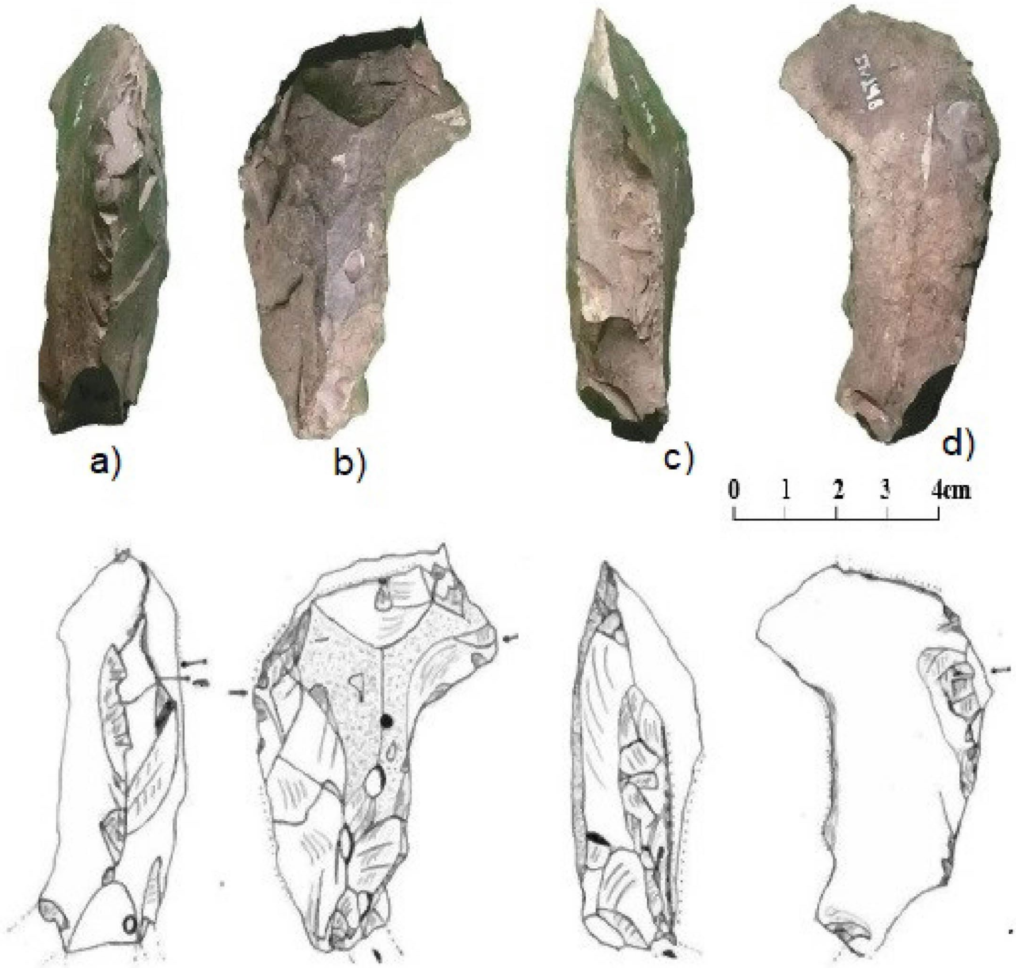


Figure 8. Technical analysis of formal artifact 1.

This artifact is 8 cm long according to the morphological axis; 3.5 cm wide on the central axis; and 2.5 cm thick, also measured from the central axis. The angles are 100° at the distal end and 50° at the proximal end. In the image it can be seen that it is a thick cortical splinter removed with hard percussion. In image b, the artifact is in a dorsal position and the fundamental aspect is its structuring in stages. There are a series of small, sequenced, rectilinear (short) withdrawals that slim the piece down and create conditions for the production of an edge. On the right bank there is execution with hard percussion, removing a large portion of the cortex. On the back there are a series of small marginal touches, irregular in shape, in a regular sequence, followed by overlapping marks or signs of use that show marked wear. There is also a removal that completely transforms the curvature of the piece. It does not appear to have been struck with a hard instrument, but a light instrument, given the precise characteristics caused by the blow. Above this removal there are staggered touches. An edge is formed caused by a series of orderly but non-standardized withdrawals. The removals follow rectangular aspects, and it is not noticeable that there is the principle of alternation in search of bifaciality. In the image, the removal of retouched flakes is present in the area close to the knapping platform, on the local internal face, where very thin removals, without curvature and without percussion waves are highlighted. Image c displays a series of signs of use caused by back-and-forth movement, which may indicate rubbing. There is the presence of a small quadrangular bead, probably made to perform this act with precision. It can be seen that the blow is applied once and extends up to two thirds of the total area of the artifact. In image d, below this area, a series of sequential, but not straight, touches are applied, forming alternations and staggering capable of creating a robust work surface area on which, after the series of touches, there are signs of use. that wear away the surface, as already mentioned for other sectors of the artifact.

Artifact 2

Artifact 2 is produced on a 7.5 cm thick flake, from the morphological axis to the distal end, which is 5 cm wide on the mesial axis and 2.5 cm thick on the mesial axis. The angles are reported as 90 degrees at the distal end, 80° in the center of the left portion, 110° in the center of the right portion, and 110° at the proximal end. There is no cortical reserve in the piece, with quadratic flakes arising from removals with few scars on the external surface. In image a, the series of retouches is concentrated only on the edge of the artifact, with concave retouches, parallel in orientation, in a continuous, irregular sequence,

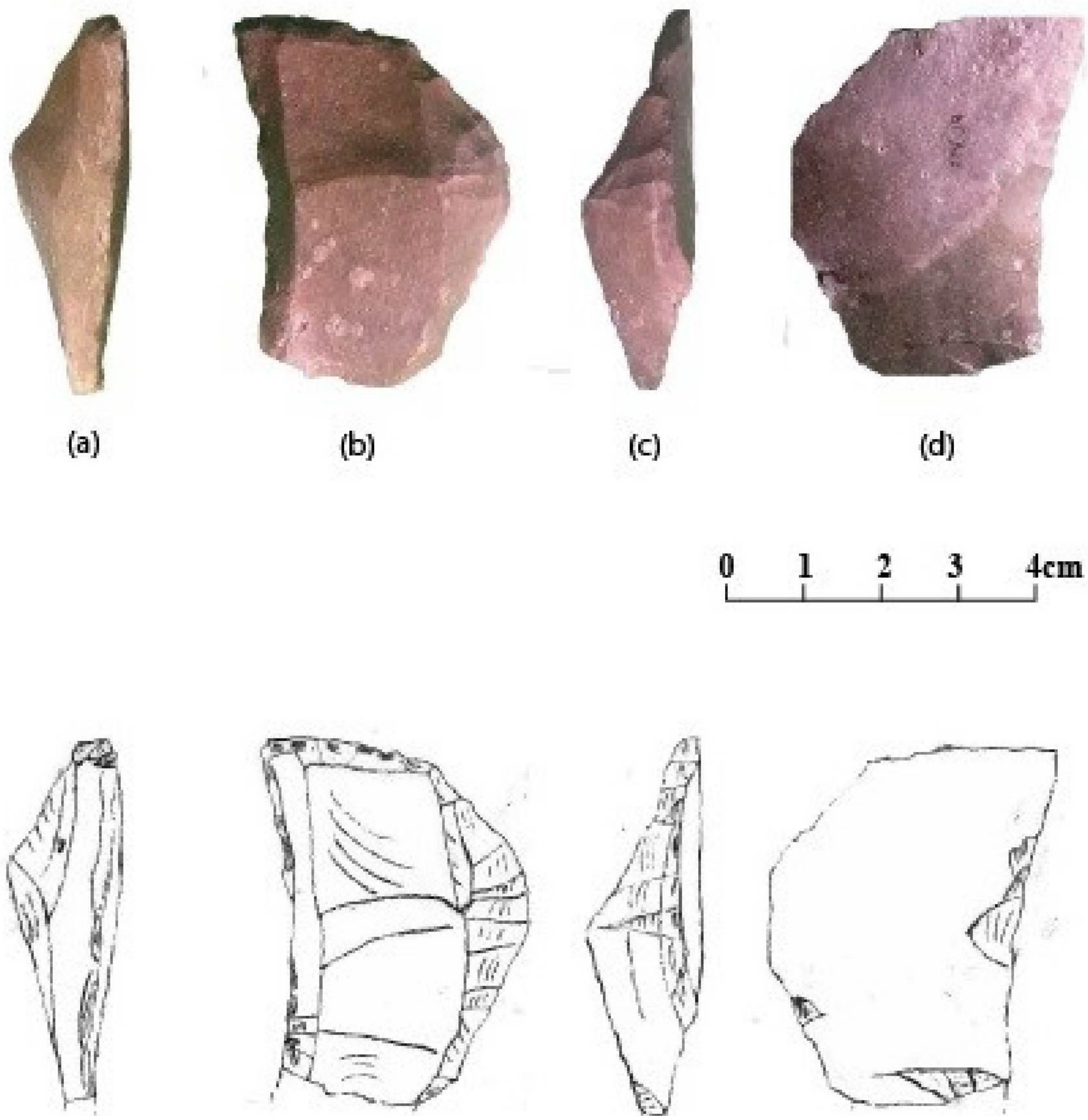


Figure 9. Technical analysis of formal artifact 2.

measuring an average of 0.1 cm. The proximal end of the piece is broken, while at the distal end there are important secondary modifications, with an average of 0.6 cm removed, in a parallel, continuous, straight section. Secondary modifications occur close to the distal proximity, in which there is a longitudinal withdrawal from the lateral edge, with the intention of thinning the piece, causing concavity. Image c shows longitudinal, sequential, continuous, proportional removals, according to size and width, measuring 1.4 cm on average and providing an important transformative prehensile area for retouch sequences. After the transformative aspects, there are a series of signs of use, causing some of the touches to be revived or worn away, losing their initial morphological characterization. The third step of action on the artifact is a series of wear caused by use and, consequently, modification of the morphology outlined by the applied touches.

Discussion

Archeological studies of lithic industries in lower, middle, and upper Paranapanema follow varied methodologies, whereby collections are still described through a very basic means of data compilation. According to the fact that these studies must be aligned with artifactual studies from northeastern Paraná and Argentina, attention must be paid to the lithic production and dispersion of the Tupiguarani and Jê groups. However, an entire expressive lithic artifactual set that is not affiliated with any ethnic group should also be considered, which is what we deal with in this work.

Using the frequency data of the technical attributes of knapping, it was possible to identify which reduction steps are present and which are in a large quantity of fragments. However, to identify reduction patterns and reduction methods, frequency analyses are insufficient, and it is not possible to know the factors that generate this behavior.

Therefore, a more refined statistical analysis with specific objectives was implemented. The generation of raw material clusters aimed to standardize the analysis data as observed throughout the industry. From this, the other statistical tests worked within the cluster distance matrix, and it was thus possible to verify how the raw material organized the knapping distributed in each cluster.

The determination that there were two predominant clusters generated the hypothesis that there were two types of combinations of raw material attributes that comprised most of the knapping carried out, providing an initial outline of which technical categories would be contained in them.

Student's T-Test had the great importance of isolating the thickness of the pieces and discovering that a different method of core reduction was being carried out.

In the cMDS analysis, the four observed clusters present both similar and different characteristics that confirmed the presence of nucleus reduction in some clusters, while also identifying an important characteristic, in that in some clusters there is no relationship between knapping and nuclei, based on the principle that the cores found at the site are not those from which the collected flakes are being extracted. Another important observation is that this test isolated the artifact modeling flakes, confirming a different knapping method, as identified in Student's T-Test. Another important observation is regarding indeterminate fragments, modified fragments, and artifacts that are always related, which corroborates the hypothesis that fragments can be used as support.

Finally, when we relate the technical characteristics observed in the knapping with the analysis of formal and informal artifacts, some important information can be detected. The first is that in formal artifacts there are measurements corresponding to the length found in industry, and technical actions are seen that are consistent with the waste found. This is mainly in terms of a series of small, sequenced, rectilinear (short) withdrawals that slim the piece down. Another important piece of information is that there appears to be the use of light percussion, which may be related to the artifact modeling flakes identified in Student's T-test. It is observed that the artifact retouch flakes are irregular, which is compatible in terms of shape, but incompatible in terms of length, width, and thickness, which may mean that the retouch flakes found do not necessarily come from this type of artifact.

Conclusion

Much archeological work with different biases has been developed over the decades on the border of the Paranapanema River, between São Paulo and Paraná (Araújo 2001; Chmyz *et al.* 2008; Loponte and Acosta 2003–2005; Morais 1999-2000; Noelli 2008). The Itapeva Shelter necessarily dialogues with these studies that discuss how the Paraná River basin was occupied by human groups in pre-colonial times.

These migratory discussions are reflected in discussions on the manufacture of lithic artifacts. In Brazil, the idea was created that from 9000/8000 BP onwards, a transformation occurred in the technological pattern of production, culminating in a process of apparent technical simplification in the middle and recent Holocene and that this decline in technical applications would be derived from a distant past. Therefore, it is believed that the lithic industries of the middle and recent Holocene have short and poorly elaborated operational sequences.

To demystify this hypothesis, over the last few years, several researchers have been focusing on the lithic industries of the middle and recent Holocene and studying their technical processes. Rocks are the main indicators of human influence when thinking about maintaining the territory and searching for the extraction zones of the populations that handled them. The way in which they are present at the archeological site, in contrast to the debitage characteristics, is what enables reflections regarding archeological remains and in this sense, we think in an integrated way in operational production chains, making formal and informal artifacts.

Therefore, it is concluded that the lithic industry at the Itapeva Shelter cannot be considered expedient or that it presents characteristics of technical simplification of short and poorly elaborated operational sequences. Statistical analyses carried out from frequency distribution to more sophisticated analyses were able to demonstrate that different techniques were applied, that different reduction steps are present, that different reduction methods are present, and that it is possible to connect an operational sequence into artifactual sets that appear short and disorganized.

Furthermore, a hypothesis arising from this study points out that human groups inserted in the middle and recent Holocene may present a new form of technological organization of lithic artefactual repertoires based on interethnic contacts, previous technical memory, and technical innovations based on a new social configuration rather than on a sharp division between hunter-gatherer groups and potters.

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