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EDITORIAL

Welcome to *Lithics* 35. We hope that you will read it with interest!

This year has been one of change for *Lithics*. As the journal's new editor, I begin by giving our warmest thanks, on behalf of the Lithics Studies Society, to Beccy and Andy Shaw, who for a great many years were the steadfast stewards of, and driving force behind, *Lithics*. I also welcome Lynden Cooper, the new assistant editor, to the editorial staff.

I am pleased to say that our inaugural issue is full of fascinating articles that span the globe. First, Riris and Romanowska take us to Argentina, where they explore the reduction of curved cleavers and raise some interesting new questions about their manufacture. Serwatka also piques our interest with a study of shape variation among central European Late Middle Palaeolithic bifacial tools focusing specifically on southern Poland. Davis highlights the importance of often-underused archival material for understanding and interpreting Pleistocene archaeological sites with his paper on the geological context of a handaxe assemblage from southern England. Harding provides his account of replicating the Neolithic axe haft from Shulishader, Lewis, UK and some of the experiences gained. Finally, Beresford gives us a preliminary report on some Palaeolithic sites from the Upper Ravensbourne area in Bromley.

This year, we mourn the unexpected passing of Ron Waite—who was instrumental to the Midlands community of prehistoric archaeologists. The two letters from friends and colleagues printed in this issue, one by Alan Saville and Anne Graf and the other by Terry Hardaker, attest to the large hole that he leaves behind. We thank them all for their touching and warm homages and offer his loved ones our condolences.

The quality of these articles is in no small part due to the peer reviewers who edited and commented on manuscripts. Their anonymous help is the quality control of scholarly discourse that keeps our discipline grounded.

The world of publishing is, for better or worse, changing and we are no exception. *Lithics* has in recent years been moving ever so slowly towards augmenting its online presence and as a result, supplementary data, colour copies of the articles and PDF copies of recent issues are now available within the members' area of the Lithic Studies Society website. We here at *Lithics* are constantly thinking about how we can improve the distribution and quality of our publication and we welcome any thoughts or suggestions by email to lithicseditor@gmail.com.

From now on, *Lithics* will only accept submissions by electronic copy. Updated notes for contributors and a cover form for submission are available on the website. Please use these! The submission deadline for *Lithics* 36 is June 27th, 2015 and submissions from all members and non-members alike are very welcome.

We hope you enjoy reading *Lithics* 35.

Wei Chu

Cover. A scanning electron microscope photograph of Brandon flint. (Photograph © Wei Chu.)

A RECONSTRUCTED REDUCTION SEQUENCE FOR CURVED BIFACIAL STONE TOOLS FROM THE EASTERN LA PLATA BASIN, ARGENTINA

P. Riris[1] & I. Romanowska[1]

ABSTRACT

A distinctive regional lithic industry is found in the eastern La Plata basin, known as the Altoparanaense culture in northeastern Argentina, and the Humaitá tradition in southern Brazil. These archaeological cultures are recognised on the basis of large bifacial tools. The earliest deposits are dated to the ninth millennium BP, and elements of these industries continue to be produced into the post-contact period (8640±95 to 310±50 cal BP). One of the most characteristic features of the assemblages in the region is the presence of a particular class of bifacial tool known as "curved cleavers", whose name stems from their distinctive asymmetrical shape. We describe the reduction sequence of these tools based on a spatially extensive sample from Misiones province, Argentina. This study provides for the first time a full chaîne opératoire *for curved cleavers and compares it to the findings of the only published experimental study. We use a logistic regression model to verify the reconstructed five-stage reduction sequence and further support it with a metric analysis of artefact attributes within each identified stage of reduction. Our results support the conclusion that many bifacially reduced artefacts encountered in the larger study region may actually be unrecognised pre-forms of curved cleavers.*

Full reference: Riris, P. & Romanowska, I. 2014. A reconstructed reduction sequence for curved bifacial stone tools from the eastern La Plata basin, Argentina. *Lithics: the Journal of the Lithic Studies Society* 35: 5–17.

Keywords: Argentina, curved cleavers, *chaîne opératoire,* regression analysis, bifacial reduction

INTRODUCTION

In this paper we identify and describe the reduction sequence of a class of lithic artefacts commonly encountered in the material record of Misiones province, Argentina and the bordering southern Brazilian states of Santa Catarina, Paraná and Rio Grande do Sul. The artefacts in question are referred to typologically as curved "cleavers", or "boomerangoids" (Menghin 1955/56; Schmitz 1984 & 1987; Prous 1992), owing to their distinctive curvaceous shape (Fig. 2)[*]. On the basis of ethnographic parallels, the function of these bifacial artefacts has been interpreted in Misiones as digging or foraging implements (Nami 2006: 141).

Typological classification has been the dominant methodology for the analysis of stone tool technology in the region for much of the history of archaeological research (Laming-Emperaire 1967; Barreto 1998: 575; Noelli 2005), and curved cleavers have been used as a fossil index of the Humaitá tradition. Additionally, the date range cited for assemblages containing curved cleavers extends over nine millennia, implying a great continuity of their production over a vast region and immense time span. This suggests that there was either a high degree of conservatism in lithic tradition on a tremendous spatial and temporal scale (see Dias 2012; Okamura & Araujo 2014) or that the spatially or temporally sensitive properties of the curved cleavers, e.g. their regional diversity, have yet to be fully characterised (Barreto 1998: 579). This paper is a step in that direction as it focuses on a spatially secure sample of these artefacts collected in western Misiones province in the upper Paraná valley, near the town of Eldorado. Unfortunately, coming from non-stratified contexts, the collected assemblages can shed no light on the variability of curved cleavers over time.

HISTORY OF RESEARCH ON CURVED CLEAVERS

Curved cleavers were first classified by Menghin (1955/56), and were ascribed to a "Palaeolithic" occupation of the territory of Misiones he named the *Altoparanaense* culture. This cultural division was based on the presence of curved cleavers—large bifacial lithic artefacts also recognised in assemblages in Paraguay (Menghin 1955/56: 181). In Menghin's framework, the appearance of the Altoparanaense represented the migration of the first South Americans into the region (Menghin 1957). In the decades following this initial description, archaeological investigators working in Rio Grande do Sul assigned curved cleavers to the pre-ceramic *Humaitá* tradition

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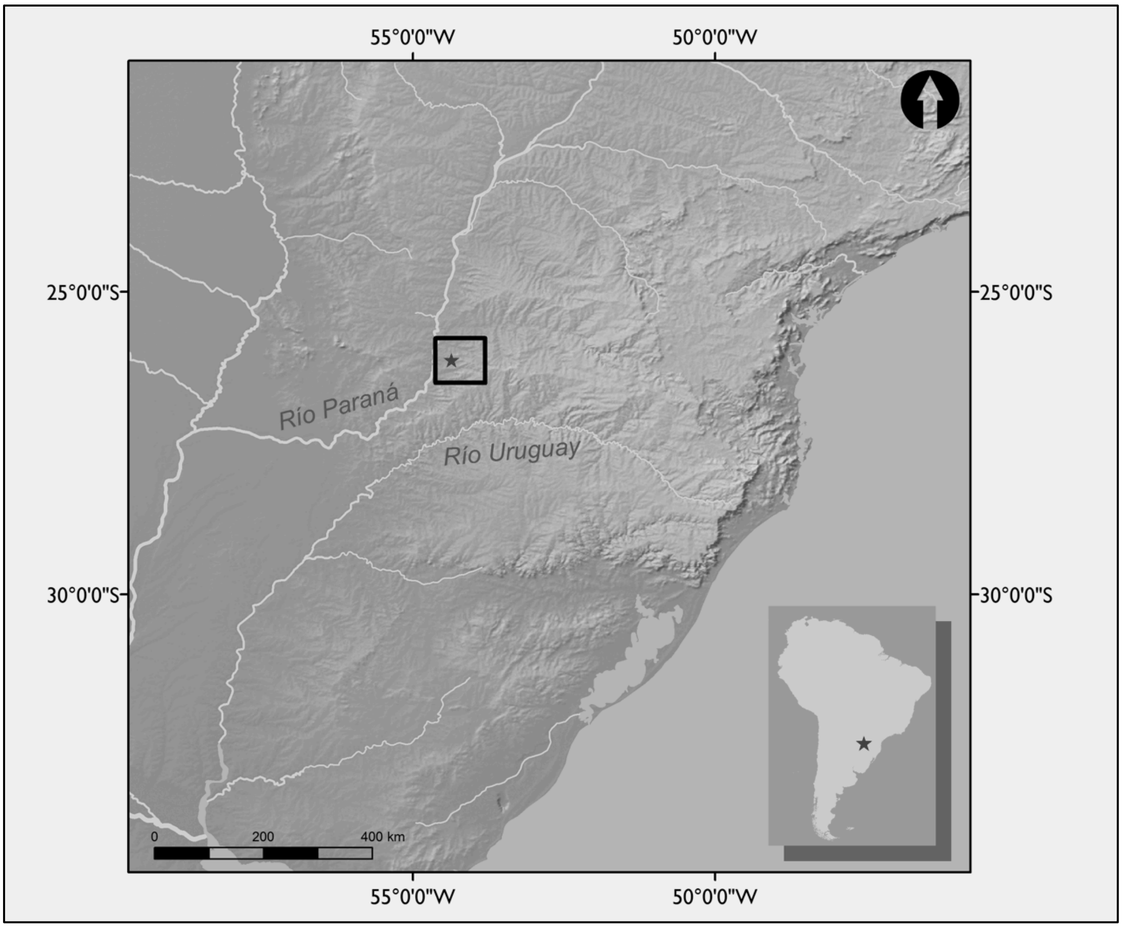

Figure 1. Location of Eldorado (star) and the Piray Mini and Piray Guazú valleys in southeastern South America

(Miller 1969a; Schmitz 1987). The expansion of coverage by later research across the southern states of Brazil showed that the artefacts recognised as curved cleavers and curved cleaver preforms are ubiquitous in the material record of the region (Miller 1969b; Brochado 1971; De Masi & Artusi 1985; Kern 1991; Hoeltz 2005). In disagreement with Menghin's original chronology, the groups that produced this particular tool type were found to post-date the first peopling of the continent (Schmitz 1987). The provenance of the cleavers was formerly thought to be small, highly mobile bands of hunter-gatherers adapted to forested environments (Schmitz 1987). This way of life, characterised by the lack of ceramic technology or cultivation, was thought to persist almost to the present (Kern 1981).

However, recent overviews of the lithic industries of southern Brazil have questioned the integrity of the received chronological and typological frameworks derived from the earliest archaeological research in the region (Hilbert 1994; Dias 2003; Dias & Hoeltz 2010; Hoeltz 2010). This critique notwithstanding, the majority of researchers assume that the Humaitá Tradition and Altoparanaense culture are effectively synonymous terms for related pre-ceramic cultures which existed over a broad time period (9th millennium BP to the contact period) within the southern Brazilian highlands including parts of Argentina and Paraguay. The earliest available radiometric date for a Humaitá assemblage is 8640±95 cal BP at site SC-U-6 in the upper Uruguay river, while the latest dates are in the mid-seventeenth century at site RS-RP-81 (Dias & Hoeltz 2010: 44). The extremely broad temporal range implies their production by both pre-ceramic groups and later ceramic-producing cultures (perhaps the Taquara/Itararé or Tupiguaraní traditions) (Hoeltz 2007: 210; Dias & Hoeltz 2010).

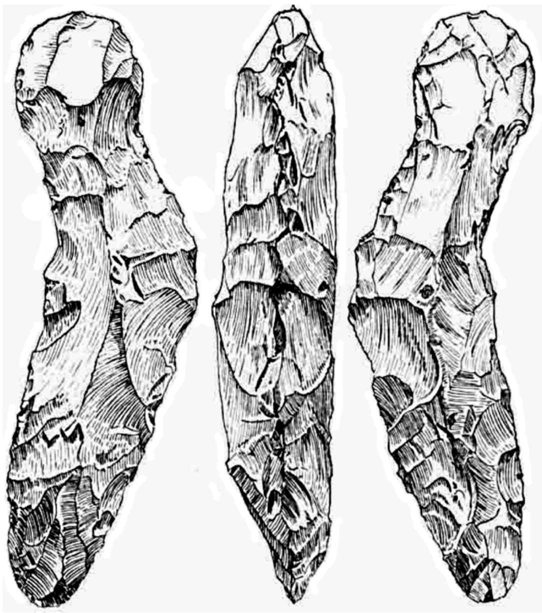

Figure 2. Curved cleaver from Yaguarazapá, Paraguay (after Menghin 1955/56)

Although the tool morphology is well recognised, a review of the literature that includes curved cleavers (e.g. Menghin 1955/56; Miller 1969b; Brochado 1971; Kern 1981; Schmitz 1984; De Masi & Artusi 1985; Schmitz 1987; Kern 1991; Hoeltz 2005) reveals a significant amount of variability in size, curvature, and overall elaboration of the tools. The large spatial and temporal range of this particular type of stone tool, as well as its association with more than a single cultural group, indicates that some of the culturally imposed variability in the shape, size and technology of curved cleavers might have not been recognised (see Dias 2003). No complete reconstruction of the curved cleaver reduction sequence based on archaeological material has been performed so far. What is the relationship between the initial blank size and subsequent stages of reduction? Is the curvature imposed during production or, as suggested elsewhere (Hoeltz 2007: 232), due to the selection of naturally curved nodules? Which attributes can be employed to distinguish curved cleaver blanks from those of other bifacial artefacts? The aim of this study is to fill some of those gaps in our understanding of the curved cleavers production process. To achieve this, we fully characterise the reduction sequence of curved cleavers from a specific region of Misiones province, Argentina, as well as compare it with an experimental study on this tool type. Apart from answering some of the aforementioned questions this should help to establish a point of reference for further comparisons with other regions, therefore providing a baseline for assessing potential variability of curved cleavers through their apparently wide spatial and temporal range.

The only technological study of curved cleavers was performed by Nami (2006), who tried to experimentally reproduce curved cleavers and identify distinctive stages of their *chaîne opératoire*. His proposed five stages of reduction (Table 1) are based on the morphological attributes of each stage, from the blank to the completed tool.

Nami (2006: 150) highlighted a lack of information on the initial stages of reduction but recognised that a blank could be obtained both by removal of flakes from a tabular core or a selection of an appropriately sized nodule of raw material (Nami 2006: 143−144). In his study, the blank was roughly worked to regularise the shape and prepare it for further work. This was followed by the main stage of the sequence, the bifacial flaking of the piece aimed at obtaining an elongated symmetrical shape. Only after this stage is the distinctive curve imposed on the tool, followed by careful regularisation of the edges by pressure flaking. Nami's experimental study provides an informed conceptual yardstick for assessing the morphology of curved cleavers; however, it does reflect the choices taken by a modern-day knapper. It is therefore informed by our knowledge of the *chaîne opératoire* of better-understood bifacial tools that are mostly unrelated to curved cleavers (e.g. Acheulean handaxes). As such, it is in need of being checked against archaeological examples. Nami notes that his experimental work was aimed to provide researchers with a framework against which to compare archaeological assemblages. Here, it serves as a benchmark for the reduction sequence as reconstructed from archaeological examples of cleavers.

ARCHAEOLOGICAL MATERIAL AND ANALYSIS

Sample creation

The dataset used in this study has been derived from three primary sources. The majority of the specimens were obtained in June−July 2013 through systematic field walking survey in Misiones province as part of the Piray Mini River Exploration Project (Fig. 1). Second, we sampled an assemblage from the upper Piray Guazú river valley, which was surface collected by a University of Exeter project in 2010 and which remained in storage in Eldorado. Finally, we extended the sample with pieces from the collection of Ulf Moensted held in the *Casa del Fundador y Museo Municipal* in Eldorado, Misiones that were made available to us. From these three sources of material, we chose all artefacts showing signs of bifacial knapping. The total combined dataset (*n* = 66) represents all the stages of reduction of the curved cleavers, which allowed us to follow a traditional *chaîne opératoire* methodology (Inizan *et al.* 1999; Martinón-Torres 2002).

Method

We undertook qualitative and quantitative analysis of the sample (*n* = 66). The qualitative analysis consisted of a visual assessment of the artefacts and identification of the variability within the assemblage as well as changes in reduction strategy from tested cobbles to fully shaped and retouched pieces. For the quantitative analysis, a total of nine attributes were recorded on each artefact. In order to understand the range of variability in artefact size throughout the reduction sequence, we recorded the length, width and thickness in millimetres as well as weight in grams. Second, in order to derive a measure of the intensity of reduction at each stage, the amount of cortex on each side was recorded in a five-point nominal scale. Finally, the number of removals on each face was counted in order to reconstruct the order and intensity of reduction.

We also sought to test the predictions of the five-stage reduction sequence suggested by Nami (2006) and therefore compared his stages with the ones identified in this study. Additionally, we wanted to understand how and at what stage the distinctive asymmetrical outline, which gives the “curved” cleavers their name, was imposed on the artefacts. Thus, we recorded the symmetry in dorsal-ventral and left-right planes of the artefact as two Boolean variables.

RESULTS

Qualitative analysis of the *chaîne opératoire*

We identified five stages of reduction in the sample assemblage. This was achieved by observing the variability in cleaver morphology and establishing an ordinal ranking based on the amount of percussion and working on the pieces (Fig. 6).

Table 1. Summary of Nami’s (2006) stages for curved cleavers

#	Stage	Description
1	Obtaining the blank	Large flakes or tabular nodules used as blanks.
2	Initial edging	No platform preparation; flakes often cover less than half of the width of the artefact; sinusoid, irregular edge.
3	Bifacial flaking	The piece is shaped into an elongated oval form; irregular pattern of flake removals; bi-convex, rectangular and triangular cross-sections.
4	Initial shaping	Careful bifacial flaking into roughly the correct shape.
5	Final shaping	Regularising the edges by pressure flaking. Cross-section is rhomboidal.

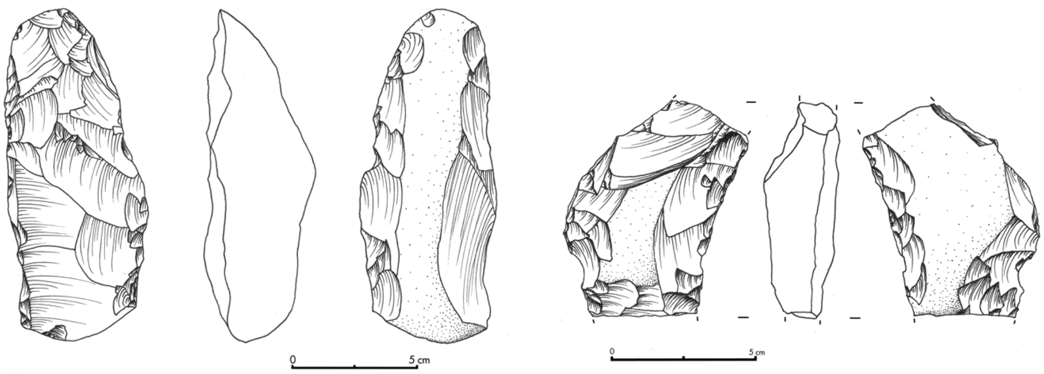

Figure 3. Examples of front-back asymmetry in a Stage 2 cleaver (left) and left-right asymmetry in a broken Stage 5 cleaver (right) from the sample assemblage

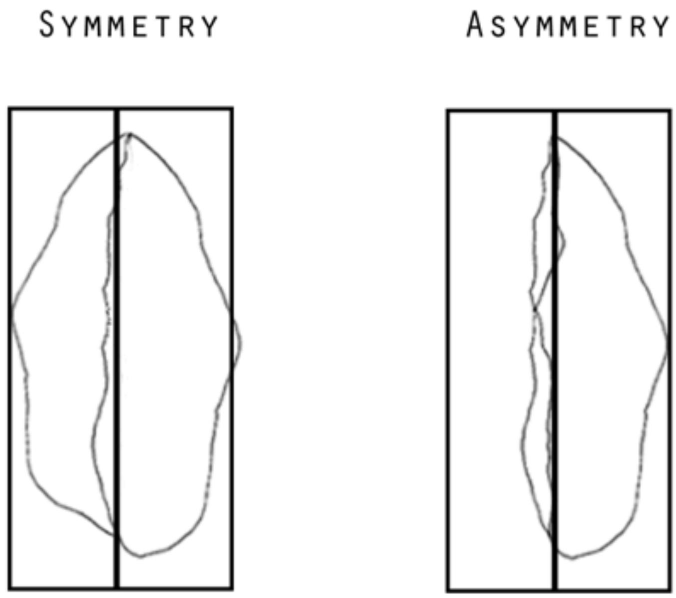

Figure 4. Method for assessing the dorsal-ventral symmetry of artefacts

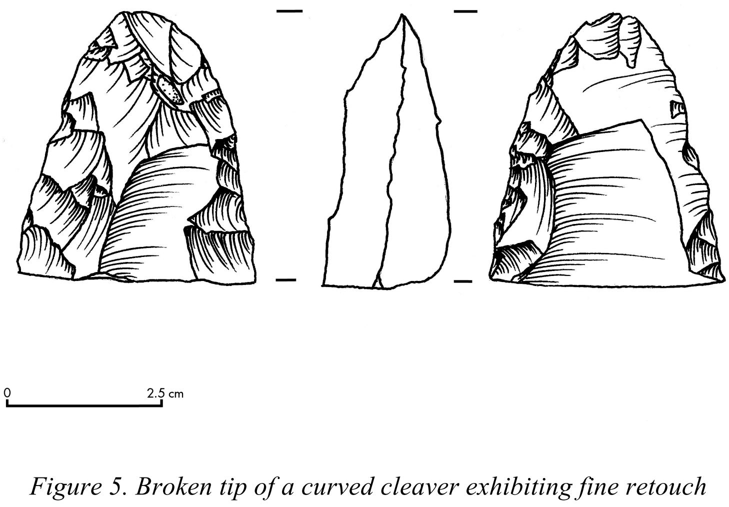

Figure 5. Broken tip of a curved cleaver exhibiting fine retouch

1. *Obtaining the blank*

   Two methods of obtaining the blank were recognised. Both classes of blank appear plano-convex.

   - 1a, in which a large flake is removed from an edge of a tabular nodule. The resulting blank has a flat surface (the ventral face of the flake) and a domed face (the edge of the original nodule) covered in cortex.
   - 1b, in which an elongated nodule had one of its faces reduced to create a flat surface, an equivalent of the ventral face in step 1a. The removals are usually broad and shallow, similar to thinning removals commonly observed in Middle Palaeolithic handaxes. The dorsal face remains cortical.

2. *Cortex removal on the domed face*

   The second stage consists of a series of detachments that remove the cortex on the domed face but maintain the dorsal-ventral asymmetry observed in the blank. These removals are usually deeper and shorter than the ones used to obtain the flat face in step 1b.

3. *Imposing dorsal-ventral symmetry*

   In the following stage, more reduction on each side is aimed at reducing the dorsal-ventral asymmetry and regularising the thickness of the piece. This stage of pre-form usually preserves small patches of cortex. A number of artefacts in the sample assigned to this stage had a triangular profile, which might have led knappers to abandon them, as suggested by Nami (2006).

4. *Shaping and regularising the rough-out*

   In stage four, the pre-form acquires its distinctive curved shape i.e. left-right asymmetry. The cross section is usually rhomboidal, and the distal end of a tool is more intensively worked.

5. *Finished product*

   Stage 5 tools have little cortex on both faces, and many display a pronounced left-right asymmetry. Most of the Stage 5 tools in our sample were broken at approximately one third of the total length of the piece (Fig. 5).

Quantitative analysis of reduction sequence

To validate this qualitative assessment, a logistic regression model was used to investigate the relationship between all of the recorded variables and the identified stages of reduction. In our case, we used logistic regression to assess the relationship between an independent variable, here the stage of reduction identified through the *chaîne opératoire*, and the dependent variables listed in Table 2. We emphasise that this quantitative analysis seeks to *verify* the stages identified through the qualitative analysis, which could be biased by the analysts' skills and previous experience. The results showed that all the dependent variables were highly significant demonstrating that each attribute has predictive power, and can explain up to 42% of variance in the sample. Furthermore, the results were assessed using a one-way analysis of variance (ANOVA), which confirmed a highly significant effect of all of the recorded variables on the affiliation between each artefact and a given reduction stage (Table 3).

Table 2. The results of the Logistic Regression Analysis performed on each dependent variable

Variable	*F-value*	*p-score (significance level)*	*R^2*
Cortex on the flat face	7.412	0.00834 **	0.1038
Cortex on the domed face	46.61	$3.74e^{-09}$ ***	0.4214
Symmetry: left-right	20.69	$2.46e^{-05}$ ***	0.2443
Symmetry: dorsal-ventral	39.12	$3.71e^{-08}$ ***	0.3793
Absolute difference between number of removals	28.12	$1.51e^{-06}$ ***	0.3053

Table 3. ANOVA results

Variable	$F_{1,60}$	*p-score (significance level)*
Cortex on the flat face	23.060	$1.09e^{-05}$***
Cortex on the domed face	79.913	$1.25e^{-12}$***
Symmetry: left-right	20.157	$3.30e^{-05}$***
Symmetry: front-back	32.200	$4.26e^{-07}$***
Difference in the number of removals on each face	6.853	0.0112*

Table 4. The results of the multiple regression analysis. R^2: 0.73 $F_{5,60}$= 32.44 p = $7.32e^{-16}$

Variable	*p-score (significance level)*
Cortex on the flat face	0.0345*
Cortex on the domed face	$1.41e^{-07}$***
Symmetry: left-right	0.0977
Symmetry: front-back	$1.37e^{-05}$***
Difference in the number of removals on each face	0.0112*

Finally, to investigate the possibility of covariance between dependent variables confounding the results of the logistic regression; a multiple regression model (termed the Full Model) was used (Table 4). The overall result of the Full Model was highly significant ($F_{5,60}$ = 32.44, p = $7.32e^{-16}$) with an R^2 value of 73%. The multiple regression model has also allowed us to recognise which, if any, of the variables have the highest predictive power that enables the attribution of an artefact to a given reduction stage. Here, we will discuss each of the recorded variables in light of the qualitative analysis. The Full Model indicated that the amount of cortex on the domed face and the dorsal-ventral symmetry are the best predictors for the reduction stage, which is consistent with our qualitative interpretation of the *chaîne opératoire*.

The amount of cortex on the domed face was more significant as a predictor for a given stage of reduction than the cortex on the flat face, which is not surprising as the latter is strongly related to the choice of blank rather than to the intensity of reduction. While Stage 2 and Stage 3 focus predominantly on removing the cortex from the domed face, the amount of cortex on this plane is a better indicator of the stage of the reduction sequence.

Further, the high significance of dorsal-ventral asymmetry is not surprising given that the early stages show a significant front-back asymmetry, which decreases as the piece is thinned in Stage 3. On the other hand, left-right asymmetry (i.e. the curve) is imposed only in the very late stages and is, therefore, virtually absent throughout most of the sequence and is therefore a worse predictor.

As would be expected, as a piece is gradually reduced, the absolute difference between the number of removals on each face steadily decreases throughout the sequence (Fig. 7), indicating that the stages identified in the qualitative analysis maintain their consistency in a quantitative analysis. This variable is also initially dependent on the method of obtaining the blank. If the blank was removed from a larger nodule then the number of removals on the flat equals one, while the domed face is fully cortical.

If, however, one side of a nodule was worked to obtain the preferred flat shape, then the number of removals on that face will be much higher than on the cortical domed face. For this reason this variable has lower predictive power compared to the dorsal-ventral symmetry and the amount of cortex. In addition, the change from a single intensively-knapped face to an equal amount of removals on both sides happens in the early stages of the reduction sequence.

Aikaike's Information Criterion (AIC) was used for model reduction and assessing the quality of each dependent variable relative to the Full Model (Table 5). This confirmed that the cortex on the domed face and the front-back symmetry possess the highest individual predictive power. Overall, the Full Model provides the best fit to the assemblage and, therefore, the statistical analysis supports the abovementioned qualitative assessment of the curved cleavers *chaîne opératoire* into the five stages presented in section 4.1.

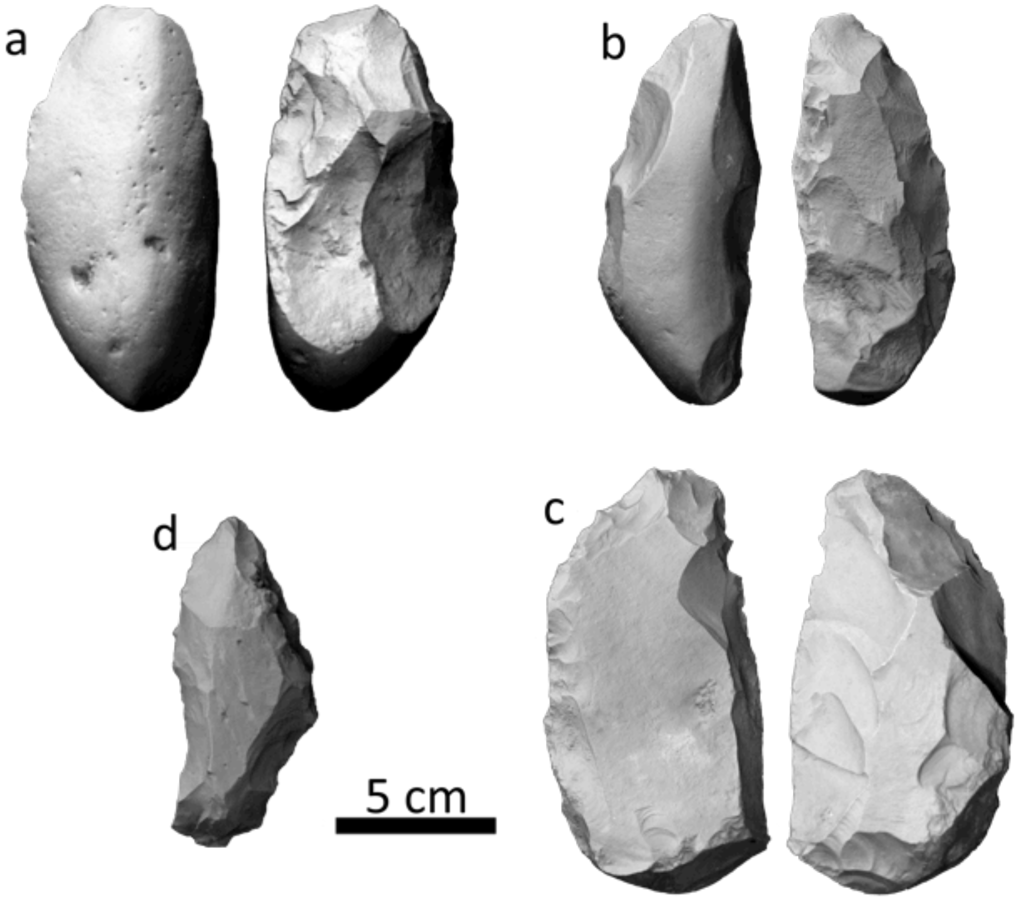

Figure 6. Photographs of cleavers in reduction stages 1 to 4 (a to d)

Table 5. The results of the model reduction using Aikaike's Information Criterion

Regression Model	*Degree of freedom*	*AIC*	*Drop 1*
Full Model	7	156.75	156.75
Cortex: flat face	3	227.92	159.71
Cortex: domed face	3	199.04	185.47
Symmetry: left-right	3	216.66	157.79
Symmetry: front-back	3	203.67	175.72
Difference in removals	3	211.11	161.89

Table 6. Descriptive statistics of the metric analysis of the sample assemblage (units in mm and g)

	Min	*1st Qu.*	*Median*	*Mean*	*3rd Qu*	*Max*	*St. Dev.*
Length	45.0	108.8	121.0	119.8	133.0	176.0	24.0335
Width	31.0	47.7	54.0	54.0	61.2	75.0	10.59034
Thickness	21.0	31.0	36.5	36.6	43.0	53.0	8.543805
Weight	29.0	204.2	324.5	303.8	371.0	618.0	135.2815

Metric analysis

All broken pieces were excluded from the metric analysis. Summary statistics of the sample assemblage shows a high degree of homogeneity in terms of dimensions, with artefact width and thickness possessing particularly low standard deviations (Table 6). In order to identify the directionality of reduction throughout the sequence, we compared the artefact dimensions within each reduction stage (Fig. 7).

Notably, the length of the artefact remains almost constant throughout the sequence until the final stage (Fig. 7). The width of the pre-forms decreases steadily from stage 2 when the tool begins to experience bifacial working and more cortical flakes are removed from its circumference. Contrary to this, the thickness shows a significant decrease only from Stage 3, which marks the beginning of the imposition of dorsal-ventral symmetry through the removal of the domed cortical surface obtained from the blank.

Not surprisingly, the weight shows a steady and continuous reduction throughout all the stages of *chaîne opératoire*. The consistency in weight decrease throughout the sequence supports the notion that the aforementioned patterns are not a result of the random noise in the sample, but instead reflect a genuine gradual reduction in the bulk of the raw material.

DISCUSSION

A number of the stages described above are consistent with the ones described by Nami (2006). Nonetheless, the two reconstructions differ significantly in several aspects, most notably in their understanding of when final shape is acquired. We performed a two-tailed, paired t-test on the data to test if the allocation of stages by Nami and the current model match. The results showed that the attribution of artefacts to his stages and the classification proposed in this paper differ significantly, which warrants further evaluation.

The point on which the two studies agree includes the suggestion that blanks are either large flakes detached from a tabular core, or a nodule. Furthermore, Nami's suggestion that the left-right asymmetry is imposed late in the sequence matches our observations. The distinctive 'curved' shape is virtually absent before the final stages. This disagrees with suggestions that naturally curved blanks were preferentially selected for producing curved cleavers (Hoeltz 2007: 232).

The main body of the experimental results, however, diverge significantly from the *chaîne opératoire* observed in the sample assemblage. The experimental study of Nami (2006) followed a standard procedure for bifacial reduction (see Callahan 1979; Le Tensorer 2006) in the experimental design. The archaeological assemblage analysed in this paper tells a different story. The asymmetrical working of the pre-form and the maintenance of one flat and one domed surface throughout the reduction sequence stands out clearly as a specific feature of the curved cleavers' *chaîne opératoire*. In terms of the sequence of actions required to produce a curved cleaver, the knappers intentionally concentrated on one face before working the other. This asymmetrical nature of the intensity of reduction was quantified by calculating the absolute difference between the numbers of removals on each face (Fig. 8). This index shows that until Stage 3, the disparity in the intensity of reduction between the two faces of a pre-form is pronounced. It is further supported by the aforementioned lack of dorsal-ventral symmetry in the early stages.

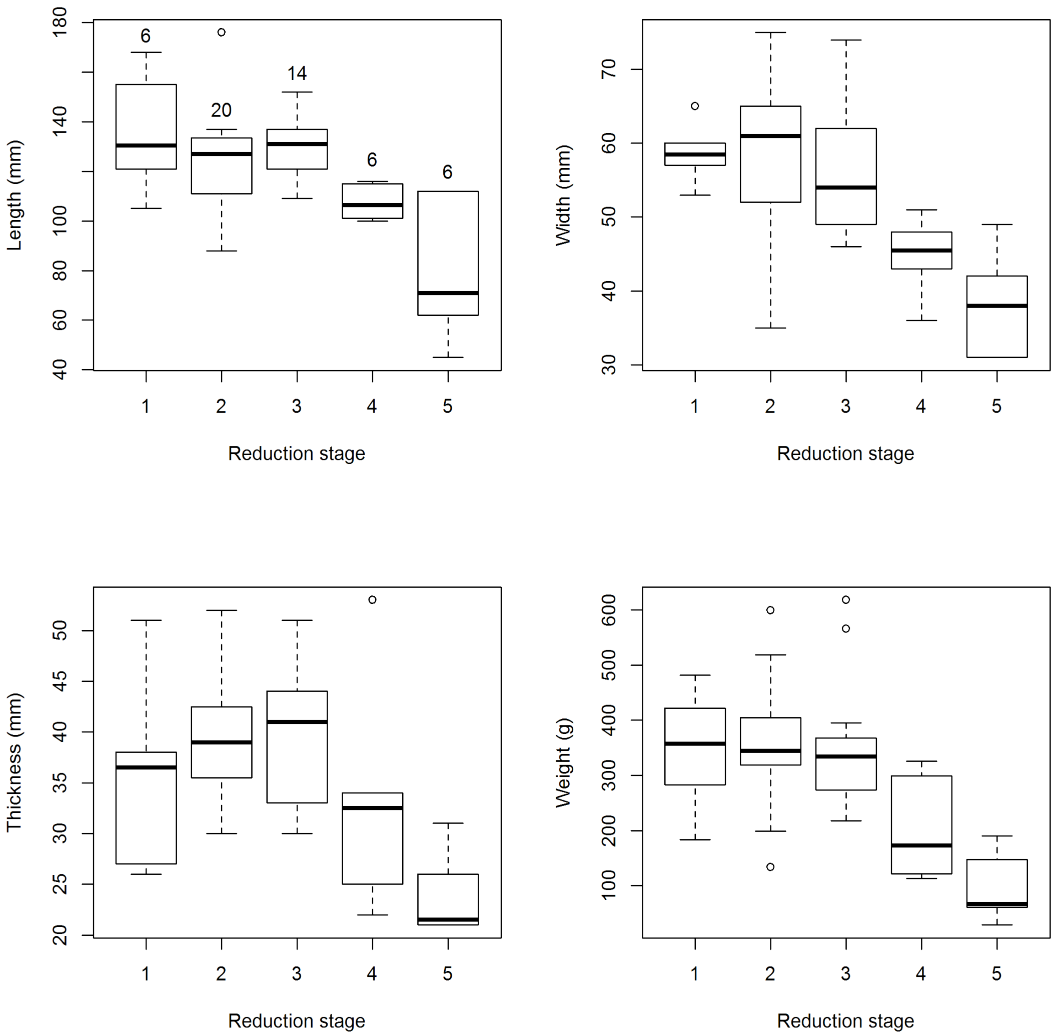

Figure 7. The metric analysis broken down by stage of reduction. Sample size for each stage displayed above each box in top-left plot

Asymmetry in the dorsal-ventral dimension only levels off when the piece undergoes the final shaping in Stages 4 and 5. Similarly, the most diagnostic feature of the artefacts, the pronounced curve, is absent and hence undetected for the majority of its reduction sequence. Finally, the metric analysis highlighted a significant degree of homogeneity in terms of dimensions in the pre-forms and finished tools. This may indicate a strong preference for obtaining raw material of a certain size and standardisation in the finished tool form, perhaps related to the functional requirements of the tools as foraging implements (Nami 2006: 150).

CONCLUSIONS

In this paper we used a sample from Misiones Province, Argentina to conduct a qualitative reconstruction of the reduction sequence of a common tool type found in large parts of eastern South America over nine millennia. Our qualitative reconstruction of the curved cleaver *chaîne opératoire* is supported by the metric analysis of the artefacts. We also compared our five-stage schema to an experimental study by Nami (2006), which used a standardised bifacial reduction sequence and highlighted the peculiarities of the curved cleavers' sequence. This study confirmed that blanks were selected from elongated nodules and large flakes. The differences between the two blank types are distinctive in the early stages of reduction but completely obscured by the final stages of working. Some cultural features of the reduction sequence, however, differed significantly from the predictions of Nami's experimental study: most notably the characteristic asymmetrical working of the preforms, and the order in which the frontal-dorsal symmetry and the cleavers' "curve" were imposed on blanks.

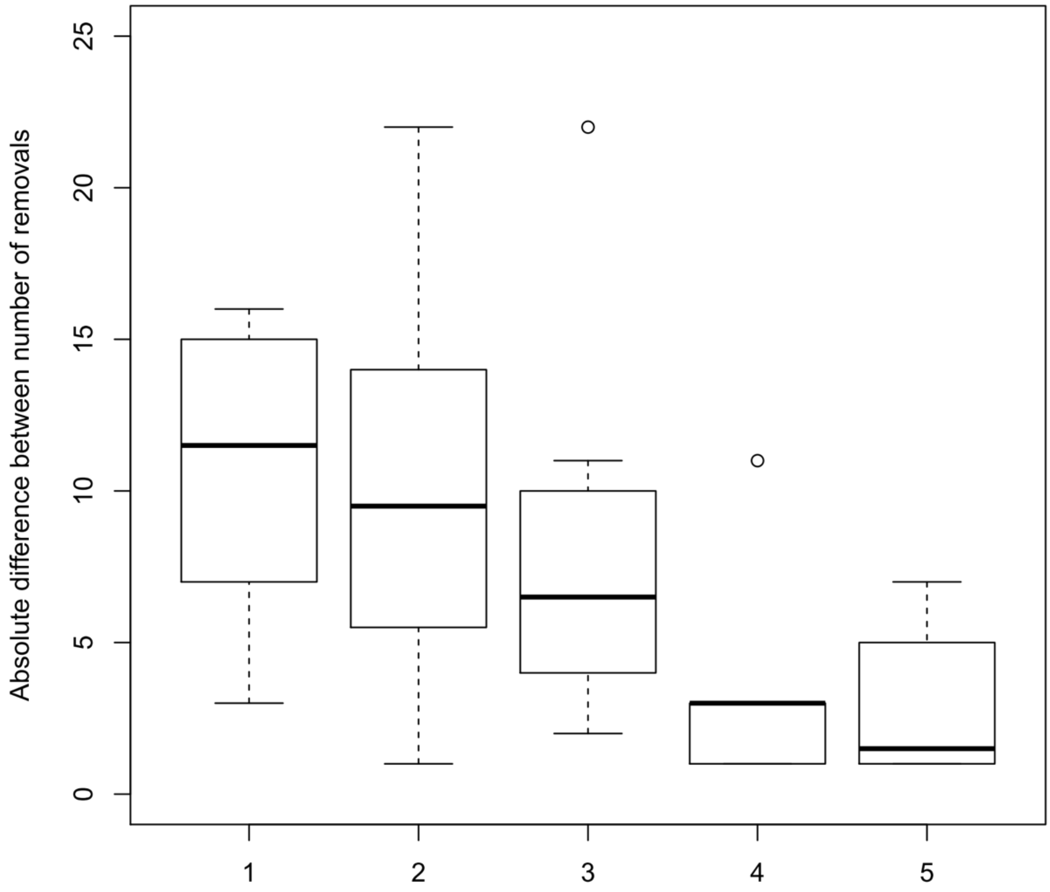

Figure 8. The absolute difference between the number of removals on each face separated by production stage

Nami (2006: 150) notes that the later stages of curved cleaver production mask the variability of earlier stages to some degree. The principal implication of this finding is that several “types” of bifacial tools possessing dorsal-ventral asymmetry (for example, Menghin 1957: fig. 11; Hoeltz 2007: fig. 2) may actually be unrecognised parts of the curved cleavers’ *chaîne opératoire.* Hence, investigations that only focus on the finished tool types are limited in their ability to reconstruct the organization of stone technology. We therefore suggest that more extensive sampling of curved cleaver pre-forms, representing the intermediate stages as defined here, should be included in future analyses in order to better distinguish between curved cleaver pre-forms and other types of bifacial tools.

Finally, as noted in the introductory paragraphs of this paper, the spatial and temporal distribution of this distinctive class of tool is tremendous. Its spatial distribution spans three Brazilian states, Misiones province (Argentina) and the eastern sectors of Paraguay (Menghin 1955/56; Miller 1969a; Schmitz 1987), while its temporal range is believed to cover almost nine millennia. The principal limitation of a better understanding of the archaeological record of the region is presently the lack of a fine-grained technological and spatial framework for comparing assemblages from different regions and time periods. We hope that this study provided a useful attempt at recognising the true variability of curved cleavers.

Due to the nature of the sample analysed in the present study, we were unable to shed any light on the temporal aspect. However, by describing the characteristics of the reduction sequence of curved cleavers within secure spatial limits, we provide a stepping stone for identifying the variability in the lithic material record of neighbouring regions. In future macro-regional scale work, examples will need to be compared across secure and dated stratigraphic contexts to construct a framework for when, how, and why curved cleavers were produced. Dissecting the long period of time when curved cleavers were produced, including throughout the pre-ceramic (Humaitá) to ceramic (Taquara/Itararé) transition, would be particularly relevant to understanding how curved cleavers were integrated in different past economies. In addition, further studies, in particular microwear analyses, should concentrate on identifying which components of curved cleaver variability are due to the functional requirements of these tools.

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* *It is worth noting that in this case the name 'cleaver' is typologically incorrect. Cleavers are defined as bifacially worked tools with either an unworked distal edge (Debénath & Dibble 1994: 170; Inizan* et al. *1995: 55−56) or with a clear transversal removal negative at its distal end when the distal part is secondarily treated (Debénath & Dibble 1994: 165). This is clearly not the case in the vast majority of 'curved cleavers' but the name is nevertheless ubiquitously used.*