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Differentiating bamboo from stone tool cut marks in the zooarchaeological record, with a discussion on the use of bamboo knives

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Abstract

The archaeological record of Southeast Asia is marked by a relative lack of Acheulian assemblages compared with the rest of the Old World. Suggestions that prehistoric human populations in this area relied instead on a non-lithic technology based on bamboo have not been supported by archaeological evidence. To provide a diagnostic means of assessing prehistoric use of bamboo, cut marks were experimentally produced on bone using chert tools and bamboo knives. A scanning electron microscope (SEM) examination revealed morphological differences in cut marks produced by the two materials that allow identification of bamboo knife cut marks on faunal materials. Such evidence, if found in Pleistocene through early Holocene archaeological sites in Southeast Asia, would indicate early human reliance on bamboo technology.

Keywords: Cut marks; Bamboo; Zooarchaeology; Southeast Asia; Stone tools

1. Introduction

The paucity of Acheulian assemblages in the prehistoric record of East and Southeast Asia led Movius [22: 539] to describe the region as a "marginal area of cultural retardation." This proposition has been challenged by the idea, first suggested by Boriskovskii [3–9], that early populations in the area may have relied heavily on a non-lithic technology which included bamboo and wood, and that the East Asian Pebble Tool tradition and the Hoabinhian tradition of Southeast Asia may have been used in the manufacture of wood tools [1,2,13]. According to this view, long-edged cutting tools, represented in the Acheulian by handaxes and cleavers, may have been made from bamboo rather than stone [14,18,23,24].

Bamboo represents an integral part of Asian culture and is used for many different purposes including building, storage, tools, and as a food source [12,15–17,20,34,36,37]. The large scale utilization of this resource can be explained by the ease with which it lends itself for use, as well as its natural abundance.

Bamboo does not preserve archaeologically and therefore the importance of this resource to past populations in Southeast Asia must be assessed through indirect means. Evidence for the prehistoric use of bamboo consists chiefly of ethnographic examples of bamboo technology utilized by modern people in Southeast Asia, Polynesia, and New Guinea [12,15–17,19,20,30,36] and also from use-wear and residue experiments that indicate the steep-edged Hoabinhian tools may have been used in the preparation of wood or bamboo artefacts [2,19]. Archaeological remains from a Holocene site in Papua New Guinea suggests the use of bamboo on human and pig remains [31,32], albeit not definitively interpreted. Ethnographic data show that today bamboo knives are

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used in rituals, in food preparation, and when butchering expediency is desired ([12,16,20,30] and references therein). These knives can be produced by splitting a fresh bamboo halm (outer stem) into thinner slips [36]. The outer halm of bamboo contains large amounts of silica and offers a thin, sharp edge. Slips ideal for knife use have a bevelled edge, which places the silica-rich halm out beyond the inner pulp (Fig. 1). Experimental work [28–30] shows that bamboo knives produce discernable cut marks on bone as do stone tools, although they are considerably smaller, shallower and less easily seen macroscopically.

SEM examination of experimentally produced stone tool cut marks has identified a number of morphological features attributable to the edge morphology of stone tools [10,25,27]. By demonstrating the relationship between the edge morphology of the cutting tool and the morphology of the cut mark, such analyses offer empirically based criteria for the interpretation of surficial damage on bones from archaeological sites. The following study attempted to produce bamboo knife cut marks on bones from two different species of large mammal in order to detail what characterises the use of bamboo, as opposed to stone tools, as preserved in the zooarchaeological record. Observations related to the use of bamboo knives are noted. In order to replicate the lowest level of technological expertise, simple stone tools (unretouched flakes) were also manufactured and utilised.

2. Methods and materials

Two experiments were conducted: (1) a defleshing experiment, from which marks were examined both macro- and microscopically, and (2) a cut mark experiment in which marks were subjected to SEM analysis. The cut marks examined in the defleshing experiment were made by bamboo knives manufactured from *Phyllostachys*, a common genus in southern China. These knives were made by splitting small diameter shoots, either by pounding them with a cobble, or by hitting them against a rock or tree, and from these tearing strips bearing the outer halm. Both recently cut (<1 week) and dry shoots were tested for their efficiency. The stone knives were made as crudely as possible in order to best mimic the least sophisticated lithic technology. These were made by striking flakes of chert from a larger core using a geological hammer. Two sheep (*Ovis aries*) humeri were defleshed, one by bamboo (Fig. 2) and the other by stone tools. Around ten bamboo blades and three stone flakes were used during the defleshing process. This experiment was conducted by novice butchers, and the marks examined both macroscopically and under a Leica MZ6 binocular microscope.

In the second experiment cut marks were experimentally produced on four *Bos* tibia using bamboo knives (manufactured as above) made of *Phyllostachys aureosulcata* (''Yellow-groove'' bamboo), native to central and eastern China, and using bifacially flaked, retouched chert tools. Twelve individual cut marks were produced on each bone, with one bamboo knife utilised per bone. Negative casts of the cut marks were made from Express® (3M Corporation), a polysilioxene dental impression material. Positive casts were then produced with Spurr's epoxy resin, coated with gold-palladium, and examined with SEM.

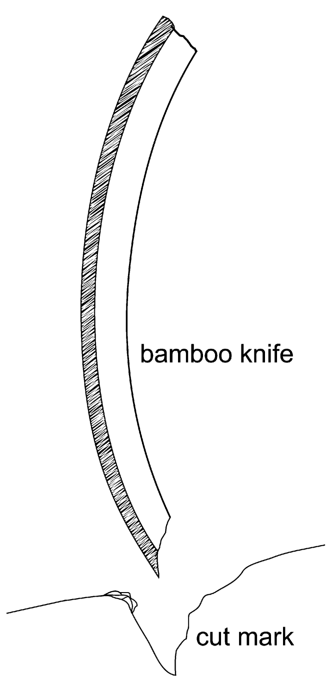

Fig. 1. Schematic cross-section through bamboo knife and cut mark showing correlations between knife edge and cut mark morphology. Greatly enlarged, not to scale.

3. Results

3.1. Observations on the mechanical qualities of bamboo and stone tools in defleshing

The following observations are those of a novice in the use of both stone and bamboo tools. Bamboo is surprisingly sharp—considerably more so than was anticipated. Relatively small halms are the easiest size to form into knives. The

Fig. 2. Cutting flesh from the sheep using a bamboo knife.

sharpest bamboo knives are thinner, bearing the silica-rich outer halm with only a small amount of inner pulp to provide it with support. Although sharp, the bamboo knives lose their edge relatively quickly, and have to be replaced often. This is particularly the case when the knives strike bone, as when cutting through the periosteum, although the knives also dull perceivably when only flesh is encountered. When the cutting edge of the knife becomes blunt, a sawing action must be used in order to cut the flesh. There seems little difference in the sharpness or the rate of dulling between dried and fresh bamboo blades. While small halms proved to be weaker under the force of heavy cutting, they were quite sufficient for filleting meat. Larger diameter halms (greater than 2–3 cm diameter) withstand more pressure during use and are more appropriate for cutting tougher tissue like tendons. However, beyond 5 mm thick they become unwieldy due to thickness of the pulp, are more difficult to cut from the growing stand than smaller ones, and are much less easily split into smaller slips. Despite employing larger halms, the use of bamboo knives in disarticulation proved more difficult than filleting.

The stone tools used in the defleshing experiment were made for their simplicity and ease of manufacture. It was found that these blades generally cut much faster and kept their edge for much longer than the bamboo. The only mechanical advantage in using bamboo knives over stone knives seems to result from the length of the edge of the blade in bamboo knives, such that a longer cutting surface can be utilised. This advantage was most appreciated when butchering large pieces of flesh. Overall, chert represents a much more reliable blade than does bamboo. However, the ease of knife manufacture and the abundance of raw materials demonstrate bamboo's value as expedient tools. This would be particularly advantageous for founding populations in the region without immediate access to appropriate stone.

3.2. Differences in cut marks between bamboo and stone tools

3.2.1. Macroscopic and microscopic analyses

Spenneman [28,29] noted that, although cut marks made by bamboo were discernable, they were shallower than corresponding lithic cut marks. Macro- and microscopic analyses of the cut marks produced in this study confirm this. The bamboo cut marks (Figs. 3 and 4) were best observed under strong light while rotating the bone. They were fainter and less obvious than lithic cut marks. Under the microscope, bamboo cut marks were generally shallower than their lithic counterparts. They did not score deeply into the bone, nor did they obviously incise the bone (unlike lithic marks; Fig. 5). The presence of faint, shallow cut marks may therefore indicate use of bamboo in butchering [30]. However, although suggestive, this evidence is not unequivocal, as some lithic cut marks were also faint and superficially resembled bamboo marks (Fig. 6).

3.2.2. SEM analysis

Shipman [27: 365] states stone tool cut marks are "V-shaped in cross-section and always show multiple fine striations within the main groove and parallel to its long axis .... These fine striations are drag marks or tracks made by the fine projections that deviate to one side or the other of the edge of the artifact." SEM examination of other types of surficial damage that can be mistaken for cut marks have also been described by Shipman [27]. These include tooth scratches, gnawing marks and preparator's marks. The primary morphological features differentiating these marks relate to the cross-section of the mark, the presence/absence of striations within the mark, and the pattern of the striations if present. The stone tool cut marks produced for this comparison show the characteristic damage previously described (Fig. 7).

Bamboo knives leave morphologically distinct cut marks that can be defined using the same categories of criteria which, in turn, can be related to the morphology of the bamboo knife edge (Table 1, Fig. 1). The outer skin contains large amounts of silica and is sharp to the touch, but presents a smooth outer

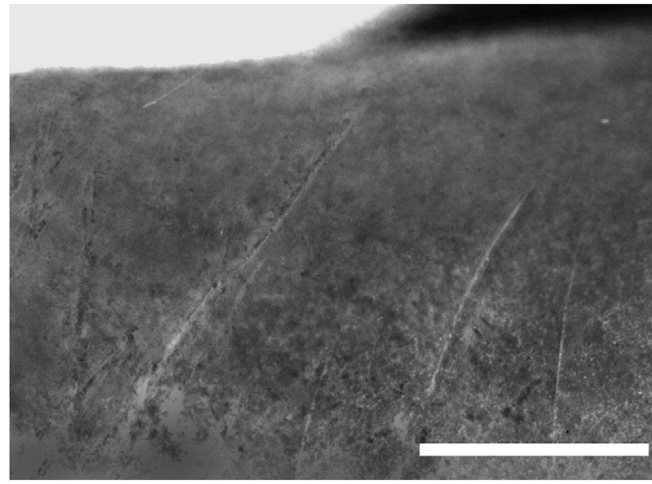

Fig. 3. Bamboo cut marks under light microscope. Magnification 8.5×. Scale bar equals 4 mm.

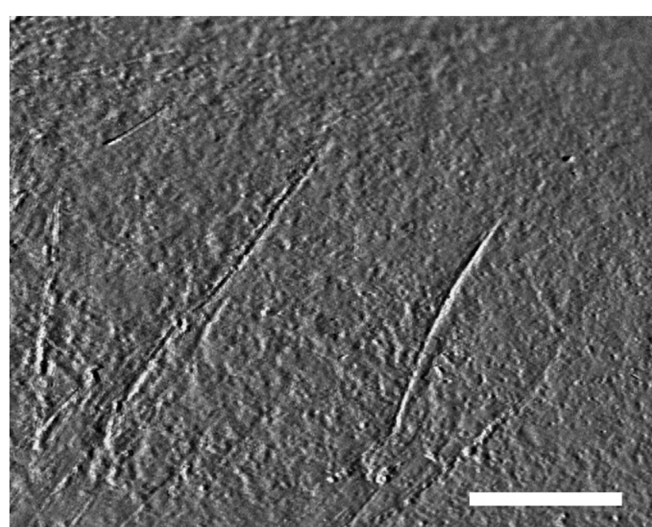

Fig. 4. Light microscope image of cut marks shown in Fig. 3 in plane view. Magnification 8.5×. Scale bar equals 4 mm.

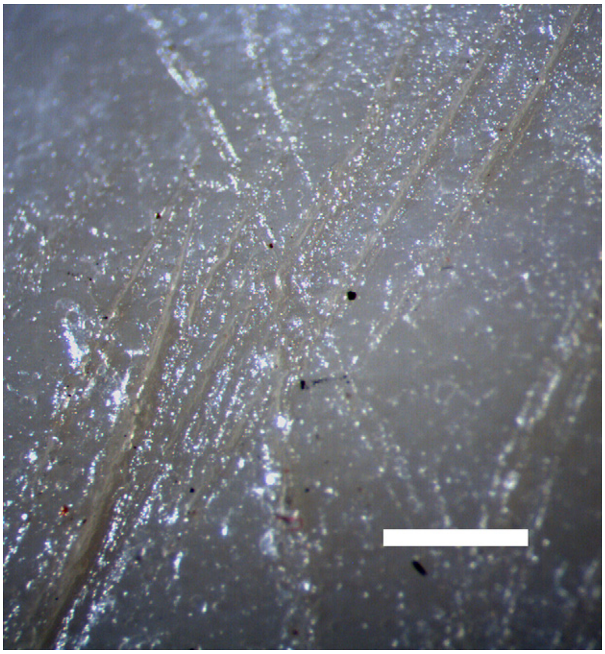

Fig. 5. Stone tool cut marks under light microscopy. Magnification 14×. Scale bar equals 2 mm.

wall when cutting. The opposite side consists of the soft, inner pulp of the bamboo which is exposed in the knife as longitudinal fibres (Fig. 8). Each side deforms the bone differently. The smooth, sharp side creates a deep groove, displacing bone to the outside of the cut mark (Fig. 9a–d). The fibrous side creates parallel striations that do not to cut into the bone as deeply, since the shallower side of the cut marks

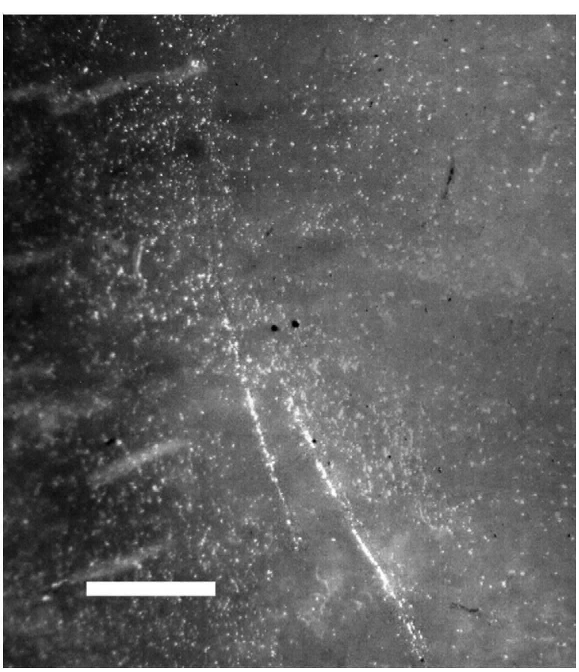

Fig. 6. Light microscope image of faint stone tool cut marks which superficially resemble those made by bamboo knives. Magnification 13×. Scale bar equals 1 mm.

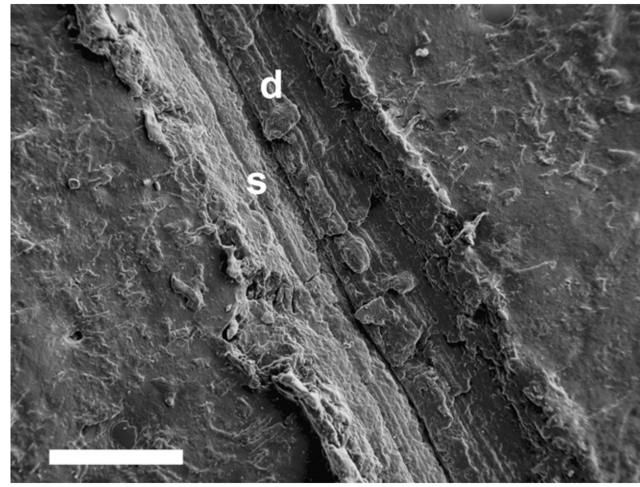

Fig. 7. Micrograph of typical stone tool cut mark. Note debris at nadir (d), multiple striations within the cut mark (s), and the well-defined edges. Compare width of stone tool cut mark (and magnification) to those of the following bamboo knife cut marks. Magnification 109×. Scale bar equals 200 μm.

shows little to no debris. As the knife dulls, the deeper side of the cut mark becomes shallower, but on the opposite side, the striations remain clearly visible (Fig. 10).

4. Discussion

Over 50 years have passed since Movius suggested a difference between the lithic technological traditions of South and Eastern Asia and that of the Old World. During this time, many new and important archaeological discoveries from Southeast Asia, particularly from China, have cast aspersions on the perceived lack of biface tools. Notable among these are Zhoukoudian, Bose, Yunxian, Lantian and Guanyindong, whose biface tools, although a rarity in the assemblage, are comparable in abundance to some Middle Pleistocene sites in Europe [21]. Despite these finds, however, and the recognition that the Southeast Asian lithic technology is not simply one of a "chopper-chopping tool complex", the distinction between the Auchelian technologies of the Old World and the less sophisticated lithic technologies of Southeast Asia remains very real [26]. Among the theories developed to explain this enigma (see [26] for a review), the theory of bamboo use has undoubtedly proven one of the most enduring.

Questions remain, however, as to why early Southeast Asians would switch to a predominately bamboo technology, given the superiority of stone blades. Two possibilities present

Table 1
SEM criteria for distinguishing bamboo from lithic cut marks

Criteria	Bamboo	Stone
Cut cross-section	Markedly asymmetrical	Symmetrical
Pattern of striations	Step-like series of striations on the shallow side of the cut mark	Multiple striations
Debris	Displaced to the surface on the deep side of the cut mark	Internal displacement

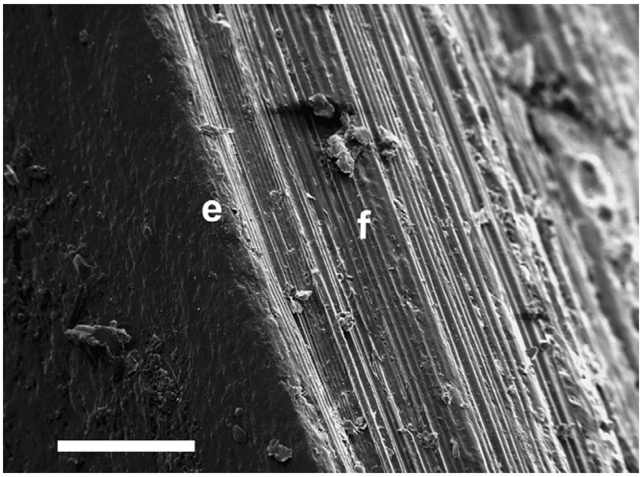

Fig. 8. Micrograph of unused bamboo knife edge. The darker left half is the outer green skin of the bamboo, and the lighter, striated, right half is the fibrous inner pulp (f). Note that the outer halm (e) extends out beyond the level of the inner portion. Magnification 105×. Scale bar equals 200 μm.

themselves: (1) that bamboo knives replaced their bifacial counterparts, and (2) that the nature of the rainforest environment precluded the use of large, heavy duty tools. In support of the latter, it has been suggested that the rainforest environment necessitated a more nomadic lifestyle [18]. This lifestyle favours the use of bamboo as a tool, because of its ubiquity and ease of manufacture. Furthermore, upon entering a new area, early Southeast Asians would have needed to locate a new source of workable stone, which might have taken some time. Watanabe [35], based on observations of modern hunter-gatherers in rainforests, suggests that bamboo blades and flake tools are more suited to the collection and exploitation of the floral and faunal resources of a rainforest. He noted that these hunter-gatherer groups were largely vegetarian and that when animals were hunted, they were generally small. Thus the absence of bifacial tools in many regions of Southeast Asia may be more a product of the redundancy of heavy duty butchery in a rainforest than merely the replacement of one material (stone) for another (bamboo). Indeed, we believe the replacement scenario unlikely based on our observations on the use of bamboo as a butchering tool. It should be noted, however, that ethnographic records show bamboo used in both defleshing and disarticulation during butchery, even when metal axes were available [29]. Furthermore, the mechanical advantage of bamboo blades, namely that of the length of the cutting edge, is one shared with large bifacial tools. However, this advantage is rendered moot if the primary fauna exploited by communities in rainforests consisted of small animals.

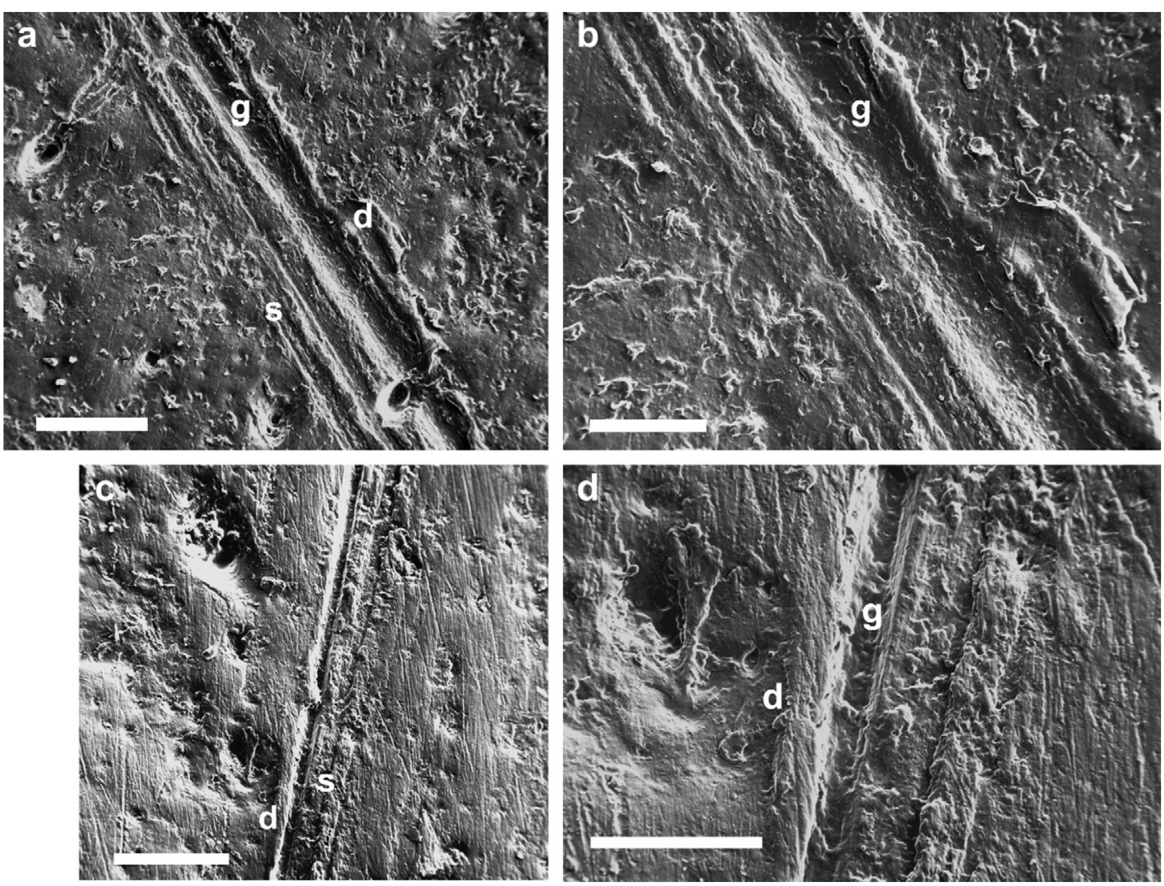

Fig. 9. (a) Micrograph of bamboo knife cut mark. Note deeper groove (g) to the left, and the shallower, step-like striations (s) to the right. Bone debris (d) is pushed back from the deeper side on the right. Magnification 104×. Scale bar equals 200 μm. (b) Higher magnification showing centre of (a). Magnification 211×. Scale bar equals 100 μm. (c) Micrograph of bamboo knife cut mark. Magnification 107×. Scale bar equals 200 μm. (d) Higher magnification of (c) showing lower 2/5 of cut mark. Magnification 326×. Scale bar equals 100 μm.

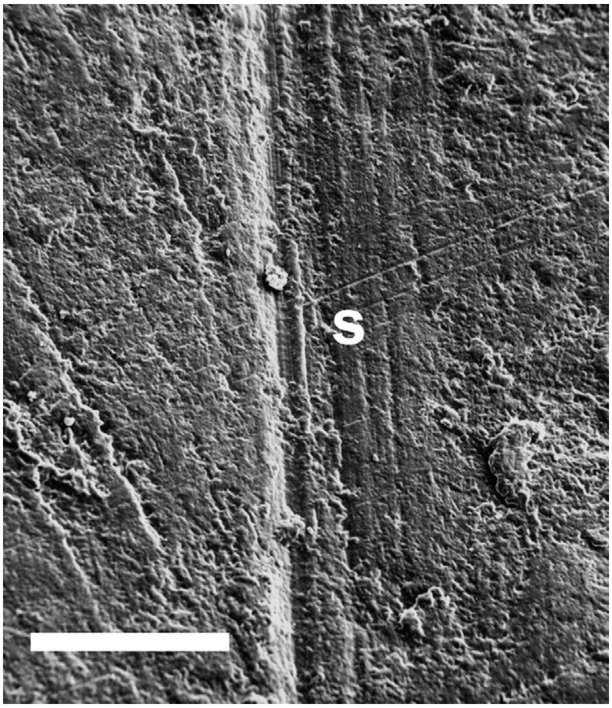

Fig. 10. Micrograph of bamboo knife cut mark. This cut mark is much more shallow than the previous cut marks, presumably due to dulling of the knife. The striations (s) caused by the fibrous portion of the blade are still clearly evident. Magnification 204×. Scale bar equals 100 μm.

The continued use of bamboo tools, coupled with continued migrations into new regions could effectively cause a break in tool manufacturing traditions—a break which, if over a generation or more, would result in extinctions of Auchelian tool manufacturing in Southeast Asia [26,33]. There is, however, as yet no positive archaeological evidence of bamboo use among Pleistocene Southeast Asians.

Although bamboo is usually associated with Asia, many other regions in the world, including India, Australia and South America possess native bamboo (Fig. 11). The use of bamboo tools has been historically documented in butchery and cannibalism practices in Polynesia and Papua New Guinea [12,29,30], and it is possible that prehistoric communities in other parts of the world may have similarly utilised this versatile plant. The use of bamboo knives has also been suggested for a Holocene deposit in Papua New Guinea [31,32]; although we submit that confirmation of this observation requires more rigorous (in the form of SEM) analysis. The criteria detailed above should allow zooarchaeologists to directly test whether this resource was utilised to effect in prehistoric times, and hence provide confirmation or refutation of some of these hypotheses.

5. Conclusions

The morphological characteristics of cut marks created by stone tools differ from those created by bamboo knives. The results of these experiments indicate that bamboo cut marks can be distinguished from stone tool cut marks on the basis of cut mark morphology. Although possible bamboo cut marks can be flagged using light microscopy, we suggest that definitive evidence of the use of bamboo will rely on SEM analysis. Archaeological work in Papua New Guinea [31,32] has described possible bamboo cut marks in a Holocene deposit, which suggests that these marks may be preserved archaeologically. However, due to the shallow nature of the bamboo cut marks, we suggest that the conditions for bone preservation must be excellent, more so than for lithic cut marks. This study has implications for zooarchaeologists studying faunal remains present where bamboo might have been a significant natural resource. Archaeological faunal remains from Southeast Asia, Polynesia, and Papua New Guinea should be examined for bone surficial damage caused by butchery. Other areas where bamboo is found, such as Australia, India and South America may also benefit from this type of analysis. These studies can be combined with micro-wear and residue analyses of stone tools which may indicate the processing of bamboo.

Fig. 11. Global distribution of woody bamboo (from [11]).

Identification of bamboo knife cut marks on Pleistocene Southeast Asian faunal remains would produce positive evidence that earlier human populations utilised a non-lithic technology that included bamboo knives. Even though bamboo knives were found to wear relatively quickly, the ease of knife manufacture and the abundance of raw materials demonstrate their value as expedient tools.

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