ANTHROPOLOGIE * XXIX/3 * 1991

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WORKED HUMAN BONES AS OBJECTS OF ART: LAMANAI, BELIZE

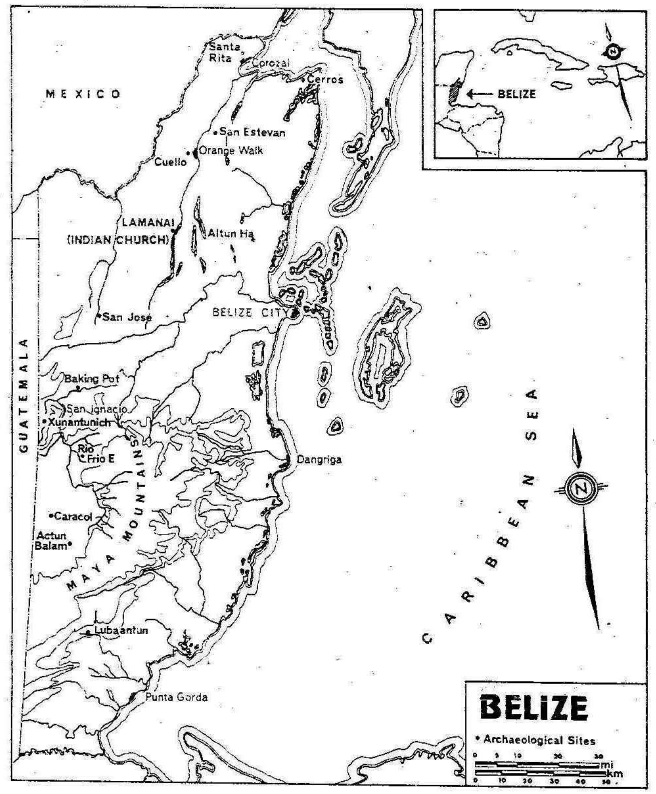
ABSTRACT: The site of Lamanai, Belize, has yielded the remains of approximately 200 human skeletons, spread out from Pre-Classic to Historic Mayan times. Several human bones were modified in specific ways which preclude their use as tools. The ratios of cortical and medullary thickness are used to identify these fragments vis-a-vis Middle and North American animal bones. Their possible usage in rituals and religion of the Maya are discussed.

KEY WORDS: Identification – Cortical thickness – Maya – Musical instruments.

During the archaeological excavations at the Maya site of Lamanai (*Figure 1*) in Belize, C. America, by Dr D. M. Pendergast (R.O.M., Toronto, Canada), some strangely modified and decorated bone pieces came to light which pose the following questions for the anthropologist:

1. How can animal and human bones be distinguished when the following conditions exist:
   a) the pieces lack species-specific morphological-anatomical features;
   b) the cultural value of the pieces precludes the application of destructive techniques;
2. What were these bone artifacts used for, what was their cultural significance?

Due to small size and/or modifications, sometimes bony pieces cannot be identified as to their species by the usual analysis of morphological features. Though anatomical - morphological comparison is clearly the simplest and most widely applied technique, it can nevertheless fool people as shown by Angel (1974), who reported on the mix-up of human with bear and pig foot bones, human infant and dog rib cage remains and others. Surveying various textbooks on how to differentiate between animal and human bones, few books on forensic Anthropology or Osteology had anything else to offer than the stereotyped remark "by anatomy/morphology" (Bass 1987; Binford 1981; Brothwell 1981; El-Najar M. and K. R. McWilliams 1978;



Krogman 1962; Krogman W. M. and M. Y. Iscan 1986; Morse D., J. Duncan and J. Stoutamire 1983; Skinner M. and R. A. Lasenby 1983; Ubelaker D. M. 1978). In addition to comparative anatomy, Hunger and Leopold (1978) discuss a histological and three chemical methods, such as immune-electrophoresis and fluorescence-immune-histological techniques. Histologically, the size of the Haversian canals and their relative density were studied by Raemsch and Zerndt (1963) at different stages of development in *Homo sapiens* and various domestic animals such as horse, cattle, goat, sheep, dog, rabbit, cat, chicken and goose. They arrive at the conclusion that "a simple and safe method according to our results is the measuring and the enumeration of Haversian canals with regard to the total picture in bone sections". However, the authors admit that both these distinguishing features of canal size and relative density overlap between different species and that they are mostly useful when applied to *small* domestic animals. Other researchers expressed their doubts regarding the reliability of this analysis and demonstrated a considerable degree of disagreement on the usefulness of this destructive technique, but Owsley D. W., A. M. Mires and M. S. Keith (1985) report on their successful differentiation between very small human bone fragments and deer bone in a forensic murder case using osteon morphology when lacking morphological features precluded any other technique.

Reichs (Forensic Osteology 1986, p. 18) offers some other suggestion by saying that "Thickness of the outer layer in comparison to the diameter of the total bone can be used to tell whether a bone is human or not. In the case of an upper arm bone (humerus) or a thigh bone (femur), thickness of compact outer layer (cortex) is approximately one-fourth of the total diameter of a normal adult human bone."

It seems that the problem of a non-destructive technique regarding animal versus human bone differentiation has rarely been investigated on a more systematic basis and this study intends to remedy this situation by focusing on cortex thickness and medullary cavity width.

MATERIAL AND METHOD

A. Material

The five bone pieces from the Lowland Maya site of Lamanai in Belize (*see Figure 1*) can be described as follows:

1. and 2. LA 247/20 (*Figure 2*): This artifact laid in the grave of an ancient Maya dignitary numbered N 10 - 4/46 which was dated as of Late Postclassic times. It consists of two pieces of nearly round shafts, 1. (or left piece): 7.4 and 2. (right piece): 9.7 cm long, wedged into each other by thinning out of the matching ends. Diameters are: 1. (left): inner: 10.88 × 8.60 mm; outer at middle: 17.56 × 16.69 mm. 2. (right): inner: 10.35 mm; outer at middle: 19.22 × 18.72 mm. The left piece (1) is thinned down to an outer diameter of 14.75 × 12.95 mm at an inner width of 10.8 mm. The longer piece (2), broken and fragmented at its outer end, is decorated with Maya signs of unknown meaning. The shorter piece 1 is unfortunately in a less well preserved state, thus it is impossible to say whether or not it has also been decorated, though some holes may indicate this. This artifact lay in the grave of an ancient Maya dignitary (Pendergast 1980) numbered N10-4/46 which was dated as of Late Postclassic times.

3. and 4. Lamanai LA 774/24 and 28 (*Figures 3, 4*): are most likely pieces cut from humeri. They were unearthed from the so-called "Hunchback tomb" (Pendergast 1984 a; b) at the base of the crypt and lay probably beside the body of the principal individual whose remains had virtually disappeared except for a few teeth. The ceramics from the tomb indicate a date after A. D. 1500 and it is quite likely that the individual buried here had been a member of the last ruling elite of Lamanai. The tomb could in fact immediately predate the Spanish arrival at Lamanai, ca. A. D. 1544. The first bone fragment, 774/24, is 141 mm long. What appears to be the distal end is irregularly broken by natural forces; its outside is rough and, not surprisingly, weathered. The distal end widens very modestly, whereas the proximal end is cut in a circular fashion with a sharp instrument. Apart from a fine weathering crack, a 2 mm hole appears 15 mm from this upper end. When viewed under magnification, the margins appear to be rough and slightly cratered; consequently the hole does not seem to be man-made. The inside reveals no spongious substance, which however, could be due to the combined efforts of nature and cleaning. Artifact 4, LA 774/28, is only marginally longer with 143 mm. It is most likely the distal piece of a left humerus with the distal end widening towards the medial epicondylar area. Again, the distal end is irregularly broken whereas the proximal end is sharply cut all around the shaft. The outside is rough; the inside is hollow and appears to be naturally rough. No other details are worth mentioning.

5. The last piece, LA 931/11 (*Figure 5*), was found in a most interesting grave, designated as N11/5-7. It is dated as being from the 15th century or later. The burial contained two individuals, one male and one female of adult age as well as an unborn or just born fetus of 7-8 months gestation. The adult pair must have been of elite status due to the rich copper objects given to them. Another interesting fact was that the female was buried with her arm around the shoulder of the male. It is in this unusual context that the larger part of a human femur was found which was obviously intentionally modified. This right side femur fragment is 291 mm long. Its proximal end was again sharply cut off which left a perfectly smooth end. The distal end is broken but fortunately one piece of the lateral epicondylar area is preserved to show that the actual epicondyles were also cut off. Apart from weathering cracks, its outside surface is beautifully smooth and appears to be highly polished. The polished surface resulted in a thinner than normal cortical diameter. A view into the bone reveals that the polishing and smoothening process was also applied to the inside; the walls are quite delicately smooth at the proximal end and only slightly rough at the distal end. No spongious material was left inside. - Thus, Lamanai has given us a sliding scale of bone fragments from one combined piece of unknown identity to others which on the basis of their morphology can be more or less easily identified as to their species and side.

Since Lamanai has yielded no series of round shaft long bones numerous enough for my purpose of

FIGURE 2. *LA 247/20*

FIGURES 3. and 4. *A 774/24, A 774/28*

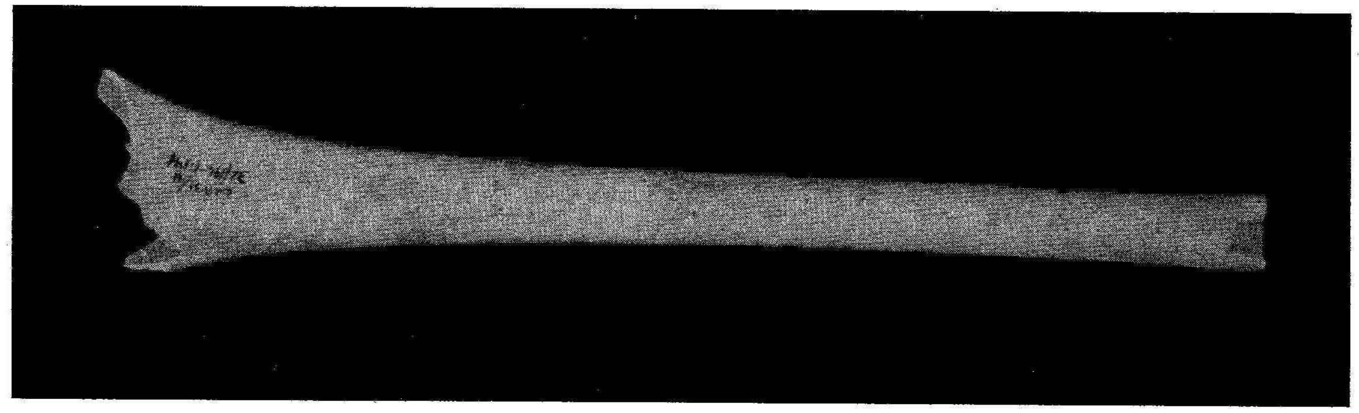


FIGURE 5. *A 931/11*

comparison, my sample includes modern and archaeological human humeri and femora from other areas. The modern bones of adult age (n=13) come from a medical supply house and are most likely East Indian in origin from a time period of the last twenty years. My archaeological specimens (n=9), from undamaged adult individuals, are from a Late Woodland site dated at approximately A.D. 1400 to 1500. In addition to the human species, other Mammalian species were studied following the List of Mammals given in: Belize. Country Environmental Profile. A Field Study. (1984). Applying the criteria of size, shape and availability, the same long bones of the following Middle and North American Mammals were used (*see Table 1*); since no jaguar was available, the very similar and closely related African leopard was added.

TABLE 1. *List of Mammals*

Common name	Species	Side(s)	Sex	Age
Giant anteater	Myrmecophaga tridactyla	left	?	Imm.
Wh.-lipped peccary	Tayassu pecari	right	?	Mat.
Red brocket deer	Mazama americana	right	m.	Mat.
Wh.-tailed deer	Odocoileus virginianus	1.right	m.	Mat.
		2.ri+le	f.	Imm.
Puma	Felis concolor	1.right	m.	Mat.
		2.right	m.	Imm.
Tapir	Tapirus bairdii	ri+le	?	Mat.
Caribou	Rangifer tarandus	ri+le	?	Mat.
Black bear	Ursus americanus	1.right	f.	Mat.
		2.ri+le	m.	Imm.
Bison	Bison bison	ri+le	?	Imm.

B. Method

Because the cultural and archaeological importance of these bones made the application of destructive techniques for identification of the species impossible, it was decided to apply a non-destructive technique such as x-raying in order to measure the cortical and medullary dimensions. The larger bones were x-rayed at a distance of 1.50 m, the smaller ones at a distance of 1.0 m to minimize possible distortion. Actual length of the bones and x-ray length were compared and found to be in close agreement of +/- 2 mm. All long bones were measured as precisely as possible at midpoint to an accuracy of 0.1 mm using a standard technical sliding caliper. This technique was employed by Garn (1970) for measuring cortical thickness changes during ontogeny. The only two raw measures needed are the total subperiosteal diameter (T) and the medullary cavity width (M) from which cortex width can be calculated as C = T-M. Since overall size is a factor to be considered, Nordin (Garn, p. 11) introduced an index or score: (T-M)/T in order to describe how much of the total width is taken up by cortical width. The total subperiosteal area for tubular bone cross-sections can be calculated as = $pi*(T/2)^2$ (or $0.7854*T^2$) which is also true for the medullary cross-sectional area which is = $0.7854*M^2$. Subtracting the latter from the first will result in the cortical area: or, cortical area = $0.7854*(T^2-M^2)$ and the percent cortical area = $100*(T^2-M^2)/T^2$. Since the modified bone pieces are nearly circular, these formulae are fitting.

C. Results

Subsequent to measuring the x-rays, the raw data were converted into the above mentioned areas and percentage areas. The statistical data are shown in *Tables 2 and 3* for each of the two human bones. To examine the possible relationships between these dimensions, matrices of the correlation coefficients *r* were calculated (*Tables 2 and 3*). On the positive side, very high and significant correlations exist between subperiosteal diameter and its area, between medullary cavity width and its area, between cortex width and percent cortex width, and between percent cortex width and percent cortex area both for humerus and femur. Highly significant negative correlations are present between percent cortex width, percent cortex area and medullary cavity area. Thus, only three measures, the subperiosteal diameter, the medullary cavity width and the cortex width are truly independent, whereas nearly all others are highly dependent on these and can even be considered as redundant.

It was decided to use the most uncorrelated measures for plotting in two dimensions. As such, the measures of the animals listed above were plotted against the archaeological specimens and *Homo sapiens* with its mean. The bivariate plots as shown in *Figs. 6, 7, 8, 9.* suggest that there is an appreciable separation between the animal and the human groups in the humerus, but not in the femur. Consequently, I concentrated my efforts on the humerus which has the greatest probability of successfully identifying these bone artifacts. Overlap of the animal means and the artifacts is minimal in the graphs using humerus bones, but much larger in the graphs using femora, pointing to the fact that the Lamanai fragments fall clearly into a human humerus sample. Thus, it was decided to calculate and compare the z-scores ((X_1 - m)/sd) and their probabilities for the questionable fragments versus the human humerus and femur and the animal humerus and femur means. Comparing the z-scores of the first three independent measures (subperiosteal diameter, medullary cavity width and cortex width), the following picture emerges (*Table 4*).

In all three measures, by far the smallest z-scores and thus the greatest probabilities of correctly placing the unknown pieces, are present in the human humerus group. In contrast to this result, the z-scores calculated by using the human femur sd's are considerably larger and are frequently outside of three sd's. It can safely be concluded from this that the probability of the unknown Lamanai fragments coming from a human humerus sample is very high, whereas their probability of being within a human femur sample is very slim indeed. Unfortunately, the known human femur fragment LA 931/11 rests squarely within the humerus sample. However, we must keep in mind that this femur has been substantially thinned down in its cortical thickness thus changing it in these simple measures to what is normal for humeri. Obviously, its true identity is masked by this artificial modification and a note of caution must be expressed if outer and inner walls of a bone appear to be altered. But animal humeri, and even animal femora, also score relatively closely. The reason for this somewhat unexpected result is the fact that many small and large Mammalian species were included in calculating means

TABLE 2. *Mean (in mm), and Standard Deviation for Human and Animal Humerus; Pearson's Correlation Coefficient for Human Humerus Measures 1 - 10*

I. Humerus (Homo s. n = 22; Animals n = 13)	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Animals X =	224.1	22.0	23.8	14.3	9.4	39.9	290.5	63.4	474.2	171.7
sd =	52.1	5.7	6.3	3.9	3.6	7.5	156.2	8.3	229.0	96.7
Homo s.										
1. Gr length X = 313.6 sd = 18.4	-	0.507	0.558	0.087	0.396	0.209	0.573	0.254	0.573	0.007
2. Diameter X = 18.7 sd = 2.0		-	0.648	0.000	0.564	0.358	0.696	0.268	0.644	0.000
3. Subper diam. X = 18.9 sd = 1.8			-	0.385	0.494	0.121	0.822	0.126	0.998	0.408
4. Med cav wi X = 10.3 sd = 2.0				-	0.611	0.866	0.202	0.857	0.392	0.996
5. Cortex wi X = 8.6 sd = 2.1					-	0.921	0.896	0.916	0.487	0.588
6. %Cortex wi X = 45.4 sd = 9.7						-	0.658	0.995	0.115	0849
7. Cort area X = 196.9 sd = 51.4							-	0.662	0.820	0.180
8. %Cort area X = 69.3 sd = 10.6								-	0.121	0.864
9. Subper area X = 283.1 sd = 55.6									-	0.414
10. Med cavity area X = 86.2 sd = 32.2										-

and standard deviations and thus, the unusually large standard deviation for an animal sample varying from peccary to tapir to caribou make the z-scores very small. I would like to recommend that for a successful application of this method, a sample each from a limited number of Mammalian species rather than a mixture be selected using the criteria of geographical distribution, size and morphology in order to positively identify unknown bone pieces. The confounding factors of age and sex had to be disregarded here because neither of them are known with any degree of certainty for the artifacts.

I would like to approach the second question now, that of the supposed cultural significance of the artifacts. First it can be safely said that worked human or animal bones are not that rare among Maya archaeological remains. Kidder (1947) reported on the discovery of 32 tubular bone objects from the site of Uaxactun, Guatemala. He suspected some of the pieces to be used as beads, others as whistles and hafts or batons, but says

TABLE 3. *Mean (in mm), and Standard Deviation for Human and Animal Femur; Pearson's Correlation Coefficient for Human Femur Measures 1 - 10*

II. Femur (Homo s. n = 21; Animals n = 14)	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Animals X =	269.9	23.0	23.1	14.2	8.9	37.7	272.5	60.8	437.2	164.7
sd =	48.1	4.9	4.9	2.7	2.8	5.9	126.2	7.1	175.7	61.1
Homo s.										
1. Gr length X = 446.1 sd = 22.6	-	0.486	0.310	0.201	0.110	0.047	0.310	0.034	0.305	0.202
2. Diameter X = 24.8 sd = 1.4		-	0.756	0.397	0.359	0.039	0.567	0.021	0.765	0.394
3. Subper diam. X = 24.4 sd = 1.8			-	0.473	0.525	0.007	0.740	0.014	0.998	0.476
4. Med cav wi X = 11.6 sd = 1.8				-	0.500	0.876	0.056	0.870	0.470	0.998
5. Cortex wi X = 12.8 sd = 1.8					-	0.854	0.673	0.855	0.526	0.496
6. %Cortex wi X = 52.5 sd = 6.4						-	0.338	0.997	0.001	0.871
7. Cort area X = 372.7 sd = 74.8							-	0.353	0.738	0.005
8. %Cort area X = 77.0 sd = 6.0								-	0.008	0.869
9. Subper area X = 471.3 sd = 69.8									-	0.472
10. Med cavity area X = 108.1 sd = 32.0										-

that "identification is so doubtful... that I have not attempted a classification" (p. 57). We know that human bone(s) in general is/are of great significance in religion and myth. Other pieces from other sites such as Uaxactun in Guatemala or Altun Ha in Belize (Pendergast 1980, p. 10) show decorations of much greater beauty, and like those from Uaxactun, they resemble most obviously pieces of a flute or recorder with finger-hole stops made to modify the frequency of the sound when covered or not covered with the finger tips. However, our bone pieces do not show any stops and their purpose is therefore even less clear. This is particularly true for LA 247/20 which has one end slightly thinned out to be fitted to another piece. Composite flutes or trumpets are indeed not that rare in Maya society, and, as the excavation of Bonampak has shown recently (Healy 1988), music must have played a greater role in Maya culture than previously thought. Some murals from the site of Bonampak in Belize show exactly these flutes and trumpets; the excavation of Pacbitun

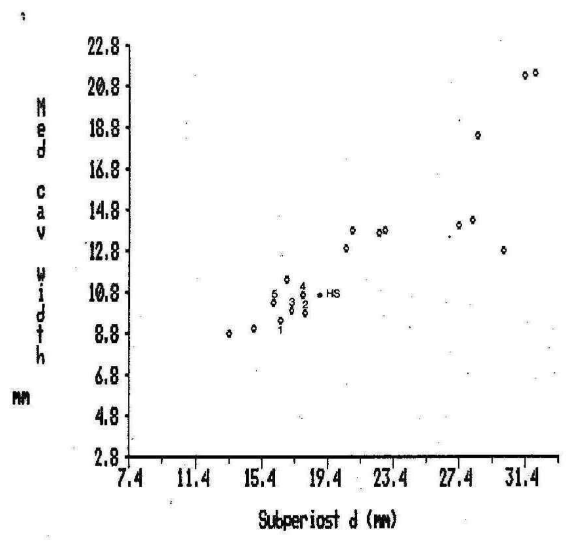


FIGURE 6. *Humerus subperiosteal diameter versus Medullary cavity width Explanations: 1-5 = Lamanai fragments 1-5, HS = Homo sapiens*

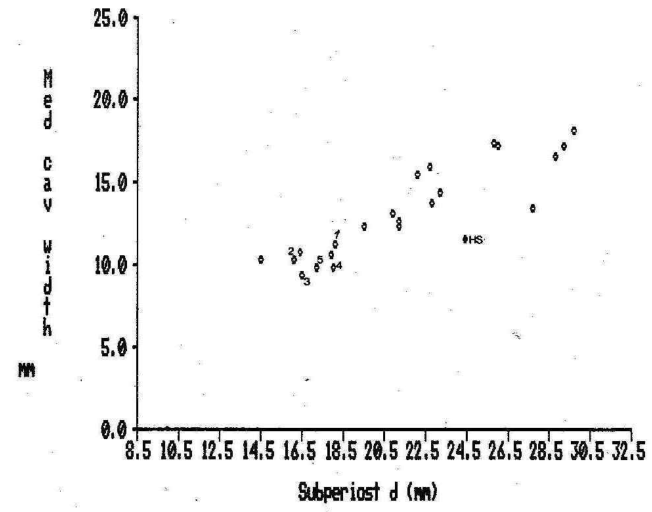


FIGURE 8. *Femur subperiosteal diameter versus Medullary cavity width*

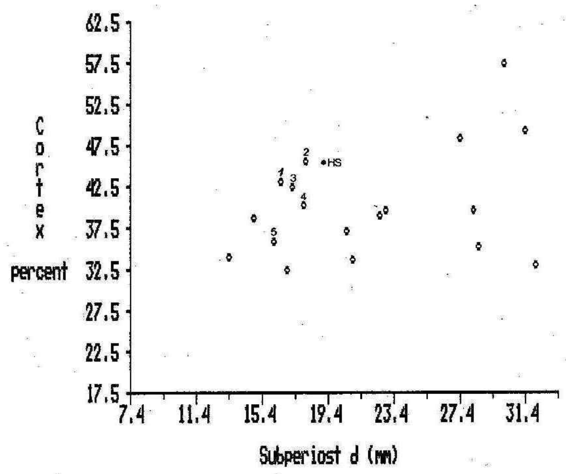


FIGURE 7. *Humerus subperiosteal diameter versus Cortex (percent)*

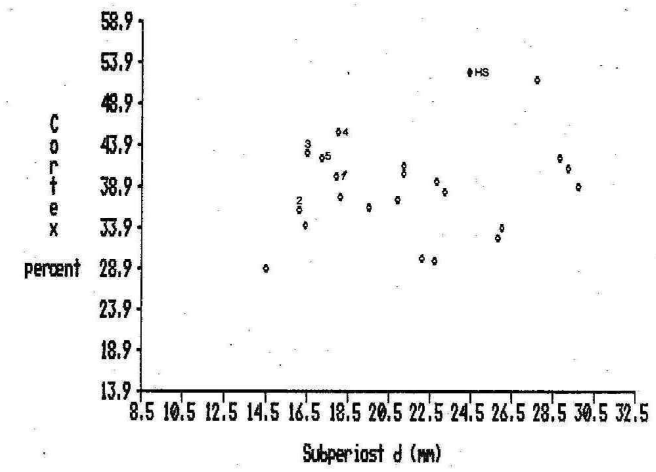


FIGURE 9. *Femur subperiosteal diameter versus Cortex (percent)*

(Healy 1988) has yielded a number of ceramic flutes or ocarinas which are partly reminiscent of our bone artifacts (Healy 1988, p. 30). One can safely assume as a possible explanation for the Lamanai artifact LA 247/20 that it was fitted into a larger instrument or more pieces which could then be played by changing the sound.

The large femur piece LA 931/11 to me resembles a trumpet with its larger and wider distal end. It could have been fitted to a mouth-piece designed to cause a sound, or, another explanation, it could have been used as a drumstick or baton. It is not logical that it was intended to be used for making beads or needles, otherwise it would have been better to polish it afterwards. Also, the shaft is too thin for beads and no longitudinal cuts are observable. Thus, a musical instrument is a likely explanation for its cultural usage. There are still the two enigmatic humerus pieces left to explain. These two conclusively human humeri come from one burial in which two more intricately carved human bones were found. Since the skeleton itself had nearly totally disintegrated, their condition virtually excludes identification with the principal individual in the tomb, unless the humeri were cut from the individual and fairly completely stripped of flesh. The decay of the principal individual would almost certainly have been paralleled by any bone encased in flesh. The possibility exists, as it does for isolated crania associated with burials elsewhere, that retention of bones of one or more ancestors is in evidence, but this cannot be substantiated in the absence of some means of relating the humeri to

TABLE 4. *Z-scores and p (one-tailed) for Lamanai fragments vs. known samples*

		Subper diam	Medcav width	Cortex	Subper diam	Medcav width	Cortex
LA 1, 247/20			Human humerus			femur	
	z=	0.56	0.21	0.67	3.56	0.50	3.11
	p=	0.57	0.83	0.50	0.00	0.62	0.00
			Animal humerus			femur	
	z=	0.94	0.92	0.61	1.06	1.36	0.60
	p=	0.34	0.35	0.54	0.29	0.17	0.55
LA 2, 247/20			Human humerus			femur	
	z=	1.5	0.00	1.33	4.56	0.72	3.11
	p=	0.13	1.00	0.17	0.00	0.47	0.00
			Animal humerus			femur	
	z=	1.22	1.01	0.99	1.43	1.44	1.09
	p=	0.22	0.31	0.32	0.15	0.15	0.27
LA 774/24			Human humerus			femur	
	z=	1.33	0.45	0.71	4.89	1.28	3.72
	p=	0.18	0.64	0.23	0.00	0.20	0.00
			Animal humerus			femur	
	z=	1.16	1.24	0.64	1.35	1.77	0.99
	p=	0.25	0.21	0.52	0.18	0.07	0.32
LA 774/28			Human humerus			femur	
	z=	0.50	0.24	0.19	3.50	1.00	2.56
	p=	0.62	0.79	0.85	0.00	0.31	0.00
			Animal humerus			femur	
	z=	0.92	1.39	0.33	1.04	1.62	0.24
	p=	0.35	0.16	0.74	0.29	0.10	0.81
LA 931/11 fe			Human humerus			femur	
	z=	0.94	0.19	0.62	3.94	0.94	3.06
	p=	0.34	0.85	0.53	0.00	0.35	0.00
			Animal humerus			femur	
	z=	1.05	1.11	0.58	1.20	1.59	0.56
	p=	0.29	0.26	0.56	0.23	0.11	0.57

the principal individual genetically or chemically - an impossibility due to the destruction of that individual's skeleton. Two other better preserved individuals "tossed in at the south side above the tomb's base" (Pendergast 1984, p. 8) were obviously not the source of these two pieces. The significance of these undecorated bones must therefore be left wide open; it can only be suspected that by using human instead of any other type of bone, these pieces acquired a special significance which we do not know. Perhaps they were intended to be composite in-between tubes, since it is only likely that many musical instruments were made from other, perishable material and that major parts which once belonged to the artifacts described above are gone forever.

ACKNOWLEDGEMENTS

I would like to express my gratitude to Dr David Pendergast (Royal Ontario Museum, Toronto, Canada) for allowing me to examine the valuable pieces at Trent and for helping me with valuable information about Lamanai. This work would have been impossible without his support and that of Dr H. Savage (Dept. of Anthropology, University of Toronto) who provided me with many animal bones for analysis for which I am very grateful. Finally, my thanks are due to Dr K. Peterson for his expertise in X-raying the bones.

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