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NATIONAL SCIENCE FOUNDATION FINAL PROJECT REPORT
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Analyses of the La Chimba Faunas

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Analyses of the archaeofaunal component from the northern highland site of La Chimba, Pichincha Province, Ecuador provide us with a comprehensive picture of the largest single archaeofaunal inventory yet excavated from one site in the country. These studies also detail, for the first time, the nature of a zooarchaeological assemblage from a high elevation area which also brackets an important 700 year temporal span in Ecuadorian prehistory. This final project report only briefly discusses the excavated contexts of the La Chimba site, as these are detailed elsewhere (Athens 1990). Emphasis is placed on the NSF-funded analyses of the archaeofaunal materials, including: 1. current disposition of the archived collections; 2. analytical techniques and methods used in the study; and, 3. descriptive documentation of the assemblage with emphasis on taxonomic identification, assemblage representation, aspects of archaeofaunal accumulation and preservation, and cultural modification. An appendix provides detailed results of the photondensitometry component of the project. We are currently in the process of compiling detailed project descriptions, along with publishing the entire archaeofaunal data base in digital format for distribution on a CD-ROM compact disk. These will eventually be distributed to appropriate authorities in Ecuador, the National Science Foundation, and archaeological and palaeontological colleagues throughout the Americas and Europe. Remaining copies will subsequently be made available upon request while supplies last.

Test Pit Excavations at the La Chimba Site

The site of La Chimba (Pi-1) is situated at an elevation of 3,180 masl along the Río La Chimba, approximately 3 km east of the town of Olmedo and 26 km east-southeast of Otavalo in the northern highland province of Pichincha, Ecuador. The site was first identified and tested during a regional program of dissertation field research undertaken by Athens (1978; 1980; Athens and Osborn 1974) between 1972 and 1976. The very deep stratigraphy at La Chimba is unique for sites in the Northern Andean area; therefore, excavation strategy was geared toward acquiring an extended column from midden deposits. An initial 1 X 1 m test pit (TP A) was excavated in the 1972 season., followed by excavation of TPs 1 through 4 in 1974. TPs A and 1-3 were situated inside an existing tapia enclosure, and varyingly contained .9 to 1.2 m of archaeological deposits representing the early and middle ceramic periods at La Chimba (Athens 1978; Goff 1980). TP 4, situated outside the enclosure, contained 2.5 m of deposits encompassing early middle and late ceramic periods, plus two reliable radiocarbon dates of 15 B.C. (L.10) and 150 B.C. (L.13). All units included multiple lenses and burned surfaces in association with dense cultural remains consisting primarily of pottery, obsidian flakes and animal bones (Athens 1978, 1990; Athens and Osborn 1974; Goff 1980; Wing 1977).

With the aid of a three month Fulbright Research Fellowship, Athens (1990) conducted several test excavations in 1989 to augment the information available from work undertaken during the mid-1970s. Three further excavation units were tested. Two of these units yielded archaeofaunal remains which were analysed in this study. TP 5 was a 1X2 m unit situated on the top of a low mound on the eastern margin of the site, and excavated in 10 to 12 cm arbitrary levels to 1.78 mbd with cultural deposits extending to 1.59 mbd. All deposits were screened through ⅛ inch wire mesh. TP 7 was a 2X2 m unit situated in the center of the highest mound on the western margin of La Chimba. The unit was excavated to a depth of 3.22 mbd, using ¼ inch mesh. Thirty, six liter samples from each provenience were water screened through ⅛ inch mesh. Cultural deposits continued to a depth of 2.96 mbd. Fifteen radiocarbon dates from throughout the unit suggest a temporal span from 750 B.C. to A.D. 100. Detailed descriptions and profile drawings of TPs 5 and 7 are found in Athens (1990).

Zooarchaeological Analyses of the La Chimba Archaeofaunas

TP 5 and TP 7

The archaeofaunal assemblage recovered in the 1989 excavation season from TPs 5 and 7 was shipped from the International Archaeological Research Institute, Inc. (IARII) in Honolulu, Hawaii to the Archaeological Analytical Research Facility (AARF) in the Department of Anthropology, Binghamton University, Binghamton, New York. The assemblage arrived in the original cloth field specimen bags which were sorted by provenience and cataloged by field specimen number. Bags and their contents were deposited, according to separate catalog number and provenience in temporary storage shelves arranged by unit and vertical level.

Table 1 lists the coding procedures employed in the assemblage analysis. Headings in bold type, preceded by separate numbers, represent distinct data base fields. Accompanying text lists the range of typical data base entries. Zoological identifications were undertaken using the comparative collections housed in the AARF, with difficult identifications separated and cataloged with indelible ink for later consultation in the various collections of the American Museum of Natural History (AMNH). Zoological identifications were coded in hierarchical taxonomic format in order to accommodate different levels of identifiability due to specimen completeness and differential diagnostic acuity. For example, dental materials identified to the genus level as *Phyllotis* (Leaf Eared Mouse), were simultaneously coded as: Mammal, Small (Class); Rodentia, Small (Order); Muridae, Small (Family). Size class designations in Table 1 were followed for mammals; otherwise, all other classes relied on more arbitrary criteria of `small,' 'medium' and 'large.' This coding system could therefore accommodate various zoological levels of identification, while at the same time facilitating data sorting for different kinds of analyses. It also eliminates an 'unidentifiable' or 'indeterminate' category above the level of Class through considering every fragment as potentially 'identifiable.' Each identification was entered into a relational data base (Paradox Ver. 3.5, File Pi1FAUNA.DB) along with identifying field catalog number and associated Test Pit number.

In addition to taxonomic identification, each specimen was related to skeletal plan using separate coding systems for skeletal element and portion thereof. Paired elements were sided

Table 1. La Chimba Archaeofaunal Coding

***1.* TP**	Test Pit #		
***2.* CAT.**	La Chimba Catalog Number		
***3.* CLASS**	Zoological Class		***4.* S1** Size Category
	gas tropod	ost eichthyes	L arge (TL>1000 mm)
	pel ecypod	amp hibia	M edium (TL=260-1000 mm)
	con drichthyes	ave s	S mall (TL<260 mm)
	rep tilia	mam malia	
***5.* ORDER**	Zoological Order		***6.* S2** Size Category
	mar supialia	per issodactyla	L arge
	pri mates	art iodactyla	M edium
	car nivora	rod entia	S mall
	lag omorpha		
***7.* FAMILY**	Zoological Family		***8.* S3** Size Category
	did elphis	pro cyon	L arge
	hom inidae	mus telidae	M edium
	urs idae	fel idae	S mall
	tap iridae	cer vidae	
	sci uridae	mur idae	
	cav iidae	ago outidae	
	lep oridae		

***9.* GENUS/species**

***10.* ELEMENT** (Code) ***11.* PORTION** (Code) ***12.* SIDE** (L eft, R ight, B oth)

***13.-20.* SCAN SITES 1-8 (or Cranial Index)** -measured in <.25, <.5, <.75, <1 increments

***21.-24.* DENTITION** (tooth bearing bones) -recorded numerically (**I** ncisor, **C** anine, **P** remolar, **M** olar)

***25.* FUSION/ERUPTION**	Column 1	Column 2 (Age Estimate)	
	F used	1	<1
	P artially fused	2	1-2
	U nfused	3	3-4
	D eciduous denition only	4	mature
	M ixed dentition	5	aged (attrition)
	S econdary dentition only		

***26.-27.* BURNING** **B1** **B2** (2 Fields, separated if burning stages are different)

	Column 1		Column 2	
1	Yellow-brown to Pink-brown (220-350 C)	1	Burned over entire piece	5 Burned Prox. and Mid.
2	Dark brown to black (350-400 C)	2	Burned Proximal	6 Burned Dist. and Mid.
3	Dark blue-gray to light grey (400-500 C)	3	Burned Middle	7 Burned Prox. and Dist.
4	Pink-grey to white (Calcined((500 C)	4	Burned Distal	8 Burned Interior Only
				9 Burned Exterior Only

***28.-30.* OBSERVATIONS** **OBS1** **OBS2** **OBS3**

a rticulated
b abraded
c hew/puncture
d igested
g rodent gnaw
I ntrusive
p olished
r root staining
w eather (+ numeric stage)
x cut/saw (+ description of separate sheet)
y calcium carbonate/caliche

***31.-32.* BREAKAGE** (2 fields to record Mixed Breakage Patterns, e.g. HE1; LO3 etc.)

	Column 1				Column 2
HE	Helical	LB	Longitudinal and Oblique	1	Proximal
TR	Transverse	TL	Transverse and Longitudinal	2	Distal
OS	Oblique, straight path	SA	Sagittal	3	Dorsal
OP	Oblique, stepped path	V	V-shaped	4	Ventral
ST	Stepped path	U	Unknown	5	Medial
LO	Longitudinal			6	Lateral

***33.* MAXIMUM LENGTH (maxl)** (mm) ***34.* MAXIMUM WIDTH (maxw)** (mm) ***35.* WEIGHT (wt)** (g)

***36.* QUANTITY (qty)** (n) ***38.* ADD** (additonal text comments) whenever possible. A separate coding system for skeletal fragmentation was used for describing the remains of cervids and leporids. The system is based upon studied density values for either taxa (see appendix) and was developed through a number of published suggestions for increasing accuracy in recording assemblage fragmentation (*e.g.* Dobney and Reilly 1988; Lyman 1992:20; Marean 1991; Morlan 1994). The preservation of each cervid or leporid element is described in terms of estimated percentage survivorship for every scan site using rough increments of .25, .5, .75, and 1. A blank field refers to the absence (lack of preservation) of that scan site. An arbitrary coding for cranial zones, modeled after Dobney and Reilly (1988) was used as the cranium has no associated scan site values.

Separate fields recorded the numerical presence/absence of teeth, as well as fusion/dental eruption states and associated age estimations. Two fields were dedicated to recording different burning states with an accompanying code for degree and anatomical orientation of any heat alteration. Observations were recorded using alphanumeric symbols, as were breakage patterns with their associated anatomical orientations. Maximum length and width of each fragment was measured in mm, as was weight in g. Quantities and any additional comments were recorded in the two final fields.

TPA, TPs 1-4

Archaeofaunal materials recovered from five of the earlier excavated test pits at La Chimba are currently curated in the collections of the Florida Museum of Natural History (FMNH). These include all materials from the initial TP A excavation in the 1972 season, and TPs 1, 2, 3 and 4, subsequently excavated in 1974. Two other proveniences are curated separately in these collections, including: Pi-1-wa, or "white ash;" and, Pi-1-40. Both proveniences are unknown as no entry exists for either catalog designation.

Through the kind courtesy of Dr. Elizabeth Wing, we were allowed to examine these collections at the FMNH during February 1996. Due to time limitations, the materials were not examined in the same detail as TPs 5 and 7. For control, TP 1 was described using the density scan site survivorship estimations; however, detailed metrical measurements of each specimen were not recorded. For all of the remaining proveniences curated at the FMNH, standardized and filed descriptions of zoological identification, skeletal element, element portion (when recorded), and side, were checked and entered into the computerized data base. Unrecorded waste was examined for potentially identifiable material, but was otherwise not recorded. Therefore, unlike TPs 5, 7, and 1, specimen quantities for the collections curated at the FMNH, should be considered as conservative figures for their respective assemblages, as 'indeterminate' material is not included in the calculations.

The La Chimba Archaeofaunas

The La Chimba archaeofaunal assemblage consists of at least 40,313 examined specimens. Larger archaeofaunal collections from excavated deposits in Ecuador are available for study; however, these assemblages represent multi-site accumulations recovered within the context of broader, regional projects. Archaeologically, little is known of the northern highland area, and even less is known about prehistoric ecology and subsistence. To date, the La Chimba archaeofaunal assemblage is by far the largest single archaeofaunal data set yet analysed from any site in Ecuador. For example, by comparison with other highland Ecuadorian sites at Cochasquí (N=409-425, Kaulicke 1989:242; Fritz and Schoenfelder 1987:145), Cotocollao (N=202, Villalba 1988: Figura 174), around Cumbayá (N=339, Gutiérrez and Iglesias 1995:404), Socapamba (N=50+, Athens 1980), Chobshi Cave (N=258?, Lynch and Pollock 1981:98), Pirincay (N=1495, Miller and Gill 1990:52) and Putushío (N=6110, Freire 1993: pers. comm.), the La Chimba archaeofaunal assemblage is truly impressive in size. We hope that knowledge gained from excavations at La Chimba might serve as a future reference point for subsequent archaeological research throughout the temporal span of prehistoric occupation in the northern highland area

Taxonomic Representation

Table 2 lists the raw counts of various zoological taxa represented in the La Chimba deposits. This table expresses the limitations of taxonomic identification based upon the use of fragmented osseous material. Zoological identifications are rarely higher than the genus level. An accompanying Table 3 lists both the scientific and common names of contemporary zoological analogs that may be used to understand aspects of prehistoric ecology and subsistence in this area of the northern Ecuadorian highlands. Nomenclature follows a number of authoritative sources (Albuja 1991; Eisenberg 1989; Hilty and Brown 1986; Morris 1966; Patzelt 1989; Voss 1992).

Indeterminate. Every effort was made to identify all material at least to the level of zoological class. In particularly ambiguous cases, this was undertaken with the aid of a magnifying lense or stereo zoom microscope. In many cases, identification to class was impossible, principally as a factor of specimen fragmentation. At least 525 fragments remain unidentifiable to the level of class. Figure 1 plots the maximum width in mm (left floor axis) and maximum length in mm (right floor axis) against frequency (vertical wall axes). The majority of these tiny pieces are generally under 10 mm in either maximum dimension.

Mollusca. A number of indeterminate molluscan shell fragments (N=69) are likely from some sort of terrestrial gastropod. The majority (N=198) of molluscan remains were identified by Dr. Elizabeth Wing and her students at the FMNH as *Scutalis quitensis*, a terrestrial gastropod of the large South American family Bulimulidae. Kaulicke (1989:242) identified the remains of another Bulimulid species *Bulimulus subfasciatus* at Cochasquí An additional fraction (N=40) of molluscan shell material from TP 5 and TP 7 is simply identified as gastropod. Most of these fragments were identical to the identified pieces in the La Chimba collections curated at the FMNH. Local residents claim that similar land snails, locally known as *churros* are imported from the nearby Chota Valley, where they are collected for sale. Four rim fragments were identified as *Spondylus*, the famous Pacific bivalve *mullu* which was widely distributed around the precolumbian Andean world from its natural habitat off the Ecuadorian coast. All were recovered in ⅛ inch mess from the same context (Pi-1-42) in TP 5, Level 9. The combined weight of the recovered pieces is less than 1 g (wt= 0.91 g) with minimum dimensions ranging from 3 to 8 mm and maximum dimensions ranging from 8 mm to 17 mm.

Fig. 1 La Chimba

Indeterminate (to Class) Fragments

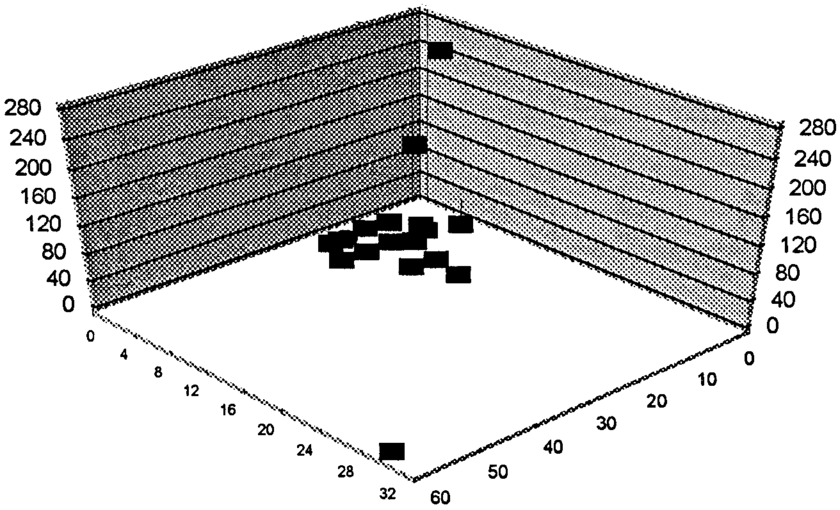


Table 2. La Chimba (Pi-1) Archaeofaunal Taxa

		Freq.
Indeterminate		525
Mollusca Indet.		69
Gastropoda Indet.		40
	Scutalis quitensis	169
	cf. *Scutalis quitensis*	29
	Spondylus	4
Decapoda Indet.		3
Osteichthyes Indet.		3
Chelonia Indet.		1
Sauria Indet.		13
Serpentes Indet.		1
Aves Indet.		298
Tinamidae Indet.		47
Anatidae Indet.		4
	cf. *Geranoaëtus*	3
Cracidae Indet.		1
Columbiformes Indet.		3
Columbidae Indet.		2
	Columba	10
	Bubo virginianus	1
	cf. *Bubo virginianus*	1
Trogonidae Indet.		1
Corvidae Indet.		7
Mammalia Indet.		18,131
Marsupialia Indet.		11
Didelphidae Indet.		3
	Chironectes	3
	Didelphis	14
	Dasypus	6
	Saimiri	1
	Homo	98
	cf. *Homo*	1
Carnivora Indet.		20
	cf. *Canis*	7
	Dusicyon	3
	cf. *Dusicyon*	1
	Tremarctos	9
	cf. *Tremarctos*	5
Procyonidae Indet.		1
	Procyon	4
	Nasua	1
	cf. *Nasua*	2
	Nasuella	1

Table 2 (cont.). La Chimba (Pi-1) Archaeofaunal Taxa

		cf. *Nasuella*	1
		Potos	1
		cf. *Potos*	1
	Mustelidae Indet.		1
		Mustela	4
		Conepatus	1
		cf. *Conepatus*	2
		Felis	1
		Felis cf. *concolor*	35
		cf. *Felis concolor*	2
		Tapirus	134
		cf. *Tapirus*	2
Artiodactyla Indet.			52
	Cervidae Indet.		1192
		Odocoileus	3987
		cf. *Odocoileus*	2
		Mazama	36
		cf. *Mazama*	39
		Pudu	446
		cf. *Pudu*	15
Rodentia Indet.			127
	Muridae Indet.		3
		Oryzomys	2
		Thomasomys cf. *aureus*	4
		Thomasomys (cf. *paramorum)*	1
		Phyllotis	7
		Akodon	1
		Sigmodon	2
		Coendou	2
		Agouti	64
		cf. *Agouti*	2
	Leporidae Indet.		10
		Sylvilagus	14,480
		cf. *Sylvilagus*	97
Total			***40,313***

Table 3. Scientific and Common Names of Contemporary Zoological Analogs Possibly Represented in Prehistoric Context at La Chimba (Pi-1)

Mollusca	Molluscs/Moluscos
Gastropoda	Gastropods/Gastrópodos, Caracoles
Scutalis quitensis	Terrestrial Gastropod/Caracoles Terrestres
Bivalvia	Bivalves/Conchas
Spondylus	Spondylus/Espondylus
Crustacea	Crustaceans/Crustáceos
Decapoda	Crabs/Cangrejos
Osteichthyes	Bony Fish/Peces Oseos
Reptilia	Reptiles/Reptiles
Chelonia	Turtles/Tortugas
Sauria	Lizards/Lagartijas
Serpentes	Snakes/Serpientes
Aves	Birds/Aves
Tinamiformes	Tinamous/Falsas Perdices
Tinamidae	Tinamous/Falsas Perdices
Nothocercus curvirostris	Paramos Tinamou/Perdiz de Páramo
Anseriformes	Ducks, Geese, Swans/Patos, Gansos, Cisnes
Anatidae	Ducks/Patos
Falconiformes	Vultures, Hawks, Falcons/Gallinazos, Aguilas, Quilicos
Accipitridae	Kites, Hawks, Eagles/Aguilas, Gavilanes, Guarros
Geranoaëtus melanoleucus	Black-Chested Buzzard Eagle/Guarro, Aguila Real
Galliformes	Chachalacas, Guans, Curassows/Pavas, Paujiles
Cracidae	Chachalacas, Guans, Curassows/Pavas, Paujiles
Columbiformes	Doves, Pigeons /Tórtolas, Palomas
Columbidae	Doves, Pigeons /Tórtolas, Palomas
Columba	Pigeon/Paloma
Strigiformes	Owls/Lechuzas, Búhos
Strigidae	Typical Owls/Lechuzas, Búhos
Bubo virginianus	Great Horned Owl/Lechuza
Trogoniformes	Trogons, Quetzals/Pilcos, Guajalitos, Mingalitos
Trogonidae	Trogons, Quetzals/Pilcos, Guajalitos, Mingalitos
Passeriformes	Perching Birds/Pájaros
Corvidae	Crows, Jays/Grajos
Cyanolyca	Jay/Grajo
Cyanocorax	Jay/Grajo
Mammalia	Mammals/Mamíferos
Marsupialia	Opossums/Comadrejas, Raposas, Zorras
Didelphidae	Opossums/Comadrejas, Raposas, Zorras
Chironectes minimus?	Water Opossum/Raposa de Agua
Didelphis albiventris	Azara's Opossum/Zorra
Xenarthra	Armadillos
Dasypodidae	Armadillos
Dasypus novemcinctus	Nine-banded Armadillo/Mulita, Armadillo
Primates	Monkeys, Humans/Monos Humanos
Cebidae	Cebid Monkeys/Monos
Saimiri sciurus	Squirrel Monkey/Barizo

Table 3 (cont.). Scientific and Common Names of Contemporary Zoological Analogs Possibly Represented in Prehistoric Context at La Chimba (Pi-1)

Hominidae	Human/Humano
Homo	Human/Humano
Carnivora	Carnivores/Carnívoros
Canidae	Dogs/Lobos, Perros
cf. *Canis familiaris*	Dog/Perro
Dusicyon culpaeus	Fox/Lobo de Páramo
Ursidae	Bears/Osos
Tremarctos ornatus	Spectacled Bear/Oso de Anteojos
Procyonidae	Raccoons, Coatis, Kinkajous/Ositos, Cuchucho, Cusumbo
Procyon cancrivorous	Crab-eating Raccoon/Osito Lavador, Mapache
Nasua narica	Coati/Cuchucho
Nasuella olivacea	Mountain Coati/Cuchucho Andino
Potos flavus	Kinkajou/Cusumbo, Cuchicuchi
Mustelidae	Weasels/Chucuris
Mustela frenata	Long-tailed Weasel/Chucuri, Comadreja
Conepatus chinga	Hog-nosed Skunk/Mofeta, Zorro Hediondo
Felidae	Cats/Gatos
Felis concolor	Puma, Mountain Lion/Puma, León Americano
Perissodactyla	Odd-toed Ungulates
Tapiridae	Tapirs/Dantas, Tapires
Tapirus pinchaque	Mountain Tapir/Danta de Monte, Gran Bestia
Artiodactyla	Even-toed Ungulates
Cervidae	Deer/Venados, Pudus
Odocoileus virginianus	White-tailed Deer/Venado de Páramo
Mazama rufina	Dwarf Red Brocket/Soche, Chivicabra
Pudu mephistophiles	Northern Pudu/Pudú, Ciervo Enano
Rodentia	Rodents/Roedores
Muridae	Murid Rodents/Ratas, Ratones
Oryzomys albigularis	Rice Rat/Ratón
Oryzomys talamancae	Talamanca Rice Rat/Ratón
Microryzomys altissimus	Andean Mouse/Ratón
Microryzomys minutus	Andean Mouse/Ratón
Thomasomys aureus	Thomas's Paramo Mouse/Ratón
Thomasomys baeops	Thomas's Paramo Mouse/Ratón
Thomasomys paramorum	Thomas's Paramo Mouse/Ratón de Páramo
Thomasomys rhoadsi	Thomas's Paramo Mouse/Ratón de Páramo
Phyllotis haggardi	Leaf-eared Mouse/Ratón
Akodon mollis	South American Field Mouse/Ratón de Campo
Sigmodon inopinatus	Cotton Rat/Ratón de Cola Peluda
Erethizontidae	Porcupines/Puerco Espines, Erizos
Coendou quichua	Porcupine/Puerco Espín
Agoutidae	Pacas
Agouti	Mountain Paca/Sacha Cuy
Lagomorpha	Rabbits, Hares/ Conejos, Liebres
Leporidae	Rabbits, Hares/ Conejos, Liebres
Sylvilagus brasiliensis	Brazilian Cottontail/Conejo Silvestre

Crustacea. Three minute crab claw portions were identified in the TP 4 fraction, in catalog entries Pi-1-104, 122, and 123. Other than this, little else can be mentioned of these remains; their status as marine or freshwater remaining indeterminate.

Osteichthyes. Three minute scales, presumably from some form of bony fish were identified in similar deposits of TP 4, Pi-1-122. Their status as marine or freshwater also remain unknown.

Reptilia. Only one chelonian specimen, a humerus fragment from some sort of turtle, was identified in TP 1, Pi-1-8 of the FMNH collections. The only remains of snakes consist of one 23 mm long proximal articulation and shaft portion of a medium-sized serpent, recovered in TP 7, Pi-1-159. As many as 12 mostly complete skeletal elements from a small lizard were identified in the fraction recovered through fine ⅛ inch screening of TP 7, Pi-168. Four of the vertebral elements were complete and articulated, suggesting that the remains might be attributed to an intrusive *in situ* death. All of the remains were examined by lizard specialists in the Department of Vertebrate Palaeontology at the AMNH who were unable to identify them. The complete rib of an unidentified larger lizard was recovered from TP 7, Pi-1-218.

Aves. A total of 378 specimens, readily identifiable as some sort of bird remain, were identified in the entire La Chimba assemblage. The majority of these remains (N=298) are indeterminate beyond the level of class. Nearly half (*40.3%*) of these indeterminate remains could not be assigned to an arbitrary size category. The remaining indeterminate specimens are from a variety of small (N=20, *6.7%*), medium (N=136, *45.6%*) and large (N=22, *7.4%*) birds.

The majority of bird remains which could be identified above the level of class, were derived from some sort of Tinamou (N=47). The remains are from a medium-sized form, examples of which are likely related to the contemporary highland genus *Nothocercus.* According to Hilty and Brown (1986:43) a Tawney-Breasted Tinamou *N. julius* currently ranges between 1700 to 3100 m in all three Andean ranges of Colombia, extending from Northwest Venezuela to Eastern Ecuador. It is presumed to replace the like-sized Highland Tinamou *N. bonapartei* at higher elevations, where it is known to inhabit forest floors and openings. Patzelt (1989:104) lists the PáramoTinamou or Perdiz de Páramo *N. curvirostris* as the best known contemporary form in highland Ecuador. A primarily terrestrial bird, the tinamou inhabits fields where it forages for seeds, tender shoots and insects, and hides in vegetation to escape predation.

Ecuador is presently home to a variety of ducks and duck-like birds. Four specimens from a medium-sized exemplar were identified in the assemblage. Three of the archaeological specimens are from contiguous levels (15 and 16) in TP 7. Currently, three medium-sized anatids are known to include high elevation areas over 3000 m into their migratory pattern in northern Ecuador: Speckled *Anas flavirostris*, and Blue-winged Teals *A. discors*; and, Ruddy Duck *Oxyura jamaicensis*. Most frequent marshy areas, ponds or lakes (Hilty and Brown 1986:78).

Three distal limb elements from diverse contexts in TPs 5 and 7 compared well with the Black-Chested Buzzard-Eagle *Geranoaëtus melanoleucus*. Perching on rocks and ledges, this large eagle-sized hawk soars over canyons, forests and lower páramo at high elevations in search of prey and carrion (Hilty and Brown 1986:104). It is also interesting to note that in the

Venezuelan páramo, this eagle is the major predator of *Sylvilagus brasiliensis*, whose remains dominate the La Chimba archaeofaunal assemblage (Durant 1983:26).

The complete quadrate of a medium-sized cracid was identified in TP 7. The Andean Guan *Penelope montagnii* is currently found at high elevations near tree cover, where these primarily terrestrial birds seek cover. The like-sized Sickle-winged Guan *Chamaepetes goudotii* is a primarily arboreal guan, which occupies forests and forest borders up to an elevation of 3000 m (Hilty and Brown 1986:124, 126).

Pigeon or dove remains are relatively common in the avian component of the La Chimba archaeofaunas. Most are likely from some form of pigeon in the genus *Columba*. The Band-tailed Pigeon *C. fasciata* frequents high mountain forests throughout large areas of the Andes, as does the Eared Dove *Zenaida auriculata* which is particularly gregarious in agricultural contexts (Hilty and Brown 1986:187, 190).

The large Great Horned Owl *Bubo virginianus* ranges throughout extensive areas of the New World, and inhabits elevations up to 4000 m in the Andes, where it nests in trees and forages nocturnally for medium-sized game like rabbits and coatis (Hilty and Brown 1986:227). A complete right tarsometatarsus in TP 7, Level 3 was positively matched with this species, and a complete left radius in TP 5, Level 13 compares well with this taxon.

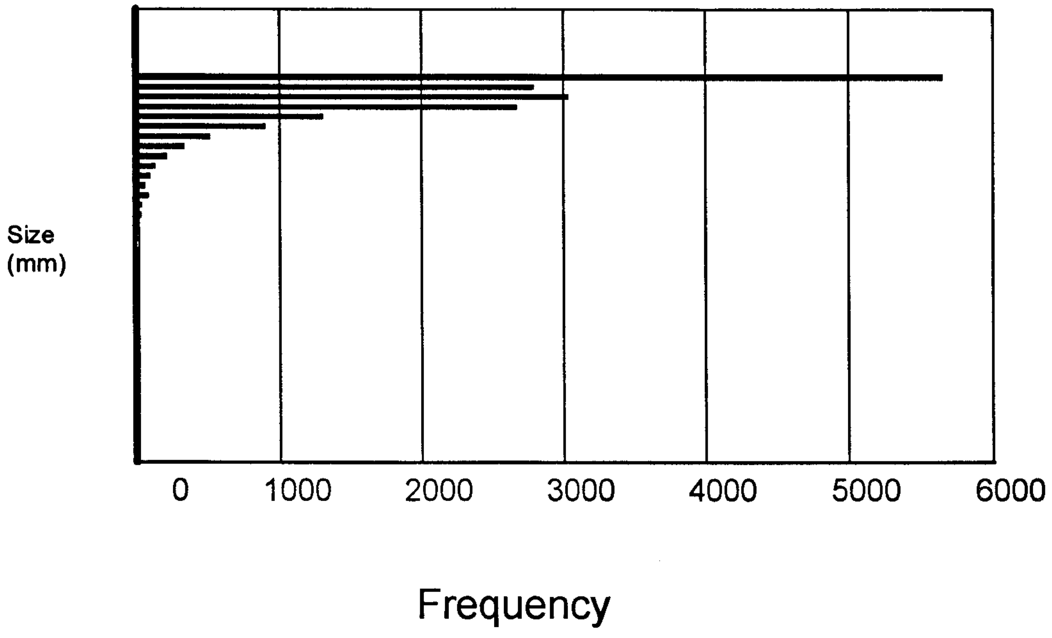
Some form of Trogon or Quetzal was identified in archaeological context at La Chimba. Currently the Masked Trogon *Trogon personatus* ranges throughout high elevations in the Andes, where it tends to be fairly common in and around wooded areas (Hilty and Brown 1986:303).

TPs 5 and 7 contained the remains of medium-sized Jays (crows are not found south of Nicaragua) from six different contexts. Two conspicuous taxa inhabit treed areas and appear to tolerate disturbed areas of secondary growth. The Turquoise Jay *Cyanolyca turcosa* is particularly common in and around Pichincha province (Ridgely and Tudor 1989:41), while the Green Jay *Cyanocorax yncas* frequents mountains and foothills at lower elevations from Venezuela to Bolivia (Ridgely and Tudor 1989:48). A third jay, the Black-collared Jay *Cyanolyca armillata* can be found in extreme northern Ecuador at elevations up to 3000 m where it appears to be less tolerant of cleared areas, preferring to frequent montane forests and forest borders (Ridgely and Tudor 1989:40).

Mammalia. The vast majority of animal remains in archaeological context at La Chimba, consist of readily identifiable mammal bones. The bulk of these specimens are not identifiable higher than the level of class (N= 18,131). The majority (N= 7,444; *41.1%*) were so fragmented that they could not be assigned an arbitrary size designation; whereas the remainder were arbitrarily assigned to Large (N= 5,371; *29.6%*), Medium (N= 4,940; *27.2%*) and Small (N= 376; *2.1%*) indeterminate mammal categories. Based upon metric data from TPs 5 and 7, it would appear that identification, or lack thereof, is largely associated with fragmentation and particle size. Figure 2 displays the frequencies of particle size groups (according to maximum length) recovered in TPs 5 and 7 by increments from smallest (top) to largest (bottom). Over thirty one percent of the indeterminate mammalian remains (N=5,658) are less than 5 mm in maximum length, and the bulk (N= 12,698; *70%*) are less than 25 mm in maximum length, or less than an inch in size. Fragmentation and size have also affected the identification of skeletal elements, as the majority of remains (N= 10,102; *56.2%*) could not be identified to skeletal element. A

Fig. 2 La Chimba

Indeterminate Mammal Fragments



significant portion of the indeterminate mammal remains consist of long bone fragments (N= 5,739; *31.6%*). Virtually all of the latter group are derived from medium- and large-sized mammals. A subsequent section of this report suggests that mammal shafts were apparently exploited for tool use. Most of the remaining indeterminate mammal fraction is composed of unidentifiable vertebral (N= 504; *2.8%*) and rib (N= 1,288; *7.1%*) fragments.

A total of 31 bones in the La Chimba deposits are those of marsupials, representing at least two genera. Firm identification to the level of genus, however, can only be made for the larger *Didelphis*, which does not overlap in size with most smaller forms. The majority of marsupial remains identified only as `Large' are likely from this taxon as well. Currently, *D. albiventris* inhabits high elevation areas in the northern Andes, where it replaces the common *D. marsupialis* above 2,000 m. Like most didelphids, Azara's Opossum is assumed to be a nocturnal generalist (Eisenberg 1989:29). A medium-sized marsupial was earlier identified in the FMNH collections (TP 4) as *Chironectes*. These specimens were not re-examined in this study; however, it is unlikely that the remains, two scapulae and one mandible, are from this genus. Currently, there is only one relatively uncommon species of semi-aquatic Water Opossum *C. minimus* which ranges throughout wide areas of northern South America, but does not appear to inhabit areas above 1,800 m in elevation (Emmons and Feer 1990:18; Marshall 1978). Although scapulae are generally unreliable for genus-level determinations, the mandible with dentition can potentially be used for identification. The only existing record of fragmentation indicates the preservation of three premolars and three molars; which is consistent for most opossums. *Chironectes* is a medium-sized opossum, and most similarly-sized forms are not associated with high elevation environments. The individual might be a smaller *Didelphis*; however, at this point, the status of these remains is uncertain. The collection does include a few examples of smaller-bodied marsupials. Highland Ecuador is home to as many as four and as little as two species of *Caenolestes*, especially *C. fuliginosus* which inhabits vegetation bordering high, moist páramo (Albuja 1991:167; Patzelt 1989:22; Nowak and Paradiso 1983:55).

A total of six immobile scutes from a medium-sized armadillo were recovered in ⅛ inch screen fraction from levels seven and eight of TP 5. The scutes are likely derived from a species of *Dasypus*, the most common being the Nine-banded Armadillo *D. novemcinctus* which generally ranges throughout large areas of lowland habitats from as far north as southern North America. Armadillos can inhabit areas as high as 3,000 m in elevation where they require shady cover and penetrable substrates (Emmons and Feer 1990:42; Patzelt 1989:52; Nowak and Paradiso 1983:466). Certainly if not locally caught at the high elevation of La Chimba, durable carapace fragments can be transported effectively over wide areas.

One fragmented right mandible with two preserved molars was earlier identified from TP 3, Lev. 4 (Cat. 57) as some form of Squirrel Monkey *Saimiri spp.* The mandible, currently housed with the FMNH collections, was reexamined in this study and appears to be from a young specimen. Currently, there are as many as three recognized species of *Saimiri*, none of which ranges higher in elevation than 1,500 m. It has long intrigued zoologists that a disjunct population of *Saimiri*, the Central American Squirrel Monkey *S. oerstedii* appears isolated on the Pacific coast from large, broadly distributed populations of Common Squirrel Monkey *S. sciureus* to the east of the Andes in the Amazon Basin. It is suggested that the former populations may have been anthropogenic introductions (Costello *et al.* 1993; Emmons and Feer 1990:115). In this respect the La Chimba find may be of great interest. Numerous remains of Humans *Homo sapiens* were found throughout the deposits, very likely representing the recovery of materials associated with interments found throughout the complex stratigraphy of La Chimba.

A total of 103 carnivore remains, representing at least nine genera, were identified in the assemblage. At least 20 specimens remain indeterminate above the ordinal level, and are derived mainly from some sort of small carnivore. As many as two different canids may be represented in the La Chimba archaeofaunal assemblage. Tentative identification of some species of *Canis*, potentially the domesticated *C. familiaris*, is suggested at La Chimba. As the remains are from lower limb elements, the identification must remain tentative. Likewise, four specimens in the FMNH collections were earlier identified as, or compared well with, *Dusicyon*. Again, all of these specimens derive from the post cranial skeleton. Currently, the Lobo de Páramo *D. culpaeus* is found in varied habitats up to extremely high elevations throughout the South American Andes where it forages both nocturnally and diurnally for a relatively catholic diet (Albuja 1991:196; Redford and Eisenberg 1992:147). A total of 14 bone fragments were identified as, or compared well with, a medium-sized bear, the only South American representative which is *Tremarctos ornatus*, the Spectacled Bear. An omnivore, the Spectacled Bear is distributed from Panama, south through Andean habitats to Peru and Bolivia. In Ecuador, it inhabits montane forests and subtropical areas (Eisenberg 1989:267; Patzelt 1989:75). With the exception of one lower incisor, all of the remains are derived from the lower extremities, especially the paws. Whether this pattern is of significance, or is merely a factor of differential identifiability brought on by fragmentation, is difficult to say. At least three taxa of Procyonids were identified on the basis of only 12 bone fragments. These tentatively include some form of *Procyon*, the only Ecuadorian representative of which is the Crab-eating Raccoon *P. cancrivorus* (Albuja 1991:197). This nocturnal omnivore appears to be widely distributed throughout northwestern South America, although different authors attribute different geographical distributions to either or both sides of the Ecuadorian Andes (Albuja 1991:197; Emmons and Feer 1990:136; Eisenberg 1989:272; Patzelt 1989:73), but not in high elevation contexts. All the specimens from this taxa include post-cranial skeletal fragments recovered from one context in TP 7 Lev. 15 (Cat. 159), and may prove to be derived from some other animal; however, only smaller felids would appear to overlap in general size. Three post-cranial fragments in the FMNH collection were earlier identified as *Nasua*, as many as two species of which are represented in Ecuador today, a Central American White-nosed Coati *N. narica* and an Amazonian South American Coati *N. nasua* (Albuja 1991:197; Emmons and Feer 1990:138). The anterior portion of a relatively complete premaxilla with no preserved teeth from TP 7 Lev. 17 (Cat. 169) compared well with *Nasuella*, as did an almost complete pelvis from TP 7 Lev. 3 (Cat. 98). The Mountain Coati *N. olivacea* is currently distributed throughout northwestern South America in high elevation montane habitats over 2,000 m (Eisenberg 1989:273). Although there appears to be no size overlap between species of *Nasua* and *Nasuella*, the La Chimba specimens may, on further study, be derived from only the latter. Finally, a distal humerus in TP 7 compared well with, and a calcaneum in the FMNH collection was identified as, *Potos*. Currently only one species of Kinkajou, *P. flavus* inhabits Ecuador, and different authors attribute different distributional ranges including restriction to the eastern lowlands, both western and eastern lowlands, as well as the sierras (Albuja 1991:197; Eisenberg 1989:273; Emmons and Feer

1990:141; Patzelt 1989:75). At least two different kinds of mustelids were identified in the La Chimba assemblage. All of the specimens identified as *Mustela spp.* are tooth-bearing or dental remains. One in particular, a burned left mandible from TP 7 Lev. 15 (Cat. 159) with most of its dentition intact, compared well with the Long-tailed Weasel *M. frenata* which is distributed throughout wide areas of the New World and can inhabit areas up to 4,000 masl. This small carnivore frequents aquatic habitats and preys on smaller wild and domestic taxa (Patzelt 1989:78). Similarly, the Hog-nosed Skunk *Conepatus chinga* is known from elevations as high as 4000 m in Ecuador where it passes the day in constructed burrows and forages nocturnally for a principally invertebrate and vegetal diet (Patzelt 1989:78-80). All identifications are tentatively based on post-cranial elements recovered from TPs 5 and 7. A relatively large number of specimens from six of the La Chimba test pits were identified as deriving from a large felid, generally comparing quite well with the Puma or Mountain Lion *Felis (Puma) concolor*. There are of course two large felid taxa in South America, the other being the Jaguar *Panthera onca*; however, this animal tends to prefer forested habitats generally below 2000 m, whereas the Puma has been recorded in mountainous areas well above 4000 m (Eisenberg 1989:283; Emmons and Feer 1991:153; Patzelt 1989:83). Nevertheless, with the exception of one burned anterior mandible fragment with no teeth, the specimens are all post cranial. The possibility that these remains are fragments of a non-local jaguar can not be ruled out. The majority (N= 30, *86%*) of large felid elements are from the paw; one specimen is potentially modified, and two appear to be weathered, suggesting that a certain degree of curation may not be improbable.

Exceeded only by rabbit and deer on the basis of frequency, Tapir *Tapirus* remains are relatively abundant throughout each excavation unit at La Chimba. Specimens tend to be relatively conspicuous. For example one complete left femur, measuring 320 mm in total length, 90 mm in maximum breadth and 430 g in weight, was recovered from deep in TP 7, Lev. 28 (Cat. 236). A quick perusal of Tapir skeletal elements identified in archaeological context at La Chimba would suggest a relatively even distribution by frequency between cranial, vertebral, upper limb and lower limb portions. These specimens are most likely derived from the Mountain Tapir *T. pinchaque* which inhabits the higher Andean zones between 1500 m and 4,500 m from Venezuela to northern Peru, in wooded or grassy habitats close to permanent water sources (Nowak and Paradiso 1983:1163; Patzelt 1989:89).

With the absence of any form of camelid altogether in the La Chimba deposits, the only artiodactyls identified archaeologically are three native Ecuadorian cervids of the genera *Odocoileus*, *Mazama*, and *Pudu*. The number of cervid specimens (N= 5,717) in the collection is second only to lagomorphs; however, in terms of sheer bulk, the archaeofaunal collection is dominated by cervid remains. With the recognition of some possible overlap between the two larger genera, most of the identifiable cervid remains were assigned arbitrary size categories (Large, Medium, Small), corresponding to the relative size differences between the native taxa. The majority (N= 4,112, *72%*) of cervid specimens which were arbitrarily sized are derived from some form of large cervid. With a marginal degree of imprecision, the majority of these specimens are likely derived from the common White-tailed Deer *Odocoileus virginianus* which inhabits the páramo zones of Ecuador. A generalized browser and grazer, it can be gregarious in zones where particular abundant (Eisenberg 1989:323). It is the only Ecuadorian cervid with highly developed antlers on male specimens (Patzelt 1989:94), thus it is likely that the majority of antler material which was apparently sought for tool modification (see below) derives from this taxon. A smaller amount (N= 467, *8.2%*) of cervid bones were assigned to some form of medium-sized deer. On the basis of size, the Red Brocket *Mazama americana* overlaps considerably with mature *Odocoileus*; however, these animals are more likely found in lower elevation forest settings, while the smaller Dwarf Red Brocket *M. rufina* is distributed into the high Andes (Albuja 1991:201; Patzelt 1989:95). Although very much smaller than the White-tailed Deer, it is still possible that fragmented specimens from small or immature *Odocoileus* might be grouped with those from a mature *M. rufina*, or for that matter, with a possible fragmented portion of *M. americana*. Finally, a slightly larger subsample (N= 613, *10.7%*) of identifiably cervid remains is derived from a small cervid, most likely the Northern Pudu *Pudu mephistophiles*. This taxon is comparatively tiny, and specializes in high elevational settings over 1,700 m where it frequents protective vegetation (Eisenberg 1989:327; Patzelt 1989:95). The entire cervid subassemblage at La Chimba is rather conspicuous and highly identifiable. It would appear from cursory observation that virtually the entire skeletal plan from all three arbitrary size classes is represented. This constitutes part of a more detailed taphonomic study based upon differential skeletal density, which is described below.

Smaller rodent remains in the La Chimba deposits were identified on the basis of molar cusp patterns. A sizeable quantity (N= 127) of post-cranial elements, along with a few edentulous mandibles and isolated incisors were placed, wherever possible, into arbitrary size categories based on live Head-Body measurements. The majority of the indeterminate rodent specimens (N = 95, *75%*) are derived from small rodents under 150 mm HB length. Most of the identifiable specimens derive from smaller murid rodents. Two tooth-bearing fragments from TP 1 Lev. (Cat. 14) are identified as *Oryzomys*. Eisenberg (1989:151) lists two similarly-sized forms of this common genus of Rice Rat which appear to be adapted to higher elevations. *O. albigularis* is distributed throughout Andean montane forests of northwestern South America above 1000 m. The Talamancan Rice Rat *O. talamancae* extends its range southward into Ecuador where it is adapted to a range of habitats including anthropogenic conditions from sea level to over 1500 m (Musser and Williams 1985:12); however Albuja (1991) makes no mention of this form in Ecuador. It should be mentioned here that two species of *Microryzomys*, a much smaller-sized genus of oryzomyine rodent, are found in high elevational contexts. In particular, *M. altissimus* is more regularly associated with páramo environments; however, it does overlap between 2500 and 3500 m with *M. minutus*, which inhabits wet and cool forests (Carleton and Musser 1989:55-57). Diaz de Pascual (1994) has observed both *O. albigularis* and *M. minutus* in Venezuelan cloud forest at 2,160 masl. At least two distinct taxa of Thomas's Paramo Mouse were identified in the collections. The relatively large *Thomosomys aureus* was positively identified on the basis of tooth-bearing specimens, including one complete rostrum and three mandibles recovered from various levels in TP 5. Taken at high elevation contexts in Colombia, this frugivore is associated with arboreal habitats (Eisenberg 1989:361). The left mandible of a smaller *Thomasomys* was identified in fraction recovered from TP 7. A number of candidates are possible. Albuja (1991:189-190) lists three smaller members of this genus: *T. baeops, T. paramorum,* and *T. rhoadsi* in terrestrial and arboreal habitats associated with high páramo. Seven tooth-bearing fragments were identified as Andean Leaf-eared Mouse *Phyllotis*, a principally herbivorous genus which tends to be concentrated amongst Andean pastoral habitats. Five of the specimens, recovered in ⅛ inch fraction from two contexts in TP 5, represent the remains of two individuals. All of the specimens compared very well with voucher samples of *P. haggardi*, a form inhabiting the northern Andes of Ecuador (Albuja 1991:188; Nowak and Paradiso 1983: 604; Steppan 1995). From the same context in TP 5 as one of the preceding specimens, one left mandibular fragment with a preserved molar was identified as deriving from a South American Field Mouse *Akodon*. Members of this genus are reported from a variety of habitats including Andean grasslands and cultivated areas , with *A. mollis* a common form in the high Andes of Ecuador (Albuja 1991:185; Nowak and Paradiso 1983:590). The relatively complete tooth-bearing structures of one medium-sized rodent recovered from TP 7 Lev. 9 (Cat. 123) were identified as the remains of one Cotton Rat *Sigmodon*. The left mandibular portion with complete molar row compared well with voucher samples of *S. inopinatus* which has been identified on the basis of specimens collected from high elevational páramo settings in central and southern Andean Ecuador (Voss 1992:44). Members of this genus tend to be restricted to open habitats, including anthropogenic settings. Two post cranial fragments were earlier identified as Porcupine *Coendou* at the FMNH from similar contexts in TP 4. Albuja (1991:190) lists the form *C. quichua* as inhabiting temperate areas of the Ecuadorian Andes; however, misidentification of these specimens is possible, as a comparably large rodent, the Paca *Agouti*, appears to be relatively common in the deposits. Remains of this genus are found throughout various contexts in each test unit at La Chimba. Specimens derive from all portions of the skeleton, and include relatively complete tooth-bearing bones and isolated teeth as well. Many can be securely identified as *A. taczanowskii*, the large Mountain Paca that inhabits the Ecuadorian páramo, and is considered in some places an agricultural pest (Nowak and Paradiso 1983:817; Patzelt 1989:60).

The most common archaeofaunal specimens encountered in virtually every context at the La Chimba site, consist of highly identifiable rabbit *Sylvilagus* bones. Over 14,500 are identified and cataloged. The only native South American lagomorph south of Colombia is the Brazilian Cottontail *S. brasiliensis*, a crepuscular browser which inhabits a variety of settings from sea level to high páramo (Eisenberg 1989:421; Patzelt 1989:55). It would appear to have been heavily persecuted by the inhabitants of La Chimba, and its mode of accumulation and exploitation will be discussed in a subsequent section.

ASSEMBLAGE REPRESENTATION

Table 4 lists various numerical permutations for vertebrate taxa identified to the generic level in the La Chimba archaeofaunal assemblage. The genus-level categories also include those specimens only tentatively identified (cf.) in each calculation.. Table 4 lists the number of identified specimens (NISP) for the entire assemblage. The minimal minimum number of individuals (Min. MNI) refers to the minimum number of individual skeletons needed to account for the specimens represented in the La Chimba deposits by level, but regardless of excavation unit. The assumption that all like levels in each test pit are contemporaneous, is made for analytical purposes only. The maximal minimum number of individuals (Max. MNI) separates the minimum number of individual skeletons needed to account for the specimens represented in the

Table 4. Numerical Representations of Identified Vertebrate Genera in the La Chimba Deposits

	NISP	Min. MNI	Max. MNI	Max. MNE	#Contexts
Geranoaëtus	3	3	3	3	3
Columba	10	5	5	10	5
Bubo virginianus	2	2	2	2	2
Chironectes?	3	2	2	3	2
Didelphis	14	7	7	10	7
Dasypus	6	2	2	2	2
Saimiri	1	1	1	1	1
Homo	99	20	42	55	44
Canis	7	2	2	2	2
Dusicyon	4	4	4	4	4
Tremarctos	14	11	12	12	12
Procyon	4	1	1	4	1
Nasua	3	1	2	3	3
Nasuella	2	2	2	2	2
Potos	2	2	2	2	2
Mustela	4	4	4	4	4
Conepatus	3	3	3	3	3
Felis	38	16	22	24	22
Tapirus	136	19	52	92	52
Odocoileus	3991	66	143	1260	80
Mazama	75	14	18	57	22
Pudu	461	32	60	295	61
Oryzomys	2	1	1	1	1
Thomasomys (lg)	4	4	4	4	4
Thomasomys (sm)	1	1	1	1	1
Phyllotis	7	4	4	4	4
Akodon	1	1	1	1	1
Sigmodon	2	1	1	1	1
Coendou	2	2	2	2	2
Agouti	66	16	34	47	34
Sylvilagus	14,577	255	661	6,028	89

La Chimba deposits by excavation unit and level. The maximal minimum number of elements lists a gross maximal estimation of the number of skeletal portions represented in the La Chimba deposits. The statistic differentiates appendicular bones by orientation, regardless of size, and incorporates separate axial portions defined as: 1. Head; 2. Neck (Cervical Vertebrae); 3. Chest (Thoracic Vertebrae and Ribs); and, 4. Lower Back (Lumbar, Sacral and Caudal Vertebrae). The statistic is included for analytical purposes, and likely has little meaning for smaller taxa like leporids which could be treated as whole units. The final category lists the number of different contexts in which the remains were recovered throughout the excavated deposits (total N=89).

A perusal of Table 4 reveals that the majority of identified genera were recovered as isolated fragments from different excavation units. In most cases, the derived counting statistic is very closely tied to the number of different excavation contexts in which the taxon was recovered. Discounting *Homo* remains, which are very likely isolated specimens associated with separately analysed burial contexts, a few taxa in the list deviate from this pattern of isolated recovery. These include the larger perissodactyl *Tapirus*, all of the cervids *Odocoileus, Mazama,* and *Pudu*, to some extent the large rodent *Agouti*, and of course the lagomorph *Sylvilagus*. In particular, cervid and lagomorph remains numerically dominate the identified (to genus) taxa.

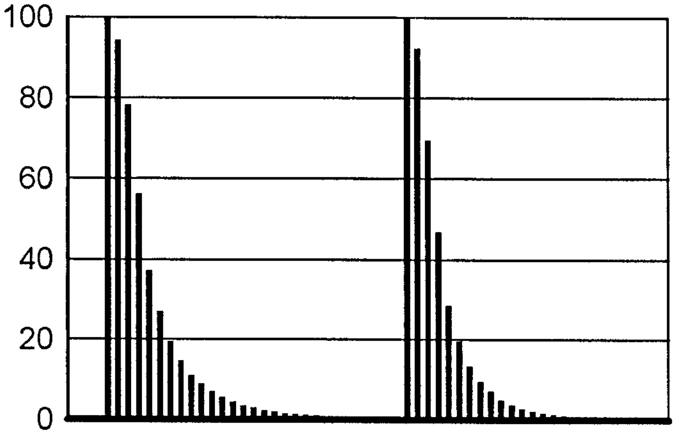
Specimen Size, Recovery and Identification

All archaeofaunal remains from the most recently excavated units, TPs 5 and 7 were meticulously sorted and examined. They can serve as a control for the earlier excavated deposits. Furthermore, TP 5 was intensively recovered, with all excavated deposits sieved through ⅛ inch mesh. Deposits from TP 7 were passed through ¼ inch mesh, with a smaller 36 l control sample sieved through ⅛ inch screen from most levels. Figure 3 illustrates cumulative percentage ogives of overall fraction size from TP 7 (left) and TP 5 (right), beginning with 0 and proceeding in 5mm increment up to 105 mm. The graphs appear to be similar, and this is independently corroborated through the use of both Chi-Square ($X^2 = 13.38$, where critical value at .01= 38.93, df=21) and Kolmogorov-Smirnov (K-S value = .2174, p=.65, where critical value = .32 at .01) statistical tests. In either case, the null hypothesis of similarity can not be rejected. This would indicate that intensive ⅛ inch screening in TP5 had little effect in terms of the overall size structure of the recovered fraction from either test unit.

This would suggest that switching from exclusive use of ⅛ inch screen in TP 5 to ¼ inch screen with smaller ⅛ inch aperture control samples in TP 7 likely had little effect in terms of the overall population of identified (*e.g.*, to the level of Order) specimens. Figure 4 graphs the maximum size categories (in 5 mm increments) for lagomorph identifications in TP 7 (left) and TP 5 (right). Lagomorph specimens tend to be highly identifiable, even when heavily fragmented, due to surface sculpturing on cranial fragments and visibly different osteological morphology from many of the similar-sized taxa of other mammalian orders. *Sylvilagus* does share post-cranial osteological similarities with the Guinea Pig or Cuy, *Cavia spp.*; however, a Cuy skeleton was always at hand during identification, and the complete lack of any diagnostic caviid dental remains in the La Chimba deposits supports the relatively certain identification of lagomorph specimens. The graphs in Figure 4 appear to be similar, and this is independently corroborated through the use of both Chi-Square ($X^2 = 12.44$, where critical value at .01= 31.90, df=16) and Kolmogorov-

Fig. 3 La Chimba

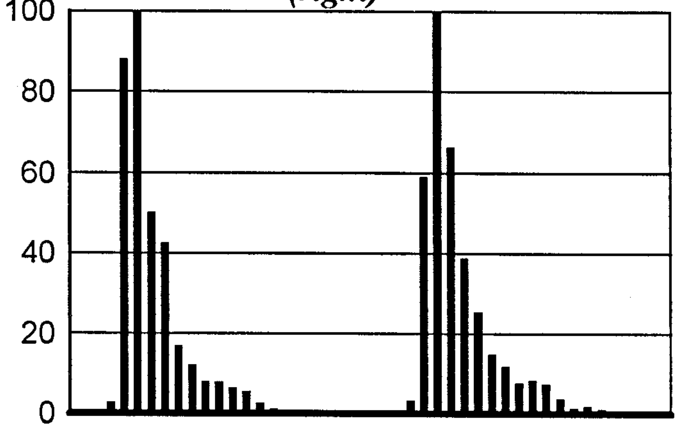
Cumulative %Ogives of Maximum Size (mm) for TP7 (left) and TP5 (right)



5 mm increments from 0-105mm (L to R)

Fig. 4 La Chimba

Maximum Size (mm) of Lagomorph IDs (by %) in TP7 (left) and TP5 (right)



Smirnov (K-S value = .1579, p=.38, where critical value = .32 at .01) statistical tests. In either case, the null hypothesis of similarity can not be rejected. This would indicate that intensive ⅛ inch screening in TP5 had little effect in terms of the overall identification of medium-sized lagomorph taxa. This is not to suggest that certain kinds of lagomorph elements were systematically lost as a factor of differential recovery. Shaffer and Sanchez (1994:527) indicate that certain *Sylvilagus* remains recovered by ⅛ inch mesh aperture, are not recovered by ¼ inch aperture. These include relatively poorly diagnostic elements like sternal segments, ribs and patellae, in addition to more diagnostic elements like metapodia and astragali. Metapodia and astragali were recovered in TP 5 and TP 7 contexts; however, it is possible that their numeric representation is skewed by differential recovery. For example, TP 7 is a much deeper unit with almost twice the number of recovered archaeofaunal specimens; however, the numbers of *Sylvilagus* remains recovered by ⅛ inch mesh aperture but not recovered by ¼ inch aperture, do not differ markedly (*e.g.*, Astragalus, TP5=21, TP7=11; Metapodium, TP 5=90, TP 7=72; Metacarpus, TP5=36, TP7=54; Metatarsus, TP 5=66; TP 7= 96). These numbers may suggest a systematic loss of these diagnostic elements from the TP7 deposits. On average, TP 7 yielded 4 identifiable lagomorph specimens for each sieved 36 l sample; a number that increases to 6.3/36 l sample in TP 5. These points are somewhat corroborated by the recovery of small rodent remains which are more or less similar in TP 5 (N=37) and in TP 7 (N=44), despite the great differences in extent of excavated deposits and archaeofaunal sample size. Nevertheless, it would appear from Figure 4 that both TP 5 and TP 7 share a maximal 10 to 15 mm size range of identified lagomorph specimens, which falls comfortably within the recoverable fraction of ¼ inch mesh screen. In addition, a higher percentage of smaller (less than 10 mm) lagomorph specimens were in fact recovered from TP 7 (raw counts are TP 5 N=381, TP 7 N=831).

Figures 5 and 6 graph the vertical distribution of identified lagomorph specimens by level in TPs 7 and 5 respectively. Although 28 levels were excavated in TP 7 compared to only 13 in TP 5, the vertical distribution reveals that specimens were recovered throughout the deposits. Both test pits reveal some larger clusterings of lagomorph bones in levels 9-12 in TP 5 and 7-10 and 16-21 in TP 7. These graphs may indicate that the identifiability of lagomorph remains is likely not associated with depth from surface, and fragmentation through sediment overburden. Instead, the frequency by level of identifiable lagomorph remains may be associated simply with the volume of sediment excavated in each level. In TP 7 the frequency of identified lagomorph specimens by level is positively and weakly correlated to the volume of excavated sediment (r=.39, p=.05, N=26); however, this is not the case for TP 5 (r=.29, p=.34, N=13). The relationship between depth below surface and specimen preservation is further explored below in an examination of density mediation and assemblage survivorship.

Assemblage Survivorship

Relatively precise statistical correlations can be calculated between surviving skeletal part frequencies and density estimates, based upon calculations of bone mineral density for two taxa represented in the La Chimba deposits: *Sylvilagus* (Pavao 1996; Pavao and Stahl 1998; and appendix) and *Odocoileus* (Lyman 1984). These calculations can provide an important starting point for understanding aspects of assemblage preservation. The nature of assemblage

Fig. 5 La Chimba

TP7: % Identified Lagomorph Specimens by Excavation Level

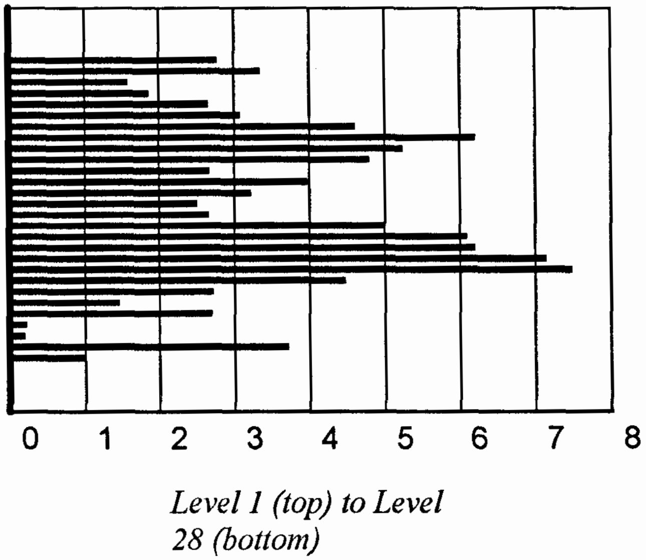
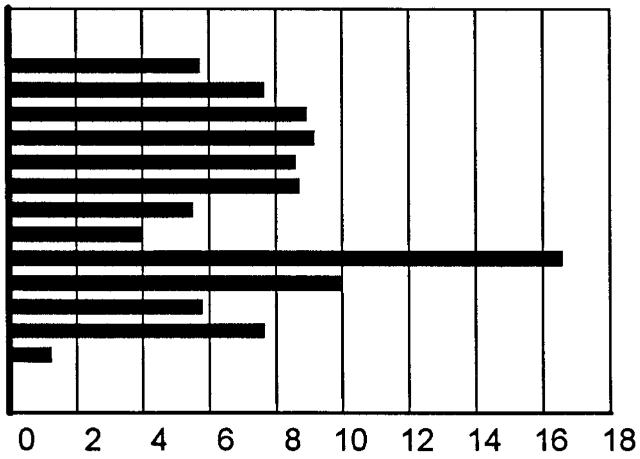


Fig. 6 La Chimba

TP5: % Identified Lagomorph Specimens by Excavation Level



Level 1 (top) to Level 13 (bottom)

preservation for other taxa must remain somewhat impressionistic. The discussion begins with detailed accounts of skeletal representation for *Sylvilagus* and *Odocoileus*, with supporting evidence for smaller cervids. This is followed by a much more impressionistic accounting of skeletal representation for other major vertebrate taxa recovered from the La Chimba archaeological deposits.

Lagomorph Skeletal Representation

The La Chimba archaeofaunal assemblage is dominated by identifiable lagomorph remains (N=14,587). It is likely that these remains are derived from *Sylvilagus brasiliensis*, as this species is the only autochthonous representative of the genus in Ecuador. As previously mentioned, many rabbit remains are easily identified, even in highly fragmented condition. They are found in every excavated context of the site, and with a few exceptions, neither recovery strategy nor sediment compaction appear to have seriously affected their recovery and identification. Figure 7 illustrates the differential skeletal representation of lagomorph remains in the aggregated assemblage. For ease of display, frequencies and associated percentages are grouped according to broader skeletal units. Vertebrae and Ribs are composed of many more potentially recoverable elements than single element categories like scapula, pelvis or dentary. Nevertheless, the figure suggests that all portions of the lagomorph skeleton appear to have been deposited, preserved and recovered in the sampled fractions at La Chimba.

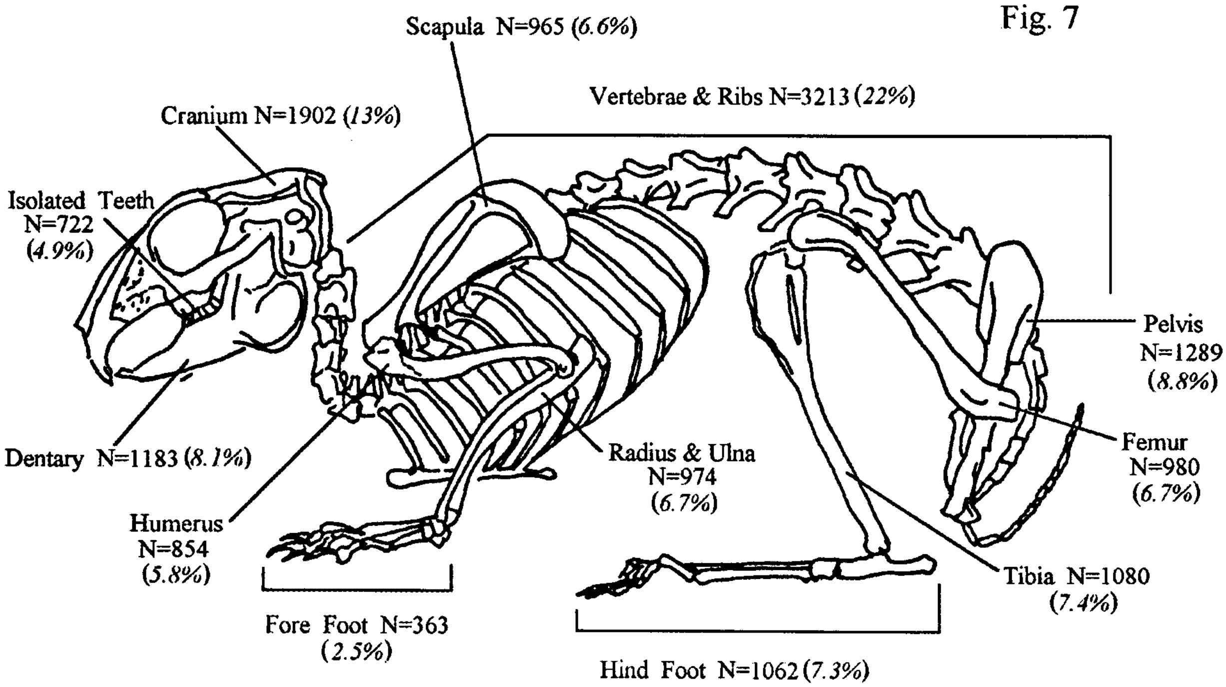
Although it would appear that entire skeletons of this relatively small-bodied taxon were introduced into depositional contexts, a detailed analysis of skeletal representation suggests that the La Chimba lagomorph subassemblage is preserved on the basis of density. As earlier mentioned, a separate coding system was employed for skeletal fragmentation of lagomorph and cervid remains. Survivorship of the different scan sites used in the densitometry studies (see appendix) was estimated by coding percentage preservation of each scan site in 0, .25, .5, .75, and 1 (complete) increments. This coding technique was used in the original analysis of TP 5 and TP 7, as well as the re-examination of TP 1. The preserved scan sites were tallied by level and unit (observed), and then statistically compared to respective Volume Density assays for various *Sylvilagus* scan sites (see Appendix). A 'percent survivorship,' similar to '%MAU' statistic was derived using the following equation (see Lyman 1994:256):

$$\frac{[\text{Scan Site}_i \div \text{number of times}_I \text{ occurs in one skeleton}]\ 100}{\text{Max. Scan Site in assemblage} \div \text{number of times that skeletal portion occurs in one skeleton}}$$

When the preserved scan site frequencies are aggregated for each test pit, it appears that lagomorph skeletal assemblage preservation is density mediated on a site-wide basis. Spearman's Rank Order Correlations between Volume Density for individual *Sylvilagus* scan sites, and identified scan sites in the recovered subassemblage are positively correlated and significant: TP 1 ($r_s = 0.6$, $p \leq 0$, N=63); TP5 ($r_s = 0.59$, $p \leq 0$, N=63); and, TP7 ($r_s = 0.69$, $p \leq 0$, N=63).

A detailed examination of lagomorph element breakage reveals that density-mediated survivorship is likely a factor of *in situ* damage. In other words, whole skeletons were accumulated and deposited, with breakage possibly subsequent to deposition. Again, the

Fig. 7



N = 14,587 (*99.8%*)

separately tallied estimates of scan site preservation can be used to illustrate this point. A tallying of the frequency at which sets of scan sites occur in the subassemblage is easily undertaken, and graphically illustrated (Figs. 8 to 14). Each figure illustrates the most and least common sets of scan sites to survive for major appendicular and dentary elements. Figure 8 illustrates differential breakage of the lagomorph dentary. Patterned breakage clearly reveals the differential recovery of high density scan sites as DN 1, DN 2 and DN3, which include teeth. These three scan sites commonly rank as amongst the most abundant lagomorph scan sites within the lagomorph subassemblage from these test units. It is very clear that the less dense, relatively fragile sites DN 4 and DN 5 tend to survive far less frequently. With the exception of the condylar process (DN 5), these fragile sites would yield far less identifiable remains when fragmented. This is certainly due in great part to the absence of teeth or tooth-bearing alveolar bone. The high numbers of isolated teeth in the subassemblage (Fig. 7) suggest a certain degree of *in situ* loss or damage. Density-mediated survivorship is clearly illustrated for the scapula (Fig. 9). If this element is not preserved intact, then 67.8% of the subsamples are represented by Scan Site SP 1, the relatively dense glenoid fossa, and the neighboring SP 2 which includes the scapular neck. Scapular blade fragments are much rarer, again for similar reasons of fragmentation and identification. Compared to the aforementioned elements, the humerus is much more uniformly dense. Nevertheless, higher density scan sites at either end of this long bone are differentially preserved in far greater frequency (Fig. 10). In particular, the tiny, dense and highly diagnostic distal shaft of the humerus (HU 5 and HU 4), usually ranks as one of the most common bone portions identified in the subassemblage. The least dense mid-shaft scan sites (HU 3 and 4) are relatively rare. Again, isolated mid-shaft fragments are far less diagnostic than their distal and proximal counterparts; therefore, the likelihood of their identification to the level of zoological Order are minimal as a factor of fragmentation. Density-mediated survivorship of the ulna and radius (Fig. 11) is clearly illustrated by the high survivorship of the olecranon, semilunar process and radial notch, at the expense of slender and fragile distal portions. The radius, unlike the ulna, tends to be relatively homogenous in volume density; nevertheless, the higher density proximal head tends to survive in higher proportions. The pelvis (Fig. 12) is interesting, because as a very complex bone, it can survive in a large number of different permutations. This is reflected in relatively uniform survival percentages. Over one in five pelves survives intact, otherwise the subassemblage is comprised of many different permutations, most incorporating the high density acetabulum (AC1) and ilium (IL 1 and IL 2). Predictably, the least dense sites of the pubis (PU1) and ischium (IS 1) are less likely to survive, and when they do, they are normally preserved along with a neighboring high-density scan site. Ilium and acetabular scan sites tend to be the best represented sites from the lagomorph subassemblage recovered in all test units. The femur of *Sylvilagus* is characterized by relatively high density values, particularly in its distal end and mid-shaft. Very few femora survive intact (Fig. 13), but appear to be broken into proximal and distal portions. Depending upon the degree of fragmentation, it is unlikely that isolated mid-shaft fragments could be identified to anything more precise than 'small mammal.' Nevertheless, high density distal and proximal ends survive in greatest proportion. Similar patterns of survivorship can be claimed for the tibia (Fig. 14), which rarely survives intact, and is dominated in its proportionate survivorship by the relatively dense proximal and distal ends. In particular, the small, dense, and highly diagnostic distal tibia (TI 5), and the neighboring distal metaphyseal scan

Fig. 8

Dentary Survivorship

(N = 597)

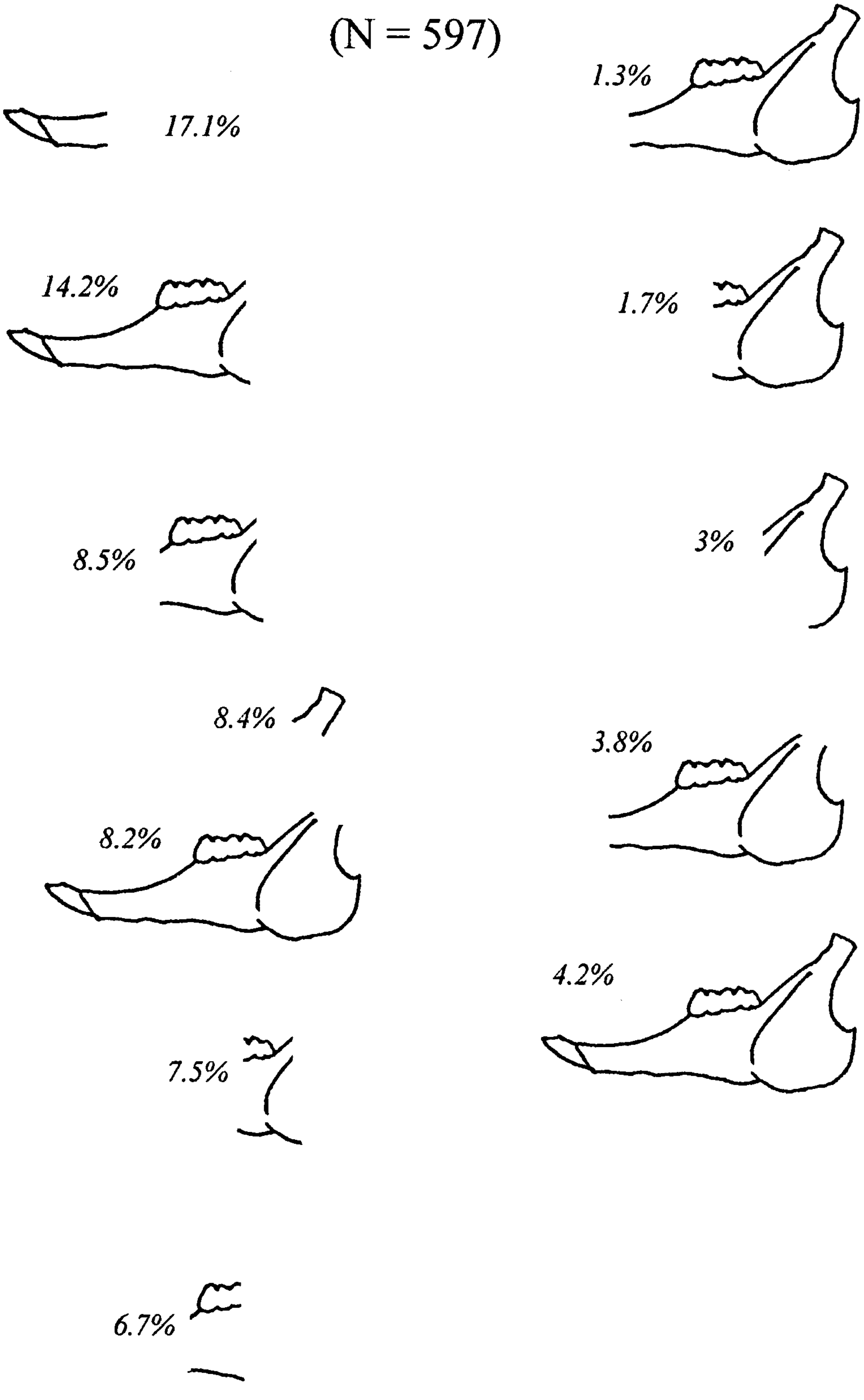


Fig. 9

Scapula Survivorship
(N=432)

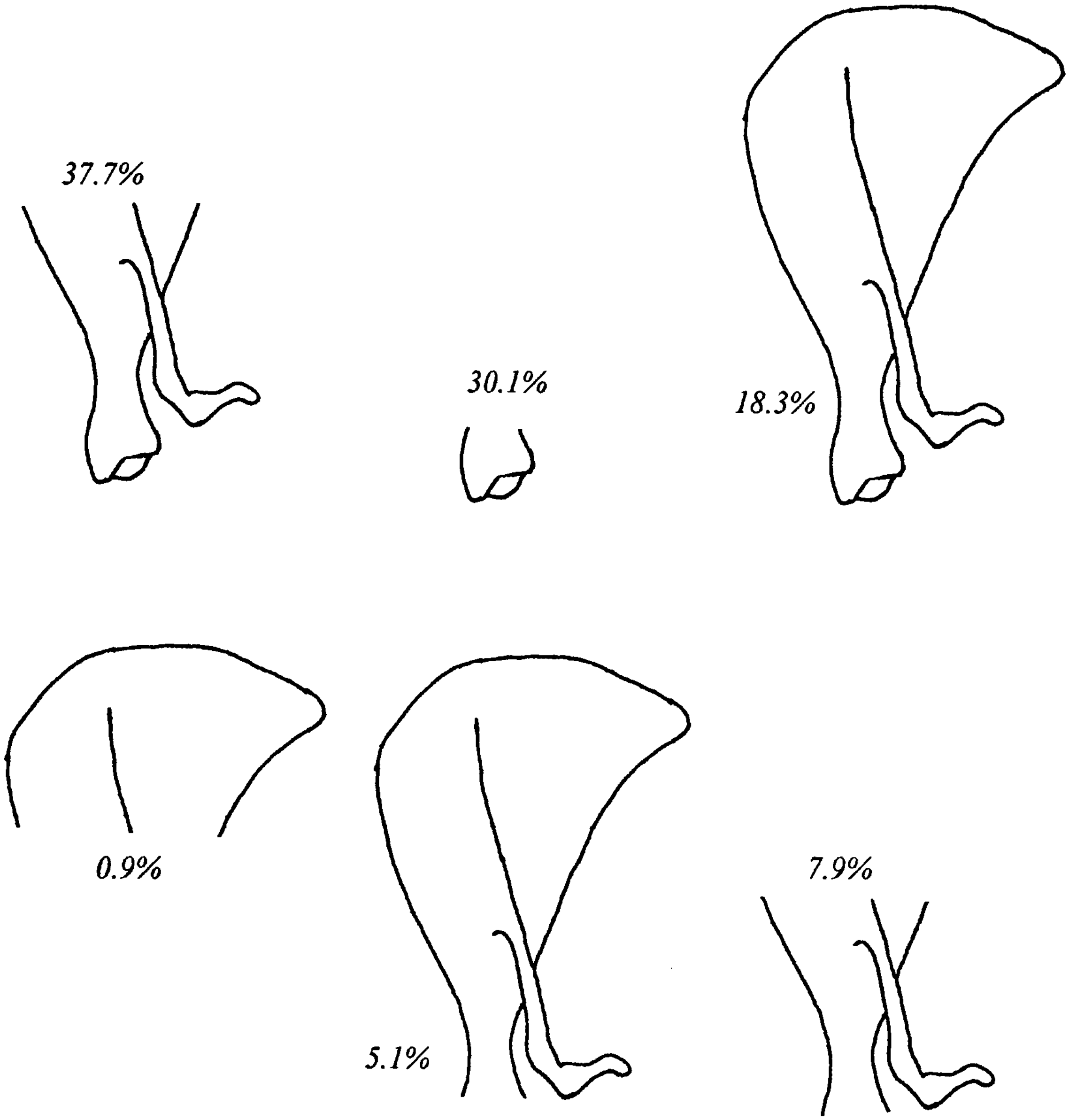


Fig. 10

Humerus Survivorship (N = 453)

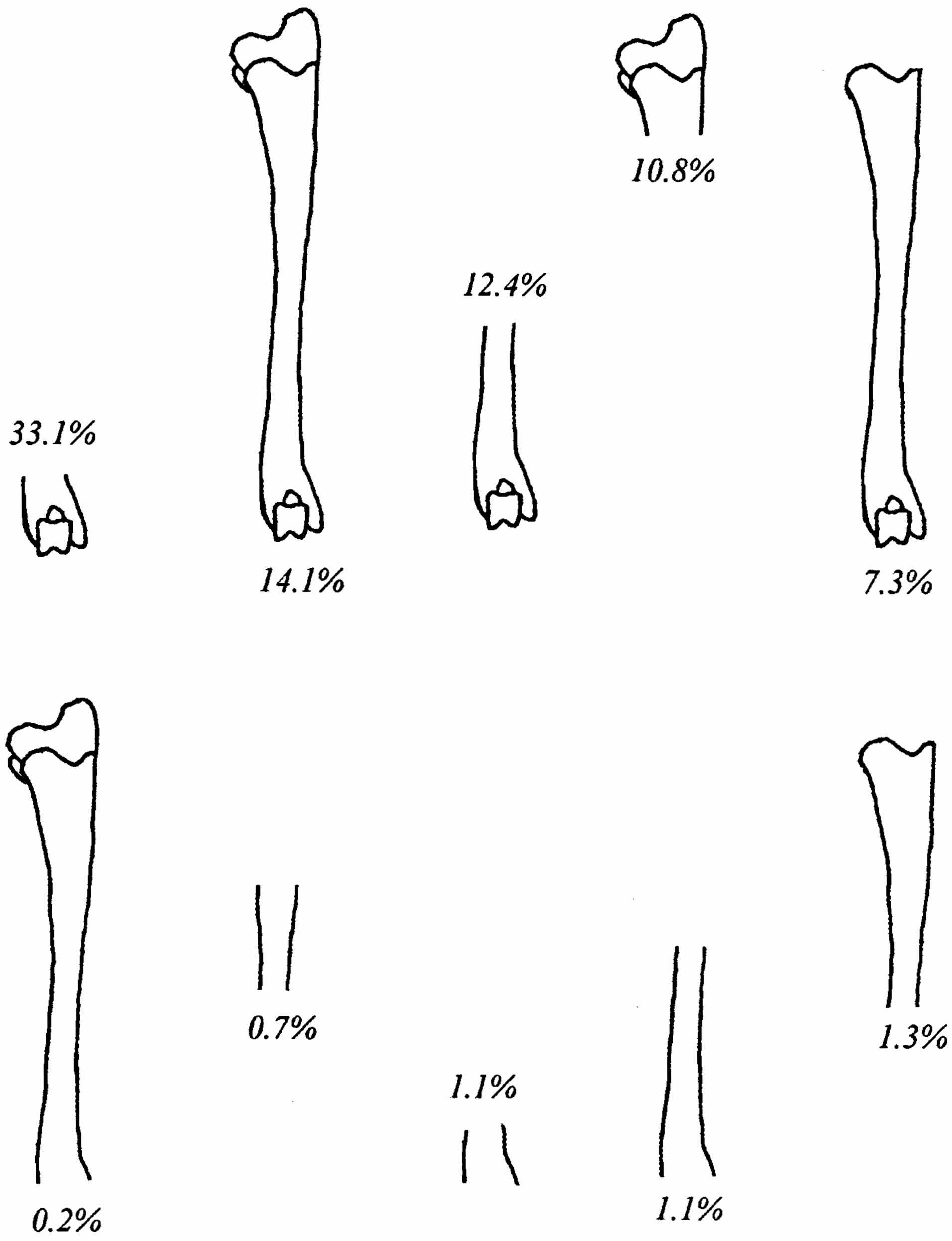
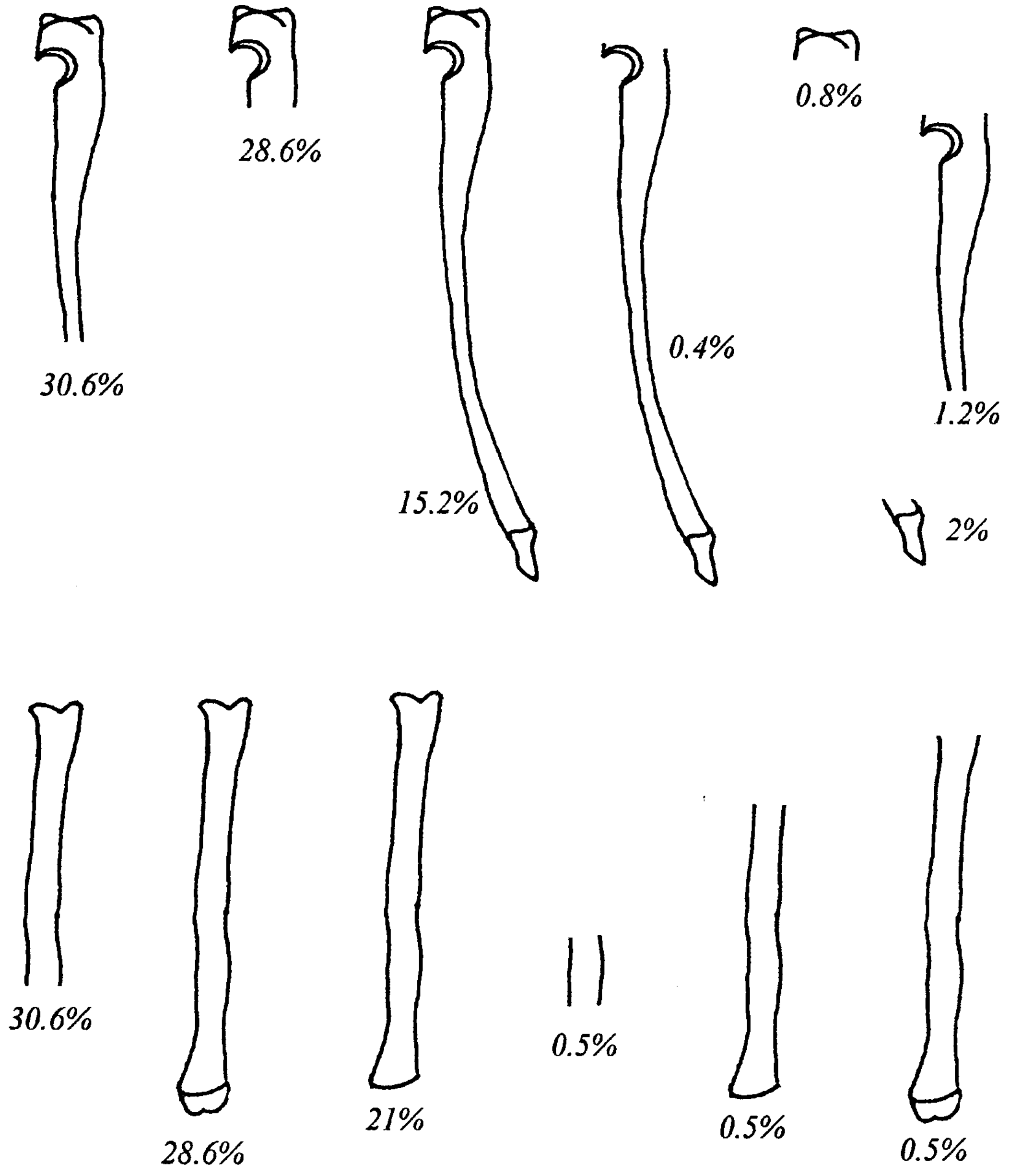


Fig. 11

Ulna & Radius Survivorship
(N = 248) (N = 191)



Pelvis Survivorship
(N=627)

Fig. 12

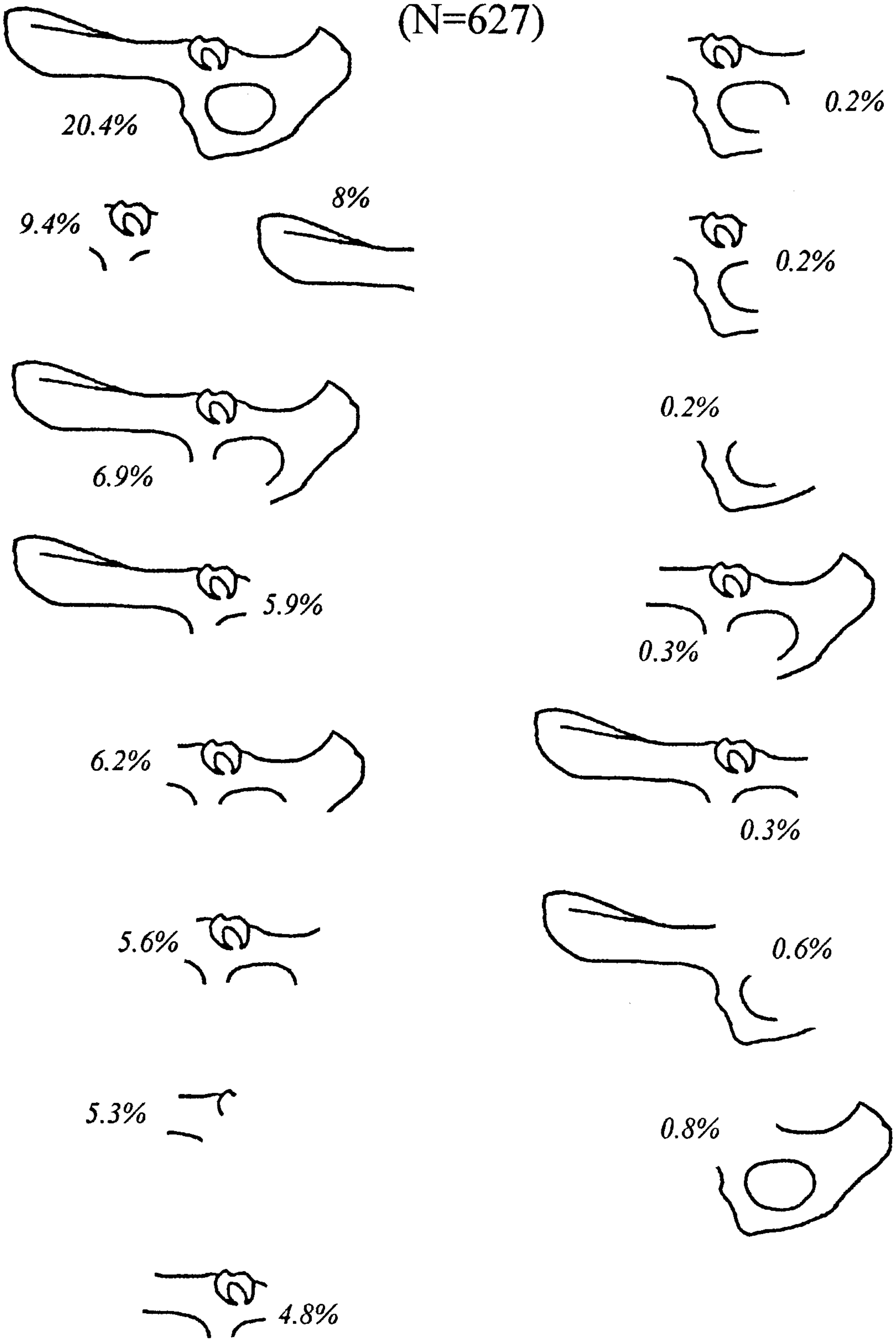
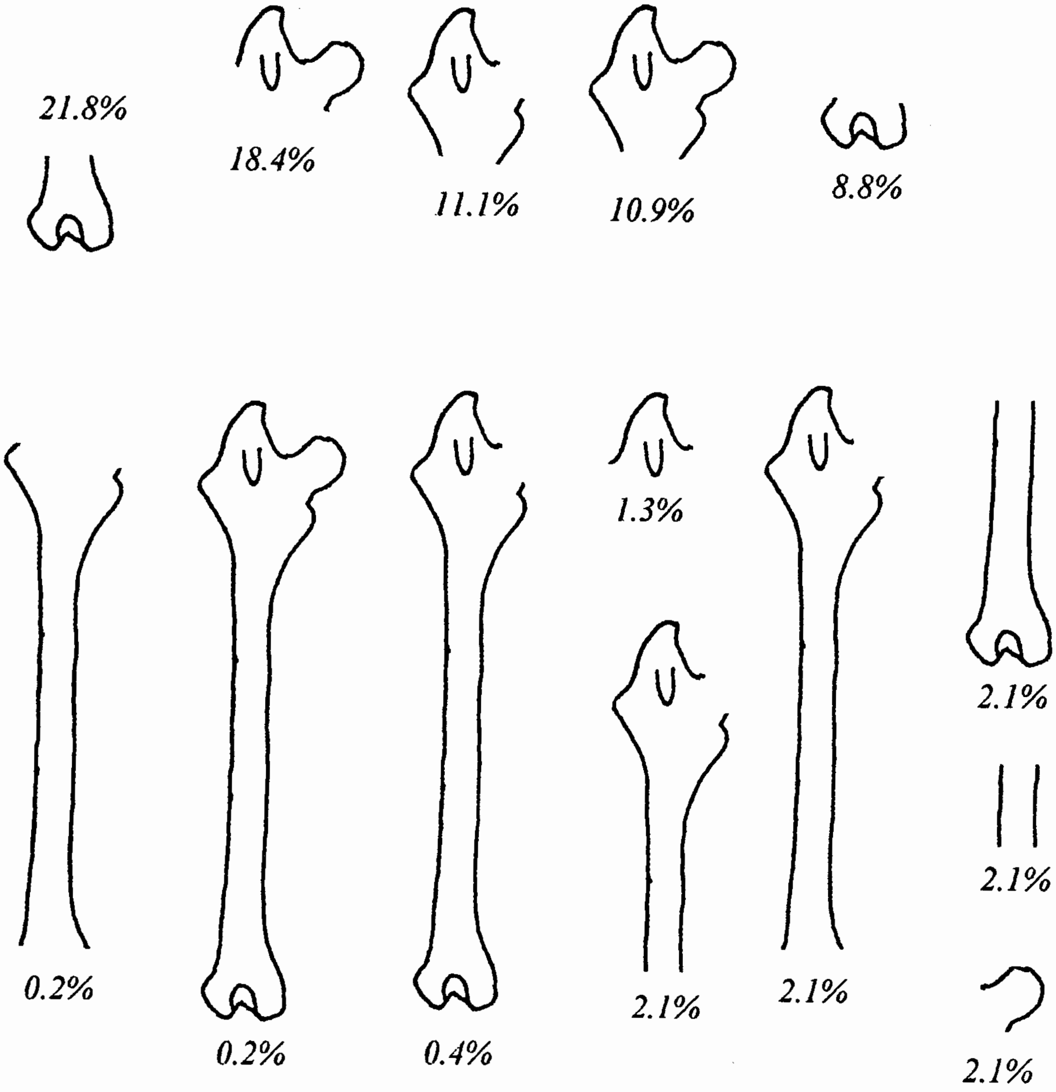
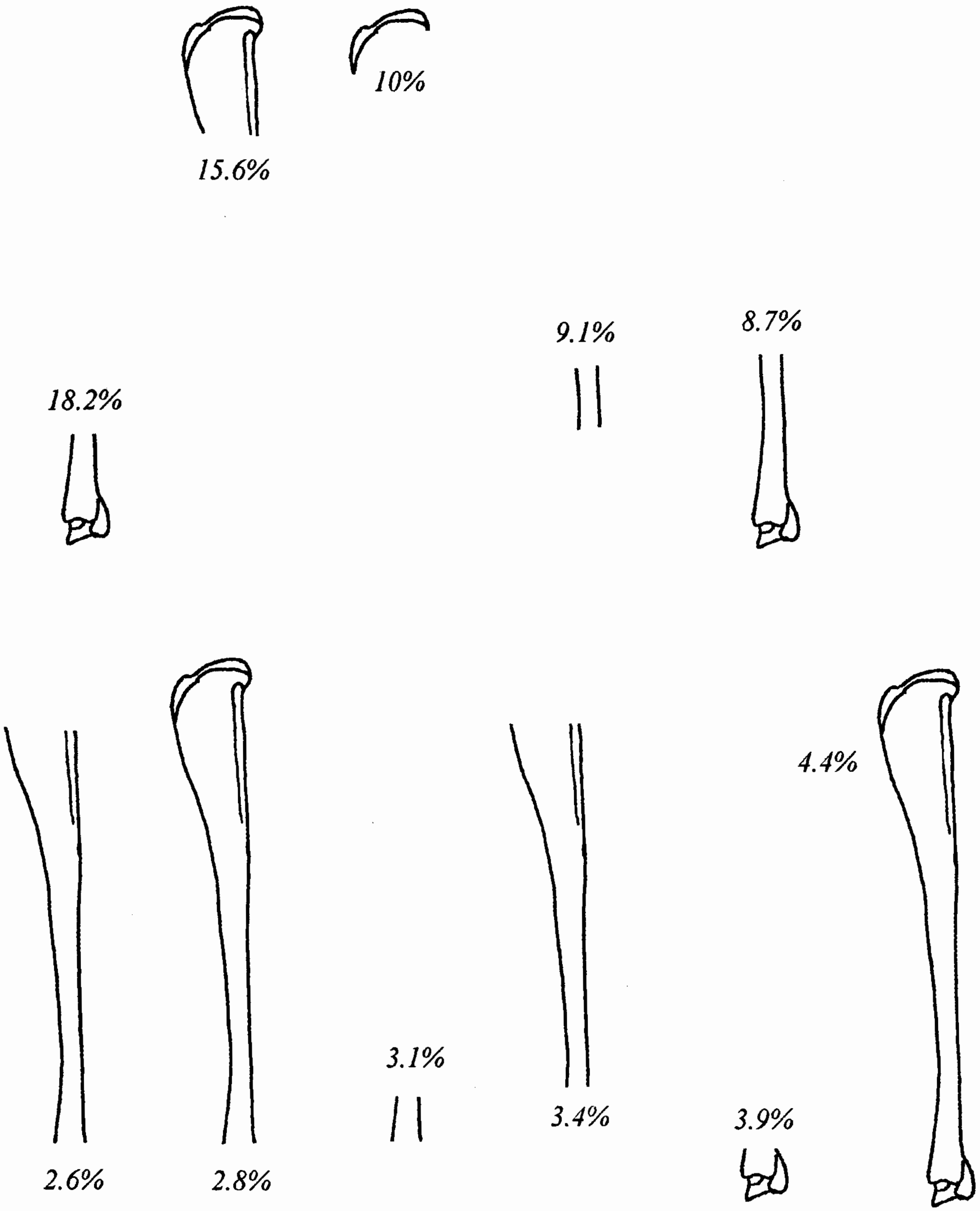


Fig. 13

Femur Survivorship (N = 531)





Tibia Survivorship (N=615)

Fig. 14

site (TI 4) are common in the subassemblage. Tibial shafts also survive, but their architecture and general morphology are on the whole much easier to identify than their primarily tubular femoral counterparts. Finally, the relatively dense and highly diagnostic calcaneum is generally one of the most common lagomorph elements recovered and identified in the Test Pit 1, 5 and 7 subassemblage.

Any number of factors could be responsible for density mediation of the lagomorph subassemblage at La Chimba. Table 5 lists the observed and expected survivorship of different rabbit elements aggregated from all vertical levels and listed by test unit. Observed figures are summed tallies of each scan site by level (*e.g.*, .5 + .25 + 1 = 1.75) aggregated for the entire test unit. Expected figures are computed by simply taking the MNI for each aggregated unit (based upon the highest frequency of sided element) and multiplying by the number of times that element occurs in the skeleton. Note that the metapodia have been combined into one analytical unit, as it is often difficult to identify fore from hind, especially when fragmented. A separate column subtracts the expected from the observed in order to model roughly the nature of assemblage attrition by scan site. A final column ranks this figure by scan site in each test unit. It should be noted that there is a very high and positive correlation between the ranked survivorship of lagomorph scan sites aggregated for each test pit. Spearman's Rank Order Correlations vary between (r_s = 0.83, p≤ 0, N=63) and (r_s = 0.9, p≤ 0, N=63). There is a clearly patterned survivorship in the lagomorph subassemblage between each test unit. This is likely caused by three potentially interrelated factors: differential identifiability; loss during recovery; and, possible *in situ* breakage.

A perusal of Table 5 reveals that rabbit rib scan sites, especially the extremely light density distal sites, are strongly under represented in each test unit. This is unquestionably due to a reluctance on the part of the analyst to assign higher acuity identification to fragments of this relatively undiagnostic element. Rib portions were occasionally identified to zoological Order, only when the proximal portion preserved either independently, or attached to the distal portions. An isolated distal rib shaft fragment would never be identified to the ordinal level. TP 1 was the first subassemblage to be examined in the study; therefore, the complete absence of any rabbit rib portions in this test pit reflects a reluctance on the part of the analyst to imbue these elements with diagnostic acuity. On the other hand, TP 5 and TP 7, both of which contain rabbit rib fragments were the final subassemblages to be studied in this project. Clearly, as analysis continued, greater confidence was placed in the identification of relatively complete ribs to the ordinal level. A similar argument can be made for the complete absence of phalangeal elements in TP 1, and significant under representation in TP 5 and TP 7. Lumbar vertebrae also tend to be under represented in each studied test pit. Although identifiable, extensive fragmentation of these relatively durable elements often leads to an identification of 'indeterminate vertebra,' for which no scan site volume density assay can be assigned.

Other elements were likely lost during recovery with ¼ inch aperture screen (Shaffer and Sanchez 1994:527). Not surprisingly, these include sternal segments, smaller ribs fragments, complete patellae, and even relatively diagnostic elements like metapodia and astragali. The astragalus is highly diagnostic and of average durability; however, very few were recovered and identified, despite the relatively high number of calcanea present. Most likely, the complete

Table 5. Observed/Expected Lagomorph Scan Site Survivorship in TP1, TP5 and TP7

Scan Site	TP1 Exp.	TP1 Obs.	Obs.-Exp.	Rank	TP5 Exp.	TP5 Obs.	Obs.-Exp.	Rank	TP7 Exp.	TP7 Obs.	Obs.-Exp.	Rank
DN1	203.5	95.75	-107.75	43	85.25	38.5	-46.75	39	216	160.25	-55.75	50
DN2	203.5	131.25	-72.25	52	85.25	40.5	-44.75	40	216	153.75	-62.25	46
DN3	203.5	126.5	-77	51	85.25	36.5	-48.75	38	216	155.25	-60.75	48
DN4	203.5	50.25	-153.25	22	85.25	3	-82.25	13	216	46	-170	18
DN5	203.5	39.25	-164.25	18	85.25	6.5	-78.75	17	216	54	-162	19
AX1	101.75	14	-87.75	47	42.625	9	-33.625	48	108	33.25	-74.75	42
AT1	101.75	31	-70.75	53	42.625	16	-26.625	51	108	47.75	-60.25	49
RI1	2442	0	-2442	5	1023	54	-969	4	2592	60.5	-2531.5	4
RI2	2442	0	-2442	2	1023	58	-965	5	2592	59.5	-2532.5	3
RI3	2442	0	-2442	3	1023	44	-979	3	2592	68	-2524	5
R!4	2442	0	-2442	1	1023	13	-1010	2	2592	38	-2554	2
RI5	2442	0	-2442	4	1023	1	-1022	1	2592	12	-2580	1
IL1	203.5	156.5	-47	56	85.25	46.75	-38.5	45	216	148.25	-67.75	44
IL2	203.5	203.5	0	58	85.25	59.5	-25.75	52	216	216	0	58
AC1	203.5	172.25	-31.25	57	85.25	76	-9.25	55	216	215.5	-0.5	57
PU1	203.5	121	-82.5	49	85.25	27	-58.25	29	216	82.75	-133.25	25
IS1	203.5	79	-124.5	38	85.25	28.25	-57	30	216	99.25	-116.75	30
IS2	203.5	143.75	-59.75	55	85.25	56.75	-28.5	50	216	184	-32	55
LU1	712.25	112	-600.25	11	298.375	23.75	-274.625	11	756	123.25	-632.75	11
PH1	2035	0	-2035	6	852.5	82.25	-770.25	8	2160	31.75	-2128.25	6
PH2	2035	0	-2035	7	852.5	79.5	-773	7	2160	33.5	-2126.5	7
ST1	101.75	0	-101.75	45	42.625	0	-42.625	41	108	0	-108	31
SC1	101.75	23	-78.75	50	42.625	6.5	-36.125	46	108	36.75	-71.25	43
SP1	203.5	141.75	-61.75	54	85.25	62	-23.25	53	216	202.75	-13.25	56
SP2	203.5	81.25	-122.25	40	85.25	22	-63.25	25	216	134.25	-81.75	39
SP3	203.5	20	-183.5	14	85.25	3.25	-82	14	216	24.25	-191.75	15
HU1	203.5	48.5	-155	19	85.25	19	-66.25	22	216	78	-138	24
HU2	203.5	67	-136.5	29	85.25	23.75	-61.5	26	216	94.5	-121.5	28
HU3	203.5	75.25	-128.25	35	85.25	17.25	-68	20	216	84.25	-131.75	26
HU4	203.5	115.25	-88.25	46	85.25	45.75	-39.5	43	216	174.5	-41.5	52
HU5	203.5	116.75	-86.75	48	85.25	52	-33.25	49	216	175.25	-40.75	53
RA1	203.5	52	-151.5	23	85.25	50	-35.25	47	216	77	-139	23
RA2	203.5	63	-140.5	25	85.25	45.75	-39.5	44	216	85	-131	27
RA3	203.5	63	-140.5	24	85.25	29	-56.25	32	216	69.25	-146.75	22
RA4	203.5	49	-154.5	20	85.25	9	-76.25	18	216	45	-171	17
RA5	203.5	29.5	-174	16	85.25	6	-79.25	15	216	22	-194	14
CA1	203.5	66	-137.5	28	85.25	81.75	-3.5	57	216	171	-45	51
CA2	203.5	66	-137.5	27	85.25	85.25	0	58	216	176.25	-39.75	54
UL1	203.5	78.25	-125.25	37	85.25	63.25	-22	54	216	97.75	-118.25	29
UL2	203.5	74	-129.5	33	85.25	80	-5.25	56	216	109.25	-106.75	33
UL3	203.5	66	-137.5	26	85.25	25.75	-59.5	27	216	66.75	-149.25	21
UL4	203.5	28.25	-175.25	15	85.25	11	-74.25	19	216	27	-189	16
FE1	203.5	73	-130.5	31	85.25	34	-51.25	36	216	117.5	-98.5	35
FE2	203.5	75	-128.5	34	85.25	32.25	-53	35	216	151.75	-64.25	45
FE3	203.5	73.75	-129.75	32	85.25	27	-58.25	28	216	135.5	-80.5	40
FE4	203.5	35.75	-167.75	17	85.25	6	-79.25	16	216	55.75	-160.25	20
FE5	203.5	72.25	-131.25	30	85.25	20.25	-65	23	216	110.25	-105.75	34
FE6	203.5	49.75	-153.75	21	85.25	21.25	-64	24	216	108	-108	32
TI1	203.5	75.7	-127.8	36	85.25	30.25	-55	33	216	118.5	-97.5	36
TI2	203.5	87.25	-116.25	42	85.25	31.25	-54	34	216	130.75	-85.25	38
TI3	203.5	79.25	-124.25	39	85.25	28.75	-56.5	31	216	122.25	-93.75	37
TI4	203.5	99.75	-103.75	44	85.25	43.75	-41.5	42	216	153.75	-62.25	47
TI5	203.5	82	-121.5	41	85.25	34.75	-50.5	37	216	137.5	-78.5	41
AS1	203.5	2	-201.5	13	85.25	17.75	-67.5	21	216	11	-205	13
PA1	203.5	0	-203.5	12	85.25	0	-85.25	12	216	0	-216	12
MET1	2035	64	-1971	9	852.5	159.75	-692.75	10	2160	202.75	-1957.25	10
MET2	2035	66.5	-1968.5	10	852.5	130.75	-721.75	9	2160	189	-1971	9
MET3	2035	56	-1979	8	852.5	59	-793.5	6	2160	75.5	-2084.5	8

absence of tiny sternal fragments and complete patellae can also be attributed to loss during recovery. Ribs and metapodia are relatively low density elements. Through heavy fragmentation they can be either lost completely to ¼ inch aperture recovery, or reduced to recovered but unidentifiable fragments.

A massive amount of rabbit skeletal remains were prehistorically accumulated and subsequently deposited at La Chimba. Moreover, it can be argued that relatively complete skeletons were introduced and subsequently deposited at the site. It appears that the studied lagomorph subassemblage survived in density-mediated fashion. Fragmentation, the subsequent inability to identify non-diagnostic fragments, some loss during recovery, and selective *in situ* breakage of lower density portions of relatively intact skeletal elements are suggested as the most likely factors behind lagomorph skeletal representation at La Chimba.

Based upon the available evidence, it would certainly be unwise to suggest a single and unequivocal mechanism responsible for the density-mediated breakage of lagomorph skeletal portions in the La Chimba midden; however, some potentially viable scenarios can be discussed and evaluated. Carnivore attrition is not heavily implicated in assemblage preservation. Although skeletal fragments from some form of *Canis*, likely the domesticated dog, were identified in the La Chimba deposits, very little evidence for carnivore involvement is visible in the lagomorph subassemblage. In fact, only two fragments in the entire subassemblage of rabbit bones potentially implicate carnivore contribution: 1. A complete leporid phalanx with pitting and possible corrosive damage on its proximal end, from TP 5, Lev. 12 (Cat.#51); and, 2. a proximal tibia fragment with possible corrosive damage from TP 7, Lev. 22 (Cat.#207). It is difficult to conceive that an open-air site with an extensive midden deposit- a virtual rabbit ossuary- did not attract the attention of many potential carnivorous scavengers. Nevertheless, wild scavengers could have easily and completely removed smaller-bodied rabbit remains from the site environs altogether. Consumption by carnivores as large as a domestic dog could have resulted in near complete ingestion of rabbit remains, with subsequent defecation elsewhere. In either case, significant attrition by carnivores would have involved complete removal, not *in situ* breakage, of rabbit remains. Also, the possibly corroded fragments in the subassemblage are certainly unique, but they do not necessarily implicate a non-human carnivore contribution to assemblage formation.

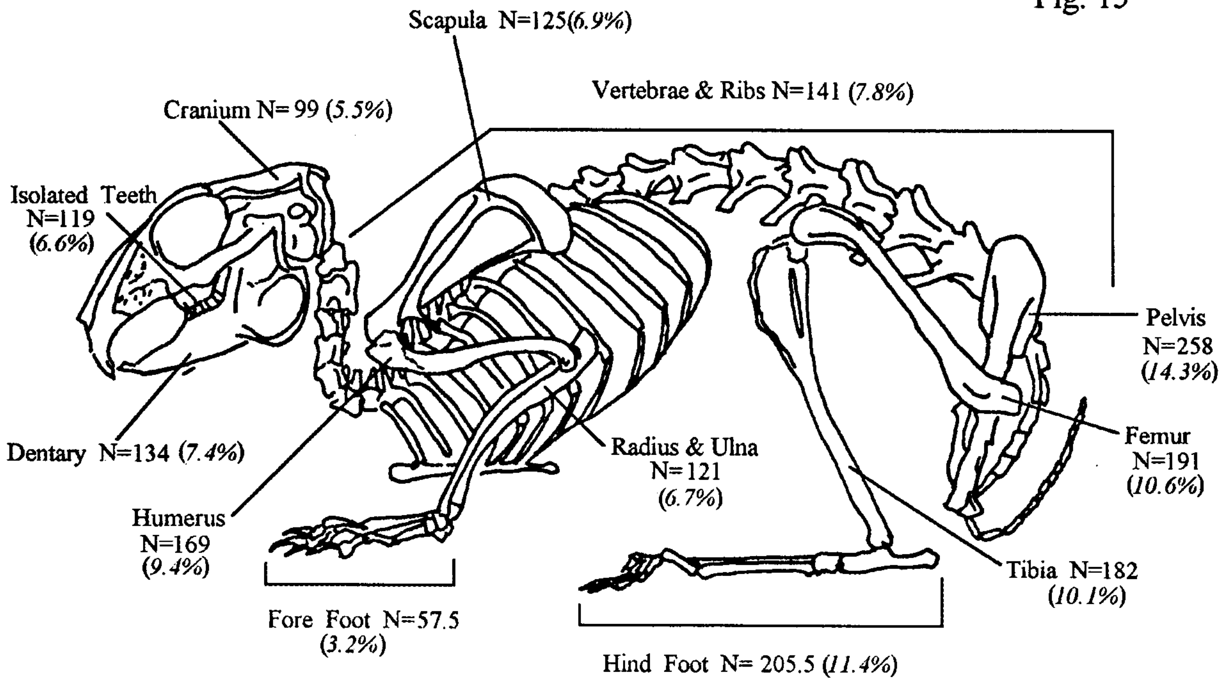
A few (N=27) cranial and post-cranial elements from TPs 1, 3 and 7 were articulated at the time of analysis. Although relatively insignificant in number, this suggests that some carcass portions, particularly from the head and lower leg, were likely deposited relatively intact. Long bone mid-shaft breakage in TP 5 and TP 7 was highly variable, but dominated by major fracture patterns: V-shaped fractures (N=204); some form of longitudinal fracture (N=183); and, helical (N=140). These can potentially implicate both fresh and dry bone breakage. It is also difficult to determine whether or not fracturing occurred before or after deposition. Depth from surface does not appear to be correlated with density mediated survivorship; instead, the lagomorph subassemblage survives in density-dependent fashion throughout practically every 10 cm excavation level in TPs 1, 5 and 7. Lagomorph survivorship in the deepest unit, TP 7, is highly and positively correlated with density for every level, except for one of the deepest (Lev. 25). A similar pattern can be observed in TP 5, in which the lagomorph subassemblage recovered from each level, except the deepest (Lev. 14), is positively and significantly correlated with density.

Each of the seven levels from which lagomorph remains were recovered in TP 1 were positively and significantly, albeit more weakly, correlated with density as well.

The obvious archaeological context of this open air site suggests that the massive subassemblage of recovered lagomorph remains was likely originally accumulated and deposited by humans. Nevertheless, only one fragment, the distal portion and shaft of a *Sylvilagus* left femur was the only specimen in the entire lagomorph subassemblage with an observable cut mark. A substantial number (N=1,802) of recovered lagomorph bones appears to have been variously altered through exposure to heat. Based upon surface coloration, a rough estimate of possible temperature exposure regimes varies from 220°C to 500°C. The distribution of these heat-altered remains around the rabbit skeleton, is illustrated in Figure (Fig. 15). A comparison of Figures 7 and 15 might suggest a slightly higher incidence of differential burning of bones from the hind limb. Nevertheless, the bulk of heat-altered bones (*89.3%*) appear to have been completely burned. Moreover, the majority of heat-altered bones appear to have been exposed to medium temperature (350-400°C) reducing atmospheres, based upon dark-brown to black coloration. Very few are heavily calcined (*0.3%*). It is possible that increasing intensity of heat alteration may have been a factor in augmented fragmentation, which in turn leads to non-identifiability. The few rabbit bones which do not appear to have been uniformly heat-altered over their entire surfaces include limb elements from both for and hind legs. It is possible that the bulk of the La Chimba rabbit subassemblage was burned or otherwise heat-altered after deposition.

Very little, yet tantalizing, information about relevant indigenous cultural practices exists. Salomon (1986:82) mentions that early Spanish sources include rabbits, partridges and especially deer as the major sources for human meat consumption in the northern páramos of Ecuador. In the region of Otavalo, rabbits and deer were among the items paid as tribute (Newson 1995:34; Salomon 1986:83). Rabbits, in particular, "were hunted en masse by surrounds (Salomon 1986:82)." Recent ecological studies of *Sylvilagus brasiliensis* on the Venezuelan páramo yielded a density of only 2.2 rabbits per hectare, a much lower figure than comparable studies of *S. floridanus* in temperate areas however, these lower figures are probably affected by recent environmental, especially human-induced, change (Durant 1983:25-26). Early documents commonly refer to great numbers of rabbits in the northern highlands (Estrella 1988:329). It is perhaps important to note that early sources from the Quito area indicate that both rabbit and deer meat was cured in the sun, somewhat similar to ch'arki, or Andean jerky (Newson 1995: 42; Salomon 1986:82). In particular, a 1569 account mentions that "...the Indians dry (rabbits) in the sun, and toss them into their cooked stews called *logro*, with a lot of capsicum pepper (Estrella 1988:329, my translation, and compare with Salomon 1986:82). It is interesting to explore these cultural patterns as potential analogs for prehistoric human processing of lagomorphs at La Chimba. Skinning of rabbits tends to be quite simple, and the loose fitting skin is easily removed, even without using a sharp implement (*e.g.*, Charles and Jacobi 1994:13). The intact pelt can then be used for a variety of purposes. Next, sun-drying can proceed either with the bones left in, or after removing larger muscles from bones. The former is akin to the current Andean practice of *chalona*, the latter to *ch'arki* in the strict sense (Stahl 1998). In the case of rabbit *chalona*, complete skeletons could conceivably have been exposed to the sun for drying. Desiccated bodies could then have found their way into stews, with relatively complete bone dregs tossed into

Fig. 15



N = 1,802 (*99.9%*)

midden context. In the case of rabbit *ch'arki*, major muscle masses could have been removed from the rabbit carcass, with thinner strips eventually exposed to the sun, and whole bones tossed into midden contexts. In either case, cut marks resulting from a need to sever major limb or body joints, are unnecessary (*cf.* Charles and Jacobi 1994:14)

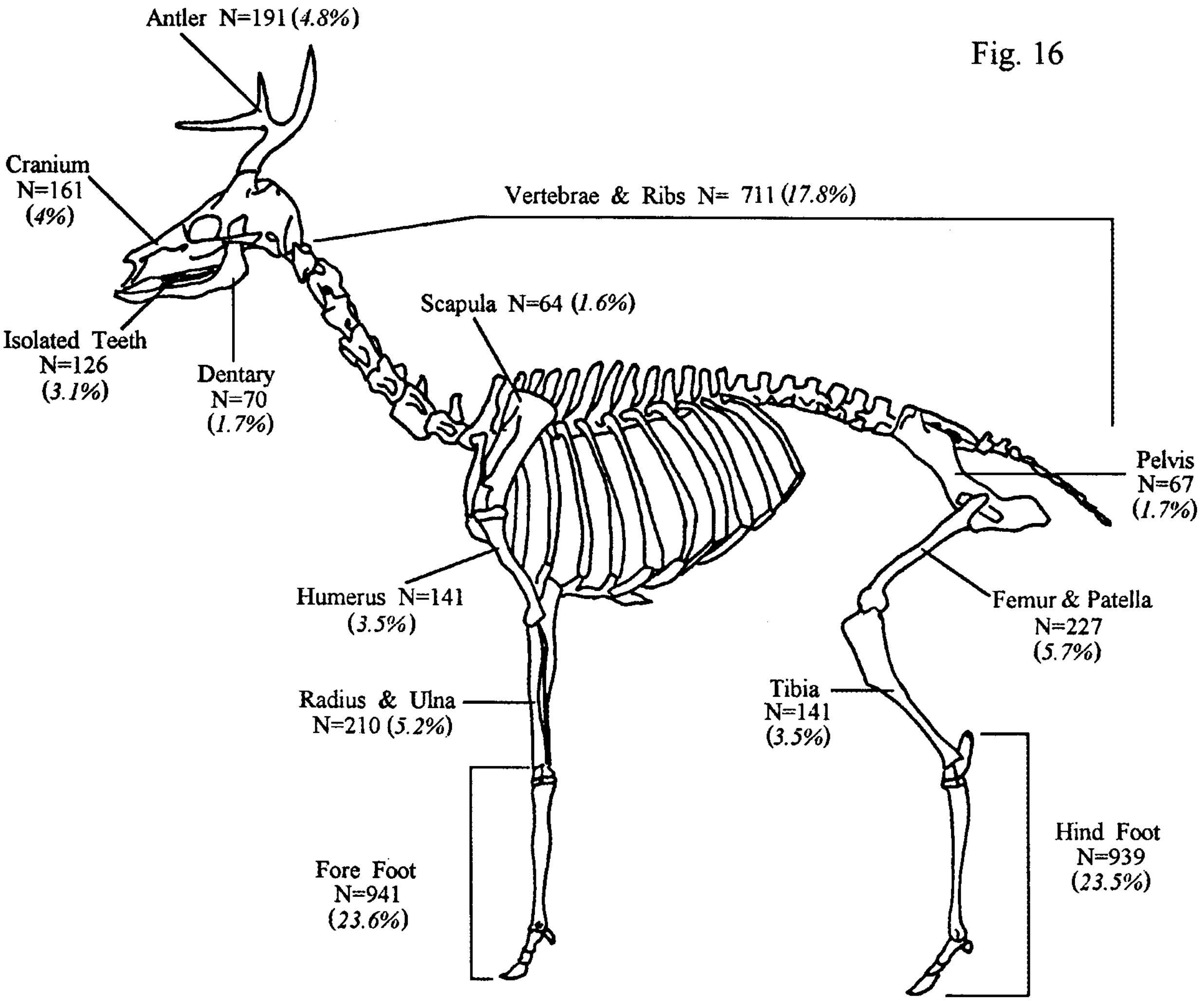
Odocoileus Skeletal Representation

Three different genera of native cervids are represented in the La Chimba deposits. Considered together, the aggregated frequency of cervid remains (N=5,717) is second only to lagomorph bones at the site; however, in terms of biomass, they were likely of far greater economic importance to the prehistoric inhabitants. As earlier mentioned, the three genera were divided into small- (*Pudu*), medium- (*Mazama*) and large- (*Odocoileus*) sized taxa, with some potential for error due to overlap in size. The cervid subassemblage is dominated by larger *Odocoileus* specimens (N=3989, including *cf.* category), and since reliable density figures are available only for this cervid taxon (Lyman 1984), a detailed exploration of density-mediation is restricted to the White-tailed Deer. The remains of the latter are found in virtually all (N=80) of the excavation contexts (Table 4). Figure 16 illustrates the differential skeletal representation of identified *Odocoileus* remains in the aggregated assemblage. Again, elements from all portions of the skeleton are represented; however, much less evenly than with lagomorphs. In particular, a quick perusal might suggest under representation of the dentary, scapula and pelvis. Also, unlike lagomorphs, when the preserved scan site frequencies are aggregated for each test pit, it appears that skeletal assemblage preservation is not density mediated on a site-wide basis. Spearman's Rank Order Correlations between Volume Density for individual *Odocoileus* scan sites, and identified scan sites in the recovered subassemblage are neither correlated nor significant: TP 1 (r_s =-0.07, p=.48, N=101); TP5 (r_s =-0.06, p=.55, N=101); and, TP7 (r_s =-0.01, p=95, N=101).

Table 6 lists the observed and expected survivorship of different *Odocoileus* elements aggregated from all vertical levels and listed by test unit, according to the same procedures outlined for Table 5. The rank orders of scan site survivorship in each test unit are highly positive and significantly correlated with each other (r_s =.89, p=0, N=101 to r_s =.92, p=0, N=101). This suggests that scan site preservation is relatively similar between each test unit, and that a consistent under-representation of certain scan sites throughout the site may be a proximate causal factor in non-density-dependent preservation. In order to explore this idea further, a companion Table 7 models a hypothetical assemblage which survives on the basis of density. Expected populations of scan sites (based upon the MNI for each aggregated unit and multiplied by the number of times that scan site occurs in the skeleton) are multiplied by respective volume density measurements for each scan site in each unit. The density-dependent expectations are subtracted from the actual observed populations and ranked. A final column lists the average ranking of each scan site expected to survive in the aggregated units, if the subassemblage had preserved in density-mediated fashion.

Certainly, identifiability and fragmentation are factors ultimately contributing to patterned under-representation. The most under-represented *Odocoileus* elements in TPs 1, 5 and 7 are ribs, which tend to be characterized by scan sites of intermediate density. The non-identification of rib fragments is precisely similar to that encountered for lagomorphs, namely an initial

Fig. 16



N = 3989 (*99.7%*)

Table 6. Observed/Expected *Odocoileus* Scan Site Survivorship in TP1, TP5 and TP7

Scan Site	TP1 Exp.	TP1 Obs.	Obs-Exp	Rank	TP5 Exp.	TP5 Obs.	Exp-Obs	Rank	TP7 Exp.	TP7 Obs.	Exp-Obs	Rank
DN1	52.25	4	-48.25	38	9	2	-7	51	22.25	8	-14.25	45
DN2	52.25	4	-48.25	36	9	1.75	-7.25	41	22.25	9	-13.25	52
DN3	52.25	4	-48.25	40	9	2.75	-6.25	57	22.25	8.25	-14	48
DN4	52.25	3	-49.25	31	9	1.5	-7.5	39	22.25	5.75	-16.5	37
DN5	52.25	1	-51.25	29	9	0.75	-8.25	31	22.25	3.5	-18.75	31
DN6	52.25	0.75	-51.5	27	9	0.25	-8.75	27	22.25	5.25	-17	35
DN7	52.25	8	-44.25	55	9	0.75	-8.25	33	22.25	5.25	-17	36
DN8	52.25	5	-47.25	44	9	0	-9	24	22.25	7.75	-14.5	42
AT1	26.125	1	-25.125	79	4.5	0	-4.5	70	11.125	1.75	-9.375	69
AT2	26.125	1.5	-24.625	80	4.5	0	-4.5	69	11.125	3.5	-7.625	72
AT3	26.125	4	-22.125	86	4.5	0	-4.5	68	11.125	4.25	-6.875	75
AX1	26.125	3.5	-22.625	85	4.5	1.5	-3	79	11.125	6	-5.125	83
AX2	26.125	2.25	-23.875	82	4.5	1.25	-3.25	78	11.125	5.75	-5.375	79
AX3	26.125	2	-24.125	81	4.5	1.25	-3.25	77	11.125	7	-4.125	84
CE1	182.875	8	-174.875	9	31.5	10.75	-20.75	17	77.875	13.75	-64.125	8
CE2	182.875	7.5	-175.375	8	31.5	11	-20.5	18	77.875	13.75	-64.125	9
TH1	339.625	46	-293.625	7	58.5	9.75	-48.75	6	144.625	34.25	-110.375	7
TH2	339.625	19.5	-320.125	6	58.5	10	-48.5	7	144.625	22	-122.625	6
RI1	627	0	-627	1	126	5	-121	4	311.5	16.75	-294.75	3
RI2	627	0	-627	4	126	5	-121	5	311.5	21.75	-289.75	5
RI3	627	0	-627	5	126	3.25	-122.75	3	311.5	21	-290.5	4
RI4	627	0	-627	2	126	2	-124	1	311.5	8	-303.5	2
RI5	627	0	-627	3	126	2	-124	2	311.5	4.5	-307	1
ST1	26.125	14	-12.125	88	4.5	4	-0.5	87	11.125	21	9.875	89
LU1	156.75	15.75	-141	14	27	4.25	-22.75	14	66.75	16.5	-50.25	11
LU2	156.75	15.75	-141	15	27	4.5	-22.5	15	66.75	17.25	-49.5	12
LU3	156.75	7	-149.75	11	27	3	-24	13	66.75	11	-55.75	10
SC1	26.125	3	-23.125	84	4.5	2	-2.5	81	11.125	4.75	-6.375	78
SC2	26.125	3	-23.125	83	4.5	1	-3.5	74	11.125	4.5	-6.625	76
IL1	52.25	9.25	-43	59	9	2	-7	44	22.25	6	-16.25	38
IL2	52.25	5.5	-46.75	46	9	3	-6	60	22.25	8	-14.25	46
AC1	52.25	8	-44.25	54	9	3.25	-5.75	61	22.25	8.75	-13.5	51
IS1	52.25	7	-45.25	52	9	3	-6	59	22.25	7	-15.25	40
IS2	52.25	6.5	-45.75	50	9	1.75	-7.25	42	22.25	8.5	-13.75	50
PU1	52.25	3	-49.25	33	9	1	-8	37	22.25	4	-18.25	33
PU2	52.25	3	-49.25	34	9	2	-7	46	22.25	3	-19.25	30
SP1	52.25	17	-35.25	73	9	2	-7	49	22.25	17	-5.25	80
SP2	52.25	10.5	-41.75	62	9	2	-7	45	22.25	10.25	-12	59
SP3	52.25	4.25	-48	42	9	1	-8	38	22.25	4.5	-17.75	34
SP4	52.25	6	-46.25	49	9	1	-8	35	22.25	2.75	-19.5	29
SP5	52.25	6	-46.25	48	9	2	-7	50	22.25	1.75	-20.5	28
HU1	52.25	4.25	-48	41	9	3.75	-5.25	63	22.25	8.5	-13.75	49
HU2	52.25	4	-48.25	39	9	1	-8	36	22.25	7.75	-14.5	41
HU3	52.25	0	-52.25	26	9	0	-9	25	22.25	1	-21.25	25
HU4	52.25	9.25	-43	60	9	2	-7	47	22.25	9	-13.25	53
HU5	52.25	10	-42.25	61	9	4	-5	65	22.25	10.25	-12	58
P11	209	76.5	-132.5	18	36	27.5	-8.5	28	89	68	-21	26
P12	209	91	-118	19	36	25.25	-10.75	20	89	65.25	-23.75	22
P13	209	94.5	-114.5	20	36	27.75	-8.25	32	89	70.75	-18.25	32
P21	209	63.5	-145.5	13	36	24.75	-11.25	19	89	60.5	-28.5	20
P22	209	70	-139	16	36	25.25	-10.75	21	89	59	-30	18
P23	209	72	-137	17	36	25.75	-10.25	22	89	59.5	-29.5	19
P31	209	60	-149	12	36	26.5	-9.5	23	89	54.25	-34.75	15
FE1	52.25	15	-37.25	71	9	8.75	-0.25	88	22.25	15.25	-7	74
FE2	52.25	52.25	0	89	9	2.25	-6.75	54	22.25	11.5	-10.75	64
FE3	52.25	6	-46.25	47	9	2.25	-6.75	53	22.25	7	-15.25	39
FE4	52.25	4	-48.25	37	9	0.5	-8.5	30	22.25	0.25	-22	23
FE5	52.25	13	-39.25	66	9	1.75	-7.25	40	22.25	8.25	-14	47
FE6	52.25	7	-45.25	51	9	2.25	-6.75	52	22.25	10.5	-11.75	60
PA1	26.125	7	-19.125	87	9	5.5	-3.5	73	22.25	12.5	-9.75	66
TI1	52.25	3.75	-48.5	35	9	5.75	-3.25	76	22.25	10	-12.25	57
TI2	52.25	4.5	-47.75	43	9	2.5	-6.5	56	22.25	10	-12.25	56
TI3	52.25	0.75	-51.5	28	9	0.5	-8.5	29	22.25	0.5	-21.75	24
TI4	52.25	8	-44.25	56	9	1.75	-7.25	43	22.25	8	-14.25	43
TI5	52.25	11.25	-41	63	9	6.25	-2.75	80	22.25	9.25	-13	54
CA1	52.25	26	-26.25	78	9	8	-1	85	22.25	18.5	-3.75	85
CA2	52.25	19	-33.25	74	9	7.25	-1.75	82	22.25	17	-5.25	82
CA3	52.25	15	-37.25	72	9	8	-1	84	22.25	15	-7.25	73
CA4	52.25	14.5	-37.75	70	9	5.25	-3.75	72	22.25	12.5	-9.75	67
AS1	52.25	21	-31.25	75	9	8.25	-0.75	86	22.25	22	-0.25	87
AS2	52.25	23	-29.25	77	9	9	0	89	22.25	22.25	0	88
AS3	52.25	23	-29.25	76	9	7.5	-1.5	83	22.25	21.5	-0.75	86

Table 6. (Cont.)

Scan Site	TP1 Exp.	TP1 Obs.	Obs-Exp	Rank	TP5 Exp.	TP5 Obs.	Exp-Obs	Rank	TP7 Exp.	TP7 Obs.	Exp-Obs	Rank
RA1	52.25	14.5	-37.75	69	9	5	-4	71	22.25	17	-5.25	81
RA2	52.25	9	-43.25	58	9	2.25	-6.75	55	22.25	14.5	-7.75	71
RA3	52.25	5.25	-47	45	9	0	-9	26	22.25	8	-14.25	44
RA4	52.25	1	-51.25	30	9	0.75	-8.25	34	22.25	12.25	-10	65
RA5	52.25	7	-45.25	53	9	4	-5	66	22.25	15.75	-6.5	77
UL1	52.25	8.5	-43.75	57	9	4.25	-4.75	67	22.25	13.75	-8.5	70
UL2	52.25	12	-40.25	65	9	5.5	-3.5	75	22.25	9.75	-12.5	55
UL3	52.25	3	-49.25	32	9	2	-7	48	22.25	12.75	-9.5	68
NC1	52.25	14	-38.25	68	9	3.75	-5.25	64	22.25	10.75	-11.5	62
NC2	52.25	14	-38.25	67	9	3.5	-5.5	62	22.25	10.5	-11.75	61
NC3	52.25	12	-40.25	64	9	3	-6	58	22.25	11	-11.25	63
MET1	104.5	0.5	-104	22	36	7.75	-28.25	12	44.5	16.5	-28	21
MET2	104.5	4.75	-99.75	23	36	5	-31	10	44.5	14.5	-30	17
MET3	104.5	0.5	-104	21	36	2	-34	8	44.5	8	-36.5	14
MET4	104.5	5.75	-98.75	24	36	3.5	-32.5	9	44.5	11.25	-33.25	16
MET5	104.5	8.5	-96	25	36	6.75	-29.25	11	44.5	23.75	-20.75	27
MET6	209	36	-173	10	36	15	-21	16	89	44.75	-44.25	13

Table 7. Density-Dependent *Odocoileus* Scan Site Survivorship in TP1, TP5 and TP7

	TP 1		TP5		TP7		
Scan Site	VDxExp	Obs-VDxExp	VDxExp	Obs-VDxExp	VDxExp	Obs-VDxExp	Avg. Rank
DN1	28.7375	-76.9875	4.95	-2.95	12.2375	-4.2375	27
DN2	29.7825	-78.0325	5.13	-3.38	12.6825	-3.6825	26
DN3	28.7375	-76.9875	4.95	-2.2	12.2375	-3.9875	30
DN4	29.7825	-79.0325	5.13	-3.63	12.6825	-6.9325	20
DN5	18.81	-70.06	3.24	-2.49	8.01	-4.51	32
DN6	16.1975	-67.6975	2.79	-2.54	6.8975	-1.6475	38
DN7	22.4675	-66.7175	3.87	-3.12	9.5675	-4.3175	32
DN8	31.8725	-79.1225	5.49	-5.49	13.5725	-5.8225	18
AT1	3.39625	-28.5212	0.585	-0.585	1.44625	0.30375	60
AT2	3.91875	-28.5437	0.675	-0.675	1.66875	1.83125	62
AT3	6.7925	-28.9175	1.17	-1.17	2.8925	1.3575	59
AX1	4.18	-26.805	0.72	0.78	1.78	4.22	74
AX2	2.6125	-26.4875	0.45	0.8	1.1125	4.6375	75
AX3	4.18	-28.305	0.72	0.53	1.78	5.22	73
CE1	34.7462	-209.621	5.985	4.765	14.7962	-1.04625	45
CE2	27.4312	-202.806	4.725	6.275	11.6812	2.06875	53
TH1	81.51	-375.135	14.04	-4.29	34.71	-0.46	21
TH2	91.6987	-411.824	15.795	-5.795	39.0487	-17.0487	8
RI1	163.02	-790.02	32.76	-27.76	80.99	-64.24	3
RI2	156.75	-783.75	31.5	-26.5	77.875	-56.125	4
RI3	250.8	-877.8	50.4	-47.15	124.6	-103.6	1
RI4	150.48	-777.48	30.24	-28.24	74.76	-66.76	3
RI5	87.78	-714.78	17.64	-15.64	43.61	-39.11	6
ST1	5.7475	-17.8725	0.99	3.01	2.4475	18.5525	84
LU1	45.4575	-186.457	7.83	-3.58	19.3575	-2.8575	24
LU2	47.025	-188.025	8.1	-3.6	20.025	-2.775	23
LU3	45.4575	-195.207	7.83	-4.83	19.3575	-8.3575	14
SC1	4.96375	-28.0887	0.855	1.145	2.11375	2.63625	71
SC2	4.18	-27.305	0.72	0.28	1.78	2.72	69
IL1	10.45	-53.45	1.8	0.2	4.45	1.55	61
IL2	25.6025	-72.3525	4.41	-1.41	10.9025	-2.9025	37
AC1	14.1075	-58.3575	2.43	0.82	6.0075	2.7425	65
IS1	21.4225	-66.6725	3.69	-0.69	9.1225	-2.1225	45
IS2	8.36	-54.11	1.44	0.31	3.56	4.94	68
PU1	24.035	-73.285	4.14	-3.14	10.235	-6.235	26
PU2	12.54	-61.79	2.16	-0.16	5.34	-2.34	49
SP1	18.81	-54.06	3.24	-1.24	8.01	8.99	66
SP2	25.6025	-67.3525	4.41	-2.41	10.9025	-0.6525	40
SP3	17.765	-65.765	3.06	-2.06	7.565	-3.065	38
SP4	14.63	-60.88	2.52	-1.52	6.23	-3.48	42
SP5	12.0175	-58.2675	2.07	-0.07	5.1175	-3.3675	50

Table 7 (cont.)

	TP 1		TP5		TP7		
Scan Site	VDxExp	Obs-VDxExp	VDxExp	Obs-VDxExp	VDxExp	Obs-VDxExp	Avg. Rank
HU1	12.54	-60.54	2.16	1.59	5.34	3.16	66
HU2	13.0625	-61.3125	2.25	-1.25	5.5625	2.1875	54
HU3	27.6925	-79.9425	4.77	-4.77	11.7925	-10.7925	17
HU4	32.9175	-75.9175	5.67	-3.67	14.0175	-5.0175	24
HU5	20.3775	-62.6275	3.51	0.49	8.6775	1.5725	57
P11	117.04	-249.54	20.16	7.34	49.84	18.16	62
P12	144.21	-262.21	24.84	0.41	61.41	3.84	47
P13	150.48	-264.98	25.92	1.83	64.08	6.67	52
P21	121.22	-266.72	20.88	3.87	51.62	8.88	55
P22	102.41	-241.41	17.64	7.61	43.61	15.39	63
P23	106.59	-243.59	18.36	7.39	45.39	14.11	62
P31	75.24	-224.24	12.96	13.54	32.04	22.21	64
FE1	21.945	-59.195	3.78	4.97	9.345	5.905	73
FE2	29.7825	-29.7825	5.13	-2.88	12.6825	-1.1825	49
FE3	14.63	-60.88	2.52	-0.27	6.23	0.77	55
FE4	13.0625	-61.3125	2.25	-1.75	5.5625	-5.3125	37
FE5	18.2875	-57.5375	3.15	-1.4	7.7875	0.4625	52
FE6	13.0625	-58.3125	2.25	0	5.5625	4.9375	65
PA1	10.7112	-29.8362	3.69	1.81	9.1225	3.3775	72
TI1	18.81	-67.31	3.24	2.51	8.01	1.99	59
TI2	17.2425	-64.9925	2.97	-0.47	7.3425	2.6575	56
TI3	29.7825	-81.2825	5.13	-4.63	12.6825	-12.1825	17
TI4	19.3325	-63.5825	3.33	-1.58	8.2325	-0.2325	45
TI5	14.63	-55.63	2.52	3.73	6.23	3.02	70
CA1	16.1975	-42.4475	2.79	5.21	6.8975	11.6025	82
CA2	15.675	-48.925	2.7	4.55	6.675	10.325	79
CA3	16.72	-53.97	2.88	5.12	7.12	7.88	78
CA4	38.665	-76.415	6.66	-1.41	16.465	-3.965	33
AS1	26.6475	-57.8975	4.59	3.66	11.3475	10.6525	75
AS2	26.125	-55.375	4.5	4.5	11.125	11.125	77
AS3	21.4225	-50.6725	3.69	3.81	9.1225	12.3775	79
RA1	33.44	-71.19	5.76	-0.76	14.24	2.76	52
RA2	29.7825	-73.0325	5.13	-2.88	12.6825	1.8175	41
RA3	17.2425	-64.2425	2.97	-2.97	7.3425	0.6575	42
RA4	24.5575	-75.8075	4.23	-3.48	10.4575	1.7925	37
RA5	30.8275	-76.0775	5.31	-1.31	13.1275	2.6225	46
UL1	31.8725	-75.6225	5.49	-1.24	13.5725	0.1775	43
UL2	28.7375	-68.9875	4.95	0.55	12.2375	-2.4875	47
UL3	33.9625	-83.2125	5.85	-3.85	14.4625	-1.7125	26
NC1	38.665	-76.915	6.66	-2.91	16.465	-5.715	26
NC2	29.7825	-68.0325	5.13	-1.63	12.6825	-2.1825	39
NC3	24.035	-64.285	4.14	-1.14	10.235	0.765	50
MET1	52.25	-156.25	18	-10.25	22.25	-5.75	15
MET2	43.89	-143.64	15.12	-10.12	18.69	-4.19	18
MET3	64.79	-168.79	22.32	-20.32	27.59	-19.59	11
MET4	71.06	-169.81	24.48	-20.98	30.26	-19.01	11
MET5	39.71	-135.71	13.68	-6.93	16.91	6.84	37
MET6	89.87	-262.87	15.48	-0.48	38.27	6.48	46

reluctance on the part of the analyst to imbue these elements with diagnostic acuity; however, as analysis continued, greater confidence was placed in the identification of relatively complete ribs to the ordinal level. A similar argument might be made for under represented thoracic and lumbar vertebral fragments which are difficult to identify to higher order zoological categories, particularly when fragmented. Thoracic and Lumbar vertebrae tend to be characterized by scan sites of intermediate density. A similar argument may be made for isolated fragments of the relatively durable pubic (PU 1) scan site, which could conceivably be difficult to identify in isolation from the remaining pelvis. The distal ulna is also very frequently absent, yet identifiable and relatively durable, as is the lateral half of the highly diagnostic naviculo-cuboid (NC 1). The former is isolated from the dense, proximal scan sites of the ulna by a relatively slender shaft; therefore, even fused specimens may be easily detached and subsequently lost. Furthermore, fragmentation of the naviculo-cuboid, an otherwise compact tarsal element with little nutritional value, would suggest a preservation environment characterized by a relatively high degree of assemblage fragmentation.

The *Odocoileus* subassemblage, aggregated for the entire site, appears to survive in non-density-dependent fashion. However, a perusal of the remaining under-represented elements might suggest that this pattern is, too at least some extent, affected by the selective removal of specific element portions for tool manufacture. A number of different scan sites that are conspicuously under-represented, constitute bone portions preferred for tool manufacture because of their durability and shape (*e.g.*, long and narrow). These include the proximal ends and shaft portions (MET 1,2,3,4) of deer metapodia, which not only tend to be relatively diagnostic, but appear in the assemblage as culturally modified implements. The examples that appear in the assemblage are likely a small sample of discarded specimens, many of which could have been selectively removed. The La Chimba assemblage also contains recovered examples of non-metapodial shaft tools, and in this regard, the under representation of highly durable scan sites from the humeral (HU 3) and tibial shafts (TI 3) might also reflect deliberate selection and possible removal for tool manufacture. To a lesser extent, femoral (FE 4) and radial shafts (RA 4) also appear to be somewhat under-represented, when compared with an assemblage hypothetically surviving on the basis of density. Isolated shaft fragments from non-metapodial long bones can also be difficult to identify, especially when modified to varying degrees through whittling, polishing or heating. Finally, mandibular scan sites, particularly from the anterior dentary (DN 1,2,3,4) and the coronoid process (DN 8) are under-represented in the White-tailed deer sub-assemblage. They are the highest density scan sites in the dentary, which begs the question why they would not survive, whereas lesser density sites of the same element would. Although there are no culturally-modified mandibles identified in the assemblage, the selective removal of these potentially useful elements for non-food purposes, is possible. A detailed examination of the La Chimba modified bone, is included below.

Numerous cut marks are visible on many *Odocoileus* specimens. The majority are located on antler pieces, which were frequently modified. Cut marks are also located on cranial fragments, and some vertebral fragments; otherwise, they are confined to major long bones (femur, humerus and radius), and portions of the lower leg (astragalus, calcaneum, phalanges). Most visibly heat-altered specimens are completely charred to a dark-brown to black (350-400°C, reducing atmosphere) hue, which might suggest post-depositional burning of bone waste. It is of interest to note that burning is heavily restricted to, in order of frequency: phalanges, antler fragments, metapodia, femora, radii, humeri, tibiae, astragali, and calcanea. Many of the aforementioned elements are selected for further modification. Some of the conspicuously modified cervid bone, such as chopped and beveled antler fragments, or scored long bone shafts appear to have been burnt, especially in specific areas of cultural modification. This may suggest that where there is evidence for patterned burning on *Odocoileus* bone elements, heat-treatment may have been used to prepare antler and bone (especially shaft) portions for detachment. There are, however, examples of non-worked bones like vertebrae, astragali and pelvis fragments that appear to have been randomly heat treated as well, suggesting that many may also have been burned for no readily apparent reason (possible reasons could include trash disposal or fuel) either prior to or after deposition.

It is possible that the *Odocoileus* assemblage, like its lagomorph counterpart, is preserved in density-dependent fashion. Non-density-dependent survivorship may, in part, be an artifact of the selective removal of shaft elements which are particularly appropriate for tool manufacture. It is clear from the following section of this report that *Odocoileus* skeletal portions were heavily utilized, and conceivably removed, used and discarded elsewhere. If this is a reasonable scenario, then the large cervid skeletal accumulation at the site is characterized by an introduction of relatively complete skeletons, which were subsequently combed for specific element portions (especially antler and long bone shafts), with the remainder then possibly surviving in density-mediated fashion after deposition.

Although speculative, we could again turn to the early chronicles in an attempt to understand cultural utilization of introduced deer carcasses. Deer are mentioned, along with rabbits, as the most abundant and utilized game animals in the northern highlands (Estrella 1988:327; Newson 1995:35; Salomon 1986:83). It has been observed that to the north of Quito, specialized hunters traded in cured venison (Newson 1995:35), again suggestive of something akin to Andean *ch'arki* (Salomon 1986:82). If the carcasses were completely stripped of muscle mass in order to prepare the necessary thin *mantas* for sun drying (Stahl 1998), this could help to explain the abundant and relatively intact *Odocoileus* skeletons in archaeological context at La Chimba.

Skeletal Representation of Other Taxa

The remainder of the cervid subassemblage at La Chimba, includes medium-sized animals, possibly *Mazama* (N= 467), as well as the small-bodied cervid, most likely *Pudu* (N= 613). No reliable density assays exist for these taxa; however, a rough breakdown of the distribution of skeletal elements by arbitrary skeletal portion would suggest that there is relatively little difference in skeletal representation between the different cervid size classes. There are some modified *Pudu* bones in the collection. With the possible exception of highly elaborated *Odocoileus* antlers, there is little reason to doubt that *Mazama* elements were culturally modified any differently than similar elements from larger cervids.

Relatively conspicuous Tapir (*Tapirus*) remains are far less common (N=136) than either lagomorphs and cervids. Although relatively few in number, Tapir remains are identified from as many as 52 separate excavation contexts. Elements from throughout the tapir skeleton tend to be represented at La Chimba, suggesting that entire carcasses were also introduced to the site. It is interesting to note that a relatively high proportion of Tapir bones appear to be either complete or almost complete. Very few are burned, and with the exception of one root-stained specimen, they tend to be relatively unmodified. In fact, a complete Tapir femur was recovered from the deepest level of TP 7 (Cat. #236, Lev. 28). It is certainly only speculative, but a form of prehistoric *ch'arki* production, described for both rabbits and deer in the historic records, could also account for the state of preserved Tapir bones in the archaeological deposits at La Chimba.

The remains of Paca (*Agouti*) are relatively scarce (N= 66) and distributed throughout 34 different excavation contexts at the site. The subassemblage appears to be dominated by teeth and tooth-bearing elements, which of course is a likely artifact of identifiability. Otherwise, there appears to be a relatively even distribution of elements from other areas of the skeleton. No obvious patterning of heat treatment on Paca bones can be discerned, with the exception that burned teeth dominate. This is likely an artifact of identifiability as well. Again, whether or not the Paca, like its medium-sized lagomorph counterpart was produced into a northern Andean form of *ch'arki*, is entirely speculative.

In terms of skeletal representation, the four numerically dominant taxa (leporids, cervids, Tapir, Paca) differ from the remainder of the La Chimba assemblage. A consideration of skeletal representation for carnivores may be potentially revealing. Identifiable remains are found isolated throughout different excavation contexts at the site, with the possible exception of tentatively identified *Canis* remains recovered in TP 1, Level 5. These consist of five metapodial and 1 phalanx fragment (Cat. #8), possibly representing the paw of one animal. Small carnivore remains (N=10) are dominated by non-foot elements (90%). These consist mainly of cranial or tooth-bearing elements from genera like *Nasuella* and *Mustela*. Medium-sized carnivore remains (N=39) from genera tentatively including *Dusicyon, Canis, Procyon, Conepatus,* and *Potos* are evenly represented by foot (46%) and non-foot elements (54%). Identifiably large carnivores (N=54) are dominated by foot elements (79%), principally phalanges (52%). Two taxa, *Felis concolor* and *Tremarctos ornatus* comprise this large carnivore category. In either case, where elements were identified to the level of genus, each subassemblage was dominated by foot elements (79% in both cases). In particular, two felid elements were heavily weathered. Both elements, one phalanx (Cat #42) and one metapodium (Cat. #51) were recovered from deep in TP 5, levels 9 and 12 respectively. Interestingly, very few of the identifications were based on dental material. The preponderance of foot elements from large carnivores like Puma and Spectacled Bear may or may not have a function associated with the use of hides, and the possible selective deposition of non-foot elements elsewhere.

Considering the overall size of the La Chimba assemblage, and the use of fine screen mesh in the most recent excavations, relatively few remains of small rodents (N=113) were identified. It is not surprising that the bulk of these remains (N=81, *72%*) were recovered from TP 5 and TP 7, in which sediment was screened through fine mesh. Only four genera of relatively common small rodents, including *Akodon, Oryzomys, Phyllotis* and *Thomasomys* were identified on the basis of dental remains, as was one genus of medium-sized rodents (N=20), including *Sigmodon* (N=2). All of the latter size category derive from TP 5 or TP 7. Elements from throughout the skeleton, many of which are relatively complete, appear to characterize the assemblage of deposited bones from both small and medium-sized rodents. The remains of smaller rodents appear distributed throughout various excavation contexts, with three notable concentration of bones associated with *Akodon* and *Phyllotis* dental remains in TP 5 Lev. 9 (Cat. #42), *Phyllotis* remains in TP 5 Lev. 12 (Cat.# 51), and smaller *Thomasomys* remains in TP 7 Lev. 15 (Cat.#8). These concentrations likely represent locally intrusive deposits. Only five small rodent bones in the entire collection are characterized by the white luster of intrusive deposits.

Bird remains appear to be generally ubiquitous throughout the excavated deposits, yet dominated by some form of tinamou. Tinamiform remains (N=47) from most major skeletal portions, are found in as many as 22 separate excavation contexts; a generally characteristic pattern of most bird remains, which appear to be scattered throughout the deposits.

CULTURAL MODIFICATION

A significant portion of the La Chimba archaeofaunal assemblage displays various forms of cultural modification, ranging from simple cut marks to clearly fashioned tools. An analysis of the modified bone remains from La Chimba reveals that two basic kinds of tools were produced at the site. In terms of numerical quantity, the acquisition and initial reduction of cervid antler material into usable pieces appears to have been particularly important. Both finished tools and waste byproducts were recovered from archaeological context. A second major class of bone tool manufacture at La Chimba apparently involved the removal of principally large mammal long bone shafts for subsequent tool production. Again, some of the finished products as well as their waste byproducts were recovered from archaeological context. The following discussion centers around extensive illustrations of materials recovered from all excavation seasons at La Chimba. Photographic plates include studied examples recovered from Test Pits 5 and 7, which are in temporary storage at the IARII in Honolulu. These are supplemented by line drawings of materials illustrated by Lynn Cunningham Balck, many of which are presently stored at the FMNH. We thank Dr. Elizabeth Wing for allowing us to reproduce them here. Other materials are currently housed in Otavalo.

Antler Modification

Significant antler portions from the larger cervids, *Odocoileus virginianus* and *Mazama spp.* were certainly abundant in the deposits. Various forms of initial reduction appear obvious (Plate 1: Pi-1-159, 153, 131: Fig 17: Pi-1-105, 16). These take the form of angled grooving and beveling on one end to remove antler peduncles (Plate 1:Pi-1-153; Fig. 18: Pi-1-105, 5, 145, 47)), or on two ends to isolate and detach a useable piece (Plate 1: Pi-1-131; Fig 18: Pi-1-170). Beveling is indicated in either plate via arrows. It would also appear from material throughout the deposits that this form of grooving and beveling may have begun as initial scoring around the circumference of the antler portion. The scored area appears to have been then widened into a beveled groove, much in the same manner as chopping a tree (Plate 2: Pi-1-177, 134, 149, 139, 123, 183, 218; Fig 19: Pi-1-83, 8, 105). A second form of detaching useable pieces is illustrated (Plate 1: Pi-1-39, 124) in which the antler piece appears to have been modified first through polishing or smoothing, followed by circumferential grooving and beveling until the desired portion is eventually detached (Plate 1: Pi-1-39, 24). This is particularly obvious in one example (Fig 20:Pi-1-26a) which consists of a detached peduncle and antler portion together with an attached and polished tine. Some pieces suggest that grooving, beveling and detachment may have been aided by heat alteration. Although none of the pieces indicating primary detachment (Plate 1; Fig. 17; Fig. 19: Pi-1-8) show evidence of patterned burning, a number of the waste pieces do suggest that this may have taken place. Some of these are burned in areas of detachment (Plate 2: Pi-1-34, 139, 183; Plate 3: Pi-1-183, 183). Others indicate burning over the entire fragment (Plate 2: Pi-1-123, 123,148; Plate 3: Pi-1-127) which may either indicate burning during detachment, or post-detachment burning of the discarded waste piece.

Plate 1

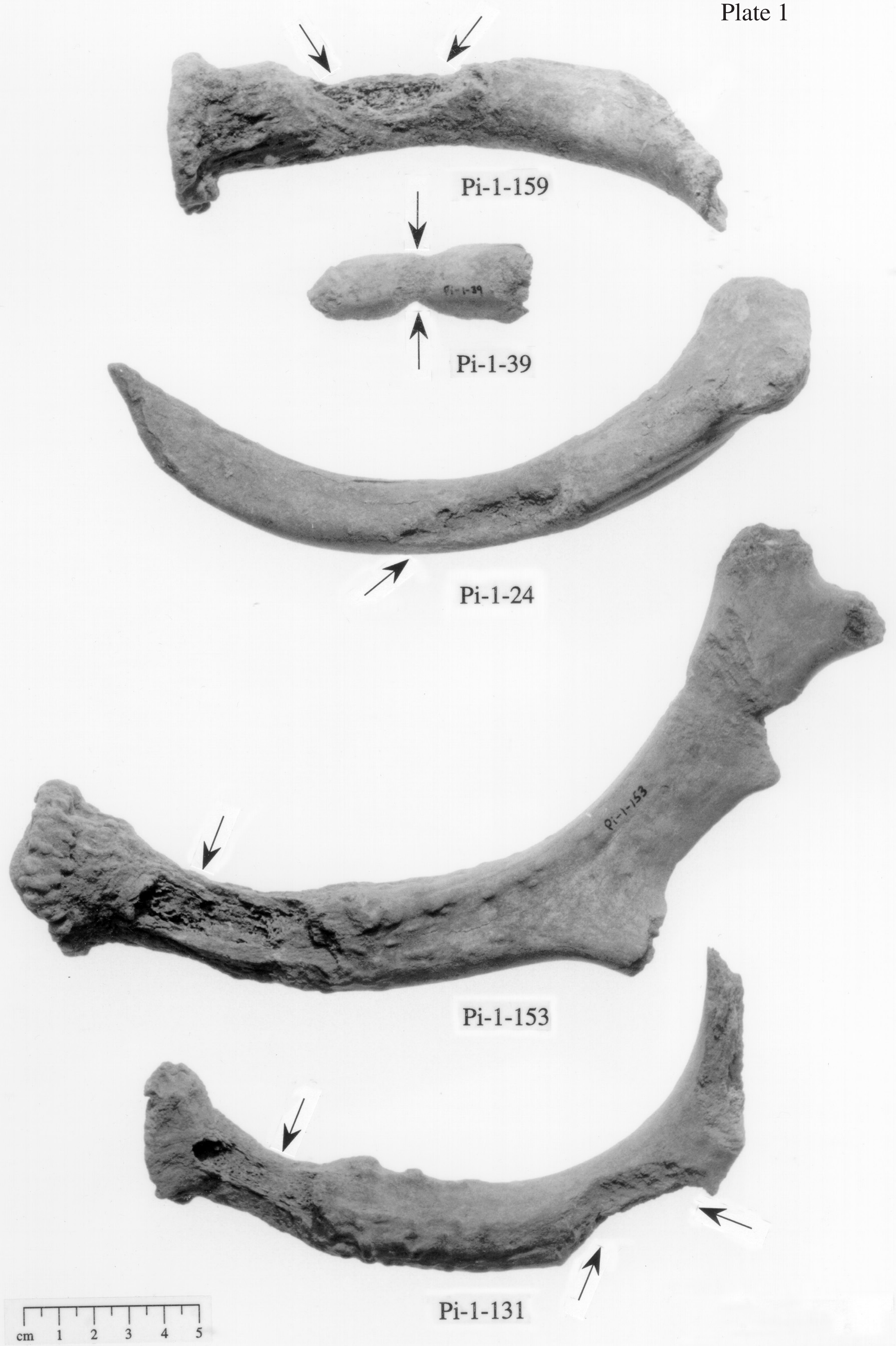
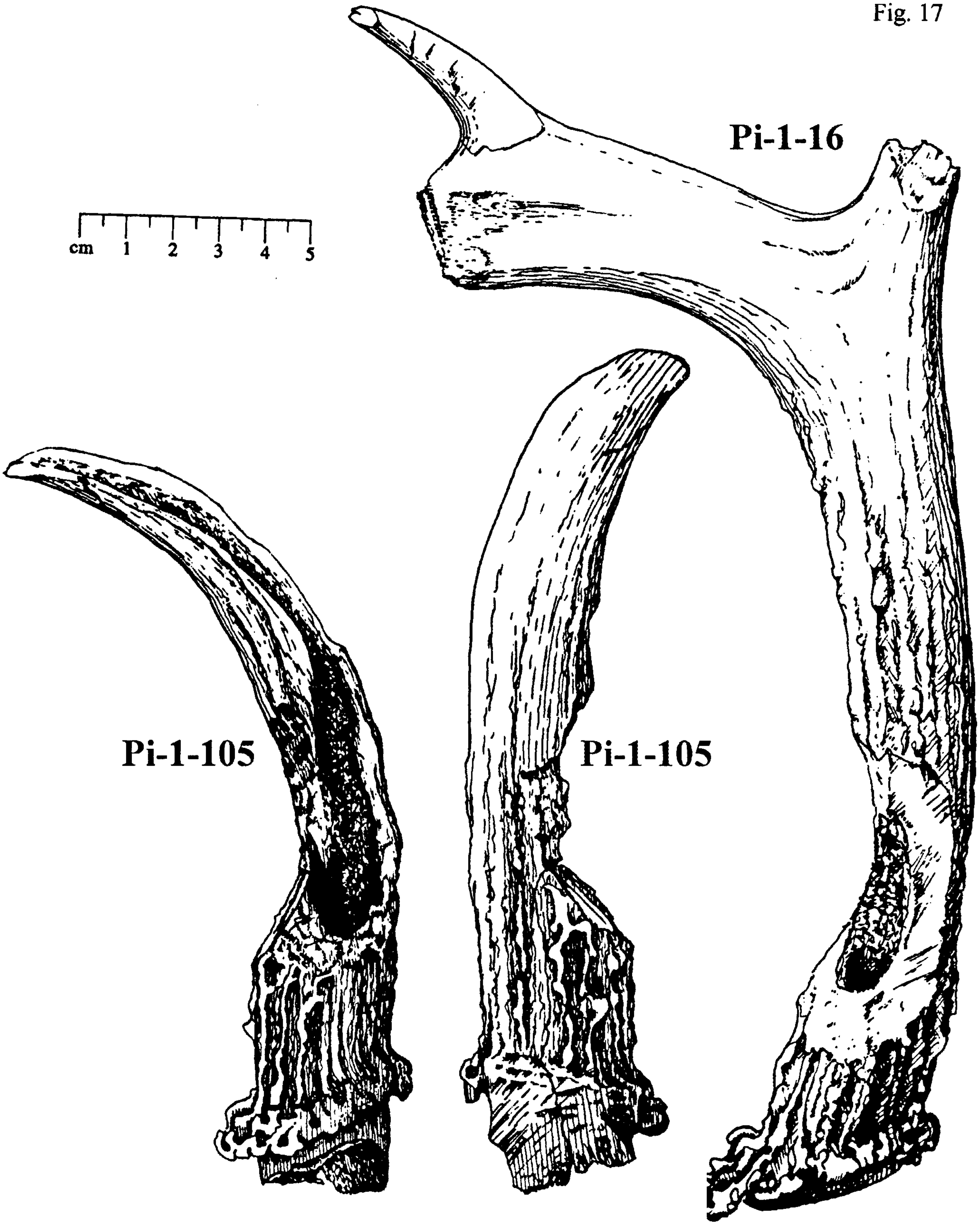


Fig. 17



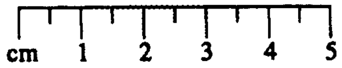
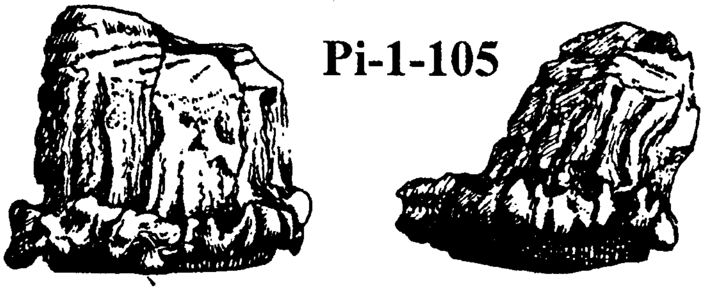
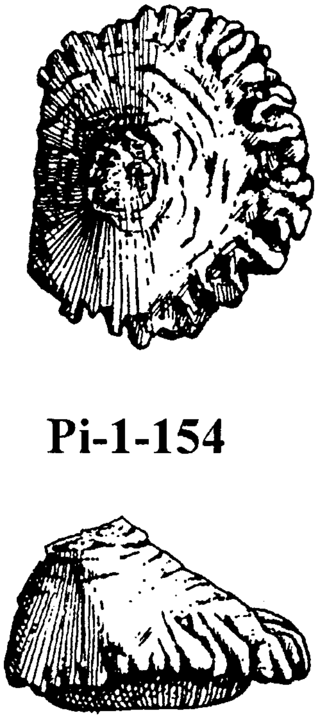
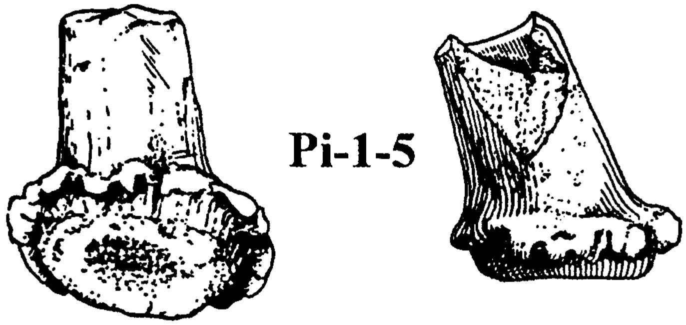
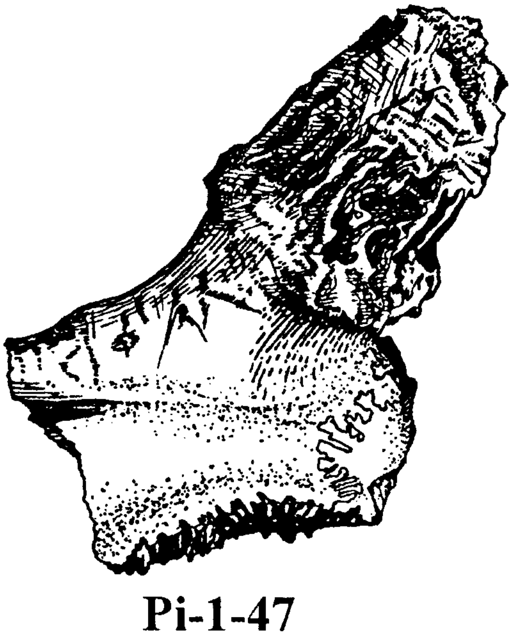


Fig. 18


Pi-1-105


Pi-1-154


Pi-1-5


Pi-1-47

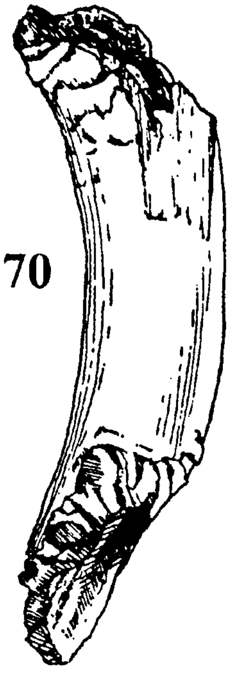
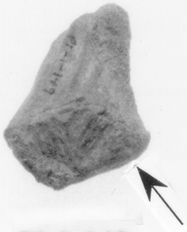

Pi-1-170

Plate 2

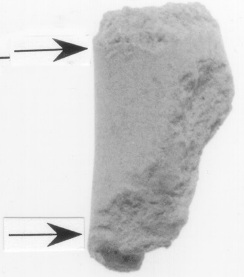

Pi-1-177


Pi-1-183

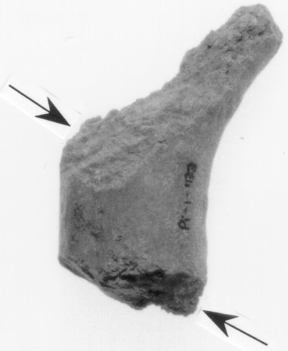

Pi-1-34

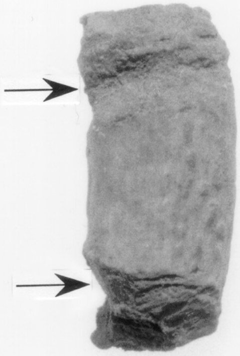

Pi-1-149


Pi-1-139

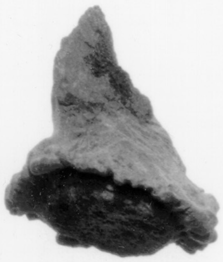

Pi-1-123


Pi-1-123


Pi-1-183


Pi-1-218


Pi-1-48


Pi-1-123


Pi-1-169


Pi-1-139

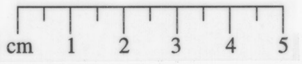


Fig. 19

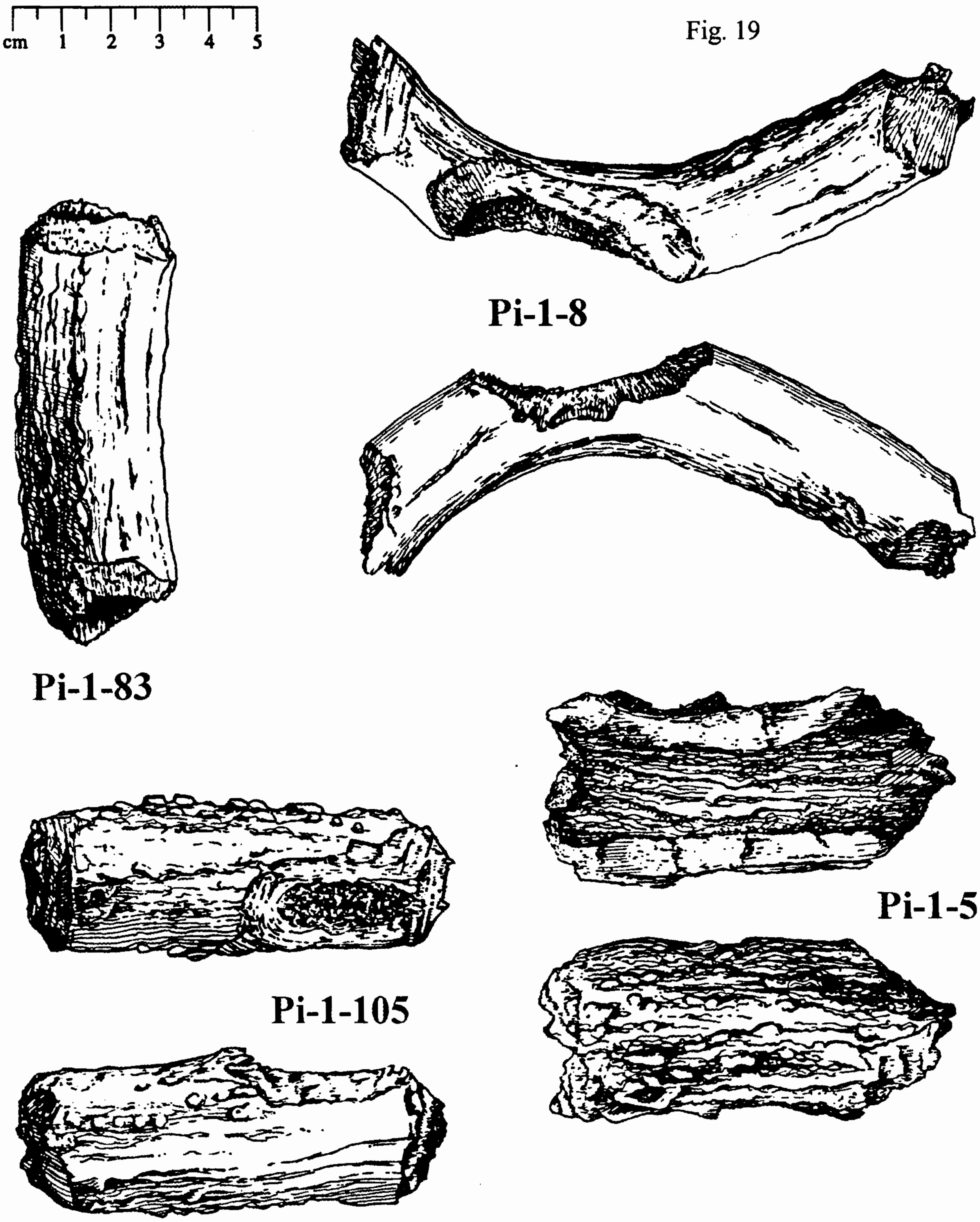


Fig. 20

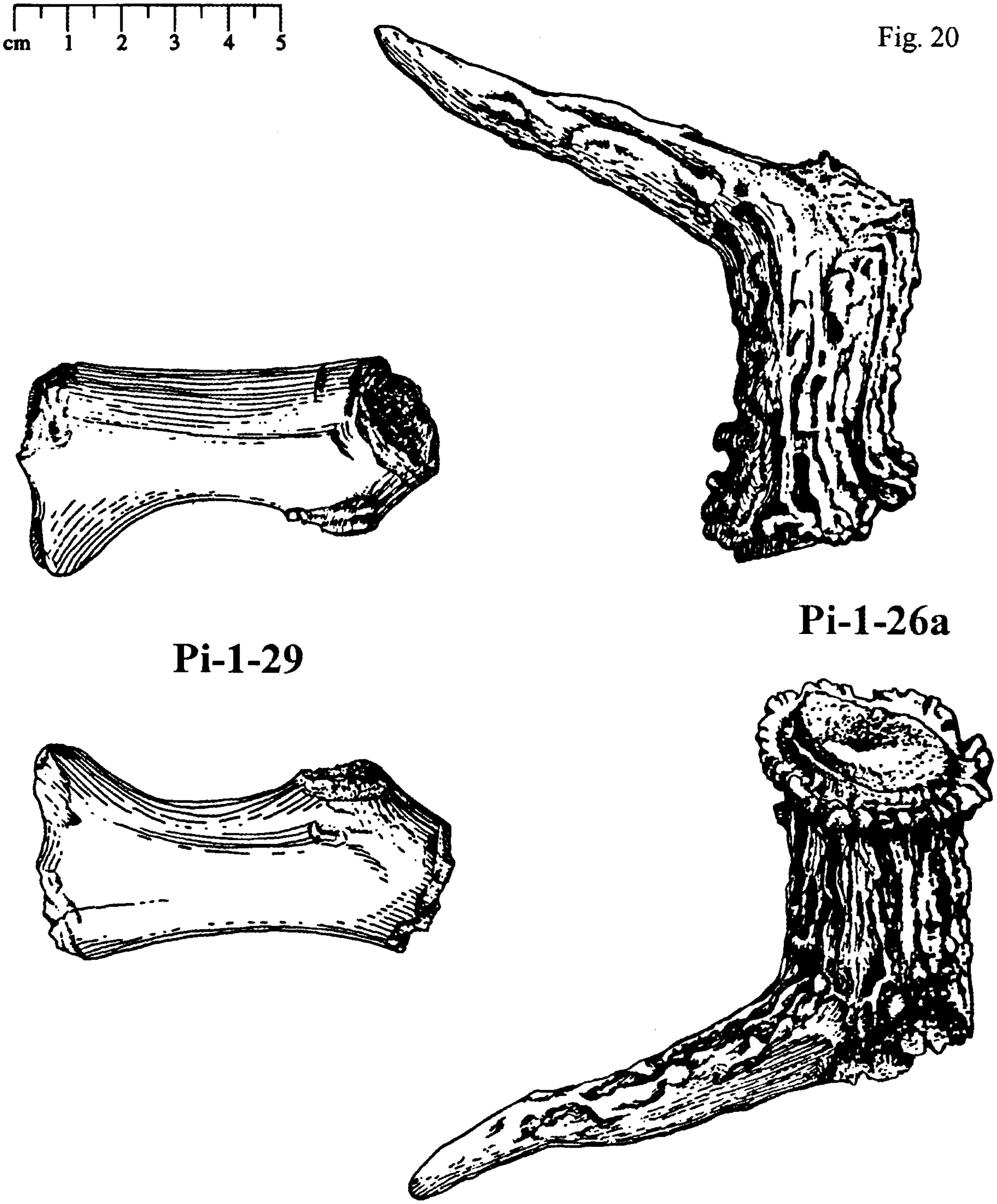


Plate 3

Pi-1-27

Pi-1-183

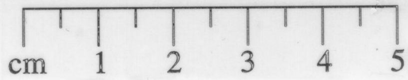
Pi-1-177

Pi-1-183

Pi-1-183

Pi-1-119

Pi-1-164



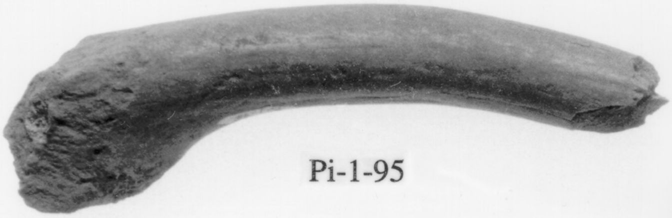
Waste byproducts of antler reduction are found throughout the deposits. These include detached, and clearly grooved and beveled antler peduncles (Plate 2: Pi-1-123, 169, 139; Fig. 18: Pi-1-105, 5, 54, 47) and various large antler shaft and tine portions (Plate 3; Fig. 19: Pi-1-83, 105, 5). Cervid cranial vaults (Plate 4: Pi-1-193) indicate detachment of antlers both below and above (Fig. 18: Pi-1-47) their peduncles. This further suggests that midden contents reflect primary-stage tool production and discard. Various intentionally detached antler portions are visible in the form of beveled edges on one or both ends of the detached piece. These may or may not appear with further modification especially through smoothing and polishing (Plate 1: Pi-1-139, 24; Plate 2: Pi-1-177, 183, 34, 149, 139, 123, 123, 183, 218, 48; Plate 3: Pi-1-164). Four pieces in particular (Plate 4: Pi-1-183, 95,16, 139; Fig. 19: Pi-1-83, 105, 5) appear to be highly modified antler tools or tool portions that were eventually discarded. Some of these pieces almost appear to be in the form of handles, being smoothed and feeling comfortable when in a grasped hand (Plate 4:Pi-1-183). MacNeish and Nelken-Terner (1980:314) suggest that similar deer antler fragments may have functioned as hammers.

The most prevalent kind of modified antler remain in the La Chimba deposits consists of simple modified antler tine points (Plates 5; 6; Fig. 21; Fig. 23: Pi-1-131, 57). Specimens similar to these kinds of artifacts, with visible scratches on their tips, are referred to as antler tine flakers by MacNeish and Nelken-Terner (1980:314). All of these examples have been modified through polishing and the majority exhibit some degree of heat treatment, ranging from various shades of brown to black. Indeed, only three of the examples illustrated in the plates appear not to have been affected by some heat treatment (Plate 5:Pi-1-139; Plate 6: Pi-1-183, 207). Many display peck marks at their proximal ends where they were presumable detached from the main branch of the antler. Whether or not they were modified before or after detachment is difficult to say; however, there is no compelling reason to suggest that only one method was adhered to. One specimen (Plate 6: Pi-1-46) is a polished tine with beveled detachment scars (indicated by the arrows) which would suggest that in at least this case, the tine was polished prior to final detachment (see also Fig. 20:26a). Modified antler tines are included in the illustrated inventory of modified animal remains from Cotocallao (Villalba 1988: Lamina 54e). Although requiring longer and increasingly elaborate preparation than their lithic counterparts, strong and flexible antler projectile points appear to be highly durable, penetrate prey carcasses well, and are readily reparable (Pokines 1998:875-886).

In addition to simple tine points, the modified antler material from La Chimba also contains more complexly fashioned points, many with hollowed interiors and heavily polished and fire-blackened exteriors (Fig. 22; Fig. 23: Pi-1-9, 124, 120). It is possible that some or all of the pieces functioned at one time as dart shaft or point pieces for composite atlatl dart shafts. The hollowed interior, opposite the pointed end of these antler artifacts, is suggestive of points attached to the foreshaft of a composite dart shaft. Atlatl points need a certain degree of weight in order to be effective (Spencer 1974:52), and cervid antler provides a heavier yet pliable material. Other hollowed antler objects (Fig. 22: Pi-1-32, 13, 38) might also have served as atlatl mid shaft sections, which hold the point-bearing fitted foreshaft, and are in turn inserted into a basal fletched shaft (Spencer 1974:50). Solid antler pieces that are pointed on one end, and not hollowed out on the other (Plate 11:Pi-1-148; Fig. 23: Pi-1-180) may or may not be unfinished atlatl point blanks.

Plate 4

Pi-1-183



Pi-1-95

Pi-1-16

Pi-1-139

Pi-1-193

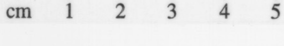
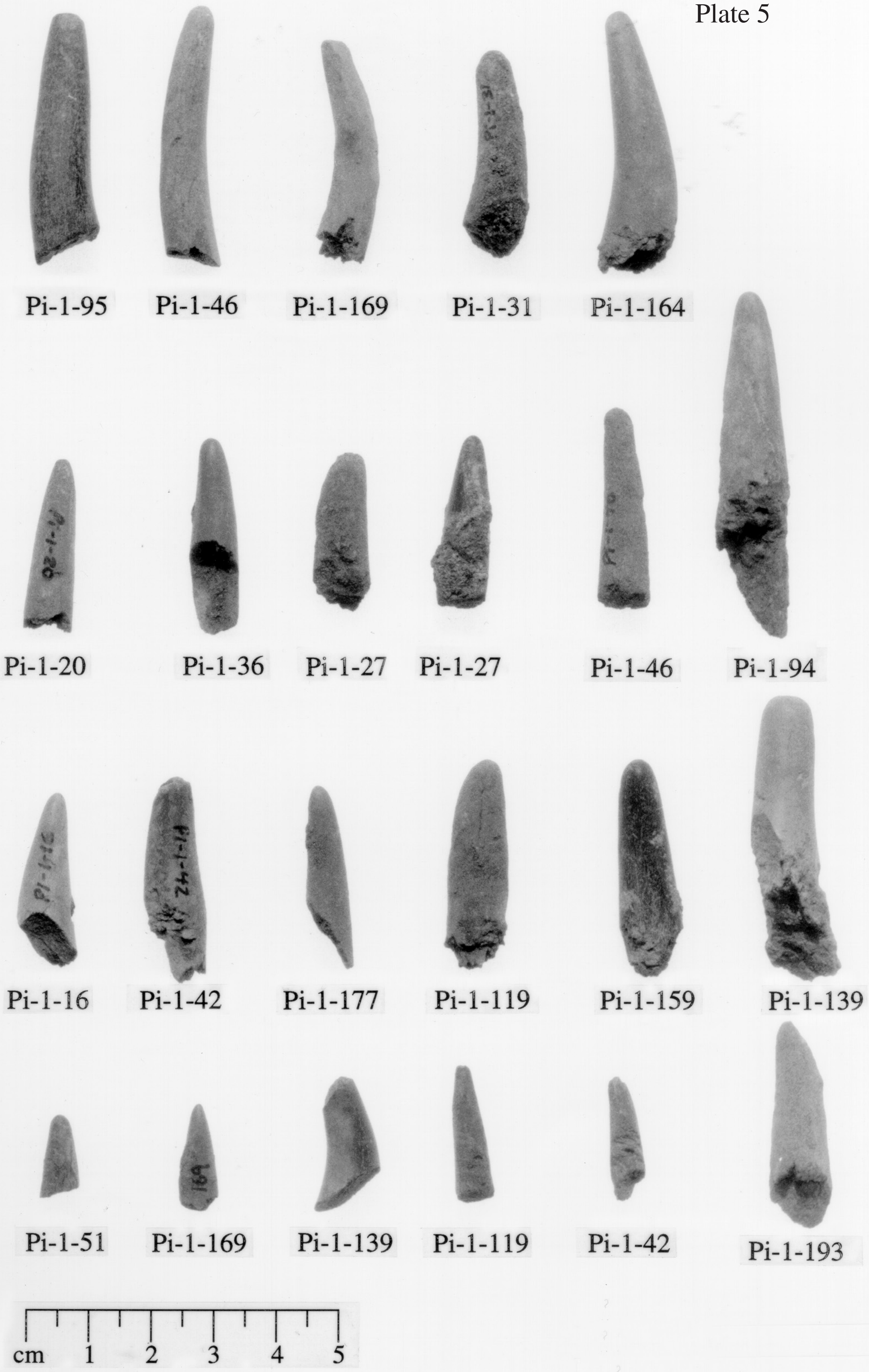


Plate 5


Pi-1-95
Pi-1-46
Pi-1-169
Pi-1-31
Pi-1-164
Pi-1-20
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Pi-1-27
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Pi-1-46
Pi-1-94
Pi-1-16
Pi-1-42
Pi-1-177
Pi-1-119
Pi-1-159
Pi-1-139
Pi-1-51
Pi-1-169
Pi-1-139
Pi-1-119
Pi-1-42
Pi-1-193
cm
1
2
3
4
5

Plate 6

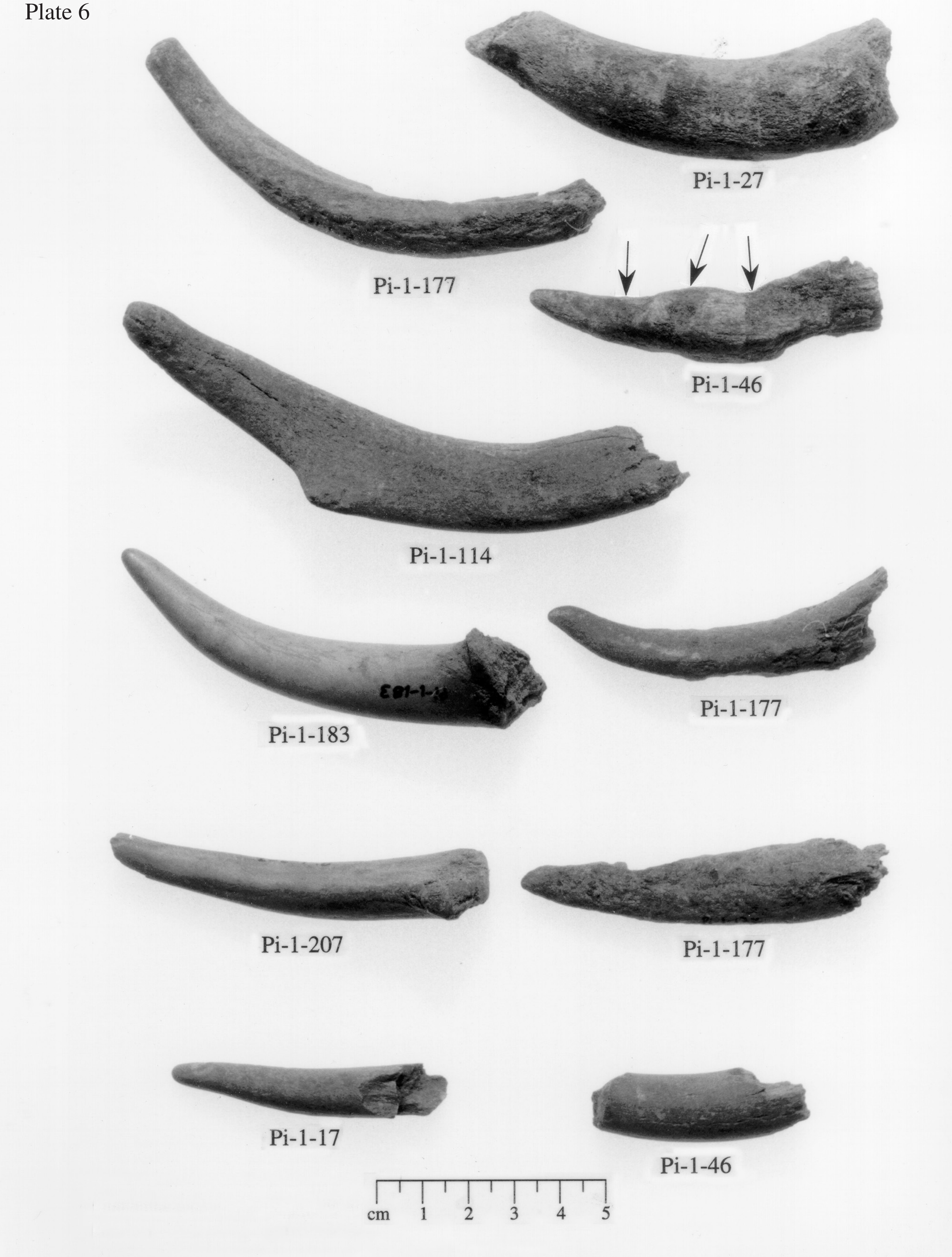
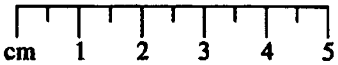
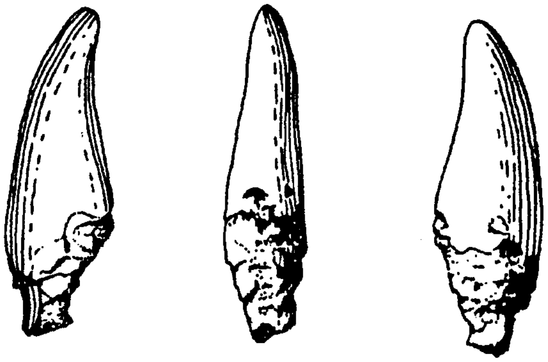
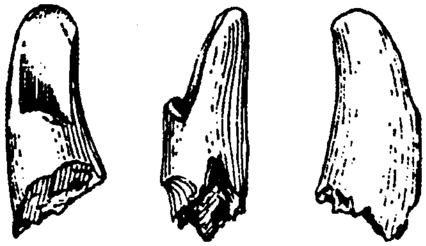

Pi-1-27
Pi-1-177
Pi-1-46
Pi-1-114
Pi-1-183
Pi-1-177
Pi-1-207
Pi-1-177
Pi-1-17
Pi-1-46
cm 1 2 3 4 5

Fig. 21




Pi-1-57

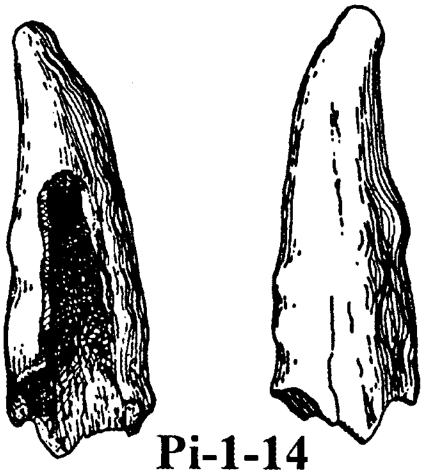

Pi-1-15


Pi-1-105

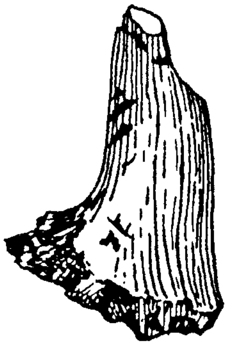

Pi-1-105


Pi-1-14


Pi-1-14


Pi-1-14


Pi-1-14


Pi-1-47


Pi-1-47

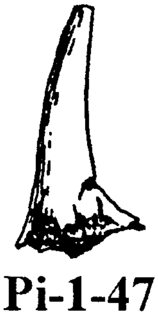
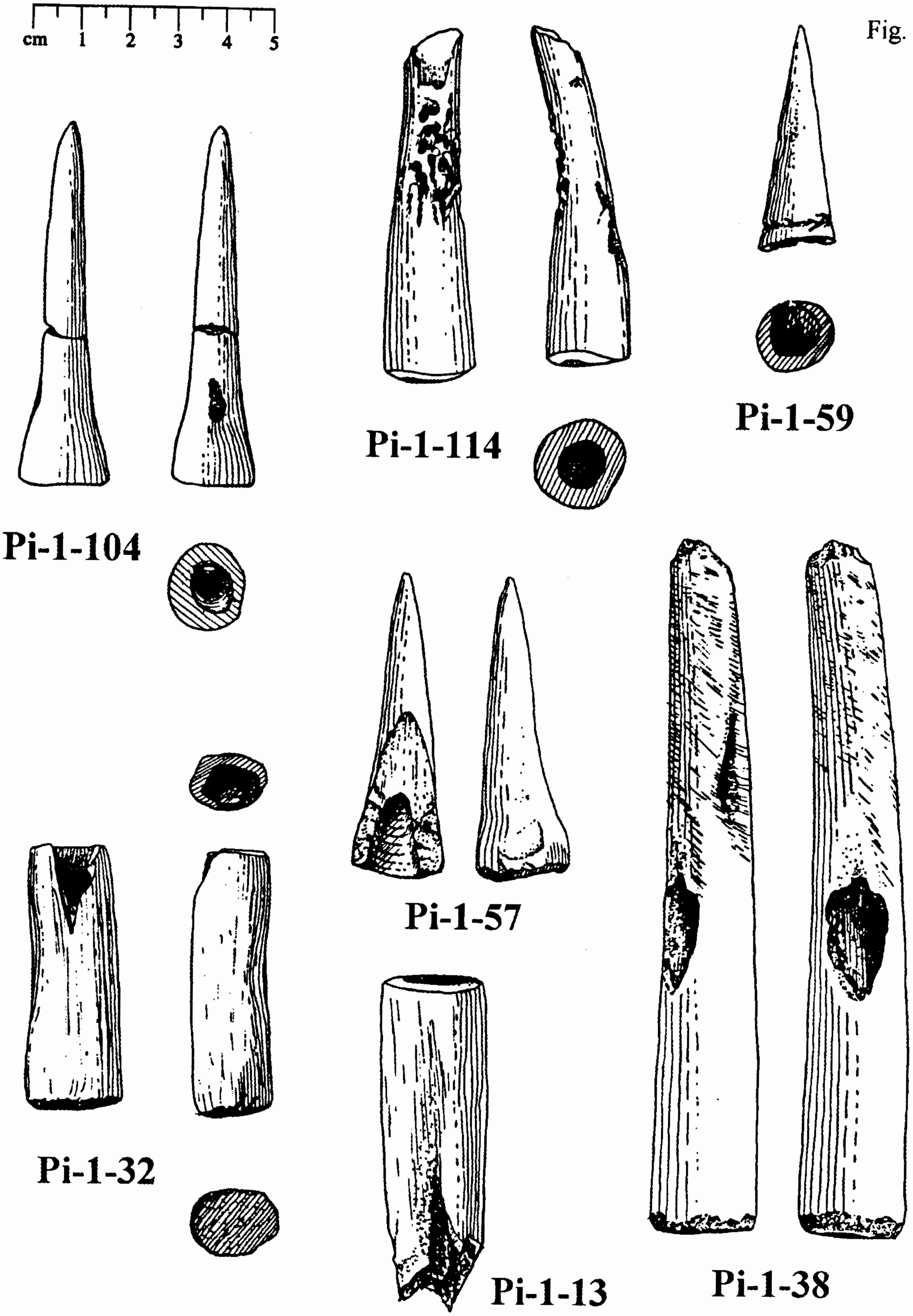

Pi-1-47

Fig. 22



Pi-1-104

Pi-1-114

Pi-1-59

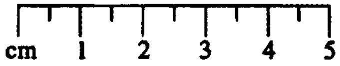
Pi-1-57

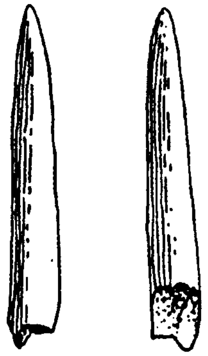
Pi-1-32

Pi-1-13

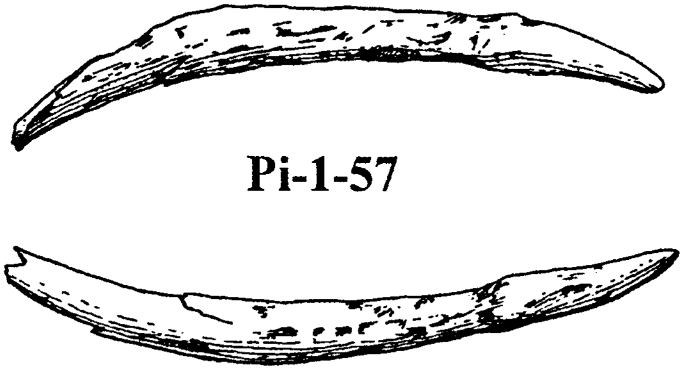
Pi-1-38

Fig. 23

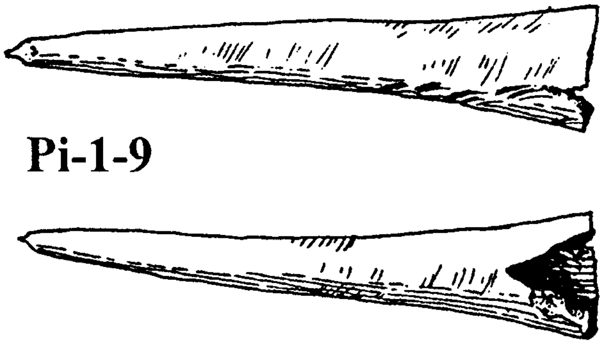




Pi-1-131

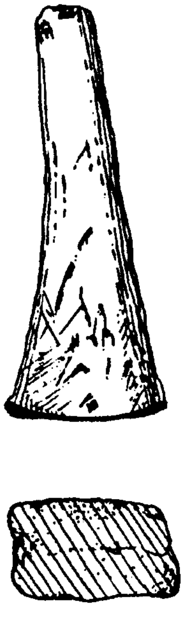


Pi-1-57



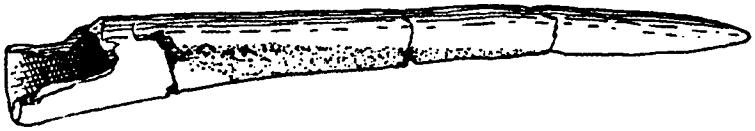
Pi-1-9

Pi-1-180

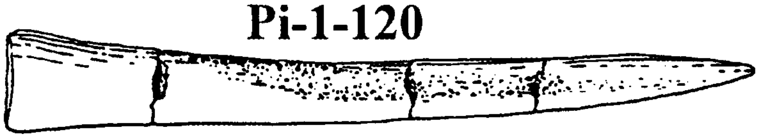


Pi-1-180

Pi-1-124



Pi-1-120



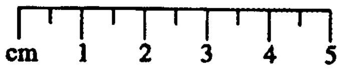
Other antler artifacts include spoons or scoops (Fig. 24: Pi-1-14, 9). Another highly smoothed and polished antler piece, with attached peduncle, is reminiscent of some form of handle (Fig. 24: Pi-1-120); whereas another displays grooving, beveling and breakage on one end, with smooth and polished `legs' on the other (Fig. 24: Pi-1-181). Its function as an unfinished figurine, or socketed artifact is debatable. Large and highly polished antler fragments are also included in the assemblage (Fig. 25: Pi-1-123, 20), with one appearing very similar to the worked ulnae found at La Chimba and other Andean sites (MacNeish and Nelken-Terner 1980:315).

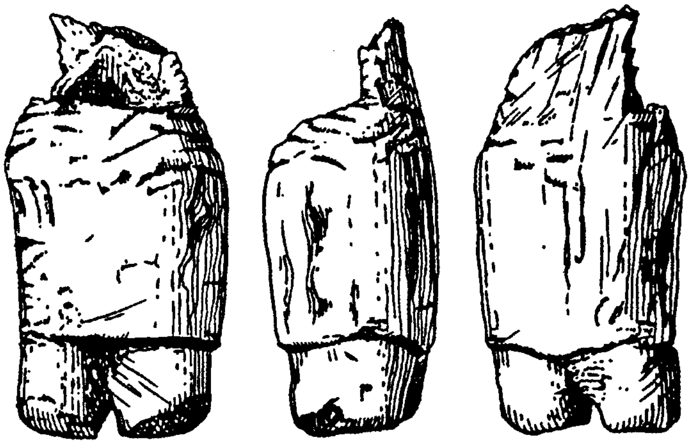
Long Bone Modification

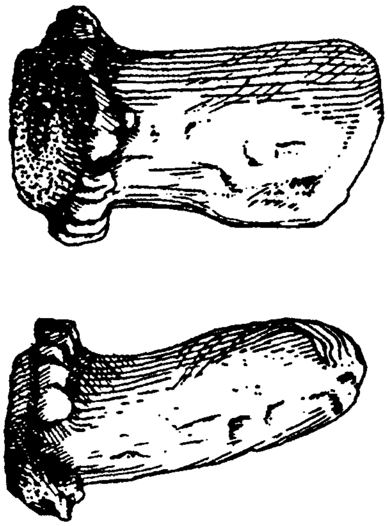
The second major form of bone modification involved the acquisition and detachment of long bone shafts from large, usually cervid, limb bones. Many of the obvious examples indicate a method of shaft detachment very similar to that displayed on antler fragments. This involves the circumscribed scoring of limb shafts, usually below or above the proximal and distal epiphyses respectively (Plate 7). This form of bone modification is prevalent throughout the Andes. The majority of these examples are from large cervid, likely *Odocoileus* limb bones, with the exception of one small cervid, likely *Pudu* (Plate 7: Pi-1-149) and one example of a similarly scored, and snapped rabbit femur (Plate 7: Pi-1-183). The proximal radius fragment of a large cervid (Plate 7: Pi-1-123) is fire-blackened over its entirety. A number of cervid longbone fragments appear to have been modified with percussion, again likely in an effort to isolate shaft segments (Plate 8). All of these examples appear to have been modified with the use of heat. In particular, one distal metapodial shaft (Plate 8: Pi-1-229) clearly shows fire-blackening restricted to the surface from which the material was eventually detached. One piece (Plate 8:Pi-1-114) illustrates the hypothetical end product of shaft detachment. The interior exit to the nutrient foramen can clearly be seen about one third the distance up from the pointed end. Although only tentatively identified, this piece is likely a detached and modified fragment from the left tibial shaft of a large cervid. This piece has been modified through heat treatment and smoothed and polished on all of its surfaces. Comparable specimens from Cotocollao, referred to as punches or awls, are illustrated (Villalba 1988: Lamina 54). Similarly detached longbone shaft portions are illustrated (Plate 9: Pi-1-42, 231, 231, 189, 183; Fig. 26: Pi-1-4, 125, 30) with scoring, and in some cases beveling marks indicated. The isolated radial shaft of a large cervid (Plate 9:Pi-1-189) illustrates the end product of epiphyseal detachment via scoring, and possibly snapping of adhering epiphyses (*e.g.*, Plate 7: Pi-1-123, 95). This method of shaft detachment is particularly noticeable on cervid metapodia (Plate 9:Pi-1-169, 169, 169, 20).

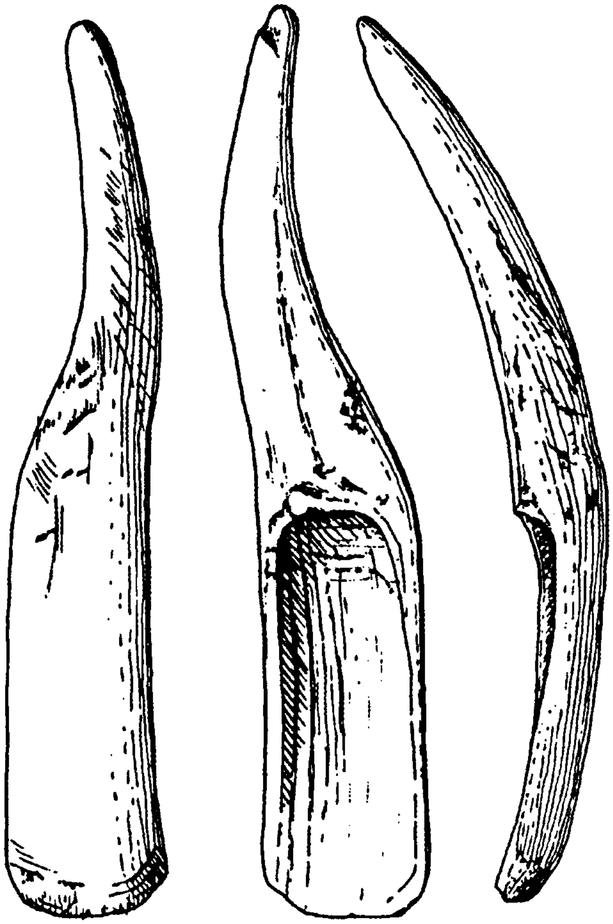
The likely end products of longbone modification are also found in the La Chimba deposits. These include modified and highly polished metapodial shaft fragments, all of which are fire-blackened (Plate 10). Many of these examples have parallel striations running along the surface of the tool, either along or at right angles to the bone shaft. Similar kinds of artifacts are illustrated from Cotocollao (Villalba 1988:Lámina 54). Other cervid metapodial tools are illustrated (Plate 11: Pi-1-131, 173; Fig. 27: Pi-1-147, 149, 42, 149). Each has an attached proximal epiphyseal portion. A similar fragment (Plate 11: Pi-1-195) may also originate from the metapodium of a large artiodactyl; however, its attached epiphyseal surface is too highly modified through grinding and polishing to render accurate identification. These pieces appear in form to

Fig. 24




Pi-1-181


Pi-1-120


Pi-1-14

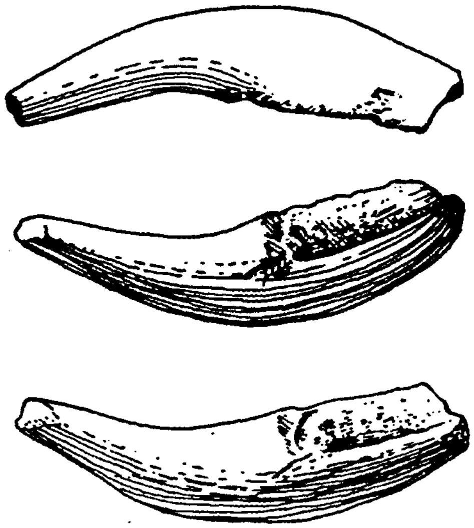
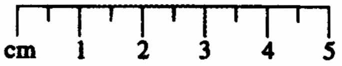
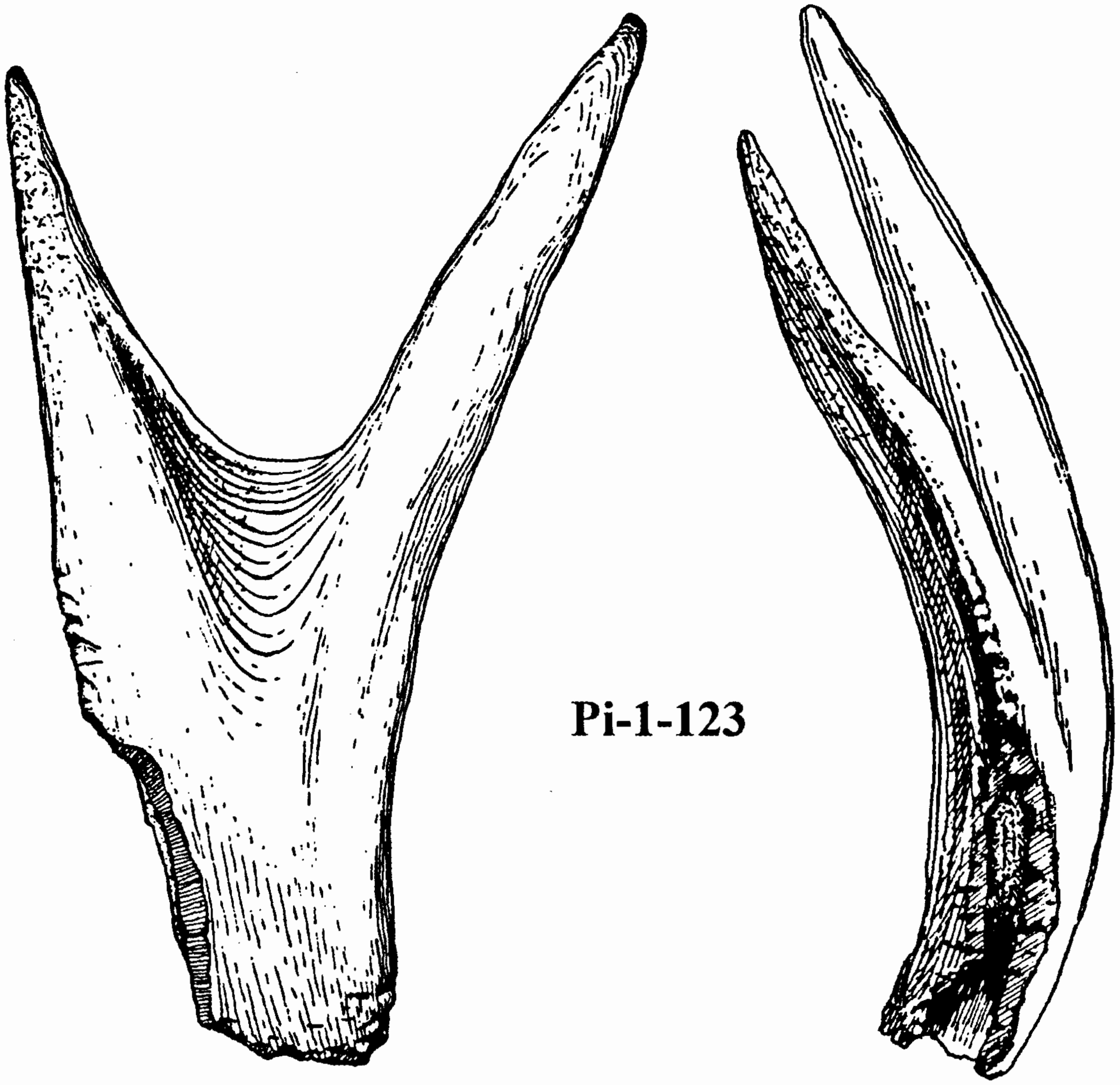

Pi-1-9

Fig. 25





Pi-1-123

Pi-1-20

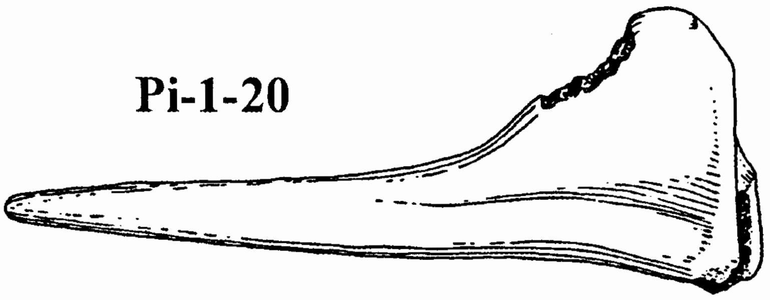
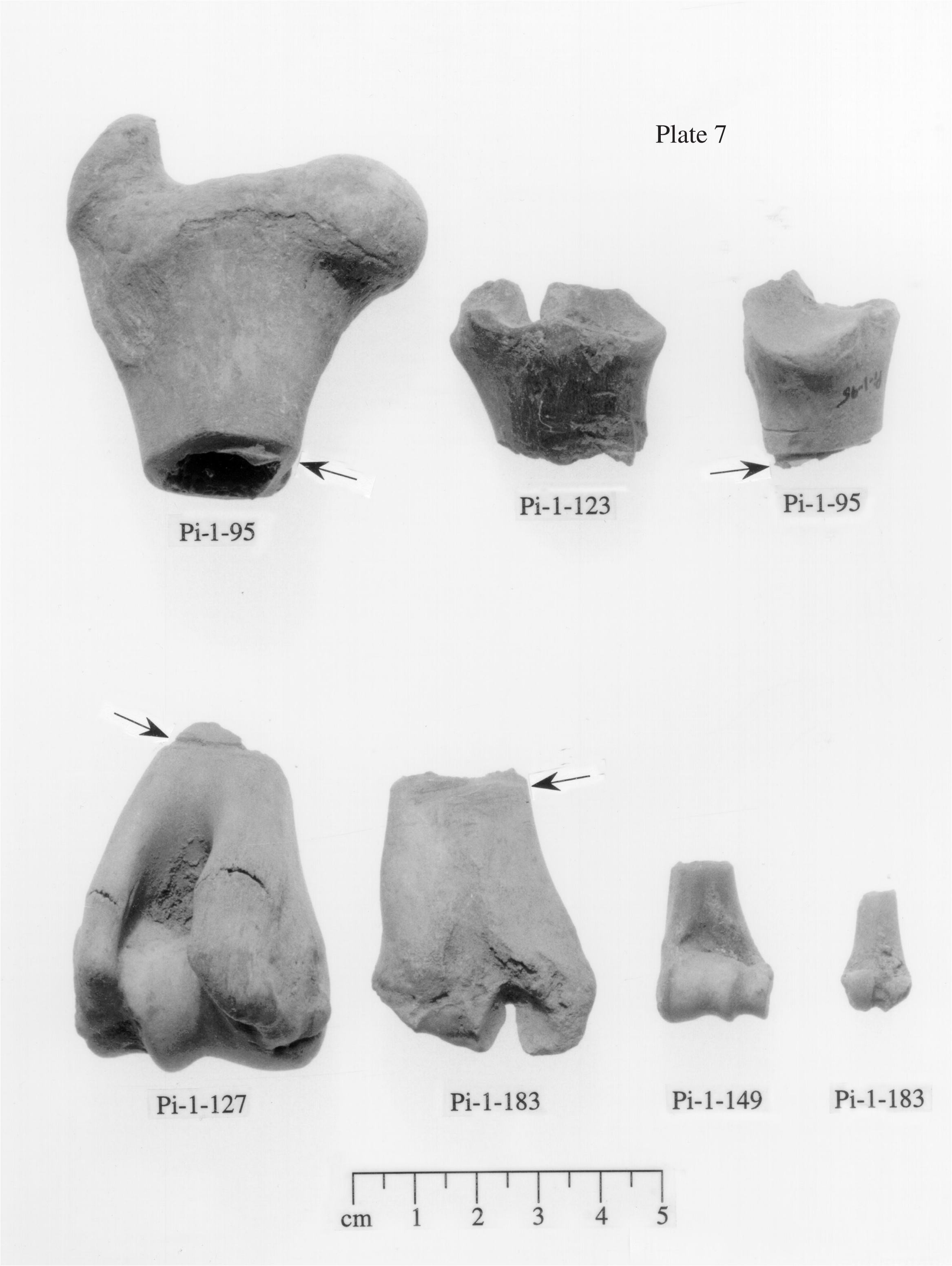


Plate 7


Pi-1-95
Pi-1-123
Pi-1-95
Pi-1-95
Pi-1-127
Pi-1-183
Pi-1-149
Pi-1-183
cm 1 2 3 4 5

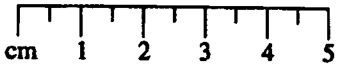
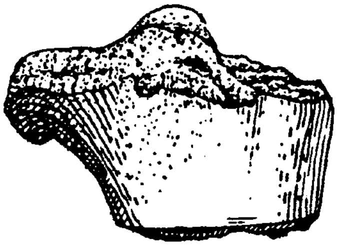
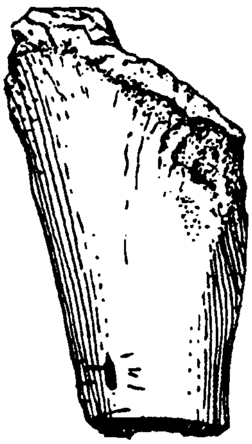


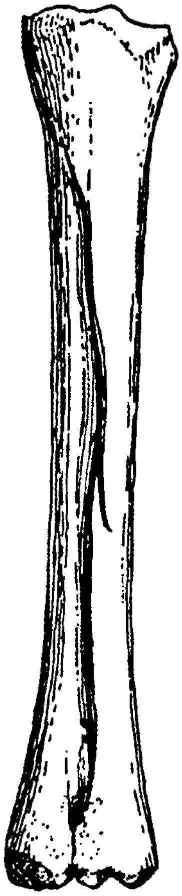
Fig. 26



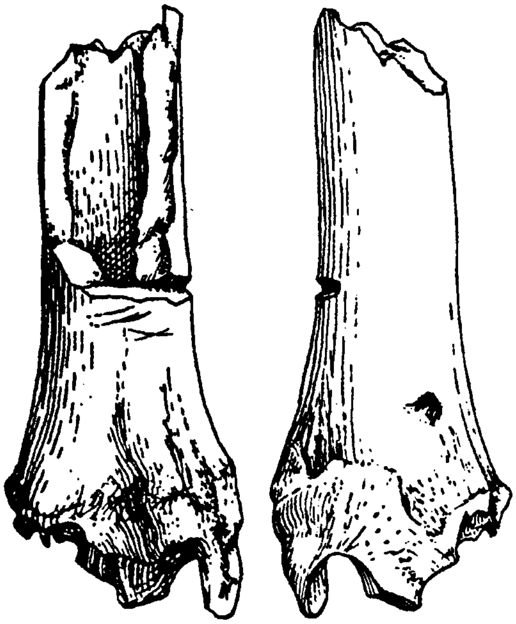
Pi-1-125



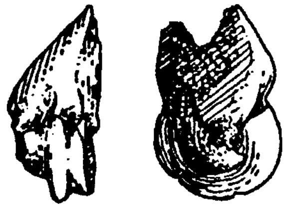
Pi-1-4



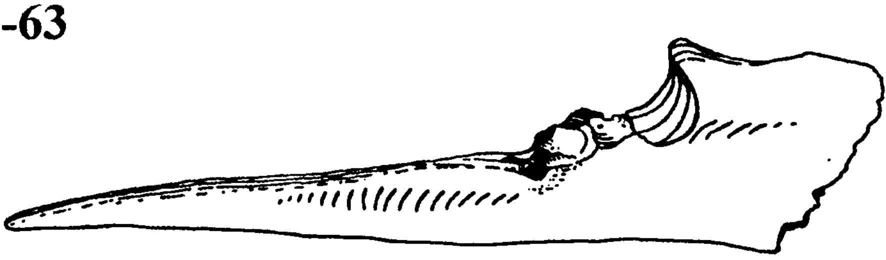
Pi-1-68



Pi-1-30



Pi-1-63



Pi-1-8

Plate 8

Plate 9

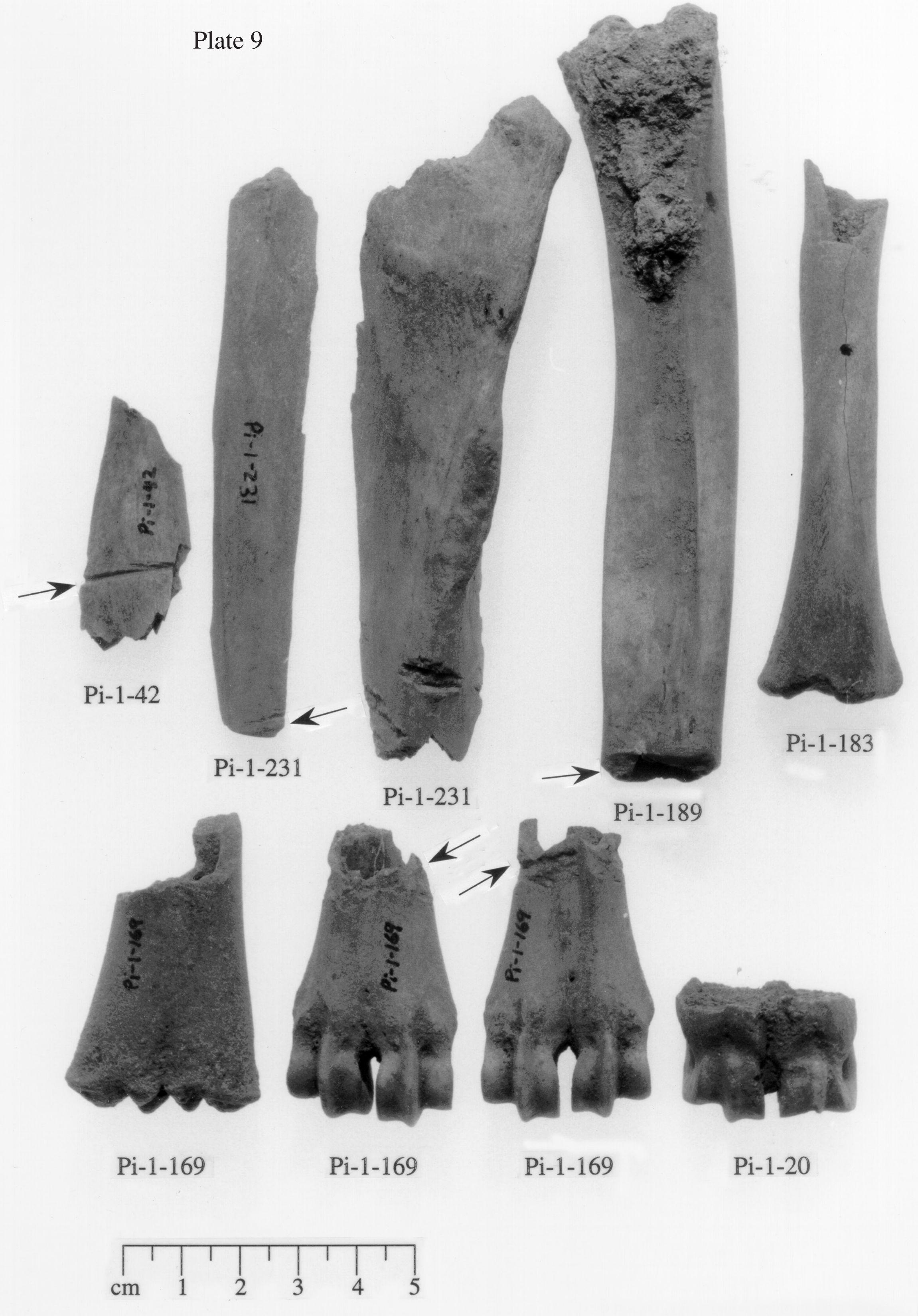
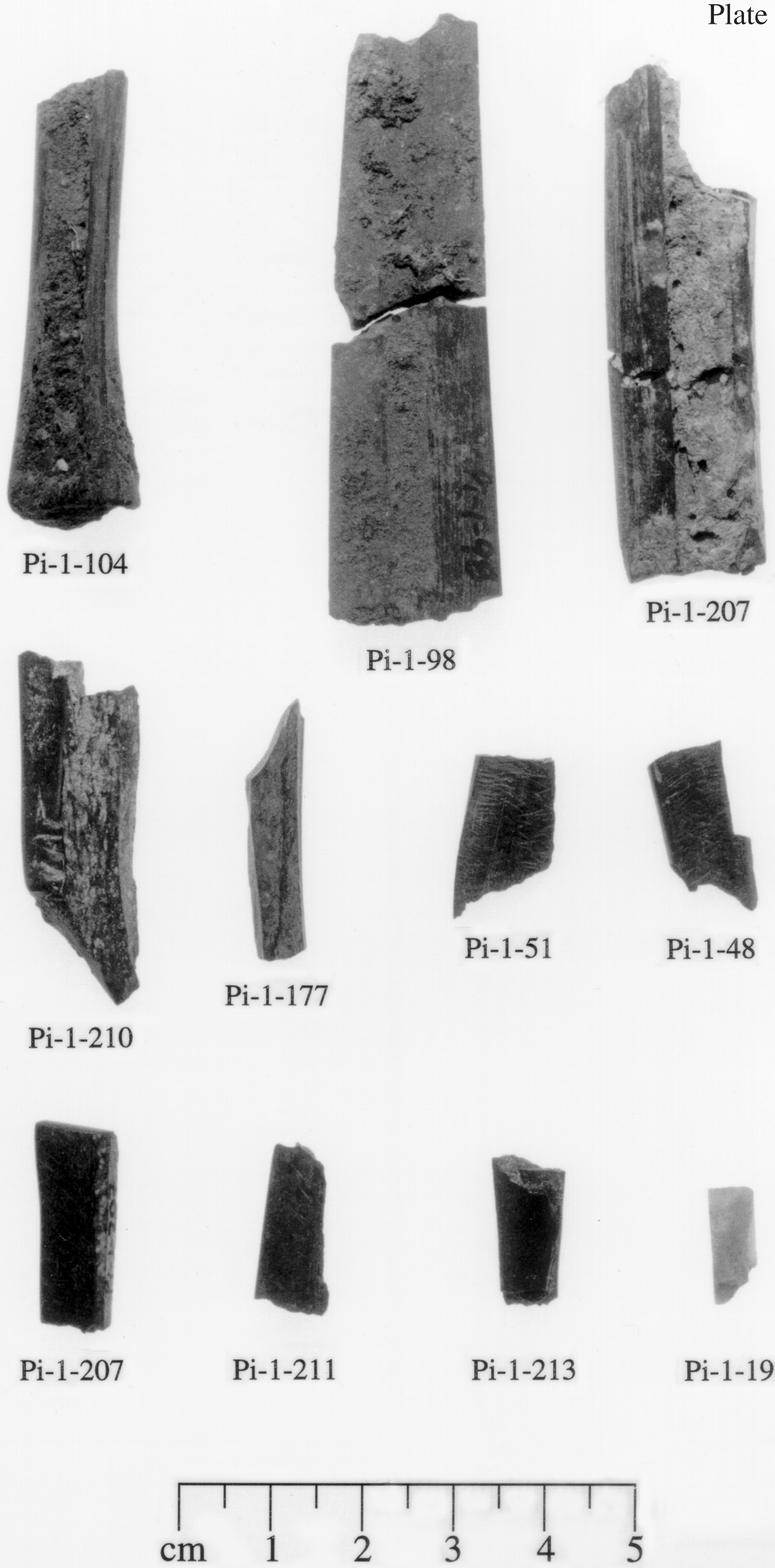

Pi-1-42
Pi-1-231
Pi-1-231
Pi-1-189
Pi-1-183
Pi-1-169
Pi-1-169
Pi-1-169
Pi-1-20
cm 1 2 3 4 5

Plate 10



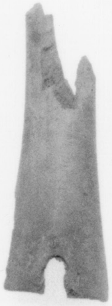
Pi-1-104 Pi-1-98 Pi-1-207

Pi-1-210 Pi-1-177 Pi-1-51 Pi-1-48

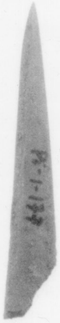
Pi-1-207 Pi-1-211 Pi-1-213 Pi-1-192

Plate 11

Pi-1-131

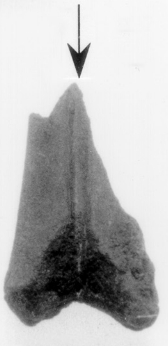


Pi-1-51



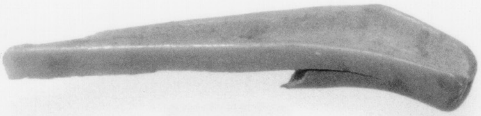
Pi-1-177

Pi-1-27

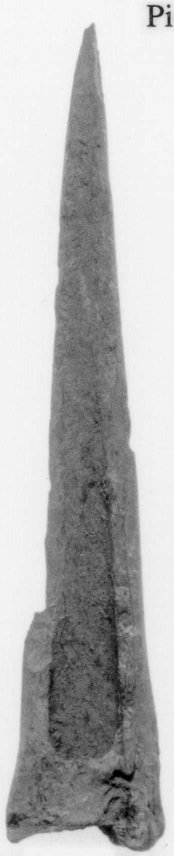


Pi-1-164

Pi-1-177

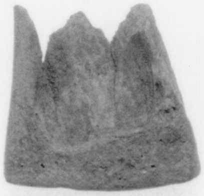


Pi-1-36



Pi-1-131

Pi-1-173



Pi-1-195

Pi-1-148

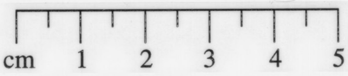
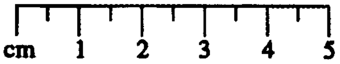
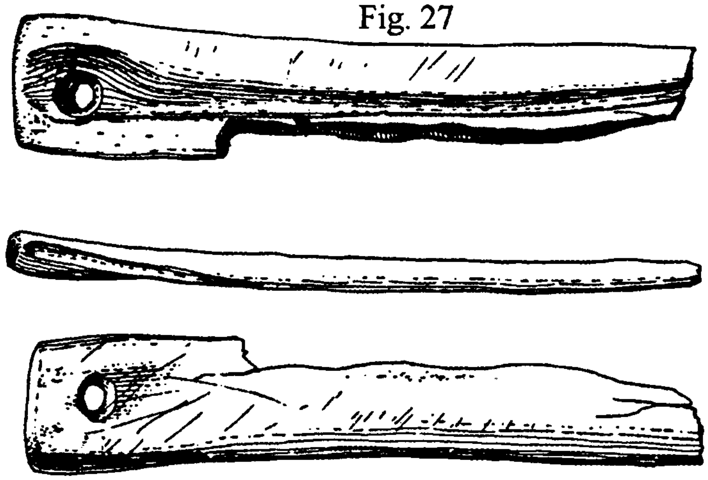
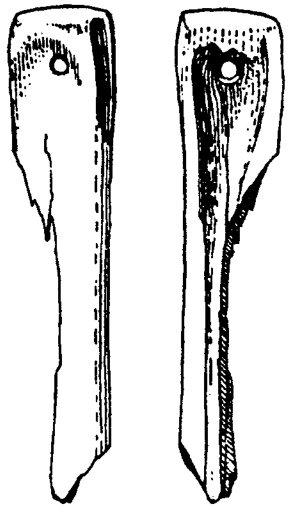
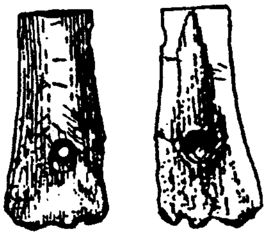


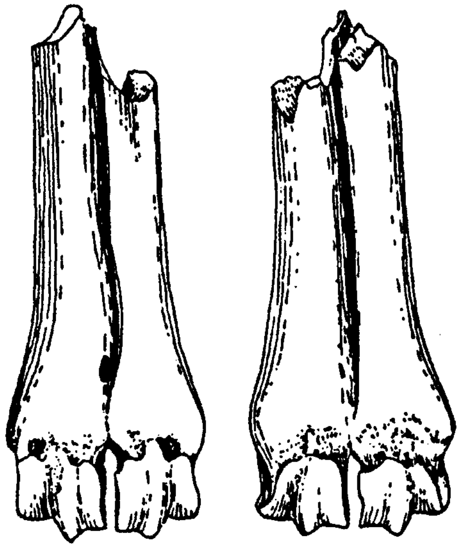
Fig. 27

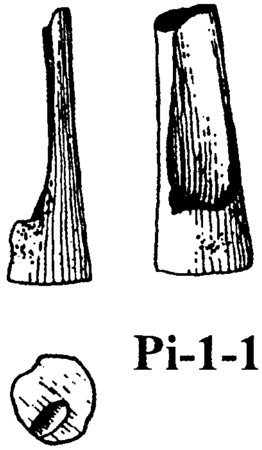


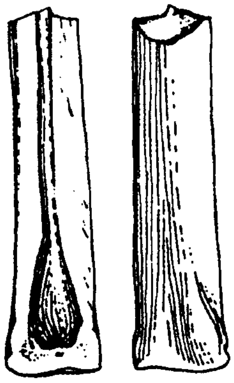

Pi-1-147

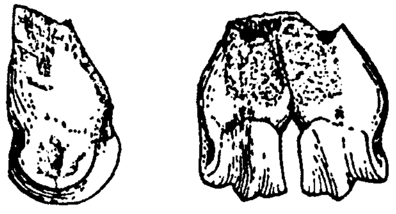

Pi-1-149


Pi-1-42


Pi-1-48


Pi-1-120


Pi-1-149


Pi-1-48

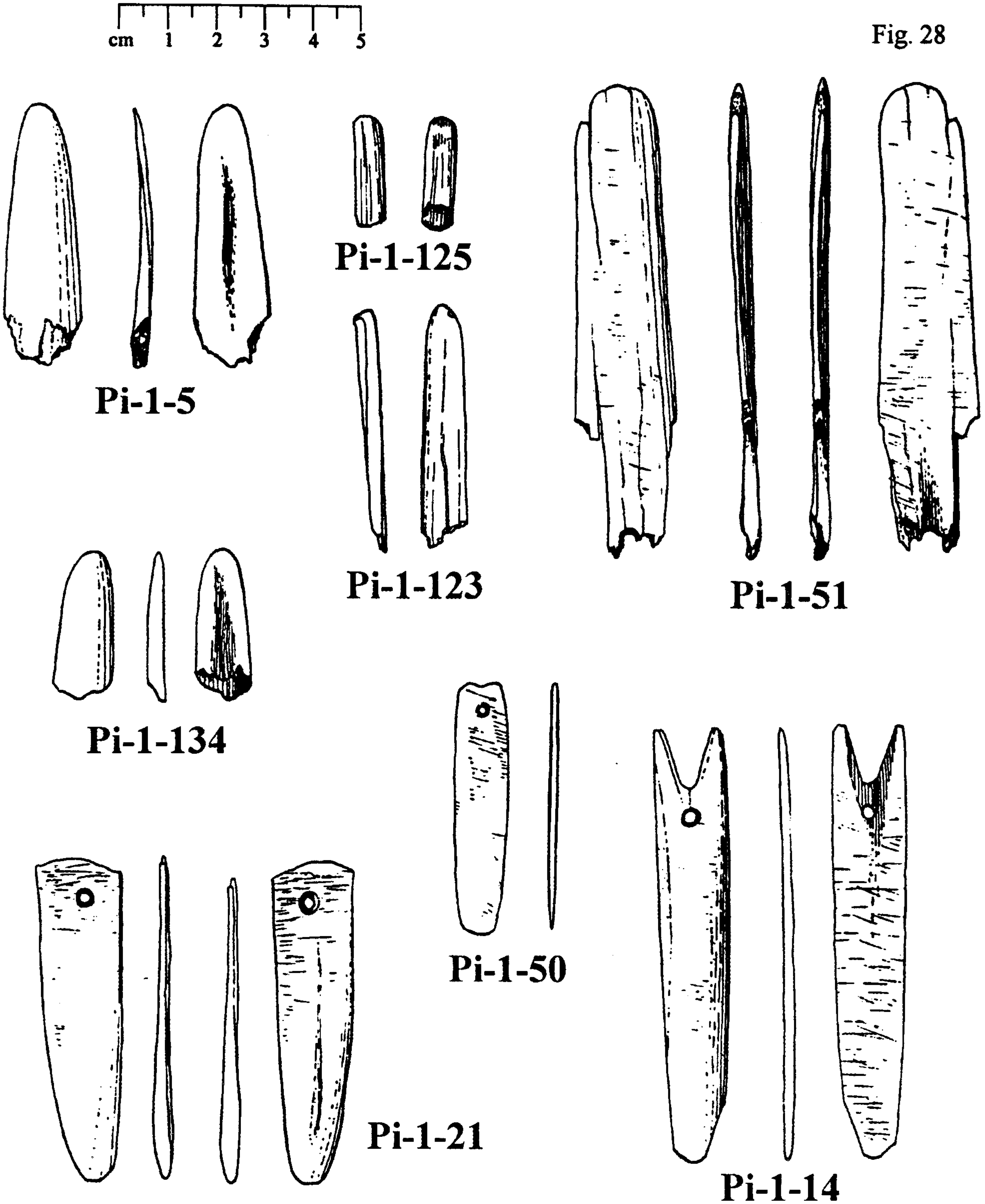
be very similar to the illustrated "spatulas" of Cotocollao (Villalba 1988:Lamina 54) and Kotosh (Izumi and Terada 1972:261). The metapodial tools with holes at one end (Fig. 27: Pi-1-149, 147, 42) are similar in form to the `pierced base netting needles' of MacNeish and Nelken-Terner (1980:318), which share great similarity with other specimens from La Chimba (Fig. 28). Bermann (1994:222) illustrates round or blunt-ended tools fashioned from camelid metapodia which he identifies as *wichuñas* or weaving tools, which were variously found in domestic and burial context at Lukurmata in the Bolivian altiplano around Lake Titicaca.

Three specimens (Plate 11: Pi-1-51, 177, 127) appear very similar to artifacts identified as needles from Cotocollao (Villalba 1988:Lamina 54). The vascular groove of a completely burned cervid metapodium appears to be artificially modified (Plate 11:Pi-1-164; Fig 26: Pi-1-68). Whether or not this represents a step in shaft removal is unknown. Certainly, distal metapodia were also used as tools (Fig. 26: Pi-1-63; Fig. 27:48). A very common form of modified bone tool consists of detached and modified long bone shaft splinters, some of which are clearly metapodial (Fig. 29). They are variously described as awls or awl-like points throughout the Andean highlands (Izumi and Terada 1972:261; Lynch 1980:236; MacNeish and Nelken-Turner 1980:315, 317; Rick 1980:168). A worked deer ulna (Fig. 26: Pi-1-8) likely served a similar function, as its distal shaft portion is naturally suited for easy modification into a pointed tool (see also MacNeish and Nelken-Turner 1980:315). Complete tubular bone shafts also appear to have been utilized, and in some cases are highly decorated (Fig. 30). Most of these items were fashioned from various long bones of different cervids. Villalba (1988: Lamina 55a) illustrates one specimen with a drilled hole, that he describes as a flute.

Miscellaneous

An inevitable category of miscellaneous items is described. Highly polished tools were fashioned from cervid scapulae (Plate 11:Pi-1-177; Fig. 32: Pi-1-29, 5). Worked scapulae are relatively common throughout the Andean highlands (Izumi and Terada 1972: Plate 148; MacNeish and Nelken-Turner 1980:320; Rick 1980:170). Other highly polished artifacts were fashioned from mammalian ribs (Plate 11:Pi-1-136) and antler (Plate 11:Pi-1-131, 148: Fig 22: Pi-1-180). A number of polished and modified deer crania are also found at La Chimba (Fig. 31). They're function is unknown; however, some of the larger examples (Fig. 31: Pi-1-62) may have served as spatular tools. Other items include a worked cervid first phalanx (Fig. 32: Pi-1-159). Worked artiodactyl phalanges are fairly common throughout highland Andean sites, as are distally-drilled teeth like the one found at La Chimba (Fig. 32: Pi-1-63). The spinous process of a mammalian vertebra was similarly drilled (Fig. 32: Pi-1-57). Two pieces (Fig. 32: Pi-1-14, 63) appear to be ground portions of cervid epiphyses. Whether or not they are tool portions or byproducts of manufacture is unknown. Highly polished (Fig. 32: Pi-1-40), and in one case fire blackened (Fig. 32: Pi-1-120), fragments likely served as adornments; whereas one (Fig. 32: Pi-1-18) appears to have the likeness of a small figurine.

Fig. 28



Pi-1-5

Pi-1-125

Pi-1-123

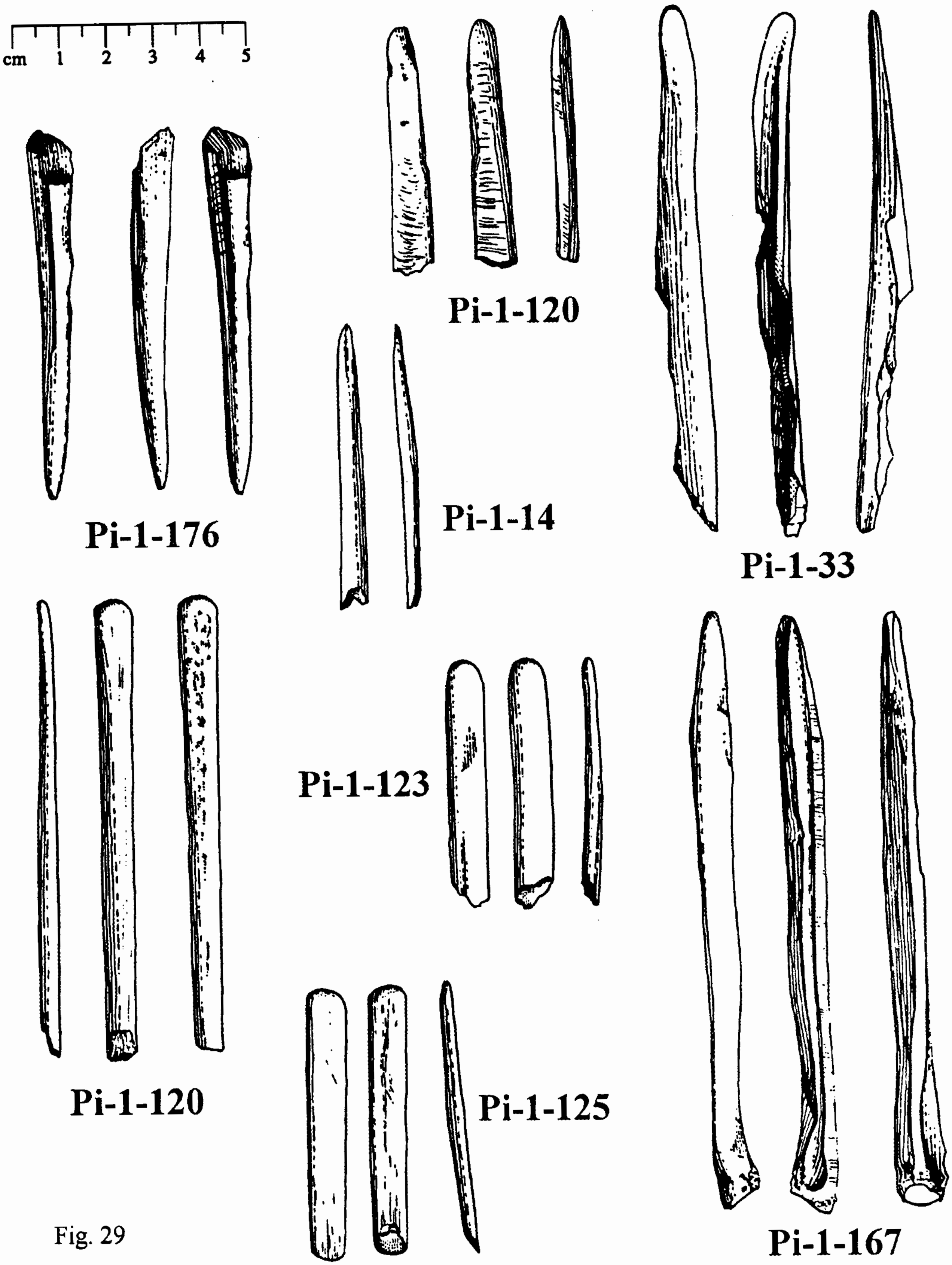
Pi-1-51

Pi-1-134

Pi-1-50

Pi-1-21

Pi-1-14



Pi-1-176

Pi-1-120

Pi-1-14

Pi-1-33

Pi-1-120

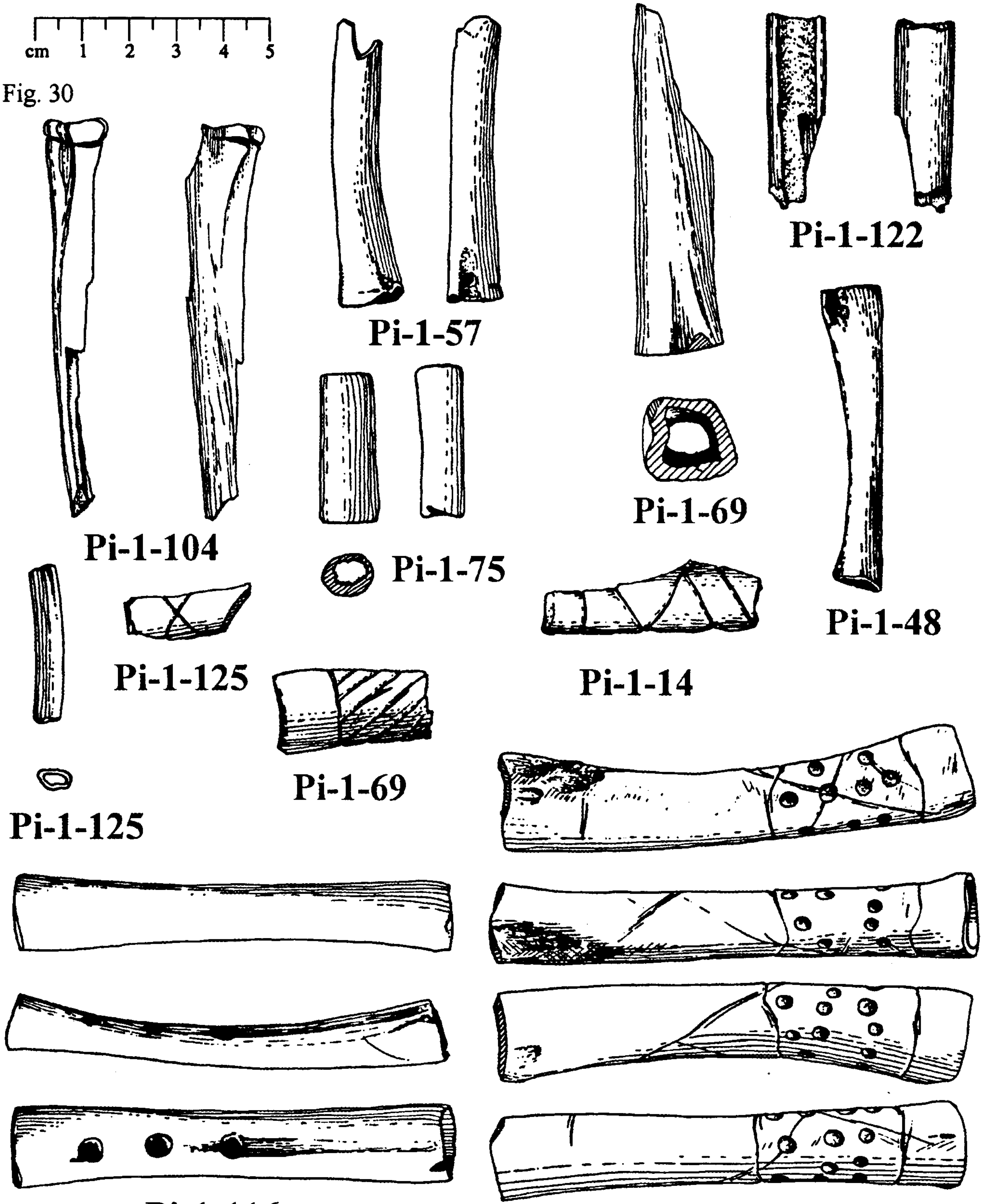
Pi-1-123

Pi-1-125

Pi-1-167

Fig. 29

Fig. 30



Pi-1-122

Pi-1-57

Pi-1-69

Pi-1-104

Pi-1-75

Pi-1-48

Pi-1-125

Pi-1-14

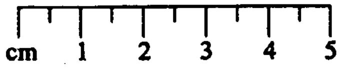
Pi-1-69

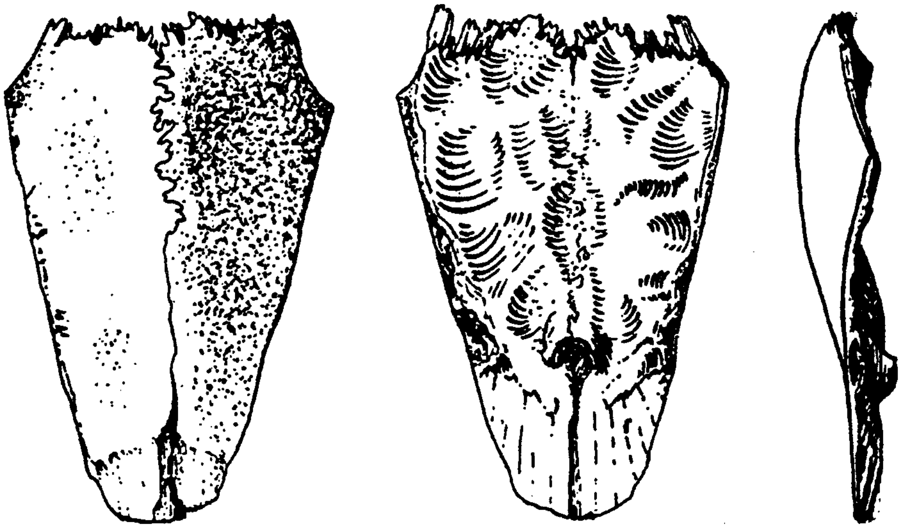
Pi-1-125

Pi-1-116

Pi-1-101

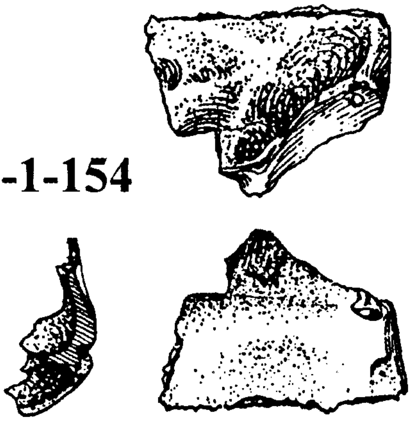
Fig. 31





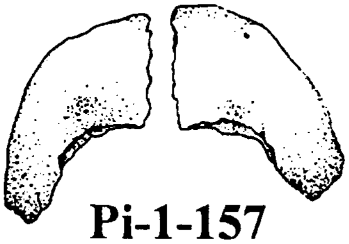
Pi-1-62

Pi-1-30

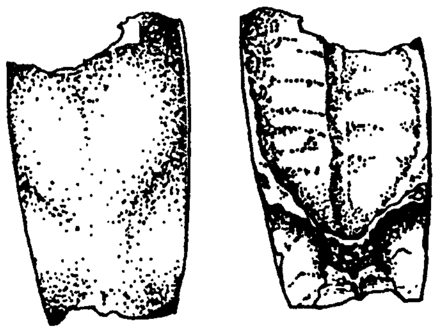


Pi-1-154

Pi-1-105



Pi-1-157



Pi-1-105

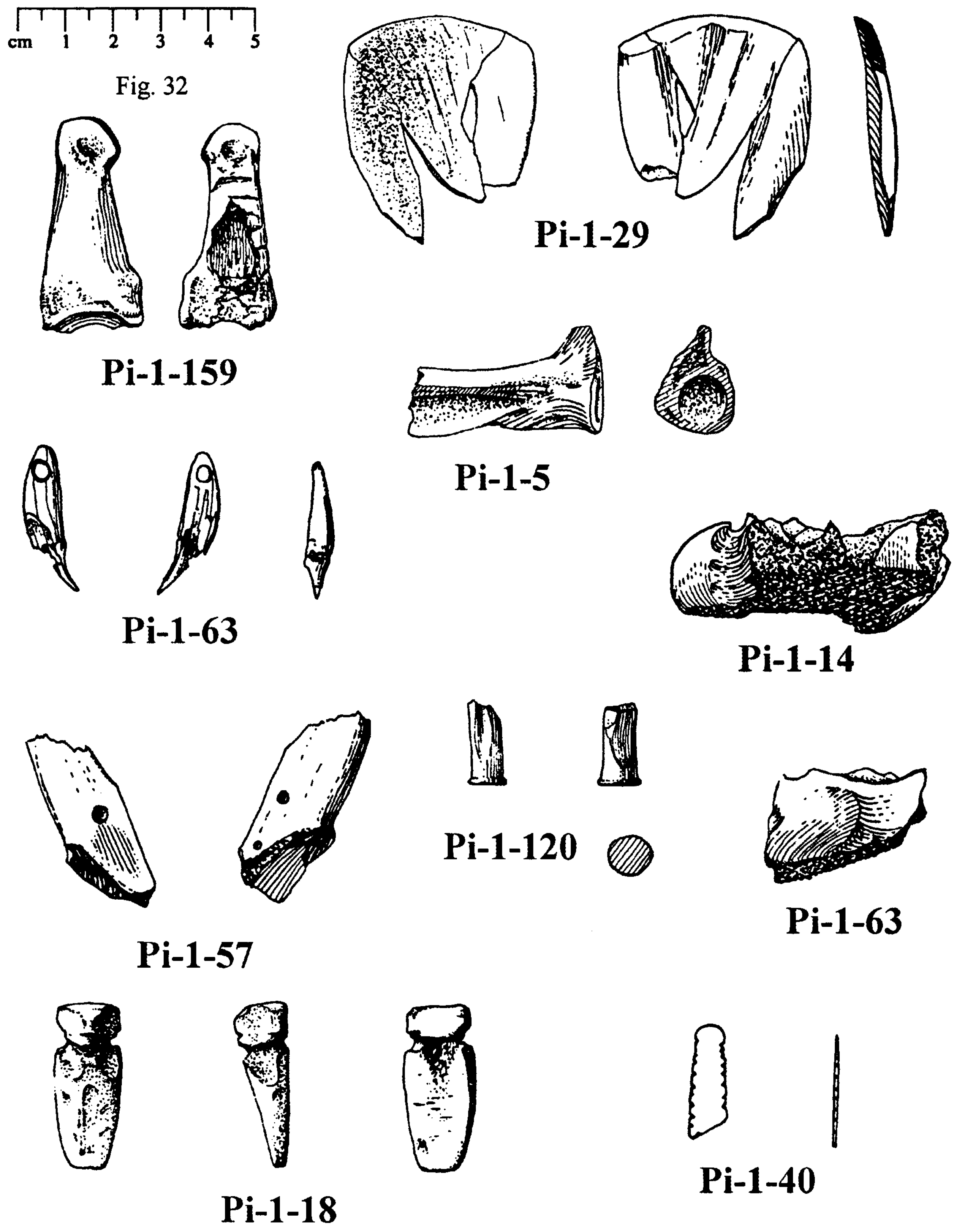


Fig. 32

Pi-1-29

Pi-1-159

Pi-1-5

Pi-1-63

Pi-1-14

Pi-1-120

Pi-1-63

Pi-1-57

Pi-1-18

Pi-1-40

SUMMARY

An analysis of the La Chimba archaeofaunas offers archaeologists an initial glimpse of prehistoric faunal utilization at a high elevation site from the northern Andes of Ecuador which was occupied over an approximately 700 year temporal span beginning in 750 BC. Including at least 40,313 examined specimens, it is the largest single archaeofaunal sample studied from any one archaeological site in Ecuador, and includes an assemblage that is relatively rich in many common, high elevation taxa, yet unevenly dominated by lagomorph and cervid remains. Many of the represented taxa are typical of environments from valley slopes and higher elevation páramo which fringe the intermontane basins of the northern Andes. The generally well-watered valley bottoms are currently under the control of large haciendas, while native farmers densely occupy the valley slopes below the upper limits of effective agriculture up to 3,000 to 3,400 m. Relict forests are found today between this zone and the higher elevation páramo grasslands (Athens 1990:1).

The identified archaeofaunal taxa analogically implicate a variety of potentially exploited and/or nearby habitats, including: high moist and lower páramo grasslands; arboreal settings of forest floors, secondary growth and forest openings; aquatic niches of marshes, ponds and lakes; and, the anthropogenic backdrop of agricultural lands. Exotic animal remains suggest the possibility of extra-local import, ranging from the long distance movement of coastal marine products, particularly the marine bivalve *Spondylus*, to the exploitation of Spectacled Bears (*Tremarctos*) from wooded habitats which were accessible to the site's inhabitants. The remains of *Saimiri*, if confirmed also suggest anthropogenic import of taxa from lower elevational settings.

The bulk of the assemblage is comprised of lagomorph remains, likely *Sylvilagus brasiliensis*, which were recovered in significant quantities from all excavation contexts. With the possible exception of certain smaller skeletal elements, recovery strategy does not appear to have significantly affected the contribution of lagomorph remains to assemblage representation. All portions of the relatively complete lagomorph skeleton were introduced and subsequently deposited in archaeological context, with a subsequent density-mediated survivorship. Fragmentation, the subsequent inability to identify non-diagnostic fragments, some loss during recovery, and selective, possibly *in situ* breakage of lower density portions of relatively intact skeletal elements are suggested as the most likely factors underlying lagomorph skeletal representation at La Chimba. Although entirely speculative, this pattern of assemblage accumulation and deposition might be accommodated in a prehistoric consumption pattern in which lagomorph hides were removed with subsequent processing of skinned carcasses into a product similar to the *ch'arki* described in early historic documents.

White-tailed deer (*Odocoileus*) and other smaller indigenous cervids comprise much of the remainder of the La Chimba archaeofaunal assemblage, and in terms of biomass were certainly the most significant animal exploited prehistorically. Although *Odocoileus* skeletal representation appears to have preserved in non-density-dependent fashion, it is suggested that this is likely an artifact of the selective removal of long bone shaft elements for tool manufacture. Entire skeletons were accumulated and subsequently deposited; however, only after they were heavily exploited for useable shafts and antler pieces. The assemblage includes ample evidence for the primary detachment of antler, the subsequent production of useable tine and peduncle portions, and the apparent discard of finished products. The latter include: many examples of simple antler tine points; possible dart shaft or point pieces for composite atlatl dart shafts; spoons; scoops; handles; and possible figurines. Evidence for primary detachment of long bone shaft fragments is also quite obvious in the assemblage. Long bone shafts were subsequently modified into tools varyingly described as punches, awls, spatulas, tubular bone shafts, needles and weaving tools akin to the Andean *wichuña*. Other tools include worked scapulae, polished ribs, modified crania, phalanges, and vertebrae. Again, although highly speculative, the consumption of deer in the form of an historically described *ch'arki* could also accommodate the accumulation and subsequent deposition of whole deer skeletons prior to their use in tool production.

Tapir (*Tapirus*) and Mountain Paca (*Agouti*) remains appear in much lower frequency, yet with relatively even representation of different skeletal parts. Larger carnivores, unlike the four most abundant archaeofaunal taxa, appear to be strongly represented by foot elements. Whether or not this may have some function associated with the use of hides and the possible selective deposition of non-foot elements elsewhere, remains speculative. Microfaunas, including an array of primarily grassland rodent taxa, including agricultural pests, are relatively scarce, even with the use of intensive fine-screen recovery. Many of these, including the articulated remains of small lizards, were likely intrusive to the deposits. A variety of birds from various taxa, representing a wide array of Andean niches were scattered throughout the deposits, but dominated by higher elevation terrestrial tinamous.

In some respects, the La Chimba archaeofaunal assemblage is similar to other northern highland sites in Ecuador, which appear to include plentiful remains of cervids, principally *Odocoileus*, along with numerous bones of *Sylvilagus*. Other wild mammalian taxa include didelphids, *Canis*, mustelids, *Felis*, *Phyllotis* and *Agouti*, with minor avian contributions of buzzards, owls and doves (Athens 1980:271; Gutiérrez and Iglesias 1995:404; Kaulike 1989:242; Villalba 1988: Figura 174). The La Chimba faunal component, however, reveals a wider array of deposited taxa, primarily due to its immense size when compared to the few, generally lower elevational, and often later prehistoric contexts in northern Ecuador. Along with the identification of exotic parrot at Cotocollao, La Chimba offers supporting evidence for the importation of animal taxa from various portions of the country. Nevertheless, the La Chimba archaeofaunal assemblage appears conspicuous in the absence of any domesticated Andean faunas, particularly camelids (*Lama*) and/or cuys (*Cavia*), despite their frequent appearance at lower elevational, and temporally later sites in the northern Andes.

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APPENDIX 1: PHOTONDENSITOMTERY STUDIES

The original NSF (SBR-9421751) grant proposal submission considered four interrelated research questions surrounding the nature and introduction of allochthanous animal domesticates into northern Ecuador: 1. When did they appear?; 2. From where were they introduced?; 3. How were they introduced?; and, 4. What was their impact on local and regional economy? Zooarchaeological methodologies for understanding the nature of their introduction (Question #3) involve the detailed notation and contextual interpretation of: variable patterning in age at death estimations; butchery and fragmentation; and, skeletal survivorship. How animal domesticates were introduced and consumed can be considered in preliminary fashion through an analysis of skeletal part profiles, particularly as they related to human utilization and transport. Derived zooarchaeological measures can then be modelled against relevant animal product utility indices which could potentially reveal prehistoric strategies for carcass utilization and/or transport.

The validity of any inference based on proportionate estimates of intra-skeletal variability must be independently assessed. A number of earlier papers skillfully addressed the significance of interpretations which inferred economic utility from surviving skeletal portions in the buried record by treating structural density mediation as an ultimate factor in assemblage formation and survivorship (Grayson 1988, 1989; Lyman 1985, 1991, 1992, 1993, 1994). Although comparable patterns in the archaeofaunal record may be produced through an assortment of proximate mechanisms, they actually may be governed by a single ultimate cause involving the relative structural density of bone tissue. It is therefore important to develop precise and replicable density assays for understanding and measuring the underlying affect of structural variability within skeletal portions on assemblage representation. This was attempted in a number of pioneering efforts (e.g., Brain 1967, 1969; Behrensmeyer 1975; Binford and Bertram 1977; Miller 1979:68; Voorhies 1969), and eventually refined by Lyman (1982, 1984; and see, 1994: Chapter 7), who effectively championed the use of photon densitometry as an accurate and reliable tool for assessing archaeofaunal assemblage formation and survivorship.

Empirically-derived bone density estimates have become "an indispensable tool in taphonomic analysis" (Kreutzer 1992:291). The potential for application of photon densitometry to taphonomic studies in archaeology is hindered only by the relatively few taxa for which reliable assays are available. These include: chinook salmon *Oncorhynchus tshawytscha* (Butler and Chatters 1994); largescale sucker *Catostomus macrocheilus* (Butler 1996); rabbits *Sylvilagus floridanus*, *Oryctolagus cuniculus*, and hares *Lepus* spp. (Pavao 1996; Pavao and Stahl 1998); marmots *Marmota* spp. (Lyman et al. 1992); humans *Homo sapiens* (Galloway et al. 1997); phocid seals *Phoca* spp. (Chambers 1992; Lyman 1994:Chapter 7); New World camelids *Lama* spp. (Elkin 1995; Elkin and Zanchetta 1991); New World deer *Odocoileus* spp., domestic sheep *Ovis aires*, pronghorn antelope *Antilocapra americana* (Lyman 1982; 1984; 1994: Chapter 7); and bison *Bison bison* (Kreutzer 1992). In the absence of taxon-specific density values, assays might be cautiously applied to closely related taxa; however, "where great differences in body size and behavioral adaptation exist between the model and subject taxa, the model may be entirely inappropriate or, at best, provide only a blunt instrument capable of detecting gross patterning across the assemblage" (Kreutzer 1992:291; see also Lyman et al. 1992:565). It is important for our taphonomic tool kit to develop a comprehensive catalog of precise and reliable assays for as many taxa as possible.

STRUCTURAL DENSITY ASSAYS OF NEW WORLD CAMELID SKELETONS

The New World camelids include four closely related taxa that can successfully interbreed. This potential for hybridization, coupled with a disagreement over phylogenetic relationships between domestic and wild taxa, has historically resulted in some taxonomic confusion amongst scientists (e.g., Franklin 1982:464; Kent 1982; Novoa and Wheeler 1984:116; Stanley et al. 1994; Webb 1974; Wheeler 1995), yet appears to be less problematic for native herders (Flores Ochoa 1986). Extant taxa include two wild forms, Guanaco (*Lama guanicoe*) and Vicuña (*Vicugna vicugna*), and two principal domesticates, Llama (*L. glama*) and Alpaca (*L. pacos*). Recent study suggests that the current state of genetic heterogeneity amongst domesticated forms may be attributed to the post-Conquest collapse of controlled breeding practices by prehispanic herders (Wheeler et al. 1995). Despite a long-standing interest in the prehistoric record of early domestication and subsequent spread of these ritually and economically important animals throughout Andean South America (e.g., Browman 1989; Hesse 1982; Kent 1982, 1987; Miller and Gill 1990; MacNeish *et al.* 1975; Moore 1989; Rick 1980; Shimada and Shimada 1985; Stahl 1988; Wheeler 1984, 1985; Wheeler et al. 1976; Wing 1975, 1977, 1986), studies devoted to improving our understanding of camelid taphonomy are just begining (e.g., Borrero 1985; 1988; 1990a; 1990b; Elkin 1995; Elkin and Zanchetta 1991; Kuznar 1995; Mengoni Goñalons 1991; Miller 1978; Mondini 1995; Olivera and Nasti 1993; Tomka 1994).

Previous Studies of Camelid Structural Bone Density

Miller (1978:68) was the first to undertake the quantification of differential densities between skeletal portions, by determining the specific gravity of selected post-cranial elements obtained through surface collection of recent camelid accumulations. Major limb bones were sectioned transversely into three parts, and metapodia were bisectioned through the mid-shaft. Each portion, along with intact calcanea, astragali, and phalanges were weighed, and respective volume determinations calculated via water displacement. Miller demonstrated a "definite correspondance" between the relative structural density of long bone epiphyses and patterned longitudinal fracturing observed during camelid carcass preparation in the southern highlands of Peru.

Elkin and Zanchetta (1991) obtained bone mineral density estimates of selected camelid elements through the use of Dual Energy X-Ray densitometry. Analyzed materials included skeletal elements from at least two Guanacos (*L. guanicoe*) and two Vicuñas (*V. vicugna*), in addition to a few archaeological specimens of indeterminate *Lama* sp. Volume density determinations for locations considered as most representative of each bone, or portion thereof, were derived through dividing machine readings of bone mineral density by corresponding bone thickness. Respective determinations for each camelid (Elkin and Zanchetta 1991: Tabla 2) were highly correlated with each other and with corresponding values for cervids (Lyman 1984).

In a subsequent study, Elkin (1995) expanded her sample to include one Vicuña (*V. vicugna*), two Guanacos (*L. guanicoe*) and one Llama (*L. glama*) skeleton. An additional set of camelid bone volume density estimates were established using water displacement of skeletal elements (excluding the head and pelvis) and sectioned long bone portions which conformed to those examined in the earlier study. Volume density values for all three taxa displayed a highly positive and significant correlation; however, only those for Llama were published as they were considered to be characteristic of all studied camelids (Elkin 1995:Table 2). The Llama assays were used to demonstrate density-mediated survivorship of artiodactyl remains at the early Holocene site of Pintoscayoc 1 in northwestern Argentina.

The structural density assays published by Elkin and Zanchetta (1991) and Elkin (1995) were derived for various camelid taxa using the technique of photon absorptiometry; however, they are not entirely comparable with the parallel studies of various vertebrate taxa. Lyman (1984:272-273) originally selected specific scan sites on each element which were structurally different, easy to locate and readily susceptible to the analysis of fragmented remains in archaeological sites. For consistency, and in order to examine underlying anatomical variation by maintaining conditioning factors constant, subsequent researchers chose similar scan sites for measurement. In most cases, the existing camelid density figures published by Elkin and Zanchetta (1991) and Elkin (1995) lack both comparability and precision as they average values for corresponding scan sites. Furthermore, published volume density values are based on only one adult Llama (*L. glama*) skeleton (Elkin 1995: Table 2), measurements from one juvenile Vicuña (*V. vicugna*), and the combined elements of two adult Guanacos (*L. guanicoe*) (Elkin and Zanchetta (1991: Tabla 2). The research described below expands on these innovative foundations.

Materials and Methods

Following published procedures (see Kreutzer 1992; Lyman 1984; Lyman et al. 1992), a series of standardized bone sites were scanned by Dual-energy X-ray Absorptiometry (DEXA) in order to generate comparable structural density values for domesticated camelid taxa. Although dual energy projections have been employed for *in vivo* clinical assessments of both hard and soft tissue composition for over a decade, the recent introduction of DEXA has increased precision while decreasing radiation dosage (e.g., Johnston et al. 1991; Lohman 1992; Mazess et al. 1990). Utilizing quantitative digital radiography, DEXA technology has been used with success to generate replicable skeletal density values for Bison (Kreutzer 1992) and Salmon (Butler and Chatters 1994). A detailed description of the instrumentation and measurement procedures is published in Kreutzer (1992:275); any departures from this approach are detailed below.

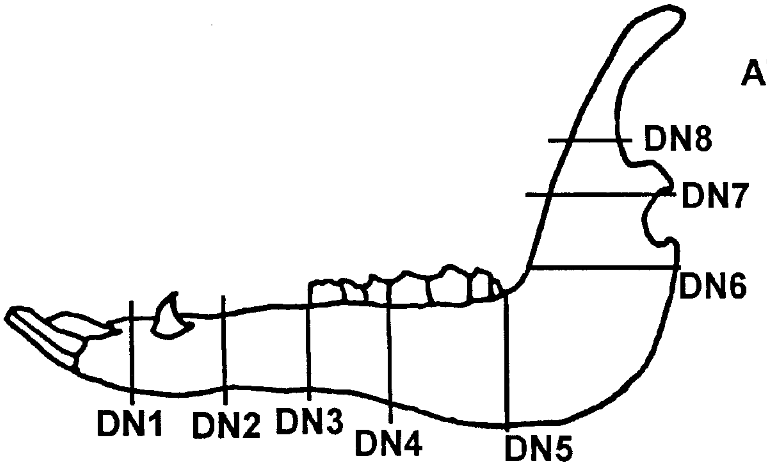
Ten adult domesticate camelid skeletons, including *Lama* indet., *L. glama*, and *L. pacos*, were obtained on loan through the courtesy of the Department of Mammalogy, American Museum of Natural History (Table 1). For sake of comparability, scan site locations originally

Table 1. Studied Camelid Skeletons

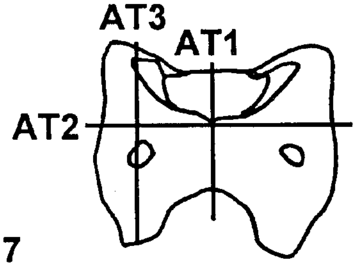
Acc. #	*Taxon*	Sex	Origin	Remarks
6240	*Lama pacos*	♂	Central Park Zoo	none
6362	*Lama pacos*	♂	no data	skull discarded
22815	*Lama glama*	♀	New York Zoological Soc.	skin discarded
35235	*Lama glama*	♂	New York Zoological Soc.	measurements
70068	*Lama pacos*	♀	New York Zoo	skin & skeleton
80113	*Lama indet.*	♂	New York Zoo	skeleton
80295	*Lama indet.*	♂	New York Zoo	complete skeleton
207764	*Lama indet.*	?	New York Zoological Soc.	none
237998	*Lama indet.*	♀	no data	skeleton only
237999	*Lama indet.*	?	no data	post cranial only, cervicals sectioned

used by Lyman (1984: Fig.2) and subsequently observed by Kreutzer (1992: Fig 2) were measured wherever possible (Fig. 1). Deviations are as follows: 1. camelids have fused radio-ulnae; 2. mandibular sites DN5 and DN6 were repositioned; 3. only two scans through the entire breadth of the scapular blade were measured; and, 4. all of the smaller carpals and tarsals were scanned, some of which can be compared with their counterparts in the Bison skeleton. The number of measured scan sites varies as some skeletons were incomplete, whereas other elements were omitted from the study due to prior modification. Portions of skeleton AMNH No. 6362 had been previously drilled for articulated display, and AMNH No. 237999 included sagitally-sectioned cervical vertebrae. Following Kreuzer (1992:275), the left member of paired elements were examined, and only substituted by their right counterpart if unavailable.

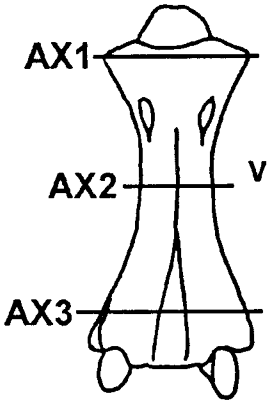
The machine used in this study was a DP3 Dual-Photon Absorptiometer, with integrated Version 2.1 Software, manufactured and developed by the Lunar Radiation Corporation, Madison Wisconsin. Except for collination, which refers to the opening of the bottom of the detector, all machine default values were maintained during the analysis. A slightly higher resolution for scans of children and severely osteoporotic patients is obtained with collination set at 8 mm diameter. A number of elements were positioned end-to-end and oriented in a standardized position under the passing beam on a backing plate of 1 mm thick aluminum, which imparted readings ranging from 0.00 to 0.03 gm/cm^2 of `background' density. Upon completion of each scan, a digitized image was generated on a linked computer monitor. The machine automatically determines bone width (BW) as it detects the outside edges of high density bone and outlines its contours. The screen image of each element could then be checked and manually adjusted if needed, in order to ensure that the defined analytical region of interest corresponded as closely as possible with the contours



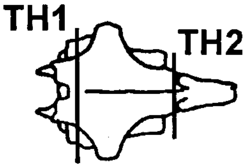
Left Mandible
Lateral View



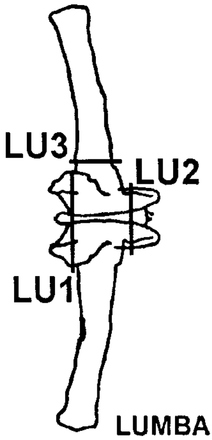
ATLAS
Dorsal
View



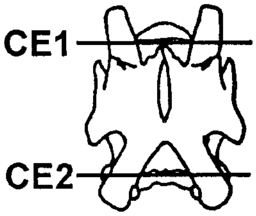
AXIS
Ventral View



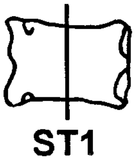
THORACIC
Dorsal View



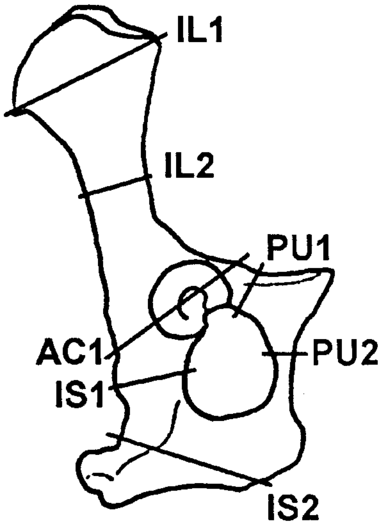
LUMBAR
Dorsal View



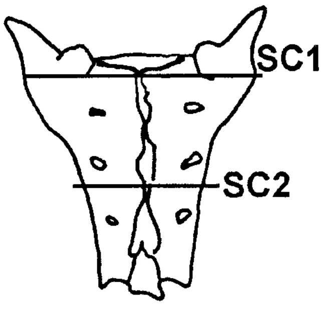
CERVICAL
Dorsal View



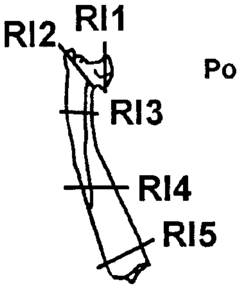
STERNABRA
Dorsal View



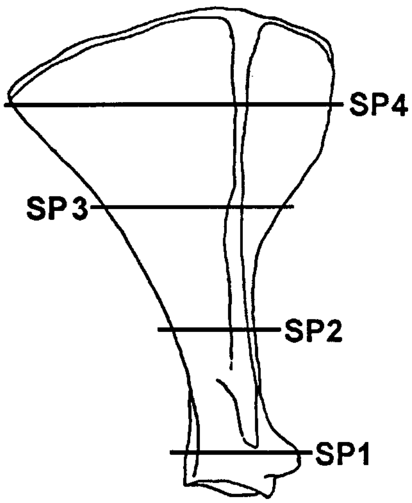
RIGHT INNOMINATE
Lateral View



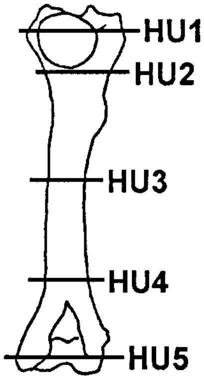
SACRUM
Dorsal View



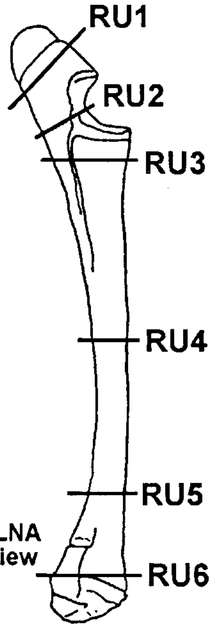
RIB
Posterior View



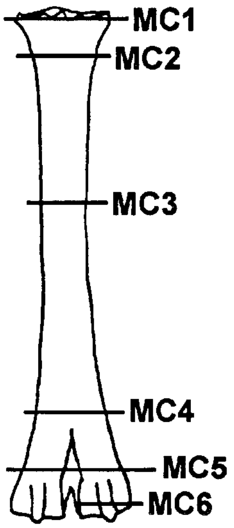
RIGHT SCAPULA
Lateral View



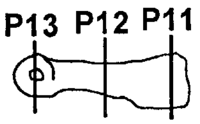
RIGHT HUMERUS
Posterior View



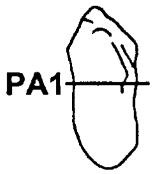
RIGHT
RADIUS-ULNA
Lateral View



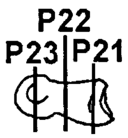
METACARPAL
Posterior View



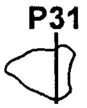
FIRST PHALANX
Medial View



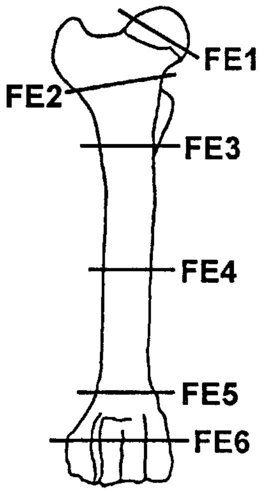
LEFT PATELLA
Anterior View



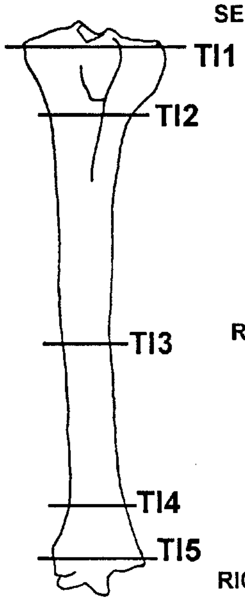
SECOND PHALANX
Medial View



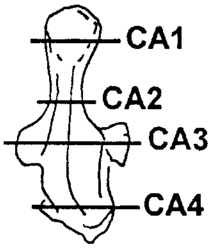
THIRD PHALANX
Medial View



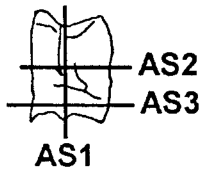
RIGHT FEMUR
Anterior View



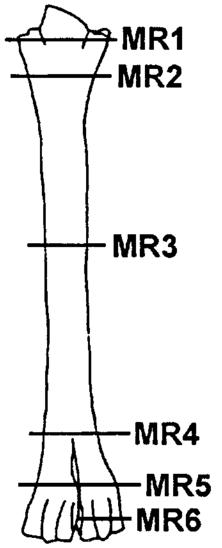
LEFT TIBIA
Anterior View



RIGHT CALCANEUM
Posterior View



RIGHT ASTRAGALUS
Posterior View



METATARSAL
posterior view

PISIFORM
Medial View

SCAPHOID
Ventral View

CUNEIFORM
Ventral View

LUNAR
Ventral View

MAGNUM
Ventral View

TRAPEZOID
Ventral View

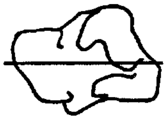
UNCIFORM
Ventral View

FIRST TARSAL
Medial View

ENTOCUNEIFORM
Ventral View

NAVICULAR
Ventral View

LAT. MALLEOLUS
Medial View



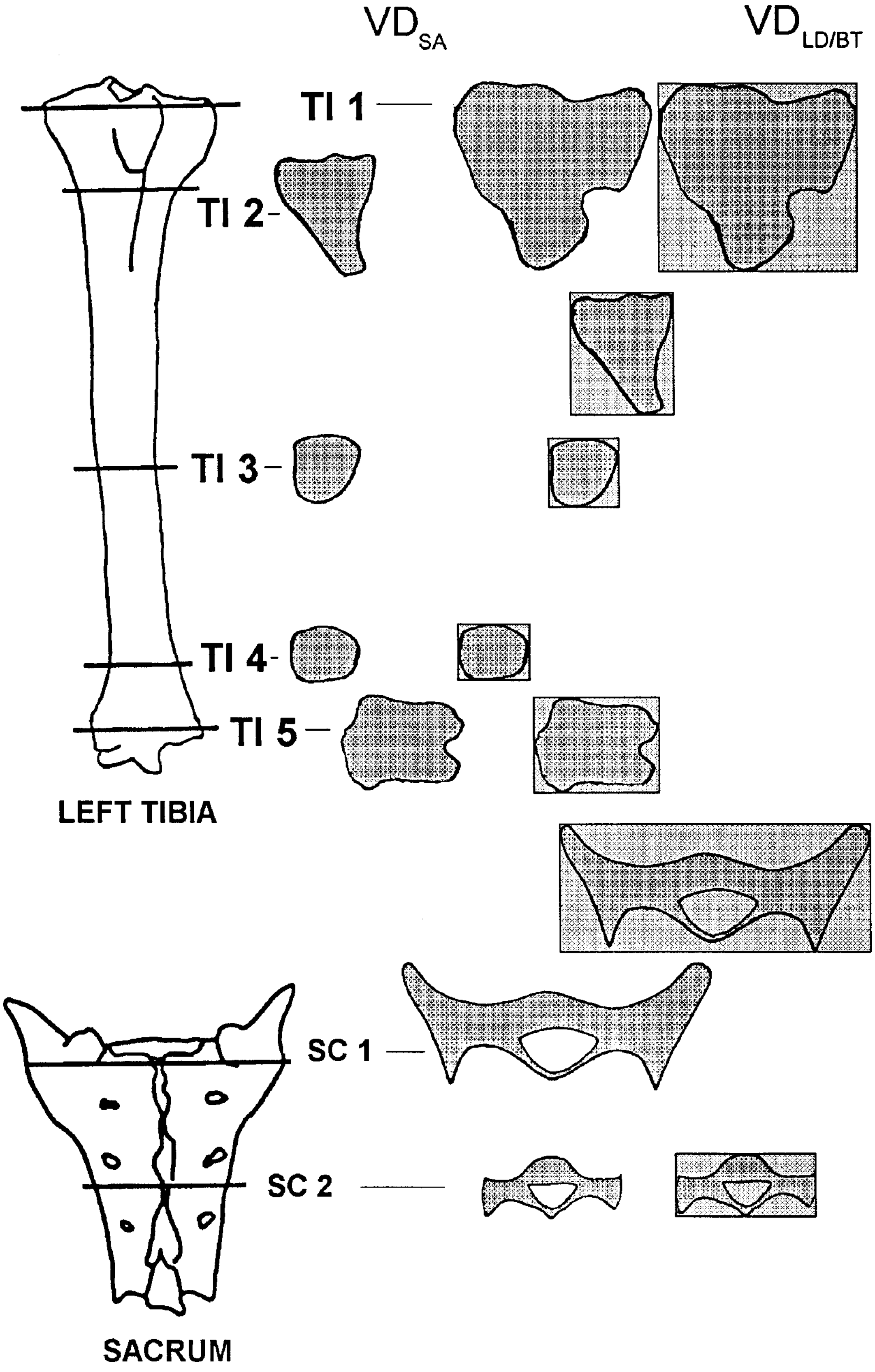
CUBOID
Ventral View

of the element outline. Each scan site was then manually defined by manipulating the selected region of interest on the screen image. The beam width was standardized at the smallest possible setting of 2 mm for all measurements. The machine then automatically calculated Bone Mineral Density (BMD in g/cm^2), also referred to as Linear Density (LD, Lyman 1984:273), from the detected Bone Mineral Content (BMC in g/cm) by factoring in the dimensions of beam width and BW for each scan site.

As previously discussed (Kreutzer 1992:283; Lyman 1984:273), this derived measure is invalid, for it does not consider bone thickness (BT) at each scan site. This additional dimension is crucial for computation because each scan site is a three dimensional volume defined as beam width X BW X BT. Respective cross-sectional configurations of different scan sites on different elements are of course highly variable. Originally, Lyman (1984:280) normed these cross-sections to a block shape by factoring in caliper measurements of bone thickness at each site. A valid and comparable Volume Density (VD) measure was then computed through dividing LD (BMD) by BT (VD = LD / BT). However, a square or rectangular shape necessarily simplifies cross-sectional area (Lyman 1984:280), which reduces shape variability and can systematically underestimate VD values. Different methods for calculating scan site cross-sections and volume estimations have been subsequently used, including: caliper measurement of each site cross section plotted on graph paper (Kreutzer 1992); water displacement of skeletal elements and sectioned long bone portions (Elkin 1995); norming of each site to a geometric shape that most closely approximated its profile (Pavao 1996); and, computing site diameter calculated from the bone circumference at each scan site measured with a linen tape (Galloway et al. 1997). Recent application of Computed Tomography (CT) to bone density determinations of caprid long bones appears to have eliminated this problem. As the technique records beam attentuation from amny different directions, CT provides density assays based upon precise assessments of cross-sectional are and scan site volume (Lam *et al.* 1998:561-562).

My method for calculating bone volume at scan sites differs from these previous estimations. I drew the cross-sectional profiles of each scan site represented in *Lama* indet. skeleton AMNH No. 80113 with the aid of a carpenter's molding tool and digital calipers (Fig. 2). Note that vertebral cross-sections take into account air space of intervertebral canals, whereas all other cross-sectional estimates do not include internal pore space. Next, I digitized the sketches of each cross-section to produce compatible files in TIFF format. With digital calipers, I measured the distance between standardized osteometric landmarks for each scan site of all the available skeletal elements. I then computed the area of each site using the Analyze Menu of NIH Image Ver. 1.52, a MacIntosh-based image processing and analysis program distributed as public domain software by the National Institute of Health. The distance between landmarks for each scan site was manually defined on the screen image, after which the corresponding known distance was entered, and the scale set to centimeters. This procedure was repeated for the entire set of scan sites, resulting in exacting areal (cm$^{2)}$ estimations.

I computed VD in two different ways. In order to use my cross-sectional area estimations, I factored BW (cm) out of BMD (g/cm^2) to calculate BMC (g/cm) (e.g., BMC = BMD X BW). I then computed "shape-adjusted" Volume Density (VD$_{SA}$) by dividing cross-sectional area (cm^2) into BMC (g/cm) (e.g., VD$_{SA}$ = BMC / Area cm^2). As only one camelid skeleton was drawn, I am assuming that it is morphologically representative of all camelid


VD_SA
VD_LD/BT
TI 1
TI 2
TI 3
TI 4
TI 5
LEFT TIBIA
SC 1
SC 2
SACRUM

skeletons; a time-saving assumption that necessarily reduces variability and introduces its own degree of error. I present a second set of VD calculations in which cross-sectional areas are simply normed to a square or rectangular shape, through dividing BMD by BT for each scan site (e.g., $VD_{LD/BT}$ = LD {BMD} / BT). This measurement conforms to the original VD calculations offered by Lyman (1984), and facilitates comparison with his figures and certain others. Results of the analyses and comparisons between VD_{SA} and $VD_{LD/BT}$ are discussed below.

Results and Discussion

Table 2 records the averaged VD_{SA} (g/cm^3) and $VD_{LD/BT}$ (g/cm^3) values for 101 camelid scan sites, including corresponding sample sizes and rankings for the different volume estimation techniques. The relationship between the two sets of averaged volume density values is characterized by a highly positive and significant correlation (Pearson's $r = 0.9$, $p \leq .001$) which is graphically illustrated in Figure 3. Variations in rank ordering between the two sets of values is produced by the differing techniques for estimating cross sectional volume. This is clearly demonstrated in many of the scan sites whose cross sectional profiles most radically depart from a block outline (e.g., AC1, IL1, SP2, SP3, SP4), and/or from which internal air space was subtracted (e.g., most of the vertebral body sites). Conversely, relative agreement in rank ordering is found amongst those scan sites whose cross sectional profiles most closely approximate a block outline (e.g., mandibular, phalangeal, and many of the carpal/tarsal sites) and from which internal air space was not subtracted. Of course, the density value for any scan site cross section which does not take into account internal air space or structural heterogeneity is inevitably innaccurate. This is particularly important for long bone diaphyses with pronounced medullary cavities. Marean and colleagues (Marean & Frey, 1997; Lam *et al.* 1998; Marean & Kim, 1998) have critically assessed the effect of consistently underestimating long bone mid-shaft density on archaeological interpretations of assemblage accumulation involving skeletal frequencies. Although the method for estimating scan-site cross-section in this study is offered as a technique for increasing the accuracy of bone mineral density calculations, it inevitably underestimates the density of those scan sites for which significant cross-sectional heterogeniety was not taken into consideration.

Comparison of Scan Site Values between Camelids. Considered separately, the two sets of density values are internally consistent. The mean correlation coefficient between VD_{SA} values of scan sites from a maximum of 10 camelid skeletons is highly positive and significant ($r = 0.79$, $p \leq .001$), as is the corresponding mean correlation coefficient for $VD_{LD/BT}$ ($r = 0.82$, $p \leq .001$). The slightly higher correlation for normed cross sections is understandable, as these values are inclined toward greater homogeneity. This reduction in variability is produced by norming all cross sectional outlines to a block profile (see Figure 2).

Despite their internal consistency, however, the averaged values mask a certain degree of sample heterogeneity. The skeletal sample upon which the values are based includes a mixture of adult males and females from at least two taxa of domesticated animals raised in zoos. There is no way to assess the extent to which unique handling has affected the computed values. The

Table 2. Average Structural Bone Density Values for Selected Camelid Scan Sites

Scan Site	N	Mean VD_{SA} (g/cm^3)	Rank	Mean $VD_{LD/BT}$ (g/cm^3)	Rank
AC1	9	1.89	50	0.76	25
AS1	10	1.91	53	1.17	52
AS2	10	2.08	60	1.20	54
AS3	10	2.14	67	1.44	70
AT1	9	1.79	42	0.97	39
AT2	9	1.80	43	0.53	10
AT3	9	1.94	54	0.58	12
AX1	10	0.69	2	0.47	7
AX2	10	1.66	37	0.75	24
AX3	10	1.35	18	0.46	6
C1	10	1.66	36	1.16	51
CA1	10	1.54	31	1.02	43
CA2	10	3.75	94	2.37	94
CA3	10	1.60	32	0.84	29
CA4	10	2.73	83	1.56	79
CD1	10	1.49	28	0.87	30
CE1	10	1.04	10	0.42	4
CE2	10	1.33	16	0.41	3
DN1	9	2.43	73	1.33	64
DN2	9	3.87	96	2.50	97
DN3	9	4.38	97	2.84	98
DN4	9	3.85	95	2.37	95
DN5	9	3.09	87	2.38	96
DN6	8	5.00	98	3.26	101
DN7	8	7.19	100	3.11	99
DN8	8	7.23	101	3.26	100
E1	10	2.45	74	1.85	90
FE1	10	1.41	22	0.96	38
FE2	9	1.03	9	0.90	32
FE3	9	1.35	17	0.93	35
FE4	9	1.50	29	0.99	41
FE5	9	1.36	19	0.83	28
FE6	9	0.86	5	0.49	8
HU1	9	0.61	1	0.44	5
HU2	9	0.84	4	0.61	14
HU3	9	1.42	23	0.92	34
HU4	9	1.39	21	0.98	40
HU5	9	1.30	15	0.81	27

Table 2. Average Structural Bone Density Values for Selected Camelid Scan Sites (cont.)

Scan Site	N	Mean VD_{SA} (g/cm^3)	Rank	Mean $VD_{LD/BT}$ (g/cm^3)	Rank
IL1	9	3.29	91	1.45	71
IL2	9	3.18	89	2.06	91
IS1	9	5.04	99	2.25	93
IS2	9	2.12	65	1.34	65
L1	10	1.86	47	1.13	48
LM1	10	2.84	84	1.51	77
LU1	10	1.84	45	0.62	16
LU2	10	1.91	52	0.72	21
LU3	10	3.02	86	1.60	83
M1	10	2.59	78	1.35	66
MC1	9	1.46	26	1.22	55
MC2	9	2.39	71	1.30	63
MC3	9	2.12	66	1.50	75
MC4	9	3.43	93	1.85	89
MC5	9	2.50	76	1.78	86
MC6	9	1.78	41	1.10	46
MR1	9	1.47	27	0.94	36
MR2	9	2.08	59	1.37	67
MR3	9	1.89	49	1.51	76
MR4	9	2.92	85	1.82	88
MR5	9	2.48	75	1.64	84
MR6	9	1.71	39	1.16	50
N1	10	2.39	70	1.24	58
P1	10	2.61	80	1.59	82
P11	9	1.53	30	1.26	60
P12	9	3.20	90	2.13	92
P13	9	1.90	51	1.27	62
P21	9	1.88	48	1.27	61
P22	9	1.61	33	1.05	44
P23	9	2.41	72	1.24	57
P31	8	3.10	88	1.45	72
PA1	10	1.45	25	1.07	45
PU1	9	1.83	44	1.00	42
PU2	8	1.03	8	0.52	9
RI4	10	2.56	77	1.67	85
RI1	10	1.61	34	1.15	49
RI2	10	2.12	64	1.10	47
RI3	10	3.36	92	1.80	87

Table 2. Average Structural Bone Density Values for Selected Camelid Scan Sites (cont.)

Scan Site	N	Mean VD_{SA} (g/cm^3)	Rank	Mean $VD_{LD/BT}$ (g/cm^3)	Rank
RI5	10	2.60	79	1.58	80
RU1	9	2.10	62	1.53	78
RU2	9	1.26	14	0.61	15
RU3	9	1.86	46	1.19	53
RU4	9	2.06	57	1.26	59
RU5	9	1.75	40	0.88	31
RU6	9	1.18	12	0.74	23
S1	10	1.98	56	1.23	56
SC1	9	1.71	38	0.59	13
SC2	9	1.65	35	0.79	26
SP1	10	1.10	11	0.72	20
SP2	10	2.22	68	0.71	19
SP3	10	1.44	24	0.29	1
SP4	10	2.12	63	0.71	18
ST1	10	0.83	3	0.63	17
T1	10	2.34	69	1.47	73
T11	7	2.62	81	1.59	81
TH1	10	0.91	6	0.40	2
TH2	10	1.97	55	0.91	33
TI1	9	0.96	7	0.57	11
TI2	9	1.25	13	0.73	22
TI3	9	2.09	61	1.43	69
TI4	9	2.07	58	1.42	68
TI5	9	1.36	20	0.95	37
U1	10	2.68	82	1.50	74

effects of special diet or unusual excercise regime in a zoo environment may be important, especially when considering that the underlying BMC (g/cm) values are much higher than those for any previously examined taxon. This is the first structural bone density study undertaken exclusively on domestic taxa. One inevitable outcome of domestication can be an increase in the degree of individual variation within an overall population structure when compared to the wild condition. In particular, camelid AMNH No. 207764 appears as a potential outlier, as corresponding VD_{SA} values are less clearly correlated with three other camelids (AMNH No. 237998 $r = 0.49$, $p \leq .001$, AMNH No. 35235 $r = 0.53$, $p \leq .001$, AMNH No. 22815 $r = 0.62$, $p \leq .001$) than any of the other conceivable permutations. Sample heterogeneity is certainly an issue when considering the averaged values of adult males and females from two species. The fact that these two interbreeding taxa are notoriously difficult to differentiate on the basis of osteological criteria certainly mitigates some of the potential problems created by lumping together *L. glama* and *L. pacos* scan site values. Nevertheless, despite some degree of overlap, the distinction between live llamas and alpacas is usually clear. Llamas are typically bred for meat consumption, and for wool used in the production of coarse bags, ropes, and rugs. Their tolerance to a wider variety of elevational conditions and forage types makes them better suited as mobile beasts of burden. Alpacas tend to be found only at higher elevations where they are exploited more for their finer wool than for meat consumption (Franklin 1982: 486; Table 1). Five of the scanned skeletons are identified only to the level of genus; therefore, the sample of sexed llamas and alpacas is minimal. A very high correlation (r =0.95, $p \leq .001$) characterizes the relationship between VD_{SA} values of two male alpacas (AMNH Nos. 6362, 6240); however, the number of scan sites available for comparison is low (N=58), as one skeleton had been previously drilled for articulated display. The available llama sample consists of one male and one female, but is also characterized by a high correlation (r =0.82, $p \leq .001$) between respective VD_{SA} values. A comparison between skeletons of similar sex, regardless of taxon (including *Lama* indet. individuals), reveals little in the way of patterning except for an overall highly positive and significant statistical correlation.

Comparison of Scan Site Values with Previous Camelid Studies. How do these scan site values compare with those generated by previous studies of camelid skeletons? Miller's (1979:68) original density calculations were estimated for selected skeletal elements and portions, including: 1. long bone end portions of the humerus, radio-ulna, femur and tibia; 2. metapodial ends including shaft portions; and, 3. intact calcanea, astragali and first phalanges. Ten examples of each element were collected from surface scatters of recent camelid accumulations, and respective mean specific gravities were estimated using weight and volume determined by water displacement. Each of Miller's 15 specific gravity measurements incorporates a number of scan sites (Miller 1979: Fig. 2-15), therefore an average of corresponding structural density values was compared. Rank order correlations between Miller's specific gravity determinations and both VD_{SA} (Spearman's r_s =.795, $p \leq .001$) and $VD_{LD/BT}$ (r_s =.81, $p \leq .001$) values are highly positive and significant.

Elkin and Zanchetta (1991:Tabla 2) provide VD (g/cm^3) estimates for selected element portions and complete bones, determined by dividing machine-derived measurements by bone thickness. $VD_{LD/BT}$ values were used, as the respective volumes were normed to a block shape, and averaged where appropriate. Averaged $VD_{LD/BT}$ assays were compared to 27 corresponding measurements for *L. guanicoe* with a positive and significant correlation (r_s =.68, $p \leq .001$). Averaged $VD_{LD/BT}$ assays were also compared to 26 corresponding measurements for a juvenile specimen of the smaller and more gracile wild *V. vicugna* with a much less positive correlation (r_s =.45, p = .002). Elkin's (1995) subsequent study includes VD (g/cm^3) estimates for selected element portions and complete bones including shaft portions from a Llama skeleton. Respective bone volumes were estimated via water displacement. Averaged VD_{SA} values were compared to 32 corresponding measurements with a relatively weak and positive correlation (r_s =.51, p =.0026), whereas a comparison with corresponding $VD_{LD/BT}$ assays (r_s =.69, $p \leq .001$) is much more positive and significant.

Comparison of Scan Site Values with other Artiodactyls. The camelid structural density assays compare favorably with corresponding values for deer (Lyman 1984) and bison (Kreutzer 1992) generated by an approach similar to the one used here. Sample sizes vary as the discrepancies between measured scan sites for camelids and other artiodactyls necessitated the following departures: 1. the fused camelid radioulnar sites are ommitted as they have no counterparts in deer, and were measured somewhat differently in bison; 2. carpal and tarsal comparisons vary as camelids do not have a fused naviculocuboid, and comparable cuneiform, lunar, lateral malleolus and unciform values are available for bison only; 3. scapular blade values for camelid sites SP3 and SP4 are considered to be comparable to sites SP4 and SP5 respectively in bison and deer; and, 4. the bison study does not include values for the second phalanx mid-toe measurement, thus site P22 is comparable to site P23, and omits assays for the sternum and patella.

Linear densities (LD, or Bone Mineral Density BMD) values of camelid scan sites are highly and positively correlated with corresponding assays of both deer (r_s =.79, p ≤.001, N=84) and bison (r_s =.77, p ≤.001, N=85). Using Kreutzer's (1992) technique of comparing the ten highest and ten lowest ranking LD scan sites for each taxon, it appears that the former similarly cluster in proximal foreleg, distal hindleg, and metapodial elements of camelids, with the addition of two sites on the mandibular body; whereas the latter tend to cluster in scapular and axial elements of camelids, with one mandibular site on the coronoid process (Table 3). As LD

Table 3. Ten most-dense and 10 least-dense LD scan sites held in common, ranked from highest to lowest in mineral content

Camelid		**Bison**		**Deer**	
Scan site	Rank	Scan site	Rank	Scan site	Rank
DN4	1	HU3	1	FE6	1
FE6	2	HU4	2	MR1	2
TI1	3	HU5	3	TI1	3
DN5	4	HU1	4	MR2	4
HU5	5	MR1	5	CA3	5
HU1	6	FE6	6	TI3	6
TI5	7	MR2	7	HU5	7
MR1	8	MR3	8	HU4	8
TI3	9	FE4	9	MR3	8
MC1	10	TI3	10	TI5	10
P22	76/77	SP4	76	RI1	75
RI3	77/78	SP3	77	P31	76
RI4	78/79	DN8	78	DN6	76
DN8	79/80	RI1	79	RI4	78
LU3	80/81	TH2	80	DN6	78
SP3	81/82	RI5	81	DN8	80

RI5	82/83	LU3	81	RI5	81
PU2	83/82	RI5	83	TH2	81
TH2	84/83	SP5	84	PU2	83
SP4	85/84	PU2	85	LU3	84
		r_s =.77, $p \le .001$, N=85		r_s =.79, $p \le .001$, N=84	

measures only two dimensional density of bone mineral (g/cm^2, calculated by BMC/BW), no adjustment is made for cross sectional volume at different scan sites. As Kreutzer (1992:285, also Lyman 1984:271) points out, these correlations reflect bone morphology more than they actually reflect differences in bone mineral content.

Correlations of volume densities in which cross-sectional areas are normed to a square or rectangular shape ($VD_{LD/BT}$) are also significant and positive for camelids and deer (r_s =.52, $p \le .001$, N=84). This is almost identical to the correlation value for comparison between bison and deer (Kreutzer 1992:285). However, similar $VD_{LD/BT}$ correlations for camelids and bison are less positive (r_s =.39, $p \le .001$, N=85). The ten most and ten least dense $VD_{LD/BT}$ scan sites are presented in Table 4. A weaker positive correlation is noted for comparisons between scan sites

Table 4. Ten most-dense and 10 least-dense $VD_{LD/BT}$ scan sites held in common, ranked from highest to lowest in mineral content

Camelid		**Bison**		**Deer**	
Scan site	Rank	Scan site	Rank	Scan site	Rank
DN6	1	AX3	1	TI3	1
DN8	2	AT2	2	MR3	2
DN7	3	CA2	3	MC3	3
DN3	4	DN7	4	MC2	4
DN2	5	DN8	4	MR2	5
DN5	6	TI3	6	CA2	6
DN4	7	AS1	7	HU4	7
CA2	8	MC3	8	DN8	8
IS1	8	MR3	9	AS3	9
P12	9	CA4	9	AS2	9
AT2	76/75	RI1	76	SC1	75
PU2	77/76	SC1	76	AX1	75
FE6	78/77	SC2	78	SC2	77
AX1	79/78	FE6	78	IS2	77
AX3	80/79	HU2	80	AX3	77
HU1	81/80	HU1	81	AT2	80
CE1	82/81	IL1	82	CE2	80
CE2	83/82	IS2	83	RI5	82

TH1	84/83	SP5	84	AT1	83
SP3	85/84	LU2	85	AX2	84
		r_s =.39, p ≤.001, N=85		r_s =.52, p ≤.001, N=84	

of camelids and deer (r_s =.34, p ≤.001, N=84) and camelids and bison (r_s =.32, p =.003, N=85) when using shape-adjusted Volume Density (VD_{SA}). This is certainly a predictable outcome of employing cross-sectional volume estimations that increasingly diverge from those normed to a block shape. It is also understandable that the differences between correlations employing VD_{SA} and $VD_{LD/BT}$ values are far less dramatic for the bison sample than those for the cervid sample, considering that the bison volumes were calculated using more accurate angular plots on graph paper (Kreutzer 1992:Figure 4). Although the VD_{SA} values potentially offer increased accuracy, all subsequent discussion is based on $VD_{LD/BT}$ values for sake of comparison.

Interpretation of Bone Density. I suspect that much of the patterned similarity and dissimilarity in structural bone densities between the South American camelid skeleton and its counterpart in deer and bison can be attributed to anatomical expressions of locomotor and dietary adaptations that emerged during the course of its unique evolutionary history (Franklin 1982; Dagg 1974, 1979; Gautier-Pilters and Dagg 1981; Webb 1965, 1972, 1974). Long before the late Pliocene dispersal of camelids from their original North American homeland, a number of distinctive changes in locomotor and feeding adaptations had occurred, most notably: 1. the appearance of equally proportioned fore- and hind-limbs with partially fused metapodia and padded digitigrade feet for support on soft substrates; and, 2. the development of hypsodont cheek teeth as an adaption for grazing abrasive vegetation, with the loss of upper incisors and the emergence of a cropping mechanism in which the lower incisors bit against split upper lips.

These Miocene progenitors developed the typical faster gait of all modern camels in their unique propensity for a unilateral pace in which both legs of one side move forward simultaneously and alternating with their counterparts on the other side. In this way, stride length can be extended and efficiency of energy expenditure increased, as moving limbs on one side of the animal never overlap (Webb 1972:100). Dagg (1974, 1979; Gauthier-Pilters and Dagg 1981:102) observes that in modern camels the sole of the foot is placed flat on the ground during stride as weight is shifted from one side to the other, followed by forward propulsion through pushing off from the toes. Therefore, locomotion involves variable plantigrade to digitigrade posture, as opposed to the typical unguligrade stance used in most artiodactyl locomotion. Foot structure is accordingly unique, including solar pads and two anterior toenails rather than cloven hooves. Lower limbs are characterized by a reduced fibula, extensively fused radio-ulna, and partially fused metapodia whose distal ends resemble an inverted `Y' (Figure 1). Furthermore, unlike most artiodactyls, the articular ridges of the distal metapodia do not completely encircle the distal articulation; rather they are restricted to the plantar surface. This enables the phalanges to spread widely during weight support, the ridges being contacted only when weight is removed (Webb 1972:106-107).

The unilateral pace of camels is well suited for long-legged animals that move about in flat and open terrains without any need for exceptional maneuverability. A pacing gait necessarily reduces lateral stability, which is further exacerbated by the resultant side to side body sway. Maneuverability is further decreased as the pacing animal's feet are on the ground less with increased stride length; therefore, a pacer is less capable of immediate directional change (Webb 1972:102). In contrast, cervids utilizing uneven paths in dense vegetation require the stability and balance afforded by diagonal support, along with superior maneuverability, in order to avoid predators (Dagg 1979:1162). The instability created by long periods of unilateral support and side to side sway is countered to some extent by limb placement near the body midline, and the weight of the head at the end of a relatively long neck which is carried low during faster gait. The typically wide and splay-toed feet tend to be larger in the forelimbs as they support this heavier counterbalancing weight (Webb 1965:33, 1972:104). Also, the forequarters generate the major force of locomotion, as modern camels tend to pull, rather than push themselves (Gauthier-Pilters and Dagg 1981:105-106).

It appears that by the beginning of the Pleistocene, a llama-like ancestor radiated into the South American Andes and pampas from its original homeland in the southern portions of North America. The typically long-limbed *Hemiauchenia* appears to have been much better suited for a cursorial existence than its descendants, *Palaeolama* and the recent llamas. During the Pleistocene, these latter forms display a marked reduction in metapodial length and an increase in epipodial length. This suggests that the speed afforded by lengthened metapodia and shortened pro- and epipodia of the plains and pampa-adapted *Hemiauchenia* had become demphasized in the more recent New World camelids as they radiated into the more rugged terrains of the Andes where maneuverability and jumping became crucial. Further developments in the masticatory appartus of the most recent llamines, including a shallowing of the jaw and the appearance of low-crowned cheek teeth and cervoid premolars, are indicative of increased dietary browse and decreased grass consumption typical of the grazing, plains adapted *Hemiauchenia* (Webb 1974:207-211). Amongst the contemporary New World camelids, *L. glama* tends toward generalized browsing and grazing in alpine grass and shrubland, while *L. pacos* inclines more toward obligate grazing of alpine grasslands, meadows and marshes (Franklin 1982:465).

The most striking pattern in *Lama* spp. structural density values is the consistently high ranking of mandibular scan sites. Mandibular scan sites in deer and bison also tend to be relatively high density sites; however, regardless of which method for volume estimation is used, the seven highest density camelid sites on average are mandibular (Table 4). It is usually the anterior-most scan site (DN 1) which is not included amongst the highest density sites. Scan sites high up on the coronoid process (DN8) and just below the mandibular condyle (DN7) are routinely the most dense. These sites are also locations of high mineral density for the other examined artiodactyl taxa. It is unclear exactly why nearly all camelid mandibular sites have such conspicuously high values in bone mineral density. The pattern is consistent between sample skeletons identified as *L. glama* and *L. pacos*, the former a grazer/browser, the latter a browser. Minor variations in the relative ordering of mandibular scan sites can be detected between male and female specimens across species, otherwise the pattern remains very consistent. One possibility for high bone mineral density may be a need for increased weight in the camelid head as it counterbalances the inherent instability of a unilateral gait. Also, unlike ruminants, the mandible of hypsodont camelids bears canines, and is characterized by a completely coosified symphysis (Webb 1965:12-13). The anterior portion of the mandible supports long, procumbent incisors that crop grass and dry browse against a unique pad formed by a deeply split and mobile upper lip which also serves as a prehensile grasping device (Webb 1965:6, 1972:108). Another possibility is that the pattern may be unique in zoo specimens due to special care and upkeep.

Excluding the seven high density mandibular sites for the moment, the majority of next highest density scan sites tend to be found in the lower limbs. Portions of the metapodial shafts and calcaneum are characteristically high in structural bone density for all studied artiodactyla. It may be important to note that the highest lower limb values are found in the distal metaphyses of camelid metapodia, as opposed to the proximal metaphysis and mid shaft portions in deer, and the mid diaphysis portions in bison. Additionally, the mid shaft of the camelid first phalanx is relatively high in structural bone density, as are most of the phalangeal scan sites in comparison with deer and bison. This is the likely reflection of a wide, splay-toed plantigrade to digitigrade stance used by camelids in unilateral gait as an adaptation to stable substrates. Unlike the obligate unguligrade stance of most cursorial animals which places enormous compressive load on the metapodium (e.g., Hildebrand 1985:56), the splayed toes and padded digitgrade feet of camelids evenly distribute load to distal members including the phalanges, and toe-like partially fused distal metapodia. As expected, the distal articular surfaces of camelid metapodia tend to be relatively less dense than comparable scan sites in deer and bison. This is very likely due to the absence of encircling ridges on upper articular surfaces, which enable the toes to spread widely when planted (Webb 1972:102).

New World camelid and deer skeletons are very similar in that relatively low structural density sites are dominated by vertebral sites in the neck. Both are typically long-necked taxa, but for different reasons, as the extended camelid neck is useful for carrying the head in a low position in order to counterbalance instability during faster unilateral gait. Kreutzer (1992:287) attributes a pattern of high density in the anterior cervical vertebrae of bison to nuchal musculature and robusticity needed to support a massive skull. Otherwise, bison and camelids share a number of low density sites, including portions of the scapular blade, the large proximal humeral head, and the broad distal articular portion of the femur. It may be pertinent in this regard to emphasize the expansion of certain bone surfaces on the upper portions of camelid shoulder and hip joints. These include an extended spine and acromian process on the scapula, a prominent deltoid crest on the lateral portion of the humerus, and a transverse expansion of the proximal femur. Each serves as an attachment for powerful abductor muscles that promote lateral stability as they pull the body in a sideways motion over the planted feet, thereby facilitating control of lateral movement (Webb 1972:104). Increased limb abductor muscle involvement in camelids requires expanded bone surface area for muscle attachment, which in turn may lead to a relative decrease in structural density for specific portions of the upper appendages.

STRUCTURAL DENSITY ASSAYS OF LEPORID SKELETONS

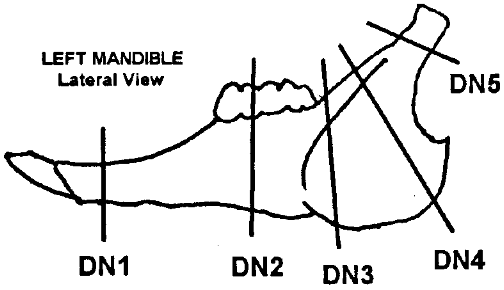
In terms of abundance, the remains of *Sylvilagus* (likely *S. brasiliensis*) dominate the La Chimba archaeofaunal assemblage. No comparable structural density measures exist for leporid (rabbits and hares) skeletons, despite their global and temporal importance in archaeological and palaeontological assemblages. Through a Research Experiences for Undergraduates supplement (SBR-9542512), a series of structural density assays were generated for standardized bone scan sites from the skeletons of four leporid taxa: European or domestic rabbit (*Oryctolagus cuniculus*), Eastern cottontail (*Sylvilagus floridanus*) snowshoe hare (*Lepus canadensis*), and black-tailed jackrabbit (*Lepus californicus*). A set of skeletons from different leporid taxa was scanned in order to assess intertaxon variability, and to provide potentially useable data for other researchers. The study was conducted by Barnet Pavao and Peter Stahl, and formed the basis for Pavao's (1996) undergraduate senior honors thesis: *Toward a Taphonomy of Leporid Skeletons: Photondensitometry Assays.*

Materials and Methods

Six complete leporid skeletons from comparative collections in the Departments of Anthropology and Biology at Binghamton University were used in the study. Two adult specimens each of *S. floridanus* and *O. cuniculus,* along with one adult *L. canadensis* and one immature *L. californicus* were chosen. The studied sample is admittedly small; however, it tentatively allows us to explore variation in bone density at the generic, inter-, and intra-specific levels. The skeletally immature specimen may also provide a provisional impression of how individual ontogeny affects bone density, at least for this and related taxa.

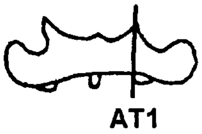
For consistency, we followed wherever feasible the methods published by Lyman (1984) and Kreutzer (1992). The scan sites chosen for investigation correspond as closely as possible to those used in Lyman et al.'s (1992) study of *Marmota* spp. skeletons. Certain sites unique to marmots and not to leporids (e.g. separate fibula, clavicle) were obviously eliminated, whereas those potentially useful for resolving aspects of locomotion (e.g. including the metacarpus in addition to the metatarsus) were added. Wherever appropriate, the left side of the skeleton was measured unless it was unavailable, in which case its right counterpart was substituted. Certain scan sites on some skeletons were not available for study, and these are noted. The scan sites and abbreviations used are illustrated in Figure 3.

Bone mineral density was measured following the same methodology outlined above. However, inevitable problems encountered in measuring bones of this small size necessitated certain on-screen data manipulations. As the machine measures the average bone mineral content across the scan site, it is important to ensure that only the defined portion of the bone element is measured. Normally, the outside edges of high density bone are automatically detected, and the contours of the bone element are highlighted. Often, however, the small size and/or limited amount of measurable bone mineral in some elements causes the machine to define its region of analytical interest in a straight line from one area of high density to the next. This results in the inclusion of air space which would, if not eliminated, erroneously skew the averaged measure

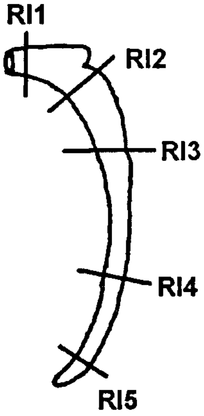


LEFT MANDIBLE
Lateral View

AXIS
Lateral View

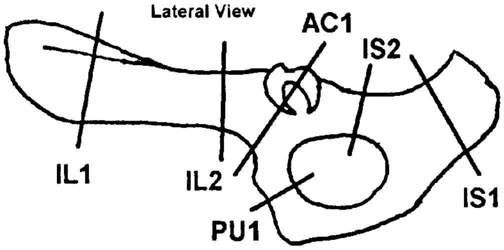


ATLAS
Dorsal View

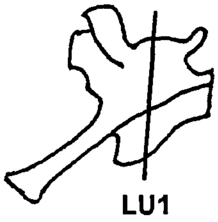


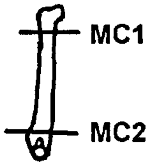
RIGHT RIB
Posterior View

LEFT INNOMINATE
Lateral View

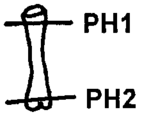


LUMBAR
Lateral View



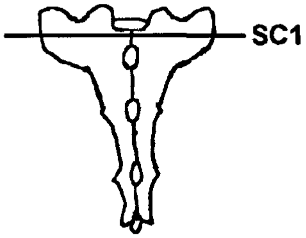


LEFT METACARPAL
Dorsal View

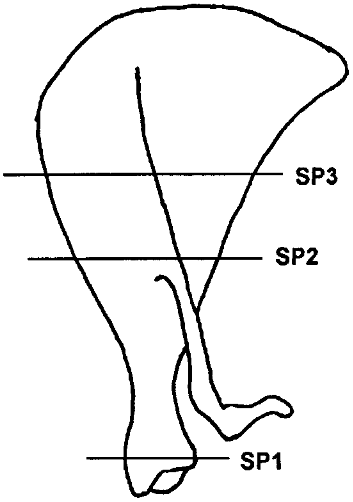


LEFT PROXIMAL
PHALANX #3
Dorsal View

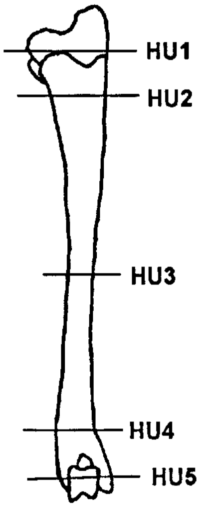
STERNUM
Ventral View



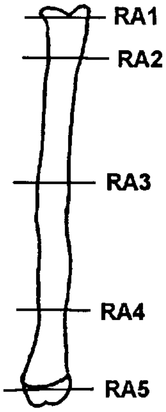
SACRUM
Dorsal View



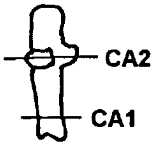
LEFT SCAPULA
Lateral View



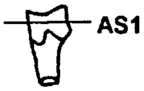
LEFT HUMERUS
Anterior View



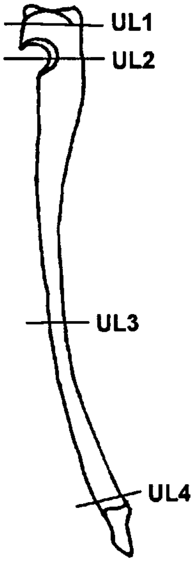
LEFT RADIUS
Anterior View



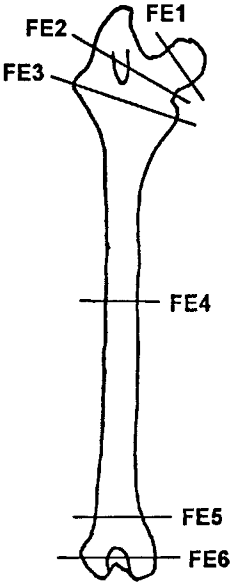
LEFT CALCANEUM
Dorsal View



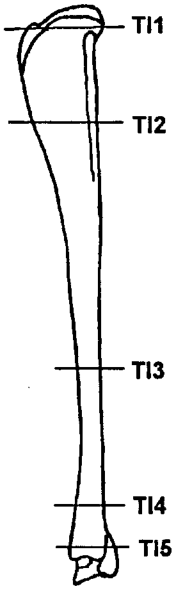
LEFT ASTRAGALUS
Dorsal View



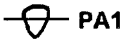
LEFT ULNA
Lateral View



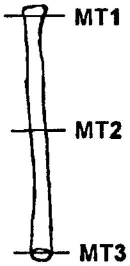
LEFT FEMUR
Posterior View



LEFT TIBIOFIBULA
Lateral View



PATELLA
Anterior View



LEFT METATARSAL
Dorsal View

across the scan. In these cases, we had to manually outline the element on-screen in order to ensure that the defined analytical region of interest (BW) corresponded with the contours of the skeletal element as closely as possible.

The small size of many scan sites constrained us from using Kreutzer's (1992) method for area determination, and would have been of dubious accuracy following the procedure of cross-sectional estimation outline above. We also chose not to follow the alternative method which uses BT to norm all the results to a square or rectangle (Lyman 1984), as this procedure would have further underestimated the already low bone mineral values. Instead, we computed area by assigning each scan site a geometric shape (e.g. circle, rectangle, trapezoid, triangle) that most closely approximated its profile. As above, we refer to these measurements as "shape-adjusted" (VD_{SA} = Shape-adjusted Volume Density). In order to facilitate comparison with results from previous studies, we present a second set of calculations in which areas are normed to a square or rectangular shape, through dividing BMD by BT ($VD_{LD/BT}$ = Volume Density derived by dividing LD {BMD} by BT). All measurements were made with a sliding digital caliper. The effect of different area computations on final results are explored below.

Results and Discussion

The Volume Density (VD) assays of 60 selected scan sites from six skeletons representing the four leporid taxa are presented in Table 5. A fifth column in the table displays averaged measures for all leporid taxa combined, and a sixth displays accompanying rank orders for each mean value. Values for both methods of cross-sectional area computation (VD_{SA} and $VD_{LD/BT}$) are presented. The data should be viewed as provisional, due to the small number of skeletons examined and the potentially great range of individual variation within each taxon. For example, although significant and positively correlated, the two specimens of *O. cuniculus* have lower Pearson's *r* values (r=0.763, P<0.001) than similar intra-familial comparisons. This small sample suggests the possibility that intraspecific variation can be greater than interspecific variation, particularly as they are domesticated animals which could exhibit potentially extreme variation. It is, however, important to note that all combinations of comparisons between the separate taxa are both significantly and positively correlated (Table 6, and compare with Table 7 which lists correlations computing $VD_{LD/BT}$). Although each correlation is high, it is not surprising that the lowest correlation values involve comparisons between *L. californicus* and all three remaining taxa. The *L. californicus* specimen is obviously immature, and a perusal of Table 5 shows that much of this difference is a factor of lower VD assays of scan sites concentrated throughout the mandible, as well as the slender and unfused distal portions of the ulna.

The data appear to suggest some major differences between the structural density of leporid skeletal elements and those of marmots (Lyman et al. 1992), the only other comparably-sized mammalian taxa for which data are available. Intra-familialy, leporid and marmot density assays are strongly and positively correlated; however, inter-familial comparisons reveal relatively weak and negative correlations in all conceivable permutations. This general pattern appears to be consistent despite which method of cross-sectional areal computation is used. Throughout the skeleton, marmot VD assays are generally greater than their leporid counterparts. We believe that these differences reflect structural differences between very dissimilar taxa, and are not simply

Table 5. Volume Density Assays of Selected Leporid Scan Sites (g/cm^3).

Scan Site		*O. cuniculus*	*S. floridanus*	*L. canadensis*	*L. californicus*	LEPORID MEAN	RANK
AC1	VD_{SA}	0.42	0.39	0.43	0.32	0.39	6
	$VD_{LD/BT}$	_0.08_	_0.08_	_0.08_	_0.05_	_0.07_	_26_
AS1	VD_{SA}	0.28	0.26	0.23	0.19	0.24	30
	$VD_{LD/BT}$	_0.1_	_0.08_	_0.06_	_0.05_	_0.07_	_30_
AT1	VD_{SA}	0.33	0.11	0.24	0.14	0.21	31
	$VD_{LD/BT}$	_0.07_	_0.02_	_0.05_	_0.03_	_0.04_	_50_
AX1	VD_{SA}	0.46*	0.36	0.32	0.27	0.35	12
	$VD_{LD/BT}$	_0.55*_	_0.06_	_0.13_	_0.05_	_0.2_	_3_
CA1	VD_{SA}	0.2	0.27	0.3	0.26	0.26	27
	$VD_{LD/BT}$	_0.09*_	_0.12_	_0.12_	_0.11_	_0.11_	_8_
CA2	VD_{SA}	0.34	0.35	0.4	0.43	0.38	8
	$VD_{LD/BT}$	_0.08_	_ND_	_ND_	_ND_	_0.08_	_19_
DN1	VD_{SA}	0.43	0.37	0.51	0.22	0.38	7
	$VD_{LD/BT}$	_0.19_	_0.18_	_0.2_	_0.09_	_0.16_	_4_
DN2	VD_{SA}	0.74	0.58	0.7	0.38	0.6	1
	$VD_{LD/BT}$	_0.22_	_0.24_	_0.24_	_0.15_	_0.22_	_2_
DN3	VD_{SA}	0.28	0.36	0.3	0.13	0.27	24
	$VD_{LD/BT}$	_0.07*_	_ND_	_ND_	_ND_	_0.07_	_27_
DN4	VD_{SA}	0.22	0.06	0.21	0.08	0.14	37
	$VD_{LD/BT}$	_0.07*_	_ND_	_ND_	_ND_	_0.07_	_33_
DN5	VD_{SA}	0.14	0.03	0.12	0.08	0.09	48
	$VD_{LD/BT}$	_0.12_	_0.03_	_0.08_	_0.07_	_0.07_	_25_
FE1	VD_{SA}	0.26	0.31	0.28	0.27	0.28	19
	$VD_{LD/BT}$	_0.08_	_0.1_	_0.07_	_0.08_	_0.08_	_18_

Table 5. Volume Density Assays of Selected Leporid Scan Sites (g/cm^3), continued.

Scan Site		*O. cuniculus*	*S. floridanus*	*L. canadensis*	*L. californicus*	LEPORID MEAN	RANK
FE2	VD_{SA}	0.28	0.29	0.3	0.23	0.28	20
	$VD_{LD/BT}$	0.07	0.08	0.08	0.06	0.07	29
FE3	VD_{SA}	0.41	0.42	0.3	0.33	0.37	10
	$VD_{LD/BT}$	0.09	0.13	0.78	0.09	0.27	1
FE4	VD_{SA}	0.39	0.34	0.25	0.33	0.33	14
	$VD_{LD/BT}$	0.13	0.14	0.07	0.11	0.11	9
FE5	VD_{SA}	0.26	0.33	0.28	0.26	0.28	21
	$VD_{LD/BT}$	0.06*	0.08*	0.07	ND	0.07	34
FE6	VD_{SA}	0.63	0.54	0.59	0.54	0.58	2
	$VD_{LD/BT}$	0.09*	0.08*	ND	ND	0.09	17
HU1	VD_{SA}	0.43	0.46	0.49	0.45	0.46	4
	$VD_{LD/BT}$	0.06	0.07	0.07	0.06	0.07	38
HU2	VD_{SA}	0.25	0.3	0.28	0.22	0.26	28
	$VD_{LD/BT}$	0.05	0.1	0.07	0.05	0.07	35
HU3	VD_{SA}	0.34	0.23	0.24	0.17	0.25	29
	$VD_{LD/BT}$	0.13	0.12	0.08	0.07	0.1	13
HU4	VD_{SA}	0.4	0.26	0.23	0.2	0.27	23
	$VD_{LD/BT}$	0.15	0.13	0.09	0.09	0.11	7
HU5	VD_{SA}	0.4	0.37	0.37	0.32	0.37	9
	$VD_{LD/BT}$	0.11	0.11	0.1	0.09	0.1	10
IL1	VD_{SA}	0.38	0.28	0.26	0.21	0.28	22
	$VD_{LD/BT}$	0.21	0.15	0.06	0.04	0.11	6
IL2	VD_{SA}	0.45	0.35	0.29	0.32	0.35	13
	$VD_{LD/BT}$	0.14	0.15	0.09	0.12	0.12	5

Table 5. Volume Density Assays of Selected Leporid Scan Sites (g/cm^3), continued.

Scan Site		*O. cuniculus*	*S. floridanus*	*L. canadensis*	*L. californicus*	LEPORID MEAN	RANK
IS1	VD_{SA}	0.17	0.24	0.16	0.14	0.18	32
	$VD_{LD/BT}$	0.06	0.12	0.06	0.06	0.07	24
IS2	VD_{SA}	0.37	0.27	0.28	0.32	0.31	16
	$VD_{LD/BT}$	0.12	0.09	0.07	0.11	0.1	11
LU1	VD_{SA}	0.35	0.35	0.31	0.18	0.3	17
	$VD_{LD/BT}$	0.06	0.06	0.05	0.03	0.05	46
MC1	VD_{SA}	0.12	0.05*	0.07	0.11	0.09	47
	$VD_{LD/BT}$	0.06	0.05*	0.06	0.06	0.06	43
MC2	VD_{SA}	0.13	0.07	0.09	0.13	0.11	42
	$VD_{LD/BT}$	0.1	0.05	0.05	0.08	0.07	28
MT1	VD_{SA}	0.11*	0.1*	0.17	0.13	0.13	39
	$VD_{LD/BT}$	0.03*	0.04*	0.05	0.06	0.04	47
MT2	VD_{SA}	0.06*	0.06*	0.1	0.1	0.08	49
	$VD_{LD/BT}$	0.04*	0.05*	0.07	0.07	0.06	42
MT3	VD_{SA}	0.12*	0.11	0.15	0.09	0.12	40
	$VD_{LD/BT}$	0.07	0.06	0.07	0.03	0.06	41
PA1	VD_{SA}	0.25*	0.07*	0.04	0.07	0.11	43
	$VD_{LD/BT}$	0.14*	0.04*	0.04	0.04	0.07	37
PH1	VD_{SA}	0.1	0.02*	0.05	0.04	0.05	55
	$VD_{LD/BT}$	0.07	0.01*	0.05	0.03	0.04	51
PH2	VD_{SA}	0.08	0.01*	0.03	0.01	0.03	59
	$VD_{LD/BT}$	0.07	0.01*	0.02	0.01	0.03	55
PU1	VD_{SA}	0.17	0.04	0.08	0.09	0.1	46
	$VD_{LD/BT}$	0.07	0.02	0.04	0.04	0.04	48

Table 5. Volume Density Assays of Selected Leporid Scan Sites (g/cm^3), continued.

Scan Site		_O. cuniculus_	_S. floridanus_	_L. canadensis_	_L. californicus_	LEPORID MEAN	RANK
RA1	VD_{SA}	0.14*	0.11*	0.2	0.18	0.16	35
	$VD_{LD/BT}$	_0.04*_	_0.06*_	_0.1_	_0.06_	_0.07_	_36_
RA2	VD_{SA}	0.14*	0.07*	0.11	0.12	0.11	44
	$VD_{LD/BT}$	_0.06*_	_0.05*_	_0.06_	_0.06_	_0.06_	_40_
RA3	VD_{SA}	0.13*	0.07*	0.13	0.15	0.12	41
	$VD_{LD/BT}$	_0.09*_	_0.06*_	_0.08_	_0.1_	_0.08_	_21_
RA4	VD_{SA}	0.12*	0.09*	0.09	0.21	0.13	38
	$VD_{LD/BT}$	_0.05*_	_0.05*_	_0.04_	_0.1_	_0.06_	_39_
RA5	VD_{SA}	0.11*	0.08*	0.12	0.28	0.15	36
	$VD_{LD/BT}$	_0.04*_	_0.04*_	_0.06_	_0.07_	_0.05_	_44_
RI1	VD_{SA}	0.04	0.04	0.03	0.05	0.04	57
	$VD_{LD/BT}$	_0.04_	_0.05_	_0.04_	_0.06_	_0.05_	_45_
RI2	VD_{SA}	0.06	0.08	0.06	0.07	0.07	50
	$VD_{LD/BT}$	_0.04_	_0.05_	_0.05_	_0.04_	_0.04_	_49_
RI3	VD_{SA}	0.07	0.04	0.01	0.04	0.04	58
	$VD_{LD/BT}$	_0.04_	_0.03_	_0.01_	_0.02_	_0.02_	_56_
RI4	VD_{SA}	0.05	0.04	0.05	0.01	0.04	56
	$VD_{LD/BT}$	_0.08_	_0.03_	_0.04_	_0.01_	_0.04_	_52_
RI5	VD_{SA}	0.01	0.01	0.03	0.01	0.02	60
	$VD_{LD/BT}$	_0.01_	_0.02_	_0.04_	_0.01_	_0.02_	_58_
SC1	VD_{SA}	0.43	0.42	0.36	0.23	0.36	11
	$VD_{LD/BT}$	_0.09_	_0.12_	_0.07_	_0.04_	_0.08_	_20_
SP1	VD_{SA}	0.33	0.28	0.23	0.24	0.27	26
	$VD_{LD/BT}$	_0.07_	_0.08_	_0.06_	_0.15_	_0.09_	_14_

Table 5. Volume Density Assays of Selected Leporid Scan Sites (g/cm^3), continued.

Scan Site		*O. cuniculus*	*S. floridanus*	*L. canadensis*	*L. californicus*	LEPORID MEAN	RANK
SP2	VD_{SA}	0.13	0.07	0.12	0.07	0.1	45
	$VD_{LD/BT}$	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
SP3	VD_{SA}	0.09	0.04	0.07	0.05	0.07	51
	$VD_{LD/BT}$	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
ST1	VD_{SA}	0.07	0.05*	ND	0.05	0.06	53
	$VD_{LD/BT}$	*0.03*	*0.02**	*ND*	*0.01*	*0.02*	*57*
TI1	VD_{SA}	0.54	0.6	0.63	0.45	0.56	3
	$VD_{LD/BT}$	*0.09*	*0.08*	*0.08*	*0.06*	*0.08*	*23*
TI2	VD_{SA}	0.33	0.33	0.32	0.28	0.32	15
	$VD_{LD/BT}$	*0.09*	*0.1*	*0.08*	*0.09*	*0.09*	*16*
TI3	VD_{SA}	0.3	0.33	0.25	0.31	0.3	18
	$VD_{LD/BT}$	*0.1*	*0.12*	*0.08*	*0.1*	*0.1*	*12*
TI4	VD_{SA}	0.26	0.28	0.21	0.31	0.27	25
	$VD_{LD/BT}$	*0.06*	*0.08*	*0.05*	*0.09*	*0.07*	*31*
TI5	VD_{SA}	0.44	0.42	0.43	0.43	0.43	5
	$VD_{LD/BT}$	*0.06*	*0.08*	*0.07*	*0.06*	*0.07*	*32*
UL1	VD_{SA}	0.2	0.16	0.13	0.16	0.16	34
	$VD_{LD/BT}$	*0.09*	*0.08*	*0.06*	*0.08*	*0.08*	*22*
UL2	VD_{SA}	0.23	0.19	0.14	0.14	0.18	33
	$VD_{LD/BT}$	*0.12*	*0.12*	*0.06*	*0.07*	*0.09*	*15*
UL3	VD_{SA}	0.12*	0.11*	0.02	0.001	0.06	52
	$VD_{LD/BT}$	*0.03**	*0.07**	*0.01*	*0.00*	*0.03*	*56*
UL4	VD_{SA}	0.14*	0.06*	0.06	0.001	0.06	54
	$VD_{LD/BT}$	*0.06*	*0.04*	*0.04*	*0.00*	*0.04*	*53*

Table 5. Volume Density Assays of Selected Leporid Scan Sites (g/cm^3), continued.

Density values (VD_{SA} = Shape-adjusted Volume Density, $VD_{LD/BT}$ = Volume Density derived by dividing LD {BMD} by BT) listed for *O. cuniculus* and *S. floridanus* are averaged values from two individual skeletons for each taxon, except where unavailable and noted by an asterix. For purpose of presentation, most values are rounded to two decimal places; however, exact values were used in all computations. Rank values are listed for the averaged value of each leporid scan site.

Table 6. Correlation of volume density assays (VD_{SA} = Shape-adjusted Volume Density) between four leporid and two *Marmota* taxa. Pearson r values with sample sizes shown in parentheses, all p<.001 except where otherwise indicated. *Marmota* data from Lyman et al. (1992).

	O. cuniculus	*S. floridanus*	*L. canadensis*	*L. californicus*
O. cuniculus	*	0.9162 (60)	0.9116 (59)	0.8192 (60)
S. floridanus	0.9162 (60)	*	0.9329 (59)	0.8751 (60)
L. canadensis	0.9116 (59)	0.9329 (59)	*	0.8559 (59)
L. californicus	0.8192 (60)	0.8751 (60)	0.8559 (60)	*

Table 7. Correlation of volume density assays ($VD_{LD/BT}$ = Volume Density derived by dividing LD {BMD} by BT) between four leporid and two *Marmota* taxa. Pearson r values with sample sizes shown in parentheses, all p<.001 except where otherwise indicated. *Marmota* data from Lyman et al. (1992).

	O. cuniculus	*S. floridanus*	*L. canadensis*	*L. californicus*
O. cuniculus	*	0.3781 (55)p=.0044	0.1984 (53)p=.1545	0.0483 (53)p=.1078
S. floridanus	0.3781 (55)p=.0044	*	0.4059 (53)p=.0026	0.6371 (53)
L. canadensis	0.1984 (53)p=.1545	0.4059 (53)p=.0026	*	0.2945 (52)p=.0340
L. californicus	0.2234 (53)p=.1078	0.6371 (53)	0.2945 (52)p=.0340	* (47) p=.8627

related to procedural or analytical differences. The majority of high-density leporid scan sites tends to be concentrated in the hind limbs of the body, particularly the femur and tibia. Marmots have an equal amount of high-density sites in the fore and hind portions, with decidedly dense forelimbs and clavicles. The least-dense scan sites of leporids are located in the forelimbs and ribs, whereas half of the least-dense marmot sites are located in the hind portions of the appendicular skeleton. A pattern of high/low density in hind/fore portions of leporids, and high/low density in fore/hind portions of marmots is further supported when the sample is expanded to the 20 most-dense and 20 least-dense scan sites. This expanded sample includes virtually the entire femur and tibia as high density elements, and more scapular, radial and rib sites as low density areas in leporids. More pelvic, phalangeal and rib sites would be included as high density, with femoral, tibial, and pelvic sites as low density areas in the marmot skeleton. If we substitute the leporid $VD_{LD/BT}$ estimates, certain rank orders are rearranged with a few new sites included; however, the basic pattern of high/low density in hind/fore portions remains. We suggest that this pattern is accounted for by the primarily fossorial activities of marmots which place high stress on forelimb elements, in contrast to the terrestrial ricochetal locomotion of leporids which places high stress on hindlimb elements (Pavao and Stahl 1998).

We are currently exploring the implications of these density values for taphonomic applications (Pavao and Stahl 1998). Furthermore, the leporid structural density assays have already been applied in zooarchaeological and taphonomic analyses of archaeofaunal remains from sites in the desert southwest (Quirt-Booth and Cruz-Uribe 1997; Stahl 1997) and in the American southeast (Pavao 1998).

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