To the Graduate Council:

I am submitting herewith a thesis written by Deborah Lenz Cornell entitled "The Morphometric Relationship of Upper Cave 101 and 103 to modern *Homo sapiens*." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

Andrew Kramer, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor and
Dean of The Graduate School

THE MORPHOMETRIC RELATIONSHIP OF UPPER CAVE 101 AND 103 TO MODERN *HOMO SAPIENS*

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ABSTRACT

Upper Cave 101 and Upper Cave 103 (UC 101 and UC 103), the much argued over *Homo sapiens* fossils from Zhoukoudian, China, figure prominently into discussions of modern human origins. Adherents to the Multiregional model see the Zhoukoudian fossils as exhibiting some of the same Asian characteristics that can be seen in modern Asian populations. On the other hand, proponents of the Out-of-Africa model see anything and everything but Asian features, frequently pointing out African characteristics which they claim are retentions of features from the initial exodus of modern humans.

UC 101 and UC 103 were compared to Howells' modern human groups and unpublished measurements of Paleoindian and Archaic Indian crania using unweighted, unrestricted canonical variate analysis (CVA) and associated Mahalanobis Distance Analysis. Results indicate that it is unlikely that these two fossils represent the same population, however the archaeological context seems to preclude any such inference. If UC 101 and UC 103 are from the same contemporaneous group, it may be inferred that ancient East Asians exhibit much more variation than modern populations, an idea postulated by Franz Weidenreich in the late 1930s.

These two fossils likely represent the robust ancestors of several modern, more homogenous groups. While UC 101 is classified as Easter Island in the Distance Analysis, its similarities to European, Eskimo, African, and Archaic Indian populations can be seen in the CVA plots. It also shows some similarities to Peru and Buriat populations. UC 103, on the other hand, is much more of an outlier to modern populations. Although the

CVA allies this fossil most closely with Archaic Indians, the Lime Creek Paleoindian, and Easter Island, the Distance Analysis consistently classifies it as Australo-Melanesian. However, UC 103's position as an outlier, combined with its extremely low typicality probabilities, indicates that this specimen is outside the range of variation present in the modern populations utilized.

No overriding support for either school of modern human origins is found. The time depth involved between the postulated exodus of modern humans from Africa 200 ka and the reliably dated 29 to 24 ka Upper Cave fossils disallows any African morphological similarities to be interpreted as lending support to the Out-of-Africa model. On the other hand, the findings presented here also give no strong support to the Multiregional school since no close affiliation is seen between these two fossils and modern East Asians. However, if the fossils are truly contemporaneous, the Pleistocene population of East Asia was much more heterogeneous than today's populations, leaving open the very real possibility that the Zhoukoudian fossils are actually ancestral to modern East Asians. The morphological variability present in the Asian Pleistocene needs to be fully appreciated in order to adequately assess Pleistocene hominid fossil affinities.

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CHAPTER I
LITERATURE REVIEW

Introduction

Upper Cave 101 (UC 101), the 25,000 year old *Homo sapiens*, frequently called the "Old Man", is, according to Howells (1995:43), "everyone's problem skull". Discovered in 1933 by Bei (Pei) at Upper Cave, or Shandingdong, a burial cave at Zhoukoudian in North China, the Old Man is considerably larger and more robust than the people presently living in East Asia. Also found with this fossil were the remains of at least six other individuals, including two other complete skulls (UC 102 and UC 103; two probable young women). These specimens have not been studied as extensively as the Old Man because of cranial deformation and fragmentation, especially of UC 102. UC 103, however, has some protrusion of the vault along the coronal suture due to taphonomic factors but it is not severe enough to significantly affect the measurements utilized in this study.

Much discourse as to the biological affinity of the Old Man has filled the pages of professional journals. Various researchers have classified UC 101 as closest to Tolais and Australians, Jomon-Pacific groups, and North/East Amerind groups. It has also been called pre-Mongoloid, Mongolian, Polynesian, and Arikara. The main contenders in this discourse are generally the metrists versus the morphologists. Metrists tend to classify the Old Man as everything but Asian while the morphologists are inclined to categorize him as Asian. The implications of these classifications to the two main schools of modern human origins, Multiregionalism and Out-of-Africa, are manifest.

Multiregionalism basically postulates that there is considerable genetic and morphological continuity between the first inhabitants of Eurasia, *Homo erectus,* and modern human populations. Continuity is the key word here, e.g., traits present in Asian *Homo erectus* and Asian archaic *Homo sapiens* should be present in modern Asians. The Out-of-Africa model, on the other hand, stresses replacement as its key word. Defenders of this model argue that modern humans appeared in Africa first and spread to Eurasia about 200,000 years ago (ka), replacing the indigenous *Homo erectus* populations that left Africa previously.

The Zhoukoudian fossils, especially UC 101, have traditionally played an important role in arguments about modern human origins. Adherents to the Multiregional model see the fossils as exhibiting some of the same Asian characteristics that can be seen in modern Asian populations, while proponents of the Out-of-Africa model see anything and everything but Asian features. They frequently see African characteristics, and some have claimed that these point to a retention of African features from the exodus of the modern humans. This will be discussed in more detail in Chapter V.

The fossils were compared to modern human groups using unweighted, unrestricted canonical variate analysis, a new approach to dealing with UC 101 and UC 103. I have included in my analysis several unpublished measurements of Paleoindian and Archaic Indian crania, another novel approach (but see Neves and Pucciarelli, 1998). I believe that the analyses performed in this thesis contribute to our understanding of Pleistocene Asian populations.

The following literature review discusses the discovery and excavation of the Upper Cave at Zhoukoudian in North China, the mysterious disappearance of the fossils found there, historical interpretations of the fossils, their chronology, and some current interpretations of their affinities.

Discovery and excavation of the Upper Cave at Zhoukoudian

The Zhoukoudian site in North China consists of several caves, called localities, that are congregated in the hills near the town of Zhoukoudian, located about 50 kilometers southwest of Beijing. Typically, the site is discussed in terms of its "Lower Cave" and its "Upper Cave". In 1921, acting on a tip from a local citizen, Johan Gunnar Andersson, Director of the Geological Survey of Sweden, Otto Zdansky, an Austrian paleontologist, and Walter Granger, an American paleontologist, discovered the Lower Cave (Jia and Huang, 1990). It was occupied 600-400 thousand years ago (ka) by members of the hominid species *Homo erectus* (Wolpoff, 1996) (called "Sinanthropus pekinensis" by the initial excavators), while the Upper Cave (also known as Shandingdong), discovered in 1930 by W. C. Bei (Bei, 1934; 1939), was occupied by hominids during the late Upper Pleistocene. The Upper Cave contained the remains of the fully modern *Homo sapiens* fossils that are the focus of this thesis. It is worth mentioning, however, that at Locality 1 in the Lower Cave, there are 40 meters of excavated deposits that have yielded the remains of more than 45 individual members of *Homo erectus* (Wolpoff, 1996).

Bei, an initial excavator of the Lower Cave, discovered the northerly facing Upper Cave while trying to find the southern extent of the *Homo erectus* deposits on the top of the hill over Lower Cave Locality 1. The gray breccia fill of the Upper Cave contrasted with the red, hard "Sinanthropus" beds, and was separated from those beds by a thick stalagmitic floor. Furthermore, the fossil material from the Upper Cave appeared less mineralized than material from the Lower Cave, suggesting to him a younger age (Bei, 1934; 1939).

Bei was not able to investigate the Upper Cave fully until the field season of 1933. He subdivides the cave into an "entrance", "upper room", "lower room", and "lower recess". Figure 1.1 shows a reproduction of his diagrammatic map of Upper Cave (Bei 1934:330; 1939:9).

Although Bei (1939) initially believed the Upper Cave deposits would be young and uninspiring, he writes that "On May 20th, 1933, we started a systematic excavation in the Upper Cave which turned out to be much richer and more interesting than we expected" (Bei, 1934:317). However, it was not until the field season of 1934 while working in the lower recess of the cave that he discovered cultural layers including four human skulls (three of them mostly complete), assorted human cranial and postcranial fragments, and numerous animal remains and archaeological materials. Table 1.1 details Bei's (1934:332-333; 1939:11) description of the cultural layers of Shandingdong.

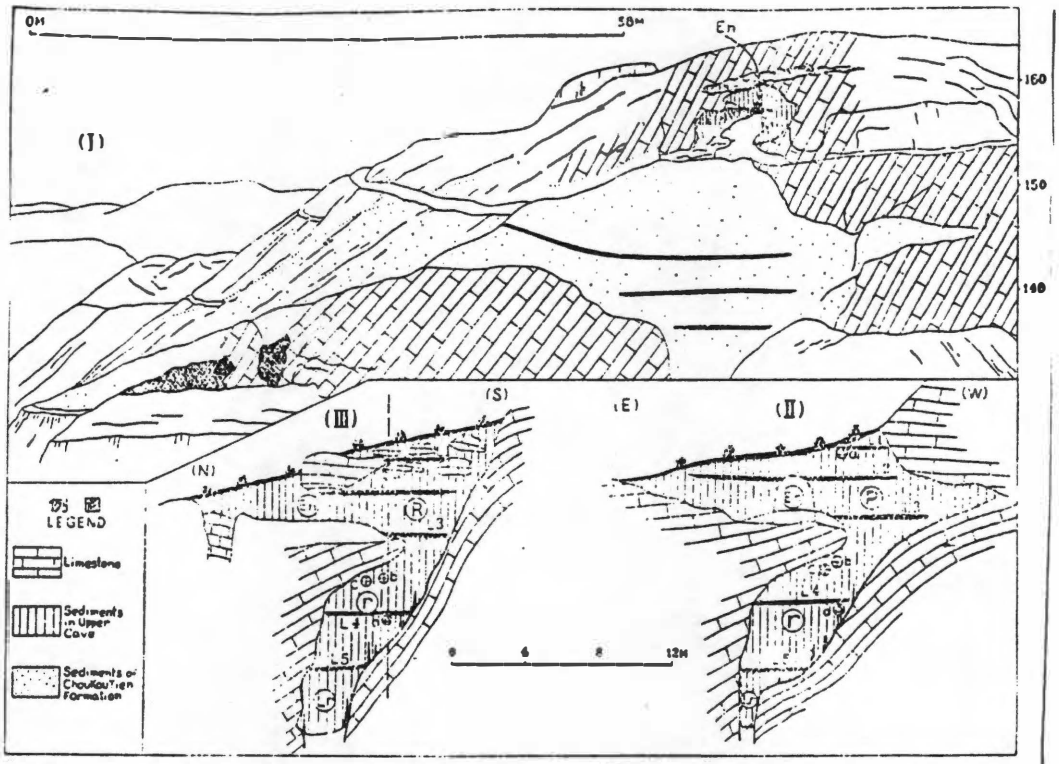


Fig. 1. (I) Diagrammatic section of Choukoutien Loc. 1 hill, sighted from the north, showing the position of the Upper Cave (vertical lines); En, entrance of Upper Cave.
(II) East-west composed section of the Upper Cave.
(III) North-south composed section of the Upper Cave.
En, Entrance; L1-L5, Cultural layers;
R, Upper room; a, Bone needle;
r, Lower room; b & c, Human skulls;
Lr, Lower recess; d, Perforated marine shell.

Figure 1.1: Bei's Map of the Upper Cave
Reprinted from Bei (p. 9, fig. 1)
[Bei W (1939) The Upper Cave industry of Choukoutien. Palaeontologia Sinica (Series D), *9:*1-41.]

TABLE 1.1: Bei's Description of the Upper Cave

LAYER	DESCRIPTION	CULTURAL ITEMS FOUND
1	30 cm thick, 3 m above the floor, near the entrance	"A few human bones, a perforated tooth, two flint implements"
2	Subdivided into several thin beds, located 1 m above the floor of the upper room	" A few human bones, and 28 perforated teeth (canines of fox or badger)"
3	Black, thick (up to 60 cm.), located at the bottom of the upper room	"Very few cultural remains, but clear traces of human occupation: the stalagmitic floor and the limestone are burnt"
4	3 m (Bei, 1934) or 5 m (Bei, 1939) above the floor of the lower room	Isolated human teeth, perforated tooth pendants, a chert flake[1]
5	On the floor of the lower room	Isolated human teeth, perforated tooth pendants, a chert flake[1]

[1]Bei (1934; 1939) does not clarify whether the chert flake was found in Layer 4 or 5.

Bei (1934; 1939) writes that it was just above Layers 4 and 5 that he found the three complete human skulls and other assorted human bones. No human or cultural remains were found in the lower recess of the cave; however numerous animal bones were present there (a detailed description of the fauna can be found in Bei, 1934). He believes that Shandingdong was a burial cave that was disturbed by carnivores rather than a dwelling place because "In spite of several cultural layers. . . it does not seem that Man lived there in a protracted way: ashy layers rather thin, practically no traces of workshop" (Bei, 1939:12). He further argues that it was a burial cave because of 1) the presence of hematite on the skulls (a substance commonly spread over the dead during the Paleolithic), 2) the ornamental objects associated with the human remains, and 3) the fact that some of the postcrania were still connected as they would have been in life (Bei, 1939).

The disappearance of the fossils

While the devastating effects of war are most acutely felt by those who die and the families they leave behind, science is also detrimentally affected by each invasion, bombing, and land mining operation. Invading armies have traditionally ransacked museums, taking the booty home with them for profit and prestige. And with each bomb dropped, or each piece of land torn apart by mines, potential and actual archaeological sites and artifacts are destroyed. Unfortunately, during World War II, the fossils from both the Upper and Lower Caves at Zhoukoudian fell victim to the scourge of war.

The story of the disappearance of the Zhoukoudian fossils begins with the founding of the Cenozoic Research Laboratory. Realizing that the initial funds from the Rockefeller Foundation, an American institution that supplied much of the monies for the Zhoukoudian project until 1928, were to be exhausted by March of 1929, Davidson Black, Weng Wenhao, and Ding Wenjiang, three scientists involved in the project from the beginning, formulated a more extensive, three and one half year plan for further excavation. This new scheme involved a collaboration between the Geological Survey of China and the Peking Union Medical College (PUMC). The three authorities agreed it was necessary to found a "truly 'Chinese' institution" in order to implement the plans for the continuation of the Zhoukoudian excavation once the initial funds ran out (Jia and Huang, 1990:52). The scientists managed to secure further funding from the Rockefeller Institution that would be managed by the new establishment. This institution was called the Cenozoic Research Laboratory, and was the precursor to the institute of Vertebrate

Paleontology and Paleoanthropology of the Chinese Academy of Sciences. The constitution of the Laboratory states that "All material collected shall entirely belong to the Geological Survey of China, including the anthropological specimens which will temporarily be deposited in the Peking Union Medical College for study. . . Nothing shall be exported out of China" (Jia and Huang, 1990:53).

In 1937, the Zhoukoudian excavations were halted due to the impending Japanese threat (Janus and Brashler, 1975). The Japanese already occupied much of mainland China and were advancing toward Peking (Beijing). However, authorities still believed the PUMC labs were safe. Janus and Brashler (1975) provide two possible explanations for this assumption: (1) the PUMC was an American-supported establishment, and (2) the United States was not yet at war with the Japanese. However, they also point out that Weidenreich was becoming apprehensive about the safety of the fossils in light of the Japanese threat (Janus and Brashler, 1975). Three plans were discussed to ensure the safety of the *Sinanthropus* and *Homo* fossils: hide them in a vault, either at PUMC or somewhere else in Peking; ship them to a peaceful part of China; or ship them out of the country (Shapiro, 1974; Janus and Brashler, 1975). Although Weidenreich was in favor of the third option, the Rockefeller Foundation and the United States Embassy in Peking were unwilling to breach the agreement they had with the Chinese, which disallowed the removal of fossils from the country (Janus and Brashler, 1975).

According to Janus and Brashler (1975), it was in 1941, after spending fourteen years at the Cenozoic Laboratory, that Weidenreich, unable to ignore the Japanese menace

any longer, departed China for the American Museum of Natural History in New York. He took with him casts, photographs, and drawings of all the "Sinanthropus" and *Homo* specimens (Shapiro, 1974). Claire Taschdjian, a laboratory assistant and translator who helped make casts of the fossils, as well as photograph and describe them, was left behind at the Cenozoic Laboratory. In late November of the same year, the Chinese government decided to allow the fossils to be removed from the country. According to Janus and Brashler (1975), Taschdjian was asked by the PUMC to prepare the specimens for transport. She inventoried them, wrapped them, placed them in small cardboard boxes, and packed the boxes in one of two redwood crates labeled "A" and "B". The "A" crate was for the *Sinanthropus* fossils from Lower Cave, and "B" was for the *Homo* fossils from Upper Cave. Additionally, "PUMC" was stenciled on the side of each crate. The crates were padlocked and moved to the college strongroom. The United States Marines were in charge of the fossils' safe passage. One week after Taschdjian packed the crates containing the specimens, a Marine gave her the two padlock keys and said casually that the mission had been accomplished. She did not question him further (Janus and Brashler, 1975).

Jia and Huang (1990) argue that Janus and Brashler (1975) are incorrect in stating that it was Taschdjian who packed the fossils for shipment and was the last known person to see them. They believe that it was two Chinese specialists, Hu Chengzhi and Ji Yanqing, who performed these tasks. Hu was the one who, at Weidenreich's request, made copies of all the fossils. According to a letter from Hu to Jia, published in Jia and

Huang (1990: 160-161), three months after Weidenreich had returned to the United States, Bei told Hu that the fossils were to be shipped away from the PUMC and that he was to await further instruction. It was two or three months later that Weidenreich's secretary (presumably Taschdjian) told Hu the fossils were to be boxed for shipment. After confirming this with Bei, Hu and Ji Yanqing wrapped and cushioned each specimen carefully, put them in small boxes, and put all the small boxes in two large unpainted wooden crates, which were delivered to the chief administrator of Controller T. Bowen's Office at PUMC. This is all that Hu knew definitively (Jia and Huang, 1990).

Janus and Brashler (1975) write that the crates were transferred, presumably by the United States Marines, from PUMC to the United States Marine Headquarters in Peking. Colonel William W. Ashurst, commander there, ordered that the contents of the crates be transported to regulation marine footlockers and placed under the supervision of Dr. William Foley, who was to return to the United States as soon as the North China marines vacated their country. The lockers, with Ashurst's name on them, were loaded onto a transport train and moved to Camp Holcomb, 140 miles from Peking in a port town called Tientsin (Janus and Brashler, 1975). They were to be loaded on the *S.S. President Harrison*, a passenger liner modified by the navy for wartime use (Shapiro, 1974; Janus and Brashler, 1975). The ship was due to land in Chinwangtao on December 11, 1941 in order to evacuate the North China marines from the mainland (Janus and Brashler, 1975). The vessel never made it; it was pursued by the Japanese and sunk near Manila (Shapiro, 1974).

A guard supervising the unloading of cargo from the transport train reported that he was approached by a Japanese army officer and a Japanese man dressed in civilian wear who quizzed him about the contents of the train. He refused to disclose any information and also declined to let them inspect the boxcars (Janus and Brashler, 1975).

Foley contacted Herman Davis, a Pharmacist's Mate Third Class, and told him to take charge of the footlockers on the train. Although Davis unloaded several lockers with Foley's name on them, he did not find any with Ashurst's name on them. Davis was captured by the Japanese on December 8, 1941, and was forced to leave all of Foley's footlockers behind in the barracks. Foley was taken prisoner shortly thereafter (Janus and Brashler, 1975).

On December 8, 1941, the PUMC was taken over by the Japanese (Shapiro, 1974). Both Taschdjian and Bei were questioned by the Japanese concerning the whereabouts of the fossils (Shapiro, 1974; Janus and Brashler, 1975). Taschdjian only reported that she was familiar with the fossils and could identify them if she saw them again (Janus and Brashler, 1975). Fortunately for Bei, he was not informed about the packing or shipping of the fossils (Shapiro, 1974).

Shapiro (1974) believes that the Japanese seized the Zhoukoudian fossils en route to Tientsin. Janus and Brashler (1975) make no mention of such a raid. However, Janus and Brashler (1975) write that before Foley was interned, he received most of his footlockers intact; missing only a few skulls he used as teaching aids. They also imply that Foley received the footlockers with Ashurst's name but did not open them (1975).

The disappearance of the Zhoukoudian fossils remains a mystery to this day. There have been several "false leads" but, if the fossils still exist, they remain hidden. The loss of the specimens has been devastating to paleoanthropology, but it is mitigated by the excellent casts, measurements, and descriptions of the original specimens that Weidenreich and his assistants were able to make.

Historical interpretations of the fossils

Although Bei gives complete descriptions of the fauna and archaeological materials discovered at Upper Cave (1934; 1939), his description of the human remains discovered there is lacking. Franz Weidenreich is credited with describing and interpreting the fossils from both the Upper and Lower Caves of Zhoukoudian (Weidenreich, 1938/39; 1939; Wolpoff, 1996). He (Weidenreich, 1938/39; 1939) writes that the human remains found at Shandingdong represent at least seven individuals. He describes them as three juveniles: a newborn or fetus, a child of approximately 5 years old, an adolescent aged between 15 and 20, and four adults: one young male, two probable women in their early twenties (UC 102 and UC 103), and an old man that Weidenreich estimated to have been at least 60 years old when he died (UC 101, a/k/a "the Old Man") (1938/39; 1939). UC 101, 102, and 103 are the only complete skulls. While most (Weidenreich, 1938/39; Wu, 1956; Kamminga and Wright, 1988; Kamminga, 1992) believe UC 103 to be a young female, Wolpoff (1996) argues that the specimen represents a teenage boy. The additional four persons are represented by skull fragments, mandibles, and assorted postcrania (Weidenreich, 1938/39).

The cause of death of the seven individuals has been debated among scientists. Weidenreich (1938/39; 1939) believes that the three adult crania represented a family that died together suddenly, but Kamminga and Wright (1988:742) call this assessment "fanciful". Weidenreich (1938/39:163; 1939:38-40) writes that four of the skulls show

evidence of violence, and believes that dismemberment could have taken place. Coon (1962:473) concurs, calling it a "mass murder". However, Bei (1934; 1938/39) points to taphonomic factors such as burrowing animals that could have disturbed the bones, simulating dismemberment. He disagrees with Weidenreich's assertion of a violent death, citing the possibility of blocks of limestone falling on the bodies of the recently deceased, smashing the skulls (1939:38). Weidenreich (1938/39:162) was convinced that a funeral had taken place after the "family's" death because of the hematite that had apparently been sprinkled over the bodies (Bei, 1938/39; 1939). The debate over whether actual murders took place, or if taphonomic factors simulated violence, will probably never be resolved with absolute certainty.

In Weidenreich's (1938/1939) initial interpretations of the fossils, he describes UC 101 as "primitive Mongoloid", UC 102 as "Melanesoid", and UC 103 as "Eskimoid" racial types and explains that, although one might expect older populations to be more racially uniform, "man was split into different racial stems already in such an early stage of evolution as is represented by Sinanthropus and Pithecanthropus", thereby contradicting any assertions of the existence of "pure" races in the past (1938/1939:170-171).

The age of the fossils

Dating the remains has been problematic (Kamminga, 1992; Kamminga and Wright, 1988). Prior to 1992, the argument was basically over whether the age of the *Homo sapiens* fossils was 18 thousand years ago (ka) (Pleistocene) or 10 to 11 ka (terminal Pleistocene/early Holocene). Wu and Wang (1985) believe that the fossils are close to 18 ka (ZK-136-0[2]) (original dates in Sun, 1976 as cited in Kamminga and Wright, 1988). However, Kamminga, alone (1992) and with Wright (1988), argues that

the C-14 dates obtained in the 1970s by Sun (1976) cannot be trusted because the deer bone that was actually dated came from a lower level (5) than the fossils themselves (4). Later C-14 dates from animal bones yielded dates of approximately 10 to 11 ka. Kamminga (1992; and with Wright, 1988) tends to believe these dates over the older AMS ones. He argues that the animal bones used to obtain these dates are more trustworthy than the previous deer bone because they were recovered on field days that generally correspond to the field days the fossils were found. Also, these animal bones were recovered 50 - 100 cm. above the bone that yielded the 18 ka date. Kamminga (1992; and with Wright, 1988) concludes that the human remains date to the early Holocene or the terminal Pleistocene.

However, the most recent AMS dates from Hedges et al. (1992) furnish a range of 29 to 24 ka for the Zhoukoudian Upper Cave fossils. They contend that this chronology is more acceptable than the younger dates for two reasons. First of all, the Upper Cave crania, while considered fully modern *Homo sapiens*, are morphologically more primitive than later specimens found in China. "If one assumes that the evolutionary process which gradually transformed Upper Cave Man into *Homo sapiens sapiens* would have required quite a long period of time, then the much older AMS chronology is to be preferred over the conventional radiocarbon one" (Hedges et al., 1992:155). The second reason is an ecological one. Northern China was extremely cold from 19 to 11 ka, and had a much milder climate from 34 to 24 ka. The fauna contained in the Upper Cave contained the remains of temperate, rather than cold-adapted, animals. No mammoth or woolly

rhinoceros remains were recovered, although both animals were common in northern China during its colder periods. The 29 to 24 ka dates seem to be widely accepted today, with Wolpoff (1996) and Howells (1995) agreeing with this range.

The description and current interpretations of the fossils

UC 102 and UC 103 have not been studied as extensively as UC 101 because of cranial deformation and fairly extreme fragmentation (especially of UC 102). Those that have studied the Old Man extensively all seem to agree he is generally more robust than the people presently living in East Asia (e.g., Kamminga and Wright, 1988). The cranial vault is quite large, falling completely outside the range of size variation for Howells' modern *Homo sapiens* sample (Cornell and Jantz, 1997). The skull has a long, low cranial vault, a well developed supraorbital region, and rectangular, broad orbits. The nasal aperture has a guttered lower border, a moderate degree of alveolar prognathism is present, and the skull exhibits an occipital torus forming a low ridge on the cranium's posterior. The fossil has a strong mental eminence and a broad ascending ramus (Kamminga and Wright, 1988; Kamminga, 1992). Also, a faint manifestation of a mandibular torus is present, a feature which Weidenreich (1939:42) calls "very ancient and inherited". He argues that the presence of a mandibular torus is evidence of regional continuity because this feature is found in fifteen percent of modern Chinese (Weidenreich, 1939).

Much discourse as to the ethnic affinity of the Old Man has filled the pages of professional journals, with most of the recent research relying primarily on Howells' well known datasets (1973; 1989). The main contenders in this dialogue are Kamminga (1992), Wright (1995), and Kamminga and Wright (1988), of the "Replacement School" of human origins, and Wolpoff (1994; 1995; 1996), of the "Multiregional School" of human origins. In a nutshell, the proponents of Replacement generally classify the Old

Man as everything *but* Asian, while Wolpoff (1994; 1995; 1996) unwaveringly categorizes him as Asian.

Numerous metrical statistical studies have been performed on UC 101. Kamminga and Wright (1988) undertook various metrical analyses of the Old Man, using such well-known statistical tests as Principal Components Analysis (PCA), KMEANS, and Penrose Shape Analysis. In the PCA, the plot of the second and third principal components places UC 101 closest to the "taxonomically challenging" Ainu (Kamminga and Wright, 1988:749), with African and European populations close behind (Kamminga and Wright, 1988:751, fig. 3). Checking their results against a KMEANS test, Kamminga and Wright (1988) conclude that when their data are divided into two groups, UC 101 is included with African, Australo-Melanesian, and Easter Islander populations, but if the data are divided into three groups UC 101 is included with the Caucasoids and the problematic Ainu. The Penrose Shape Analysis included in their study also puts UC 101 with African, Australo-Melanesian, and Easter Island populations. Although they stress that in no circumstances does the Old Man cluster with Mongoloid populations, they fail to definitively state which ethnic population UC 101 seems most likely to belong to based on their myriad statistical tests.

In a later analysis using his multivariate computer program CRANID, Wright (1992) concludes that UC 101 has morphological similarities with African, Australian, and Melanesian crania. In a subsequent analysis (1995), using the Giles-Elliot (1962) discriminant functions, he classifies the Old Man as closest to Afro-American populations. Howells' (1989) C-score findings place UC 101 closest to Polynesian populations, while his DISPOP results (1995) place the skull closest to the Arikara. He thought that it was important to note that his DISPOP analysis using distances calculated from discriminant scores failed to replicate Wright's CRANID findings (Howells, 1995:44). Van Vark and

Dijkema (1988), using squared Mahalanobis distances, place UC 101 closest to South Australian, Norse, Ainu, North American Indian (Arikara and Santa Cruz), and Easter Island populations respectively, again finding no support for Mongoloid affinity. Two recent canonical discriminant analyses by Cornell and Jantz (1997; 1998) found that UC 101 was most similar to Polynesian (especially Easter Island), European, and Amerindian populations respectively, concluding that UC 101 is allied with the robust ancestors of Pacific and Amerindian populations present in East Asia 25 ka. Using PCA, Neves and Pucciarelli (1998) support this conclusion. In summary, the ethnic affiliation that the Old Man is most closely affiliated with seems to depend on which metrical statistical test is performed on the fossil.

Wolpoff (1996:723), using non-metric morphological analysis, believes that the Old Man is ethnically Mongoloid but does not resemble living Asian groups because the specimen exhibits many "archaic characteristics". He believes that UC 101 is from a racial stock from which some later Mongoloids, including Eskimos and Amerindians, evolved. Wu (1961) and Coon (1962) concur with a Mongoloid affinity of the Old Man.

Wolpoff (1995) discounts multivariate statistical analysis in general, his main point being that it is inappropriate to perform a discriminant function analysis on a specimen from a population not represented in the data upon which the function is based. Wolpoff (1995:186) believes that "a multivariate analysis of measurements is not an anatomical analysis" and that multivariate clustering of principal components does not mean morphological similarity. In a previous review article, Wolpoff (1994) also discounts Howells' (1973) data:

> William Howells's pioneering publications . . . [are] a series of measurements that have been very widely used in population analysis, even though their inadequacy was exposed in two aspects of Howells's ongoing work: (1) varying multivariate techniques sort his populations differently, and (2) the patterns of relationships for males and females invariably differ, often dramatically (1994:186).

Howells (1995), however, counters with:

> Wolpoff (1994) has made the mystifying assertion that my measurement set, and multivariate analyses, are exposed as inadequate, in part because 'the patterns of relationships for males and females invariably differ, often dramatically.' Quite the contrary; the most casual inspection of the figures and tables in *Skull Shapes* will demonstrate the close correspondence of the sexes in several independent analyses, and I remarked then that this close agreement was important in demonstrating the general reliability of the results (1995:7, footnote).

Summary

The extremely significant *Homo erectus* and *Homo sapiens* fossils discovered in the 1920s and 1930s at Zhoukoudian have greatly contributed to knowledge about hominid evolution in East Asia. The impact that their unfortunate disappearance had on paleoanthropology was assuaged because Franz Weidenreich was able to take casts of the fossils with him to the American Museum of Natural History when he fled China at the beginning of World War II. The ethnic affinities of the *Homo sapiens* fossils, dated to between 29 and 24 ka, have long been argued about. Historically, Weidenreich (1938/39; 1939), one of the first multiregionalists, believed the fossils indicated the antiquity of racial distinction. Since his first interpretations, researchers have constantly argued in the anthropological literature over whether he was correct or not. The research performed for this thesis will hopefully shed light on this important problem.

CHAPTER II
MATERIALS

Description of comparative samples

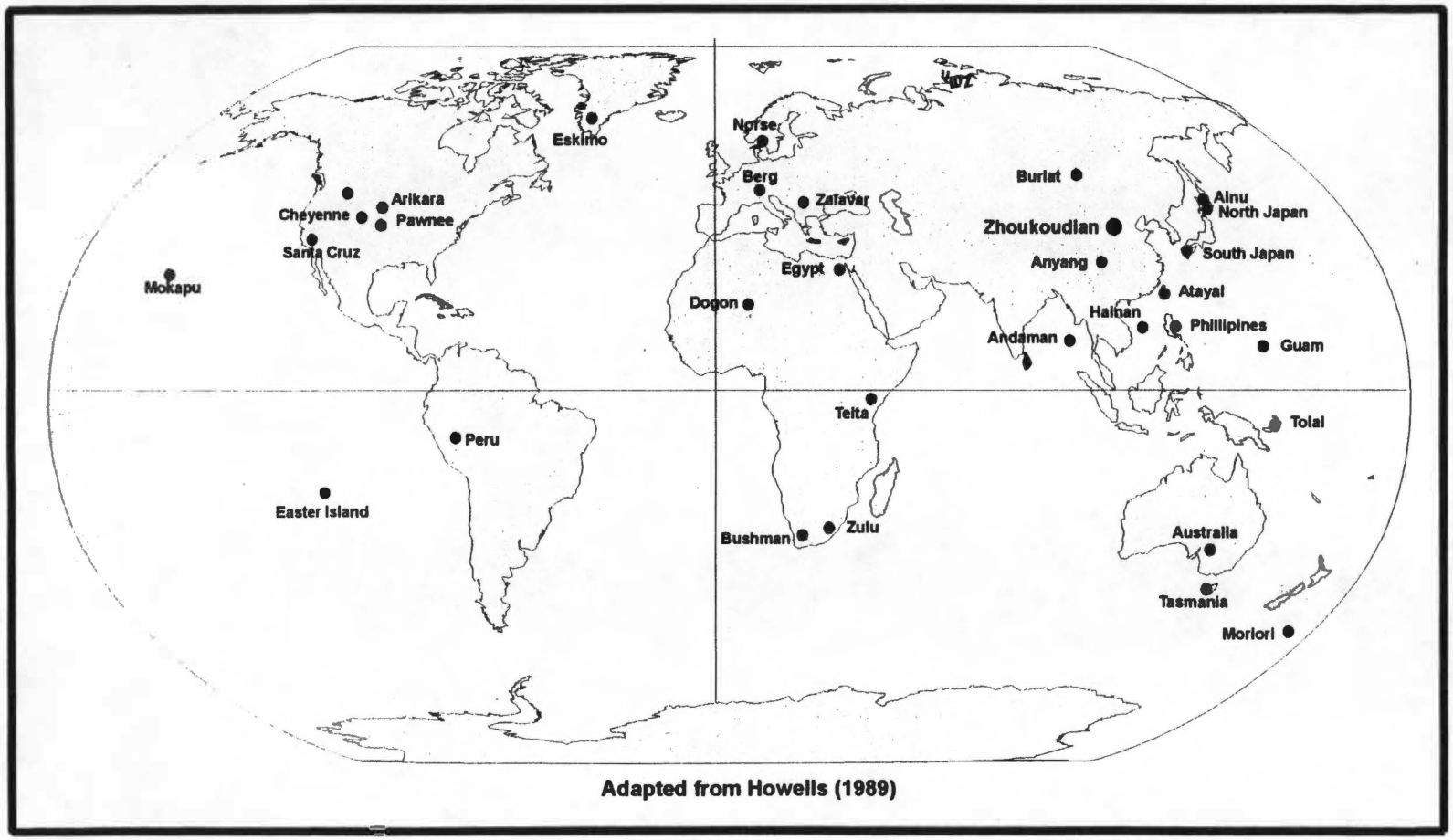
The Zhoukoudian *Homo sapiens* fossils have been associated with various populations by several researchers using a myriad of metric and non-metric techniques, as mentioned in Chapter I. Generally, only UC 101 and (occasionally) UC 103 are evaluated. UC 102 was cast in its unreconstructed form and is unusable for any serious analysis. Therefore, UC 101 and UC 103 are compared with a wide range of modern human cranial samples, following the methodology described in Chapter 3. The crania are from the following sources: W.W. Howells database, W.W. Howells' unpublished measurements of the Liujiang cranium, and R.L. Jantz's unpublished measurements of Paleoindian, Archaic Indian, and modern Amerindian samples. Sample sizes are listed below and in Table 2.1.

W.W. Howells' data (1973; 1989)

Howells' (1973; 1989) cranial data can be divided into eleven geographical regions (see Figure 2.1): (1) East Asia, (2) Hokkaido, (3) Pacific Islands, (4) Andaman Island, (5) Australo-Melanesia, (6) Polynesia, (7) Americas, (8) Greenland, (9) Europe, (10) Egypt, and (11) Africa. He usually names his populations after the geographical locality from which they were excavated, but, if the actual tribal name associated with the crania is known, he uses that. The names of the sample are listed in bold and their geographical locations are listed in italics.

Table 2.1: Sample Sizes

POPULATION	MALES	FEMALES	TOTAL	SOURCE
AINU	48	38	86	Howells (1973; 1989)
ANDAMAN	35	35	70	Howells (1973; 1989)
ANYANG	42	0	42	Howells (1973; 1989)
ARCHAIC INDIAN	8	7	15	Key (1983), R.L. Jantz (unpub.)
ARIKARA	42	27	69	Howells (1973; 1989)
ATAYAL	29	18	47	Howells (1973; 1989)
AUSTRALIA	52	49	101	Howells (1973; 1989)
BERG	56	53	109	Howells (1973; 1989)
BLACKFOOT	23	43	66	R.L. Jantz (unpub.)
BURIAT	55	54	109	Howells (1973; 1989)
BUSHMAN	41	49	90	Howells (1973; 1989)
CHEYENNE	16	6	22	R.L. Jantz (unpub.)
DOGON	47	52	99	Howells (1973; 1989)
EASTER ISLAND	49	37	86	Howells (1973; 1989)
EGYPT	58	53	111	Howells (1973; 1989)
ESKIMO	53	54	107	Howells (1973; 1989)
GUAM	30	27	57	Howells (1973; 1989)
HAINAN	45	38	83	Howells (1973; 1989)
LIUJIANG	1	0	1	W.W. Howells (unpub.)
MOKAPU	51	49	100	Howells (1973; 1989)
MORIORI	57	51	108	Howells (1973; 1989)
N. JAPAN	55	32	87	Howells (1973; 1989)
NORSE	55	55	110	Howells (1973; 1989)
PALEOINDIAN	5	1	6	Key (1983), R.L. Jantz (unpub.)
PAWNEE	17	10	27	Key (1983), R.L. Jantz (unpub.)
PERU	55	55	110	Howells (1973; 1989)
PHILIPPINE	50	0	50	Howells (1973; 1989)
S. JAPAN	50	41	91	Howells (1973; 1989)
SANTA CRUZ	51	51	102	Howells (1973; 1989)
TASMANIA	45	42	87	Howells (1973; 1989)
TEITA	33	50	83	Howells (1973; 1989)
TOLAI	55	55	110	Howells (1973; 1989)
ZALAVAR	53	45	98	Howells (1973; 1989)
ZULU	55	46	101	Howells (1973; 1989)
TOTALS	1417	1223	2640	



Adapted from Howells (1989)

(1) East Asia

Howells' (1973; 1989) data from East Asia are samples from five populations: Buriat (Siberia), Hainan (island of South China), Anyang (continental mid-China), North Japanese from Hokkaido, and South Japanese.

Buriat
Siberia
55 males, 54 females

The extant Buriat populace are pastoralists that live at the southern end of Lake Baikal in Siberia (Howells, 1973; 1989). Howells (1973; 1989) does not give a temporal range for this skeletal population.

Hainan
Haikou City, South China
45 males, 38 females

The Chinese settlers of Hainan, an island in southern China, were mainly from the Canton region. Although they initially arrived around 200 B.C.E., Howells (1989) writes that the principal immigration to the area happened more recently, but does not specify when. He believes the collection to "be a good representation of South China generally" (1989:108). Even though the island of Hainan is geographically located in the North Pacific Islands, the crania measured were ethnic Chinese so I consider this population a member of the East Asian series.

Anyang
East - Central China
42 males, 0 females

This Bronze Age collection from the Shang Dynasty originally numbered in the thousands, but much of it was destroyed during World War II (Howells, 1989). These crania are from the sacrificial burial pits in and around the imperial tombs dating from the Shang Dynasty at Anyang in the Honan Province. No female skulls were complete enough to use (Howells, 1989).

Hokkaido
Hokkaido, North Japan
55 males, 32 females

This collection is from cadavers dissected at the University Medical School at Hokkaido University. Howells (1989:107) notes that "the collection does not represent a strictly regional population in the sense of long establishment and local isolation" since the Japanese did not immigrate to Hokkaido until the mid-nineteenth century. Therefore, although Japan is geographically a Pacific island, it is included with East Asia.

South Japan
North Kyushu, Japan
50 males, 41 females

This sample is also from dissecting room collections, this time from the Department of Anatomy at Kyushu University.

(2) Hokkaido

Howells' (1973; 1989) data from the island of Hokkaido are a series of skulls from one population: Ainu. He deals separately with this North Pacific island because, as we shall see below, the Ainu are not considered ethnically Japanese.

Ainu
Hokkaido, Japan
48 males, 38 females

The Ainu are the original inhabitants of Hokkaido. Howells (1966:4) calls them "one of anthropology's favorite problems". Since this population exhibits many European, non-Mongoloid characteristics (Howells, 1966), researchers have long argued about their affiliation with the modern Japanese and the Jomon, the ancestors of the Japanese. In the nineteenth century, the Ainu were so drastically reduced by disease, that by 1970 it was believed that only 20 or 30 "pure" Ainu were still alive (Howells, 1989).

Although the modern Japanese have traditionally disdained the Ainu, claiming that they were primitive hunters and gatherers, the facial features which have conventionally been associated with high social status in Japan actually depict the genetic contribution that the Ainu made to the ancient Samurais (Brace and Hunt, 1990). Brace et al. (1989:108) write that "the kabuki actors, courtesans, and samurai portrayed so often in paintings, screens, kites, and wood block prints (cf. Streeter, 1974; Neuer et al., 1979; Halloran, 1986) all tend to display the elevated nasal skeleton, the slight swelling at the center of the brow, the point on the chin, and the flat-sided cheeks that set apart Ainu form from that of the typical Japanese". While the Ainu are well known for their

uncommon hirsutism, especially for Asian populations (Brace et al., 1989), they also can be differentiated from the modern Japanese in terms of their crania, hair, skin, facial features, and dermatoglyphics (Howells, 1966).

Brace and Tracer (1992:456) write that the Jomon's "most unmodified descendants are clearly the Ainu" who various researchers have typified into numerous ethnic classifications (e.g., see Howells, 1966). Hanihara (1985) also believes that the Ainu are directly descended from the Jomon and finds supporting evidence in dermatoglyphics, serum protein types, red cell enzymes, blood groups, and dental morphology. However, Howells (1966) is careful to state that viewing everything in terms of ancestor-descendant relationships oversimplifies the issues, disallowing the possibilities of contributions by unknown populations or the presence of unknown variations.

Howells' (1989) Ainu cranial sample, mostly derived from Hokkaido, was collected from abandoned graves and cemeteries that date to the eighteenth, nineteenth, and twentieth centuries. Japanese researchers informed Howells that the south and southwest parts of the island represented one homogeneous cranial unit with south-central Hokkaido being the least affected by Japanese contact. Therefore, Howells decided to focus on the south for his sample, excluding material from areas with known Japanese admixture. "The effort is not simply to get 'pure' Ainu. It must be supposed that Ainus, like other tribal peoples, varied locally, so the attempt here has been to assemble a more

specific population as well as one for which Japanese admixture could be assumed to be minimal" (Howells, 1989:116).

(3) Pacific Islands

Howells (1989) Pacific island data are from three populations: Atayal, Philippines, and Guam.

Atayal
Taiwan
29 males, 18 females

The Atayal are the aboriginal inhabitants of the island of Taiwan. The crania in this sample are from the victims of an annihilation of an Atayal village in 1932.

Philippine
Philippine Islands
50 males, 0 females

Howells (1989:110) calls this sample "a very general one for the islands". The crania are those of convicts who died in prison in Manila before World War II. Since no relatives claimed the bodies for burial, Howells (1989) believes that few of the convicts were from Manila, but rather from remote areas of the islands.

Guam
Guam
30 males, 27 females

These crania are from the Latte Period, a pre-Spanish contact archaeological complex dating to approximately 1100 C.E.

(4) Andaman Islands

One population is represented in Howells' (1973; 1989) data from the Andaman Islands: the Andaman (Andamanese).

Andaman
Andaman Islands
35 males, 35 females

The Andaman population has, until recently, been hostile to outsiders, leading Howells (1973; 1989) to believe that the skeletal sample he measured was definitively aboriginal. He does not give a temporal range for the samples utilized.

(5) Australo-Melanesia

Howells' (1973; 1989) Australo-Melanesian sample is represented by three populations: Lake Alexandrina tribes from South Australia, Tasmania, and Tolai.

Australia
South Australia
52 males, 49 females

Howells (1973:21; 1989:95) considers this series to be "one of the nearly ideal samples in the present investigation: a real local and time-limited population". The sample is from the aboriginal Jarildekald and Warki-Korowalde tribes from South Australia. The majority of these crania are probably from people who died during a smallpox epidemic in the nineteenth century (Howells, 1973; 1989).

Tasmania
Tasmania
45 males, 42 females

Melanesians, Maoris, and Australian aborigines all migrated to the island of Tasmania during the nineteenth century (Howells, 1973; 1989). Therefore, Howells (1973; 1989) took great pains to ensure that the crania measured and labeled "Tasmanian" was really of aboriginal stock. This sample is considered regional rather than local. Howells (1973; 1989) does not give a temporal range for this sample.

Tolai
Melanesia
55 males, 55 females

The details about the recovery of this sample and its associated dates are unavailable, however Howells (1973; 1989) feels with some certainty that the series is composed of Tolai natives.

(6) Polynesia

Howells' (1973; 1989) Polynesian data are samples from three populations: Mokapu, Easter Island, and Moriori.

Mokapu
Oahu, Hawaii
51 males, 49 females

These skeletal remains, representing more than 500 individuals, were uncovered from sand burial plots along the north shore of the Mokapu Peninsula from 1938 to 1940 (Howells, 1973; 1989). Howells (1973; 1989) writes that the burials probably occurred between 1400 and 1790 C.E. These crania are very affected by artificial modification.

"Head-shaping manifests itself here in an obvious vertical flattening of the back of the skull, often accompanied by a small asymmetry of the flattened area" (Howells, 1973:26; 1989:100). Howells (1973; 1989) tried to select the skulls that were the least modified, without creating a sample that would be falsely dolichocepalic.

Easter Island
Easter Island
49 males, 37 females

Howells (1989:102) writes that "This population, on its spectacularly isolated island, surely represents a limited breeding population. . . both spatially and apparently temporally as well, though it does cover some centuries". The burials are assigned to the Middle (1100-1680 C.E.) and Late (1680-1868 C.E.) Periods. Howells (1989) notes that the "females" are exceptionally robust.

Moriori
Chatham Islands
57 males, 51 females

These remains were obtained from burial grounds as well as from exposures of interments by beach erosion (Howells, 1989). The Moriori were isolated from other Polynesians until they were invaded by the Maori in 1835. Although most Maori returned home, Howells writes that the shock of the invasion led to the rapid deterioration of the Moriori, with the last survivor dying in the 1930s. He does not think it likely that any of the skulls deemed Moriori are actually Maori (Howells, 1989).

(7) Americas

Howells' (1973; 1989) Amerindian data from North and South America are samples from three populations: Arikara, Peru, and Santa Cruz.

Arikara
South Dakota, North America
42 males, 27 females

These remains come from the Sully site (39 SL 4) located near the center of South Dakota (Howells, 1973; 1989). These proto-historic Arikara are thought to have been deposited here from about 1600 to 1750 C.E. The village was excavated during the summer field seasons of 1957, 1958, 1961, and 1962 and yielded 566 human burials (Howells, 1973; 1989).

Peru
Peru, South America
55 males, 55 females

These remains were exhumed in the nineteenth century and probably are from the old Peruvian province of Yauyos, which lies on the western slopes of the Andes mountains (Howells, 1973; 1989). While no evidence of vault modification was present, trephination had been performed on many of the skulls. Howells excluded any crania on which the trephination would interfere with his measurements (Howells, 1973; 1989).

Santa Cruz
Santa Cruz Island, California - North America
51 males, 51 females

Roughly 565 crania were recovered from this island in the summer of 1875. Although no records exist regarding the excavation of these remains, besides one letter,

Howells (1989:105) believes that "The series is . . . judged to be relatively homogeneous genetically: not tightly restricted temporally or locally, but nonetheless one restricted to a single island, culture, and tradition". He writes that the crania are from people assigned to the Canaliño archaeological culture (1989).

(8) Greenland

Howells (1973; 1989) Greenland sample is from one population: the Inugsuk Eskimos.

Eskimo
Greenland
53 males, 54 females

The crania were excavated from graves in west and southeast Greenland and are associated with the Inugsuk culture. Temporally, they fall between the early Norse settlement and the mid-eighteenth century Danish colonization (Howells, 1973; 1989).

(9) Europe

Howells' (1973; 1989) European data are samples from three populations: Norse, Zalavár, and Berg.

Norse
Oslo, Norway - Northern Europe
55 males, 55 females

This skeletal population was excavated from medieval parish graveyards and represents different periods of a fairly isolated population (Howells, 1973; 1989). Howells (1973:11; 1989:89) favored this sample because of its "parochial nature and simple conditions of life".

Zalavár
Zalavár, Hungary - Central Europe
53 males, 45 females

The rather heterogeneous Zalavár population was excavated from 1948 to 1952 (Howells, 1973; 1989). Four cemeteries were uncovered whose inhabitants lived during the 9th, 10th, and 11th centuries C.E. The populace represents a rather diverse citizenry, as political change swept the area during these centuries. In the beginning of the 9th century, after the Franks destroyed the ruling Avar Empire, the area became a Frankish territory ruled by the Bishop of Salzburg, in which Zalavár was a crucial stronghold. During this tumultuous period, numerous ethnic shifts occurred, creating a rather heterogeneous population. Howells (1973:12; 1989:90) writes that the people of Zalavár could be lumped into three general groups: "surviving Avars, surviving Romanized and newly arrived Germanic and Slavic elements . . . and small numbers of the earliest Magyars".

Berg
Carinthia, Austria - Central Europe
56 males, 53 females

This sample selected by Howells is from a large collection of Felix von Luschan acquired by the American Museum of Natural History in 1924. Von Luschan obtained the remains from charnel houses where bones were deposited following the decree of the Austrian government enforcing exhumation because of the restricted size of church cemeteries. He believed that he had collected essentially all the crania representing five generations of the village's population, excluding some damaged juvenile skulls. Although

von Luschan's collection totaled 496, Howells only measured the most "suitable" specimens (Howells, 1973:13; 1989:91).

(10) Egypt

Egypt
Gizeh, Egypt - North Africa
58 males, 53 females

This skeletal population represents Egyptians that lived during from the 26th to the 30th Dynasties (approximately 600 - 200 B.C.E.). They were excavated from a single cemetery located south of the Gizeh pyramids. Over 1800 skulls are included in the complete collection. Although Egypt is geographically located in Africa, the Egyptians tend to cluster with Europeans rather than sub-Saharan Africans (Howells, 1973; 1989), and therefore are considered separately from the other Africans.

(11) Africa

Howells' (1973; 1989) other African data are samples from four populations: Teita, Dogon, Zulu, and Bushman.

Teita
Teita, Kenya - East Africa
33 males, 50 females

These crania, collected by Louis Leakey in 1929, represent a remarkably homogeneous tribe living in the southeast corner of Kenya. The Teita's custom is to exhume the skulls of their dead after about two years and put them in a cave or rock shelter, thereby setting up an ancestral shrine. They allowed Leakey to visit the shrines and collect the skulls of those who no one remembered anymore, and those whose

relatives had been converted to Christianity. Howells (1973; 1989) writes that it is believed that all the skulls collected by Leakey had not been deposited more than three or four generations prior to collection.

Dogon
Dogon, Mali - West Africa
47 males, 52 females

This sample was collected in 1934 from burial caves in the territory of the Dogon tribe in the Mali Republic. According to Howells (1973; 1989), it is possible that this sample is actually a composite representing the Dogon as well as their predecessors, the Tellem. However, "Since the desideratum for the study as a whole is a good local West African series, its actual affiliation within the region is not of primary importance here" (Howells, 1973:16; 1989:93).

Zulu
South Africa
55 males, 46 females

The Zulu sample was derived mainly from cadavers dissected in the Department of Anatomy at the University of Witwatersrand, although some archaeological specimens are included.

Bushman
South Africa
41 males, 49 females

"This series is in a quite different category from the others: it does not pretend to be a local population but rather, of necessity, a whole 'race' . . . the Bush population in general, although this itself remains a poorly defined idea" (Howells, 1973:18; 1989:113).

Some of the individuals in this sample are from archaeological sites, individual graves, or cemeteries, while some have been murdered or executed. One specimen is the famous "Hottentot Venus" Sarah Bartman (who Howells points out was neither Hottentot nor Venus), who died in 1816.

Other data

Liujiang cranium
1 male

The early modern *Homo sapiens* specimen Liujiang from China is dated to 67,000 B.P. (Yuan et al., 1986) and is usually called proto-Mongoloid. Howells however (1995:75) calls this ancient date "questionable". The commonly accepted, although yet unpublished, opinion on the chronology of this skull is that it is in the 10,000 to 30,000 B.P. range. It is possible that this person was contemporary with the Zhoukoudian *Homo sapiens* population. Because of missing measurements, Liujiang is only included in Analysis 2. Forty-seven cranial measurements of the fossil were generously provided by W.W. Howells.

Paleoindian data
5 males, 1 female

Paleoindians, the first settlers of the Americas, probably crossed the now submerged Bering land bridge from Asia around 15,000 B.P. following their Ice Age megafaunal prey across Beringia, which, due to lower sea levels, was a land bridge from 25,000 to 14,000 B.P. (Fagan, 1995). From about 75,000 to 10,000 years ago, there was an "ice-free zone" between the Cordilleran and Laurentide ice sheets which covered much

of North America (Porter, 1988:4). Paleoindians traveled through this corridor and initiated the peopling of North and South America, and were widespread by 10,000 B.P. (Key, 1983). How many migrations actually made up the Paleoindian occupation is a source of debate (e.g., see Greenberg, et al., 1986 and Neves and Pucciarelli, 1991).

Recent studies have indicated that the Paleoindian skeletal morphology is not consistent with a typical "mongoloid" morphology, but rather an unspecialized, pre-mongoloid East Asian population (Neves and Pucciarelli, 1991; Lahr, 1995). In fact, it is not unusual for Paleoindian skeletal material to morphologically resemble European populations rather than modern Amerindian populations. For example, when the well known Paleoindian skeleton called "Kennewick Man" was found in Washington, the initial researchers believed he exhibited caucasoid morphological features rather than Amerindian ones (Preston, 1997). Unfortunately, due to legal wranglings, it was impossible to include Kennewick Man in this study. The Paleoindian period is considered to end at 8,000 B.P. (Bamforth, 1988; Fagan, 1995). Paleoindian samples utilized in this study are listed in Table 2.2.

Archaic Indian data
8 males, 7 females

As the climate warmed and the Ice Age megafauna hunted by the Paleoindians disappeared, subsistence strategies changed by necessity and the Paleoindian way of life gradually became replaced by an Archaic one. The Archaic subsistence strategy was characterized by the hunting of smaller, modern animals such as white-tailed deer, as well as an increased gathering of plant foods. The Archaic samples utilized in this thesis are

Table 2.2: Paleoindians

SITE	SPECIMEN	NAME	ABBR.	SEX	SITE DATE	METHOD	SOURCE
25CM2	UN30631	Wet Gravel Pit	WG F	F	11550 B.P.	GEOL	Key (1983)
25CM2	UN30632	Wet Gravel Pit	WG M	M	11550 B.P.	GEOL	Key (1983)
25FT--	UN31444	Lime Creek	LC	M	11524 B.P.	C14*	Key (1983)
21TR05	Brown's Valley	Brown's Valley	BV	M	9049 B.P.	C14	Myster and O'Connell (1997)
NSM	2023	Wizard's Beach	WB	M	9250 B.P.	C14	Tuohy and Dansie (1997)
NSM	2064	Spirit Cave	SC	M	9415 B.P.	C14	Tuohy and Dansie (1997)

listed in Table 2.3. While "Minnesota Woman" could be considered either Paleoindian or Archaic due to her borderline date, I have chosen to consider her as an early Archaic since she is slightly younger than 8,000 B.P.

Additional modern Amerindian samples: Blackfoot (23 males, 43 females), Cheyenne (16 males, 6 females), Pawnee (17 males, 10 females)

The Blackfoot, Cheyenne, and Pawnee Amerindians are all central and northern Plains dwellers. These cranial data are from the database at the University of Tennessee, and include some repatriated remains.

Table 2.3: Archaic Indians

SITE	SPECIMEN	NAME	ABBR.	SEX	SITE DATE	METHOD	SOURCE
13MN2	#1	Turin	Turin	M	4720 B.P.	C14	Fisher et al. (1985)
25DO9002	SI94-03		SI94-03	M	3770 B.P.	C14	unpublished C14 date
25MP2	B137	Dry Lake	DL	F	3250 B.P.	ARCH	Key (1983)
25MP2	B3138	Dry Lake	DL	F	3250 B.P.	ARCH	Key (1983)
25SF10	1B854	Gering	Gering	M	2000 B.P.	ARCH	Key (1983)
25SF10	852	Gering	Gering	F	2000 B.P.	ARCH	Key (1983)
32MO97	2-12B	Bahm Burial	Bahm	M	1900 B.P.	C14	Williams (1994) (as cited in Williams (1997)
32MO97	4-14D	Bahm Burial	Bahm	F	1900 B.P.	C14	Williams (1994) (as cited in Williams (1997)
32MO97	5-15E	Bahm Burial	Bahm	M	1900 B.P.	C14	Williams (1994) (as cited in Williams (1997)
32MO97	6-16F	Bahm Burial	Bahm	F	1900 B.P.	C14	Williams (1994) (as cited in Williams (1997)
32MO97	8-18H	Bahm Burial	Bahm	F	1900 B.P.	C14	Williams (1994) (as cited in Williams (1997)
14LV315	3103	Lansing Man	LM	M	5579 B.P.	C14	Bass (1973)
NSM	871		871	M	4480 B.P.	C14	Jantz (unpub.)
UOFOREGON	11-110	Prospect Location	Prospect	M			
210T3	MNWOMAN	Pelican Rapids	MW	F	7840 B.P.	C14	Myster and O'Connell (1997)

CHAPTER III
METHODS

In order to assess the probabilities of UC 101's and UC 103's group membership, I have performed four unweighted, unrestricted canonical variate analyses. While this approach describes group differences, it is also commonly used to allocate individuals into a group (Campbell, 1984). Canonical variate analysis (CVA) is an appropriate method to address the problem at hand because it combines "multiple descriptor variables [i.e., cranial measurements] into a reduced number of functions which maximize, or most efficiently summarize, the *overall* differences among the populations" (Albrecht, 1980a:680, italics in original). It pulls these transformed dimensions (canonical variates) out of multivariate space and maximizes variation in a reduced number of axes. These canonical axes are uncorrelated to both "(1) the distribution of individuals about their respective group centroids, and (2) the overall distribution of the group centroids" (Albrecht 1980a:684).

Pooling the Sexes

Since the two Zhoukoudian fossils are widely considered to be a male (UC 101) and a female (UC 103), it was necessary to include both sexes in the analyses. Since size was removed following the Darroch and Mosimann (1985) method explained below, sexes were pooled without centering. The rationale for this is that size is the main sex difference.

Missing Data

Four separate analyses were performed because of the fragmentary nature of the cranial data. The first utilizes fifty-five cranial measurements, the second forty-five, the third thirty-four, and the fourth fifteen. They are described in detail below. Missing data were not estimated because, in order to appropriately use regression to predict missing datapoints, it is necessary to have an estimate of the group means. Since the crania that are missing datapoints are Paleoindian and Archaic Indian, and this thesis incorporates the majority of the individuals available from these populations, an adequate sample is not available in order to correctly calculate a regression line.

Adjusting for size: Darroch and Mosimann (1985)

The Darroch and Mosimann (1985) method of size/shape adjustment was followed in this thesis. This method yields dimensionless shape variables by dividing each variable by the geometric mean of all variables for that case.

If size is not corrected for, then the sexes could not be pooled. If they were, then sex differences based on size would account for most of the variation along the axes rather than group differences. Additionally, Neves and Pucciarelli (1998) found that, when size was not corrected in a Principal Components Analysis that included UC 101, the fossil was always an outlier because it is so large. While part of group differences is surely size, much more "true" separation will be seen by solely analyzing shape.

Canonical variate analysis

Canonical variate analysis (CVA), first developed by Rao (1952), is a useful tool in describing differences among groups. It is a technique that describes and summarizes data by maximizing the between-group variation of the original multidimensional data in a small number of transformed variates, allowing group configuration to be seen in a reduced number of dimensions (Albrecht, 1980a; Campbell, 1978). The canonical variates are linear functions of the original variables, chosen in such a way that the ratio of among-group to within-group variation is maximized (Campbell, 1980). These canonical variates allow group configurations to be seen. CVA is applicable when multivariate data are used to distinguish morphological relationships among populations while taking into account within-group dispersions (Albrecht, 1980a).

In CVA, the original variables are rotated and rescaled, yielding an isometric canonical variate space with regard to the within-group dispersions; i.e., a multivariate data space in which distances among all group centroids are equal. This makes interpretation of them easier while preserving their integrity (Albrecht, 1980a). In it, between-groups distances in all directions are evaluated according to the scale of one standard deviation of the within-group variation.

The most traditional form of canonical variate analysis is the weighted analysis in which sample size is a weighting factor (Albrecht, 1980b; 1992). The group's influence on the variances and covariances in the among-groups covariance matrix is affected by its sample size as well as its mean values. However, Albrecht (1992) writes that it is

inappropriate to define the among-group covariance matrix in terms of group sample sizes when there is no justification in assuming that the groups differ in significance or *a priori* probabilities. This is because sample size affects the construction of the canonical variate axes. Their structure is determined by the well sampled groups while the inadequately sampled groups' variation contributes only a slight influence (Albrecht, 1992).

Albrecht (1992) argues that a more appropriate approach is an unweighted analysis. In this method, a group's influence is contingent only on its mean values and not its sample size. Arrangements of unweighted canonical variates assume all groups to be equally meaningful without the *a priori* weightings that are inherent in a weighted analysis (Albrecht, 1992). Therefore, the construction of the canonical variate axes is independent of sample size (Albrecht, 1980b; 1992). This is an important consideration when comparing single fossil specimens to well sampled groups, as is done in this study. Since the Zhoukoudian fossils are of interest in this study, it is important that they contribute to the multivariate space in which they are analyzed. This method also addresses Wolpoff's (1995) criticism of traditional multivariate studies, in which he contends that it is inappropriate to perform a discriminant function on a specimen from a population not represented in the data upon which the function is based.

Additionally, Albrecht (1992) stresses the importance of differentiating between a "restricted" versus an "unrestricted" analysis. In a restricted analysis, it is assumed that the unknown specimens *must* belong to one of the reference groups under consideration. However, an unrestricted analysis assumes that the unknown specimens belong to one,

several, or none of the reference groups. In other words, the unrestricted analysis makes no assumptions about group affiliation.

In this case, an unrestricted analysis is appropriate. Albrecht (1992:58) writes that this approach is more realistic for paleoanthropologists because of the "possibilities for temporal, spatial, and taxonomic variation among living primates, previously described fossil species, and yet to be discovered fossil taxa".

Typicality probabilities

The unrestricted approach makes use of "typicality probabilities", multivariate extensions of the univariate t-test, for determining whether or not the unknown specimens belong to a specific population (Albrecht, 1992). Campbell (1984:182) formally defines typicality probabilities as "the probability of observing data vectors with values of the probability density function greater than the value of the probability density function for the given data vector for the individual to be allocated". In simpler terms, typicality probabilities allow the evaluation of whether or not the individual classified by the unweighted CVA into a specific population is a typical member or an outlier of that population by determining whether the individual in question falls within the multivariate normal distribution of at least one of the reference groups. Low probabilities indicate that the specimen is unlikely to belong to one of the reference groups (Albrecht, 1992).

Unlike posterior probabilities inherent in the restricted approach, the typicality probabilities utilized in the unrestricted procedure do not have to sum to one (1.0) (Albrecht, 1992). Here, typicality probabilities were drawn from a Chi-square table based

on the Mahalanobis D-squared distance rendered from the unweighted, unrestricted analysis.

Since most statistical packages do not allow for an unweighted CVA, the methodology followed here was a covariance based principal components analysis on the data matrix of the weighted CVA. "The resulting axes are identical to canonical variates derived from an unweighted among-groups covariance matrix with a fossil included directly in the calculations. This approach amounts to a rigid rotation of the weighted canonical variates to new orthogonal axes that maximize the variation among the reference groups and the fossils without regard for sample sizes" (Albrecht, 1992:66).

Assumptions

In any type of statistical analysis, certain assumptions must be met. In CVA, the assumptions are 1) multivariate normal distributions of each population and 2) equality of the within-group variance-covariance matrices. The first assumption is likely met because, due to the large sample sizes employed in this study, a normal distribution can be assumed with relative confidence because of the multivariate central limit theorem (Rencher, 1995). Additionally, Seal (1964) writes that a linear transformation of variates, such as is performed in CVA, will result in a set of transformed variates more normally distributed than the original ones. Therefore, the analysis performed here increases the likelihood that the first assumption is met. The second assumption is assumed to be satisfied, although in reality, it is probably not. Even if the variance-covariance matrices are not equal, their structure is not drastically different. For example, Key (1983:54) found that his

component structure based on a sample of Plains Indians was "virtually identical" to Howells' (1973) component structure based on a world-wide sample, demonstrating approximate equality of the variance-covariance matrices. Additionally, Howells (1973; 1989) used most of the same dataset that is utilized in this thesis with confidence, and numerous other researchers have relied on his findings without questioning whether the basic assumptions of multivariate statistics were met by the raw data.

CVA 1

55 variables, N=2,635

Fifty-five of Howells' (1973; 1989) fifty-seven cranial measurements were used in this analysis (Table 3.1). Abbreviations and names of all measurements used are listed in Appendix A, but see Howells (1973) for a complete description. Supraorbital projection (SOS) and glabella projection (GLS) were eliminated because they can be zero, and his thirteen angle calculations were not performed. All of Howells (1973; 1989) modern crania were used, as were the most complete Paleoindian and Archaic Indian samples (Table 3.2).

CVA 2

45 variables, N=2,636

The same samples were utilized as in Analysis 1 with the addition of the Liujiang cranium. Since the ten radii measurements were not available for Liujiang, only forty-five measurements were used. See Tables 3.3 and 3.4.

Table 3.1: CVA 1 Measurements

GOL	NDS
NOL	WNB
BNL	SIS
BBH	IML
XCB	XML
XFB	MLS
STB	WMH
ZYB	FOL
AUB	FRC
WCB	FRS
ASB	FRF
BPL	PAC
NPH	PAS
NLH	PAF
OBH	OCC
OBB	OCS
JUB	OCF
NLB	VRR
MAB	NAR
MDH	SSR
MDB	PRR
ZMB	DKR
SSS	ZOR
FMB	FMR
NAS	EKR
EKB	ZMR
DKS	AVR
DKB	

Table 3.2: CVA 1 Samples

PALEOINDIANS		
SITE	**SPECIMEN**	**NAME**
25CM2	UN30631	Wet Gravel Pit
25CM2	UN30632	Wet Gravel Pit
25FT--	UN31444	Lime Creek
NSM	2023	Wizard's Beach
ARCHAIC INDIANS		
SITE	**SPECIMEN**	**NAME**
13MN2	#1	Turin
25DO9002	SI94-03	
25MP2	B137	Dry Lake
25MP2	B3138	Dry Lake
25SF10	1B854	Gering
25SF10	852	Gering
32MO97	2-12B	Bahm Burial
32MO97	4-14D	Bahm Burial
32MO97	5-15E	Bahm Burial
32MO97	6-16F	Bahm Burial
32MO97	8-18H	Bahm Burial
NSM	871	
UOFOREGON	11-110	Prospect Location

Table 3.3: CVA 2 Measurements

GOL	FMB
NOL	NAS
BNL	EKB
BBH	DKS
XCB	DKB
XFB	NDS
STB	WNB
ZYB	SIS
AUB	IML
WCB	XML
ASB	MLS
BPL	WMH
NPH	FOL
NLH	FRC
OBH	FRS
OBB	FRF
JUB	PAC
NLB	PAS
MAB	PAF
MDH	OCC
MDB	OCS
ZMB	OCF
SSS	

Table 3.4: CVA 2 Samples

PALEOINDIANS		
SITE	**SPECIMEN**	**NAME**
25CM2	UN30631	Wet Gravel Pit
25CM2	UN30632	Wet Gravel Pit
25FT--	UN31444	Lime Creek
NSM	2023	Wizard's Beach
ARCHAIC INDIANS		
SITE	**SPECIMEN**	**NAME**
13MN2	#1	Turin
25DO9002	SI94-03	
25MP2	B137	Dry Lake
25MP2	B3138	Dry Lake
25SF10	1B854	Gering
25SF10	852	Gering
32MO97	2-12B	Bahm Burial
32MO97	4-14D	Bahm Burial
32MO97	5-15E	Bahm Burial
32MO97	6-16F	Bahm Burial
32MO97	8-18H	Bahm Burial
NSM	871	
UOFOREGON	11-110	Prospect Location

CVA 3

34 variables, N=2,638

In order to include two more Paleoindians in an analysis and an additional Archaic ("Minnesota Woman"), it was necessary to reduce the measurement set because of the fragmentary nature of the crania or because, in the case of the Spirit Cave mummy, some of the cranial landmarks are covered with tissue. See Tables 3.5 and 3.6.

CVA 4

15 variables, N=2,639

In order to include the Archaic Indian "Lansing Man" in the analysis, it was necessary to once again reduce the measurement set because only the neurocranium is preserved in this individual. See Tables 3.7 and 3.8.

Table 3.5: CVA 3 Measurements

GOL	EKB
NOL	WMH
XCB	FRC
XFB	FRS
AUB	FRF
NPH	PAC
NLH	PAS
JUB	PAF
NLB	NAR
MAB	SSR
MDH	PRR
MDB	ZOR
OBH	FMR
OBB	EKR
DKB	ZMR
FMB	AVR
NAS	VRR

Table 3.6: CVA 3 Samples

PALEOINDIANS		
SITE	**SPECIMEN**	**NAME**
25CM2	UN30631	Wet Gravel Pit
25CM2	UN30632	Wet Gravel Pit
25FT--	UN31444	Lime Creek
21TR05	Brown's Valley	Brown's Valley
NSM	2023	Wizard's Beach
NSM	2064	Spirit Cave
ARCHAIC INDIANS		
SITE	**SPECIMEN**	**NAME**
13MN2	#1	Turin
25DO9002	SI94-03	
25MP2	B137	Dry Lake
25MP2	B3138	Dry Lake
25SF10	1B854	Gering
25SF10	852	Gering
32MO97	2-12B	Bahm Burial
32MO97	4-14D	Bahm Burial
32MO97	5-15E	Bahm Burial
32MO97	6-16F	Bahm Burial
32MO97	8-18F	Bahm Burial
210T3	MNWOMAN	Pelican Rapids
NSM	871	
UOFOREGON	11-110	Prospect Location

Table 3.7: CVA 4 Measurements

GOL	FRF
NOL	PAC
XCB	PAS
XFB	PAF
AUB	NAR
MDH	FMR
FRC	VRR
FRS	

Table 3.8: CVA 4 Samples

PALEOINDIANS		
SITE	**SPECIMEN**	**NAME**
25CM2	UN30631	Wet Gravel Pit
25CM2	UN30632	Wet Gravel Pit
25FT--	UN31444	Lime Creek
21TR05	Brown's Valley	Brown's Valley
NSM	2023	Wizard's Beach
NSM	2064	Spirit Cave
ARCHAIC INDIANS		
SITE	**SPECIMEN**	**NAME**
13MN2	#1	Turin
25DO9002	SI94-03	
25MP2	B137	Dry Lake
25MP2	B3138	Dry Lake
25SF10	1B854	Gering
25SF10	852	Gering
32MO97	2-12B	Bahm Burial
32MO97	4-14D	Bahm Burial
32MO97	5-15E	Bahm Burial
32MO97	6-16F	Bahm Burial
32MO97	8-18H	Bahm Burial
14LV315	3103	Lansing Man
NSM	871	
UOFOREGON	11-110	Prospect Location
210T3	MNWOMAN	Pelican Rapids

CHAPTER IV
RESULTS

In canonical variate analysis, it is desirable for the first few canonical axes to explain large percentages of the among-group variation. However, when the number of samples, including individual specimens of Archaic and Paleoindians, is large the amount of variation explained by each axis is inevitably reduced. That is the case here. Each axis will still provide a good description of general patterns of craniofacial variation.

The populations in each canonical plot are grouped according to the geographical areas described in Chapter II. Individual populations contained in each geographical group are also described in Chapter II.

CVA 1: Figures 4.1 and 4.2

In Canonical Variate Analysis 1, CAN 1 explains 12.1% of the total variation, CAN 2 11.2%, CAN 3 9.9%, and CAN 4 7.4%, for a total of 40.6% of total variation. The measurements and populations incorporated in this analysis are listed in Tables 3.1 and 3.2. Abbreviations of the major contributing measurements to the canonical loadings can be found in Table B-1, Appendix B. Full names of the measurements can be found in Appendix A.

Figure 4.1 shows UC 101 closely clustering near all the European populations included in the analysis, and also near the Archaic specimen 871, Egypt, and Peru. Specifically, on CAN 1 the fossil is closest to Peru, Santa Cruz, Zalavár, Berg, Australia, three Archaic Indians (852, B3138, and 871), Eskimo, Buriat, Moriori, Egypt. On CAN

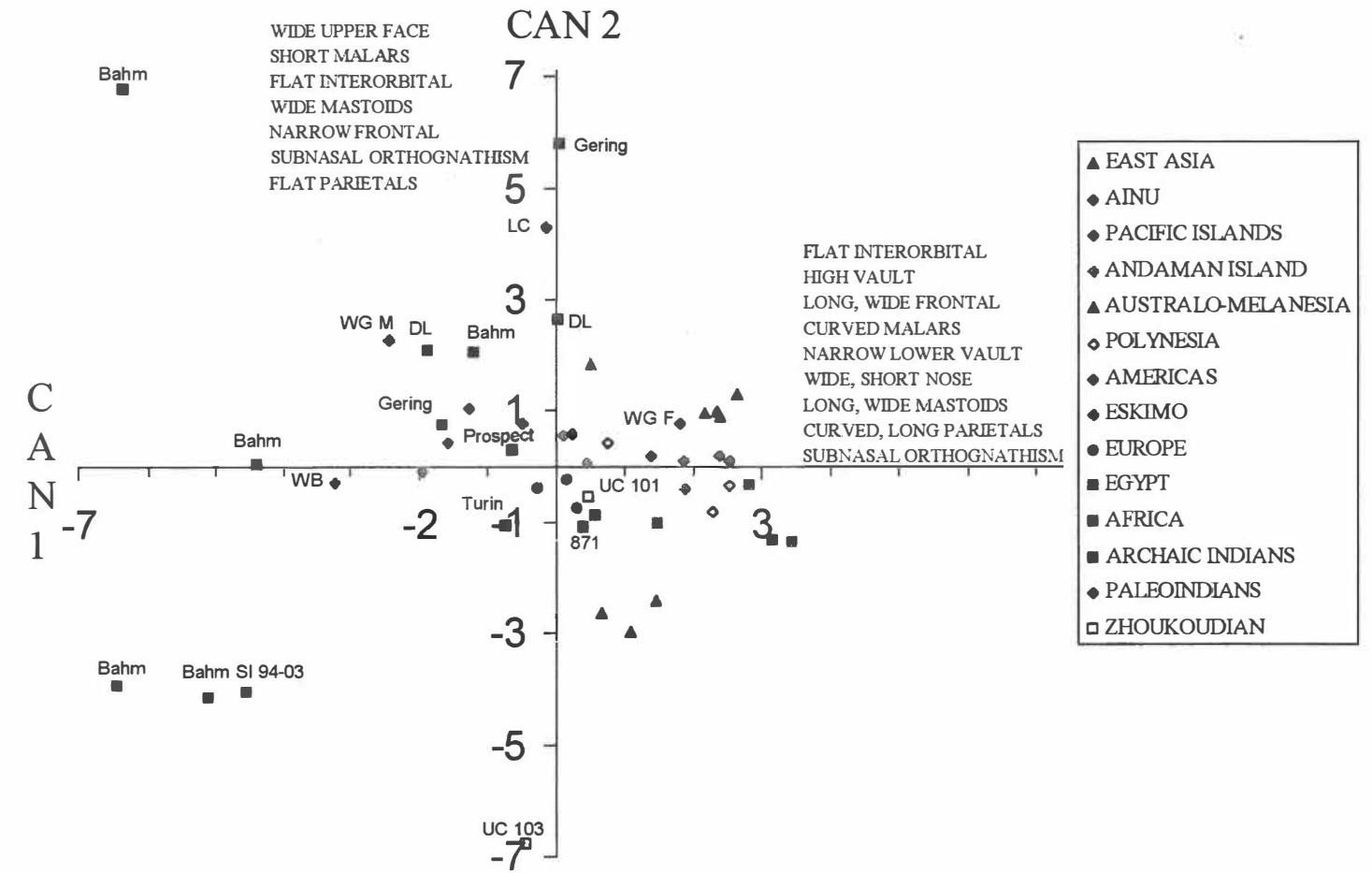


Figure 4.1: CVA 1

2, it is nearest Europe, three Archaic specimens (2-12B, #1, and 871), Africa, Andaman, Mokapu, Easter Island, the Paleoindian specimen Wizard's Beach, and Cheyenne.

On CAN 1, UC 103 is near several Archaic Indian populations (#1, B3138, 11-110, and 852), Europe, Santa Cruz, Arikara, Eskimo, and the Lime Creek Paleoindian. UC 103 and UC 101 are not very far apart on this axis. UC 103 lies farther away from most populations on CAN 2. Its closest neighbors are Australo-Melanesian populations and three Archaic Indians (5-15E, 8-18H, and SI 94-03).

In Figure 4.2, UC 101 is very close to the Archaic specimen #1. On CAN 3, the fossil is closest to the Archaic Indian #1, Africa, the Wet Gravel Female and Wizard's Beach Paleoindians, Ainu, Pacific Islands, Tolai, East Asia, Eskimo, Norse, Easter Island, Andaman, and two other Archaics (6-16F and B3138). On CAN 4, UC 101 is closest to two Archaics (#1 and B137), Tolai, Tasmania, Philippines, Berg, Zalavár, Egypt, Arikara, and Peru.

On CAN 3, UC 103 is close to the Lime Creek Paleoindian and the Archaic specimen 871. On CAN 4, it is closest to the Archaic Indian 4-14D (Figure 4.2).

A Mahalanobis D-squared Distance Analysis was performed using the same measurements and populations used in CVA 1. This evaluates the distances of an unknown specimen from each known group's centroid, and classifies it based on the shortest distance. UC 101 was classified as Easter Island and UC 103 was classified as Tolai. Distances, posterior probabilities, and typicality probabilities for the fossils are shown in Table 4.1. The posterior probabilities indicate the likelihood that, given an

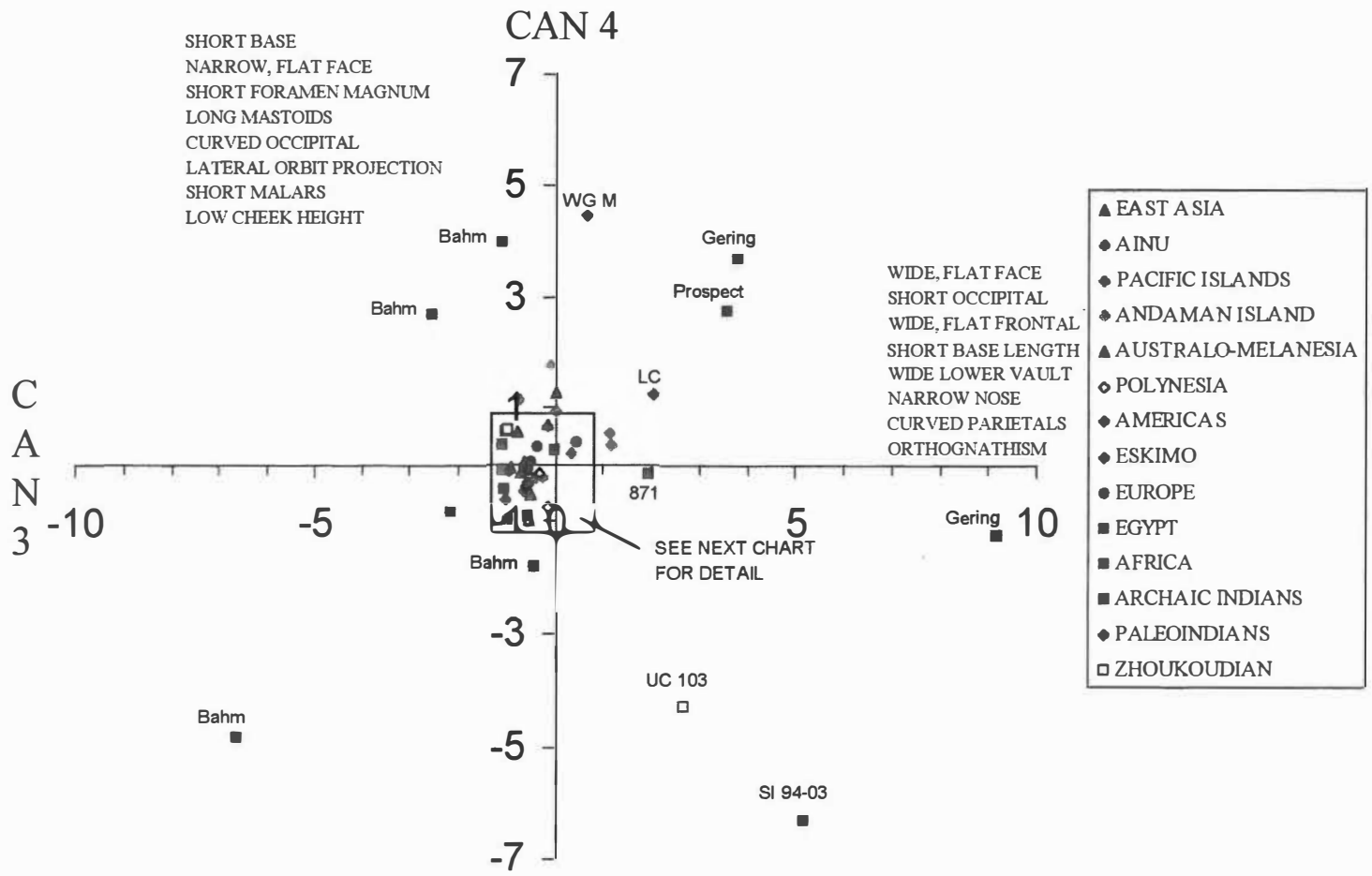


Figure 4.2: CVA 1 and CVA 1 Detail

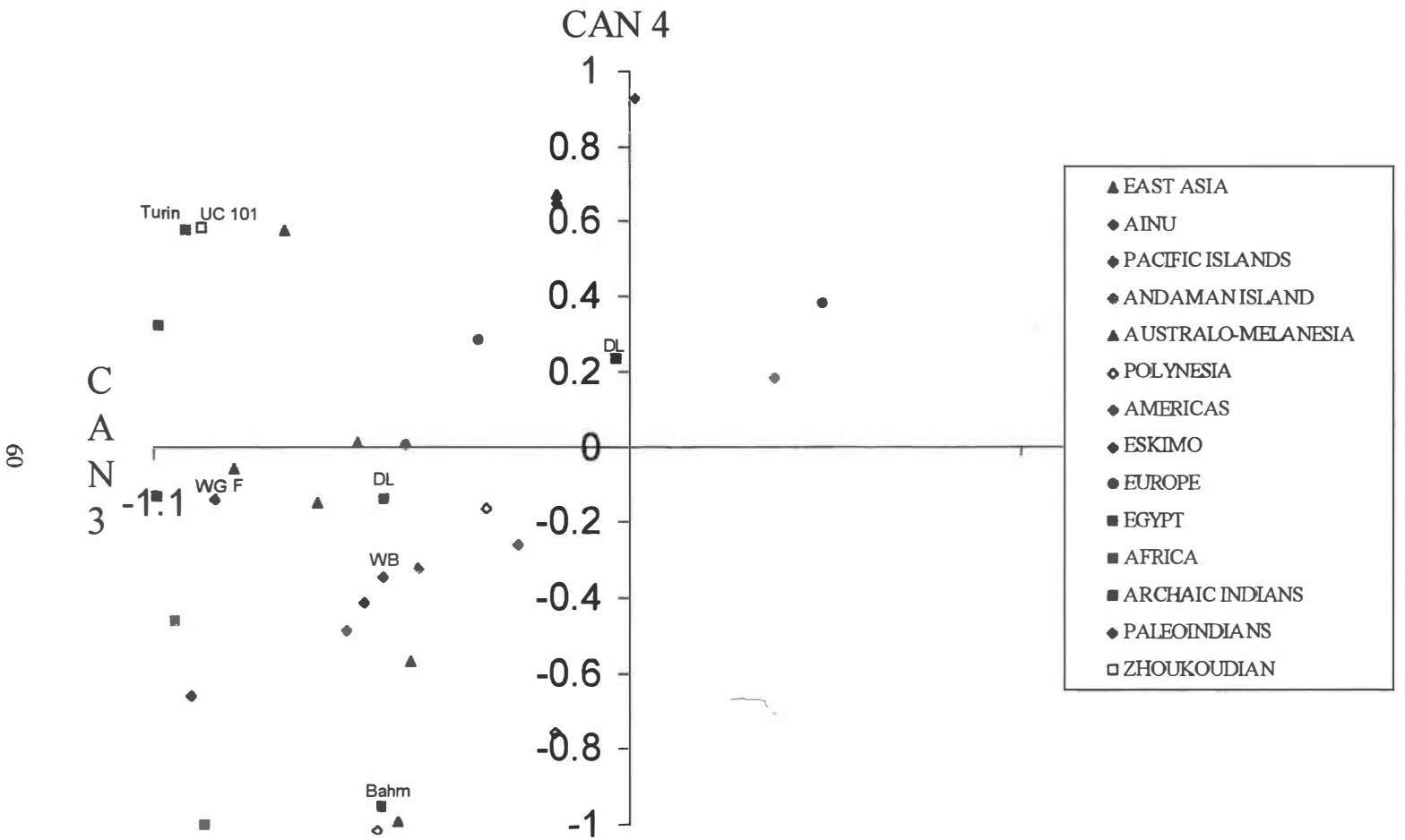


Figure 4.2 (Continued)

Table 4.1: Distance Analyses of Fossils

ANALYSIS	FOSSIL	CLASSIFICATION	SQUARED DISTANCE	TYP. PROB.	POST. PROB.
1	UC 101	EASTER ISLAND	66.701	0.134	0.76055
	UC 103	TOLAI	121.58	<0.001	0.8649
2	UC 101	NORSE	57.368	0.102	0.50172
	UC 103	TASMANIA	113.326	<0.001	0.65809
3	UC 101	ZALAVAR	44.543	0.107	0.52406
	UC 103	TOLAI	56.428	0.009	0.99713
4	UC 101	AUSTRALIA	14.042	0.522	0.6619
	UC 103	TOLAI	27.789	0.023	0.60121

unknown specimen *has* to belong to one of the known groups, the specimen actually does. The typicality probabilities show whether or not the unknown specimen is a typical member or an outlier of the population to which it has been assigned. Low probabilities indicate that the specimen is unlikely to belong to one of the reference groups. UC 103 has consistently lower typicality probabilities than UC 101. See Appendices C and D for the same information on the Paleoindian and Archaic crania.

CVA 2: Figures 4.3 and 4.4

In CVA 2, CAN 1 explains 12.9% of the variation, CAN 2 11.6%, CAN 3 10.5%, and CAN 4 7.2%, for a total of 42.2%. The measurements and populations incorporated in this analysis are listed in Tables 3.3 and 3.4. Abbreviations of the major contributing measurements to the canonical loadings can be found in Table B-2, Appendix B. Full names of the measurements can be found in Appendix A.

On CAN 1, UC 101 clusters most closely with the Archaics specimens #1, 871, 11-110, 1B854, 852, and B3138, Europe, Eskimo, Peru, Santa Cruz, Arikara, the Lime Creek Paleoindian, Moriori, Buriat. On CAN 2, the skull is closest to the Archaic Indians #1, 871, 8-18H, and 2-12B, Europe, Africa, Polynesia, the Liujiang cranium (Figure 4.3).

On CAN 1, UC 103 is closest to modern Amerindian populations (especially Blackfoot, Cheyenne, and Pawnee), two Archaics (B137 and 6-16F), and the Wet Gravel Male Paleoindian. On CAN 2, it is not close to any population, but its nearest neighbors are the Archaics SI 94-03 and 5-15E and the Australo-Melanesia populations (Figure 4.3).

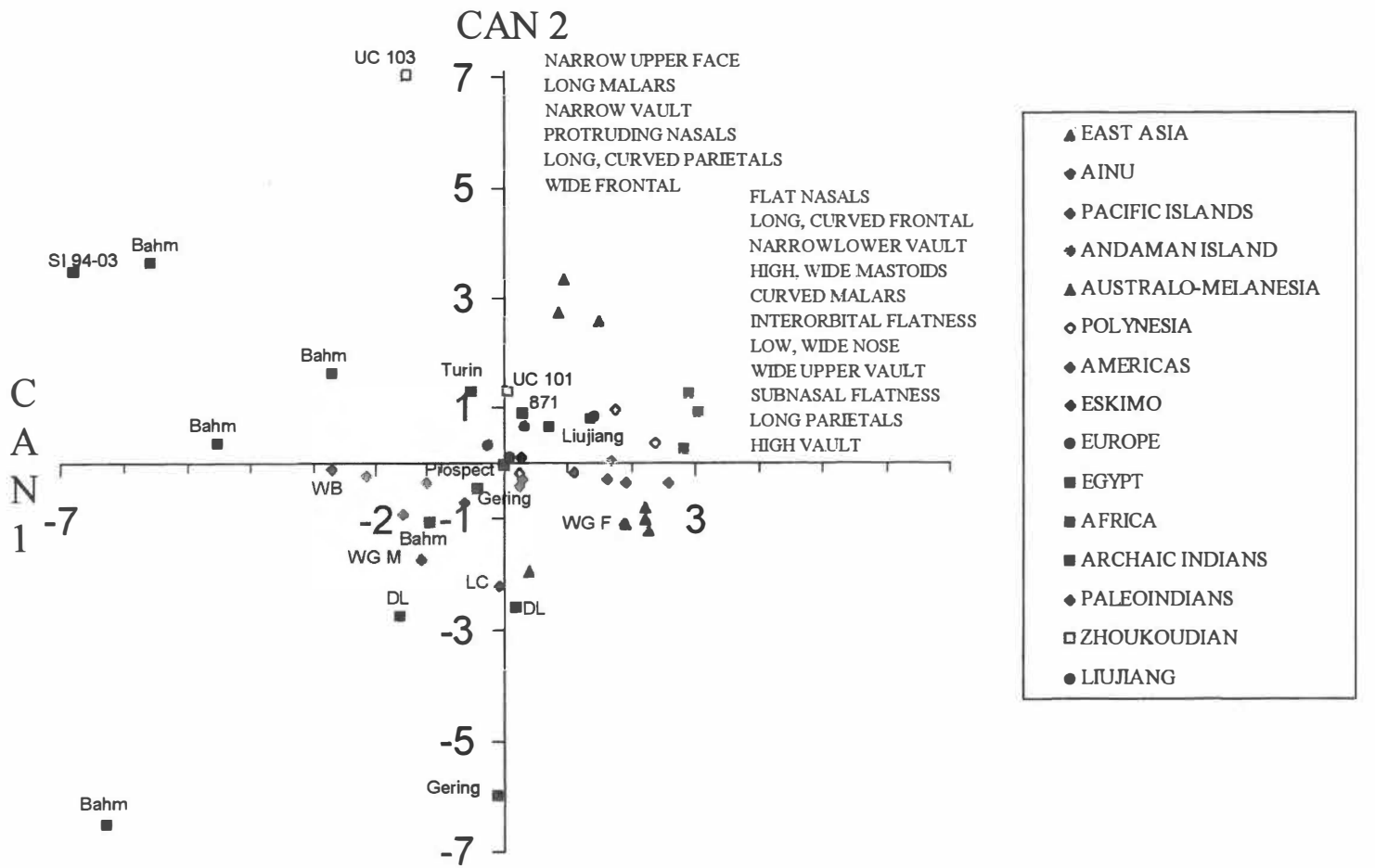


Figure 4.3: CVA 2

On CAN 3, UC 101 is closest to the Archaics #1 and 8-18H, as well as Blackfoot, Buriat, and Dogon populations. On CAN 4, it is closest to modern Amerindian populations and the Archaic specimen #1 (Figure 4.4).

On CAN 3, UC 103 is closest to many Archaic specimens (11-110, 1B854, and 871). On CAN 4, it is closest to the Archaic Indian 4-14D (Figure 4.4).

The associated Distance Analysis classifies UC 101 as Norse and UC 103 as Tasmanian. Distances, posterior probabilities, and typicality probabilities are shown in Table 4.1.

CVA 3: Figures 4.5 and 4.6

In CVA 3, CAN 1 explains 12.5% of the variation, CAN 2 11.6%, CAN 3 10.2%, and CAN 4 8.5%, for a total of 42.8%. The measurements and populations incorporated in this analysis are listed in Table 3.5 and 3.6. Abbreviations of the major contributing measurements to the canonical loadings can be found in Table B-3, Appendix B. Full names of the measurements can be found in Appendix A.

On CAN 1, UC 101 is clusters closely with Moriori, the Archaic specimens 1B854, #1 and 11-110, Santa Cruz, Peru, Europe, Eskimo, and the Paleoindians Wet Gravel Female and Brown's Valley. On CAN 2, the fossil is closest to Eskimo, three Paleoindians (Wet Gravel Female and Male, and Spirit Cave), Pawnee, Arikara, Polynesia, Atayal, and Buriat (Figure 4.5).

On CAN 1, UC 103 falls closest to the Archaic specimens B3138, 871, and 11-110, Mokapu, Easter Island, Pacific Islands, Ainu, Peru, Zalavár (all Europeans cluster

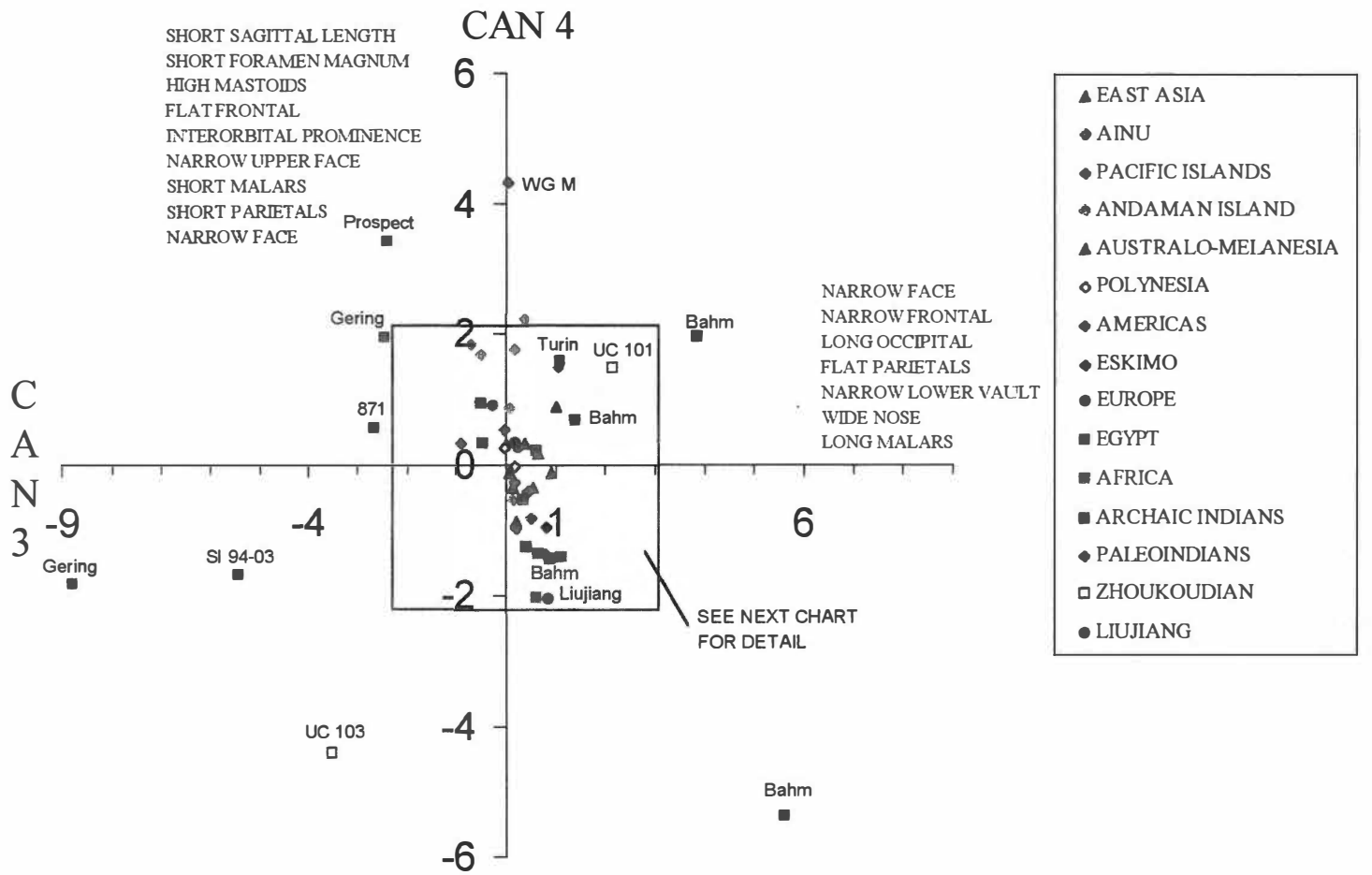


Figure 4.4: CVA 2 and CVA 2 Detail

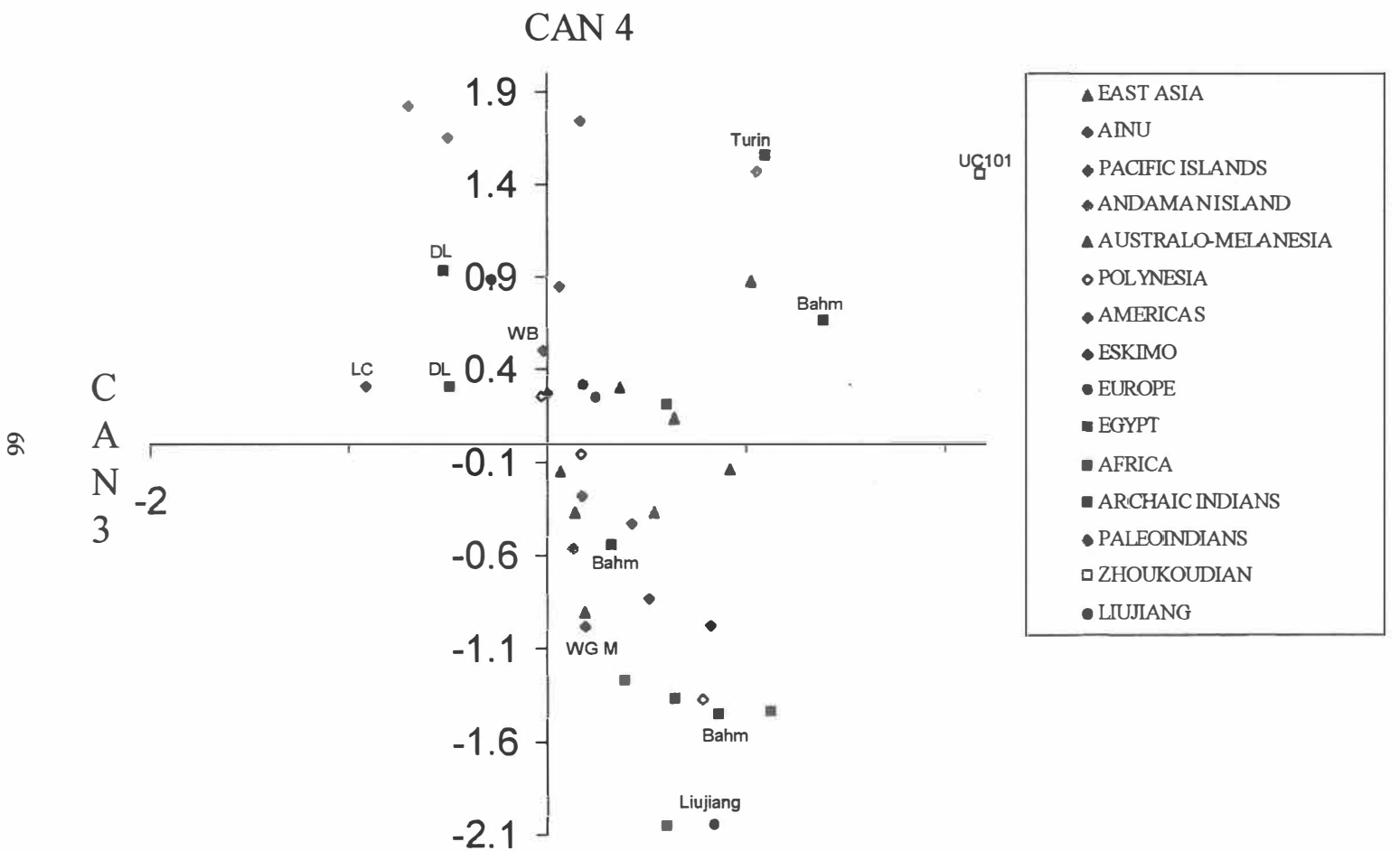


Figure 4.4 (Continued)

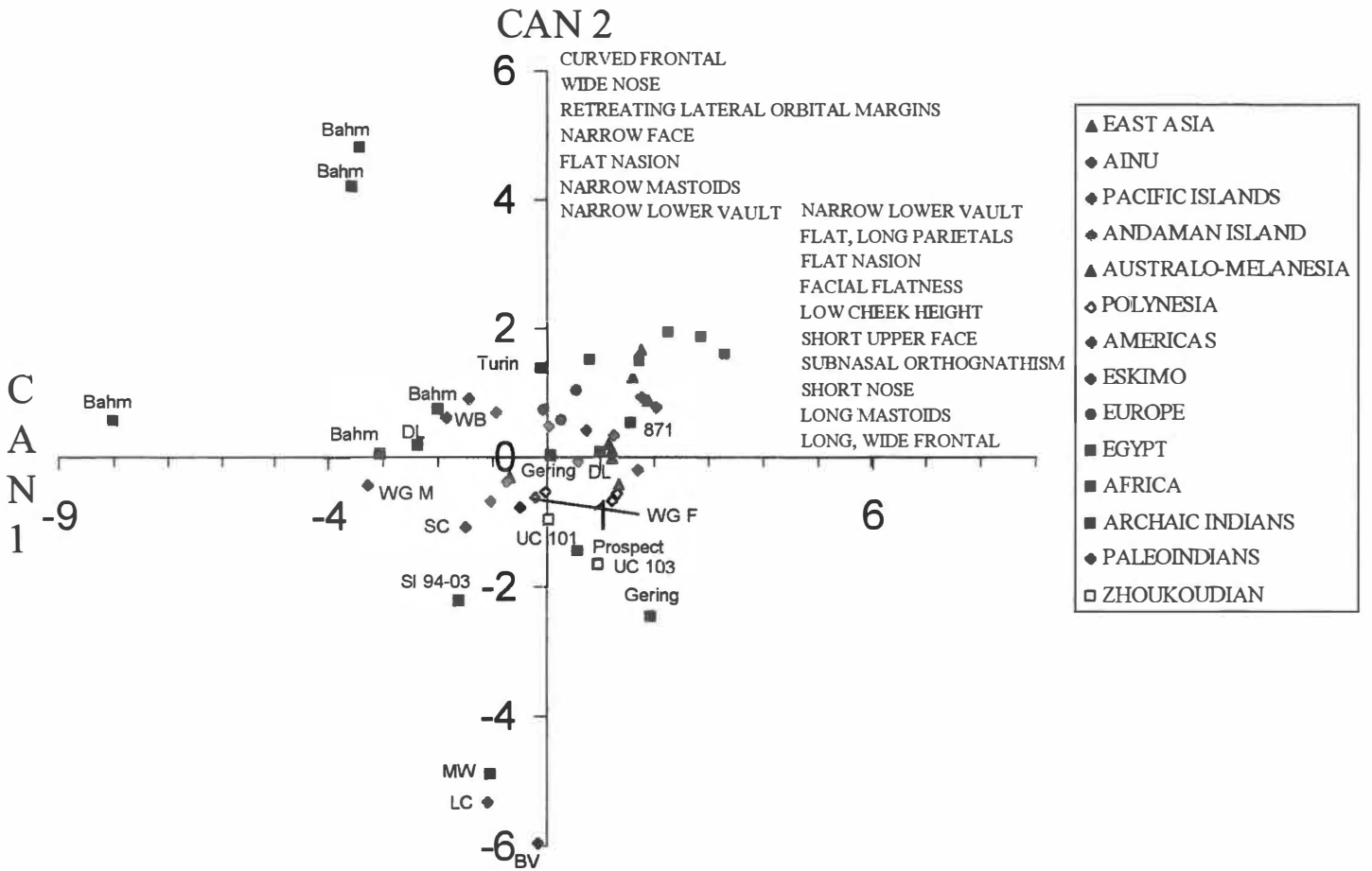


Figure 4.5: CVA 3

nearby), Atayal, Hainan, and Egypt. On CAN 2, it is closest to the Archaics 11-110 and SI 94-03 (Figure 4.5).

On CAN 3, UC 101 is closest to Africa, Pacific Islands, Europe, Ainu, Hainan (all East Asians cluster nearby), Eskimo, Andaman, and the Paleoindians Spirit Cave and Lime Creek. On CAN 4, it is closest to Africa, Pacific Islands, Norse, Zalavár, the Archaics 2-12B and 6-16F, Ainu, and Easter Island (Figure 4.6).

On CAN 3, UC 103 is closest to the Archaic Indians SI 94-30 and 1B854 as well as the Paleoindian Brown's Valley. On CAN 4, it is closest to the Archaic specimen 5-15E and the Lime Creek Paleoindian.

The associated Distance Analysis classifies UC 101 as Zalavár and UC 103 as Tolai. Distances, posterior probabilities, and typicality probabilities are shown in Table 4.1.

CVA 4: Figures 4.7 and 4.8

In CVA 4, CAN 1 explains 17.5% of the variation, CAN 2 14.5%, CAN 3 13.9%, and CAN 4 11.1%, for a total of 57%. The measurements and populations incorporated in this analysis are listed in Table 3.7 and 3.8. Abbreviations of the major contributing measurements to the canonical loadings can be found in Table B-4, Appendix B. Full names of the measurements can be found in Appendix A.

On CAN 1, UC 101 is closest to three Paleoindians (Brown's Valley, Wet Gravel Male, and Lime Creek) and two Archaics (8-18H and 6-16F). On CAN 2, it is closest to the Archaic specimens #1, 852, 1B854, 11-110, Lansing Man, and Minnesota Woman, the

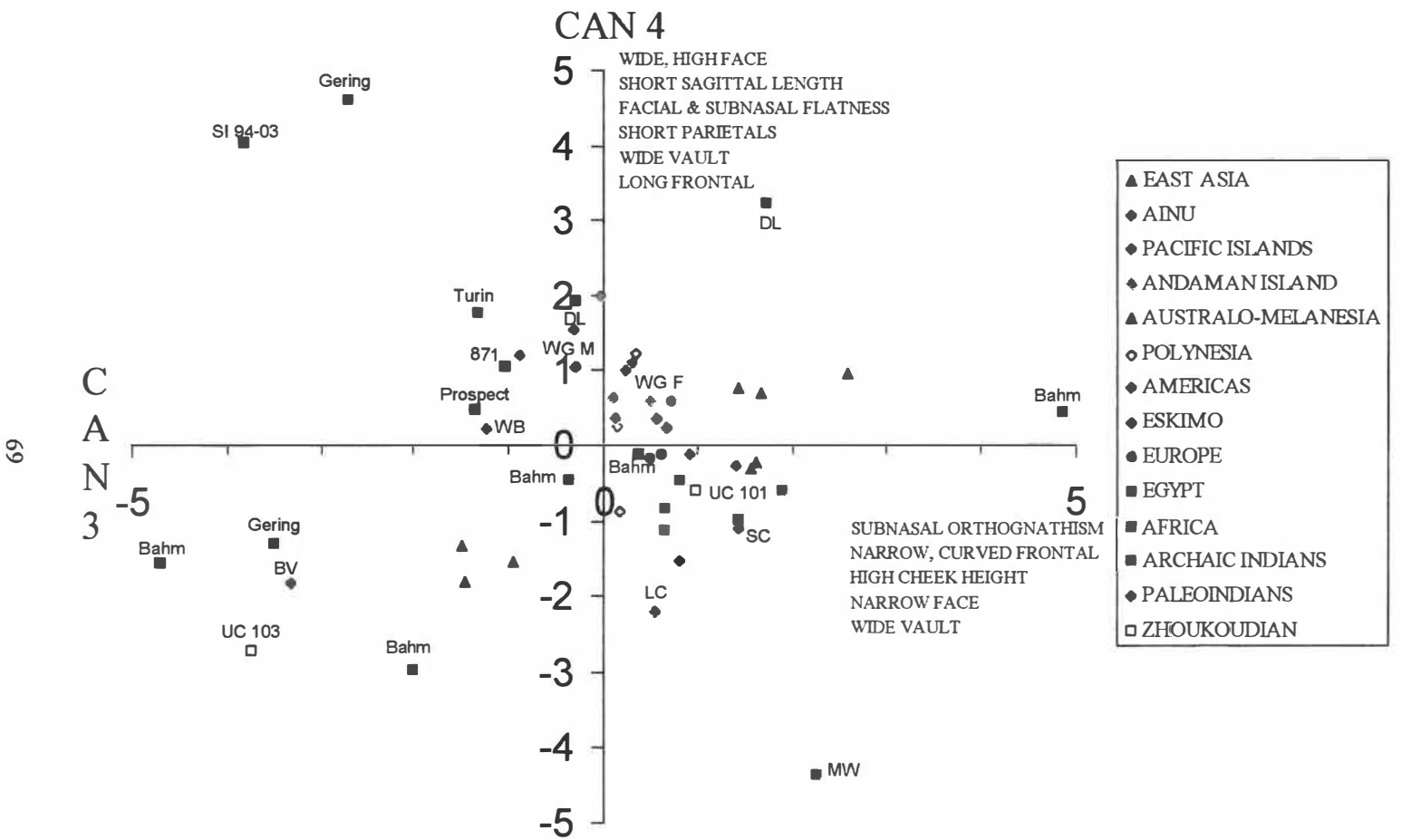


Figure 4.6: CVA 3

Paleoindian Spirit Cave, Berg, Pacific Islands, Andaman, East Asia, modern Amerindian populations, Tasmania, and Easter Island (Figure 4.7).

On CAN 1, UC 103 is not very close to any population. Its nearest neighbors are three Paleoindians (Brown's Valley, Wet Gravel Male, and Lime Creek) and one Archaic (4-14D). On CAN 2, it is closest to the Archaics 8-18H and 6-16F, the Lime Creek Paleoindian, Norse, Australia, Eskimo, Ainu, Dogon, Zulu, and Egypt (Figure 4.7).

On CAN 3, UC 101 is closest to Australo-Melanesia, the Archaics 871 and 11-110, Eskimo, and the Paleoindians Wizard's Beach, Wet Gravel Female, and Brown's Valley. On CAN 4, UC 101 is closest to Archaics 11-110, SI 94-03, 2-212B, B3138, and 6-16F, Paleoindians Brown's Valley, Wet Gravel Female and Male, and Lime Creek, Australia, Tasmania, Moriori, Europe, modern Amerindians, Ainu, and Zulu (Figure 4.8).

On CAN 3, UC 103 is closest to the Archaic 1B854, the Paleoindians Spirit Cave and Lime Creek, and Easter Island. On CAN 4, it is closest to the Archaics 1B854 and 4-14D, Easter Island, Mokapu, and Buriat (Figure 4.8).

The associated Distance Analysis classifies UC 101 as Australian and UC 103 as Tolai. Distances, posterior probabilities, and typicality probabilities are shown in Table 4.1.

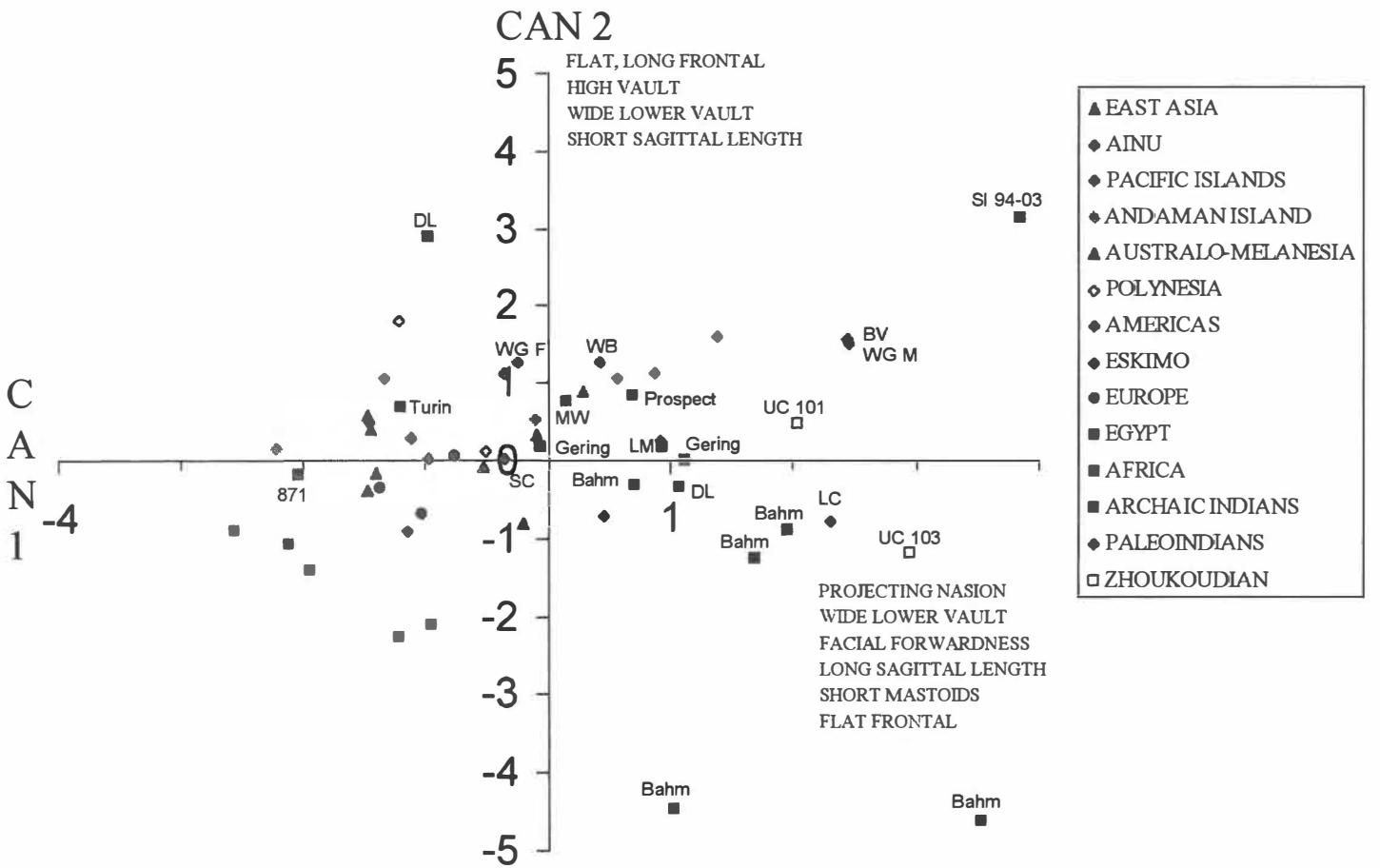


Figure 4.7: CVA 4

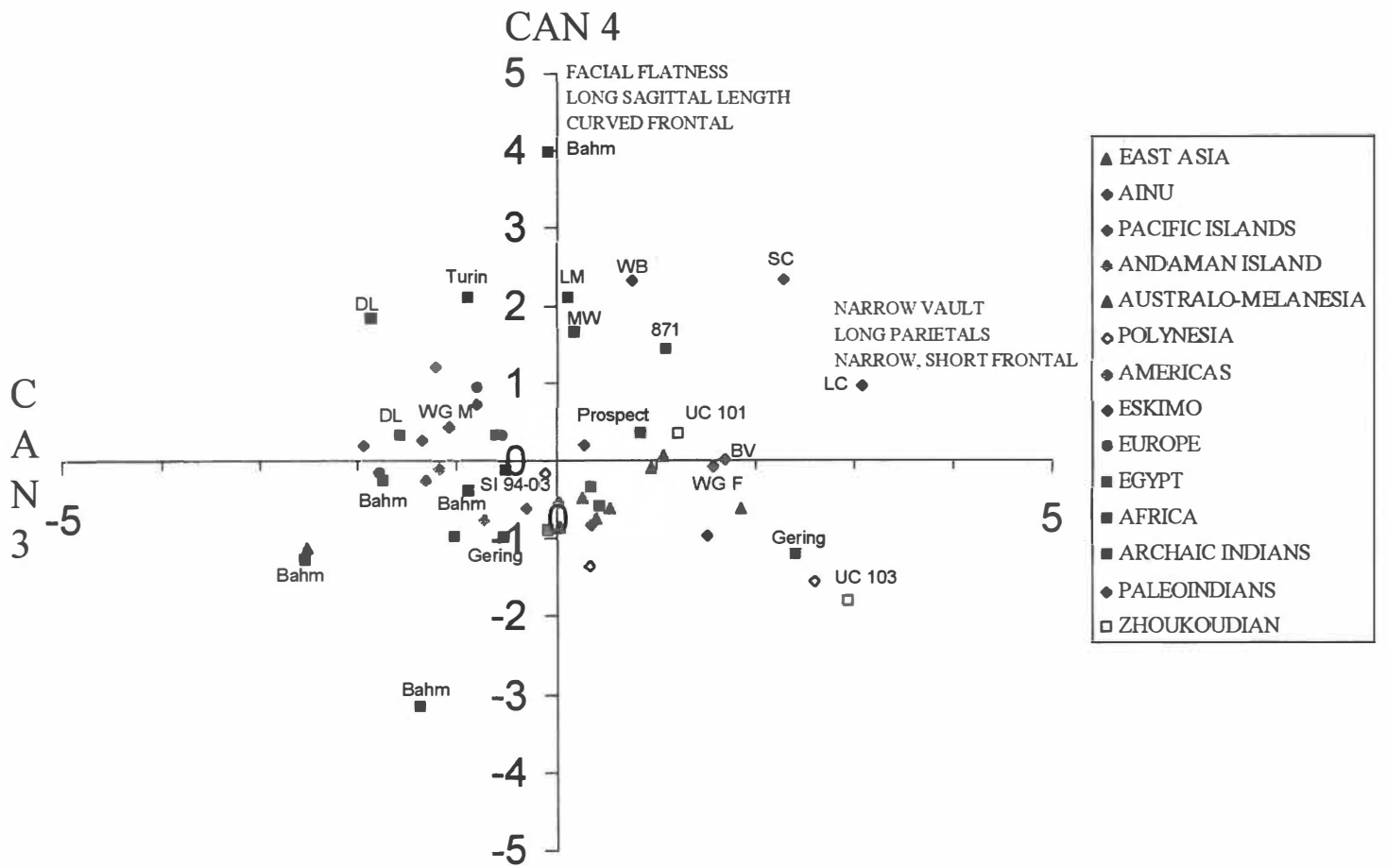


Figure 4.8: CVA 4

CHAPTER V
DISCUSSION

The relationship of UC 101 and UC 103

First of all, it is important to note that UC 101 and UC 103 are almost always widely separated on all canonical variates, although it has been stated that they have many morphological features in common (Wu, 1961). The closest they come to each other is in CVA 3 which reflects mainly facial and a few vault dimensions (Figure 4.5). If they truly are contemporaneous, it is interesting that they are so divergent. As I discussed in Chapter I, in Weidenreich's (1938/1939:170-171) initial interpretation of the fossils, he described UC 101 as "primitive Mongoloid", UC 102 as "Melanesoid", and UC 103 as "Eskimoid" racial types. While his actual typology may be questionable, he was correctly observing the amount of variation present in Asia in the late Upper Pleistocene. Ancient East Asians, represented in this study by UC 101 and UC 103, exhibit much more variation than modern populations, as can be seen in the canonical plots in Chapter 4.

Another possibility is that the two fossils were not contemporaneous as Weidenreich (1938/39; 1939) believed. In order to evaluate their differences, I performed a Distance Analysis between UC 101 and UC 103. The expected distance between two skulls drawn at random from the same modern population is 10.392 with a variance and standard deviation of one. The distance between the two fossil skulls is 14.291 which is quite a bit larger than expected, if one assumes that their Pleistocene population exhibits the same amount of internal variation as modern populations do. This indicates that these two specimens may represent separate burial events and separate populations. However,

this seems unlikely given the archaeological details that are known about the Zhoukoudian Upper Cave, i.e., that all the fossils were found on the same level (Bei, 1934; 1939).

Ancestor-descendant relationships

UC 101 and UC 103 likely represent the robust ancestors of several modern, more homogenous groups. While UC 101 is classified as Easter Island in the Distance Analysis (Table 4.1), its similarities to European, Eskimo, African, and Archaic Indian populations can be seen in the CVA plots. It also shows some similarities to Peru and Buriat populations. It is likely that the European tendencies show up so consistently because UC 101 is actually part of the modern European ancestral stock present in Eurasia, and the relatively high amount of gene flow that occurred in Eurasia allowed for the retention of traits present in the Pleistocene. However, the ancestors of the modern Polynesians were also present in East Asia at this time, and since they became more geographically restricted than the Europeans did, evolutionary factors such as limited gene flow and the presence of genetic drift allowed for the fairly rapid development of the derived Polynesian morphology.

UC 101's affiliations with Howells' (1973; 1989) Eskimo population can also be explained in terms of ancestor-descendant relationships. When the ancestors of the Eskimos crossed Beringia, they likely included members of this highly variable Pleistocene population present in Zhoukoudian. However, UC 101's alliance with Archaic Indians is more difficult to explain, especially since the fossil has a lack of resemblance to any

Paleoindians. If UC 101 is representative of the ancestors of the Paleoindians, which I think is likely, it is possible that reversals or parallelisms are coming into play here.

UC 101's African affiliations are harder to explain. Likely, environmental or unknown factors are responsible for this association, or pure coincidence. As discussed below, this alliance does not give strong support to the Out-of-Africa theory of modern human origins.

UC 103, on the other hand, is much more of an outlier to modern populations than the Old Man is. Although the unrestricted CVA allies this fossil most closely with Archaic Indians, the Lime Creek Paleoindian, and Easter Island, the Distance Analysis consistently classifies it as Australo-Melanesian (Table 4.1). Frequently, its closest neighbors on the graphs are the Australo-Melanesian populations. However, UC 103's position as an outlier, combined with its extremely low typicality probabilities, indicate that this specimen is outside the range of variation present in the modern populations utilized in this thesis.

I initially expected both fossils to resemble Paleoindians, assuming that they represented the ancestors of those who crossed Beringia. I still think this is likely the case, but the 10,000 year time difference between the Zhoukoudian fossils and the Paleoindians analyzed here allows for the rapid differentiation of the Paleoindian morphology. It is interesting to note, however, that both fossils ally themselves with Archaic Indians regularly. If the previously accepted terminal Pleistocene/early Holocene dates for the Upper Cave crania (Kamminga and Wright, 1988; Kamminga, 1992) are actually correct, the explanation for this phenomenon could be that the fossils and the

Archaic Indians present in North America beginning roughly 8,000 B.P. diverged from the same ancestral population; some crossed Beringia approximately 15,000 B.P. while some remained in East Asia. This seems unlikely given the relative certainty of the 24 to 29 ka date range given by Hedges et al. (1992). Presumably, the morphometric similarity is due to chance or reversal.

Many authors (Wu, 1961; Coon, 1962; Wolpoff, 1996) associate the Zhoukoudian fossils with modern East Asians. Little support for this position is found from these results, although UC 101 does cluster close to Buriat in four charts (Figures 4.1, 4.3, 4.4, and 4.5). But, as mentioned above, its affinities to European, Eskimo, African, and Archaic Indian populations seem to override this similarity.

As discussed in Chapter I, other researchers claim the fossils resemble African (Kamminga and Wright, 1988; Wright, 1992; Neves and Pucciarelli, 1998), Australo-Melanesian (Kamminga and Wright, 1988; van Vark and Dijkema, 1988; Wright, 1992; Neves and Pucciarelli, 1998), Polynesian (Kamminga and Wright, 1988; van Vark and Dijkema, 1988; Howells, 1989; Cornell and Jantz, 1997; 1998; Neves and Pucciarelli, 1998), modern Amerindian (van Vark and Dijkema, 1988; Howells, 1995; Cornell and Jantz, 1997), European (Kamminga and Wright, 1988; van Vark and Dijkema, 1988; Cornell and Jantz, 1997; 1998), Ainu (Kamminga and Wright, 1988; van Vark and Dijkema, 1988), and Paleoindian (Neves and Pucciarelli, 1998) populations. The research conducted here sheds some light on why the fossils classify so differently so often. These

two fossils are truly "all over the board" in these CVAs, leading me to believe that they truly do not represent *any* population to which they have been compared.

In the Distance Analyses, UC 101 has much larger typicality probabilities associated with its ethnic classification than UC 103 does (Table 4.1). UC 101 could actually fall within the range of variation of those populations. It is much more typical of modern populations than UC 103 is. UC 103's typicality probabilities indicate that it is very unlikely that it actually could be a member of the Australo-Melanesian groups into which it is forced. Although these robust groups are its nearest neighbors, UC 103 is mostly outside the range of variation for these populations. However, in CVA 4, which consists of fifteen vault measurements, both fossils are classified as Australo-Melanesian with relatively high typicality probabilities. Obviously, more similarities between the Zhoukoudian fossils and the Australo-Melanesians lie in the vault than in the face. Most likely, this is a reflection of the general robusticity of the neurocranium that is present in the fossils as well as the modern Australo-Melanesians. This is supported by Lahr and Wright's (1996) findings that Australian cranial morphology is an outlier among modern groups.

The Zhoukoudian Upper Cave fossils and implications for theories of modern human origins

Contrary to Wright's (1992) assertion that UC 101's and UC 103's resemblance to African and Australo-Melanesian crania gives credence to the Out-of-Africa theory of modern human origins, the time depth involved seems to preclude any such inference. The

time difference of approximately 175,000 years seems unreasonably long for the fossils to retain any significant African features, even if modern humans did leave Africa 200,000 years ago as is postulated by the Out-of-Africa model. While there has probably always been some gene flow between Africa and East Asia, it most likely was not significant enough throughout the 175,000 years to prevent differentiation of these widely dispersed groups, especially considering there were major environmental differences. The Pacific Islands can be used as an example of the rapid differentiation that can occur. According to Brace and Tracer (1992:458, Fig. 26.6), these islands were populated by the people of the "Jomon Pacific Cluster" who left the mainland around 12,500 B.P. At 4,000 B.P., the descendants of this cluster split into three groups, populating Melanesia by 4,000 B.P., Hawaii and Easter Island by 1,500 B.P., and New Zealand by 1,200 B.P. This indicates rather rapid morphological differentiation between these three offshoots from the same ancestral population. This is evident as Howells (1989) has no problem differentiating these populations from each other. I concede that island populations are more isolated geographically and therefore genetically than the Upper Cave individuals were, but this kind of rapid regional differentiation can be seen in modern populations all over the world.

On the other hand, the findings presented here also give no support to the Multiregional Model of modern human origins. Since no close affiliation is seen between these two fossils and modern East Asians, regional continuity from the Pleistocene to today in that area cannot be argued for on the basis of my findings. However, as stated above, the Pleistocene population of East Asia was much more heterogeneous than

today's populations, leaving open the very real possibility that the Zhoukoudian fossils are actually ancestral to modern East Asians.

Conclusions

While I expected the findings to support Cornell and Jantz's (1997) assertion that the robust ancestors of Pacific and Amerindian populations were present in East Asia 25,000 years ago, stronger support for this could be garnered by the fossils' overriding resemblance to Paleoindian cranial morphology. However, numerous studies have shown the resemblance of Paleoindians from North and South America to South Pacific modern populations (Neves and Pucciarelli, 1989, 1991; Steele and Powell, 1992, 1993, 1994; Neves *et al*, 1993; Powell and Steele, 1993; Munford *et al.*, 1995; Neves *et al.*, 1996). These results are supported by the findings of this thesis which indicate that, 25,000 years ago, East Asia was inhabited by people morphologically similar to modern Polynesians and Australo-Melanesians. This also attests to a short time depth for modern East Asian morphology. However, the Mahalanobis Distance Analyses of the Paleoindian crania used in this study (Appendix C) classify the crania most consistently with modern Amerindian groups. Once again, it is the fourth analysis, consisting of mainly vault measurements, in which affiliations to South Pacific modern populations are manifested.

What seems to be clear from these findings is that the Zhoukoudian Upper Cave fossils, if actually contemporaneous, depict more variability than is present in modern populations, and do not closely cluster with any modern group to which they have been

compared. The morphological variability present in the Asian Pleistocene needs to be fully appreciated in order to adequately assess Pleistocene hominid fossil affinities.

A reassessment of the original archaeological reports from the 1930s seems to be necessary in order to adequately assess the possibility that UC 101 and UC 103 actually represent separate burial events. However, until that assessment is performed, it will be difficult to state confidently that the two fossils are individuals from different populations, although I think that is likely the case. Therefore, the interpretation must be one of great morphological variability in the Asian Pleistocene.

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APPENDICES

APPENDIX A: Howells' (1973; 1989) Measurements

SHORT NAME	DESCRIPTION	SHORT NAME	DESCRIPTION
GOL	Glabello-Occipital Length	DKB	Interorbital Breadth
NOL	Nasio-Occipital Length	NDS	Naso-Dacryal Subtense
BNL	Basion-Nasion Length	WNB	Simotic Chord
BBH	Basion-Bregma Height	SIS	Simotic Subtense
XCB	Maximum Cranial Breadth	IML	Malar Length Inferior
XFB	Maximum Frontal Breadth	XML	Malar Length Maximum
STB	Bistephanic Breadth	MLS	Malar Subtense
ZYB	Bizygomatic Breadth	WMH	Cheek Height
AUB	Biauricular Breadth	FOL	Foramen Magnum Length
WCB	Minimum Cranial Breadth	FRS	Nasion-Bregma Subtense
ASB	Biasterionic Breadth	FRF	Nasion-Subtense Fraction
BPL	Basion-Prosthion Length	PAC	Bregma-Lambda Chord
NPH	Nasion-Prosthion Length	PAS	Bregma-Lambda Subtense
NLH	Nasal Height	PAF	Bregma-Subtense Fraction
OBH	Orbit Height Left	OCC	Lambda-Opisthion Chord
OBB	Orbit Breadth Left	OCS	Lambda-Opisthion Subtense
JUB	Bijugal Breadth	OCF	Lambda-Opisthion Fraction
NLB	Nasal Breadth	VRR	Vertex Radius
MAB	Palate Breadth	NAR	Nasion Radius
MDH	Mastoid Height	SSR	Subspinale Radius
MDB	Mastoid Width	PRR	Prosthion Radius
ZMB	Bimaxillary Breadth	DKR	Dacryon Radius
SSS	Zygomaxillary Subtense	ZOR	Zygoorbitale Radius
FMB	Bifrontal Breadth	FMR	Frontomalare Radius
NAS	Nasio-Frontal Subtense	EKR	Ectoconchion Radius
EKB	Biorbital Breadth	ZMR	Zygomaxillare Radius
DKS	Dacryon Subtense	AVR	M1 Alveolus Radius

APPENDIX B: Canonical Loadings

Table B-1: CVA 1 Canonical Loadings

CAN 1		CAN 2		CAN 3		CAN 4	
NDS	-0.683	ZMB	0.654	JUB	0.667	BNL	-0.488
VRR	0.624	IML	-0.575	OCC	-0.473	JUB	-0.462
FRC	0.599	NDS	-0.482	FMB	0.37	FOL	-0.425
MLS	0.583	MDB	0.431	BNL	-0.369	MDH	0.373
AUB	-0.571	FMB	-0.43	NLB	-0.355	OCF	0.361
SIS	-0.561	SSS	-0.408	FRS	-0.321	OCS	0.338
OCF	0.543	PAS	-0.403	WCB	0.321	EKR	-0.335
NLB	0.542			PAS	0.312	DKS	0.332
MDH	0.52			ZOR	-0.305	IML	-0.324
BBH	0.498			BPL	-0.301	WMH	-0.323
STB	0.497						
PAS	0.473						
SSR	-0.465						
SSS	-0.461						
NLH	-0.45						
PAC	0.449						
MDB	0.424						

APPENDIX B (Continued)

Table B-2: CVA 2 Canonical Loadings

CAN 1		CAN 2		CAN 3		CAN 4	
NDS	-0.759	ZMB	-0.689	JUB	-0.695	BNL	-0.661
FRC	0.618	IML	0.612	FMB	-0.421	BPL	-0.528
AUB	-0.593	XCB	-0.478	OCC	0.419	PAF	-0.527
MDH	0.559	NDS	0.444	PAS	-0.393	FOL	-0.499
MLS	0.546	PAC	0.424	WCB	-0.34	MDH	0.42
OCF	0.526	FMB	0.415	NLB	0.332	FRS	-0.412
SIS	-0.523	PAS	0.413	XML	0.32	NOL	-0.403
NLH	-0.514					SIS	0.399
NLB	0.506					EKB	-0.375
STB	0.485					BBH	-0.374
SSS	-0.474					IML	-0.366
MDB	0.439					PAC	-0.359
PAC	0.432					OCF	0.344
BBH	0.415					JUB	-0.343
FRS	0.41					GOL	-0.335

APPENDIX B (Continued)

Table B-3: CVA 3 Canonical Loadings

CAN 1		CAN 2		CAN 3		CAN 4	
AUB	-0.695	FRS	0.577	SSR	-0.538	JUB	0.587
PAS	0.586	NLB	0.498	FMB	-0.412	GOL	-0.521
NAR	-0.541	EKR	-0.437	WMH	0.397	ZMR	-0.513
ZOR	-0.504	JUB	-0.376	PRR	-0.364	NOL	-0.459
WMH	-0.5	NAR	-0.36	JUB	-0.361	PAC	-0.428
NPH	-0.489	MDB	-0.329	XCB	0.309	ZOR	-0.427
SSR	-0.482	AUB	-0.3	FRS	0.306	PRR	-0.421
PAC	0.475					NPH	0.387
NLH	-0.458					XCB	0.343
MDH	0.456					FRC	0.325
FRC	0.449						
FMB	0.436						

APPENDIX B (Continued)

Table B-4: CVA 4 Canonical Loadings

CAN 1		CAN 2		CAN 3		CAN 4	
NAR	0.802	FRS	-0.582	XCB	-0.844	FMR	-0.52
AUB	0.754	FRC	0.567	PAC	0.646	NOL	0.387
FMR	0.746	VRR	0.469	XFB	-0.616	FRS	-0.376
GOL	0.565	AUB	0.327	AUB	-0.39	GOL	0.363
MDH	-0.563	NOL	-0.325	FRC	-0.316		
NOL	0.505						
FRS	-0.432						

APPENDIX C: Distance Analyses of Paleoindians

ANALYSIS	PALEOINDIAN	CLASSIFICATION	SQUARED DISTANCE	TYP. PROB.	POST. PROB.
1	WIZARD'S BEACH	BLACKFOOT	73.58	0.048	0.8628
	WET GRAVEL F	HAINAN	51.478	0.61	0.7558
	WET GRAVEL M	BLACKFOOT	80.984	0.013	0.6909
	LIME CREEK	ESKIMO	89.594	0.002	0.9987
2	WIZARD'S BEACH	PAWNEE	60.044	0.066	0.7583
	WET GRAVEL F	HAINAN	40.668	0.656	0.597
	WET GRAVEL M	PAWNEE	66.477	0.02	0.7861
	LIME CREEK	ESKIMO	75.555	0.003	0.8678
3	WIZARD'S BEACH	BLACKFOOT	29.361	0.694	0.6485
	WET GRAVEL F	HAINAN	31.036	0.614	0.8183
	WET GRAVEL M	BLACKFOOT	25.291	0.86	0.6648
	LIME CREEK	ESKIMO	51.21	0.029	0.6837
	SPIRIT CAVE	NORSE	45.043	0.098	0.8238
	BROWN'S VALLEY	MOKAPU	74.15	<0.001	0.8748
4	WIZARD'S BEACH	PERU	12.534	0.638	0.617
	WET GRAVEL F	MOKAPU	10.459	0.79	0.2347
	WET GRAVEL M	PAWNEE	7.637	0.938	0.5367
	LIME CREEK	TOLAI	29.256	0.191	0.5066
	SPIRIT CAVE	TOLAI	18.229	0.251	0.2917
	BROWN'S VALLEY	ESKIMO	15.383	0.424	0.2998

APPENDIX D: Distance Analyses of Archaic Indians

ANALYSIS	ARCHAIC INDIAN	CLASSIFICATION	SQUARED DISTANCE	TYP. PROB.	POST. PROB.
1	#1	PERU	59.611	0.312	0.548
	11-110	PAWNEE	57.35	0.388	0.949
	4-14D	BLACKFOOT	163.874	<0.001	0.956
	5-15E	BLACKFOOT	119.789	<0.001	0.899
	6-16F	ARIKARA	39.746	0.94	0.872
	8-18H	BLACKFOOT	120.072	<0.001	0.86
	852	ARIKARA	152.424	<0.001	0.661
	871	ZALAVAR	50.166	0.659	0.985
	B137	SANTA CRUZ	56.354	0.424	0.934
	B3138	ARIKARA	56.36	0.424	0.455
	SI94-03	CHEYENNE	128.367	<0.001	0.754
	1B854	SANTA CRUZ	76.573	0.029	0.331
	2-12B	ARIKARA	60.799	0.275	0.414
2	#1	PERU	39.884	0.688	0.879
	11-110	PAWNEE	46.394	0.415	0.859
	4-14D	BLACKFOOT	147.881	<0.001	0.495
	5-15E	BLACKFOOT	95.089	<0.001	0.979
	6-16F	ARIKARA	35.353	0.848	0.44
	8-18H	BLACKFOOT	42.218	0.59	0.979
	852	PAWNEE	138.787	<0.001	0.889
	871	ZALAVAR	40.123	0.678	0.987
	B137	SANTA CRUZ	38.859	0.728	0.982
	B3138	ARIKARA	44.643	0.487	0.761
	SI94-03	CHEYENNE	116.082	<0.001	0.68
	1B854	CHEYENNE	52.823	0.198	0.291
	2-12B	ARIKARA	50.413	0.268	0.318
3	#1	NORSE	34.384	0.449	0.455
	11-110	PAWNEE	27.871	0.761	0.573
	4-14D	AINU	99.173	<0.001	0.977
	5-15E	BLACKFOOT	76.324	<0.001	0.627
	6-16F	NORSE	25.482	0.854	0.31
	8-18H	BLACKFOOT	89.112	<0.001	0.881
	852	ARIKARA	75.353	<0.001	0.563
	871	ZALAVAR	35.518	0.397	0.643
	B137	SANTA CRUZ	41.402	0.179	0.878
	B3138	MORIORI	29.611	0.683	0.257
	SI94-03	PAWNEE	51.117	0.03	0.505
	1B854	AUSTRALIA	40.569	0.203	0.612
	2-12B	ARIKARA	31.237	0.604	0.798
	MW	S. JAPAN	84.309	<0.001	0.421

APPENDIX D (Continued)

ANALYSIS	ARCHAIC INDIAN	CLASSIFICATION	SQUARED DISTANCE	TYP. PROB.	POST. PROB.
4	#1	NORSE	14.607	0.48	0.415
	11-110	ATAYAL	12.7	0.625	0.195
	4-14D	BLACKFOOT	38.05	<0.001	0.437
	5-15E	AINU	40.04	<0.001	0.651
	6-16F	BLACKFOOT	14.3	0.503	0.369
	8-18H	BLACKFOOT	20.18	0.165	0.439
	852	ZALAVAR	9.455	0.853	0.31
	B137	SANTA CRUZ	10.366	0.796	0.799
	B3138	MORIORI	9.472	0.852	0.281
	SI94--03	PAWNEE	19.219	0.204	0.865
	1B854	TOLAI	16.822	0.33	0.429
	2-12B	CHEYENNE	9.967	0.822	0.455
	MW	BLACKFOOT	16.592	0.344	0.291
	LM	SANTA CRUZ	16.683	0.338	0.414

VITA

Deborah Lenz Cunningham Cornell was born in South Florida where she grew up and attended Fort Lauderdale High School. She moved to Boone, North Carolina in 1987 to attend Appalachian State University. In 1991 she received a Bachelor of Arts degree with a major in Anthropology and a minor in History. After taking a few years off from school, she moved to Maryville, Tennessee and attended the University of Tennessee, Knoxville. She received a Master of Arts degree in December, 1998 with a major in Anthropology and a minor in Statistics.

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