TIERRA DEL FUEGIANS:

COMPARATIVE STUDY OF FRONTAL BONE MORPHOLOGY

An Undergraduate Research Scholars Thesis

By

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ABSTRACT

Tierra del Fuegians: Comparative Study of Frontal Bone Morphology. (May 2014)

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There exists a large disagreement among scholars concerning the origin of the Tierra del Fuegian (TDF) population of South America. This population is distinctive because its members possess extremely robust crania compared to other populations of the Americas. Although most anthropologists agree that a northeastern Asian population migrated to the New World, there is still much debate over the origin of modern Native Americans and their relationship to one another. The frontal bone has been proved to provide valuable information indicating morphological and, by inference, genetic differences among populations. This study seeks to determine if variation in TDF frontal bone morphology lies outside the range of variation of other New World populations. Cranial outlines of adult males and females were collected from Point Hope, Labrador, the North American Southwest and Northeast, California, Mexico, Peru, Central and South America, Australia, Polynesia and Tierra del Fuego. The midsagittal (nasion to bregma) outline was taken using a modified pantograph designed by Dr. Sheela Athreya. The outlines were then digitized and analyzed using Procrustes analysis. If the frontal bones exhibit similar enough characteristics independent of size, then it will support the hypothesis that Tierra del Fuegians and other Native American populations are descendent from the same migratory population.

DEDICATION

I wish to dedicate this thesis to my wonderful husband and family. Your love and support have enabled me to go further in life than I thought I would ever go.

ACKOWNLEDGEMENTS

Firstly, I would like to thank Dr. Sheela Athreya for serving as my adviser during this project. Her guidance and instruction have been invaluable resources without which this project would not have been possible. I would also like to extend my thanks to the staff at the American Museum of Natural History and Harvard's Peabody Museum for their time and assistance. Additionally, I would like to thank Texas A&M University's Department of Anthropology for awarding me research scholarships that enabled my plans to become a reality.

CHAPTER I

INTRODUCTION

There is a broad consensus among scientists that the New World was peopled by a Northeast Asian population which crossed from Asia to Alaska by the Bering Land Bridge. However, there are different perspectives on when and how many populations migrated. One theory holds that all Native American populations are descendent from a single ancestral group of Northeastern Asians and that all phenotypic differences between Native American populations reflect microevolutionary processes such as gene flow, genetic drift or biomechanical adaptations (Jose et al 2002; Neves, Hubbe 2005; Powell, Neves 1999). A second school of thought believes that phenotypic variation between Native American populations is so substantial that it could only be explained by waves of migration from a series of different founding populations (Jose et al 2002; Neves, Hubbe 2005; Powell, Neves 1999). One example of this extreme case of variation can be found in the Tierra del Fuegian TDF population of southern South America. The overall cranial robusticity of this population is far greater than any other Native American population (Hernadez et al 1997).

Tierra del Fuego is the southern-most region of South America, a part of what is now modern day Chile. Tierra del Fuego was first colonized by humans in the late Pleistocene era (Salemme, Moitti 2008). The first colonists of this region migrated there by way of the Magellan Straits; however, once marine waters flooded the glacier, the island that is now known as Isla Grande de Tierra del Fuego was formed, and the population remained mostly isolated until European contact (Bentley et al 2005; Hernandez et al 1997). These first colonists were welcomed into the region by a very arid and cold environment (Salemme, Miotti 2008). The Tierra del Fuegians did not shy away from these extreme conditions, however. They were known to submerge themselves in icy cold water to hunt marine animals for food and wore very little clothing (Hernandez et al 1997).

Previous genetic studies have indicated that the Tierra del Fuegians originated from the same founding population as the rest of the Amerindians, although they separated quickly afterwards (García-Bour et al 2004). The unique frontal bone morphology of the Tierra del Fuegians could then be attributed to a combination of retention of Pleistocene features and an adaptation to their cold environment rather than to preservation of the features of a separate and distinct founding population from other Amerindian populations.

The object of this study is to determine if the cranial robusticity of the TDF population differs significantly from other Native American populations. Specifically, I will focus on the frontal bone, which has been shown to reflect genetic relationships between populations (Roseman 2004). This study focuses on the frontal bone morphology of approximately twenty representative males and females from populations spanning the Americas, Polynesia and Austrialia. Here, I will explore the affinity of the TDF relative to other New World populations. Phenotypic differences within the frontal bone are examined and used to establish if the robust morphology of TDF crania significantly differ from other Native American populations. I predict that the TDF frontal bone will vary significantly from all American populations excluding the populations of Point Hope and Labrador. I will fail to reject my hypothesis if the majority of the principle components used in the Point Hope and Labrador populations differ significantly from the Tierra del Fuegians.

CHAPTER II

METHODS

Frontal outlines were collected from eight populations from North America, Central America, South America and a single representative sample from Polynesia. Additionally, cranial outlines collected by Sheela Athreya of populations from Tierra del Fuego and Australia were used in this study. Individuals were pre-contact, meaning that they died prior to European contact. This was done in order to insure that phenotype differences were not the result of European admixture. The periods of the collections available had been determined by previous research, and those records were available at the museum where the remains were located. Only individuals who had been previously sexed and aged by a museum representative were included in this study. No frontal outlines were collected from subadults or unsexed individuals.

Sample

The American populations included Point Hope, Labrador, the Southeastern USA (Ohio & Tennessee), California, Southwestern Colorado, Mexico, Peru, and South America (Argentina & Brazil). Point Hope is located on the western tip of Alaska. 21 males and 20 females were collected from this population. Two male individuals and three female individuals were from the Norton period (1000 BCE -800 BP). Nineteen males and 17 females were from the Ipiutak period (700-1200 BP). The area of the Southeastern US is represented by individuals from Ohio and Tennessee. 10 males and 10 females were from Ohio. All of these were collected from the Fort Ancient site, excluding one male individual from the Turpin site. Likewise, 10 males and 10 females were collected from Tennessee and were dated to be from the Mississippian period, but the specific sites of their origin were not recorded in museum recorded. Eleven females and 10 males were collected from Colorado. All were from the Basketmaker III period (AD 500-750) in La Plata County. Twenty males and 20 females were also collected from California. The sites from which the individuals were found include Battlefield California, Santa Catalina, Triburon Island, San Nicholas Island, Santa Barbara, Mill Valley, Lompoc, Avila San Louis, San Miguel Island, Point Mago, San Clement Island, and San Joaquin county. Unfortunately, unprofessional circus travelers dug many of these individuals up, and their exact geological age could not be determined. All individuals were found in burials that suggest that they were pre-contact, but the possibility that they are not does exist.

The museums did not have specific exact geological age available for the following populations but the curators of the museums housing the remains did believe that they were pre-contact based upon the information available in the museum's archives concerning the context of their burials, location and recoveries.

Labrador is located on the Northeastern part of Canada near Newfoundland. Fifteen females and 8 males were collected from this population originating from the sites at Okkak Island, Hebron, Semburges, Cape Mugford and the northern and western extremity of Labrador. Twenty males and 20 females were collected from Mexico from the regions of Huichol, San Andres Jatisco, Northern Mexico,Tarahumara Mexico, Tarasco, and Zacape. Twenty females and 20 males were collected to represent the Peruvian sample from the Lima Region/Llacta Highlands, Peru Punkuaiki Highlands, Orkulla Highlands, and Pukutay. The South American sample is composed of individuals from both Argentina and Brazil. Nine males and 5 females were collected from the Argentinian population. All of the females were from the Patagonia region, and all but one of the males was from the Patagonia region as well. Additionally, 2 males and 1 female were collected from Brazil from Linguodo River, Tapajos River, and Minuan site.

The Polynesian sample was composed of individuals from the Marquesas, Tahiti, Easter Island, the Cook Islands, and the Solomon Islands. Thirteen males and 2 females from Marquesas, 11 females and 1 male from Tahiti, 7 females and 6 males from Easter Island, 2 males from Cook Islands, and 2 males from Solomon islands.

Individuals from each population, excluding the 20 pre-contact Tierra del Fuegians and 40 Australian Aborigines formally collected by Sheela Athreya, were selected from the collections at the American Museum of Natural History and Harvard's Peabody Museum. Cranial outlines were not collected from crania that had been culturally modified, had a poorly preserved frontal, were that of a subadult, or remained unsexed.

Data Collection

Each cranium was placed on a donut lying with its right side facing downward. The Frankfurt Horizontal plane was parallel to the surface of the table. When poor preservation was present on the left side, an outline was taken from the right side of the individual. If the orbit or external auditory meatus were damaged, the Frankfurt Horizontal plane was estimated. An outline of the midsagittal frontal bone was collected using a modified pantograph designed by Sheela Athreya. The placement of the outlines was determined by using calipers to measure the distance from the point of minimum breadth from behind one orbit to the other. The wand of the pantograph was aligned to be parallel with the Frankfort horizontal. The outline began at nasion, passed over and marked glabella by moving the pen up perpendicularly to the outline and creating a vertical line extending form the outline and ended at bregma.

A straight baseline stretching across from nasion (the beginning of the curve) to bregma (the end of the curve) was drawn to close each outline. The length of the baseline was then recorded in millimeters using digital calipers. The closed midsagittal outlines were then scanned into the computer. Using tpsDig2, a geometric morphometric analysis program, the outlines were then digitized using 20 equidistance points (landmarks), which fell along the curve of the original outline. Each outline was scaled by the length of the baseline.

Outlines were then analyzed using Procrustes analysis in PAST to generate Procrustes-transformed x-y coordinates. A Principal Components Analysis (PCA) was also performed in PAST. The PCA test was performed in order to determine what percentage of the variation each of the 20 landmarks was responsible for the among populations. The results of this test revealed that roughly 93% of the variance between populations was concentrated in the first 4 principal components, so all of the other remaining components were eliminated from further statistical analysis, because their contribution to the overall variance was negligible. Component 1 was eliminated since it is associated with size, and the interest here was primarily shape differences. An analysis of variance (ANOVA) was performed using the populations as the independent variable and values of principle components 2, 3 and 4 as the dependent variables, along with a Hochberg's GT2 post-hoc test with a significance level of $p < .05$ to look at pairwise comparisons of populations and see which differed significantly in regards to components 2, 3 and 4.

CHAPTER III

RESULTS

The ANOVA and post-hoc tests showed that the TDF were significantly different from all of the populations excluding Australia, Point Hope, South West Colorado and Polynesia by component 2 (Table 1). In regards to component 3, the TDF were significantly different from all populations except Labrador, Point Hope, and South America. In the case of component 4, the TDF were significantly different only from the Southeastern US and Southwestern Colorado (Table 1). Figure 6 describes the relationship between components 2 and 3 in all populations. Figures 1-4 provide a visual aid for the values of components 2 and 3 in Figure 6. They represent what the outline of the frontal would appear to be if it existed at that component's positive or negative extremity. In order to deduce the appearance of an outline located in a particular quadrant, both images for the values of both axes must be considered, and the outline will be a combination of the characteristics displayed in both images.

Figure 1 displays the outline of a frontal bone when both components 2 and 3 are located at the coordinates 0,0. As the value of component 2 decreases, the sulcus and glabella become less pronounced, and the distance between nasion and bregma decreases (Figure 2). As the value of component 2 increases, the glabellar region becomes more pronounced, a defined sulcus develops, the distance from nasion to bregma increases, and the frontal squama becomes less bulging (Figure 3). When the value of component 3 decreases, the distance between nasion and bregma increases, and the browridge becomes less prominent (Figure 4). When the value of component 5 increases, the browridge becomes far more prominent. When the value of component 3 increases, the distance between nasion and bregma decreases and the browridge becomes more prominent, but does not result in a sulcus. The greater portion of within population variance happens along component 2 in the Australian and the Tierra del Fuego population, and both populations have the most inner population variance as compared to the remaining populations (Figure 6).

Table 1. Populations which differed significantly from Tierra del Fuegians in Components 2,3 & 4 (p <. 05)

PCA	POPULATION	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
PCA 2	AUSTRALIA	.0043435041	.0022115575	.934	-.003037395	.011724403
	CALIFORNIA	-.0134084969*	.0022115575	.000	-.020789396	-.006027598
	LABRADOR	-.0125393266*	.0025123885	.000	-.020924226	-.004154427
	MEXICO	-.0122080374*	.0022021665	.000	-.019557595	-.004858480
	PERU	-.0141322918*	.0022115575	.000	-.021513191	-.006751393
	POINTHOPE	-.0072289470	.0022021665	.060	-.014578505	.000120611
	POLYNESIA	-.0015761760	.0021764093	1.000	-.008839771	.005687419
	SEAMERICA	-.0176759056*	.0022213998	.000	-.025089653	-.010262159
	SOUTHAMERICA	-.0131578666*	.0026526559	.000	-.022010897	-.004304836
	SWCOLORADO	-.0071249531	.0024843789	.212	-.015416372	.001166466
PCA 3	AUSTRALIA	.0106166078*	.0023605030	.001	.002738615	.018494601
	CALIFORNIA	.0101045263*	.0023605030	.001	.002226533	.017982520
	LABRADOR	.0054057831	.0026815947	.910	-.003543828	.014355395
	MEXICO	.0094602737*	.0023504796	.004	.001615733	.017304815
	PERU	.0158408271*	.0023605030	.000	.007962834	.023718820
	POINTHOPE	.0022386278	.0023504796	1.000	-.005605913	.010083169
	POLYNESIA	.0118858545*	.0023229877	.000	.004133066	.019638643
	SEAMERICA	.0122499322*	.0023710082	.000	.004336879	.020162986
	SOUTHAMERICA	.0064918509	.0028313090	.702	-.002957420	.015941122
	SWCOLORADO	.0145990977*	.0026516986	.000	.005749262	.023448933
PCA 4	AUSTRALIA	-.0012155623	.0014852846	1.000	-.006172583	.003741458
	CALIFORNIA	-.0001832340	.0014852846	1.000	-.005140255	.004773787
	LABRADOR	-.0025669717	.0016873231	.999	-.008198280	.003064337
	MEXICO	-.0029649978	.0014789776	.916	-.007900969	.001970974
	PERU	.0000145871	.0014852846	1.000	-.004942434	.004971608
	POINTHOPE	.0004617958	.0014789776	1.000	-.004474176	.005397767
	POLYNESIA	-.0041539505	.0014616791	.227	-.009032189	.000724288
	SEAMERICA	-.0056598410*	.0014918947	.010	-.010638922	-.000680760
	SOUTHAMERICA	-.0045912912	.0017815269	.429	-.010536997	.001354415
	SWCOLORADO	-.0055904064*	.0016685118	.048	-.011158933	-.000021879

Based on Figures 1-6, the greater portion of the Tierra del Fuegan sample had a relatively flatter frontal squama, as well as a more prominent browridge. Yet, in general, the sulcus was small. The population that shared a pattern closest to the Tierra del Fuegians was the Point Hope population, although this population did appear to have equal members within a positive component 2 value as a negative one. The Tierra del Fuegians also did not display significant differences from the Polynesian and Australian populations regarding components 2 and 4. In fact, the Tierra del Fuegans varied significantly from only Southwestern Colorado and the Southeastern USA population in regards to component 4.

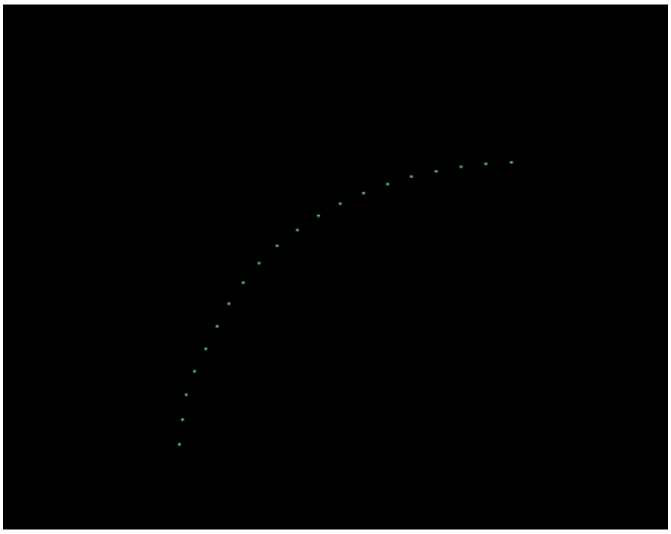

Figure 1. Values of PC 2 and PC 3 are 0

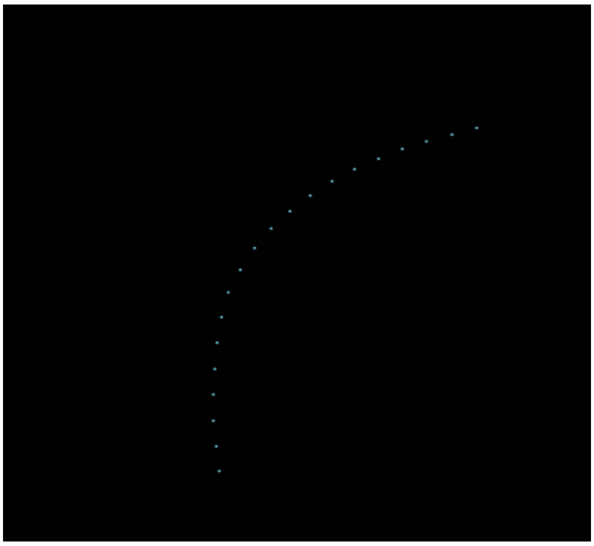

Figure 2. PC 2 Negative Value

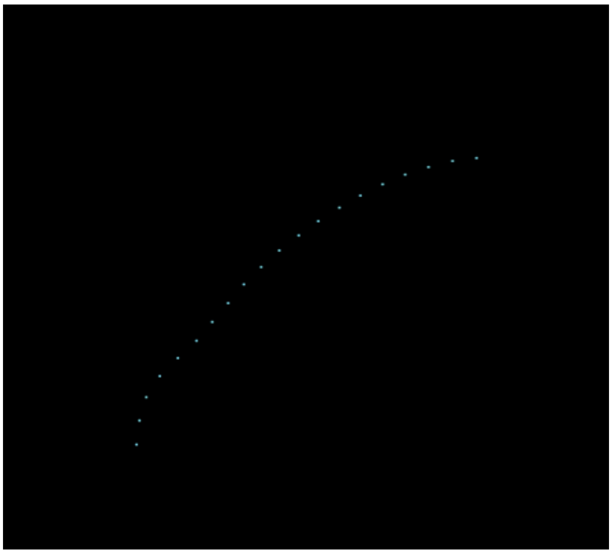

Figure 3. PC 2 Positive Value

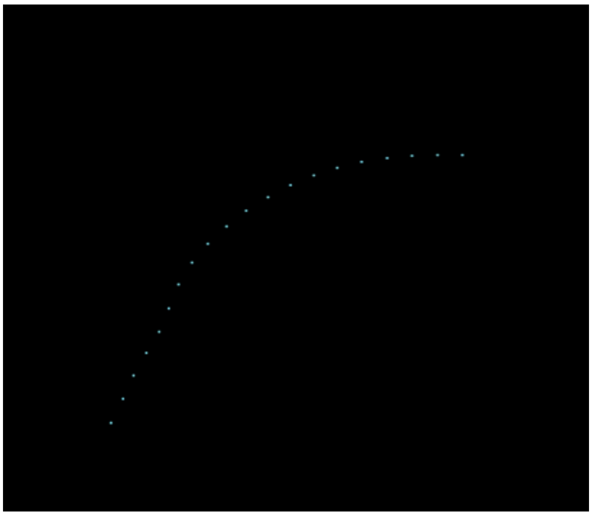

Figure 4. PC 3 Negative Value

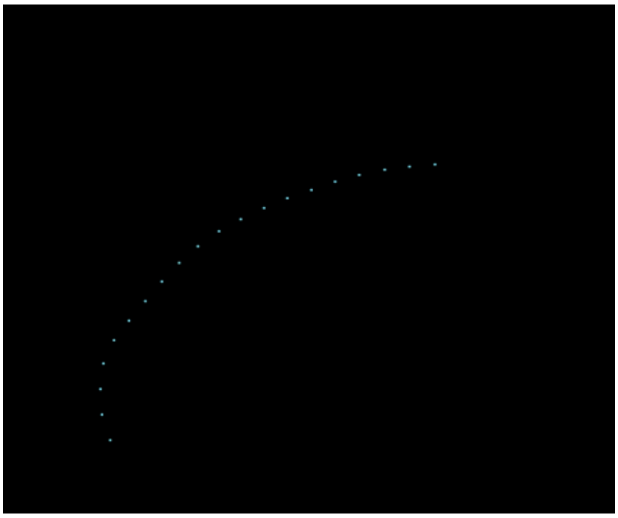

Figure 5. PC 3 Positive Value

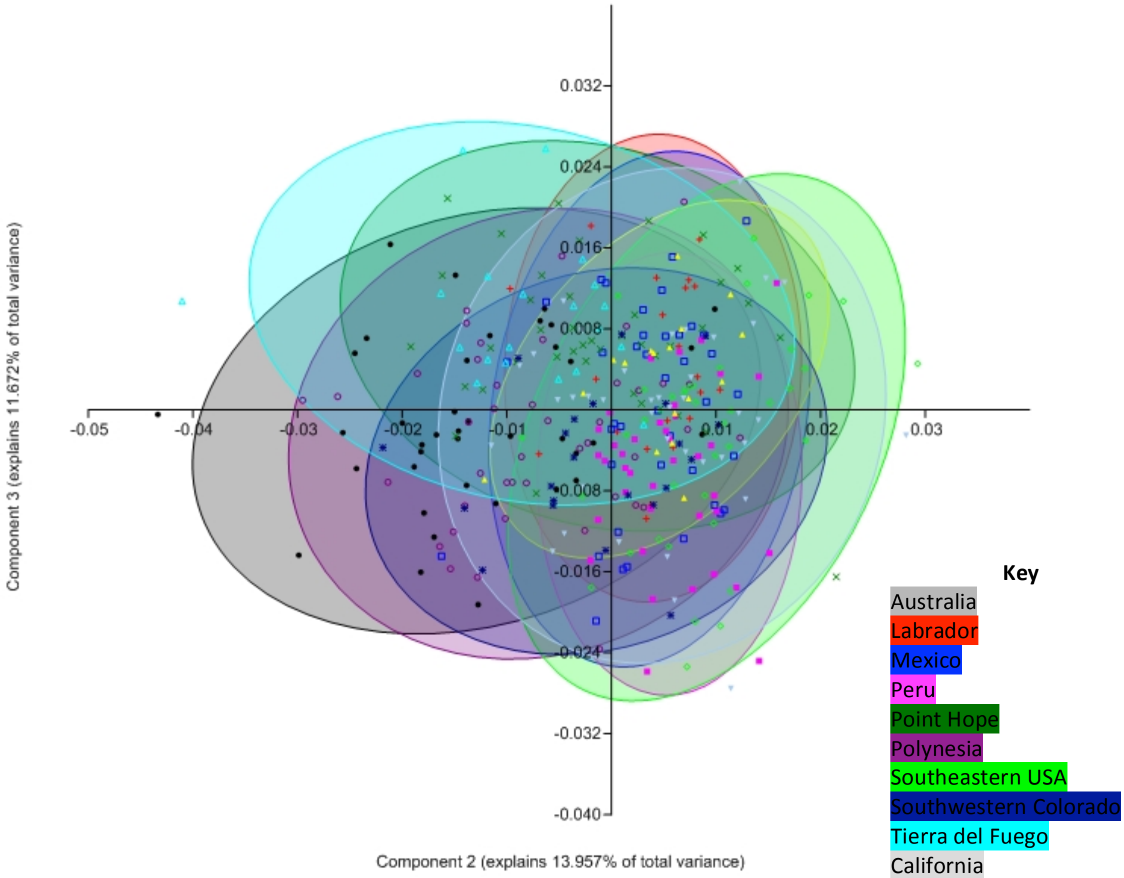

Figure 6. 95% of the range of variation in PC 2 and 3

CHAPTER IV

DISCUSSION

The two American populations with the most similarity to the Tierra del Fuegians were Point Hope and Labrador. Morphologically, the Point Hope and Labrador populations appear to be the closest to the Tierra del Fuegians, as most of their variation fell within the range of variation seen in the Tierra del Fuegians (Figure 6). Tierra del Fuego is a very cold, harsh environment, as are the environments of Point Hope and Labrador. The similar environmental conditions could be responsible for the similarities seen here between these populations. It has been demonstrated that climate can greatly impact the distribution of phenotypic variation across space (Hancock et al 2011). The Pleistocene was also extremely cold, and cranial features that arose because of this would have been retained in populations settling in regions with a similar environment, because of the similar selective pressures acting upon them. However, populations settling in the warmer regions of what is now the USA, Central, and South America would not have the same selective pressures of a cold climate acting upon them, thus allowing more gracile characteristics.

Out of all the populations studied, the Tierra del Fuegians and the Australians possessed the widest range of variation. It has been suggested that the robust cranial features seen in the Australians are because they are descendent from a Pleistocene population from Asia (Curnoe 2007). Additionally, there is a large overlap between the two populations in the first quadrant (Figure 6). Furthermore, these populations also vary in similar ways in that the largest distribution of variation is along component 2 rather than component 3. This is significant in that it shows that individuals within these two populations could have substantial variation between their component 2 values. The features seen in the Tierra del Fuegians could also be the result of this retention of Pleistocene traits as well.

CHAPTER V

CONCLUSION

The initial results of this research appear to provide support for the theory of a single founding population in the New World. However, there still remains room for further research. In addition to the midsagittal outlines that I collected, I also collected parasagittal outlines from each individual. The use of this data would provide a more complete picture of the entire frontal bone rather than just the midsagittal. This could potentially alter the significance of the differences between these populations. This study also fails to account for sexual diamorphism, or the difference between males and females. In the future, it would be valuable to reevaluate this data separating the males and females. This will enable the comparison of the differences between male and female frontal bone morphology within a single population, as well as the differences between a single sex spanning multiple populations. Furthermore, it will allow the observation of differences in the degree of sexual diamorphism across these populations.

In addition to the Australian and Tierra del Fuegian populations, Sheela Athreya collected frontal bone outlines of several Old World populations. It would be very interesting to compare the morphology of the Tierra del Fuegians to other populations around the globe. If my conclusions about the causes of the Tierra del Fuegian robusticity are correct, then other Old World populations inhabiting similar environments could possess similar characteristics.

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