



American Journal of
Physical Anthropology

FUEGUIAN CRANIA AND THE CIRCUM-PACIFIC RIM VARIATION

Journal:	<i>American Journal of Physical Anthropology</i>
Manuscript ID	AJPA-2016-00225.R2
Wiley - Manuscript type:	Research Article
Date Submitted by the Author:	n/a
Complete List of Authors:	Turbon, Daniel; U. of Barcelona, Evolutionary Biology, Ecology and Environmental Sciences Arenas, Conxita; University of Barcelona, Genetics, Microbiology and Statistics Cuadras, Carles ; Universitat de Barcelona Facultat de Biologia, Genetics, Microbiology and Statistics
Key Words:	Fuego-Patagonians, Sexual dimorphism, Discriminant Analysis (LDA), Canonical Variate Analysis (CVA)
Subfield: Please select your first choice in the first field.:	Human biology [living humans; behavior, ecology, physiology, anatomy], Bioarchaeology [including forensics]

SCHOLARONE™
Manuscripts

FUEGUIAN CRANIA
AND THE CIRCUM-PACIFIC RIM VARIATION

D. Turbon^a, C. Arenas^b & C. M. Cuadras^b

^aZoology and Anthropology Section. Dept. of Evolutionary Biology, Ecology and Environmental Sciences Faculty of Biology, University of Barcelona Avda. Diagonal 643, 08028 Barcelona (Spain).

^bDept. of Genetics, Microbiology and Statistics. Faculty of Biology, University of Barcelona Avgda. Diagonal 643, 08028 Barcelona (Spain)

Keywords: Fuego-Patagonians, Discriminant Analysis (LDA), Canonical Variate Analysis (CVA), Mahalanobis distance, Sexual dimorphism.

Corresponding Author: turbon@ub.edu

ABSTRACT

Objectives: The Fueguians are descendants of the first settlers of America, a 'relict' isolated geographically for 10,000 years. We compared their cranial variation with other Americans, and samples from Asia and Australia to know whether the modern extinct Fueguians can be considered Paleoamericans or not.

Materials and Methods: Herein we study 176 Fuego-Patagonian skulls, the largest cranial sample to be studied, refined and well documented, using CVA, and the D² of Mahalanobis. The affinities between populations and sexual dimorphism were jointly studied.

1
2
3
4
5 *Results:* Terrestrial hunters (Selknam) have a different cranial morphology from sea canoeists
6 (Yamana, Alakaluf) particularly with regard to cranial size and robustness. In the American
7 context, there are extreme differences between the canoeists of Santa Cruz (California) and
8 the Eskimos and canoeists of Fuego-Patagonia in terms of cranial size, prognathism and
9 development of the frontal region. Fueguian canoeists are cranially closer to the Californian
10 ones than to their Fueguian neighbours, the Selknam. **Our results favour the hypothesis of**
11 **two different flows for the origin of the first populators of Tierra del Fuego.**
12
13
14
15
16
17
18
19

20
21
22
23 *Discussion:* We concluded that the robusticity of some Fuegians (Selknam) might be the
24 result of an allometric pattern of overall robusticity expression well as a result of epigenetics
25 or differential reproduction (Larsen 2015:264) or hypothetical endocrine changes (Bernal et
26 al. 2006). When compared with three Australian-Melanesian series, the group comprising
27 Amerindians, Ainu and Eskimos clusters together as they are all extremely different from the
28 former in terms of both cranial size and shape.
29
30
31
32
33
34
35
36
37
38
39

40 INTRODUCTION

41
42
43
44
45 The aborigines from Tierra del Fuego, nowadays extinct, play a key role in the under
46 standing of the colonization of the American continent. They lived in the most distant area
47 from the Beringian source, where one of the most ancient archaeological sites of the entire
48 continent has been found, the Monte Verde Chilean site, dated in 12,300 B.P. (Dillehay et al.,
49 2008). The new element in this study is the assessment of the facial-cranial variation of the
50 three Holocenic ethnic groups of Tierra del Fuego-Patagonia, bearing in mind their sexual
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

dimorphism, examined with the same variables for each sex. The human genome is expressed in men and in women, where both sexes are influenced by the genetic inheritance, regulation and gene expression, by the environmental influence and the role of social norms that manage reproductive strategies. These organizational strategies were determined in intra-group relationships of Fueguians, such as the division of labour, taboos and nutritional dictates, etc., and were probably more marked by a volcanic catastrophe, in about 7000 BP, when the Fueguians were already isolated in the Isla Grande (Prieto et al. 2013, Estevez and Vila, 2013).

In this article we do not set out to study archaeological remains, given that remote bio-anthropological and social history is little known and the archaeological sample is scarce and as yet not well dated. Our study focuses on the ethno-historical sample, one of the aims of which is to verify precisely the bio-anthropology of what the ethno-historical sources marked as a characterisation of these populations, and by doing so contribute precisely to resolving the problem.

The Fuegians lived at the extreme tip of South America and were adapted to cold and humid surroundings that were nevertheless very rich in food resources. The Andes divide Patagonia and Tierra del Fuego into two ecosystems. To the south and west there are numerous archipelagos, formed by sunken mountains, that are exposed to very humid winds from the Pacific Ocean. These islands are covered by dense forests in which, in contrast to the coast, there is little animal life. In contrast, to the East, the so-called Isla Grande is covered by forest and extensive, extremely dry steppes, with large grasslands that were previously grazed by guanacos (*Lama guanicoe*) (Rabassa and Coronato 2009).

1
2
3 In the southern and western archipelagos two ethnic groups, namely the Alakaluf (Kaweskar)
4 and Yamana (Yaghan), exploited the marine resources, mainly sea lion and shellfish. The
5 Alakaluf inhabited the Fuegian channels of western Patagonia, between Cabo de Penas and
6 the Strait of Magellan (Gusinde 1982, 1986, 1989, 1991). Some researchers call the latter
7 Chilean zone Fuego-Patagonia. Their physiological adaptations of resistance of the canoeists
8 to low temperatures were already recorded by scientific expeditions in the nineteenth century.
9
10 In Isla Grande, the Selknam (Ona) were land-based hunters who specialised in hunting the
11 guanaco, a Camelidae they hunted with bow and arrow (Yesner et al., 2003). The Fuegian
12 way of life vanished at the beginning of the last century mainly because of intrusive illness,
13 emigration or depletion of food resources under the pressure of European colonisation (Fig.
14 1). [Figure 1 here]

15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30 As noted by several scientific expeditions and can be seen from metric data, photographs and
31 film recordings, the Selknam were tall, burly and strong. Their crania are usually large, solid
32 and heavy (Lebzelter and Gusinde, 1989) (Fig. 2), which contrasts with those of the canoeists
33 (Figs. 3, 4), except for some exceptions resulting from cross-breeding, mainly the
34 *Dawsonians* (South American Missionary Magazine, SAMM, 1867-1919) (Aspillaga and
35 Ocampo 2005, Martinic 1999). [Figures 2, 3 and 4 here] The cranial size and robusticity of
36 the Selknam has attracted the attention of researchers since the nineteenth century, which was
37 when the idea that they pertained to an ancient Humanity, called Australoid (not Australian),
38 that is, vestiges of an ancient *H. sapiens* that had survived on the periphery of the continents
39 before the expansion of current modern Humanity, was first put forward. Cranial robusticity
40 is important because palaeoanthropology reconstructs human past on the basis of bones. As
41 such, the Fuegians were an example of “living fossils” because of their robusticity, their
42 isolation, and their way of living in very harsh surroundings, which could be studied

1
2
3 biologically before their disappearance. Many crania and other skeletal remains were taken to
4
5 all the important American and European museums at the beginning of the 20th century. A
6
7 full summary of the anthropological research work on the settlement of the Southern Cone of
8
9 America **puede hallarse (= se encuentra en) en Gusinde, y posteriormente a este autor**
10
11 **en Pérez et al. (2007).**
12
13

14
15
16 Herein we provide new information about a high sample level of well-conserved Fuegian
17
18 crania, by ethnic group and gender, excluding the deformed cases and analysing the gender
19
20 differences that in terms of the genome and environmental activity have made their mark on
21
22 this valuable scientific material. All these indigenous peoples were decimated upon contact with
23
24 Europeans, leading to their virtual extinction between the turn of the XIX century and the early part
25
26 of the XX. The Patagonians (Aonikenk, Tehuelche) had already vanished during the XVIII and
27
28 XIX centuries and there are no contemporary survivors descended from the Selknam. For this
29
30 reason the sample provided here is irreplaceable. Likewise, the Amerindian workers that reached
31
32 Tierra del Fuego after the colonising impact to work in the timber industry brought with them
33
34 genetic variants, which are the same (or not) as those of the historical Fueguians, which in turn
35
36 makes it essential to retrieve the DNA of the archaeological human remains.
37
38
39
40
41

42
43 Our study is developed in three scenarios: 1) Fuego-Patagonia, 2) the American continent,
44
45 and 3) the Circum-Pacific rim. As regard the first, **we shall examine the population**
46
47 **relationships of the Fuegian ethnic groups at the time (time, period) of their extinction;**
48
49 **and secondly the adaptations that historically had an influence on a negative and**
50
51 **unbalanced vision of these peoples.** In the second we shall analyse the Fuegian cranial
52
53 variation in the American context, particularly amongst the Fuegian canoeists, those of
54
55 California and the Inuit. It was proposed to consider the Fueguians as descendants of the first
56
57
58
59
60

Paleoindian settlers in America, which maintained a more generalized morphological pattern observed throughout the rest of the continent, a 'relict' in many ways, and closer morphologically to Paleoindians than to other recent Amerindian groups (Lahr, 1995, 1996); we set out to confirm or reject this hypothesis. The third scenario is in fact the morphological controversy concerning the existence of Paleoamericans in Tierra del Fuego-Patagonia and their direct relationship to modern Australian-Melanesians.

MATERIAL AND METHODS

The skeletal remains of 211 modern aborigines from Tierra del Fuego located in 16 collections in Europe and America were examined (Table 1). [Table 1 here] This is the largest sample of aboriginal crania from Tierra del Fuego published to date. The metrics of W.W. Howells (1973, 1989) were applied. Our study is solely craniological, since most collections do not have post-cranial remains of Fuegians, with the exception of those in Rome and Santiago de Chile.

The final sample studied was Yamana: 74; Alakaluf: 35; Selknam: 67; Patagonian (not deformed): 20 (Tables 1 and 2). [Table 2 here] The differences in numbers for the different ethnic groups and sexes is due to the unique circumstances in which the European and American collections were formed, when live natives were exhibited at universal expositions, circuses and shows as "primitive humans". The strong male Selknam crania were more spectacular and appreciated than those for females. The Alakaluf is the smallest sample as these nomadic canoeists disappeared into the intricate network of Fuegian canals whenever

colonists were sighted. The Yamana canoeists, in contrast, are better represented as these mainly come from the cemetery of the Anglican mission in Ushuaia (Argentina).

All the European and American series, were studied by one of us (DT) following the same protocol. Access to the remains was granted by the institutions housing them (Table 3).

[Table 3 here] No destructive analysis was done for this study. No permits were required for this study, which complied with all relevant regulations.

Once the sex and the historical ethnic group had been assigned (Table 2), the relationship between groups and sexes was analysed statistically using the following procedure (Cuadras et al., 1995; Arenas and Cuadras, 2004): 1) Initial selection of variables using a Stepwise Discriminant Analysis, using the D^2 Mahalanobis as criterion as it selects size and shape simultaneously. Both sexes of each ethnic group were included in this selection and treated as if they were independent populations. Consequently, the selection of variables is common to both men and women. This means that the variables selected represent the influence of both sexes on the Canonical Variate Analysis irrespective of whether the MANOVA is significant. As such, the sexual variation will have an effect with all its consequences, including the bias in the sexual diagnosis conducted by the authors as the series are of unknown sex. The parallel study of biological variation provided similar information for both sexes. 2) No more variables than individuals in the least numerous group (Alakaluf: 16 males. Patagonians: 6 females) have been included. This is obligatory in order to avoid distortion of the matrices when calculating the inverse matrix. 3) Study of intragroup variability resulting from selection of the most discriminating variables with MANOVA. If the differences are statistically significant, the next step must be represented for each sex separately. 4) Canonical Variate Analysis (CVA). 5) D^2 Mahalanobis distances between the centroids

represented by neighbour-joining unrooted trees. **The scenarios of the Fuegian and American craniological variation have been analysed in parallel using Principal Component Analysis (PCA) as well as by squared Euclidean distances from its loading factors, representing them in UPGMA trees, so as to contrast the results with the ones obtained using CVA.**

A rigorous ethnic identification of the biological interaction between the Fuegian groups themselves and with other samples from America and Australia has been carried out. Cephalometric studies using the data provided by M. Gusinde (1989) do not coincide with the same author's craniometric data even though they come from contemporaneous samples, with *“the deviation from the craniometric pattern [being] due to the incorrect assignment to a particular ethnic group or sex”* (Varela et al., 1997). Similarly, deformed crania have been detected and discarded, and cases of repeated cross-breeding between Selknam and Alakaluf (the so-called *Dawsonians*), which the Anglican missionary eyewitnesses reported to the SAMM, have also been taken into account (South American Missionary Magazine, 1867-1919).

Twelve crania presented strong artificial deformation (Selknam) (Fig. 5). [Figure 5 here] Others presented less gradients and the deformation was only detectable by Linear Discriminant Analysis (LDA). The affected variables in the technique used by Howells were: VRR, FRC, FRS, FRF, OCA, OCC, OCS, OCF, FRA, NBA, BBA, BRA. The inclination of the frontal referred to above was an additional difficulty since it is easily confused with that of masculinity and authentic primitivism, thereby disconcerting some authors, such as M. Gusinde. The age and geographical distribution of intentional cranial deformation among the

prehistoric groups of Fuego-Patagonian (Chile) was recently highlighted (Alfonso-Durruty et al., 2015).

Sex and ethnic group were determined on the basis of archaeological and ethnographic information. As some Fuegians exhibit an unusual cranial robusticity (Figs. 2, 6), [Figure 6 here] the following criteria were used to diagnose the sex of Fuegian crania: those of Lebzelter and Gusinde (1989); those of W.W. Howells (1973); the observations of forensic anthropologists applicable to General Craniofacial identification (Gill, 1986), Midfacial Skeleton (Gill et al., 1988), Nasal Root Contours (Brues,1990), Non-metric traits (Rhine, 1990), Alveolar Prognathism Contour (Brooks et al., 1990), the Midfacial Skeleton (Gill and Gilbert, 1990), with the latter being especially useful. We did not apply discriminant functions because the sexual dimorphism of modern humans contrasts markedly with that of ancient Native Americans (Walker, 2008). Such functions must be used with caution on populations other than those for which they were developed. We also checked our estimations of sex on the basis of cranial features by Buikstra and Ubelaker (1994).

Poorly documented individuals were reassigned by LDA. Initially, the sex in each respective group was assigned by LDA, with doubtful cases being compared with well documented cases. Secondly a bilateral LDA analysis between ethnic groups, in other words Yamana-Alakaluf, Yamana-Selknam and Selknam-Alakaluf, was carried out. Finally, the ethnic group and sex assignments were verified in a general discriminatory analysis of the three ethnic groups and two sexes. The good state of conservation of the crania means that the missing values of our samples are very few. During the final sex and ethnic group assignment process, 53 variables were used with the doubtful cases in accordance with the technique of W.W. Howells.

1
2
3
4
5 Additionally, 20 non-deformed crania of Patagonians (18 Tehuelches and 2 Araucanian) from
6
7 the New York and Washington collections were studied as these samples are well
8
9 documented. The effective sample for this sample is low as the Patagonians often exhibit
10
11 cranial deformation. As a result of their biological and ethnological relationship with the
12
13 Selknam, on occasions we have used our sample of Patagonians as a valuable outgroup. Due
14
15 to the geographical heterogeneity of this last series, we chose the term 'Patagonians'
16
17 (meaning 'giants', because they were tall), which was a name given to the Tehuelche indians
18
19 in 1520 by the Spanish expedition under the command of Ferdinand Magellan. The Patagons
20
21 were a mythical tribe of a 16th century Spanish chivalric romance. In much the same manner,
22
23 the name of the State of "California" came from a similar romance about an imaginary
24
25 location. The term 'Patagonians' is important here because of their physical resemblance to
26
27 the Selknam in terms of build and stature, which has been commented on time and again by
28
29 many travellers over four centuries.
30
31
32
33
34
35

36 Just as an additional complement to improve the biological interpretation, the respective
37
38 Pensize values and C-scores of Howells (1989) of some samples were calculated only for two
39
40 variables, one of which, NAA, is an angle and therefore not affected at all by the size factor.
41
42 Thus it is possible to make simple descriptions of populations by simple inspection of the C-
43
44 scores (Tables 4 and 7). Although some researchers have criticized the application of C-score
45
46 data to multivariate analyses (e.g. Jungers et al., 1995), the transformation to C-scores has
47
48 little effect on the reliability of the pattern of interpopulation relationships (Pietrusewsky,
49
50 1997; Demeter et al. 2003, Grine et al. 2007, Kawakubo et al., 2009, Kaburagi et al. 2010).
51
52 Whatever the case, we insist that in our study we have only used the inter-population
53
54 comparison of Pensize y C-scores in just two variables.
55
56
57
58
59
60

RESULTS

1) Fuego-Patagonia, Samples from the Southern Cone.

The success rate in determining sex on the basis of LDA were 1) by ethnic group: Males: 99.04%. Females: 100%, 2) by ethnic group and sex: 94.9% with variables affected by deformation (common in the Selknam); 3) by ethnic group and sex: 93.2% without variables affected by deformation.

This study commenced with an analysis of Fuegian and Patagonian samples in order to obtain an overview. Although there is a marked imbalance in terms of effective sample size between the sexes (Patagonians: 21 male crania but only 6 female ones) that could lead to some degree of bias, and thereby restrict the number of variables selected by the stepwise analysis to only five, their study is nevertheless worthwhile as the results can be compared using other analytical techniques.

The results of the multivariate analysis of variance indicate that the differences between ethnic groups and between sexes are highly significant. However, there is no significant interaction between ethnic groups ($p > 0.05$) and, as the same distribution is obtained for each sex, it appears feasible to apply a generalized CVA. The percentage variations accounted for by the first two canonical variables are 68% and 26,7%, respectively, with a cumulative total of 95% that reflects the ethnic differences common to both sexes for the five variables used in the analysis (Fig. 7A). [Figures 7A and 7B here] The results show some degree of proximity between the two canoeist ethnic groups, with an overlap of 95% for both canonical axes at a variation level, and a separation between the series of land-based hunters, which, in turn, exhibit significant distances between each other and between the canoeists.

1
2
3
4
5 The differences between canoeists and land-based hunters are clear from the first axis, with
6 the former exhibiting smaller sizes for both the longitudinal dimensions of the braincase
7 (GOL) and face (EKR) and for the corresponding transversal dimensions (AUB and FMB).
8
9 Moreover, the NAA angle, which only expresses shape differences, suggests that the
10 canoeists are much more prognathic. The second axis, in turn, shows the unique features of
11 the Selknam, which are clearly separated from the remainder despite some degree of overlap
12 with the Alakaluf. When considering ethnic groups, the Yamana have smaller overall
13 dimensions and are more prognathic than any of the other groups. This contrasts with the
14 Selknam, with the Alakaluf being found closer to the Yamana although with some tendency
15 towards the former.
16
17
18
19
20
21
22
23
24
25
26
27
28

29 The sexual differences, as deduced from the canonical functions of the generalised CVA,
30 give a greater weight to FMB (correlation $r = 0.82$) and AUB ($r = 0.74$), followed by GOL (r
31 $= 0.53$) and EKR ($r = 0.52$). There are no sexual differences as regards prognathism (NAA r
32 $= 0.07$), thus meaning that this is a trait exclusive to the ethnicity factor, and specifically the
33 canoeists. These results suggest the idea of two different biological stocks in the first
34 settlement of Patagonia and Tierra del Fuego, with canoeists on one side of the Andes and
35 land-based hunters on the other. To improve the understanding of this aspect, the D^2
36 Mahalanobis distances have been calculated for the same variables but distinguishing
37 between sexes, as mixing size variations when samples do not have the same numerical
38 weighting may have a masking effect. As can be seen from the neighbour-joining tree (Fig.
39 7B), the results show both size and shape differences, with the canoeist groups generally
40 being located further away from the land-based hunters for females. A greater degree of
41 heterogeneity is observed for males, although the same trend is maintained. Sexual
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 dimorphism is low in Patagonians ($D^2 = 1.7$) and somewhat higher for the Selknam ($D^2 =$
4
5 2.3), while progressively increasing for the Yamana ($D^2 = 3.5$) and the Alakaluf ($D^2 = 5.5$).
6
7 This appears to be due to the greater presence of Selknam males in the canoeist groups as a
8
9 result of miscegenation, especially between the Alakaluf, in the secondary branch of the tree,
10
11 as the same phenomenon is not seen in females.
12

13
14
15
16 **To contrast the results obtained via CVA, we have analysed the variation of Fueguians**
17
18 **and Patagons by using Principal Component Analysis (PCA) as well as Euclidean**
19
20 **distances derived from the first 12 first factors (79.6% of the variation), represented in**
21
22 **a UPGMA tree diagram (Figures 8A and B). [Figures 8A and 8B here]. In the ellipses**
23
24 **represented at 75%, in the first two factors (38.9% of the total variation), what stands**
25
26 **out is the larger cranial size of Patagons and Selknam, and the intra-group diversity of**
27
28 **these, which overlaps with the canoeists. The tree diagram (Figure 8B) shows the**
29
30 **apparent grouping of the Patagons and the Selknam on the one hand, and the canoeists**
31
32 **on the other.**
33
34
35

36
37
38 *Sexual dimorphism of the three Fuegian ethnic groups*
39

40
41
42
43 To gain further insight, the relationship between the Fuegian groups has been studied (**Figs.**
44
45 **9A and 9B). [Figures 9A and 9B here]** Exclusion of the female Patagonian series, which
46
47 comprises only six specimens, allowed the number of variables in the subsequent analysis to
48
49 be increased to 15, one less than the effective sample size for Alakaluf males. As the
50
51 MANOVA found significant differences in the ethnicity/sex interaction ($p = 0.0021$), the
52
53 study had to be performed for each sex separately even though the variables selected using
54
55 the discriminant analysis are the same; in other words, they reflect the influence of
56
57
58
59
60

population-based groups including the sex factor. The results suggest the aforementioned trend of some degree of miscegenation with Selknam males amongst the Alakaluf, showing that, although the Yamana and Selknam remain separated for both sexes, the position of the Alakaluf is closer to the Selknam for males. The high values obtained for most variables highlight the marked difference in size between the Selknam. In contrast, the canoeists tend to differ in terms of prognathism (NAA) (Figs. 8A, 8B).

Although the conclusion of this study depends on the bias in the sample studied, it cannot be overlooked that this sample comprises essentially all the material available. Finally, the Chilean Lipschutz Expedition (1946, 1947) detected a greater presence of Yamana than Selknam on Navarino Island, where the latter were deliberately taken.

2) The American continent: variation in the context of the American continent

In order to consider the variation in the Fuegian series in the population-based context of the American continent, the same type of analysis was performed and compared with the series published by Howells (1989). As the difference between sexes, as determined by MANOVA, was significant, the respective distributions had to be analysed separately, although the results are not markedly different (Figs. 10A and 10B). [Figures 10A and 10B here] The first two canonical axes, which account for 70% of the variation in both sexes, show that, despite being a heterogeneous group, Amerindians can distinctly be distinguished from Eskimos. The greatest variability in Amerindians, as calculated using the D^2 Mahalanobis, is found in South America, with the series from Peru and the Selknam being the most distant for the entire analysis (Fig. 10B).

Each canonical axis reflects independent events, and in the first of them, which explains 10% more of the variation in females (49%) than in males, the heterogeneity of American aborigines is observed, with the series of crania of larger size having negative values. The differences are more marked for females such as Eskimos and Selknam, which exhibit high values for the general dimensions of the braincase and the length of the face (GOL, BBH, ZOR, PRR). The second canonical axis differentiates between Amerindians and Eskimos, the former of which have negative values, with the coefficients for the most influential variables being more marked for females. The variables that stand out the most are the greater width of the skull (XCB), greater relative height of the face (BAA) and, to a lesser extent, of the orbit (OBH), and the greater width of the upper face (FMB), with the mid-line width of the face (ZYG), the frontal width (XFB) and, in particular, the cranial base width (AUB) being even more marked in females, with the latter of these being noted previously by Howells (1989:79).

Amerindians are distributed along the first two canonical axes along a diagonal, the ends of which are Selknam and Peru, respectively, thus meaning that the greatest variability is found in South America. Similarly, the Selknam can clearly be distinguished from the Yamana, with the Alakaluf being found in an intermediate position, thereby confirming the findings in the previous section as regards the greater presence of Selknam males amongst the Alakaluf. Indeed, the Yamana are found close to the northern Amerindians and not distant from the Californian canoeists (Santa Cruz) but distant from the Eskimos for both sexes. The canoeist way of life does not produce cranial homologies in these three American groups.

The variability of the set of canonical axes, as reflected 100% by D^2 Mahalanobis distances between the centroids of the groups considered (**Fig. 10B**), has been represented graphically

using neighbour-joining trees. Taken together, these trees reinforce the previous findings, although two specific aspects should be noted. Firstly, the greatest distances are found between the Selknam and Peru (D^2 = males: 23.4; females = 27.6) followed by Selknam and Santa Cruz (D^2 = males: 13.5; females = 18.1), when not considering the Eskimos. The Yamana are found closer to the Californian canoeists than their Selknam neighbours, with whom they shared an isolation of 10,000 years in Tierra del Fuego.

The variable GLS (glabella projection) is located at the midpoint of Fuegians and Patagonians, with the Yamana having the same glabellar robusticity as the Patagonians despite their lower cranial size (Table 4). [Table 4 here] Male canoeists from Santa Cruz exhibit a clear glabellar projection, which contrasts with their small cranial size [see also the Pensize and C-score values published by Howells (1989) for both sexes]. Our Selknam series have the highest mean GLS, in the mid point, recorded for modern humans (5.49 mm. for males; 3.83 mm. for females), only exceeded by Australian-Melanesians.

The D^2 Mahalanobis distances (**Figs. 10A, 10B**) confirm the differences between the Amerindian and Eskimos series. The dolichocranic Eskimos are found distant from the Fuegians, who have much broader crania (FMB, AUB, XCB, ZYB). Similarly, Peruvians can be separated from the rest due to their short (GOL), wide cranium, as well as their short facial radii (ZMR, DKR, SSR and PRR).

A PC analysis (Figures 11A and B). [Figures 11A and 11B here], based on 41 variables (the 53 initial ones minus 12 affected by cranial deformation), only males considered, gives a result similar to the one obtained by CVA. The 75% confidence regions for the individual scores of the first and second Factors (PC) explaining 38.9% of the variation,

show an evident overlap of Amerindian intra-grupal diversity. While Eskimo and Selknam are located together, to the right by the first factor due to their large cranial size (see the Pense scores in Table 4), they are the two groups that are most opposed by the second factor. The Euclidean distances, only for the male American samples, calculated with the 8 first factors that explain the 75.4% variance, do not show important differences with regard to our analysis via CVA (Figs. 10A and 10B).

3) The Circum-Pacific rim. Amerindians and Australian-Melanesians

Previous authors have noted the presence of “Australoid” or, in a very different sense, plesiomorphic traits (Neves and Pucciarelli, 1991; Lahr, 1995; Lahr, 1996, Neves and Hubbe, 2005). As a result, three series from the database of Howells’ worldwide extant series (1996) representing the Australian-Melanesian and the Ainu series, the latter of which are considered to be a segment of the late Jomon population, have been included in our analysis. The aim of this was to observe the effect of these series, which differ so apparently from the Amerindian series, on the analysis.

The variables introduced into the MANOVA and the canonical analyses were the first 15 selected by the D^2 Mahalanobis distances in a stepwise discriminant analysis. The number of Alakaluf specimens available imposes the limitation on the number of variables. These variables represent the differences between 22 series (11 population-based series and their corresponding sexes).

The data set can be understood as an unbalanced two-way MANOVA (unequal number of individuals per sample) of two interacting factors, namely ethnicity, with 11 levels (the population-based samples), and sex, with two levels (male and female). The multivariate analysis of variance indicates that the differences between these two factors are significant ($p = 0.0001$), as are the differences in the ethnicity/sex interaction. CVAs were performed for each sex (**Figs. 12A, 12B**). **[Figures 12A and 12B here]** For both sexes the Australian and Melanesian series are distinctly separate from the Amerindians, Ainu and Eskimos when considering the variables selected on the basis of the D^2 Mahalanobis, which reflect both cranial size and shape. Thus, the Australians are prognathic (NAA, BPL) and have smaller crania, according to the Pensize values (**Table 7**), at least when compared with the Selknam, Eskimos and Ainu. **[Table 7 here]** The latter are grouped diagonally, with the breadth of the skull (AUB, XCB, XFB) and face (ZYB) being notable for the first canonical axis; the Selknam and Eskimos, which have the highest Pensize values, have high values for the braincase (NAR, BNL, GOL, BBH). Similarly, Eskimos and Australian-Melanesians share values related to prognathism or mastication (FMB SSR, IML), with the latter having the highest Pearson coefficient for the second canonical axis ($r = 0.53$ and 0.52 respectively). The neighbour-joining trees for the D^2 Mahalanobis distances separate the population-based entities known prior to this statistical analysis (Australian-Melanesians, Ainu and Eskimos) for both sexes (**Fig. 12B**). The set of Amerindians is found at the other extreme with, once again, the proximity between the Yamana (Tierra del Fuego) and Santa Cruz (California) canoeists, and the marked distance between the Yamana and Selknam, both from Tierra del Fuego, being evident. As noted above the Alakaluf are located at different positions depending on the sex, with males being closer to the Selknam than females.

Cranial size and frontal robusticity

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

As some authors have considered the cranial robusticity of some American samples to be plesiomorphic, the Pensize values and C-Scores have been calculated for GLS (glabella projection) for each of the male series in the two scenarios proposed above (**Tables 4 and 7**). Both are discussed jointly for comparative purposes but the calculation of each one differs for each scenario. The glabella projection does not appear to be adaptive or to depend on exercise of the main facial muscles (Larsen, 2015:264) The American samples with the highest value for the glabella in Table 4 are, respectively, the Selknam land-based hunters (Tierra del Fuego) and the canoeists from Santa Cruz (California), which contrasts with the values for Eskimos and Peru. In Table 7, the Australian-Melanesians follow the same trend as Santa Cruz as, together with their moderate cranial size, the Californian canoeists have a robust glabella. At the other extreme the Peru series has the smallest size for both the Pensize values and for the glabella in both series. With regard to Fuego-Patagonians, the Selknam have a large cranial and frontal size whereas the Alakaluf and Yamana exhibit more moderate values. Patagonians also exhibit lower values than those found for the Selknam, thus suggesting that the morphotype for land-based hunters from Tierra del Fuego found at the time of the first contact with Europeans was the result of a founder effect or differential reproduction in isolation.

When studying the values of GLS, PENSIZ and those of prognathism (NAA) what can be seen is the heterogeneity of the Amerindian series, already mentioned by W.W. Howells (1989) (Table 4). In the American context a noteworthy feature are the extreme differences between the canoeists of Santa Cruz (California) in comparison to the Eskimos and canoeists of Fuego-Patagonia. On the other hand, the canoeists of Santa Cruz, whose crania are small,

very robust in the glabella and very prognathous [they are the most prognathous American group], contrast with the robust Selknam, which are large and orthognathous.

If we add the Ainu and the Australian-Melanesians to the above (**Table 7**), the above mentioned point is maintained although the differences are reduced when the Australian-Melanesians act as an outgroup. The Ainu, in turn, are integrated into the Mongoloid-Amerindian group.

DISCUSSION

1) The Fuego-Patagonians

Our results show that when four more Fuego-Patagonians craniological series are added to those of Howells (1989), there continues to be considerable heterogeneity in the Amerindians. The higher degree of miscegenation between the Alakaluf and the Selknam is unsurprising given the absence of geographical barriers along the west coast of Isla Grande. In contrast, there is a mountain range, between the Yamana and the Selknam, parallel to the Beagle Channel (Fig. 1). Although eyewitness note that contact between the Yamana and the Selknam was limited and there was a mutual distancing, despite occasionally coinciding at the same locations, there is some evidence that cross-breeding between Alakaluf and Selknam did occur, thereby coinciding with the conclusions of this study. A further area of cross-breeding between the Selknam and Alakaluf was the region of Isla Grande facing Dawson Island (the *Dawsonians* proposed by T. Bridges) (see Aspillaga and Ocampo 1996). The interaction between deportees from these two ethnic groups continued as marriage between them was encouraged at the

mission on Dawson Island, as can be seen from some Fueguian collections such as that held by the Natural History Museum in Santiago de Chile (Castro and Aspillaga, 1991) or that in the Chilean city of Porvenir (Isla Grande, Tierra del Fuego).

In Prehistory, little notice has traditionally been taken of sudden and catastrophic changes, which should be included in the study of human populations (Estevez, 2005). In our case two population crises that affected the Fueguians could be documented. The first one was the H1 eruption of Hudson volcano (46° S) in about 7750 cal BP. This eruption, which was more than five times larger than the 1991 eruption of the same volcano, covered much of Tierra del Fuego with up to >20 cm of tephra. According to Prieto et al (2013), all of southernmost Patagonia may have devastated for an extended time period along with the flora and fauna supporting the local terrestrial hunter-gatherers in this area, particularly in Tierra del Fuego, which was already isolated by the opening of the Strait of Magellan in 9240 cal BP. It has been well established that there was a change towards intensive exploitation of littoral resources, from the island of Chiloe to Tierra del Fuego, 1500 km to the south (see also Estevez and Vila, 2013 for details). This important bottleneck probably explains the loss of mitochondrial haplotypes A and B, detected by Lalueza et al. (1997) and García-Bour et al. (2004) amongst others, due to the effect of genetic drift amongst the Fueguian-Patagonians. As the eruption of the volcano was unlikely to have affected marine species, the hypothesis has been made that the littoral people of Fuego-Patagonia, originally terrestrial, adapted themselves to the sea and became maritime populations (Prieto et al 2013: 7). As a consequence they had to readjust their productive strategies. The origin of the Dawsonians (Aspillaga and Ocampo 2005, Martinic 1999) may be seen in the cooperation of both terrestrial and maritime hunter-gatherers.

After 3300 BP the basic features of the tools and the archaeologically documented strategies remained unchanged in Tierra del Fuego until the arrival of the Europeans. A successful social control of social reproduction together with flexibility and a rich supply of marine resources which flowed in from breeding grounds that were located outside the normal reach of groups, maintained the balance between resources and population until the arrival of Europeans (Estevez and Vila 2013:177). The social norms, these organizational strategies, that manage reproductive strategies in the studies always do have a determinant weight in intra-group relationships and therefore in the sexual dimorphism of mastication, since, for example, fishing was probably a task performed only by women.

The second population crisis in Tierra del Fuego took place with the impact of European colonisation. More Selknam males were directly exterminated than females, who tended to be deported to the other two Salesian missions in Rio Grande and Ushuaia or to the refuges for Selknam and Yamana in Estancia Harberton (1886) and Estancia Viamonte (1902), both of which belonged to the Bridges family (Bridges, 1987). This resulted in more cross-breeding between Selknam and Yamana than previously existed to the east of the Beagle Channel. Some Selknam were also taken to Navarino Island. The greatest morphological distances in our study are found between females (**Fig. 7B**), perhaps due to kidnapping of male children, as stated by Gusinde (1982:128), who grew and lived as Alakaluf as they were biologically Selknam, by the canoeists, or due to differential reproduction of Selknam males in the *Dawsonian* population. This increase in mixtures at a time of ethnic dispersion was detected by Varela et al. (1997) who show, from the Fuegians cranial measurements provided by Gusinde (1989), that Alakaluf and Selknam males are very close to each other, whereas females are not, thus coinciding with our findings. However, the same authors obtained the opposite result when using the cephalometric measurements in living Fuegians taken by

Gusinde himself (1989), namely a greater interaction between Yamana and Selknam than between the latter and the Alakaluf. Both Gusinde's series (craniometric and cephalometric) were contemporary.

With current bio-anthropological data our craniometric results support the hypothesis of a population from the southern tip of America with two different biological origins that subsequently formed the historical Fuego-Patagonian ethnicities and partially mixed together, especially the Alakaluf and the Selknam. Exactly when these the Fuegian ethnicities formed remains unknown (Orquera and Piana, 2009; Piana and Orquera, 2009). According to numerous somatic, physiological, ethnographic and linguistic data compiled by scientific expeditions and from eyewitness accounts, the Patagonians, name that means 'giants', are associated with the Selknam. The alternative hypothesis, whereby the Fuegians have a common biological origin and their local diversification is due to a prolonged adaptation to different environments, is not supported by our findings if we exclude the miscegenation of the Dawsonians.

Numerous eyewitnesses, travellers, colonists, missionaries and scientific expeditions that observed the aborigines prior to their extinction noted the marked morphological and physiological differences between the canoeists and land-based hunters in Tierra del Fuego. The similarities between the Patagons (Aonikenk) of the continent (South Patagonia) (Fig. 1), on the one hand, and the Selkam and the Haush, of Isla Grande de Tierra del Fuego, on the other, have been widely recognised, even linguistically (Casamiquela, 1965). Although to some extent it is to be expected that the concept of ethnicity and biological population coincide in this case due to their isolation, any differences there may have been between the Alakaluf and Yamana are not documented due to the nomadic behaviour of the canoeists in

the intricate channels of Tierra del Fuego. This uncertainty particularly affects the cranial Alakaluf sample. However, with regard to the morphological affinity between Yamana and Alakaluf, Gusinde (1989) has commented on a note from G. Sergi concerning the Rome crania: the 11 Yaghan and 2 Alakaluf cannot be differentiated and Sergi adds that: "... according to Fitzroy the Alakalufs are barely distinguishable from the Yaghans..." (Sergi, 1886-1887; Sergi, 1888).

The first canonical axis of our analysis (68% of variation) (Figures 7A and B), clearly separates the canoeists on the one hand from the Patagonians and Selknam on the other. The NAA angle distinguishes the two sexes of the canoeists by their prognathism. At the same time the Patagonians show a considerable projection forward of the ends of the orbs (EKR), one of the features of the facial mask (Howells 1989:15) or facial flatness. The second canonical axis (27% of variation) separates the Selknam from the Yámanas and the Patagonians, which we interpret as an endogamous reflection of a founder effect on this ethnic group, after the volcanic catastrophe. Thus it could be interpreted that the C-scores of the prominence of the glabella (GLS) are notably different between Fuegian canoeists and the Selknam (Table 4). The robustness and build of the Selknam, proceeding from the same population source as the tall Patagonians, increased, caused by the reduction of the reproductive population, as a result of a bottleneck. This possibility is strengthened by the explicit assertion of Gusinde (1982:426-427), which states that after combat it was a social norm (amongst the Selknam) to not take prisoners, only women and children; the children as a rule were soon abandoned. To satisfy their desire for revenge, some of the wives and children of the dead enemy were taken. Gusinde adds that sometimes after the fight the winner raped a woman of the defeated group, the effect of which as differential reproduction

would have been more important when there were small population groups, decimated by the volcanic catastrophe.

Another argument that makes it difficult to relate the origin of the canoeists of Tierra del Fuego with the robust and corpulent Selknam is the extreme metabolic adaptation to cold recorded in the canoeists. The comment by Darwin (1839) about the woman who breastfed her baby and looked with curiosity at the Europeans of the Beagle, while snow fell abundantly on her bare breasts and on the baby is well known. The amazing resistance to cold of the Fuegian canoeists was recorded and studied scientifically by Hyades and Deniker (1891) in 1882-1883. The physiologist H.T. Hammel (1960, 1964), who had previously studied the metabolic resistance to cold amongst the Australian aborigines, found in 1959, when accompanied by eight other physiologists and anthropologists, that the Alakaluf of Wellington Island (Chile) presented high metabolic rates when night fell, and remained in this state until dawn. This people may have developed an exceptional "non-shivering thermogenesis". The Selknam and the Patagonians do not present a similar adaptation, given that they wore guanaco skins. But this does not exclude the possibility that they had some "cold acclimatisation" capacity; but "cold acclimatisation" is a very different concept from the "metabolic adaptation" recorded amongst the Alakaluf.

Contrarily to Hernandez et al (1997), no variable relating to the nose bone has been selected in our analysis, as regards adaptation to cold and the plasticity of the human cranium. In Table 6 it is shown that the height of the nose has little influence on the first factor of the PCA and very little in the second, the two that explain the greater biological variation of the analysis. The publication of Hernandez et al (1997), on a sample of Fuegian crania very similar to ours, is questionable in various areas. Firstly

the origin of their data base is legally dubious. An example of this is that the institutions that financed such an extensive study in two continents are not cited. Secondly, in 2003, one of the co-authors, C. Lalueza-Fox was found guilty of misappropriation of scientific data, the final sentence of which was published in *Annals of Human Biology* (2005) 32(1): 98-110. Since the judgment and sentence in 2003, the craniometrical base of 180 Fueguians studied by Hernandez et al. (1997) has not been used again although some of these authors have continued to publish work about Fueguians. Thirdly, the authors included deformed crania in their analysis, as shown by the significant statistical differences in the FRC and PAC variables respectively of their own data (Table 4, p. 108, in Hernandez et al. 1997). Finally, Hernández et al. (1997) also confused the height of the nose according to the Martin technique with that of W.W. Howells and interpreted that the Eskimos and Fueguian ethnic groups coincided in having a modification of the nose bone as an adaptation to the cold, which they highlighted in the main title and the abstract. This error is demonstrated with their own data, (Table 5 of this study).

When we entered our measurements of the nose as per Howells, in Figures 4 and 5 respectively of Hernandez et al. (1997), given that we have a very similar sample, the Fueguian ethnic groups are placed with the other samples studied and move away from the Eskimos. We have also calculated the American scenario with our new data, including undeformed Patagons, following the same methodology as Hernandez et al. (1997) (Figs. 11A and 11B) [Figures 11A and 11B here]. Our results do not associate the Eskimos with the Fueguians in any way.

The present study of the Fuegian groups allows us to conclude that the interaction as a result of miscegenation is mainly due to the presence of Selknam males amongst the Alakaluf and, to a lesser extent, amongst the Yamana. Despite this, the D^2 values obtained lead us to conclude that they were both different ethnicities, as noted by Gusinde, and different biological populations.

2) The variation in America and the Circum-Pacific rim

From the evolutionary perspective, some authors identify two broad clusters of craniofacial morphology in the Holocene of America. Thus, the oldest stock, known as the Paleoamerican, can be distinguished from subsequent Native Americans by a number of skeletal differences (Larsen, 2015: 382), such as the pronounced development of supraorbital ridges, low frontals, marked post-orbital constriction, prominent and protruding occipitals, small mastoids, long crania and a relatively narrow bizygomatic breadth. Furthermore, they conclude that the morphology of the Paleoindian sample is more consistent with a proto-Mongoloid definition that is less “sinodont-Mongoloid” than more recent Amerindians. Paleoamerican morphological traits among Holocene samples have been observed in a number of studies (see Gonzalez-Jose et al. 2003), including Early Colombian series (Neves et al., 2007), in remains from Meso-America (Gonzalez-Jose et al., 2005), as well as in isolated individuals from North-Eastern Brazil (Neves et al., 2007; Strauss et al., 2015). Here we are lacking an evaluation of the canoeists of Santa Cruz (Howells 1973, 1989), who have a small cranium and a highly prominent glabellum in comparative terms (GLS) that, according to what is shown by the C-scores, is the largest of all the American series (Tables 4 and 7). There is no record that they have been regarded as “Paleoamericans”.

1
2
3 In contrast, other authors believe that Amerindians, of Asian origin, were the first populators
4 of America and subsequently differentiated in the New World. This idea was first put forward
5 by Captain James Cook in the report of his third voyage around the Pacific and subsequently
6 supported by Alex Hrdlicka (1869-1943), who made an in-depth study of the morphological
7 transformation, especially as regards the masticatory muscles and the dental reduction
8 associated with cultural and dietary changes, arising as a result of the change from a hunter-
9 gatherer to an agricultural culture. The result was the aforementioned dental reduction and a
10 reduction in the supporting bone structures due to a decreased strength of the masticatory
11 muscles, an idea first developed by C.L. Brace, D.S. Brase, M.H. Wolpoff, D.W. Frayer,
12 F.H. Smith (cited in Spencer and Smith, 1981). In our analysis, the Peruvian series is the only
13 one that can be historically associated with agriculture. This justifies its significant separation
14 from the other series, and, as a result of the gracile form of the crania, presents the longest
15 Mahalanobis distance with regard to the Selknam.
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33

34 It has been proposed that Fuegian aborigines may have retained an “ancestral” cranial
35 robusticity shared with Australian aborigines (Neves et al., 1999; Neves and Hubbe, 2005).
36
37

38 We feel that there is another simpler explanation, for which it is necessary to distinguish,
39 firstly, the robust and corpulent Selknam and Haush of the Isla Grande of Tierra del Fuego,
40 from the Fuego-Patagonian shorter canoeists. The latter present a certain cranial robustness
41 but to a much lesser extent than the Fuegian land-based hunters, **as can be seen in Table 4.**
42
43
44
45
46

47 Although the interbreeding between some Selknam with Alakaluf (Dawsonians tone down
48 this fact) has disoriented some previous authors, the CVA of this article show that both the
49 Selknam, men and woman, are at the extreme end of all the analysed scenarios. The
50 robustness of the frontal of the Selknam, measured in the prominence of the glabella at its
51 middle point, is one of the highest in present-day Humanity, and is only exceeded by the
52
53
54
55
56
57
58
59
60

Australians. Furthermore, the Australian-Melanesian and Selknam totally differ in terms of cranial structure: large size and ortognathic face of the Selknam versus the small cranium and prognathism of the Australian-Melanesians.

This is also borne out by numerous tests and eyewitness reports, already mentioned, the crania of the Patagonians (Tehuelches) are very similar to the Selknam, although the former are smaller and less robust (Figs. 7A, 7B). It is generally accepted that the supraorbital torus is a general indicator of overall craniofacial robusticity (Perez et al., 2007). According to Larsen (2015: 264) there is an allometric pattern: when other indicators of robusticity change the supraorbital torus increases in its expression. This explains why the Selknam would have greater overall robustness than Fuego-Patagonian canoeists, despite the three ethnic groups lived in the same or similar environment during at least 10,000 years. For Fuego-Patagonians, gene expression and/or differential reproduction are more parsimonious explanations than ancestral robustness. In this respect we agree with Bernal et al. (2006).

The Australian-Melanesian series differ, for both sexes, from the group of Amerindians, Ainu and Eskimos, which group together despite their clear differences (**Figs. 12A, 12B**). The above indicates that both groups derive from distinct phylogenetic origins and that the robusticity, generally taken as the frontal robusticity, does not agree sufficiently with the Pensize value, the highly variable development of the glabella or with the prognathism to be able to establish a plesiomorphic relationship that supports the existence of an Australoid morphotype.

On the other hand, irrespective of whether the Patagonians are included, our analysis confirms the marked morphological heterogeneity in the South American samples, as noted

by other authors (Howells, 1989; Rothhammer and Dillehay, 2009), thereby reflecting distinctive patterns of genetic, morphological and cultural variation as the greatest distances are found between Selknam and Peru. The cranial differences are not wholly attributable to size as the Arikara present a higher Penseize than Santa Cruz and Peru but are not close to the Selknam. The differences can also not be attributed solely to cranial plasticity, as the Eskimos are distant from the Patagonians and Fuegians in general. The hypothesis of two population flows that arrive in Tierra del Fuego via different routes can be deduced from the present study as the Yamana are found closer to the Santa Cruz canoeists than to the Selknam and Peruvians in all analyses, in both sexes. This hypothesis is supported by the frequency of an Esterase-D enzyme variant and the HLA alleles (Llop et al., 1995) studied in living Yamana from Navarino Island. In addition, the blood groups results obtained by both Lipschütz (Lipschütz et al., 1946; Lipschütz et al., 1947) and Etcheverry (1967) are similar to those obtained by Llop et al. (1995). However, whether the Yamana come from a coastal movement from the northern hemisphere or coastal adaptation was repeated in South America remains to be confirmed or ruled out by future studies as this aspect exceeds the scope of the current study.

As regards the existence of the Paleoamerican "stock" of, our data confirms the greater heterogeneity in South America. The peculiar Fuegian features, which morphologically do not represent a unit, as well as the cranial robustness, may be the result of their respective evolutionary histories in geographical or reproductive isolation, from groups of Native Americans after a volcanic catastrophe.

On the other hand, human populations contain tremendous diversity in their genomes, which would explain why the current intra-group variation is higher than the inter-group one. At the

same time the genome sequence does not say everything; it can be expressed in very different ways in the phenotypes.

Our data does not confirm the assertion: “*The Fuegian-Patagonian crania may be said to represent a combination of some generalized Mongoloid traits observed today in most southern and typical Mongoloids, some traits un-typical of most Mongoloid populations, and a very distinct pattern of robusticity... involving the pronounced development and use of the muscles of mastication, resulted in the retention of features common in Pleistocene crania.*” (Lahr 1995:184-185).

Raghavan et al. (2015) using ancient and modern genome-wide data, including now extinct Fuego-Patagonians, conclude “*Putative ‘Paleoamerican’ relict populations, including the historical Pericúes and South American Fuego-Patagonians, are not directly related to modern Australo-Melanesian as suggested by the Paleoamerican Model*” (Raghavan et al., 2015).

Perhaps more evidence can be found in the prehistoric crania of Fuego-Patagonia. But we did not carry out this craniometric analysis because of the inevitably poor conservation of the prehistoric crania and the large number of missing values, mainly affecting the facial traits, limits the conclusions and requires careful analysis. In this respect Hanihara (1996) has demonstrated the importance of craniofacial features in craniofacial shape among recent populations of different geographical areas.

We agree with those who feel that the differences between early and late American samples, related to evolutionary processes, are difficult to support using only cranial morphometric

1
2
3 differences (Menendez et al., 2015). The craniometric data is limited, and needs to be
4
5 examined in the light of archaeological and additional kind of evidence (see Roseman 2016).
6
7 More refined future studies using Geometric Morphometrics should enable significant
8
9 advances to be made. In any case, craniological studies shall continue to be essential for
10
11 understanding past human evolution.
12
13

14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60

ACKNOWLEDGMENTS

21 This work would not have been possible without the help of numerous people. As
22 such, we would like to give our most sincere thanks to them and the 16 institutions (Table 1)
23 that allowed access to the Fuego-Patagonian material. In particular, we would like to thank
24 C.B. Stringer (BMNH) for his valuable comments as well as J. Estevez, A. Vila, E. Piana, L.
25 Orquera, R. Machiarelli, R. Guichon, M. Martinic, S. Quevedo, E. Aspillaga, and M. Castro.
26 The help provided by M. Alcina, A. Ceresuela, A. Lucea, A. Pujol, M. San Millan during
27 preparation of the manuscript is also gratefully acknowledged. This study was financed as
28 part of the Spanish-Argentinian CSIC-CONICET agreement (CSIC-CONICET -1988-1994),
29 and by the European Union: CEE: CI1-CT93-0015 ALAMED 1994-1998.
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Author contributions:

DT designed and performed research. CMC and CA analyzed data. DT wrote the paper.

REFERENCES

Alfonso-Durruty MP, Giles BT, Misarti N, San Roman M, Morello F. 2015. Antiquity and geographic distribution of cranial modification among the prehistoric groups of Fuego-Patagonia, Chile. *Am J Phys Anthropol* 158:607-623.

Arenas C, Cuadras CM. 2004. Comparing two methods for joint representation of multivariate data. *Communications in Statistics – Simulation and Computation* 33:415-430.

Aspillaga E, Ocampo C. 1996. Restos óseos de la isla Karukinka (Seno Almirantazgo). Informe Preliminar. *Anales del Instituto de La Patagonia, Serie Cs.Hs.* 24:153-161, Punta Arenas.

Bernal V, Perez SI, Gonzalez PN. 2006. Variation and Causal factors of Craniofacial Robusticity in Patagonian Hunter-Gatherers from the Late-Holocene. *Am J Hum Bio* 18:748-765.

Bridges L. 1987 [1949] *Uttermost Part of the Earth*. Originally published by Hodder & Stoughton, London. Re-issued by Century, London.

Brooks S, Brooks RH, France D. 1990. Alveolar Prognathism Contour, An Aspect of Racial Identification. In: Gill and Rhine, editors. *Skeletal Attribution of Race. Methods for Forensic Anthropology*. Maxwell Museum of Anthropology. Albuquerque. p 41-46.

Brues A. 1990. The Once and Future Diagnosis of Race. In: Gill G.W. and Rhine S, editors. Skeletal Attribution of Race. Methods for Forensic Anthropology. Maxwell Museum of Anthropology. Albuquerque. p 1-6.

Buikstra J, Ubelaker D. 1994. Standards for data collection from human skeletal remains. Research series 44. Fayetteville: Arkansas Archaeological Survey.

Casamiquela RM. 1965. Rectificaciones y ratificaciones hacia una interpretación definitiva del panorama etnológico de la Patagonia y área septentrional adyacente. Bahía Blanca: Instituto de Humanidades, Universidad Nacional del Sur.

Castro MM, Aspillaga EA. 1991. Fuegoian Paleopathology. Antropología Biológica 1(1):1-13.

Cuadras CM, Fortiana J, Oliva F. 1995. Representation of Statistical Structures, Classification and Prediction using Multidimensional Scaling. In: Gaul W. and Pfeifer D, editors. Berlin: From Data to Knowledge. p 20-31.

Darwin CR. 1839. *Journal of researches into the geology and natural history of the various countries visited by H.M.S. Beagle*. London: Colburn. <http://darwin-online.org.uk/contents.html#researches>.

Demeter F, Manni F, Coppens Y. 2003. Late Upper Pleistocene human peopling of the Far East: multivariate analysis and geographic patterns of variation. C.R. Palevol 2:625-638.

Dillehay T D, Ramirez, C, Pino M, Collins M, Rossen J, Pino-Navarro D. 2008. Monte

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Verde: Seaweeds, food, and medicine and the peopling of the Americas. *Science* 325:1287–1289.

Estévez J. 2005. *Catástrofes en la prehistoria*. Bellatera Ed. Barcelona.

Estevez JE, Vila A. 2013. On the extremes of hunter-fisher-gatherers of America’s Pacific Rim. *Quatern Int* 285:172-181.

Etcheverry R, Boris E, Rojas C, Villagran J, Guzman C, Regonesi C, Muranda M, Duran N. 1967. Investigación de grupos sanguíneos y otros caracteres genéticos sanguíneos en indígenas de Chile II parte. In: *Fueguinos*. *Rev Med Chile* 95:605-608.

Garcia-Bour J, Perez-Perez A, Alvarez S, Fernandez E, Lopez-Parra AM, Arroyo-Pardo E, Turbon D. 2004. Early population differentiation in extinct Aborigines from Tierra del Fuego-Patagonia: Ancient mt-DNA sequences and Y-chromosome STR characterization. *Am J Phys Anthropol* 123:361-370.

Gill WG. 1986. Craniofacial Criteria in forensic race identification. In: Reichs KJ, editors. *Forensic Osteology, Advances in the identification of human remains*. Ch. C. Thomas Pub. p 143-159.

Gill WG, Hughes SS, Hughes MA, Bennett SM, Gilbert BM. 1988. Racial Identification from the Midfacial Skeleton with Special Reference to American Indians and Whites. *J Forensic Sci* 33(1):92-99.

Gill GW, Gilbert BM. 1990. Race Identification from the Midfacial Skeleton: American Black and Whites. In: Gill G.W and Rhine S, editors. Skeletal Attribution of Race. Methods for Forensic Anthropology. Albuquerque: Maxwell Museum of Anthropology. p 47-53.

Gonzalez-Jose R, Gonzalez-Martin A, Hernandez M, Pucciarelli HM, Sardi M, Rosales A, Van der Molen S. 2003. Craniometric evidence for Palaeoamerican survival in Baja California. *Nature* 425:62–65.

Gonzalez-Jose R, Ramírez-Rossi F, Sardi M, Martínez-Abadías N, Hernandez M, Pucciarelli HM. 2005. Functional-Cranial Approach to the Influence of Economic Strategy on Skull Morphology. *Am J Phys Anthropol* 128:757-771.

Gonzalez-Jose R, Neves WA, Lahr MM, Gonzalez S, Pucciarelli H, Hernandez M, Correa G. 2005. Late Pleistocene/Holocene Craniofacial Morphology in Mesoamerican Paleoindians: implications for the Peopling of the New World. *Am J Phys Anthropol* 128:772-780.

Grine FE, Bailey RM, Harvati K, Nathan RP, Morris AG, Henderson GM, Ribot I, Pike AWG. 2007. Late Pleistocene human skull from Hofmeyr, South Africa, and Modern Human origins. *Science* 315:226-229.

Gusinde M. 1982 [1931]. Los Indios de Tierra del Fuego. I (1 and 2). Los Selk'nam. Buenos Aires: Centro Argentino de Etnología Americana.

Gusinde M. 1986 [1937]. Los Indios de Tierra del Fuego. II (1 and 2). Los Yamana. Buenos Aires: Centro Argentino de Etnología Americana.

Gusinde M. 1989 [1939]. Los Indios de Tierra del Fuego. IV (1 and 2). Antropología Física. Buenos Aires: Centro Argentino de Etnología Americana.

Gusinde M. 1991 [1974]. Los Indios de Tierra del Fuego. III (1 and 2). Los Halakwulup. Buenos Aires: Centro Argentino de Etnología Americana.

Hammel HT. 1960. Response to cold by the Alacaluf Indians: a first report on a 1959 Expedition. Curr Anthropol 1:146.

Hammel HT. 1964. Terrestrial animals in cold: Recent studies of primitive man. In: DB. Dill DB, Adolph EF, and Wilber CG, editors. Adaptation to the Environment. Handbook of Physiology, Section 4. Washington DC: Am Physical Soc p 413-434.

Hanihara T. 1996. Comparison of craniofacial features of major human groups. Am Phys Anthropol 99:389-412.

Hernandez M. (1992) Morfología craneal de las etnias fueguinas de la Tierra del Fuego: diferencias sexuales e intergrupales. Ans. Inst Pat Ser. Cs. Hs. 21:81-98.

Hernandez M, Lalueza-Fox C, Garcia-Moro C. 1997. Fuegian cranial morphology: the adaptation to a cold, harsh environment. Am J Phys Anthropol 103(1):103-17.

1
2
3 Howells WW. 1973. Cranial Variation in Man. Papers of the Peabody Museum. A Study by
4
5 Multivariate Analysis of Patterns of Differences Among Recent Human Populations. Papers
6
7 of the Peabody Museum of Archaeology and Ethnology 67:259.
8
9

10
11
12 Howells WW. 1989. Skull Shapes and the Map. Craniometric Analyses in the Dispersion of
13
14 Modern Homo. Papers of the Peabody Museum of Archaeology and Ethnology 79:189.
15
16

17
18
19 Howells WW. 1996. Notes and Comments. Howells' Craniometric Data on the Internet. Am
20
21 J Phys Anthropol 101:441-442.
22
23

24
25 Hubbe M, Neves WA, Amaral HL, Guidon N. 2007. "Zuzu" Strikes again morphological
26
27 affinities of the early holocene human skeleton from Toca Dos Coqueiros. Piaui, Brazil. Am J
28
29 Phys Anthropol 134:285-291.
30
31

32
33
34 Hyades PD, Deniker J. 1891. Anthropologie et Ethnographie. In: Mission Scientifique du Cap
35
36 Horn, 1882-1883, vol. VIII. Paris.
37
38

39
40
41 Jungers WL, Falsetti AB, Wall CE. 1995. Shape, relative size, and size-adjustments in
42
43 morphometrics. Yearb Phys Anthropol 38:137-161.
44
45

46
47 Kaburagi M, Ishida H, Goto M, Hanihara T. 2010. Comparative studies of the Ainu, their
48
49 ancestors, and neighbors: assessment based on metric and nonmetric dental data. Anthropol
50
51 Science 118(2):95-106.
52
53
54
55
56
57
58
59
60

1
2
3 Kawakubo Y., Hanihara T., Shigematsu M., and Dodo Y. 2009. Interpretation of
4 craniometric variation in northeastern Japan, the Tohoku region. *Anthrop Science*, 117: 57–
5 65.
6
7
8

9
10
11 Lahr MM. 1995. Patterns of modern human diversification: implications for Amerindian origins.
12 *Yearb Phys Anthropol* 38:163-198.
13
14
15

16
17
18 Lahr MM. 1996. Who were the first Americans? *Mammoth Trumpet*. Center for the study of
19 First Americans 11(3):7-11.
20
21
22

23
24
25 Lalueza C, Perez-Perez A, Prats E, Cornudella L, Turbon D. 1997. Lack of founding
26 Amerindian mitochondrial DNA lineages in extinct Aborigines from Tierra del Fuego-
27 Patagonia. *Hum Mol Genet* 6(1): 41-46.
28
29
30

31
32
33
34 Larsen CS. 2015. *Bioarchaeology. Interpreting Behavior from the Human Skeleton*. Second
35 Edition. Cambridge University Press.
36
37
38

39
40
41 Lebzelter V, Gusinde M. 1989. Craneología de los Fueguinos. In: Gusinde M. 1989 [1939]. *Los*
42 *Indios de Tierra del Fuego*. IV (1 and 2). *Antropología Física*. Buenos Aires: Centro Argentino
43 de Etnología Americana.
44
45
46

47
48
49 Lipschütz A, Mostny G, Robin L. 1946. The bearing of ethnic and genetic conditions on the
50 blood groups of three Fuegian tribes. *Am J Phys Anthropol* 4:301-322.
51
52
53
54
55
56
57
58
59
60

Lipschütz A, Mostny G, Helfritz H, Jeldes F, Lipschütz M. 1947. Physical characteristics of Fuegians. An analysis aided by photography. *Am J Phys Anthropol* 5:295-322.

Llop E, Harb Z, Moreno R, Aspillaga E, Rothammer F. 1995. Genetic composition of the last Yamana Indians from South America. *Homo* 45(3):207-214.

Martinic M. 1999. Dawsonians o Selkhar. Otro caso de mestizaje aborigen histórico en Magallanes. *Ans. Inst. Pat., Ser. Cs. Hs. (Chile)*, 1999.79-88

Menendez LP, Perez SI, Pucciarelli HM, Bonomo M, Messineo PG, Gonzalez ME, Politis GG. 2015. Early Holocene human remains from the Argentinean Pampas: cranial variation in South America and the American Peopling. *PaleoAmerica* 1(3): 251-265.

Neves WA, Pucciarelli HM. 1991. The origin of the first Americans: an analysis based on the cranial morphology of early South American human remains. *J Hum Evol* 21:261-273.

Neves WA, Powell JF, Ozolins EG. 1999. Extra-continental morphological affinities of Palli Aike, southern Chile. *Interciencia* 24:258–63.

Neves WA, Hubbe M. 2005. Cranial morphology of early Americans from Lagoa Santa, Brazil: Implications for the settlement of the New World. *P Natl Acad Sci Usa* 102:18309-18314.

Neves WA, Hubbe M, Correal G. 2007. Human skeletal remains from Sabana de Bogotá, Colombia: a case of Paleoamerican morphology late survival in South America? *Am J Phys Anthropol* 133:1080–1098.

Orquera LA, Piana EL. 2009. Sea Nomads of the Beagle Channel in Southernmost South America: Over Six Thousand Years of Coastal Adaptation and Stability. *The Journal of Island and Coastal Archaeology* 4(1):61-81.

Oxnard CE. 1987. *Fossils, Teeth and Sex. New perspectives on human evolution.* Seattle: University of Washington Press.

Perez SI, Bernal V, Gonzalez PN. 2007. Morphological differentiation of aboriginal human populations from Tierra del Fuego (Patagonia): implications for South American peopling. *Am J Phys Anthropol* 133:1067–1079.

Piana EL, Orquera LA. 2009. The Southern Top of the World: The First Peopling of Patagonia and Tierra del Fuego and the Cultural Endurance of the Fuegian Sea-Nomads. *Arctic Anthropol* 46(1-2): 103-117.

Pietrusewsky M. (1997) The people of Ban Chiang: an early Bronze-Age site in northeast Thailand. *Bull Indo-Pacific Preh Assoc* 6: 119–148.

Prieto A, Stern Ch, Estevez J. 2013. The peopling of the Fuego-Patagonian fjords by littoral hunter-gatherers after the mid-Holocene H1 eruption of Hudson Volcano. *Quatern Int* 317: 3-13.

Rabassa J, Coronato A. 2009. Glaciations in Patagonia and Tierra del Fuego during the Ensenadan Stage/Age (Early Pleistocene-earliest Middle Pleistocene). *Quat Internat* 68-210:18-36.

Raghavan M, Steinrücken M, Harris K, Schiffels S, Rasmussen M, De Giorgio M, et al., Eriksson A. 2015. Genomic evidence for the Pleistocene and recent population history of Native Americans. *Science* 349(6250) DOI: 10.1126/science.aab3884 (in press).

Ramos MD, Lalueza C, Girbau E, Perez-Perez A, Quevedo S, Turbon D, Estivill X. 1995. Amplifying dinucleotide microsatellite loci from bone and tooth samples of up 5,000 years of age: more inconsistency than usefulness. *Hum Genet* 96: 172-180.

Rhine S. 1990. Non-metric Skull Racing. In: Gill W.G and Rhine S, editors. *Skeletal Attribution of Race. Methods for Forensic Anthropology*. Albuquerque: Maxwell Museum of Anthropology. p 7-20.

Roseman CC. 2016. Random Genetic Drift, Natural Selection, and Noise in Human Cranial Evolution. *Am J Phys Anthropol* 160:582-592.

Rothhammer F, Dillehay TD. 2009. The Late Pleistocene Colonization of South America: An Interdisciplinary Perspective. *Ann Hum Genet* 73:540-549.

Sergi G. 1886-87. *Antropologia Física della Fuegia*. *At Reale Acad Med di Roma* 13(3): 33-70.

Sergi G. 1888. *Antropologia Física della Fuegia (nuove osservazioni)*. *Archiv per l'Antrop e la Etnol* 18(1): 25-32.

SOUTH AMERICAN MISSIONARY MAGAZINE (1867-1919)
<http://www.britishonlinearchives.co.uk/group.php?pid=72009-mag>. London. Between Alacaluf and North Selknam on one side (T. Bridges 1876:60, 1881:156, 1882:225; J. Lawrence 1887:174, 1896:128); and Yamana and South Selknam (T. Bridges 1881:226, 1883:139, 1886:33; J. Lawrence 1887:77-78) on the other.

Spencer F, Smith FM. 1981. The significance of Alex Hrdlicka's "Neanderthal Phase of Man": A historical current assessment. *Am J Phys Anthropol* 56:435-459.

Strauss A, Hubbe M, Neves WA, Bernardo DV, Atui JPV. 2015. The cranial morphology of the Botocudo Indians, Brazil. *Am J Phys Anthropol* 157:202-216.

Varela HH, Cocilovo JA, Guichon RA. 1997. Evaluation of the craniometric information published by Gusinde on the natives from Tierra del Fuego. *Homo* 48(2):125-134.

Vila A, Casas A, Vicente O. 2006. Mischiuen III, un contexto funerario singular en el Canal Beagle (Tierra del Fuego). *Rev Esp Antropol Amer* 36(1):47-61.

Walker PL. 2008. Sexing skulls using discriminant function analysis of visually assessed traits. *Am J Phys Anthropol* 136:39-50.

Yesner DR, Figuerero MJ, Guichón RA, Borrero LA (2003) Stable isotope analysis of human bone and ethnohistoric subsistence patterns in Tierra del Fuego. *J. Anthrop. Archaeol* 22:279-291.

FIGURE CAPTIONS

Figure 1. Geographical distribution of the three Fuegian and the non-deformed Patagonian ethnicities studied. The cross-breeding Dawsonians (Selknam-Alacaluf), reported by the Anglican missionaries, affect the Alacaluf sample studied.

Figure 2. Male Selknam (Punta Arenas, Chile).

Figure 3. Female Yamana (Naturhistorisches Museum, Wien).

Figure 4. Female AlaKaluf (M. M. *Borgatello* Punta Arenas, Chile).

Figure 5. Selknam skull with frontal plane deformation. (M. F. *Cordero Rusque*, Porvenir, Chile).

Figure 6. Occipital robusticity in the Selknam. (A) Deformed skull from M F. *Cordero Rusque*, Porvenir (Chile). (B) Selknam skull from the BMNH (London).

Figure 7A and B. CVA 95% confidence regions. A) The three Fuegian groups and the Patagonians, both sexes combined. B) Squared Mahalanobis distances neighbour-joining tree, both sexes separately.

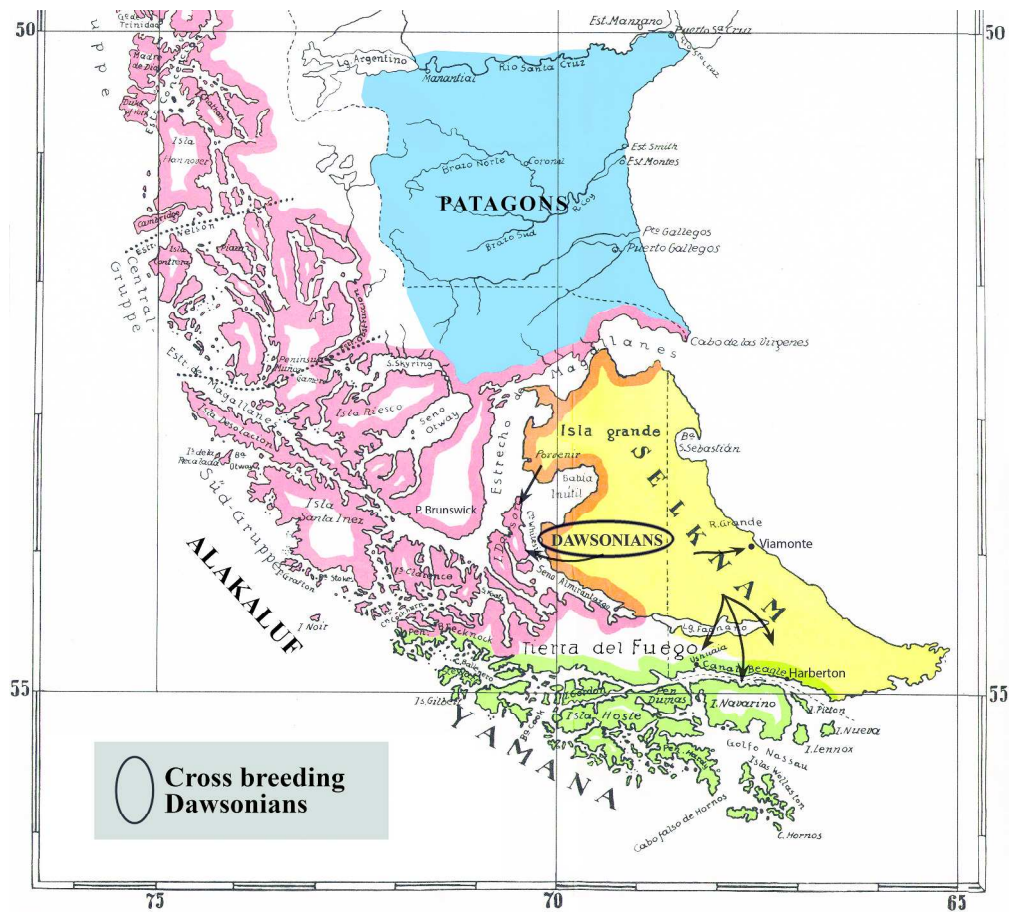
Figure 8A and B. A) Seventy-five per cent confidence regions for the individual scores of the first and second Factors (PC) explaining 38.9% of the variation. B) Average linkage phenogram (UPGMA) based on Euclidean distance for the male Fuegian samples. Percentages indicate the frequency of each branch among 100 bootstrapped trees.

Figure 9A and B. Sexual dimorphism in the cranial population-based variation for the Fuegian samples studied. Note that Alacaluf males (A) are closer to Selknam, whereas the opposite is found for females (B).

Figure 10A and B. CVA 95% confidence regions. A) Above: male American samples. Below: female American samples. B) Squared Mahalanobis distances neighbour-joining tree.

Figure 11A and B. A) Seventy-five per cent confidence regions for the individual scores of the first and second Factors (PC) explaining 46.2% of the variation. B) Average linkage phenogram (UPGMA) based on Euclidean distance for the male American samples. Percentages indicate the frequency of each branch among 100 bootstrapped trees.

Figure 12A and B. CVA 95% confidence regions A) Above: male variation for American, Asian and Australian-Melanesian samples. Below: female samples. B) Squared Mahalanobis distances neighbour-joining tree.



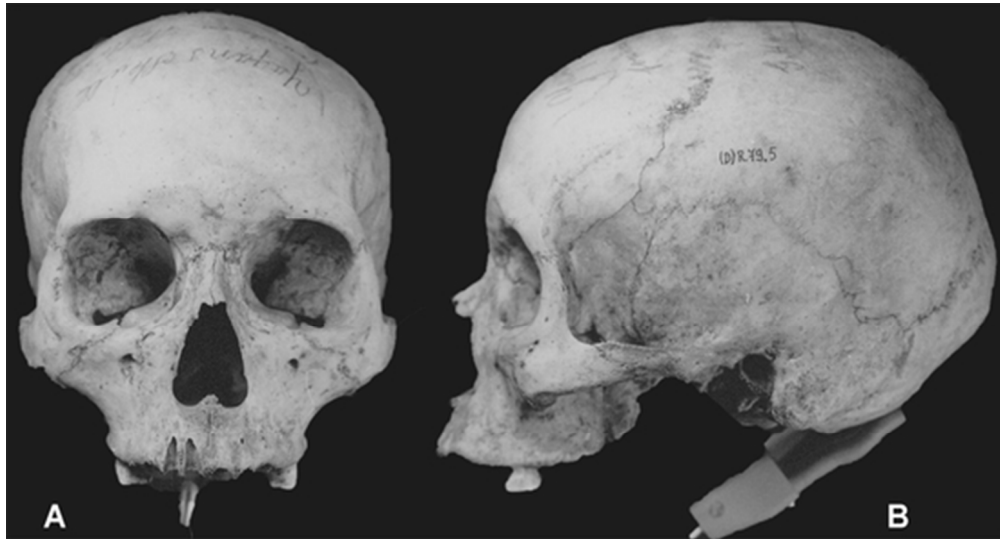
321x289mm (300 x 300 DPI)



43x22mm (300 x 300 DPI)



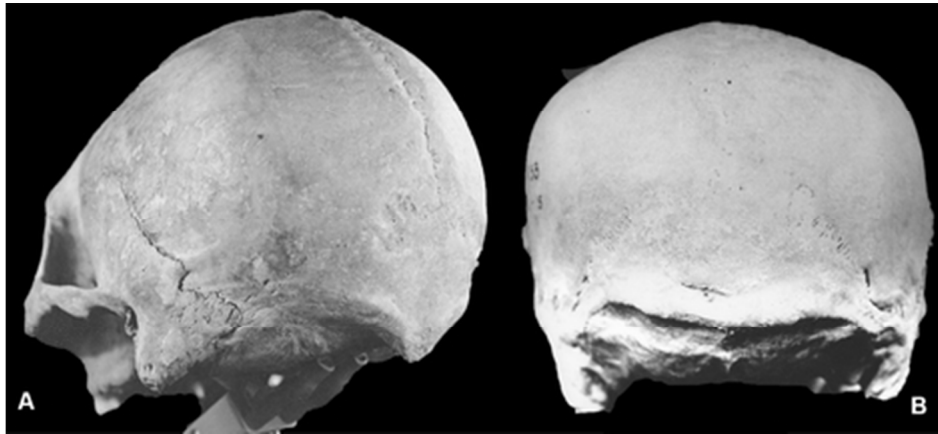
47x25mm (300 x 300 DPI)



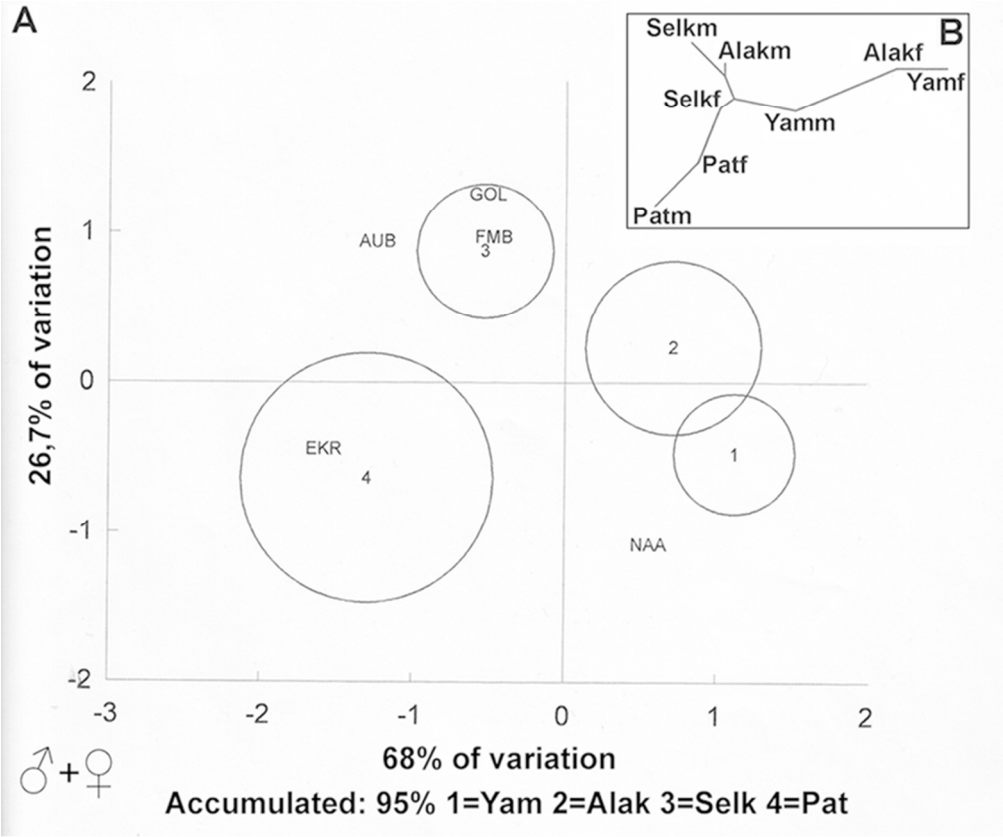
46x24mm (300 x 300 DPI)



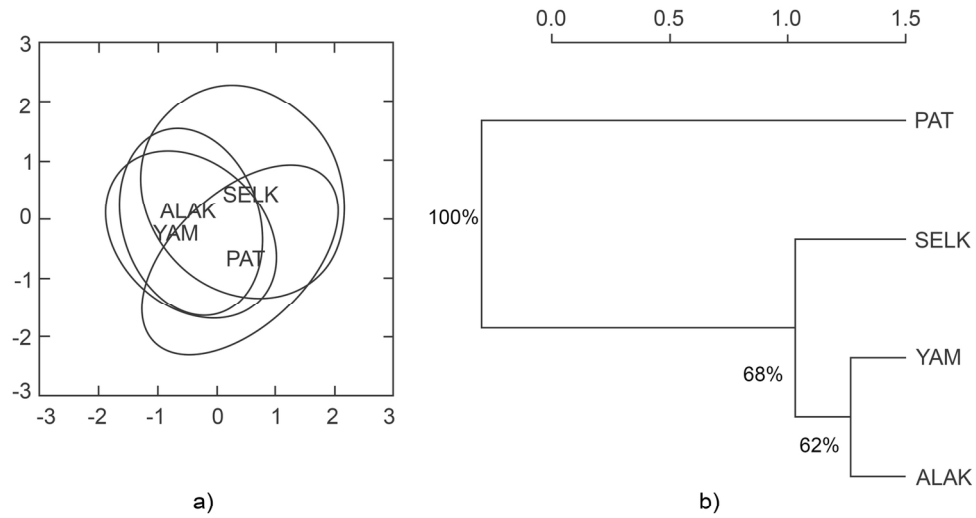
44x22mm (300 x 300 DPI)



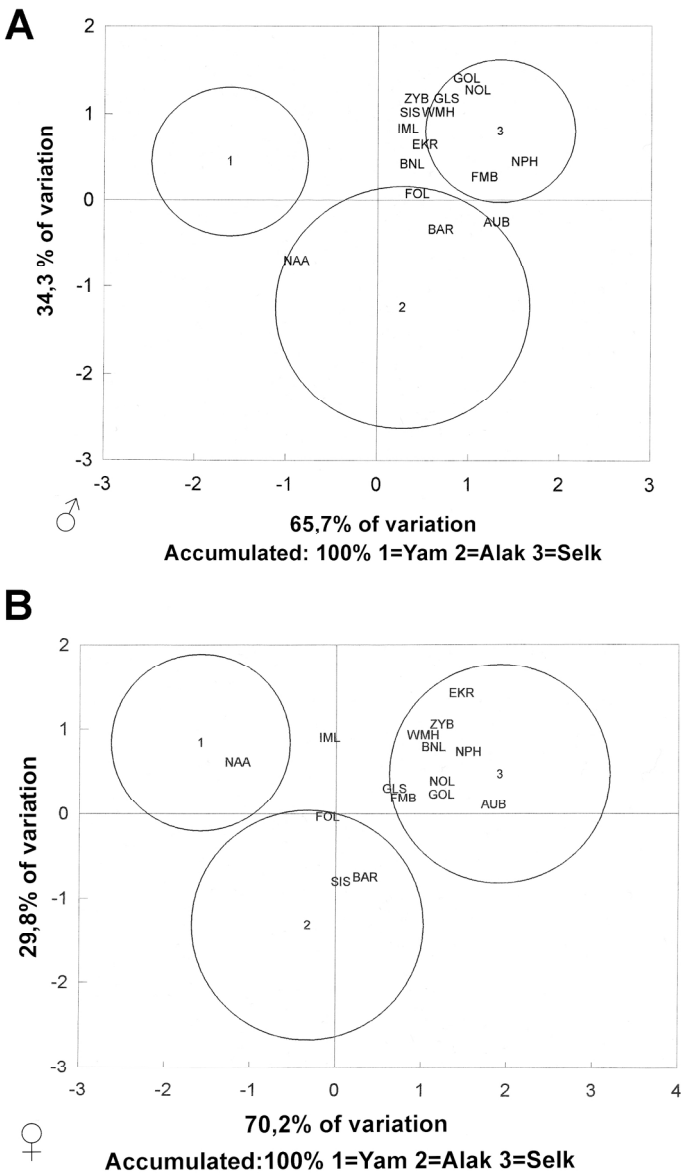
39x18mm (300 x 300 DPI)



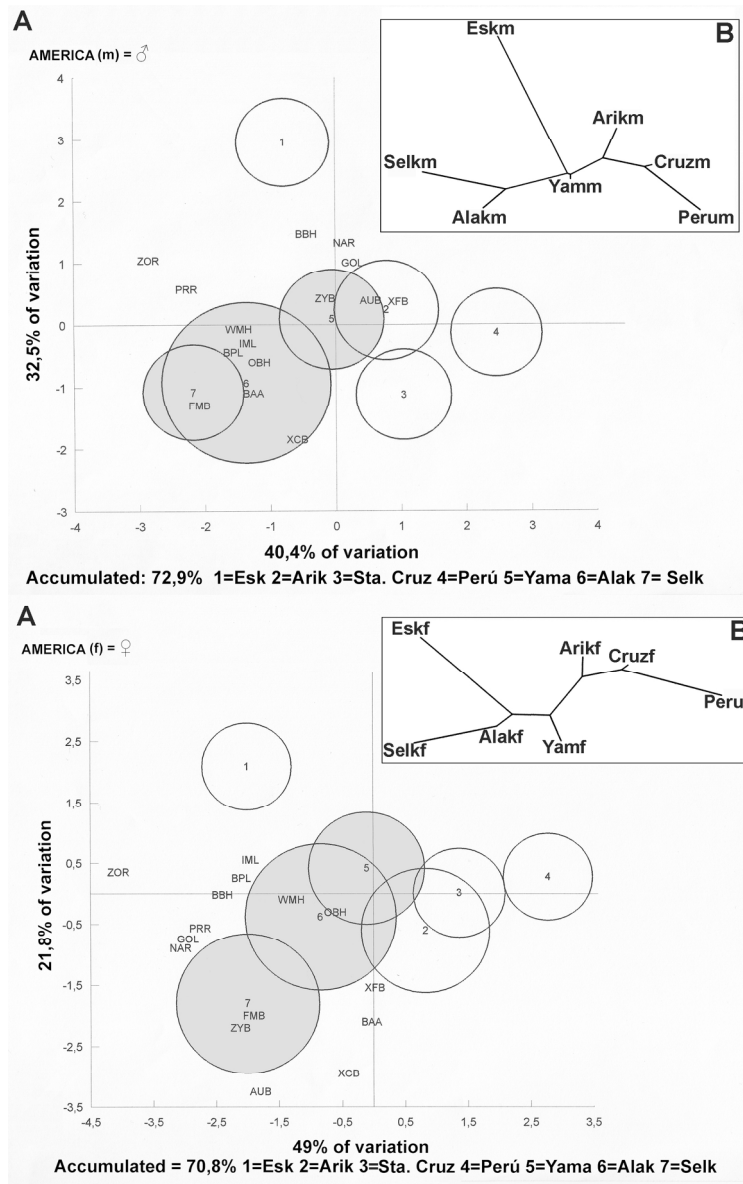
72x60mm (300 x 300 DPI)



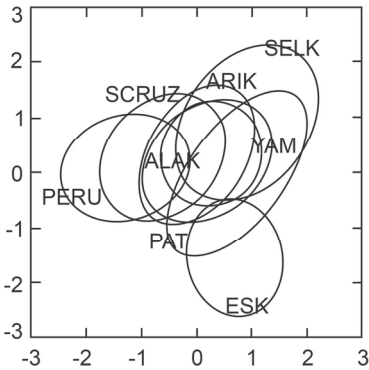
147x104mm (300 x 300 DPI)



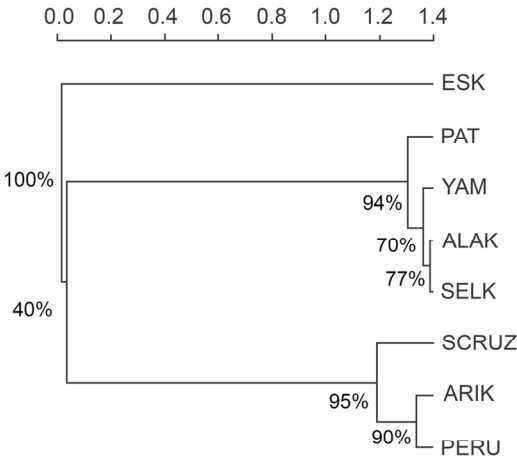
142x234mm (300 x 300 DPI)



140x225mm (300 x 300 DPI)

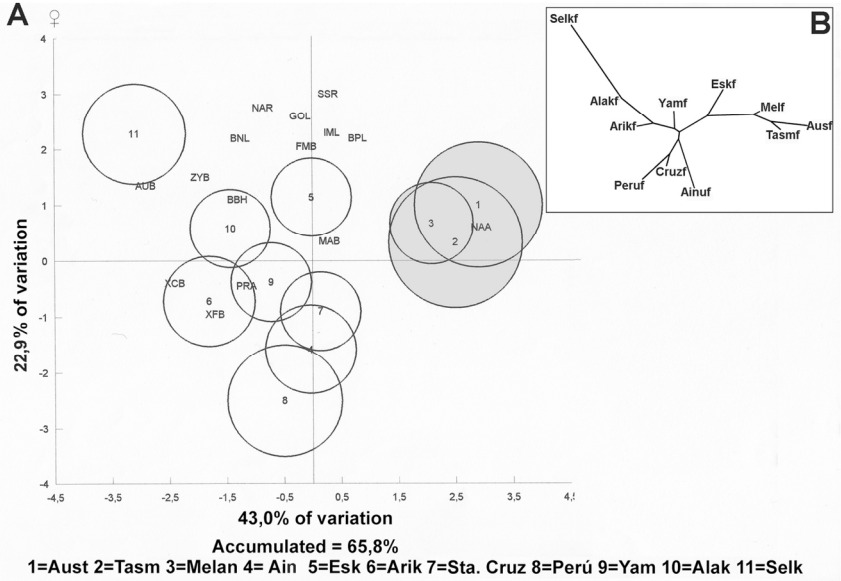
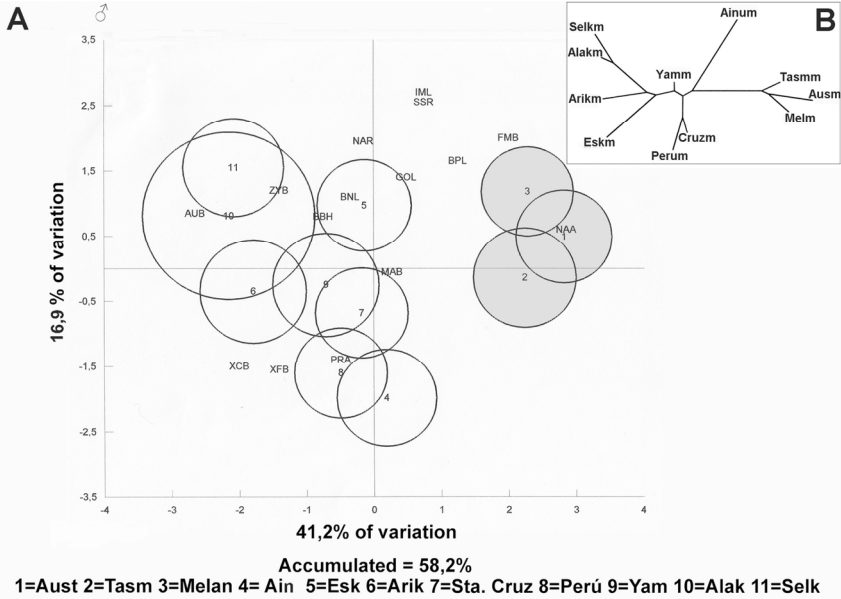


a)



b)

147x104mm (300 x 300 DPI)



123x174mm (300 x 300 DPI)

Table 1. Fuegian crania examined and studied.

	Fuegian crania examined	Adult Fuegian crania studied
Naturhistorisches Museum, Wien	21	20
Istituto di Antropologia, Florence	20	16
Università degli Studi <i>La Sapienza</i> , Rome	14	14
The Natural History Museum, London	18	13
Musée de l’Homme, Paris	12	10
Museo Etnográfico <i>J.B. Ambrosetti</i> , Buenos Aires	17	15
Museo de La Plata (Argentina)	11	8
Museo del Fin del Mundo, Ushuaia (Argentina)	8	7
Misión <i>La Candelaria</i> , Río Grande (Argentina)	11	8
Instituto de la Patagonia, Punta Arenas (Chile)	20	13
Museo <i>Mayorino Borgatello</i> Punta Arenas (Chile)	6	6
Museo Provincial de Tierra del Fuego <i>F. Cordero Rusque</i> , Porvenir (Chile)	6	5
Museo <i>Martin Gusinde</i> Puerto Williams (Chile)	10	5
National Natural History Museum, Santiago de Chile	24	23
American Museum Natural History, New York	11	11
National Museum Natural History Smithsonian Institution, Washington	2	2
TOTAL	211	176

Table 2. Fuegian-Patagonian crania studied.

	Male	Female	
Yamana	42	32	74
Alakaluf	16	19	35
Selknam	46	21	67
Total Fuegians	104	72	176
Non-deformed Patagonians	14	6	20
TOTAL	118	78	196

Table 3. Institution and Fuegian-Patagonian crania studied.

Institution	Case studied
Naturhistorisches Museum, Wien	Gus 1-6032, Gus 2-6031, Gus 3-6034, Gus 4-6040, Gus 5-6042, Gus 6-6035, Gus 8-6041, Gus 9-6038, Gus 10-6039, Gus 11-6036, Gus 12-6044, Gus 13-6033, Gus 14-6030, Gus 15-6043, L-N1-15359, L-N2-15358, L-N3-15357, L-N4-15360, Gus 99-21462, Gus 100-21463
Istituto di Antropologia, Florence	Fi 3115, Fi 3116, Fi 3117, Fi 3119, Fi 3120, Fi 3122, Fi 3124, Fi 3125, Fi 3126, Fi 3127, Fi 3128, Fi 3129, Fi 3130, Fi 3133, Fi 3134, Fi 3323
Università degli Studi La Sapienza, Rome	Ro 1, Ro 2, Ro 3, Ro 4, Ro 5, Ro 6, Ro 7, Ro 8, Ro 9, Ro 10, Ro 11, Ro 12, Ro 13, Ro 13A
The Natural History Museum, London	Lo 1025, Lo 1025-1, Lo 1025-2, Lo 1025-3, Lo 1025-4, Lo 1025-5, Lo 1025-6, Lo 1025-7, Lo 1027, Lo 1899.4.27.1, Lo 1933.6.15.1, Lo 1938.8.10.1, Lo AM 80-4
Musée de l'Homme, Paris	Pa 2283, Pa 10285, Pa 10289, Pa 10290, Pa 10291, Pa 19826, Pa 20912, Pa 20913, Pa 20914, Pa 26858
Museo Etnográfico J.B. Ambrosetti, Buenos Aires	BA 70, BA 119, BA 4964, BA 12589, BA 12590, BA 12618, BA 13276, BA 14751, BA 15193, BA 15194, BA 25883, BA 25884, MT1, MT2, BA Estancia M ^a Luisa
Museo de La Plata (Argentina)	LP 1335, LP 1338, LP 1339, LP 1340, LP 1863, LP 1864, LP 1865, LP 1867, LP 1869
Museo del Fin del Mundo, Ushuaia (Argentina)	Us 2636, Us 2637, Us Bahía Ushuaia, Us A-796, Us A-795, Us IG-794, Us Tolkeyén
Misión La Candelaria, Río Grande (Argentina)	RG 2, RG 3, RG 4, RG 7, RG 8, RG 11, RG 12
Instituto de la Patagonia, Punta Arenas (Chile)	L2 288, 848, 849, 850, 858, 859, 6780, 6789, 10412, 12489, 12490, 33833, 33950
Museo Mayorino Borgatello Punta Arenas (Chile)	D(R) 79.2, D(R) 79.3, D(R) 79.4, D(R) 79.5, D(R) 79.8, D(R), 79.12
Museo Provincial de Tierra del Fuego F. Cordero Rusque, Porvenir (Chile)	A(R) 79.3.1, A(R) 79.3.3, A(R) 79.3.6, A(R) 79.3.7, A(R) 79.4.2
Museo Martin Gusinde Puerto Williams (Chile)	PW2, PW5, PW6, PW7, PW9
National Natural History Museum, Santiago de Chile	414, 415, 416, 417, 418, 421, 424, 427, 428, 430, 431, 432, 434, 436a, 437, 438, 442, 446, 447, 449, 450, 458, 459
American Museum Natural History, New York	99-9744, 99.1-760, 99.1-761, 99.1-762, 99.1-763, 99.1-758, 99-6590, 99-3671, 99-3670, 99-6593, 99-6596
National Museum Natural History Smithsonian Institution, Washington	225.227, 380.377

Table 4. Pensize and C-Score values for the glabella projection (GLS) in the mid plane and prognatism (NAA) (Howells 1989). A) Male crania from America.

POB	PENSIZ	C-SCORES (GLS)	C-SCORES (NAA)
ESKIMO	12.459	-52.968	-20.679
ARIKARA	1.728	-28.719	-25.533
S. CRUZ	-13.566	18.282	53.911
PERU	-29.708	-20.429	26.581
PATAGON	4.371	-2.316	-4.942
SELKNAM	20.917	14.152	-43.003
ALAKALUF	1.226	-6.079	0.909
YAMANA	2.573	-2.619	12.755

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

Tabla 5. Measurement of the height of the nose (NLH) according to the techniques of R. Martin and W.W. Howells. The latter gives lower values. The values of the nasal height between the first studies are almost identical, due to the variation in ethnic assignment of one case. The authentic values, according to the technique of W.W. Howells (this study), give different results.

	Yamana						Alakaluf						Selknam					
	Male			Female			Male			Female			Male			Female		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
Hernandez et al. (1997) NLH supposedly 'according to Howells'	42	54,02	3,59	35	51,11	3,49	15	56,07	2,71	10	51	2,91	48	55,38	3,41	23	54,04	2,82
Hernandez (1992) NLH 'according to Martin'	42	54,1	3,6	36	51,2	3,4	15	56,1	2,6	10	53	6,9	49	55,8	4	23	54,1	2,8
This study, NLH 'according to Howells'	42	51,07	2,59	32	48,44	2,29	16	51,88	2,03	19	49,42	2,41	46	53,13	3,03	21	51,67	3,28

Table 6. Male American samples: factors 1 and 2.

	FACTOR 1 (34.6%)		FACTOR 2 (11.6%)	
1	NAR	0,889	XCB	0,66
2	ZOR	0,875	BAA	0,652
3	PRR	0,87	SSS	0,571
4	EKR	0,862	XFB	0,519
5	SSR	0,854	AUB	0,464
6	BNL	0,847	NAS	0,435
7	FMR	0,846	NPH	0,423
8	AVR	0,846	NDS	0,409
9	ZMR	0,817	FMB	0,407
10	DKR	0,802	ZYB	0,387
11	GOL	0,797	ZMB	0,327
12	NOL	0,771	ASB	0,317
13	ZYB	0,732	GLS	0,312
14	BPL	0,723	MDH	0,309
15	NPH	0,676	MAB	0,287
16	EKB	0,674	FOL	0,233
17	FMB	0,658	NLB	0,211
18	IML	0,654	EKB	0,208
19	BBH	0,652	DKS	0,147
20	AUB	0,579	WMH	0,13
21	ZMB	0,571	NLH	0,118
22	NLH	0,549	OBH	0,113

Table 7. Pensize and C-Score values for the glabella projection (GLS), in the mid plane, and prognathism (NAA) (Howells 1989). Male crania from America, Asia and Australia.

POB	PENSIZE	C-SCORES (GLS)	C-SCORES (NAA)
AUSTRALIA	2.919	32.232	44.672
TASMANIA	-6.418	43.785	50.421
TOLAI	-3.079	16.881	70.564
AINU	9.278	-14.898	-15.102
ESKIMO	13.339	-53.849	-44.788
ARIKARA	1.331	-28.323	-38.844
S. CRUZ	-14.564	19.279	19.443
PERU	-31.142	-18.995	2.442
PATAGON	4.448	-2.394	-11.590
SELKNAM	20.556	14.513	-58.739
ALAKALUF	1.051	-5.905	-6.702
YAMANA	2.280	-2.327	-11.776