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Metric and non-metric variants in prehistoric populations of Argentina

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Summary – *Metric and non-metric traits were studied in male and female crania belonging to collections from different regions in Argentina. Matrices of differential data were then created and subjected to cluster and principal components analysis. Biological distances were thus obtained and groups of similarity were delimited. Characteristics with major discriminatory value among groups were isolated. The absolute and relative incidences of non-metric variants were assessed using estimates from the mean measures of differences. Previous studies have demonstrated significant heterogeneity which may have modified the levels of morphologic variation in these populations. This study presents a model of intra and interpopulation interactions with a significant geographic component related to the mobility of these populations.*

Keywords – *Skull analysis, Biodistance, Morphological variation levels.*

Introduction

The study of biological relationships among populations - based on the study of skeletal remains - has a long history among bioanthropological researchers (Armelagos et al., 1982). In order to estimate the genetic relationship between populations, researchers in skeletal biology must start with the basic assumption that populations which show a greater similarity are more closely related (Howells, 1989; Saunders, 1989). The inference of relationship depends upon the appropriateness of the sample as well as the type of traits chosen (Ubelaker, 1978). Osteologists have systematically used metric and non-metric variants in an isolated or combined form (Berry and Berry, 1967; Kellock and Parsons, 1970; De Stefano and Macchiarelli, 1980/81; Molto, 1983; Yamaguchi, 1985, 1987; Sokal et al., 1987; Ishida and Kida, 1991) in order to solve problems dealing with the composition of populations (Fix, 1982) and the influence of this composition on the true genetic structure of the population (Ossenberg, 1976; Cheverud and Buikstra, 1978; Lane, 1978; Conner, 1990).

Thus far, there have been only a few significant studies in Argentina analyzing the population distributions of morphological variants of the aborigines who inhabited the territory (Salceda et al., 1981; Cocilovo, 1981; Marcellino and Colantonio, 1983; Colantonio and Marcellino, 1983, 1986; Méndez et al., 1984; Méndez and Salceda, 1990). Previous works have demonstrated that the series of crania from museum collections show a high level of morphological heterogeneity (Marcellino and Ringuelet, 1973; Salceda, 1984; Méndez and Salceda, 1989). This results from combining collections - the most numerous of which generally date from the beginning of the century - and the lack of information about skeletal provenance. It is therefore necessary to adjust sampling and data processing procedures in order to diminish the influence of these problems on the outcome of the study.

The purpose of this paper is to present the results obtained from the metric and non-metric analysis of cranial variants in the remains of aboriginal populations who inhabited what is now the Argentine Republic. A hypothetical and sequential model is suggested to explain the different levels of morphological variation between populations.

Material and methods

Data were obtained from 365 crania of adult aborigines from different regions of the geographic area in this study corresponding to collections in the Museo de La Plata and in the Museo de Prehistoria y Arqueología de la Universidad Nacional de Tucumán. To avoid an arbitrary distribution of the material present-day Argentina was split into three regions (Fig. 1). The Northwest mountains region, which included sedentary populations with an economy based on agriculture that were directly or indirectly influenced by the Andean Culture. The Northeast plains and grasslands are comprised of the eastern part of the country including a segment of the province of Buenos Aires, where sedentary people lived with a mixed economy of agriculture, hunting, fishing and harvesting. The south region consists of steppes and subantarctic forests comprising Pampa and Patagonia, including Tierra del Fuego, where people with an economy based on hunting, fishing and gathering were established (See Caggiano and Sempé, 1994).

The material was considered as a whole by the authors of the present work, even when previously described by other researchers in order to diminish interobserver error. Only intact or partly damaged crania were considered (Table 1). Thirty metric variants and thirty non-metric variants were identified on each cranium. Metric variants (Table 2) were primarily selected from the splanchnocranium because they are the least sensitive to plastic deformation (Mizoguchi, 1992).

Tab. 1 - Provenance of specimens of each region

Northwest	n	Northeast	n	South	n
Pampa Grande	54	Chaco	18	Valle del Rio Negro	10
Sta. Rosa de Tastil	18	Alto Paraguay	7	Chabut	5
Jüella	7	Delta del Paraná	62	Gaiman	2
Casabindo	8	Saavedra	4	Valle de Chubut	46
San Juan Mayo	1	Arroyo Malacara	1	Lago Buenos Aires	6
Surugá	2	Santa Clara	2	Tierra del Fuego	11
La Rinconada	2	Arroyo Las Viboras	2		
El Fuerte	1	Bahia Blanca	1		
Antofagasta Sierra	7	Tapalqué	1		
Antofalla	1	San Blas	25		
Tucumán	24	Isla Gama	14		
Buenos Aires	1				
El Arenal	2				
Posadas	5				
Total	125	*Total*	151	*Total*	89

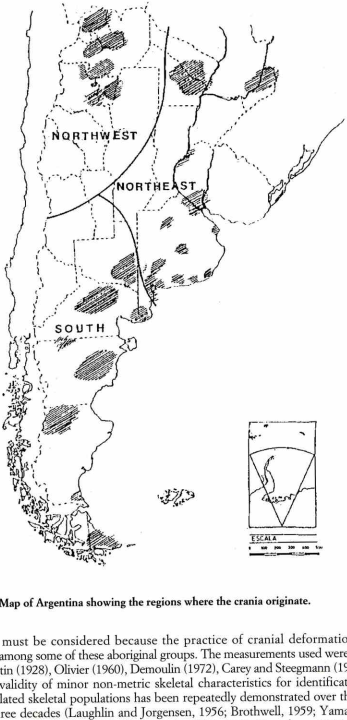

Fig. 1 - Map of Argentina showing the regions where the crania originate.

This must be considered because the practice of cranial deformation was common among some of these aboriginal groups. The measurements used were taken from Martin (1928), Olivier (1960), Demoulin (1972), Carey and Steegmann (1981).

The validity of minor non-metric skeletal characteristics for identification of closely-related skeletal populations has been repeatedly demonstrated over the past two or three decades (Laughlin and Jorgensen, 1956; Brothwell, 1959; Yamaguchi, 1967; Berry, 1968; Korey, 1970; Pietrusewsky, 1971; 1975; Ossenberg, 1977; Berry, 1979; Molto, 1983). More than 200 characteristics have been described for the

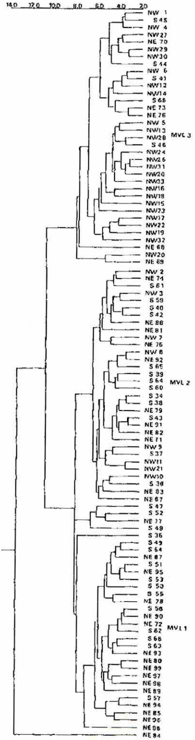

Fig. 2 - Phenogram of 99 crania results of group techniques applied. NW: northwest, NE: northeast, S: south, MVL: Morphological Variation Level.

Tab. 2 - List of metric characters used

Number	Characters	Number	Characters
1	Interorbital distance (d-d)	15	Bi-asteric diameter (ast-ast)
2	Bi-frontomalar diameter (fmt-fmt)	16	Length of palate (fi-sta)
3	Midline-frontomalarorbitale distance (fmo)	17	Length of palate (ol-sta)
4	Bi-zygoorbitale diameter (zyo-zyo)	18	Width of palate (bi-fpm)
5	Piriform aperture-zygomaxillare distance (zm)	19	Width of palate (1ro. -2do. M)
6	External bi-zygomaxillare diameter (zm-zm)	20	Nasion-basion diameter (n-ba)
7	Width of alveolar process	21	Prosthion-basion diameter (pr-ba)
8	Minimum height of zygomatic bone	22	Nasion-porion diameter (n-po)
9	Width of orbit (d-ek)	23	Prosthion-porion diameter (pr-po)
10	Height of orbit	24	Propterion-asterion diameter (sphn-ast)
11	Width of nose	25	Height of mastoid apophysis
12	Height of nose (n-ns)	26	Width of mastoid apophysis (po-ast)
13	Bi-porionic width (po-po)	27	Nasion-bregma curve (n-b)
14	Bi-zygomatic width (zy-zy)	28	Nasion-lambda curve (n-l)
		29	Nasion-opisthion curve (n-o)
		30	Nasion-prosthion height (n-pr)

cranium (Ossenberg, 1976) and an almost equal number for the postcranium. The impetus for the use of such characteristics in human populations was provided by Berry and Berry (1967) with their publication of a set of cranial characteristics analyzed by the multivariate Smith-Grewal statistic. Although controversies have arisen concerning the variability of these characteristics in regard to sex, age and laterality, in this study the use of these characteristics was adjusted to account for the sample distribution and documentation. In this way, equal numbers of adult of both sexes were considered. The total cranium was treated as an individual datum point. Observations were made by a single researcher to avoid inter-observed error. Although other sets of characteristics may show interdependence (Korey, 1980), numerous works have shown that the characteristics used in this study are independent (Berry and Berry, 1967; Kellock and Parsons, 1970; Neves, 1984).

Method of data analysis

Skeletal samples of 125, 151 and 89 crania were studied for each region, northwest-northeast and south, respectively (Fig. 1). Thirty-three groups from each region were chosen using cluster analysis of metric variants (Sneath and Sokal, 1973). One specimen was selected from each group as being representative of that group. In this way, each area was represented by approximately 33 specimens displaying variability as shown by the original set as a whole. The frequency of non-metric variants in each region was calculated by dividing the number of individuals representative of the groups that contained these variants by the number of groups in each region (Korey, 1970; Birkby, 1973; Suchey, 1975; Saunders, 1977). The comparison between groups was made using the methods of C. A. B. Smith (Grewal, 1962) and Saunders (1989) to assess differences or divergence. The incidence of each character was transformed to an angular value measured in radians. The magnitude of divergence between groups for each characteristic was calculated. The total difference between regions was then quantified by adding the difference of the mean value for each character. The standard deviations for the groups were also calculated.

All 99 crania were processed for the 30 metric variants using NTSYS-pc programs (Rohlf, 1992). A Basic Data Matrix (BDM) was constructed and the Taxonomic Distance coefficient for each possible pair of Operational Taxonomic Units (in the sense of Sneath and Sokal, 1973) was calculated to obtain a Matrix of Similarity to which cluster analysis techniques were applied unweighted pair group method using arithmetic averages (Sokal and Michener, 1958). In this way a phenogram of 99 crania showing the relationships between whole specimens was created (Fig. 2). The resulting groups were considered as an expression of Morphological Variation Levels (MVL).

The intrinsic variability of each MVL was determined using non-metric variants, thus obtaining new mean measures of difference between morphological levels. The mathematical methods used were the same as those described above.

Lastly, in order to identify the characteristics with the greatest discriminatory value between the MVL s, principal component analysis (Blackith and Reyment, 1971) was applied to all 99 crania.

In this way, the axis or components that constitute a new multidimensional space were obtained. These axes were interpreted as different dimensions of variability.

Tab. 3 - Absolute and percent incidence of non-metric cranial variants in three regions.

	South			Northwest			Northeast		
Variants	n	f	%	n	f	%	n	f	%
1	33	14	42.42	32	22	68.75	33	14	42.42
2	32	3	9.37	30	5	20.00	31	1	3.22
3	32	17	53.12	30	23	76.67	29	12	41.38
4	33	23	69.69	31	24	77.42	33	23	69.69
5	33	0	0	31	1	3.22	33	0	0
6	33	1	3.03	32	4	14.28	33	0	0
7	30	6	20.00	31	13	41.93	29	3	10.34
8	27	5	18.52	27	3	11.11	29	2	6.90
9	27	1	3.70	27	2	7.41	29	1	3.45
10	32	8	25.00	32	9	28.12	33	8	24.24
11	32	9	28.12	31	13	41.93	33	13	39.39
12	33	8	24.24	32	15	46.87	33	20	60.61
13	33	8	24.24	32	18	56.25	33	8	24.24
14	33	31	93.94	32	22	68.75	33	27	81.82
15	33	19	57.57	32	23	71.87	33	26	78.79
16	33	30	90.91	32	28	87.50	30	21	70.00
17	32	2	6.25	32	4	12.50	29	6	20.69
18	32	2	6.25	31	4	12.90	30	4	13.33
19	33	9	27.27	32	7	21.87	29	13	44.83
20	33	4	12.12	32	4	12.50	32	5	15.62
21	33	11	33.33	32	20	62.50	33	17	51.52
22	33	33	100.00	32	30	93.75	33	29	87.88
23	33	4	12.12	32	11	34.37	32	10	31.25
24	33	5	15.15	30	15	50.00	32	18	56.25
25	33	14	42.42	32	12	37.50	33	18	54.54
26	33	11	33.33	32	19	59.37	33	13	39.39
27	33	30	90.91	32	26	81.25	33	31	93.94
28	29	20	60.61	31	19	61.29	24	12	50.00
29	27	9	27.27	30	14	46.67	24	10	41.67
30	33	11	33.33	32	7	21.87	32	4	14.28

Results

Table 3 shows the absolute percentage incidence of non-metric variants recorded per region. Mean measures of difference between regions for all paired possible comparisons are shown in Table 4. By summing mean measures of difference between each region and all the rest, an estimation of the uniqueness of each region was obtained. The results are presented in Table 4. The greatest differences were found between the south and northeast. Mean values between the northeast and northwest and between the south and northwest are very similar. Therefore, the highest expression of uniqueness was observed in the northeast, followed by the south and northwest in a decreasing order. This tendency was explored considering only those minor variants showing differential incidence among regions presented in Table 3, as some variants have a scarce or null variation range. The greatest variability of incidence of each character was estimated by summing the mean measures of difference between pairs of regions for that character and dividing the total by the number of comparisons. This provides an average measure of the difference per comparison for a single variant. The ten variants with the largest values were selected. They are foramen of Huschke present, auditory torus present, lambdoid ossicle present, coronal ossicle present, accessory lesser palatine foramen present, metopism, mastoid foramen exsutural, palatine torus present, highest nuchal line present and parietal notch bone present. These variants are responsible for 76.69% of the total variation among regions based on the 30 variants considered at the beginning. Using a similar procedure, Kellock and Parsons (1970) found that in Australian aborigines, a group of ten variants was responsible for 90% of the total variation within the populations. Only four of the ten variants isolated in this study coincide with those selected by Kellock and Parsons because of their higher frequency. These are: auditory torus present, lambdoid ossicle present, palatine torus present and highest nuchal line present. The present results confirm the value of non-metric characteristics for the differentiation of skeletal populations.

Mean measures of divergence between regions and measures of uniqueness were recalculated on the basis of these ten variants. The results are presented in the lower half of Table 4.

Tab. 4 - Mean measures of difference and uniqueness among crania from three regions

	Northwest	Northeast	Measure of Uniqueness
Based on 30 variants			
South	0.0786 (0.0258)	0.0929 (0.0281)	0.0175
Northwest		0.0796 (0.0255)	0.1582
Northeast			0.1725
Based on 10 variants			
South	0.2414 (0.0776)	0.133 (0.0574)	0.3744
Northwest		0.1966 (0.0702)	0.438
Northeast			0.3296

Tab. 5 - Absolute and percent incidence of non-metric cranial variants in three morphological variation levels.

	MVL3			MVL2			MVL1		
Variants	n	f	%	n	f	%	n	f	%
1	34	23	67.65	32	15	46.87	26	8	30.72
2	33	4	12.12	30	3	10.00	25	2	8.00
3	33	18	54.54	29	21	72.41	24	11	45.83
4	33	29	87.88	32	21	65.62	26	15	57.69
5	34	1	2.94	31	0	0	26	0	0
6	34	5	14.70	32	0	0	26	0	0
7	32	9	28.12	30	11	36.67	24	1	4.17
8	29	2	6.89	28	4	14.28	23	3	13.04
9	29	2	6.89	28	1	3.57	23	1	4.34
10	34	10	29.41	31	8	25.81	26	6	23.07
11	34	12	35.29	30	11	36.67	26	12	46.15
12	34	15	44.12	32	11	34.38	26	16	61.53
13	34	17	50.00	32	12	37.50	26	4	15.38
14	34	23	67.65	32	28	87.50	26	23	88.46
15	34	24	70.59	32	21	65.62	26	19	73.08
16	33	27	81.82	31	29	93.55	25	18	72.00
17	33	2	6.06	30	5	16.67	24	4	16.67
18	32	4	12.50	31	4	12.90	24	1	4.17
19	33	9	27.27	31	10	32.26	24	8	33.33
20	34	5	14.70	32	2	6.25	25	4	16.00
21	34	21	61.76	32	14	43.75	26	10	38.46
22	34	32	94.12	32	30	93.75	26	24	92.31
23	34	8	23.53	32	12	37.50	25	4	16.00
24	32	13	40.62	31	8	25.81	26	14	53.85
25	34	16	47.06	32	13	40.62	26	13	50.00
26	34	16	47.06	32	17	53.12	26	13	50.00
27	34	30	88.23	32	29	90.62	26	22	84.61
28	32	19	59.37	29	17	53.12	18	11	61.11
29	31	12	38.71	27	11	40.74	19	8	42.10
30	34	7	20.59	32	11	34.38	25	2	8.00

Tab. 6 - Mean measures of difference and uniqueness between crania belonging to three levels of morphological variation.

	MVL2	MVL1	Measures of Uniqueness
Based on 30 variants			
MVL3	0.0385 (0.0179)	0.0523 (0.0222)	0.0908
MVL2		0.0364 (0.0185)	0.0794
MVL1			0.0887
Based on 10 variants			
MVL3	0.1263 (0.0559)	0.2165 (0.0775)	0.3428
MVL2	(0.0747)	0.1953	0.3216
MVL1			0.4118

In the first place, we observe an increase in the values of the mean measures of difference and uniqueness is observed. Secondly are notice that the measure of difference between south and northwest is greater than the difference between south and northeast.

Fig. 2 presents the results of group analysis in the 99 selected crania. Three groups can be identified representing the three Morphological Variation Levels. The first level (MVL1) is integrated exclusively from crania from the northeast (57.7%) and south (40.3%). The second level (MVL2) includes crania from the three regions represented in this way: south 40.6%, northeast 34.4% and northwest 25%. The third level (MVL3) corresponds mostly to crania from the northwest (71.4%). The participation of the other two regions amounts to 14.3%.

Mean measures of divergence were calculated between the three MVL s. Table 5 shows the absolute and percent incidence of the 30 non-metric variants in different levels. Table 6 presents the mean measures of differences between levels with their respective standard deviations for each pair of possible comparisons and the measures of uniqueness corresponding to each level. The greatest differences are between MVL1 and MVL3, followed by the pairs MVL2-MVL3 and MVL1-MVL2 having similar values of difference. MVL3 represents the greatest uniqueness. New values of difference and uniqueness presented in the lower half of Table 6 were obtained by considering the ten variants with the greatest differential incidence among levels selected with the same methodology as the one used in the comparison between regions. We find the greatest differences between MVL1 and MVL3 followed by the pair MVL1-MVL2 with lesser difference between MVL2-MVL3. The greatest uniqueness is given by MVL1. The considered variants are: coronal ossicle present, foramen of Huschke present, highest nuchal line present, parietal notch bone present, metopism, infraorbital foramen present, lambdoid ossicle suture, posterior condylar canal present, mastoid foramen exsutural and palatine torus present. These variants contribute 69.71% to the total variation.

Tab. 7 - Principal components analysis of major traits and percent variation of the first three component.

Traits of major contribution	Contribution	Variation	Accumulate
Principal Component 1			
23. prosthion-porion diam	0.893	46.7	46.7
22. nasion-porion diam.	0.883		
14. bizygomatic width	0.842		
20. nasion-basion diam.	0.839		
2. bi-frontomalar diam.	0.836		
Principal Component 2			
27. nasion-bregma curve	– 0.509	7.39	54.09
18. width of palate	0.498		
25. ht. of mastoid apophysis	0.495		
28. nasion-lambda curve	– 0.475		
29. nasion-opisthion curve	– 0.445		
Principal Component 3			
10. height of orbit	0.533	6.61	60.7
17. length of palate	– 0.461		
16. length of palate	– 0.457		
11. width of nose	0.425		
4. bizygomaxilarorbital diam	0.399		

The results obtained from the application of principal component analysis were assessed to determine the morphological differential pattern among the unique levels. The first three components explain 60.7% of the entire variation. Table 7 shows the five characteristics with the greatest contributions to each of the components, their contribution value, the variation percentage provided by each component and the accumulated percentage. The three MVL s obtained from the group analysis differ fundamentally in lineal metric variants in regards to: relative positions of cranial osteometric points in relation to porion, maximum and superior facial widths, dimensions of the basis of facial pyramid and in minor degree, neurocranial curves and dimensions of mastoid region, palate, orbit and piriform aperture.

Discussion and conclusion

One of the most important problems to clarify in connection with prehistoric populations is the determination of the grade and nature of biological variability. Such knowledge helps to establish biological differences among these populations and infer probable geographic, demographic and /or environmental patterns. The variability within a population is a manifestation of complex factors, including genetics, populations structure, microevolutionary effects and environmental plasticity, all of which have an adaptive value in their own right (Key and Jantz, 1990).

It was thought that archaeologically obtained skeletal samples represent biological populations, but the reality is far more complex. This complexity derives from the high likelihood that the individuals comprising a collection of skulls may represent a true amalgam of microevolutionary effects, especially if the collection represents a long period of inhabitation at a site. It would thus be more appropriate to speak about biological lineages (Cadien et al., 1974) instead of populations as the latter would be undistinguishable from an archaeological point of view. In this work it is assumed that samples delimited by regions and integrated by cranial series derived from an archaeological registry constitute biological lineages composed of one or several populations which cannot be distinguished a priori.

The use of non-metric traits showing significant genetic components (Grüneberg, 1952; Berry and Berry, 1967), even when some authors (Jantz, 1970; Corruccini, 1974; Carpenter, 1976) question their inheritance and use in the analysis of populations, was regarded as valid to establish intersample divergence showing a close relationship between that divergence and geographic distance. The use of metric and non-metric characteristics was also combined in order to get a better approximation of the real morphological variation which results from existing biological variability.

This allowed differentiation of levels of variations which transcend geographical regions, as they express similarity due to ancestry or genetic flux. The measured differences between MVL s, their uniqueness and the metric characteristics with discriminatory values among levels allowed the formulation of a hypothetical explanatory model of the actual collections and their relationships. This can be synthesized as follows (Fig. 3): The prehistoric population of present-day Argentina constitutes a network of biological lineages different in genetic contribution among regions and the interchange rates increase in inverse proportion to their uniqueness. Total variation is possibly included in three variation levels. These levels, however, express a geographic pattern - possibly

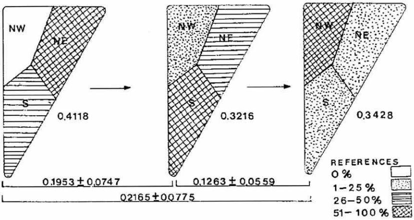

Fig. 3 - Diagram representing the explanatory pattern based on Figure 2 and the lower part of Table 6.

shaped by environmental influence on chosen characteristics - that could well be interpreted as temporal sections reflecting temporal stages in the evolution of the populations (structure and mobility with the concomitant expression in genetic terms). The uniqueness of measures for each MVL suggests direct association with time. Thus, the greater the uniqueness of the population, the greater its age. The mean measures of divergence allow the establishment of the temporal sequence.

It is likely that the primitive populations distributed in the northeast and south of Argentina coincided with the first waves of populations with greater mobility from northeast to south. Later, the coming of new waves in the northwest of present-day Argentina would modify the morphological variation level and the mobility and interaction would minimize the uniqueness of the morphological pattern. An even later time was characterized by a high prevalence of new populations connected with an increase in morphological uniqueness. This stage appears to be coincident with theories establishing that population movement from the major centers have contributed to absorption and replacement of populations in contiguous geographic areas (Hanihara, 1993). This was achieved by increased interregional contact with a subsequent increase in genetic flux between primitive, geographically isolated populations (Brace, 1992).

In conclusion, the lack of chronocultural context information in the majority of collections considered here prevents precise determination of the age of each MVL. Nevertheless, the interpretative model corroborates previous research regarding variation and morphological relations (Cardich et al., 1987; Dillehay and Meltzer, 1991; Meltzer, 1993).

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ABSTRACT

Varianti metriche e non-metriche in popolazioni preistoriche dell'Argentina

Riassunto – I tratti metrici e non-metrici del cranio sono stati studiati in individui di sesso maschile e femminile appartenenti a collezioni scheletriche provenienti da diverse regioni dell'Argentina. Sono state create matrici di dati differenziali e quindi sottoposte a "cluster analysis" e ad analisi in componenti principali, il che ha consentito di ottenere le distanze biologiche e di delineare i gruppi di somiglianza. Le caratteristiche con maggiore valore discriminante tra i gruppi sono state isolate. L'incidenza assoluta e relativa delle varianti non-metriche è stata valutata usando stime dalle misure medie di differenze. Studi precedenti hanno messo in evidenza una significativa eterogeneità che può aver modificato i livelli di variazione morfologica in queste popolazioni. Questo studio presenta un modello di interazione intra- e inter-popolazione con una significativa componente geografica relativa alla mobilità di queste popolazioni.

Parole chiave – Analisi del cranio, Distanza biologica, Livelli di variazione morfologica.

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