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Morphometric distances among five ethnic groups and evaluation of the secular trend in historical Libya

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Summary - *This study analysed the variations, both in space and time, of 10 body dimensions and 2 anthropometric indexes of 745 adult males belonging to 5 ethnic groups of historical Lybia (el-Haràbi, el-Baraghìts, Marabtìn, Oases inhabitants and Tuareg). The data were collected in the years 1928 and 1932 by Puccioni and Cipriani, two Italian anthropologists. The aim was to reconstruct the biological history of Libya at the time, and thus contribute to the ongoing debate on the evolution of the biological standard of living in developing Countries. The subjects were analysed by ethnicity and by 10-year age groups, after adjusting for age. The results of ANCOVA and Tukey's post-hoc test show that among and between groups there are statistical significant differences overall for armspan, height, head breadth, bizygomatic breadth, biiliac breadth/height and head breadth/head length indexes. By means of the cluster analysis, the el-Haràbi, el-Baraghìts and Marabtìn groups cluster together, whereas the Tuareg and Oases inhabitants cluster separately one from the other and both from the other three ethnic groups. Within-group variations are not very marked in all ethnicities. In general, there is the tendency, not statistically significant, to the reduction and/or stasis of body dimensions from the older to the younger, and the differences are greater among the older than the younger age classes. In conclusion, it can be argued that these groups, all different culturally and geographically, were following the same tendency of stasis of the secular trend of the body dimensions considered in this study, and such stasis persisted since, at least, the last twenty years of the 19th century, when the older were born.*

Keywords – *Morphometric distances, Secular trend, Historical Libya.*

Introduction

The last decades have seen growing interest in the study of the historical development of the biological standard of living in developing Countries. In many of them this is made possible thanks to the establishment of statistical bureaux and to the presence of long-lasting national surveys such as the DHS (*http://www.measuredhs.com/countries/*; Tiroitich-Ruto, 1999; Akachi & Canning, 2007; Baten, 2008; Moradi, 2010). In others, it is the result of field research projects conducted on single populations by research groups (Pretty *et al.,* 1998; Henneberg & van der Berg, 1990; Bhuiya & Mostafa, 1993; Ulijaszek, 2003; Khanna & Kapoor, 2004; Malina *et al.*, 2004, 2008a, b, 2010; Virani, 2005; Zhen-Wang & Cheng-Ye, 2005; Ji & Chen, 2008; Stock & Migliano, 2009).

These studies necessarily analyse a period of time limited to more or less the last 50 years, i.e.

since the beginning of the availability of large series of national data. Thus, the biological history of previous generations is still unknown. This is of main interest to biological anthropologists, who deal with long lasting consequences of geographic and/or cultural isolation, of different subsistence regimens, with patterns of marital choices, or who study the biomolecular patterns of peopling both at the macro- and micro-geographic level (Little *et al.*, 1989, 2006, 2008; Destro Bisol *et al.,* 2004; Little & Malina, 2005; Batini *et al.*, 2007; Patin *et al.*, 2009; Stock & Migliano, 2009; Cruciani *et al.*, 2010; Laval *et al.*, 2010; Zhong *et al.*, 2010).

Also, little is known on the historical evolution of the standard of living in developing Countries, namely on secular changes of body dimensions. The phenomenon in Western countries is well establishment and known, and is mainly associated with improved nutrition and health (Danubio *et al.*, 2003; Jacobs & Tassenaar, 2004; Buretić-Tomljanović *et al.*, 2006; Padez, 2007; Danubio & Sanna, 2008; Webb *et al.*, 2008; Sanna & Danubio, 2009). In developing countries, there are research papers that analyze some aspects of the phenomenon in small populations, in specific ethnicities, and/or at the regional level, too. They mostly deal with limited number of generations (Ganguly, 1979; Shaturugna & Rao, 1987; Prazuck *et al.*, 1988; Henneberg & van der Berg, 1990; Khanna & Kapoor, 2004; Marques-Vidal *et al.*, 2008; Baynouna *et al.*, 2009; Malina *et al.*, 2010). Concerning sub-Saharan Africa, the paper recently published by Moradi (2010) represents a milestone in this field. The author highlighted three models of the secular trend in 28 sub-Saharan countries in the last half of the 20th century. The first includes countries where there is a progressive, albeit slow, increase of height over time. The second is characterized by countries that show stable mean values of height through time, and the third refers to countries where changes in mean values of height show an alternate rhythm with a slight decrease in more recent times.

However, little or nothing is still known on the evolution of the standard of living during the periods preceding the 1950s all over the developing world. Baten (2008) is currently attempting to compile and standardize all available sources of heights for 165 countries around the world between 1810 and 1984, including Asian, Latin American and sub-Saharian Africa to fill this gap. Still, the Maghreb countries are lacking.

The present work is aimed at contributing to the reconstruction of the biological history of Libya through estimates of the variations in space and time of several anthropological parameters among adult males of five ethnic groups. The data were recovered at the Italian Institute of Anthropology (*www.isita-org.com*) at the University of Rome La Sapienza and the Museo di Storia Naturale at the University of Florence, that both house many volumes and files containing individual data relating to several anthropological surveys conducted worldwide. The data relating to Libya were collected by Puccioni in 1928-29 (Puccioni, 1936) and refer to people settled in Cyrenaica (Nort-East), while those from Cipriani refer to a group of Tuareg settled in Fezzan. To our knowledge these are the only data on the bioanthropological characteristics of the people of that area at that time.

Firstly, the work evaluates the morphometric distances between the different groups by statistically comparing the mean values of body dimensions among the total samples of the ethnic groups and by means of the cluster analysis applied to the less '*environment sensitive*' variables, e.g. the craniofacial morphometric measurements. The following analysis investigates the variations of body dimensions within each group to highlight their variations in time, thus contributing to the ongoing debate on the secular trend of body dimensions in developing countries by investigating if those groups show increases and/or decreases, or alternate periods, of the considered variables. In this latter case only those variables that are considered to be more '*environment sensitive*' were considered.

Materials and methods

The dataset and anthropometry

The global dataset utilized in this study consists of 745 adult males: 301 *el-Haràbi*, 159

Tab. 1 - Descriptive statistics of the anthropometric variables in the five considered ethnic groups and one-way ANCOVA (controlling for age) results.

ANTHROPOMETRY	ETHNIC GROUPS										ANCOVA
	el-Haràbi (N=301)		el-Baraghìts (N=159)		Marabtìn (N=184)		Oases inhab. (N=37)		Tuareg N=(64)		
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	*p*
Armspan	174.6	7.3	172.0	7.2	173.6	7.4	170.9	7.7	178.4	7.0	**
Height	168.0	6.0	167.5	6.3	168.0	6.1	162.9	6.8	171.1	5.6	**
Biacrom. breadth	38.9	1.7	38.9	1.9	38.7	1.7	38.0	1.8	37.4	1.5	**
Biiliocrist. breadth	27.4	1.9	27.7	1.6	27.2	1.7	27.1	1.5	26.5	1.2	**
Head length	19.4	0.8	19.2	0.6	19.4	0.5	19.4	0.6	19.3	0.7	
Head breadth	14.6	0.4	14.6	0.4	14.6	0.5	14.0	0.4	14.4	0.4	**
Head circumph.	55.2	1.3	54.9	1.4	55.3	1.4	54.5	1.4	55.3	1.8	
Bizyg. Breadth	13.8	0.5	13.8	0.5	13.6	0.5	13.2	0.5	13.1	0.5	**
Nasal height	5.5	0.4	5.5	0.4	5.3	0.4	5.1	0.4	5.3	0.4	**
Nasal breadth	3.6	0.3	3.5	0.3	3.6	0.3	3.6	0.3	3.6	0.2	
Biiliocrist. br/Height	16.3	1.1	16.5	0.8	16.2	0.9	16.7	0.7	15.5	0.7	**
Head br./Head. length	75.5	2.9	75.9	2.9	75.3	2.5	72.3	2.9	74.8	3.3	**

el-Baraghìts, 184 *Marabtìn*, 37 *Oases inhabitants* and 64 *Tuareg*. The data were recovered from two sources: 1) the tables relating to the ethnic groups of the 'People of Cirenaica' that report the individual data collected by Puccioni, listed in the volume published by Le Monnier in 1936; and 2) the unpublished individual forms filled by Cipriani in 1932 referring to 64 adult males of the Tuareg group. The data were considered reliable for the following reasons: 1) places of birth and/or ethnicity are clearly identifiable 2) the measurements are recorded in mm, and 3) the Italian anthropological school of the time was well established and highly competent in the field of anthropometry (Cipriani, 1940; Genna, 1938, 1943; Puccioni, 1929, 1936). The only doubtful data were the individual ages. This is due to the absence of regular statistical bureaux in the Country at the time. This was overcomed by analysing the dataset by 10-year age classes. Indeed, age grouping considerably reduces the error of misreporting. Three age groups were considered: 20.0-29.9, 30.0-39.9 and 40.0-over years old. Concerning the anthropometric parameters, there were 11 variables collected by both Puccioni and Cipriani. Of these, sitting height was discarded because unreliable. In addition, two indexes considered interesting for the purposes of the study were calculated: head breadth/head length and biiliocristal breadth/height. All considered variables were adjusted for age. The complete list of the considered variables can be seen in Table 1.

The ethnic groups

In the 1920s, according to De Agostini (1922-23), the population of Cyrenaica (North-East Region) counted 180,950 inhabitants, of whom 24,900 were in urban centers and 4,300 in the inland oases. The remaining population belonged to two main ethnic groups: the *Saàdi* and the *Marabtìn*. The *Saàdi*, considered descendants of the ancient Arabs, included the *el-Baraghìts*, with 4 tribes, in the western area of the Region and the *el-Haràbi*, with 6 tribes, in the eastern area. The *Marabtìn*, considered descendants of the ancient Berbers, included 12 tribes, scattered in isolated groups. The *Tuareg*, mostly nomads, were in many of the countries

surrounding the western borders of the Sahara desert, and had a troubled history with neighbouring groups and colonialists. In the 20th century they were reported to be 900,000 throughout Africa. In Libya, they were settled in Tripolitania and Fezzan (Western Region) (Nicolaisen, 1963; Bernus, 1981; Rasmussen, 1998).

Statistical analyses

The descriptive statistics of the 12 variables were calculated. ANCOVA (age as covariate) was used to evaluate significant differences for the anthropometric variables among groups and among age classes of each ethnic group. In the case of a significant difference in the ANCOVA, Tukey's HSD for unequal sizes was used for post-hoc analysis.

It is noteworthy to underline that to perform ANCOVA correctly some distributional and linearity assumptions must be respected. Namely, the variables must present a normal distribution in the different groups, the variances must not present heteroscedasticity, the covariate must be linearly related to the dependent variable(s), the covariate must have a homogeneity of regression slopes, the covariate and the independent variable must be unrelated. However, ANCOVA assumptions can be violated to some degree without seriously affecting the overall robustness of the test (Olejnik & Algina, 1985; Poremba & Rowell, 1997; Rutherford, 2001), in the presence of non-normality (Warton, 2007). However, in the case of a variable presenting systematic highly significant violations of the assumptions, the appropriate corrections were carried out to meet the assumptions (Afifi & Clark, 1984; Pesaran & Yamagata, 2008).

Cluster analysis has been chosen to evaluate the morphometric distances among the five Libyan groups. To perform cluster analysis the data of six craniofacial morphometric variables were utilized: head circumference, head length and breadth, nasal height and breadth, bizygomatic breadth, in accordance with the increasing evidence that head size and shape are more genetically determined than the other body dimensions that, by contrast, are more '*environment sensitive*' (Carels *et al.*, 2001; Kamakar *et al.*, 2007; Jelenkovic *et al.*, 2008; Sherwood *et al.*, 2008). The Squared Euclidean distance applied to standardized variables has been adopted as distance index between groups to carry out a pairwise distance matrix. The amalgamation method used is UPGMA (Unweighted Pair Group Average).

All statistical analyses were carried out with SPSS, version 16.0.

Results

The first performed analysis considers the descriptive statistics of the 12 variables in the total samples (Tab. 1).

The *Tuareg* show the highest mean values of height (171.1 cm) and armspan (178.4), whereas the inhabitants of the *Oases* have the lowest: 162.9 cm and 170.9 cm, respectively. The other three ethnic groups average 168.0 cm for height and 173.0 cm for armspan. In the case of biacromial and biiliocristal breadths, the *Tuareg* display the lowest mean values: 37.4 cm and 26.5 cm, respectively, and the other groups have mean values between 38.0 and 39.0 cm for the former, and 27.5 cm on average for the latter. Head and facial dimensions show very little variations among all ethnic groups. Finally, in the case of biiliocristal breadth/height and the cephalic indexes , the *Tuareg* show the lowest value of the former (15.5 cm), and the inhabitants of the *Oases* show the lowest value of the latter (72.3 cm). By means of ANCOVA, the observed differences among the ethnic groups resulted highly statistically significant ($p \leq 0.001$) in all cases, with the exception of those reported for the length and circumpherence of the head, and the nasal breadth. Results of Tukey's HSD test for unequal sizes (Appendix) highlight that the main responsible for the observed differences are the *Tuareg* and the inhabitants of the *Oases* vs. the others.

Craniofacial morphometric distances

Results of the cluster analysis constructed by standardized data of the six craniofacial measures of the five Lybian ethnic groups, using UPGMA linkage rule applied to pairwise distance matrix

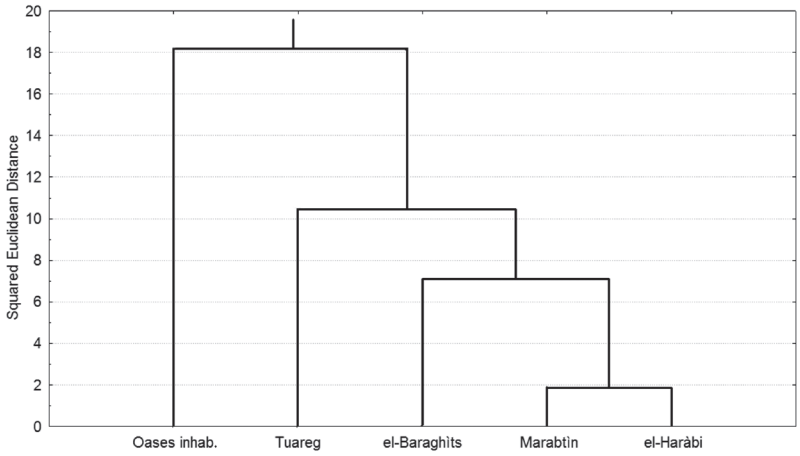

Fig. 1 - UPGMA tree based on six craniofacial morphometric measures of five Libyan ethnic groups.

of the squared Euclidean values, are shown in Figure 1. There is a compact sub-cluster at step 1, constituted by the fusion between the *el-Haràbi* and the *Marabtìn* groups, and the *el-Baraghìts* group, at step 2. The following association involves the *Tuareg* group, whereas amalgamation takes place with the outlier *Oases inhabitants* group. These results are in general agreement with those obtained from post-hoc analysis of the six craniofacial morphometric measures. In fact, the statistical significant differences between groups are mainly due to comparison with the *Tuareg* and the inhabitants of the *Oases*. By contrast, the *el-Haràbi*, the *el-Bagarìts* and the *Marabtìn* did not differ significantly one from the other, with the only few exceptions related to nasal height and bizygomatic breadth (Appendix). The results obtained by cluster analysis suggest that the *el-Haràbi*, the *el-Bagarìts* and the *Marabtìn* groups can be considered a well defined bioanthropological group.

Estimates of the secular trend

The following step was the statistical evaluation of the observed differences within each ethnic group among three age classes: 20.0-29.9; 30.0-39.9: 40.0-over yrs. To this purpose, only those variables that are considered to be more '*environment sensitive*' were considered: height, armspan, biacromial and biiliocristal breadths, biiliocristal/height and head breadth/head length indexes. Table 2 shows the descriptive statistics of the considered variables for each age class and ethnic group, and the statistical significance of the variations among age classes within each considered group. The results of ANCOVA are reported on top of the correspondent column of each anthropometric variable in each ethnic group. Mean values of all considered variables show slight variations among the different age classes in all groups. Interestingly, these variations show the tendency to the stasis or light decreases from the oldest to the youngest in all ethnic groups. The only exception is found in the small group of inhabitants of the *Oases*, who show increased mean values of armspan, from 167.3 cm to 173.3 cm and height, from 159.4 cm to 166.0 cm, in the youngest individuals. The latter is the only case in which the observed differences of these two variables are close to statistically significance: p=0.058. Concerning the other variables, biacromial and biiliocristal breadths decrease from the oldest to the youngest in the *el-Haràbi*, *el-Baraghìts* and *Marabatìn* groups, they remain unchanged in the *Tuareg*, whereas biacromial breadth increases from the oldest to the youngest in the inhabitants of the *Oases*.

In general, at all ages, namely in all periods, the *Tuareg* and the inhabitants of the *Oases*

Tab. 2 - Descriptive statistics of the anthropometric variables by age classes in the five considered ethnic groups.

ETHNIC GROUP		ARMSPAN		HEIGHT		BREADTHS				INDEXES			
						Biacromial		Biiliocristal		Biiliocr/ height		Cephalic	
age	N	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd
el-Haràbi													
20.0 - 29.9	99	173.7	6.9	167.9	6.0	38.8	1.8	26.8	1.4	16.1	0.8	75.8	2.5
30.0 - 39.9	104	174.1	7.1	167.6	6.0	39.0	1.7	27.5	2.0	16.4	1.1	75.4	2.3
40.0 - over	98	176.0	7.8	168.6	6.0	39.1	1.7	27.9	1.9	16.6	1.1	75.4	3.6
el-Baraghìts													
20.0 - 29.9	67	172.2	7.6	167.0	6.3	38.4	2.1	27.1	1.3	16.2	0.6	75.9	2.5
30.0 - 39.9	36	170.9	5.5	166.7	5.8	39.2	1.6	27.5	1.3	16.5	0.8	75.6	3.1
40.0 - over	56	172.5	7.6	168.5	6.4	39.2	1.9	28.5	1.8	16.9	0.9	76.1	3.2
Marabtìn													
20.0 - 29.9	71	172.1	6.8	166.8	5.7	38.4	1.6	26.7	1.4	16.1	0.7	75.4	2.5
30.0 - 39.9	41	173.6	7.1	167.9	6.1	38.5	1.5	27.3	1.8	16.3	1.1	75.2	2.8
40.0 - over	72	175.1	8.0	169.2	6.4	39.2	1.7	27.6	1.7	16.3	0.9	75.4	2.2
Oases inhab.													
20.0 - 29.9	11	173.3	7.8	166.0	6.0	38.3	1.4	27.2	1.7	16.4	0.7	72.7	1.8
30.0 - 39.9	12	173.0	6.1	164.2	4.7	38.6	1.4	27.1	1.2	16.5	0.5	73.1	3.2
40.0 - over	14	167.3	8.0	159.4	7.6	37.2	2.3	27.2	1.7	17.1	0.8	71.4	3.3
Tuareg													
20.0 - 29.9	30	177.3	6.3	170.2	6.1	37.3	1.5	26.7	1.2	15.7	0.7	75.7	3.3
30.0 - 39.9	19	178.7	8.7	170.8	5.8	37.5	1.3	26.2	1.4	15.3	0.6	73.9	3.3
40.0 - over	15	180.2	6.1	173.3	4.1	37.4	1.7	26.3	0.8	15.2	0.5	74.2	2.9

differed one from the other, and from the other three groups. In particular, the Tuareg mainly differed in body dimensions, except for height in the younger, whereas the inhabitants of the *Oases* show differences from the other groups mainly in the older for all considered variables and for width of the head in all age cohorts. The *el-Haràbi* and *el-Baraghìts*, considered descendants of the ancient Arabs, and the *Marabtìn*, considered descendants of the ancient Berbers, show no appreciable morphometric differences among them. Finally, the differences are greater among the older (40 years and over) than the younger (20.0-29.9 years).

Discussion

The discussion must consider some inherent limitations of the dataset. Firstly, the data were collected by operators whose number and training are unknown, and some errors may have been introduced during the collection of data. However, as stated in the *'Subjects and Methods'* section, the dataset can be considered reliable due to the technical accuracy of anthropologists of the time. Secondly, the ages are those declared by the individuals, who may not have known their exact age and/or remembered their date of birth. To overcome this inconvenience, we analysed the data by 10-year age classes. Thirdly, the small number of subjects, especially in the inhabitants of the Oases group, could lead to misleading conclusions and/or speculations about those individuals. Finally, there are very few references on height that refer to Libyan males from Benghazi measured in the late 1980s (Shamssain, 1988, 1989), but they lack for more recent years, thus preventing detailed considerations on the developing of the standard of living since then. Indeed, recent publications focused on defining the nutrition profiles of southern-Mediterranean countries, consider some anthropometry, namely the BMI and the percentage of individuals in its categories (FAO, 2005), and report its increasing trend since the 2000s (Belahsen & Rguibi, 2006), calling attention on the prevention and control of obesity. They do not report mean values of height and weight.

The data from Shamssain (1988, 1989), although they refer to urban people, are interesting because they report mean values of height by 10 years age-groups, except for the youngest, and allow the best set for the analysis on the occurrence of the secular trend. Indeed, those born in the 1930s had an average height of 167.8 cm, similar to that reported in the present paper for the *el-Haràbi*, the *el-Bagarìts* and the *Marabtìn*, the ethnic groups settled in the neighbouring area. Since the 1940s there was an average increase of height of 3 cm in the two following decades, 170.8 cm and 172.8 cm, respectively, followed by a stasis in the 1960s: 172.8/173.0 cm. Whether this trend was followed by the total Libyan population or not it is impossible to tell.

Despite the above limitations, the data presented in this work provide the best available dataset on different Libyan ethnicities in an unknown historical period that allow to investigate the occurrence of general tendencies of varying morphological distances among five ethnic groups, as well as of their changes in time within each group.

Summarizing, the main results are:

- these Libyan groups, taken globally, differed significantly in body dimensions. These differences are mainly due to the *Tuareg* and the inhabitants of the *Oases*, who both differ from each other and from the other three ethnicities. By contrast, the *el-Haràbi*, the *el-Bagarìts* and the *Marabtìn* can be considered a similar bioanthropological group;
- within-group variations are not very marked in all ethnicities. However, there is the general tendency to reduction/stasis of body dimensions from the older to the younger. In particular, observed variations of height and armspan among the three age cohorts are not statistically significant. Thus, it can be stated that there is no evidence of secular changes of height in the studied ethnicities;
- the *Tuareg* maintain their diversity throughout the three generations, whereas the other groups show the tendency toward similar mean values of, at least, height and armspan: the *el-Haràbi*, the *el-Bagarìts* and the *Marabtìn* because of their slight reduction/stasis, the *Oases inhabitants* because of their increase.

In conclusion, it can be argued that these groups, all different culturally and geographically, were following the same tendency of stasis of the secular trend of the body dimensions considered in this study, and such stasis persisted since, at least the last twenty years of the 19th century, when the older subjects (40 years and over) were born.

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Appendix - Ethnic groups responsible for the observed differences of mean values and p values.

	EL-HARÀBI	EL-BARAGHÌTS	MARABTÌN	OASES INHAB.	TUAREG
el-Haràbi					
Armspan		0.015			0.025
Height				0.003	0.034
Biacrom. breadth					0.001
Biiliocrist. breadth					0.007
Head length					
Head breadth				0.001	
Head circumph.					
Bizyg. Breadth			0.008	0.001	0.001
Nasal height			0.002	0.002	
Nasal breadth					
Biiliocrist. br/Height					0.001
Head br./Head. length				0.001	
el-Baraghìts					
Armspan	0.015				0.001
Height				0.010	0.007
Biacrom. breadth					0.001
Biiliocrist. breadth					0.001
Head length					
Head breadth				0.001	
Head circumph.					
Bizyg. Breadth				0.001	0.001
Nasal height			0.002	0.002	0.041
Nasal breadth					
Biiliocrist. br/Height			0.010		0.001
Head br./Head. length				0.001	
Marabtìn					
Armspan					0.002
Height				0.003	0.029
Biacrom. breadth					0.001
Biiliocrist. breadth					
Head length					
Head breadth				0.001	
Head circumph.					
Bizyg. Breadth	0.008			0.001	0.001
Nasal height	0.002	0.002			

Appendix - Ethnic groups responsible for the observed differences of mean values and p values (continued).

	EL-HARÀBI	EL-BARAGHÌTS	MARABTÌN	OASES INHAB.	TUAREG
Marabtìn (Continued)					
Nasal breadth					
Biiliocrist. br/Height		0.010			0.001
Head br./Head. length				0.001	
Oases inhab.					
Armspan					0.001
Height	0.003	0.010	0.003		0.001
Biacrom. breadth					
Biiliocrist. breadth					
Head length					
Head breadth	0.001	0.001	0.001		0.002
Head circumph.					
Bizyg. Breadth	0.001	0.001	0.001		
Nasal height	0.002	0.002			
Nasal breadth					
Biiliocrist. br/Height					0.001
Head br./Head. length	0.001	0.001	0.001		0.001
Tuareg					
Armspan	0.025	0.001	0.002	0.001	
Height	0.034	0.007	0.029	0.001	
Biacrom. breadth	0.001	0.001	0.001		
Biiliocrist. breadth	0.007	0.001			
Head length					
Head breadth				0.002	
Head circumph.					
Bizyg. Breadth	0.001	0.001	0.001		
Nasal height		0.041			
Nasal breadth					
Biiliocrist. br/Height	0.001	0.001	0.001	0.001	
Head br./Head. length				0.001	