THREE-DIMENSIONAL CRANIAL SHAPE ANALYSES AND GENE FLOW IN NORTH AFRICA DURING THE LATE HOLOCENE

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Introduction

The hyper-arid climate and harsh physical terrain of the Sahara Desert would be expected to inhibit population contacts during the Late Holocene[1]. However, archaeological evidence further provided during the DMP project (2007-2011) suggests that there was human occupation and extensive contacts across the desert at that time[2,3]. The Garamantes are one of such populations that flourished in South-West Libya approximately 3,000 years ago and largely controlled trans-Saharan trade[4]. This research explores the biological affinities of the Garamantes with other coeval Algerian, Tunisian, Egyptian and Nubian populations, by means of cranial shape variation as captured by three-dimensional morphometrics. Figure 1 illustrates the geographic location of the populations under study. Figure 2 shows the city of Garama, the old capital of the Garamantes in the Libyan Fazzan.

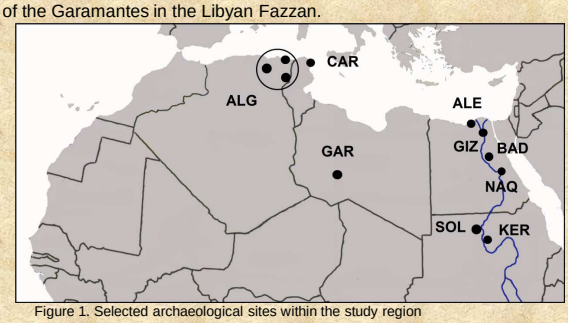
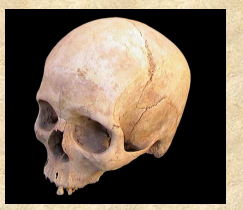


Figure 1. Selected archaeological sites within the study region

Figure 2. Old Garama, the capital of the Garamantes (Fazzan, Libyan Sahara)

Materials and Methods

The coordinates of 116 landmarks were recorded using a portable digitizer (Microscribe G2X). These landmarks were then superimposed through Generalized Procrustes Analysis (GPA) and analyzed with non-parametric MANOVA (NPM)[5,6]. Principal Components Analysis (PCA) and the number of PCs that accounted for 99.5% of the total variance was used for the estimation of the Mahalanobis distance and the performance of NPM. The sample size of the populations analysed is reported in Table 1.



Population-Origin	Symbol	M	F	Date	Country
Garamantes	GAR	11	13	900BC-500AD	Libya
Kerma	KER	45	88	2000-1550BC	Sudan
Soleb	SOL	10	17	1575-1380 BC	Sudan
Gizeh	GIZ	85	63	664-343 BC	Egypt
Alexandria	ALE	11	9	323 BC- 330AD	Egypt
Naqada	NAQ	42	77	4000-3200 BC	Egypt
el-Badari	BAD	15	19	4400-4000 BC	Egypt
Carthage	CAR	12	8	751BC-435AD	Tunisia

Table 1. Populations under study and relative sample size.

Results

Most groups, including the Garamantes, show a significant distance from most of their neighbours. Carthagenian and Alexandrian males and females, as well as Soleb and Alexandrian, and Soleb and Carthagenian males are exceptions. However, this result may be a sampling bias derived by the small sample size of these populations. Mahalanobis D values for both sexes are given in Table 2. Most D values are statistically significant with the exception of the following pairs of populations: Carthagenians-Alexandrians, Soleb-Alexandrians, and Soleb-Carthagenians. Interestingly, Garamantes exhibit the greatest distance from all populations.

	GAR	CAR	ALE	GIZ	BAD	NAQ	SOL	KER
GAR	0	8.771***	7.899***	6.648***	8.541***	7.772***	7.021***	7.033***
CAR	8.111***	0	4.933	7.322***	6.555***	5.796***	4.289	7.005***
ALE	9.286***	5.595*	0	6.471***	5.830*	4.678**	3.945	6.062***
GIZ	7.849***	6.465***	7.751***	0	5.679***	4.713***	6.623***	4.630***
BAD	7.888***	7.299***	6.485***	6.804***	0	2.871*	5.388***	4.513***
NAQ	8.336***	5.896*	6.116***	4.141***	3.795	0	5.645***	3.572***
SOL	8.157***	5.313	2.997	6.818***	6.776***	5.436*	0	5.337***
KER	9.449***	6.953***	8.402***	3.905***	8.490***	5.183***	6.949***	0

Table 2. Corrected Mahalanobis distances for males (below the diagonal) and females (above the diagonal) * values are significantly different at P < 0.05, **significant at P < 0.01, ***significant at P < 0.001

Figures 4 and 5 give the MDS plots based on D values. For males, the Garamantes appear isolated along Dimension 1. Among the remaining populations three clusters can generally be identified, one includes the Gizeh and Kerma, another consists of the Badari and Naqada, and the third includes the Carthagenians, Soleb and Alexandrians. These results are similar for females, with the Garamantes again standing out along Dimension 1, and the remaining groups clustering in the same way as for males.

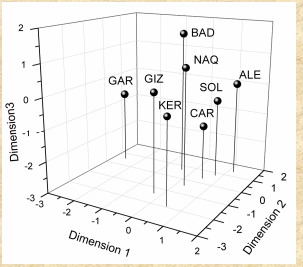


Figure 4. Three-dimensional MDS based on Mahalanobis distances for males

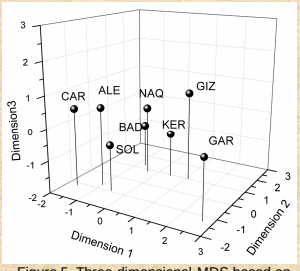


Figure 5. Three-dimensional MDS based on Mahalanobis distances for females

Discussion and Conclusions

These results suggest an important role of the Sahara Desert in shaping human populations in the middle to late Holocene:

- Garamantian men and women stand out as different from the other populations; we suggest that their geographical position restricted gene flow from other groups and shaped their unique characteristics.
- The cluster formed by the el Badari and Naqada is to be expected, two well-known pre-Dynastic populations along the Nile.
- The cluster consisting of the Carthagenians and Alexandrians is interesting, as it suggests much important exchanges among Mediterranean groups in North Africa despite the distances. The proximity of the population from Soleb to this group is not clear at present and requires further investigation.
- The case of the Kerma and Gizeh is interesting, although difficult to explain. These groups do not overlap temporally, and would not be expected to form a separate cluster from other populations. The fact that this cluster is found in both the present craniometric and the recent non-metric analyses gives strong support to the results.

Overall the results suggest that the Sahara desert restricted gene flow among North African populations at this time, while the trade networks evidenced by archaeological data possibly involved a subset of male merchants.

References

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