An Odontometric Investigation of Canary Islander Origins

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ABSTRACT   Attempts by anthropologists to account for the peopling of the Canary Islands have led to theories that call for one, two, and even four immigration events. However, most agree the Canary Island Guanche are biologically closest to Berbers from Morocco and Algeria. Genetic contributions from Arabs, Romans, and Carthaginians have also been proposed. An earlier study by Irish using Penrose analysis of odontometric data in samples of Guanche, Shawia and Kabyle Berbers, and Bedouin Arabs supports many of these proposed genetic relationships.

The present investigation expands upon this earlier work by adding samples of Carthaginians, Egyptians, and Nubians, and by using tooth size apportionment analysis, a more robust statistical approach for assessing inter-sample differences in the distribution, or allocation, of tooth size in the maxillary and mandibular dental arcades. The analysis yielded three components that account for >80% of the total variance. Cluster analysis and three-dimensional ordination of group component scores provide additional insight into Canary Island/North African relationships. Except for one early Nubian sample, the Guanche exhibit some measure of affinity to all others. However, they are most like Berbers and Carthaginians. These results suggest that Canary Islanders belong to a greater North African gene pool, yet show the closest affinities to Northwest Africans—which corroborates earlier dental and non-dental findings. *Dental Anthropology 2004;17:8-17.*

The Canary Islands are located in the Atlantic Ocean off the northwest coast of Africa (Fig. 1). Seven small islands comprise the archipelago: La Palma, Gomera, Hierro, Tenerife, Grand Canaria, Fuerteventura, and Lanzarote. Of the seven islands, Fuerteventura is nearest the continent, approximately 100 km west of Cape Juby, Morocco. The Canary Islands have been a part of Spain since the late 15th century. However, prior to that time they were occupied by the Guanche—the aboriginal inhabitants of the archipelago. These early people were primarily cereal agriculturalists who practiced a Neolithic lifestyle (Cavalli-Sforza *et al.*, 1994). They possessed domesticated goats and pigs, and supplemented their diet with shellfish, fish, and various wild plants (Mercer, 1980).

Over the past 100 years, numerous researchers have attempted to determine the origins and biological affinities of the Guanche (*e.g.*, Verneau 1887, 1891; Hooton 1916, 1925; Falkenburger 1939; Fusté 1959, 1965; Schwidetzky 1963; Roberts et al., 1966; Vallois 1969; Mercer 1980; Gonzalez and Tejera, 1981; Onrubia Pintado, 1987; Bermudez de Castro, 1989). As a result, the original Guanche homeland has alternately been identified as Africa, Europe, and/or the eastern Mediterranean area. The purpose of the present investigation is to reexamine four of these origins hypotheses using evidence from principal components analysis of odontometric data in Canary Island, North African, and West Asian-derived samples. Although other theories exist (see Vallois 1969 for an overview), the four examined here afford a representative sampling of those envisioned by all researchers. Components obtained from statistical analyses yield information on overall crown size, as well as the allocation of size across dimensions and tooth types in both jaws among samples. This approach, termed tooth size apportionment analysis (see Harris and Bailit, 1988; Harris and Rathbun, 1991; Lukacs and Hemphill, 1993),

Authors' note: A preliminary version of this paper was included in the 2001 volume La Paléo-Odontologie: Analyses et Méthodes d'Étude, Paris: Éditions Artcom, edited by Djillali Hadjouis and Bertrand Mafart. That article (Irish and Hemphill, 2001) was published in French, is generally not available outside of western Europe, and contained several publisher errors in the tables and figures. As such, we decided to provide a modified and expanded English translation to facilitate dissemination of our findings to a wider audience of dental and Canary Island researchers.

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is intended to provide new insight into the old problem of understanding Guanche ancestry.

PREVIOUS PEOPLING HYPOTHESES

Hooton (1916, 1925) was one of several early anthropological researchers to investigate the origins and population history of Canary Islanders (see also Verneau 1887, 1891, and among others, Quatrefages and Hamy 1874, Shrubsall 1896, von Luschan 1896, von Behr 1908 (as presented in Vallois 1969)). He hypothesized that four migrations to the islands from North Africa took place during the Neolithic and Bronze Age. Based on the analyses of craniometric and ethnographic data, Hooton maintained that the Guanche were comprised of different stocks of people largely exhibiting Mediterranean and Alpine Caucasoid components, supplemented perhaps, by sub-Saharan and other elements. He further proposed that they originated from populations inhabiting southern Morocco, the Atlas Mountains of northern Morocco and Algeria, and the eastern Mediterranean (Fig. 1). Subsequent intermixture among these four groups, along with later Arab, Berber, and Carthaginian gene flow, was thought to have resulted in the pre-European Contact peoples of the Canary Islands.

Based on cranial morphometric data, Schwidetzky (1963) envisioned two migrations from the adjacent African mainland during the Neolithic. These two groups consisted of "Cro-Magnoid" and "Mediterranean-like" cranial types, asserted to be evident in prehistoric Guanche remains. These same findings are echoed by Fusté (1959, 1965), Vallois (1969), and others. The former cranial type is said to be characterized by a wide low face with robust features, whereas the latter is more gracile with a narrow, high face.

Roberts and coworkers (1966) proposed that the Guanche were the product of an ancient colonization from Europe (which reprises Verneau's thesis to some extent (see Vallois 1969)). They based their conclusions on perceived osteological affinities of ancient Guanche skeletons (per Hooton, 1925; Hiernaux, 1975) and serological and dermatoglyphic affinities of living Canary Islanders (Mourant, 1954; Roberts et al., 1966) to Northwest Europeans.

Lastly, Mercer (1980) described an immigration of Northwest African Berbers during the Roman era, based on 15th-17th century ethnographic accounts of Guanche oral traditions and paleo-serological analyses of Guanche mummies. He suggested that Berber malcontents from the Atlas Mountains of northern Morocco and Algeria were exiled to the islands as punishment for resistance to Roman rule. Mercer also sees a lack of definite radiocarbon dates prior to the first century AD in the archipelago as supportive of this
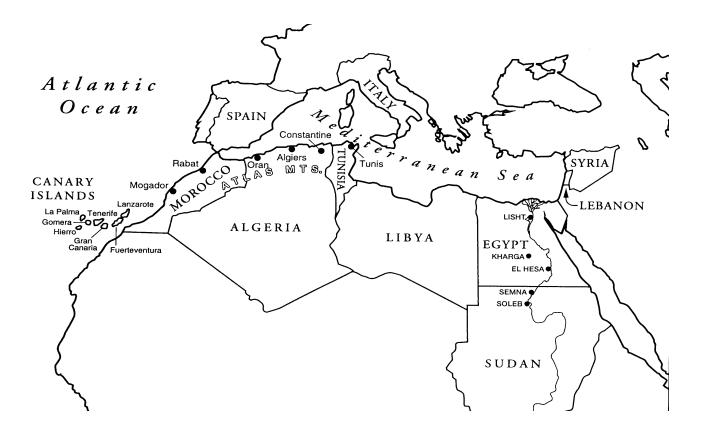

Fig. 1. Regional map showing Canary Islands, North Africa, and the Mediterranean area.

late-arrival model. In addition, his hypothesis provides an explanation for sea transportation to the islands—an ability the Guanche apparently did not possess at the time of European Contact. However, others maintain (*e.g.*, Cavalli-Sforza *et al.*, 1994) that the Guanche originally sailed to the islands of their own accord, and subsequently lost the skill to make adequate sea-going vessels. Like Hooton, Mercer suggests later contact by Carthaginians and Arabs may have provided an additional genetic contribution to the Canary Island gene pool.

Despite these widely varying scenarios all workers agree that, at the time of European Contact, the native Guanche comprised a lightly-pigmented population (Murdock, 1959; Vallois, 1969) reminiscent of peoples living throughout Europe, the Mediterranean area, and parts of North Africa. This contention is based on 15th century French and Spanish accounts, in addition to the aforementioned ethnographic, serological, skeletal, and other data. Further, excluding Roberts *et al.* (1966), most researchers believe the Guanche were closely related to Northwest African Berbers (see Hooton, 1916; Schwidetzky, 1963; Gonzalez and Tejera, 1981; Onrubia Pintado, 1987; Bermudez de Castro, 1989); perhaps those from the Atlas Mountains region of northern Morocco and Algeria (Mercer, 1980). Support for this relationship is bolstered by recent genetic analyses (Cavalli-Sforza *et al.*, 1994), as well as long-standing linguistic evidence that Guanche, the Canary Islander's extinct language (Bynon, 1970), shows a close affinity to the Afroasiatic Berber language (Hooton, 1916, 1925; Greenberg, 1966; Mercer, 1980). The Berber language may in turn be derived from the Late Paleolithic North African Mechta and Capsian cultures (Hiernaux, 1975; Mercer, 1980; Onrubia Pintado, 1987). However, as Hooton (1925) and Mercer (1980) note, the islands' population may have also been influenced by Arab, Roman, and Carthaginian contact prior to the 15th century Spanish occupation.

ODONTOMETRIC ANALYSES

In a preliminary study (Irish, 1993a), aspects of the four hypotheses were tested via Penrose shape analysis of tooth crown diameters in samples of pre-European Contact Canary Islanders (n=163), and historic Northwest African Shawia Berbers (n=26), Kabyle Berbers (n=32), and Bedouin Arabs (n=49). Although metric data are employed, the Penrose shape component is analogous to morphological analysis because it emphasizes differences in the form of a structure (crown form) rather than size (Penrose, 1954; Rahman, 1962; Corruccini, 1973). The results tentatively support a Canary Island/Northwest Africa link. The Guanche comparison to the Shawia and Kabyle Berbers yielded low, insignificant shape values (0.09 and 0.10, respectively), indicating a close phenetic similarity that would be expected if Berbers colonized the Islands. The magnitude of the Guanche/ Arab value is twice that of the other comparisons (0.18) and is significant

(Rahman, 1962), suggesting a more distant affinity.

The present investigation expands upon this previous odontometric study. Besides the Guanche, Berbers, and Arabs, samples of West Asian-derived Carthaginians and Northeast African Egyptians and Nubians are added. In total, 12 prehistoric through historic Northwest and Northeast African samples, comprising 669 dentitions, are analyzed and compared. Moreover, in place of Penrose, tooth size apportionment analysis (Harris and Bailit, 1988; Harris and Rathbun, 1991; Lukacs and Hemphill, 1993) is used on the odontometric data. This technique provides a more robust statistical approach that uses principal components analysis for assessing inter-sample differences in allocation of tooth size.

MATERIALS AND METHODS

The samples

The Canary Islands sample used in both the previous and present odontometric studies consists of 163 skeletal dentitions (male=70, female=52, indeterminate=41). Eight crania are from the island of La Palma, 25 from Gomera, 54 from Tenerife, 56 from Gran Canaria, 11 from Fuerteventura, and nine from unidentified locations in the archipelago. Most specimens are curated at the Musée de l'Homme, Paris, although 13 are located at the American Museum of Natural History, New York, and two are at the National Museum of Natural History in Washington, D.C. The exact date(s) of the series is unknown, but radiocarbon dating of grottoes, caves, and tumuli similar to those from which the present materials were removed range from 20 BC to AD 1690$\pm$70, with a median range of AD 400-900 (Mercer, 1980; Bermudez de Castro, 1989).

The Shawia Berber sample consists of 26 historic individuals who originally lived just south of Constantine, Algeria (see Fig. 1). The sample consists of dentitions from 16 males, seven females, and three individuals of unknown sex, all from the Musée de l'Homme. Greenberg (1966) characterizes Berbers as speaking one of several dialects (*e.g.*, Shawia) of the Berber language, which belongs to the Berber language family in the Afroasiatic superfamily. Their language also reflects influence from Phoenician, Latin, and Arabic sources (Bynon, 1970). Such heterogeneity is consistent with the fact that Berber populations, especially those from the less-mountainous regions of Algeria and Morocco, show evidence of admixture with Arabs and other intrusive peoples (*i.e.*, Carthaginian, Greek, Roman, Spanish, Turkish, French) (Wysner, 1945).

The Kabyle Berber sample is made up of 32 historic crania (male=21, female=7, indeterminate=4) from the Algiers and Oran region of the Djurdjura Mountains in northern Algeria (Wysner, 1945). They are all curated at the Musée de l'Homme. Unlike many Berbers, the Kabyle remained isolated from the many outsiders who successively conquered lands throughout northern Africa

beginning in 750 BC. As such, they experienced relatively little genetic admixture (Wysner, 1945). The Berbers may be indigenous to North Africa, being descended from earlier Capsian and perhaps Mechta peoples (Hiernaux, 1975; Irish, 1998a,b, 1999, 2000).

The Bedouin Arab sample (n=49) is composed of a heterogeneous mix of historic crania (male=18, female=24, indeterminate=7). Thirty-six individuals were recovered from the coast of Morocco between Rabat and Mogador, ten are from Algeria between Oran and Algiers, two are from Tunis, Tunisia, and one is from the Sahel region of Libya. The latter specimen was recorded at the University of Minnesota; the rest are at the Musée de l'Homme. Arabs first entered Africa along the Suez isthmus in the 7th century, conquering Byzantine lands in Egypt and to the west. A second wave of Arabs arrived in the 11th century, when entire tribes of Bedouin immigrated from the Syrian desert (Julien, 1970; Hiernaux, 1975). These nomadic peoples are similar in physical appearance to the Berbers with whom they are heavily admixed (Julien, 1970; Hiernaux, 1975).

The Carthaginian sample is made up of 28 individuals (male=16, female=8, indeterminate=4) from the site of Carthage, north of Tunis, Tunisia. Twenty-four crania were recovered from Punic period levels (751?-146 BC) (Charles-Picard and Picard, 1968). The four remaining skulls may be from the Punic period, or are perhaps from early Roman times (146 BC-AD 435) (Wysner, 1945). All of the material is curated at the Musée de l'Homme. Carthage was founded in *ca.* 751 BC by the Phoenicians, a West Asiatic people from the area now comprising Lebanon (Charles-Picard and Picard, 1968). In 146 BC, Carthage was conquered by the Romans, who remained in control until AD 435. Both the Carthaginians and Romans are thought to have had extensive contact with local Berber populations (Wysner, 1945).

The remaining seven samples, from Northeast Africa, are included in the dental analysis to help delineate Guanche affinities on a broader, geographically-oriented scale. Three samples comprise 12th Dynasty through Byzantine Egyptians (1991 BC-AD 600) (Elliot Smith and Wood-Jones, 1910; Baines and Malek, 1982) from Lisht (n=61), El Hesa (n=72), and Kharga Oasis (n=26) in Egypt. The specimens are located at the American Museum of Natural History and National Museum of Natural History. There are several hypotheses concerning Egyptian origins; they may be non-African (*i.e.*, West Asian or southern European) (Angel, 1972; Curto, 1972; Hiernaux, 1975; Mourant, 1983), an admixed people, with African and non-African roots (*e.g.*, Hamid Zayed, 1981), or indigenous (White, 1970; Davidson, 1974; Trigger, 1976; July, 1992; Phillipson, 1994; Newman, 1995; Williams, 1997). Whichever the case, by the Dynastic period they were likely a heterogeneous people from the combining of many ethnic elements (Curto, 1972; Davidson, 1974). The other four Northeast samples are from Nubia, in

northern Sudan. One sample consists of 18th Dynasty Pharonic Nubians (1575-1380 BC) (Trigger, 1976) from Soleb (n=32); the others are Meroitic (n=91), X-Group (n=39), and Christian (n=18) Nubians (100 BC-AD 1400) from Semna (Zabkar and Zabkar, 1982) (see Irish, 1993b, 1998b for a more complete description of all samples). The Pharonic sample was recorded at the Musée de l'Homme; the others are curated at Arizona State University, Tempe. The origin of the Nubians is unclear; they may be locals that possess a sub-Saharan component (*e.g.*, Greene, 1967, 1972; Carlson and Van Gerven, 1977, 1979), or are heavily-admixed migrants from elsewhere in North Africa (Irish and Turner, 1990; Turner and Markowitz, 1990).

Methods employed

Mesiodistal and buccolingual dental crown measurements were taken by Irish on each individual's maxillary and mandibular permanent teeth (I1-M3), following the method of Moorrees (1957), with Boley gauge vernier calipers accurate to 0.1 mm. Excessively worn or carious teeth, as well as those antimere pairs exhibiting obvious size asymmetry (most often M3s), were not measured. The degree of intra-observer measurement error was assessed by comparing replicate measurements of the left side of 25 Meroitic dentitions. The mean measurement error between sessions one month apart is 0.2 mm; this figure is within the range noted by Wolpoff (1971). Moreover, none of the measurements are significantly different based on paired-sample t-tests.

Dimensions of teeth on the left side in each sample were used for statistical analysis because, based on paired-sample t-tests, no significant differences occurred between antimeres for any dimensions (per Hemphill, 1991; Hemphill *et al.*, 1992; Lukacs and Hemphill, 1993). If a significant difference ($p \leq 0.05$) would have existed, the average of the dimensions from the antimere pairs would have been used per individual to compute the sample average. In cases where a tooth on the left side was missing in an individual, the right antimere (if present) was measured to maximize sample size. The resulting 32 or fewer mesiodistal and buccolingual dental crown measurements per individual were then used to calculate mean crown diameters for use in the assessment of odontometric affinity among samples.

Tooth size apportionment analysis was conducted according to the procedures of Harris and Bailit (1988) and Harris and Rathbun (1991), as modified by Hemphill (1991). The covariance matrix of mean crown diameters for each of the 12 samples was submitted to principal components analysis to obtain component loadings. Crown diameters for each sample were multiplied by the loadings for each tooth diameter, and this product was summed across all 32 crown diameters. This methodology yielded three component scores per sample (see Lukacs and Hemphill, 1993).

The mean total crown area (MD X BL) for all 16 teeth,

per sample, was used to assess differences in overall tooth size. If samples differed significantly in total crown area (>5%), residual component scores were calculated for those components significantly correlated with overall tooth size. Group component scores were then submitted to cluster analysis and three-dimensional ordination. A minimum spanning tree (Hartigan, 1975) was imposed on the array of component scores for ease of interpretation of association among the individual samples. All statistical analyses were performed with SYSTAT statistical software (Wilkinson, 1990).

Ideally, odontometric research should involve separate analyses by sex. However, out of necessity, the

TABLE 1.   Component loadings, eigenvalues, and variance explained for the 12 dental samples.

| Variable | Components | | |
	1	2	3
UI1MD	0.837	0.078	0.151
UI1BL	0.377	0.631	0.606
UI2MD	0.960	-0.102	0.090
UI2BL	0.724	0.263	0.043
UCMD	0.563	0.570	0.332
UCBL	0.491	0.642	0.280
UP3MD	0.952	0.021	0.076
UP3BL	0.911	-0.056	0.232
UP4MD	0.730	-0.057	-0.424
UP4BL	0.923	-0.089	0.081
UM1MD	0.774	-0.066	-0.425
UMIBL	0.909	0.044	0.198
UM2MD	0.777	-0.371	-0.312
UM2BL	0.770	-0.325	-0.312
UM3MD	0.499	-0.661	0.428
UM3BL	0.802	-0.485	0.008
LI1MD	0.737	0.175	0.235
LI1BL	0.177	0.497	-0.511
LI2MD	0.833	0.216	0.149
LI2BL	0.177	0.850	-0.161
LCMD	0.807	0.252	-0.340
LCBL	0.347	0.765	-0.347
LP3MD	0.817	-0.343	-0.010
LP3BL	0.817	-0.129	0.358
LP4MD	0.847	0.051	-0.257
LP4BL	0.933	0.040	-0.123
LMIMD	0.844	-0.034	0.207
LM1131	0.927	0.100	-0.023
LM2MD	0.917	0.055	-0.150
LM2BL	0.895	-0.035	-0.254
LM3MD	0.781	-0.222	0.207
LM3BL	0.837	0.275	-0.094
Eigenvalue	19.147	4.133	2.462
Variance (%)	59.834	12.916	7.695
Total Variance	80.445		

sexes were pooled by sample in this study. This approach follows the lead of Harris and Rathbun (1991), and Lukacs and Hemphill (1991), who report that any dental size variation between the sexes was not great enough to justify the markedly smaller sample sizes. Moreover, Hemphill *et al*. (1992) and Lukacs and Hemphill (1993) found that while males and females within an ethnic group differ in absolute tooth size, apportionment of tooth size is unaffected by sex dimorphism.

RESULTS

Tooth size apportionment analysis of the 12 samples' crown measurements yielded the component loadings in Table 1; component eigenvalues and percentage of the variance explained are also tabulated. The dental crown measurements themselves will be presented in a separate publication on African odontometric variation, and thus are not listed. Although six principal components possess eigenvalues greater than 1.0, the first three alone account for 80.4% of the total variance.

Component one is dominated by a general size factor, which is illustrated by the strong positive loadings for most variables (see top of Fig. 2). Nevertheless, a second factor involving relative dimensions of the teeth is also evident, as reflected by much lower loadings for buccolingual dimensions of the maxillary and, particularly, mandibular anterior teeth. In other words, high scorers along this component are characterized by generally large dentitions, with anterior teeth that exhibit long mesiodistal relative to narrow buccolingual diameters.

The second component separates samples on the basis of two criteria (see middle of Fig. 2). The first is similar to the secondary factor of component one. Anterior teeth (I1, I2, C) feature dimensional segregation, with buccolingual breadths receiving higher loadings than mesiodistal lengths; this is true for both maxillary and, especially, mandibular teeth. The second distinction involves the distal molars (M2, M3). Mandibular mesiodistal and buccolingual diameters receive fewer negative loadings than their maxillary counterparts. This difference is slightly greater for the mesiodistal than buccolingual dimensions. Thus, high scorers along component two exhibit broad buccolingual diameters among anterior maxillary and, especially, mandibular teeth relative to mesiodistal dimensions, as well as relatively large mandibular distal molars compared to their maxillary isomeres.

The loadings for component three are, at first glance, confusing. However, there appears to be a distinction in buccolingual dimensions by isomere; that is, with the exception of P4 and M2, maxillary breadths receive higher loadings than their mandibular counterparts (see bottom of Fig. 2). This is especially true for I1 and C. Thus, high scorers for component three possess maxillary teeth that are broader in their buccolingual
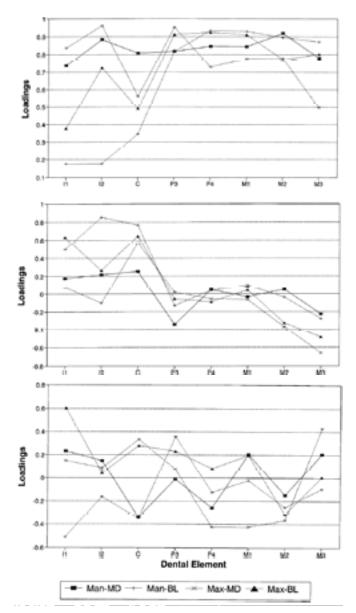
Fig. 2. Loadings among the 12 dental samples for components one, two, and three.

dimensions than the corresponding mandibular isomeres.

Once component loadings were obtained, total crown areas by sample were regressed on component scores to determine if overall tooth size represents a significant contributing factor behind group scores. As is often the case, component one scores are highly associated with size (see Table 2)—in this case overall tooth size (F=1537.84, p=0.00). However, components two and three do not show a significant association. To compensate for the effect of overall tooth size, the regression formula was used to obtain expected component one scores. Expected scores were subtracted from the observed to calculate group departures (residuals) from expected results from general tooth size.

The next step in analysis requires the use of some technique to illustrate the patterning of biological distances delineated by the residual component one, component two, and component three scores (Table 2). In the present investigation four methods of cluster analysis—complete linkage, single linkage, average linkage, and Ward's minimum variance, as well as three-dimensional ordination were employed.

The complete linkage dendrogram is presented in Figure 3. Results obtained with other associating algorithms produced analogous results. The Guanche sample is phenetically most similar to Northwest African Shawia Berbers, a relationship revealed by the previous Penrose analysis (Irish, 1993a). The Guanche also show a close affinity to the Carthaginian and Kabyle samples. Members of this four-group aggregate share anterior teeth of intermediate buccolingual size, and maxillary and mandibular isomeres of proportionate dimensions.

The Guanche are next most-like the aggregate at the center of the dendrogram that contains Christian, X-Group, and Meroitic Nubians, Lisht, El Hesa, and Kharga Egyptians, and Bedouin Arabs. The earlier Penrose analysis (Irish, 1993a) also showed the Arab sample

TABLE 2. Total crown area (TCA), component scores (COMP), and residuals (RCMP) for the 12 dental samples.

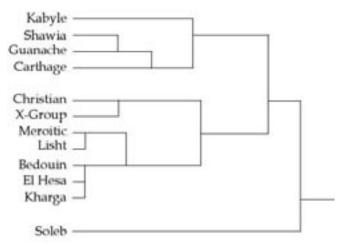| Sample	TCA	COMP1	RCMP1	COMP2	COMP3
Guanche	1098.09	-0.399	-0.185	0.150	-0.377
Shawia	1100.64	-0.164	0.002	0.820	-0.112
Kabyle	1117.97	0.125	-0.038	2.001	-0.654
Bedouin	1084.59	-0.457	0.014	-0.489	0.659
Carthage	1058.07	-1.058	-0.084	0.931	-1.394
Lisht	1050.73	-1.191	-0.077	-0.730	0.110
El Hesa	1051.15	-1.130	-0.024	-0.701	0.865
Kharga	1086.70	-0.624	-0.194	-0.508	0.983
Soleb	1193.56	1.566	-0.043	1.176	2.012
Meroitic	1145.27	0.750	0.068	-0.746	0.009
X-Group	1191.73	1.431	-0.134	-1.239	-0.883
Christian	1177.20	1.162	-0.127	-0.664	-1.218

Fig. 3. Complete linkage cluster analysis dendrogram of principal component scores among the 12 samples.

to be slightly divergent from the Guanche. Moreover, except for the West Asian-derived Arabs who, as noted comprise a mix of individuals from throughout North Africa, this seven-group aggregate is composed entirely of Northeast Africans. For the most part, these samples exhibit a tendency toward broad maxillary teeth relative to the corresponding mandibular isomeres. This pattern is particularly evident in the Christian and X-Group Nubian samples; they also possess relatively large teeth (see TCA in Table 2).

Lastly, the Guanche, as well as all other samples, are most divergent from Pharonic Nubians from Soleb. The Soleb sample is characterized by the largest teeth of all samples, as well as broad buccolingual anterior tooth diameters and large mandibular molars relative to the maxillary counterparts.

Similar dental relationships are illustrated by ordination of the three principal component scores (Figure 4). Axes X, Y, and Z correspond to the sample scores for residual component one (RCMP1), component two (COMP2), and component three (COMP3). The Guanche (CAN), located on the far left of the figure, link most closely with Northwest Africans; that is,
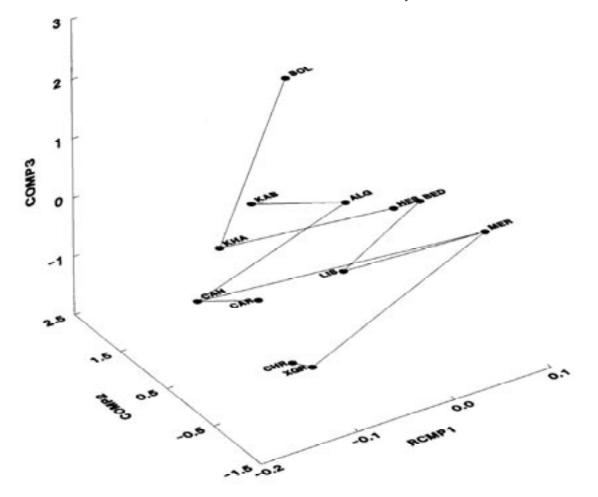

Fig. 4. Three-dimensional ordination with minimum spanning tree of principal component scores among the 12 samples. See text for explanation of abbreviations.

with Carthaginians (CAR), Shawia Berbers (ALG), and Kabyle Berbers (KAB). However, they also exhibit some affinities to Northeast Africans. This affinity is evident by the Guanche connection to the Meroitic sample (MER) from Semna. Meroitic Nubians are in turn linked to X-Group (XGR) and Christian (CHR) Nubians, and to Lisht (LIS), the Bedouin Arabs (BED), El Hesa (HES), Kharga (KHA), and the Soleb (SOL) outlier, respectively.

DISCUSSION AND CONCLUSIONS

Although the timing and circumstances under which the immigration event(s) occurred have not been addressed by these odontometric results, tooth size apportionment analysis has revealed two important findings that pertain to other aspects of the four peopling hypotheses. First, the Canary Island Guanche show closest dental affinities to Northwest Africans, relative to other samples of various ages. Second, the pattern of phenetic affinities possessed by the Guanche suggest that some degree of biological relatedness extends beyond the adjacent mainland to Nubians and Egyptians in Northeast Africa.

The Guanche share a very similar pattern of tooth size apportionment with the Shawia and, to a lesser extent, Kabyle Berbers. This similarity corroborates results of a preliminary odontometric study (Irish, 1993a), and supports those aspects of Hooton's (1916, 1925), Schwidetzky's (1963), and other's (*e.g.*, Fusté 1959, 1965; Vallois 1969) models that suggest at least some Guanche originated in Northwest Africa; it specifically sustains Mercer's (1980) and other's (*e.g.*, Gonzalez and Tejera, 1981; Onrubia Pintado, 1987; Bermudez de Castro, 1989; Cavalli-Sforza et al., 1994) claims for a sole Berber ancestry from populations living in northern Morocco and Algeria.

Conversely, this finding cannot completely rule out Hooton's (1925), Schwidetzky's (1963), and other's (*e.g.*, Fusté 1959, 1965; Vallois 1969, *etc.*) evidence for some eastern Mediterranean input, considering the Guanche affinity to most Northeast Africans. Moreover, Guanche similarity to West Asian-derived Carthaginians could be interpreted as support for this contention. However, such an affinity may simply identify evidence for Berber/Carthaginian admixture, or could imply genetic relatedness via the latter's proposed direct contact (Hooton, 1916, 1925; Mercer, 1980) with the Guanche; a similar situation might explain the slightly more distant Guanche affinity to West Asian-derived Bedouin Arabs. In addition, Hooton's (1925) suggestion for a sub-Saharan genetic component has not been directly tested here, although data from dental morphological studies (see Irish, 1993b, 1997, 1998a,b, 2000) do not support such a relationship. Whatever the case, the concordance of skeletal, ethnographic, linguistic, genetic, and now dental data, should put to rest any notion of a non-

African (*i.e.*, European) origin for aboriginal Canary Islanders (as per Roberts *et al.*, 1966).

The evidence for a lesser Guanche affinity to Egyptian and three of four Nubian samples implies aboriginal Canary Islanders belong to a greater North African gene pool. Some level of diachronic dental homogeneity apparently exists throughout North Africa—from the Canary Islands to Egypt and northern Sudan. Indeed, this east-west similarity suggests that a clinal relationship in tooth size apportionment existed, considering the separation of Northwest and Northeast African samples. These conclusions support previous findings based on dental morphological analyses published elsewhere (Irish, 1993b, 1997, 1998a,b; Guatelli-Steinberg *et al.*, 2001).

ACKNOWLEDGMENTS

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