Biological Relationships and Population History of Native Peoples in Spanish Florida and the American Southeast

Mark C. Griffin, Patricia M. Lambert, and Elizabeth Monahan Driscoll

This study was conducted in order to estimate population distances between Native American skeletal samples from the southeastern United States and to place Guale in particular in the larger landscape of biological distance and population history in this region. Previous research (Griffin 1989, 1993; Griffin and Nelson 1996) using dental and cranial nonmetric traits has placed some of these samples in a local perspective. This study takes a broader regional perspective, examining population samples from North Carolina, Tennessee, Georgia, and Florida. These additional samples represent a diverse cross section of cultural and linguistic groups from the southeastern United States.

In order to assess population affinity, biological distances are calculated using dental and cranial morphological data. Previous studies have demonstrated that this combined approach of including more than one source of data provides complementary rather than redundant results (Corruccini 1974; Trinkaus 1978; Kennedy 1981; Molto 1983; Hanihara 1992; Griffin 1993). The two sets of traits were chosen because of their demonstrated usefulness in describing population relationships. Dental morphology—more specifically, the number, configuration, and size of cusps and other surface features of teeth—has been shown to be highly correlated with genetic ancestry below the level of reproductive population and often to the level of family group (Scott and Turner 1997). Cranial morphology, specifically the presence, number, and placement of ossicles, foramina, and other features of the skull, has similarly been shown to be highly correlated with genetic ancestry (Hauser and De Stefano 1989). Biological distance, in the sense used here, refers to a statistical expression of morphological

similarity between populations that is derived from genetically controlled traits.

Dental and cranial nonmetric traits have been extensively used to assess population affinity and patterns of microevolution (Saunders and Popovich 1978; Pietrusewsky 1981, 1984; Greene 1982; Turner 1986a, 1986b, 1987a, 1987b, 1990; Dodo 1987; Sofaer et al. 1986; Katayama 1988; Haeussler et al. 1989; Nichol 1989, 1990; Ishida 1990; Sciulli 1990; Townsend et al. 1990; Lukacs and Hemphill 1991; Dodo et al. 1992; Ishida and Dodo 1993; Scott and Turner 1997). Recent research using both types of nonmetric traits has focused on population microdifferentiation. That is, nonmetric traits in recent research have been used to differentiate between local populations rather than between large, aggregate, geographically defined populations (e.g., between groups of Native Americans rather than between Native Americans and Europeans). The present study is also focused on population microdifferentiation.

Materials

Skeletal samples from 13 archaeological sites used for this study all derive from the southeastern United States. The geographic locations of the sites are indicated in figure 9.1, and the population samples are summarized in table 9.1. Culturally, the population samples included here represent a diverse cross section of the protohistoric Southeast spanning a period from around A.D. 1200 to 1700. In broad geographic terms, they can be divided into three physiographic areas: coastal plain, piedmont, and ridge and valley.

Three of the coastal samples have been archaeologically and ethnographically identified as Guale. These samples come from the geographic area described by David Thomas as La Florida (Thomas 1987). The Guale skeletal samples examined here were recovered from three sites: (1) Irene Mound in Chatham County, Georgia (9Ch1), (2) Santa Catalina de Guale (9Li274) on St. Catherines Island, Georgia (hereafter referred to as Santa Catalina), and (3) Santa Catalina de Guale de Santa Maria (8Na41) on Amelia Island, Florida (hereafter referred to as Santa Maria).

The first of the Guale sites, Irene Mound, is located in coastal Georgia near the Savannah River mouth. This prehistoric site was occupied from around A.D. 1150 to 1450 (Caldwell and McCann 1941). The second Guale site, Santa Catalina, is located on St. Catherines Island, Georgia, and represents the first of a series of Spanish missions. The mission was occupied from A.D. 1608 to 1680. The third Guale site, Santa Maria, is
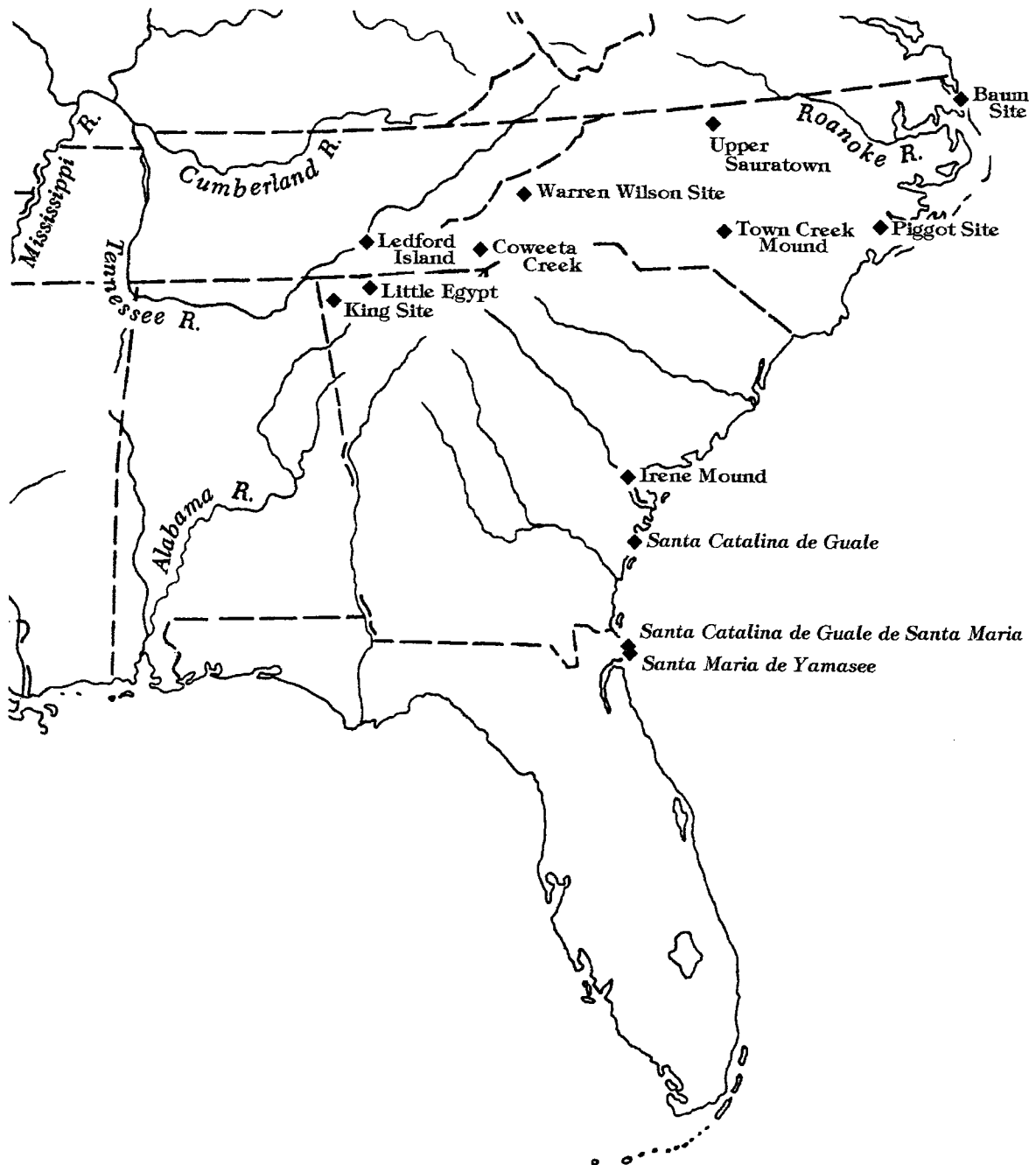
Fig. 9.1. Geographic locations of population samples for biodistance study.

located on Amelia Island, Florida, and represents the last in this same series of Spanish missions. This mission was occupied from A.D. 1686 to 1702. Ethnographic records indicate that the Guale inhabitants of the Santa Catalina and the Santa Maria missions were descendant populations from the pre-contact Guale of Irene Mound.

A fourth sample from the coastal plain area is from the Spanish mission of Santa Maria de Yamasee (8Na41d) on Amelia Island, Florida. This skel-

Table 9.1. Summary of population samples

Site	N	Temporal period A.D.	References
Guale			
Irene Mound (9Ch1)	248	1150–1550	Caldwell and McCann 1941; Hulse 1941; Larsen 1982; Anderson 1990
Santa Catalina de Guale (9Li274)	431	1608–1680	Thomas 1987; Larsen 1990; Larsen et al. 1990
Santa Catalina de Guale de Santa Maria (8Na41)	112	1686–1702	Saunders 1988; Larsen 1991
Yamasee			
Santa Maria de Yamasee (8Na41d)	105	1675–1683	Saunders 1988
Lamar/Dallas/Mouse Creek			
Ledford Island (16By13)	456	1400–1600	Lewis and Kneberg 1946; Boyd 1984; Sullivan 1986
King site (9Fl5)	213	1500–1650	Blakely 1988; Hally 1975a, b
Little Egypt (9Mu102)	65	1350–1500	Hally 1979
Carolina Algonquian			
Baum, Burial 1 (31Ck9)	55	1315±70	Phelps 1980a, b
Baum, Burial 5 (31Ck9)	33	1315±70	Phelps 1980a, b
Baum, Burial 7 (31Ck9)	27	1425±70	Phelps 1980a, b
Piggot site (31Cr14)	40	1230±65	Phelps 1980a, b
Pisgah			
Warren Wilson site (31Bn29)	61	1200–1400	Dickens 1976
Pee Dee			
Town Creek Mound (31Mg2,3)	216	1200–1400	Ward and Davis 1999
Qualla			
Coweeta Creek (31Ma34)	105	1620–1650	Dickens 1978
Siouan			
Upper Saura Town (31Sk1a)	103	1670–1710	Ward and Davis 1999

etal sample, tentatively identified as Yamasee (Bushnell 1986; Saunders 1988), was recovered immediately south of the Santa Catalina de Guale de Santa Maria cemetery on Amelia Island. The population sample is referred to here as Santa Maria de Yamasee. The Yamasee, like the Guale, were refugees from northern Georgia and lower South Carolina and are considered inland relatives of the coastal Guale (Mooney 1969). Although it is clear that the Yamasee were probably close linguistic and cultural relatives of the Guale, the biological affinity of these two groups is unclear.

The final two coastal plain samples derive from the Late Woodland Baum (31Ck9) and Piggot (31Cr14) prehistoric Carolina Algonquian sites. Prior to European contact, the North Carolina coastal region was occupied by two distinct cultures, the Carolina Algonquians of the Tidewater zone and the Tuscarora of the Inner Coastal Plain (Phelps 1983). Two local phases have been established for these Late Woodland cultures of the North Coastal region: Colington is the phase name given the Algonquian culture of the Tidewater zone, and Cashie is applied to the territory of the Tuscarora, Meherrin, and Nottaway in the interior Coastal Plain (Phelps 1983). Current radiocarbon dates for the Colington phase range from A.D. 860 ± 85 to 1315 ± 70 (Phelps 1977). The North Carolina population samples used here are all from the Colington phase Algonquian cultural tradition. Three of the Algonquian population samples included in this study were recovered from the Baum site. The Baum site, located in coastal North Carolina, covers at least five acres and contains a Middle Woodland period component (300 B.C.–A.D. 800) and a Late Woodland component (A.D. 800–1650). Five ossuary-type burials have been recovered from the Baum site in excavations from 1972 to 1983. All five ossuaries have been found overlying the Middle Woodland component, indicating a Late Woodland, Colington phase affiliation. A radiocarbon date for the Burial 1 ossuary of A.D. 1315 ± 70 confirms this association (Phelps 1980b). The remaining ossuary sample was recovered from the Piggot site (31Cr14). The Piggot site is located in Carteret County, North Carolina, near the southern boundary of the traditional Algonquian distribution (Phelps 1980a). The site has been radiocarbon dated to A.D. 1230 ± 65. The pattern of deposition in the ossuary suggests that it is associated with the Colington phase (Truesdell 1995).

The population samples from the Piedmont include Town Creek Mound (31Mg2 and 3) and Upper Saura Town (31Sk1a), both located in North Carolina. Town Creek is a late prehistoric Pee Dee phase palisaded mound and village dating to about A.D. 1200 to 1400 (Ward and Davis 1999). The

site is located on the southern piedmont near the confluence of the Pee Dee and Little rivers. The so-called Pee Dee people who occupied this site had cultural traditions distinct from those observed at more northerly piedmont settlements. According to Coe (1995), physical traits (e.g., nose form and stature), the practice of fronto-occipital cranial deformation, ceramic styles, and mound construction link Town Creek biologically and culturally more closely with South Appalachian Mississippian traditions better known at sites like Irene Mound than to northern Siouan villages like Upper Saura Town. Upper Saura Town, the second piedmont sample included here, is a historic Siouan village dating to the latter part of the 17th century. The site is located along the Dan River on the northern piedmont, well outside the sphere of Mississippian cultural influence (Ward and Davis 1999).

The population samples from the ridge and valley area include Warren Wilson (31Bn29) and Coweeta Creek (31Ma34) in North Carolina; Ledford Island (16By13) in Tennessee; and the King (9Fl5) and Little Egypt (9Mu102) sites in Georgia. The Warren Wilson site is a Pisgah phase palisaded proto-Cherokee village dating to about A.D. 1200 to 1400. The site is located on the Swannanoa River east of Asheville, North Carolina. Coweeta Creek is an early Qualla phase Cherokee village dating to the early 17th century. According to Ward and Davis (1999), the prehistoric mountain villages in this area were part of the South Appalachian Mississippian cultural tradition.

The remaining three sites, Ledford Island, King, and Little Egypt are all from the Lamar/Dallas/Mouse Creek traditions. The Mouse Creek phase site of Ledford Island was a large Mississippian town located in the Hiwassee River of eastern Tennessee on an island of the same name. The site of Ledford Island was likely inhabited from around A.D. 1400 to 1600. The final two sites, the King and Little Egypt sites, are from the Late Mississippian Lamar cultures. The King site is an early historic town located in northwest Georgia in the floodplain of the Coosa River, approximately 20 miles west of the city of Rome, Georgia. The site was occupied in the 16th century for less than 50 years. According to Crowder (1988), the cultural affiliation of the King site has been archaeologically identified as Creek. The Little Egypt site is located on the south side of the Coosawattee River, approximately 35 miles northeast of Rome, Georgia. The predominant occupation of Little Egypt was during the Late Mississippian period, from A.D. 1350 to 1500. According to Hally (1980), Little Egypt was probably the center for the paramount chiefdom of Coosa.

Previous Studies: Guale

Previous examination of the Guale samples included here (Griffin 1989, 1993; Griffin and Nelson 1996) indicate a number of interesting relationships. Univariate and multivariate analyses demonstrated that the Guale samples in the present study are particularly diverse in terms of expression of dental and cranial nonmetric traits. However, despite the diversity demonstrated by statistically significant differences in frequencies in a large number of cranial and dental traits, the Guale samples from Santa Catalina and Santa Maria were consistently placed close to one another in multivariate analyses (figs. 9.2, 9.3, and 9.4). This result supports the contention that Santa Maria is a descendant population from that of Santa Catalina. The sample from Santa Maria de Yamasee was consistently placed close to the Santa Maria sample in multivariate analyses. This outcome may suggest a close biological affiliation between these two populations. The relationship between the Santa Catalina sample and the Santa Maria de Yamasee sample was less clear but may also suggest a biological affiliation between the two groups. The ethnographic record indicates that the Guale and Yamasee were distinct groups (Bushnell 1986; Mooney 1969). However, evidence presented in this analysis may suggest a closer affinity than the ethnographic record indicates. It may be that historically the Guale and Yamasee were distinguished solely by geographic location and not by cultural, linguistic, or biological differences.

The Santa Catalina population has been identified as the descendants of the prehistoric inhabitants of Irene Mound. The degree of dissimilarity suggested by univariate and multivariate analyses casts some doubt on this relationship. Separate multivariate analyses of dental and cranial nonmetric traits in the Griffin (1993) study consistently placed this sample relatively far from the other Guale samples and closer to the inland sample from Ledford Island. This result is especially notable with regard to the placement of the other Guale samples quite far from the Ledford Island sample and distinct from the Irene Mound sample. These results do not necessarily indicate a biological relationship between the population samples from Irene Mound and Ledford Island, but they do call into question the putative relationship between the inhabitants of Irene Mound and the historic Guale.

The degree of dissimilarity observed between the Irene Mound sample and the other Guale samples cannot be adequately explained by random genetic drift. Other mechanisms must be invoked to explain this difference. This is not to suggest that inhabitants of Irene Mound migrated from Ten-
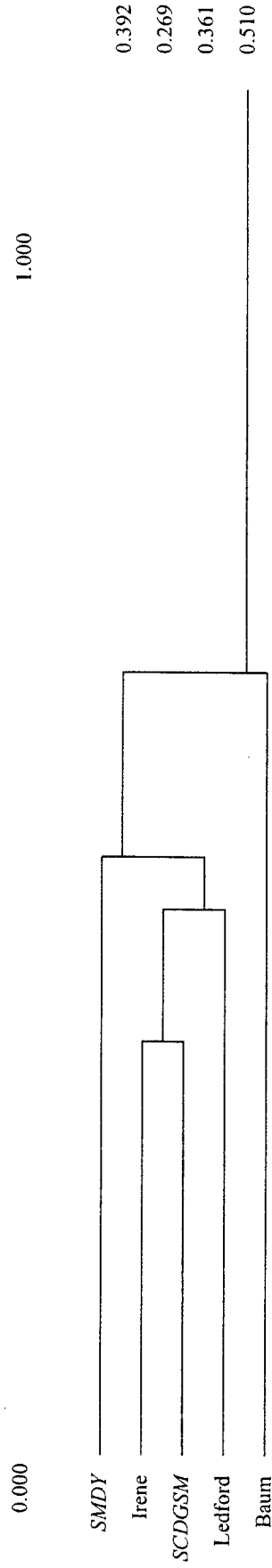
Dental Samples
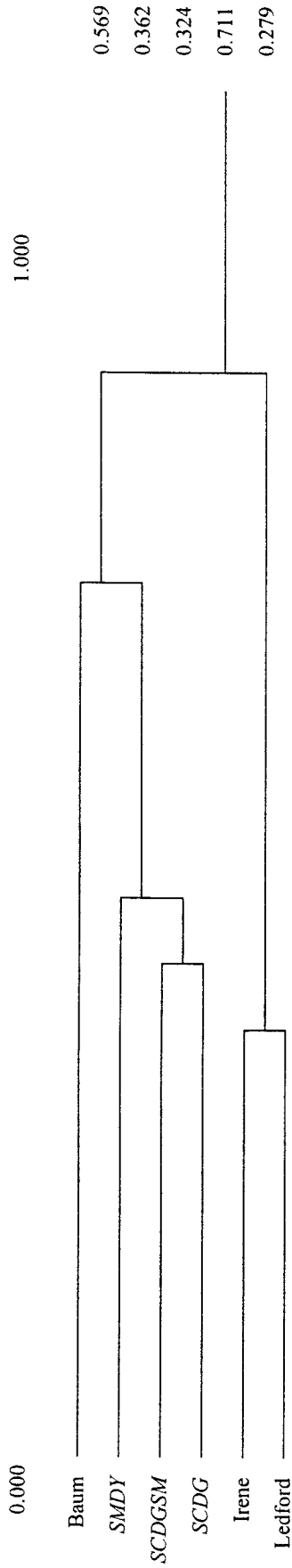
Cranial Samples

Fig. 9.2. Results of cluster analyses (after Griffin 1993). Baum = Baum ossuary and Piggot ossuary; Irene = Irene Mound; Ledford = Ledford Island; SCDG = Santa Catalina de Guale (Georgia); SCDGSM = Santa Catalina de Guale de Santa Maria (Florida); SMDY = Santa Maria de Yamasee.
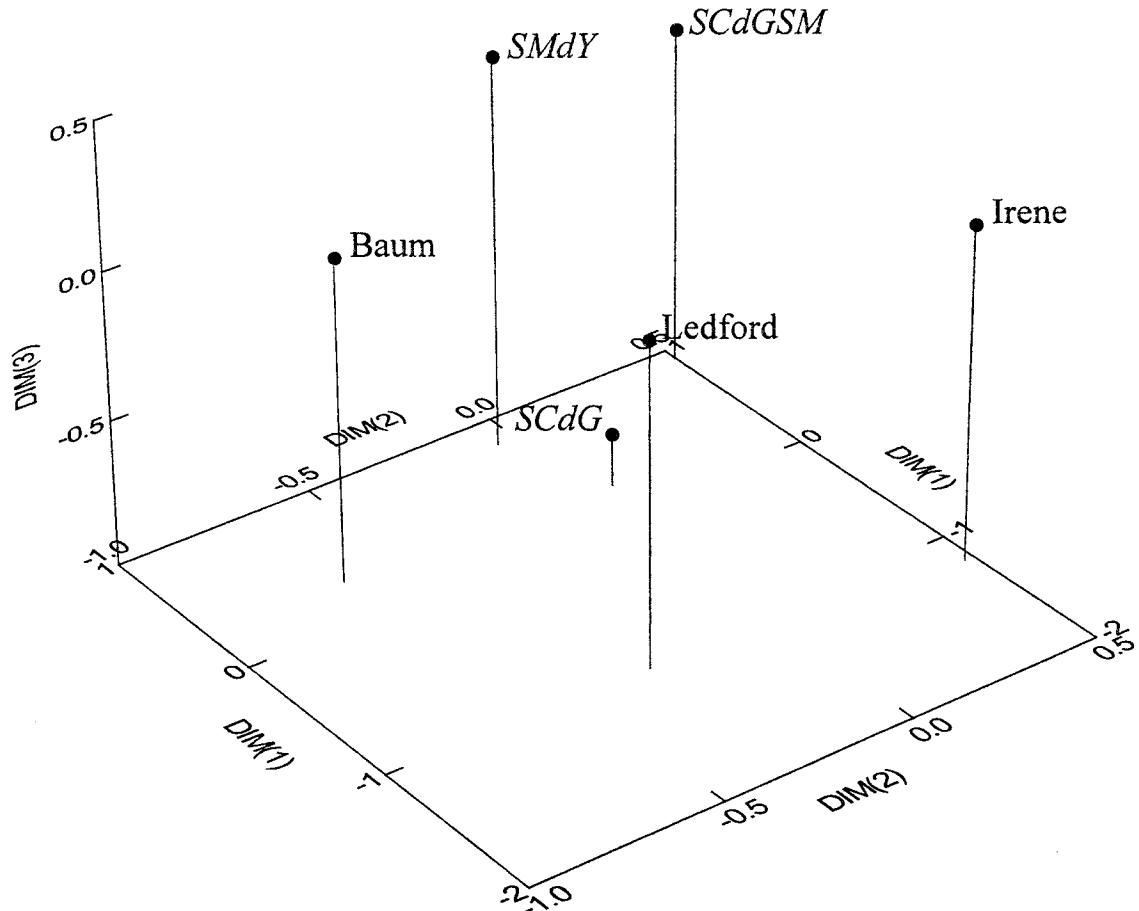
Fig. 9.3. Results of multidimensional scaling analysis of southeastern U.S. dental samples, sites as identified for figure 9.2 (after Griffin 1993).

nessee. It does, however, cast some doubt on the contention that the Irene Mound sample and the later Guale samples are a continuous population.

It has been inferred from the ethnographic record that the Guale were a derivative group from the inland Creek (Spencer and Jennings 1977). That the Guale sample from Irene Mound and the population sample from Ledford Island are quite similar in terms of dental and cranial morphology suggests a close biological connection between these groups. While the results of multivariate analyses of dental morphology consistently placed the Irene Mound and Ledford samples close to one another, the results obtained from analysis of cranial morphology were less consistent. The somewhat equivocal results of the cranial analyses with regard to the placement of Irene Mound and Ledford Island samples may suggest a less straightforward relationship than that suggested by analyses of dental nonmetric traits. It should also be noted that the term Guale was used interchangeably by Spanish explorers to mean a geographic location and a
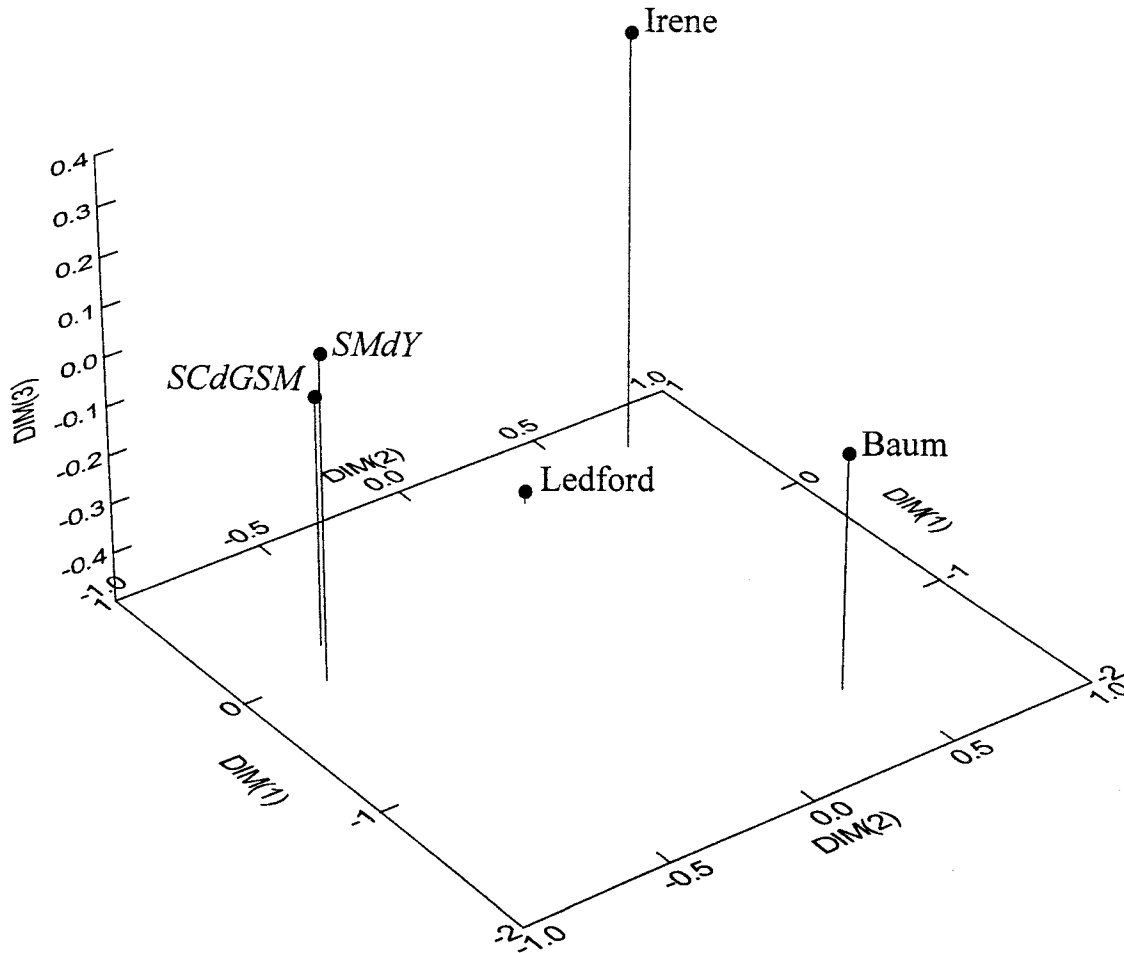
Fig. 9.4. Results of multidimensional scaling analysis of southeastern U.S. cranial samples, sites as identified for figure 9.2 (after Griffin 1993).

cultural/linguistic group (Jones 1978). Therefore, referring to a group as Guale may have connoted geographic location and not necessarily linguistic, cultural, or biological affiliation. It may also be the case that while the Guale represented a distinct linguistic and cultural group, they did not represent a distinct biological one.

If the historic Guale populations of the Georgia coast derive from the late prehistoric Irene Mound population, quite substantial population changes must have occurred. If this is the case, extensive gene flow from other populations was likely involved because of the relatively brief time interval between the occupation of Irene Mound and that of Santa Catalina de Guale (~100 years). Given the particularly unstable political and social conditions among the Guale after European contact and the extensive period of missionization of the native inhabitants, aggregation of local populations could have precipitated such gene flow.

Methods

Dental Traits

Morphological observations were made on 100 dental crown and root variables using the standardized Arizona State University dental anthropology system (Turner et al. 1991). This system consists of a wide range of dental morphological variables, including multitooth expression of a single trait and traits involving a single pair of antimeres. This information facilitates the identification of the most variable tooth or site for trait expression. The ASU system has proven particularly useful for distinguishing between local populations as well as larger regional series (Scott and Dahlberg 1982; Turner 1985). Most of the traits in this study are observed using ordinal scales with several grades.

Previous research on population samples from the southeastern United States has demonstrated that 35 traits from the ASU system are particularly useful for population distance studies in this area (Griffin 1989, 1993). The traits were identified on the basis of intra-observer reliability, wear sensitivity, and ease of observation. The traits consist of 35 dental nonmetric traits and two cranial nonmetric traits. The dental nonmetric traits used in the present study are summarized in table 9.2.

Cranial Traits

Morphological observations were made on 25 nonmetric cranial traits described by Berry and Berry (1967) and Hauser and De Stefano (1989). Numerous nonmetric cranial traits have been described in the literature, but these descriptions generally lack information on the reliability of specific traits in describing and comparing populations. This creates a situation in which the researcher must rely to a large degree on precedents set by other workers or on personal preference.

The traits selected for this study were chosen on the basis of three criteria: (1) reliability of scoring and observation, (2) demonstrated ability to discriminate populations, and (3) low intercorrelation with sex and age. The 25 traits included in this study are listed in table 9.3. The traits used here were observed recording presence or absence of the trait. No ordinal scales are used because these tend to be highly subjective (see Kennedy 1981).

Dental nonmetric traits were scored along a continuum of expression in each population sample using the methodology provided by Turner and others (1991). Cranial nonmetric traits were recorded as present or absent, with present representing any degree of trait expression. The dental

Table 9.2. Dental morphological traits

Trait	Teeth observed	References
Winging	upper central incisors	Enoki and Dahlberg 1958; Dahlberg 1963; Scott 1973
Shoveling	upper incisors	Hrdlička 1920; Dahlberg 1956, 1963; Moorrees 1957; Scott 1973
Curvature	upper central incisors	Nichol et al. 1984
Double-shoveling	upper central incisors	Dahlberg 1956; Turner 1967
Interruption groove	upper lateral incisors	Turner 1967
Tuberculum dentale	upper lateral incisors	Scott 1973; Turner et al. 1991
Canine mesial ridge	upper canines	Morris 1975; Turner et al. 1991
Canine distal accessory ridge	upper canines	Turner 1967; Scott 1973, 1980
Premolar mesial and distal accessory cusps	upper premolars	Turner 1967
Tri-cusped premolars	upper premolars	Turner et al. 1991
Distosagittal ridge	upper premolars	Morris et al. 1978
Metacone	upper 3rd molars	Turner et al. 1991
Hypocone	upper 1st and 2nd molars	Larson 1970, 1978; Scott 1973; Turner et al. 1991
Metaconule	upper 1st and 2nd molars	Harris 1977; Harris and Bailit 1980
Carabelli's trait	upper 1st and 2nd molars	Dahlberg 1956, 1963; Scott 1973, 1980
Parastyle	upper 3rd molar	Katich 1975; Turner et al. 1991
Enamel extensions	upper 1st and 2nd molars	Pedersen 1949
Premolar root number	upper premolar 3	Turner 1967, 1981
Molar root number	upper 2nd molars	Turner 1967
Radical number	all teeth	Turner 1967
Peg-shaped incisor	upper lateral incisor	Turner et al. 1991
Peg-shaped molar	upper 3rd molar	Turner et al. 1991
Odontome	premolars	Pedersen 1949; Alexandersen 1970
First lower premolar lingual cusp variation	lower 1st premolars	Pedersen 1949; Kraus and Furr 1953; Scott 1973
Second lower premolar lingual cusp variation	lower 2nd premolars	Pedersen 1949; Kraus and Furr 1953; Scott 1973
Anterior fovea	lower 1st molar	Hrdlička 1924; Turner et al. 1991
Groove pattern	lower 1st and 2nd molars	Gregory 1916; Hellman 1929; Jørgensen 1955

(continued)

Table 9.2—*Continued*

Trait	Teeth observed	References
Cusp number	lower 1st and 2nd molars	Gregory 1916; Hellman 1929; Turner 1967
Deflecting wrinkle	lower 1st molars	Weidenreich 1937; Scott and Dahlberg 1982; Turner et al. 1991
Distal trigonid crest	lower 1st molars	Hrdlička 1924
Protostylid	lower 1st and 2nd molars	Dahlberg 1956, 1963; Turner 1967; Scott 1973
Cusp 5	lower 1st and 2nd molars	Turner 1970; Scott and Dahlberg 1982; Turner et al. 1991
Cusp 6	lower 1st and 2nd molars	Turner 1970; Scott 1973; Scott and Dahlberg 1982; Turner et al. 1991
Cusp 7	lower 1st and 2nd molars	Turner 1970; Turner et al. 1991
Canine root number	lower canines	Turner 1967
Tomes' root	lower 1st premolar	Tomes 1923; Turner et al. 1991
First molar root number	lower 1st molar	Turner 1967; Turner et al. 1991
Second molar root number	lower 2nd molar	Turner 1967; Turner et al. 1991
Torsomolar angle	lower 3rd molar	Neiberger 1978; Turner et al. 1991
Palatine torus	palate	Miller and Roth 1940; Turner et al. 1991
Mandibular torus	mandible	Johnson et al. 1965; Morris 1970

Table 9.3. Cranial morphological traits

Trait	References
Ossicle at lambda	Bennett 1965; Berry and Berry 1967; Molto 1983
Lambdoid ossicles	Bennett 1965; Berry and Berry 1967; Herzog 1968
Ossicle at asterion	Berry and Berry 1967; Suchey 1975; Molto 1983
Parietal notch bone	Oetteking 1930; Berry and Berry 1967; Ossenberg 1969
Epipteric bone	Wood-Jones 1930a, b, c; Berry and Berry 1967; Molto 1983
Bregmatic bone	Wood-Jones 1930a, b, c; Berry and Berry 1967
Coronal ossicle	Wood-Jones 1930a, b, c ; Sublett 1966; Berry and Berry 1967
Metopism	Limson 1924; Bolk 1931; Tørgersen 1951
Fronto-temporal articulation	Collins 1926, 1930; Ossenberg 1969
Supraorbital foramen	Le Double 1903; Berry and Berry 1967; Ossenberg 1969; Korey 1970
Frontal notch	Wood-Jones 1930a, b, c; Berry and Berry 1967
Auditory torus	Wood-Jones 1930a, b, c; Berry and Berry 1967
Foramen of Huschke	Anderson 1962; Berry and Berry 1967; Molto 1983
Condylar facet double	Anderson 1962; Berry and Berry 1967; Kennedy 1981
Precondylar tubercle	Inglemark 1947; Berry and Berry 1967
Foramen ovale	Wood-Jones 1930a, b, c; Berry and Berry 1967
Foramen spinosum	Berry and Berry 1967; Korey 1970; Suchey 1975
Accessory lesser palatine foramen	Berry and Berry 1967
Palatine torus	Suzuki and Sakai 1960; Turner et al. 1991
Maxillary torus	Berry and Berry 1967
Parietal foramen	Berry and Berry 1967; Ossenberg 1969; Molto 1983
Posterior condylar canal patent	Boyd 1930; Berry and Berry 1967; Ossenberg 1969; Korey 1970
Mastoid foramen exsutural	Berry and Berry 1967
Anterior condylar canal double	Berry and Berry 1967; Korey 1970; Ossenberg 1969; Molto 1983
Zygomatico-facial foramen	Berry and Berry 1967; Molto 1983
Accessory infraorbital foramen	Berry and Berry 1967

nonmetric traits were dichotomized for the statistical analyses involving angular transformations using the criteria suggested by Turner (1987a). Dental and cranial morphological trait frequencies are presented in appendices 9.A and 9.B.

Trait Intercorrelation

With the large number of genetic and nongenetic factors influencing the expression of nonmetric traits, the number of traits that are statistically correlated is expected to be low. Research has shown this presumption to be generally false (Suzuki and Sakai 1960; DeVilliers 1968; Buikstra 1972; Corruccini 1974; Ossenberg 1976; Molto 1983). Molto (1983) attributes the higher than expected frequencies of correlations to four major factors: nonmetric traits (1) are often alternative expressions of a single underlying

variable, (2) often have a common regional or embryological origin, (3) can be affected by similar developmental phenomena, and (4) may be affected by the shared interaction of some combination of the foregoing. Given these factors, frequencies of nonmetric traits are expected to show a considerable number of positive correlations. Arguably, nonmetric traits offer redundant information in the real population.

Many authors have simply assumed a priori that correlations between frequency of expression for nonmetric traits are nonexistent (Berry and Berry 1967; Benfer 1970; Spence 1971; Berry 1972). In part, this decision was based on studies of *Mus musculus* (Truslove 1961) and *Homo sapiens* (Berry and Berry 1967; Kellock and Parsons 1970a; Corruccini 1974). Other researchers have suggested significant correlation between classes of traits (Suzuki and Sakai 1960; DeVilliers 1968; Ossenberg 1976). That is, traits that have similar developmental pathways (e.g., hypostotic, hyperstotic, oral tori, basicranial foramina) will have similar degrees of expression in an individual. However for the most part, as Corruccini (1974) has pointed out, the nature of such correlations often differs randomly from group to group.

The question here is not whether nonmetric traits are correlated. Some very clearly are. The real issue is what to do with those that are significantly correlated. Many approaches have been used to deal with this issue. Kennedy (1981) reasoned that because correlations are usually "random" when compared between populations, they could be ignored. Sjøvold (1977) has taken a similar approach, claiming that the pattern of low correlation will not cause serious distortion of the results. Buikstra (1972) has taken a reductionist approach by simply eliminating traits until the matrix was free of all significant correlations. Ossenberg (1976) has taken yet a different approach by amalgamating significantly intercorrelated matrices of common traits as a single trait. A reductionist approach approximating Molto's (1983) is adopted here. Traits that have significant correlations and clear etiological connections are eliminated from the analyses of population distance.

Many authors have recommended the use of the phi coefficient rather than other coefficients to detect the correlations between nonmetric traits in place (Benfer 1970; Sjøvold 1977; Molto 1983). Another related statistic, Tau-b (Goodman and Kruskal 1954, 1959, 1963), is used here because many of the traits are not exclusively dichotomous, as required for phi correlation analysis. Tau-b, like phi, gives a close approximation to the chi-square distribution and therefore is more sensitive to this task than are

other coefficients of association (Thomas 1986). Correlation coefficients were calculated for both classes of traits in this study.

The statistics commonly used to analyze nonmetric trait variation do not take into account the existence of intertrait correlations and depend on the assumption that the traits used are not statistically correlated (Kennedy 1981). For this reason the dental and cranial traits chosen for this analysis were tested separately in pair-wise combinations via two-way contingency tables and Tau-b correlation coefficients. These analyses were performed in order to detect statistically significant and strong intertrait correlations.

A number of strong correlations were observed between traits in this study. Without exception, these correlations result from the nature of the traits. That is, in each case either the traits involved occur on multiple teeth (i.e., field effects) or the traits are different manifestations of the same complex. An example of the latter would be central incisor curvature and central incisor double-shoveling. By definition, these traits vary inversely. Therefore, they are strongly negatively correlated. Two of the traits showing a strong association with each other are central incisor shoveling and lateral incisor shoveling. The traits eliminated from the analysis because of intercorrelation are central incisor curvature, upper first molar hypocone, upper second molar metaconule, lower second molar cusp number, lower first molar cusp five, lower first molar cusp six, and mastoid foramen exsutural.

Population Distance

The objective of this study is to estimate biological distances among a time-successive series of Guale samples and place them in a context with other culturally and linguistically distinct Native American groups. A number of different statistical procedures are employed to compare these groups. Among these procedures are estimations of mean measures of divergence (Green and Suchey 1976; Sofaer et al. 1986), cluster analysis (Aldenderfer and Blashfield 1984), and multidimensional scaling (Kruskal and Wish 1978).

Assessment of biological distance is best achieved by expressing the degree of dissimilarity between populations with a single numerical value, rather than trying to evaluate relationships on a trait by trait basis using univariate statistics (Cybulski 1975; Molto 1983). The single numerical value is calculated using multivariate statistics and is derived from the sum of the squared differences between corresponding variates of two popula-

tion samples (Smith 1972). When the populations are similar, the coefficient value should be small, and when the populations are dissimilar, it should be large. Dissimilarity in population studies is equated with biological distance. The distance for population models is usually defined in terms of Euclidean distance. In other words, populations are plotted relative to one another in terms of their values for a given set of variables. Euclidean distance is the distance between the plotted positions. In the simplest case, one could describe two populations in terms of two variables, X and Y. Plotting the populations two-dimensionally and measuring the distance between the two points on the graph gives one the Euclidean distance between the populations. As more variables are added, calculation of Euclidean distance becomes more complex and requires the use of distance coefficients.

Most of the distance coefficients used for nonmetric morphological data are based on C.A.B. Smith's mean measure of divergence (Grewal 1962). This statistic uses an angular transformation of the original trait frequencies for each population sample being compared. The angular transformation stabilizes the variance so that sampling error does not distort the estimation of distance. This is necessary with dichotomous traits because the variance of the *sample* proportion is a function of the *population* proportion (Sjøvold 1977; Molto 1983). The mathematical foundation of the Mean Measure of Divergence as an appropriate distance measure using nonmetric data has been substantiated by Sjøvold (1977). This is the most widely utilized statistic for estimating population distance for nonmetric data (Sjøvold 1977; Molto 1983). However, use of the mean measure of divergence without corrective statistics on small population sample sizes has been cautioned against (Green and Suchey 1976; Sjøvold 1977). There are a number of transformations currently used to remove the effects of small sample size (Anscombe 1948; Freeman and Tukey 1950). The usefulness of each technique is dependent on how quickly and effectively they stabilize the variance (Molto 1983). The transformation devised by Smith (in Grewal 1962) has been widely used (Pietrusewsky 1969, 1971; Jantz 1970; Kellock and Parsons 1970a, b; Buikstra 1972; Lane and Sublett 1972; Corruccini 1974; Cybulski 1972; Finnegan 1972; Rightmire 1972; Birkby 1973; Berry 1974; Gaherty 1974; McWilliams 1974). Green and Suchey (1976) have demonstrated that this transformation produces inflated variances for small sample sizes combined with small trait frequencies. Thus the variance is not adequately stabilized and tests of significance between samples are unreliable.

Other researchers have proposed the use of alternate transformations (Green and Suchey 1976; De Souza and Houghton 1977; Sjøvold 1977). The best are those of Freeman and Tukey (1950) and Anscombe (1948). According to Molto (1983), there is little empirical difference between the two transformations. However, the Freeman and Tukey transformation is slightly more efficient at stabilizing the variance of very small proportions, which are common in archaeological samples (Green and Suchey 1976; Sjøvold 1977).

The mean measures of divergence for this study were calculated using the Freeman and Tukey transformation and the method suggested by Green and Suchey (1976). The angular transformation for each trait was carried out using the formula suggested by Freeman and Tukey (1950). The standard deviation of the mean measures of divergence was calculated using the method suggested by Sofaer and others (1986). A mean measure of divergence equal to or greater than twice its standard deviation is considered to be statistically significant at the $p < 0.05$ level (Molto 1983). When two samples have identical frequencies of each variant or sample sizes are small, the mean measure of divergence assumes a negative value (Turner and Bird 1981). As Constandse-Westermann (1972:3) points out, "lack of significance usually does point to a close association of populations." However, nonsignificant distance does not necessarily mean that the samples being compared are drawn from the same population (Constandse-Westermann 1972; Hiernaux 1972; Rightmire 1972; Sjøvold 1977). It is equally misleading to interpret statistically significant distances as indicating samples from different populations. As Grüneberg (1952, 1963) has noted, distances between populations may increase at a constant rate over generations due to random genetic drift.

Taxonomic Statistics

Interpreting biological relationships from a large matrix of distance coefficients can be quite a confusing task. In order to make interpretation easier, two related taxonomic statistical techniques have traditionally been employed (Lukacs and Hemphill 1991; Molto 1983). These two techniques are cluster analysis and multidimensional scaling. Both of these procedures express biological dissimilarity in terms of Euclidean distance (Molto 1983).

Affinity of the groups is assessed using cluster analysis, a metric approach leading to the establishment of clusters of similar groups (Aldenderfer and Blashfield 1984; Anderberg 1973; Blashfield 1976; Everitt

1974). The object of the analysis is: given a sample of n objects, each of which has a score on p variables, devise a scheme for grouping the objects into classes so that similar ones are in the same class. The objects here are the population samples and the scores are the arcsine transformed trait frequencies. The method must be completely numerical and, unlike in discriminant function analyses, the number of classes is not known.

There are several hierarchical methods available for cluster analysis. These methods operate on a distance matrix to construct a dendrogram that illustrates the relationships among the population samples. Agglomerative hierarchical methods in cluster analysis start with the calculation of the distances of each individual to all other individuals. Groups are then formed by a process of agglomeration. All objects start by being alone in groups of one. Close groups are then gradually merged until finally all individuals are in a single group. Of the methods available, Ward's minimum variance provides the most accurate results for the type of data used here (Blashfield 1976; Molto 1983). This method is designed to generate clusters so that the variance within clusters is minimal (Ward 1963). The procedure uses an error sum of squares function that computes the sum of squares of the distance from each point to its parent cluster. At each step, it combines those two clusters, which results in the least increase in the within-group sum of squares objective function. A cluster formed by this method can, therefore, be defined as a group of entities such that the error sum of squares among the members of each cluster is minimal (Blashfield 1976).

The next procedure used to illustrate population distances is multidimensional scaling (Tørgersen 1952; Kruskal and Wish 1978; Schiffman et al. 1981). Multidimensional scaling is a technique that attempts to position objects in space according to distance measures rather than classifying them as in cluster analysis. The objects in this case are again the population samples, and the distances used are the standardized mean measures of divergence derived with the Freeman-Tukey transformation and using the method of Sofaer and others (1986). A point is usually specified in terms of its coordinate location in reference to a set of axes. An axis defines a direction of movement and the number of axes defines the dimensionality of the space. The reference axes are assumed to be at right angles to each other and can be referred to as a Cartesian coordinate system (Molto 1983).

The procedure for multidimensional scaling is iterative and the groups are moved around within a space of specified dimensionality in order to find a monotone function expressing the original distances and the distances in the configuration. The fit between the two distances and a mono-

tone function is expressed as a measure referred to as "stress" (Kruskal 1964a, b). The stress is computed as the square root of the sum of the squared deviations of the distances in the configuration space from the monotone function divided by the sum of the squares in the configuration space (Kruskal 1964a, b). This statistic has a theoretical range from 0 to 1 with the larger the value the weaker the fit of the data to a given configuration. After a series of iterations has produced a configuration of minimal stress in some number of dimensions, the procedure is terminated. Generally, increasing the number of dimensions improves the fit of the data to a configuration. However, beyond three dimensions, interpretation becomes problematic.

In multidimensional scaling, the position of the objects in space can be described in one dimension (if the objects fall on a line), in two dimensions (if the objects lie on a plane), in three dimensions (if the objects can be represented by points in space), or in a higher number of dimensions (in which case an immediate geometrical representation is not possible). In this study, the representations are in three dimensions because interpretation of more dimensions is problematic at best.

Results

Biological distance is most easily evaluated by expressing the degree of divergence between the populations with a single numerical value rather than by trying to evaluate relationships on a trait by trait basis using univariate statistics (Cybulski 1975; Molto 1983). The single numerical value chosen for this analysis is the mean measure of divergence based on the method of Green and Suchey (1976) and standardized mean measures of divergence using the method of Sofaer and others (1986).

Standardized mean measures of divergence were calculated by dividing each mean measure of divergence by its standard deviation. The standardized mean measures of divergence are more appropriate for comparison of distances among groups of populations with greatly varying sample sizes (Sofaer et al. 1986). In order to be considered statistically significant at the $p < 0.05$ level, the mean measure of divergence must be at least twice its standard deviation. An examination of the distance matrices for the dental and cranial traits (tables 9.4 and 9.5) reveals that the vast majority of the mean measures of divergence are statistically significant. Two notable and consistent exceptions to this are the comparisons of Santa Maria with Santa Maria de Yamasee and Town Creek with Upper Saura Town. Both dental and cranial morphological measures of divergence for these com-

parisons are quite small and with one exception are not statistically significant.

As one can see, it is impossible to assess simultaneously the relationships among large numbers of population samples from a matrix of distance coefficients. In order to make interpretation easier, two related taxonomic statistical techniques were used: cluster analysis and multidimensional scaling.

Cluster Analysis

For the first multivariate method, arcsine transformed trait frequencies were used as input for a cluster analysis program (Cluster, SYSTAT Inc., Wilkinson 1988a). This program is designed to construct dendrograms in Euclidean space based on Ward's Minimum Variance method (Ward 1963). The results of cluster analyses are reported in figure 9.5. Examination of cluster analyses derived independently from the dental and cranial traits reveals some differences in results.

In the dental analysis, the eleven population samples form four distinct clusters. Some of these clusters are somewhat unexpected. According to ethnographic accounts, the Irene Mound, Santa Catalina, and Santa Maria population samples represent part of a temporally successive and biologically continuous series. Cluster analysis suggests, however, that the Irene Mound sample is biologically more similar to the population samples from Ledford Island and the King site than to the other Guale samples. In fact, this cluster separates as a distinct isolate from the other eight sites at a higher level than even the Carolina Algonquian samples. The results of cluster analysis also suggest that the Santa Maria and Santa Maria de Yamasee samples are biologically similar. However, the results of this analysis do not indicate such a close relationship between Santa Catalina and Santa Maria. Two notable isolates from the other clusters are the Baum sample and the Town Creek–Upper Saura Town cluster. The Algonquian are archaeologically and ethnographically identified as quite separate from the other southeastern U.S. populations examined here. This analysis reflects that separation. Some have speculated that the Guale of Irene Mound and the inhabitants of Town Creek are biologically affiliated (Coe 1995). This analysis does not confirm that relationship.

The clusters produced by the cranial analysis are slightly different from those produced by the dental traits. In this analysis, Irene Mound does not separate from the other Guale samples as in the dental analysis. Instead a close cluster is formed by Irene Mound and Santa Maria. The Santa Maria and Santa Maria de Yamasee samples are separated by two hierarchical

Table 9.4. Mean measures of divergence, cranial samples

	Irene	SCdGSM	SMdY	Baum	Ledford	U. Saura Town	Town Creek	Warren Wilson
Irene	—	0.04193	0.07725	0.15449	0.08102	0.22426	0.19217	0.29136
SCdGSM	3.38009	—	0.04364	0.09825	0.04275	0.19716	0.14840	0.22026
SMdY	3.24833	1.77934	—	0.15589	0.05047	0.39893	0.31170	0.40970
Baum	13.69704	8.13507	6.64755	—	0.20261	0.28868	0.28466	0.31375
Ledford	4.46042	2.25475	1.66520	11.35671	—	0.46151	0.25455	0.44014
U. Saura Town	8.54383	7.32912	10.50533	11.11083	14.24488	—	0.06067	0.04525
Town Creek	14.91720	10.87424	12.47359	22.62514	13.14351	2.17251	—	0.04082
Warren Wilson	12.61187	9.23929	11.66509	13.75196	14.91050	1.20289	1.66757	—

Note: Mean measures of divergence above diagonal (Green and Suchey 1976), standardized mean measures of divergence below diagonal (Sofaer et al. 1986).

Table 9.5. Mean measures of divergence, dental samples

	Irene	SCdG	SCdGSM	SmdY	Baum	Ledford	King	Little Egypt	Coweeta Creek	U. Saura Town	Town Creek
Irene	—	0.11228	0.18057	0.19898	0.31603	0.04826	0.03475	0.16008	0.05196	0.10575	0.20653
SCDG	14.43324	—	0.06330	0.09839	0.16060	0.11460	0.09557	0.03995	0.03638	0.08318	0.15661
SCDGSM	12.10184	4.57742	—	0.04278	0.12991	0.23015	0.23119	0.16367	0.07159	0.16606	0.25132
SMDY	12.83859	6.86477	1.99151	—	0.11897	0.21463	0.26445	0.11715	0.07018	0.13877	0.21698
Baum	9.78760	5.13672	3.42878	3.08025	—	0.20130	0.35235	0.25701	0.20186	0.24332	0.27652
Ledford	4.92674	13.26569	14.61100	13.04322	6.09860	—	0.04462	0.09926	0.08787	0.20840	0.28299
King	2.72717	8.26442	12.35684	13.61961	9.84655	3.23763	—	0.07062	0.09795	0.14760	0.26312
Little Egypt	4.90792	1.27115	4.27929	2.98623	4.67250	2.94672	1.92750	—	0.03570	0.14928	0.21868
Coweeta Creek	3.55730	2.69237	3.46452	3.31042	5.33413	5.68262	5.32419	0.93773	—	0.03088	0.08084
U. Saura Town	6.33256	5.31141	7.37429	5.97279	6.11322	11.85859	7.20889	3.71976	1.37398	—	-0.02018
Town Creek	18.27998	15.27574	14.52446	12.14013	7.96241	23.26790	17.42754	6.27282	4.72243	-1.04934	—

Note: Mean measures of divergence above diagonal (Green and Suchey 1976), standardized mean measures of divergence below diagonal (Sofaer et al. 1986).

Cluster Analysis, Dental Samples

Town Creek	0.192
U. Saura Town	0.761
Little Egypt	0.408
SCDG	0.278
Coweeta Creek	0.506
SCDGSM	0.329
SMDY	0.644
Baum	0.833
Ledford Island	0.291
Irene Mound	0.270
King	
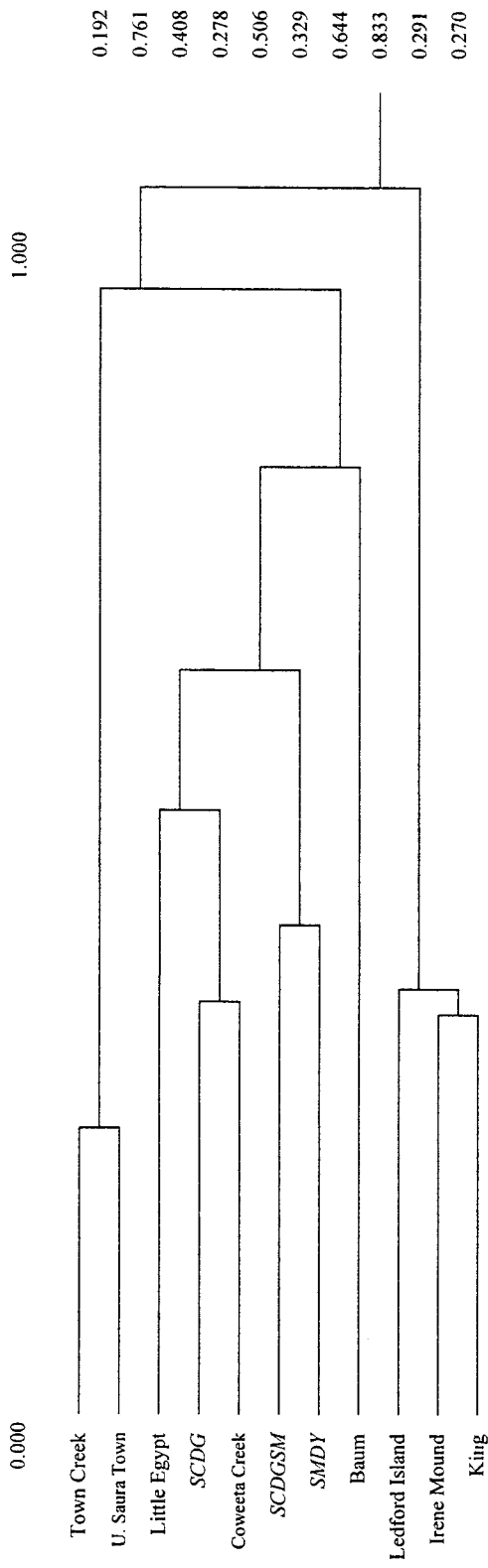
Cluster Analysis, Cranial Samples

SMDY	0.393
Ledford Island	0.363
SCDGSM	0.282
Irene Mound	0.507
Baum	1.212
U. Saura Town	0.399
Town Creek	0.338
Warren Wilson	

Fig. 9.5. Results of cluster analysis.

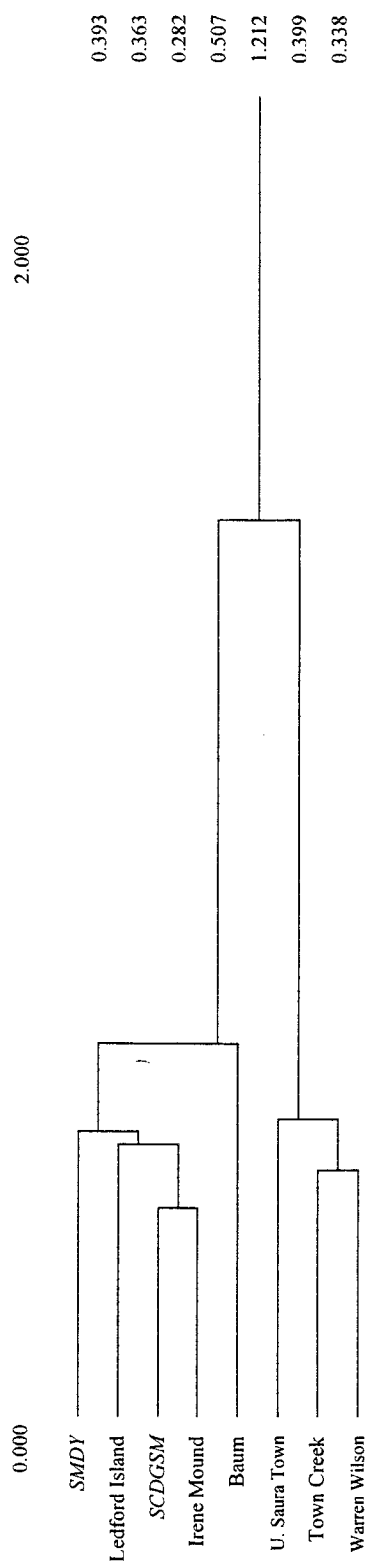levels rather than clustered together. The Baum site is still separated into a unique isolate in the cranial analysis. A widely divergent cluster is formed by the sites of Upper Saura Town, Town Creek, and Warren Wilson. These are slightly different relationships from those suggested by the dental analysis. The Baum sample and the other three North Carolina samples reflect much the same relationship as indicated by the dental analysis. However, the relationships between the Guale samples and the sample from Ledford Island appear more complicated.

Multidimensional Scaling

For the second multivariate technique, multidimensional scaling, arcsine transformed trait frequencies were utilized in a mean measure of divergence analysis. The standardized mean measures of divergence were used as input for a multidimensional scaling analysis (MDS-Guttman, SYSTAT Inc., Wilkinson 1988a). Guttman's (1968) coefficient of alienation was used. Each analysis was stopped when a level of stress in fitting the coordinate points to the monotonic function dropped below zero. The output from this program results in a table of three-dimensional coordinates in Euclidean space for each sample. These coordinates are then plotted in three-dimensional space, giving a representation of the relative distances between populations (Plot, SYGRAPH, Wilkinson 1988b). The results of multidimensional scaling analyses are reported in figures 9.6 and 9.7.

The results of multidimensional scaling of the dental trait frequencies in many ways correspond with the conclusions derived from cluster analysis of the dental traits. The same close placement of Irene Mound, the King site, and Ledford Island are indicated here. Likewise as in the cluster analysis, a close relationship between Santa Catalina, Santa Maria, and Santa Maria de Yamasee is suggested. Two notable differences from the cluster analysis are the cluster of Upper Saura Town, Little Egypt, and Coweeta Creek and the isolation of Town Creek well away from all the other sites.

The results of multidimensional scaling derived from the cranial traits also in many ways correspond with the conclusions derived from cluster analysis of the cranial traits. The close relationship between Santa Maria and Santa Maria de Yamasee is more clearly defined here. A similar relationship between Ledford Island and Irene Mound is also more clearly defined here. As in all of the previous analyses, the Baum samples are clearly demarcated from the rest of the samples. Slightly different from the cluster analysis, a close relationship is suggested between Upper Saura Town and Warren Wilson, while Town Creek appears as a relative isolate.
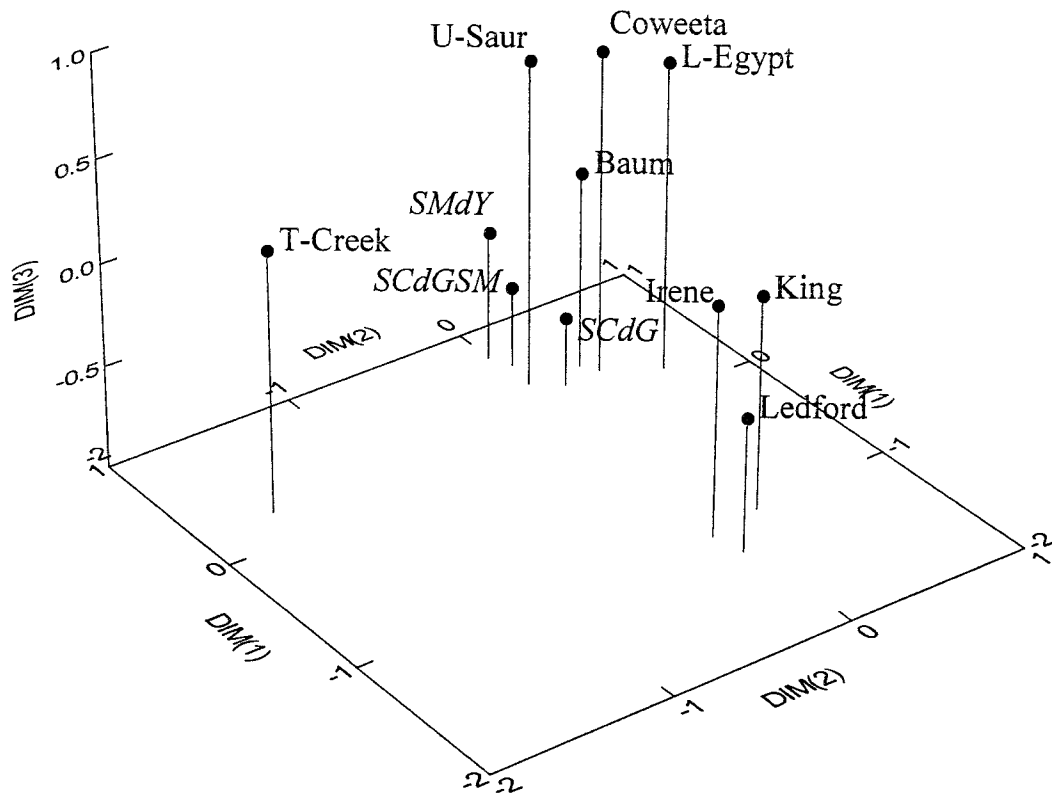
Fig. 9.6. Results of multidimensional scaling analysis of dental samples. Baum = Baum ossuary and Piggot ossuary; Coweeta = Coweeta Creek; Irene = Irene Mound; King = King site; Ledford = Ledford Island; L-Egypt = Little Egypt; SCDG = Santa Catalina de Guale (Georgia); SCDGSM = Santa Catalina de Guale de Santa Maria (Florida); SMDY = Santa Maria de Yamasee; T-Creek = Town Creek; U-Saur = Upper Saura Town; .
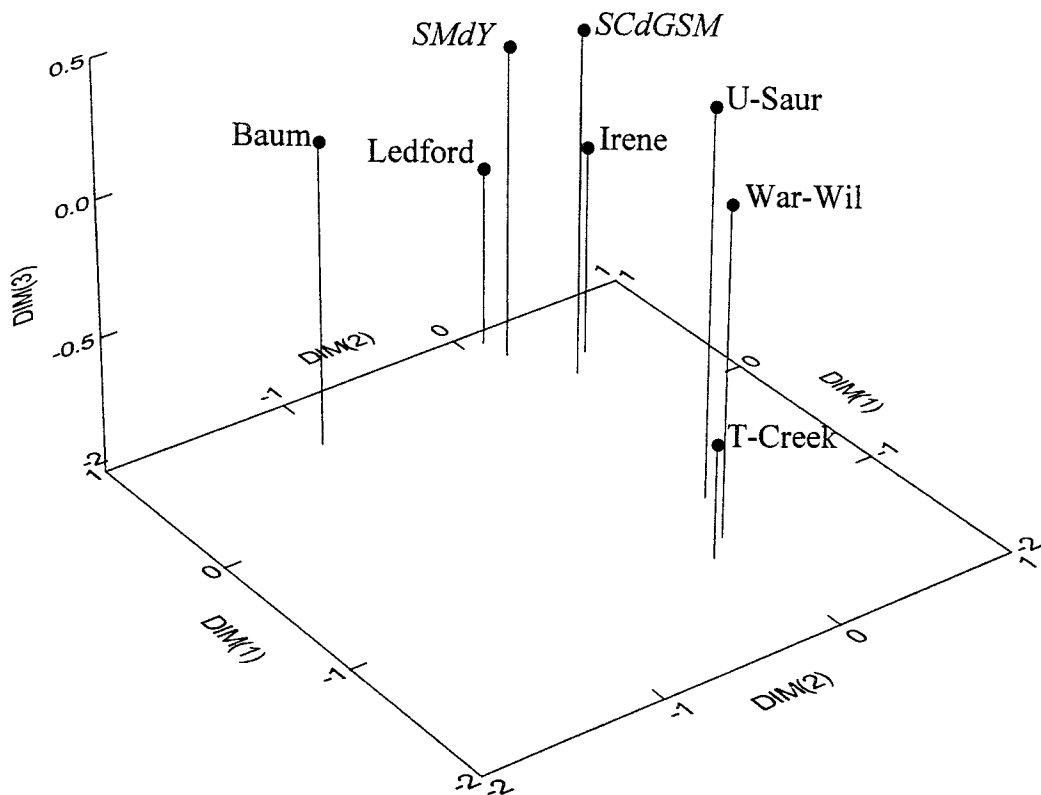
Fig. 9.7. Results of multidimensional scaling analysis of cranial samples from seven sites identified for figure 9.6, plus War-Wil = Warren Wilson.

Discussion

The results of this study can be discussed in relation to at least two specific issues: (1) the likely biological relationships between the three Guale samples, and (2) the biological affinity of the Guale to other groups from the Southeast. With regard to the suggested relationship among the Guale samples, ethnographic sources indicate that the samples included here represent a continuous series of populations. According to independent analyses of distance estimates generated from dental and cranial traits, the Guale samples do not represent a continuous population.

Specifically, the assertion that the Santa Maria population represents the migrants and descendants from the Santa Catalina population is supported by all of the analyses. The degree of dissimilarity between the Santa Catalina and Santa Maria samples, although statistically significant, is relatively small compared to other sample distances. This degree of dissimilarity can best be explained by genetic drift. This interpretation is supported by the comparatively smaller sample size observed at Santa Maria, which represents the temporally later sample.

An explanation for the significant differences between Santa Catalina and Santa Maria may be inferred from the differing degrees of diversity observed within each sample. The Santa Catalina sample exhibits a great deal more variability in terms of trait expression than that observed for the Santa Maria sample. Because Santa Catalina was one of the early missions in the area and may have been characterized by the mixture of diverse gene pools, one might expect that this sample would exhibit a wide range of trait variability. Given that (1) in terms of biological distance the Santa Catalina and Santa Maria samples are quite close, (2) the Santa Catalina sample temporally preceded the Santa Maria sample, and (3) the population of Santa Maria most likely derived from that of Santa Catalina, the evidence suggests a population "bottleneck" between the two temporal periods. That is, the gene pool was sharply restricted between the temporal period of Santa Catalina and that of Santa Maria. Considering the volatile social circumstances at the time, many possible explanations for such a bottleneck exist (e.g., warfare, circumscription, differential mortality, and migration).

Separate analyses consistently placed the Irene Mound sample relatively far from the other Guale samples and closer to the samples from the Lamar/Dallas/Mouse Creek cultures. This degree of dissimilarity is not likely due to the action of random genetic drift alone. This result casts some doubt on the contention that the Irene Mound sample and the later Guale samples

are a continuous population. The explanation may be that the Irene Mound sample was more closely affiliated with prehistoric inland groups rather than with the later Guale from Santa Catalina and Santa Maria. Because populations in this geographic area were in a state of political and social flux between the temporal period of Irene Mound and that of the later Guale samples, this interpretation is plausible. It should also be noted that the term *Guale* was used interchangeably as a geographic location and a cultural/linguistic group (Jones 1978). Therefore, referring to a group as Guale may have connoted geographic location and not necessarily linguistic, cultural, or biological affiliation.

As noted, the Spanish called the location Guale as well as using this name for a cultural group. The sample from Santa Catalina likely represents an aggregate population. If this is the case, one would hardly expect the prehistoric Irene Mound inhabitants to be similar to the population sample from Santa Catalina. This is further complicated by the probability that because it was a ceremonial center, Irene Mound likely was also an aggregate population. Regardless of which interpretation one chooses, it is clear from the results presented here that the prehistoric Guale from Irene Mound were significantly dissimilar in terms of dental and cranial morphology from the historic Guale of both Santa Catalina and Santa Maria.

If the historic Guale populations of the Georgia coast derive from the late prehistoric Irene Mound population, quite substantial population changes must have occurred. If this is the case, extensive gene flow from other populations was likely involved because of the relatively brief time interval between the occupation of Irene Mound and that of Santa Catalina (less than 100 years).

In regard to the suggested relationships for the Guale and non-Guale samples, with the exception of the Irene Mound sample, the coastal La Florida samples appear fairly distinct from the inland samples from North Carolina, Georgia, and Tennessee. This is especially true for the North Carolina piedmont and ridge and valley samples. Considering the samples one at a time, the population sample from Santa Maria de Yamasee was consistently placed close to the Santa Maria sample in multivariate analyses. This outcome may suggest a close biological affiliation between these two populations. The relationship between the Santa Catalina sample and the Santa Maria de Yamasee sample was less clear but may also suggest a biological affiliation between the two groups.

It is unexpected that the Santa Maria and Santa Maria de Yamasee population samples consistently placed close together in a population distance analysis. The ethnographic record is unclear as to the cultural and

linguistic affiliation of the Guale and Yamasee. However, these two groups are usually considered distinct groups (Mooney 1969; Bushnell 1986). Evidence presented in this analysis may suggest a closer affinity than the ethnographic record indicates. It may be that historically the Guale and Yamasee were distinguished solely by geographic location and not by cultural, linguistic, or biological differences.

A consistent result for all of the analyses is the close association of the Irene Mound sample with the inland samples from Ledford Island and the King site. This does not necessarily imply a biological connection between these groups; however, the small standardized mean measures of divergence are notable. The distinct similarity between these samples is in sharp contrast to the consistent dissimilarity with the historic Guale.

Another consistent result for all the analyses is the marked dissimilarity between the Guale samples and the samples from the piedmont. Not only do these samples consistently cluster separately in the cluster and multidimensional scaling analyses but the standardized mean measures of divergence are some of the highest of all the comparisons. This is especially true for the Town Creek sample. This result does not support the proposal of biological affinity between Town Creek and coastal populations of La Florida.

In all analyses, the Carolina Algonquian samples from the Baum and Piggot sites are consistently identified as a distinct isolate from the other southeastern United States samples. This outcome is not unexpected considering the ethnographic identification of the Algonquian as a group with origins far to the north and unlike many of their geographically close neighbors in the Southeast.

Conclusions

The results of this study support the earlier contention that the Native American inhabitants of the Georgia and Florida coasts do not necessarily represent a biologically continuous series of populations. As might be expected, the analyses suggest a complex series of relationships among these populations.

Univariate and multivariate analyses indicate that the Guale population samples examined here are particularly diverse in terms of expression of dental and cranial nonmetric traits. This diversity cannot be fully explained in terms of in situ genetic drift. These results contradict, in part, earlier assumptions of population relationships on the Georgia coast. Given the unstable political and social conditions among the Guale after

European contact and the extensive period of missionization of the native inhabitants, aggregation of local populations could have precipitated such gene flow.

There are at least two alternative hypotheses that the results of this study could support. The first possibility is that the pre-contact Guale of the Georgia coast and the post-contact Guale of the Georgia and Florida coasts represent a single temporally and biologically continuous population. If this were indeed the case, the results of this study should have indicated a homogeneous population over all of the temporal periods with few significant differences in frequency for the dental and cranial nonmetric traits. Likewise, if the population samples in this study represented a temporally continuous population, it would be expected that the biological distances between the Guale samples would be small in comparison to distances from other non-Guale groups. In this case, comparison with the non-Guale population samples should reveal a significant difference in trait frequencies and in biological distance. It would be expected that the differences would be greater for those groups geographically more distant from the Guale (e.g., Algonquian and inland groups) than for the closer populations (e.g., Yamasee), which have a greater opportunity for gene flow.

The second possibility is that the results of this study could have indicated a heterogeneous population with differing degrees of diversity between the temporal periods. This being the case, large biological distances between the Guale samples would suggest the presence of discontinuous populations. The possibilities for such an apparent lack of continuity include: (1) high levels of genetic drift occurred between generations of an in situ population, (2) significant amounts of gene flow from other populations altered the composition of the gene pool, or (3) the samples actually represent genetically different populations rather than a series of related populations. Any one of these processes or a combination of them could cause significant changes in composition of the gene pool between temporal periods.

The results of this study support the later alternative. The Guale samples examined here represent a diverse series of population samples in terms of both dental and cranial morphology. Although biological continuity may be argued for the post-contact Guale from Santa Catalina and Santa Maria, the same argument does not seem to hold true for the relationship between the pre-contact Irene Mound sample and the post-contact Guale groups. The marked similarity between the inland population sample from Ledford Island and the Guale sample from Irene Mound may suggest a

biological connection between these populations. According to ethnographic sources, the Guale are a derivative group from the Creek (Spencer and Jennings 1977). The similarity between the Ledford Island and Irene Mound samples may therefore reflect the retention of ancestral Muskogean traits in both samples. This contention cannot be fully explored without further comparative studies of other Muskogean groups.

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Appendix 9.A. Dental trait frequencies

<div style="text-align:center">Frequency (%)</div>

Dental trait	Grade	Irene	SCDG	SCDGSM	SMDY	Baum	Ledford	King	Little Egypt	Coweeta Creek	Upper Saura Town	Town Creek
Shoveling I1	0	0(0.0)	1(1.6)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	1(1.4)	5(8.1)	3(6.9)	2(5.7)	1(20.0)	0(0.0)	1(1.7)	0(0.0)	0(0.0)	0(0.0)	2(7.1)
	2	25(36.2)	25(36.2)	20(46.5)	10(28.6)	2(40.0)	22(28.9)	11(19.3)	1(7.1)	2(8.3)	5(16.1)	7(25.0)
	3	29(42.0)	29(42.0)	14(32.6)	17(48.6)	1(20.0)	28(36.8)	25(43.9)	8(57.1)	10(41.7)	15(48.4)	11(39.3)
	4	14(20.3)	14(20.3)	5(11.6)	4(11.4)	1(20.0)	20(26.3)	17(29.8)	5(35.7)	5(20.8)	7(22.6)	6(21.4)
	5	0(0.0)	1(1.6)	1(2.3)	2(5.7)	0(0.0)	5(6.6)	3(5.3)	0(0.0)	6(25.0)	4(12.9)	2(7.1)
	6	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.3)	0(0.0)	0(0.0)	1(4.2)	0(0.0)	0(0.0)
Shoveling I2	0	0(0.0)	1(1.2)	5(11.9)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	1(1.5)	11(12.8)	4(9.5)	2(6.1)	3(27.3)	1(1.4)	1(2.0)	2(14.3)	1(3.4)	1(3.4)	3(6.1)
	2	5(7.5)	33(38.4)	16(38.1)	13(39.4)	2(18.2)	12(16.7)	5(10.0)	5(35.7)	6(20.7)	5(17.2)	10(20.4)
	3	18(26.9)	18(21.0)	10(23.8)	8(24.2)	3(27.3)	28(38.9)	14(28.0)	1(7.1)	8(27.6)	11(37.9)	17(34.7)
	4	22(32.8)	15(17.4)	5(11.9)	4(12.1)	1(9.1)	26(36.1)	16(32.0)	2(14.3)	6(20.7)	7(24.1)	11(22.4)
	5	18(26.9)	4(4.6)	0(0.0)	3(9.1)	1(9.1)	4(5.6)	8(16.0)	3(21.4)	2(6.9)	4(13.8)	6(12.2)
	6	2(3.0)	2(2.3)	0(0.0)	3(9.1)	1(9.1)	1(1.4)	1(2.0)	0(0.0)	5(17.2)	1(3.4)	2(4.1)
	7	1(1.5)	1(1.1)	2(4.7)	0(0.0)	0(0.0)	0(0.0)	5(10.0)	1(7.1)	1(3.4)	0(0.0)	0(0.0)
	8	0(0.0)	1(1.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)			
Double shoveling	0	2(2.9)	8(12.3)	11(22.9)	5(15.1)	2(40.0)	3(3.9)	2(3.6)	2(14.3)	1(3.3)	1(4.0)	1(3.0)
	1	0(0.0)	8(12.3)	7(14.6)	2(6.1)	0(0.0)	2(2.6)	0(0.0)	0(0.0)	2(6.7)	1(4.0)	1(3.0)
	2	9(13.2)	15(23.1)	11(22.9)	9(27.3)	1(20.0)	7(9.1)	9(16.1)	1(7.1)	12(40.0)	5(20.0)	4(12.1)
	3	10(14.7)	19(29.2)	2(4.2)	8(24.2)	0(0.0)	20(26.0)	11(19.6)	4(28.6)	3(10.0)	3(12.0)	2(6.1)
	4	20(29.4)	8(12.3)	13(27.1)	3(9.1)	1(20.0)	28(36.4)	21(37.5)	5(35.7)	6(20.0)	6(24.0)	12(36.4)

Dental trait	Grade	Irene	SCDG	SCDGSM	SMDY	Baum	Ledford	King	Little Egypt	Coweeta Creek	Upper Saura Town	Town Creek
	5	19(27.9)	7(10.8)	4(8.3)	5(15.1)	0(0.0)	14(18.2)	10(17.9)	1(7.1)	6(20.0)	7(28.0)	13(39.4)
	6	8(11.7)	(0.0)	0(0.0)	1(3.0)	1(20.0)	3(3.9)	3(5.4)	1(7.1)	0(0.0)	2(8.0)	0(0.0)
Interruption groove	0	41(62.1)	28(41.8)	15(34.1)	15(51.7)	0(0.0)	36(58.1)	23(53.4)	9(81.8)	15(57.7)	6(40.0)	14(42.4)
	1	5(7.6)	22(32.8)	8(18.2)	9(31.0)	3(27.3)	17(27.4)	8(18.6)	1(9.1)	5(19.2)	4(36.7)	5(15.1)
	2	19(28.9)	11(16.4)	13(29.6)	4(13.8)	6(54.6)	2(3.2)	11(25.6)	1(9.1)	3(11.5)	5(33.3)	9(27.3)
	3	1(1.5)	2(2.9)	0(0.0)	0(0.0)	2(18.2)	7(11.3)	0(0.0)	0(0.0)	1(3.8)	0(0.0)	1(3.0)
	4	0(0.0)	4(5.9)	8(18.2)	1(3.4)	0(0.0)	0(0.0)	1(2.3)	0(0.0)	2(7.7)	0(0.0)	4(12.1)
Metacone M3	0	1(1.6)	3(2.6)	0(0.0)	2(9.5)	0(0.0)	0(0.0)	1(4.0)	0(0.0)	0(0.0)	3(9.1)	0(0.0)
	1	0(0.0)	1(0.8)	0(0.0)	1(4.7)	0(0.0)	0(0.0)	0(0.0)	1(14.3)	0(0.0)	1(3.0)	1(1.8)
	2	3(4.8)	3(2.6)	2(5.9)	2(9.5)	2(16.7)	0(0.0)	1(4.0)	0(0.0)	5(14.3)	7(22.2)	12(21.4)
	3	11(17.7)	23(19.8)	7(20.6)	2(9.5)	1(8.3)	7(18.9)	5(20.0)	0(0.0)	12(34.3)	5(15.1)	9(16.1)
	3.5	27(43.5)	34(29.3)	12(35.3)	11(52.4)	5(41.7)	17(46.0)	13(52.0)	5(71.4)	6(17.1)	10(30.3)	19(33.9)
	4	20(32.2)	48(41.4)	10(29.4)	3(14.3)	3(25.0)	13(35.1)	5(20.0)	1(14.3)	8(22.9)	6(18.2)	10(17.9)
	5	0(0.0)	4(3.4)	3(8.8)	0(0.0)	1(8.3)	0(0.0)	0(0.0)	0(0.0)	4(11.4)	1(3.0)	5(8.9)
Hypocone M1	3	0(0.0)	1(0.6)	1(1.9)	0(0.0)	0(0.0)	1(1.1)	0(0.0)	0(0.0)	0(0.0)	3(6.0)	1(1.3)
	3.5	2(2.1)	11(6.3)	4(7.8)	4(8.7)	2(12.5)	1(1.1)	1(1.5)	1(5.3)	3(4.8)	1(2.0)	13(16.9)
	4	39(41.0)	68(39.3)	40(78.4)	33(71.7)	8(50.0)	78(86.7)	57(83.8)	14(73.7)	42(66.7)	36(72.0)	48(62.3)
	5	54(56.8)	93(53.7)	6(11.7)	9(19.6)	6(37.5)	10(1.1)	10(14.7)	4(21.0)	18(28.6)	10(20.0)	15(19.5)
Hypocone M2	0	0(0.0)	1(0.7)	0(0.0)	1(2.8)	0(0.0)	0(0.0)	0(0.0)	1(9.1)	2(4.2)	3(8.1)	7(11.5)
	1	0(0.0)	7(4.7)	2(5.3)	1(2.8)	1(7.1)	0(0.0)	1(2.4)	1(9.1)	1(2.1)	1(2.7)	2(3.3)
	2	7(8.6)	5(3.3)	2(5.3)	3(8.3)	0(0.0)	0(0.0)	1(2.4)	0(0.0)	2(4.2)	3(8.1)	8(13.1)
	3	12(14.8)	29(19.5)	8(21.0)	8(22.2)	5(35.7)	19(28.8)	13(30.9)	3(27.3)	6(12.5)	7(18.9)	17(27.9)
	3.5	25(30.8)	74(49.7)	11(28.9)	15(41.7)	5(35.7)	25(37.9)	20(47.6)	2(18.2)	26(54.2)	18(48.6)	23(37.7)
	4	35(43.2)	30(20.1)	15(39.5)	8(22.2)	2(14.3)	22(33.3)	7(16.7)	3(27.3)	11(22.9)	5(13.5)	4(6.6)
	5	2(2.5)	3(2.0)	0(0.0)	0(0.0)	1(7.1)	0(0.0)	0(0.0)	1(9.1)	0(0.0)	0(0.0)	0(0.0)
Metaconule M10	0	62(72.9)	83(73.4)	30(88.2)	26(65.0)	4(25.0)	35(42.2)	38(65.5)	12(66.7)	34(85.0)	34(87.2)	57(82.6)
	1	8(9.4)	7(6.2)	0(0.0)	4(10.0)	6(37.5)	27(32.5)	9(15.5)	4(22.2)	2(5.0)	3(7.7)	3(4.3)

Dental trait	Grade	Irene	SCDG	SCDGSM	SMDY	Baum	Ledford	King	Little Egypt	Coweeta Creek	Upper Saura Town	Town Creek
	2	8(9.4)	5(4.4)	0(0.0)	3(7.5)	4(25.0)	17(20.5)	8(13.8)	0(0.0)	3(7.5)	1(2.6)	5(7.3)
	3	2(2.3)	9(7.9)	3(8.8)	6(15.0)	2(12.5)	4(4.8)	1(1.7)	2(11.1)	1(2.5)	0(0.0)	2(2.9)
	4	0(0.0)	9(7.9)	1(2.9)	1(2.5)	0(0.0)	0(0.0)	2(3.4)	0(0.0)	0(0.0)	1(2.6)	2(2.9)
	5	5(5.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Metaconule M2	0	68(94.4)	78(77.2)	24(96.0)	30(96.8)	9(64.3)	49(84.5)	32(94.1)	10(90.9)	37(97.4)	29(100)	48(98.0)
	1	0(0.0)	4(3.9)	0(0.0)	0(0.0)	3(21.4)	7(12.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	3(2.9)	0(0.0)	1(3.2)	0(0.0)	2(3.4)	1(2.9)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	3(2.9)	0(0.0)	0(0.0)	1(7.1)	0(0.0)	0(0.0)	1(9.1)	1(2.6)	0(0.0)	0(0.0)
	4	1(1.3)	8(7.9)	0(0.0)	0(0.0)	1(7.1)	0(0.0)	1(2.9)	0(0.0)	0(0.0)	0(0.0)	1(2.0)
	5	3(4.1)	5(4.9)	1(4.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Carabelli's trait M1	0	33(35.8)	23(23.7)	18(58.1)	22(55.0)	5(33.3)	11(13.1)	10(16.4)	6(35.3)	6(15.0)	6(20.0)	7(11.1)
	1	8(8.7)	14(14.4)	5(16.1)	5(12.5)	6(40.0)	11(13.1)	3(4.9)	0(0.0)	12(30.0)	5(16.7)	17(27.0)
	2	24(26.0)	20(20.6)	4(12.9)	6(15.0)	3(20.0)	17(20.2)	16(26.2)	6(35.3)	8(20.0)	6(20.0)	17(27.0)
	3	10(10.8)	14(14.4)	4(12.9)	1(2.5)	0(0.0)	14(16.7)	10(16.4)	1(5.9)	10(25.0)	5(16.7)	10(15.9)
	4	11(11.9)	11(11.3)	0(0.0)	4(10.0)	0(0.0)	23(27.4)	16(26.2)	3(17.6)	3(7.5)	3(10.0)	5(7.9)
	5	3(3.2)	13(13.4)	0(0.0)	2(5.0)	0(0.0)	4(4.8)	6(9.8)	1(5.9)	0(0.0)	2(6.7)	7(11.1)
	6	0(0.0)	1(1.0)	0(0.0)	0(0.0)	1(6.7)	1(1.2)	0(0.0)	0(0.0)	1(2.5)	3(10.0)	0(0.0)
	7	3(3.2)	1(1.0)	0(0.0)	0(0.0)	0(0.0)	3(3.6)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Carabelli's trait M2	0	74(94.8)	71(98.6)	23(95.8)	29(96.7)	13(100)	57(95.0)	26(78.8)	10(100)	31(86.1)	21(87.5)	41(87.2)
	1	2(2.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.7)	2(6.1)	0(0.0)	5(13.9)	2(8.3)	3(6.4)
	2	1(1.2)	1(1.4)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4(12.1)	0(0.0)	0(0.0)	1(4.2)	2(4.3)
	3	1(1.2)	0(0.0)	1(4.2)	0(0.0)	0(0.0)	2(3.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	1(3.3)	0(0.0)	0(0.0)	1(3.0)	0(0.0)	0(0.0)	0(0.0)	1(2.1)
Parastyle	0	62(100)	88(92.6)	36(97.3)	20(95.2)	12(100)	36(97.3)	24(92.3)	5(62.5)	23(88.5)	18(100)	37(94.9)
	1	0(0.0)	2(2.1)	0(0.0)	1(4.8)	0(0.0)	0(0.0)	0(0.0)	2(25.0)	1(3.8)	0(0.0)	0(0.0)

(continued)

Dental trait	Grade	Irene	SCDG	SCDGSM	SMDY	Baum	Ledford	King	Little Egypt	Coweeta Creek	Upper Saura Town	Town Creek
	2	0(0.0)	1(1.0)	0(0.0)	0(0.0)	0(0.0)	1(2.7)	1(3.8)	1(12.5)	1(3.8)	0(0.0)	2(5.1)
	3	0(0.0)	2(2.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(3.8)	0(0.0)	0(0.0)
	4	0(0.0)	1(1.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	1(1.7)	1(2.7)	0(0.0)	0(0.0)	0(0.0)	1(3.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Peg-shaped incisor	0	67(100)	79(98.7)	50(100)	32(100)	11(100)	73(100)	49(98.0)	13(92.9)	39(92.9)	22(91.7)	49(92.4)
	2	0(0.0)	1(1.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(2.0)	1(7.1)	3(7.1)	2(8.3)	4(7.6)
Peg-shaped molar	0	61(98.4)	82(91.2)	40(97.6)	22(91.7)	13(100)	39(100)	25(96.1)	6(100)	32(97.0)	21(84.0)	38(79.2)
	1	0(0.0)	19(18.2)	1(2.4)	0(0.0)	0(0.0)	0(0.0)	1(3.9)	0(0.0)	1(3.0)	4(16.0)	10(20.8)
	2	1(1.6)	0(0.0)	0(0.0)	2(8.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Anterior fovea	0	0(0.0)	3(3.6)	3(11.1)	2(8.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.3)	0(0.0)	1(2.9)
	1	0(0.0)	4(4.9)	2(7.4)	2(8.3)	0(0.0)	1(1.2)	0(0.0)	0(0.0)	1(5.3)	0(0.0)	0(0.0)
	2	0(0.0)	6(7.3)	5(18.5)	1(4.2)	0(0.0)	1(1.2)	3(5.7)	1(6.2)	1(5.3)	2(8.3)	1(2.9)
	3	2(3.2)	12(14.6)	9(33.3)	16(66.7)	9(81.8)	19(22.6)	20(37.7)	6(37.5)	7(36.8)	8(33.3)	9(25.7)
	4	61(96.8)	57(69.5)	8(29.6)	3(12.5)	2(18.2)	63(75.0)	30(56.6)	9(56.3)	10(52.6)	14(58.3)	24(68.6)
Groove pattern M1	1	78(95.1)	126(88.7)	27(87.1)	13(92.9)	78(90.7)	57(96.6)	15(93.7)	32(80.0)	43(93.5)	77(92.8)	2(2.4)
	2	0(0.0)	3(2.1)	1(3.2)	1(2.9)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(2.5)	0(0.0)	4(4.8)
	3	4(4.9)	13(9.1)	3(9.7)	7(20.6)	1(7.1)	8(9.3)	2(3.4)	1(6.3)	7(17.5)	3(6.5)	
Groove pattern M2	1	9(11.8)	22(15.7)	11(45.8)	12(44.4)	1(9.1)	4(6.8)	6(17.6)	1(10.0)	5(13.2)	2(5.3)	0(0.0)
	2	4(5.3)	12(8.6)	10(41.7)	1(3.7)	0(0.0)	4(6.8)	11(32.4)	0(0.0)	5(13.2)	7(18.4)	16(25.4)
	3	63(82.9)	106(75.7)	3(12.5)	14(51.8)	10(90.9)	51(86.4)	17(50.0)	9(90.0)	28(73.7)	29(76.3)	47(74.6)
Cusp number M1	4	1(1.3)	0(0.0)	1(2.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(3.3)
	5	56(70.9)	92(70.8)	21(58.3)	27(77.1)	7(50.0)	54(61.4)	35(60.3)	11(61.1)	26(66.7)	21(55.3)	28(45.9)
	6	20(25.3)	35(26.9)	14(38.9)	8(22.9)	7(50.0)	32(36.4)	20(34.5)	7(38.9)	13(33.3)	17(44.7)	31(50.8)
	7	2(2.5)	3(2.3)	0(0.0)	0(0.0)	0(0.0)	2(2.2)	3(5.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)

Dental trait	Grade	Irene	SCDG	SCDGSM	SMDY	Baum	Ledford	King	Little Egypt	Coweeta Creek	Upper Saura Town	Town Creek
Cusp number M2	4	6(8.3)	8(6.8)	4(14.8)	5(20.0)	1(9.1)	0(0.0)	0(0.0)	0(0.0)	4(19.0)	9(37.5)	9(23.7)
	5	54(75.0)	68(58.1)	16(59.3)	14(56.0)	6(54.5)	45(76.3)	24(72.7)	6(54.6)	14(66.7)	10(41.7)	20(52.6)
	6	12(16.7)	41(35.0)	7(25.9)	6(24.0)	4(36.4)	14(23.7)	9(27.3)	5(45.4)	3(14.3)	5(20.8)	9(23.7)
Deflecting wrinkle	0	9(34.6)	5(8.9)	6(27.3)	11(57.9)	4(80.0)	14(25.4)	17(47.2)	4(28.6)	0(0.0)	1(3.6)	2(4.3)
	1	2(7.7)	11(19.6)	3(13.6)	4(21.0)	1(20.0)	6(10.9)	5(13.9)	3(2.9)	5(10.6)		
	2	8(30.8)	35(62.5)	11(50.0)	2(10.5)	0(0.0)	30(54.6)	11(30.6)	7(50.0)	7(43.7)	15(53.6)	23(48.9)
	3	7(26.9)	5(8.9)	2(9.1)	2(10.5)	0(0.0)	5(9.1)	3(8.3)	0(0.0)	9(56.3)	7(25.0)	17(36.2)
Distal trigonid crest	0	35(87.5)	55(67.1)	21(94.4)	21(100)	5(83.3)	58(86.6)	45(95.7)	12(75.0)	20(90.9)	32(97.0)	34(73.9)
	1	5(12.5)	27(32.9)	1(4.6)	0(0.0)	1(16.7)	9(13.4)	2(4.3)	4(25.0)	2(9.1)	1(3.0)	12(26.1)
Protostylid M1	0	3(3.7)	6(8.4)	3(14.3)	17(50.0)	8(57.1)	16(18.2)	0(0.0)	2(11.8)	6(20.0)	5(15.6)	11(24.4)
	1	34(41.5)	29(40.8)	14(66.7)	17(50.0)	5(35.7)	51(57.9)	34(58.6)	12(70.6)	14(46.7)	8(25.0)	4(8.9)
	2	45(54.9)	36(50.7)	4(19.0)	0(0.0)	1(7.2)	21(23.9)	24(41.4)	3(17.6)	8(26.7)	9(28.1)	11(24.4)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(6.7)	7(21.9)	12(26.7)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(9.4)	7(15.6)
Protostylid M2	0	5(6.9)	14(24.1)	6(66.7)	12(50.0)	10(90.9)	13(21.3)	5(14.7)	3(27.3)	8(32.0)	4(21.0)	16(41.0)
	1	35(48.6)	25(43.1)	1(11.1)	12(50.0)	1(9.1)	39(63.9)	20(58.8)	7(63.6)	12(48.0)	7(36.8)	16(41.0)
	2	32(44.4)	19(32.7)	2(22.2)	0(0.0)	0(0.0)	9(14.7)	9(26.5)	1(9.1)	2(8.0)	6(31.6)	5(12.8)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(8.0)	1(5.3)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(4.0)	1(5.3)	2(5.1)
Cusp 5 M1	0	1(1.3)	0(0.0)	1(2.9)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(3.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.1)	2(3.4)	0(0.0)	0(0.0)	0(0.0)	1(3.0)
	3	6(6.7)	18(14.1)	1(2.9)	3(8.8)	0(0.0)	20(22.7)	7(12.1)	2(11.1)	3(11.1)	1(4.8)	0(0.0)
	4	28(35.4)	58(45.3)	27(77.1)	20(58.8)	9(64.3)	32(36.4)	33(56.9)	11(61.1)	11(40.7)	6(28.6)	1(3.0)
	5	44(55.7)	52(40.6)	6(17.1)	11(32.4)	5(35.7)	35(39.8)	16(27.6)	5(27.8)	13(48.2)	14(66.7)	30(91.0)

Dental trait	Grade	Irene	SCDG	SCDGSM	SMDY	Baum	Ledford	King	Little Egypt	Coweeta Creek	Upper Saura Town	Town Creek
Cusp 5 M2	0	7(9.7)	9(7.9)	4(16.7)	5(20.0)	1(9.1)	0(0.0)	0(0.0)	0(0.0)	4(20.0)	9(50.0)	9(30.0)
	1	0(0.0)	2(1.7)	0(0.0)	2(8.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(3.3)
	2	3(4.2)	6(5.3)	0(0.0)	2(8.0)	2(18.2)	6(10.2)	5(15.1)	0(0.0)	8(40.0)	1(5.6)	8(26.7)
	3	13(18.0)	32(28.1)	2(8.3)	4(16.0)	2(18.2)	20(33.9)	16(48.5)	7(63.6)	2(10.0)	1(5.6)	6(20.0)
	4	34(47.2)	59(51.7)	15(62.5)	11(44.0)	5(45.4)	23(39.0)	10(30.3)	3(27.3)	5(25.0)	3(16.7)	3(10.0)
	5	15(20.8)	6(5.3)	3(12.5)	1(4.0)	1(9.1)	10(16.9)	2(6.1)	1(9.1)	1(5.0)	4(22.2)	3(10.0)
Cusp 6 M1	0	59(74.7)	92(71.9)	17(56.7)	26(76.5)	7(50.0)	55(62.5)	36(62.1)	11(61.1)	21(61.7)	19(52.8)	29(47.5)
	1	1(1.3)	6(4.7)	3(10.0)	1(2.9)	1(7.1)	1(1.1)	1(1.7)	1(5.6)	1(2.9)	4(11.1)	4(6.6)
	2	5(6.3)	12(9.4)	6(20.0)	4(11.7)	4(28.6)	10(11.4)	11(19.0)	3(16.7)	5(14.7)	7(19.4)	16(26.2)
	3	12(15.2)	6(4.7)	4(13.3)	3(8.8)	2(14.3)	13(14.8)	4(6.9)	2(11.1)	5(14.7)	4(11.1)	8(13.1)
	4	2(2.5)	12(9.4)	0(0.0)	0(0.0)	0(0.0)	8(9.1)	6(10.3)	1(5.6)	1(2.9)	1(2.8)	1(1.6)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.1)	0(0.0)	0(0.0)	1(2.9)	1(2.8)	3(4.9)
Cusp 6 M2	0	60(88.3)	76(66.7)	17(80.9)	19(76.0)	7(63.6)	44(74.6)	24(72.7)	6(54.5)	19(82.6)	17(77.3)	27(71.1)
	1	0(0.0)	2(1.7)	1(4.8)	1(4.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(7.9)
	2	1(1.4)	10(8.8)	1(4.8)	2(8.0)	0(0.0)	4(6.8)	0(0.0)	1(9.1)	0(0.0)	2(9.1)	2(5.3)
	3	5(6.9)	7(6.1)	1(4.8)	1(4.0)	2(18.2)	7(11.9)	6(18.2)	1(9.1)	1(4.3)	2(9.1)	3(7.9)
	4	6(8.3)	17(14.9)	0(0.0)	1(4.0)	2(18.2)	4(6.8)	3(9.1)	3(27.3)	1(4.3)	0(0.0)	1(2.6)
	5	0(0.0)	2(1.7)	1(4.8)	1(4.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(8.7)	1(4.6)	2(5.2)
Cusp 7 M1	0	75(94.9)	123(96)	31(100)	34(100)	14(100)	87(98.9)	55(94.8)	18(100)	33(97.1)	34(87.2)	56(90.3)
	1	0(0.0)	3(2.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(2.9)	3(7.7)	3(4.8)
	2	4(5.0)	1(0.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(5.2)	0(0.0)	0(0.0)	1(2.6)	2(3.2)
	3	0(0.0)	1(0.8)	0(0.0)	0(0.0)	0(0.0)	1(1.1)	0(0.0)	0(0.0)	0(0.0)	1(2.6)	1(1.6)
Cusp 7 M2	0	71(98.6)	114(100)	23(100)	24(96.0)	11(100)	59(100)	33(100)	11(100)	29(100)	27(100)	44(100)
	2	1(1.4)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	1(4.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)

Appendix 9.B. Cranial trait frequencies

N (% present)

Cranial trait	Irene	SCDG	SCDGSM	SMDY	Baum	Ledford	Upper Saura Town	Town Creek	Warren Wilson
Ossicle at lambda	70 (34.3)	0 (0.0)	63 (31.7)	18 (5.5)	68 (17.6)	29 (27.6)	15 (33.3)	64 (37.5)	18 (55.6)
Lambdoid ossicles	70 (62.9)	0 (0.0)	63 (42.9)	19 (31.6)	67 (32.8)	30 (36.7)	23 (87.0)	70 (75.7)	23 (73.9)
Ossicle at asterion	62 (37.1)	0 (0.0)	62 (32.3)	20 (30.0)	67 (13.4)	25 (12.0)	16 (43.7)	55 (43.6)	18 (55.6)
Parietal notch bone	64 (15.6)	0 (0.0)	64 (6.2)	20 (10.0)	65 (6.1)	29 (6.9)	17 (5.9)	57 (8.8)	21 (4.8)
Epipteric bone	51 (19.6)	0 (0.0)	36 (2.8)	18 (0.0)	56 (0.0)	26 (11.5)	15 (0.0)	54 (0.0)	20 (0.0)
Bregmatic bone	67 (0.0)	0 (0.0)	62 (1.6)	21 (0.0)	69 (0.0)	32 (0.0)	22 (0.0)	63 (1.6)	22 (4.6)
Coronal ossicle	67 (4.5)	0 (0.0)	62 (1.6)	21 (0.0)	67 (4.5)	32 (3.1)	18 (0.0)	50 (8.0)	20 (0.0)
Metopism	69 (0.0)	0 (0.0)	70 (0.0)	21 (0.0)	69 (0.0)	32 (0.0)	28 (3.6)	73 (5.5)	24 (0.0)
Fronto-temporal articulation	50 (2.0)	0 (0.0)	38 (0.0)	18 (0.0)	60 (0.0)	28 (0.0)	14 (7.1)	42 (4.8)	16 (0.0)
Supraorbital foramen	67 (17.9)	0 (0.0)	66 (18.2)	20 (25.0)	67 (43.3)	32 (12.5)	29 (27.6)	72 (31.9)	17 (52.9)
Frontal notch	66 (56.1)	0 (0.0)	65 (36.9)	20 (60.0)	68 (69.1)	32 (50.0)	25 (24.0)	64 (35.9)	14 (57.1)
Auditory torus	69 (0.0)	0 (0.0)	66 (0.0)	21 (0.0)	69 (0.0)	32 (0.0)	38 (5.3)	97 (17.5)	31 (51.6)
Foramen of Huschke	69 (24.6)	0 (0.0)	68 (32.3)	21 (33.3)	65 (12.3)	32 (15.6)	39 (33.3)	99 (22.2)	31 (9.7)
Condylar facet double	48 (0.0)	0 (0.0)	36 (0.0)	16 (0.0)	45 (0.0)	19 (0.0)	19 (26.3)	36 (17.1)	16 (12.5)
Precondylar tubercle	44 (0.0)	0 (0.0)	33 (12.1)	16 (0.0)	47 (17.0)	18 (11.1)	16 (0.0)	37 (8.1)	18 (5.6)
Foramen ovale	48 (2.1)	0 (0.0)	53 (1.9)	16 (0.0)	62 (11.3)	25 (4.0)	19 (5.3)	53 (7.5)	23 (0.0)
Foramen spinosum	44 (29.5)	0 (0.0)	55 (21.8)	16 (18.7)	60 (26.7)	25 (8.0)	21 (42.9)	48 (41.7)	27 (33.3)
Accessory palatine foramen	45 (75.6)	0 (0.0)	42 (78.6)	12 (41.7)	45 (60.0)	21 (42.9)	9 (100.0)	27 (85.2)	17 (100.0)
Palatine torus	57 (80.7)	0 (0.0)	57 (77.2)	18 (83.3)	54 (31.5)	29 (100.0)	6 (33.3)	24 (91.7)	13 (61.5)
Maxillary torus	59 (3.4)	0 (0.0)	58 (27.6)	18 (11.1)	51 (0.0)	31 (25.8)	22 (0.0)	52 (13.5)	22 (0.0)
Parietal foramen	67 (31.3)	0 (0.0)	65 (44.6)	21 (19.0)	69 (56.5)	32 (50.0)	18 (5.6)	69 (0.0)	21 (0.0)
Posterior condylar canal	39 (33.3)	0 (0.0)	32 (18.7)	7 (57.1)	38 (63.2)	18 (16.7)	23 (43.5)	38 (52.6)	12 (41.7)
Mastoid foramen extrasutural	61 (16.4)	0 (0.0)	63 (12.7)	16 (18.7)	67 (10.4)	24 (8.3)	19 (21.0)	60 (35.0)	16 (56.2)
Ant. condylar canal double	48 (14.6)	0 (0.0)	33 (18.2)	14 (42.9)	50 (16.0)	20 (10.0)	29 (24.1)	50 (28.0)	21 (28.6)
Zygomatico-facial foramen	61 (60.7)	0 (0.0)	56 (66.1)	18 (83.3)	64 (32.8)	29 (75.9)	19 (26.3)	40 (25.0)	11 (18.2)
Accs. infraorbital foramen	47 (6.4)	0 (0.0)	49 (6.1)	12 (0.0)	46 (28.3)	27 (18.5)	0 (0.0)	0 (0.0)	0 (0.0)

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