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Genetic Admixture and Tooth Size in an Enslaved Population from Newton Plantation, Barbados

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GENETIC ADMIXTURE AND TOOTH SIZE IN AN ENSLAVED POPULATION FROM NEWTON PLANTATION, BARBADOS

by

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This study examined the amount of European genetic admixture in the enslaved African population from Newton Plantation, Barbados. Newton Plantation was a British sugar plantation from the 17th to 19th centuries. Approximately 150 individuals were recovered from an unmarked slave cemetery during archaeological investigations in the 1970s and 1990s.

Using maximum mesiodistal and buccolingual tooth measurements of the available teeth from the individuals in the cemetery, Newton was compared to nineteen comparative samples of African, European, African American and European American populations that date from the time of British colonization to the 20th century.

Previous European admixture estimations in the Newton Plantation cemetery sample were 5-10% (Corruccini et al., 1982; Ritter, 1991); this study found similar rates of admixture in the population (5.38-10.25%). Because of social practices in the Caribbean during the time of slavery, European admixture could have resulted in preferential treatment of slaves with such genetic background.

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CHAPTER 1

INTRODUCTION

The historical record is created with silences, both intentional and unintentional, resulting from unique circumstances of power inequality. Trouillot (1995) finds that these silences enter the process of historical production at four primary moments: 1) the moment of fact creation, or the making of sources; 2) the moment of fact assembly, or the making of archives; 3) the moment of fact retrieval, or the making of the historical narrative; and 4) the moment of retrospective significance, or the making of history. Thus it is clear that the issue of power cannot be excluded from the investigation of history. In fact, that power is the framework in which the story is created and power subsequently contributes to and influences the interpretation of the facts (Trouillot, 1995). In order to gain a more full understanding of the past, silences need to be acknowledged and deconstructed.

Biodistance studies allow anthropologists a way to deconstruct some of these historical silences. Trouillot (1995:29) asserts that "history begins with bodies and artifacts." The bodies of the enslaved Africans who were brought to the New World permit bioarchaeologists to examine the physical indicators of health, physical stress, and nutritional adequacy. In effect, this gives bioarchaeologists a way to begin writing a more complete biohistory of enslaved Africans in the New World. The stories gleaned from analyses of the skeletal remains of the enslaved serves to highlight areas in the accepted history that are lacking or completely inaccurate.

A substantial amount of research has been conducted with contemporary populations in order to determine the genetic admixture of the descendants of enslaved Africans in the New World (e.g., Benn-Torres et al., 2007, 2008; Miljkovic-Gacic et al., 2005; Parra et al., 1998, 2001). While these studies are decidedly important, there is almost no work done in this area on the enslaved populations themselves; Corruccini et al., 1981 being a notable exception. The results of admixture studies in enslaved African populations are important for revealing the histories of these people about whom relatively little biohistory is known. Understanding the biological context of slavery allows us to have a more nuanced understanding of the lives of enslaved Africans in the New World. This knowledge adds to our comprehension of the type and extent of diversity, both cultural and genetic, that is found within the populations of the African Diaspora (Benn-Torres et al., 2008; Jackson et al., 2004). Furthermore, multiple complementary lines of evidence are available including comparing archaeological and biological studies to the historical record thus allowing us to obtain a more accurate reflection of the life experiences of the enslaved.

This study will focus on the genetic admixture of the enslaved population from Newton Plantation, Barbados. Using odontometrics and statistical analyses, this study will attempt to make an estimation of European genetic admixture in the African and African-descended slaves recovered from the Newton Plantation Cemetery. Newton Plantation affords us a unique opportunity to study the skeletal remains of slaves within a context of historic documentation as Newton has more extensive historic documentation compared to almost any other plantation on Barbados. Additionally, Newton Plantation has one of the earliest and largest enslaved African cemeteries in the Caribbean (Shuler, 2005). This combination makes Newton a valuable resource with which to investigate many aspects of the lives of the enslaved laborers (Handler and Lange, 1978).

CHAPTER 2

BACKGROUND

Barbados, Sugar, and the Slave Trade

Barbados is a small island (approximately 430 square miles) in the Caribbean. It was first colonized by the British in 1627, having been located by a small group of Englishmen and a few Africans they had captured during their journey (Handler and Lange, 1978). Barbados was the second colonized island in the Caribbean; the first colony was founded on St. Christopher, now known as St. Kitt's. Approximately 100 people were living on Barbados in late 1627, primarily Europeans and Africans though there was a small Amerindian population, as well. By 1629 the total population had increased to nearly 2,000. Just a few years later there were approximately 6,000 "English" and an untold number of African and Amerindian slaves. The slave trade continued to bring slaves to Barbados resulting in 5,680-6,400 slaves by the mid-1640s; European men on Barbados numbered over 18,000 at this time (Handler and Lange, 1978).

The early economy of Barbados was based on the small-scale farming of crops such as indigo, tobacco, ginger and cotton. These small farms were manned by enslaved Africans and both free and indentured Europeans (Handler and Lange, 1978). However, selling these crops was difficult and eventually the cultivation of sugar cane was encouraged. In the mid-17th

century the demand for sugar in the Old World was on the rise and large-scale plantation production of sugar began on Barbados; it was the first British Caribbean colony to cultivate sugar on a large scale (Handler and Lange, 1978). With the increased demand for sugar (cf., Mintz 1985) there was also an increased demand for cheap labor. Sugar plantations required larger numbers of workers and more intense labor than other types of plantations like cotton and tobacco. The physically demanding labor resulted in high rates of mortality in the enslaved population, necessitating a continuous source of new labor (Handler and Lange, 1978). Thus, demographics of plantations in the sugar islands were characterized by a high ratio of male to female slaves, a high ratio of African-born slave to total slave population, and a high death to birth ratio (Curtin, 1969). In order to meet the constant need for labor, slaves were imported from Africa; in a short time the labor force on Barbadian sugar plantations was primarily composed of enslaved Africans brought by the Atlantic Slave Trade (Handler and Lange, 1978; Taylor, 1991).

The Atlantic Slave Trade exported an estimated 11 million Africans to the New World as slaves. An additional estimated 2 million or more individuals died on their way through the Middle Passage (Salas et al., 2004). It is difficult to know how many Africans were brought to the island of Barbados over the entire period of slavery. Figures reported in the historic documents of the slave trade in Barbados, as in other slave trade locations, are imprecise and frequently non-existent (Handler and Lange, 1978). Though the exact numbers of slaves brought to Barbados is not known, estimated numbers of imported slaves from 1651 until the end of the British slave trade in 1834 include 353,069 (Handler and Lange, 1978), and 368,200 (Curtin, 1969). Benn-Torres et al. (2008) note that by 1748, there were four Africans for each European on the island of Barbados. In the early 19th century slaves accounted for over 80% of the population of Barbados (Handler and Lange, 1978).

Slave shipping lists indicate that most of the Africans who were brought to the New World came primarily from western and west-central Africa (Curtin, 1969; Handler and Lange, 1978) in the regions extending from present-day Senegal to Angola (Handler and Lange, 1978; Parra et al., 1998). This has been supported by DNA studies that trace Y-chromosome and mtDNA genes of African-descended populations in the New World (Salas et al., 2004; Destrol-Bisol, 1999) and more recently by stable isotope studies on individuals from the Newton Plantation cemetery (Schroeder et al., 2009). Historic records indicate that during the most intense slave-trading years on Barbados the majority of their enslaved Africans originated in the areas of the Gold Coast and the Bight of Benin (present-day Ghana, Togo, Republic of Benin, and western Nigeria) (Handler and Lange, 1978). Though these were by no means the only areas from which slaves were acquired, there is evidence that slaves from these areas were preferred by Barbadian planters (Handler and Lange, 1978).

By the mid-18th century, the majority of the slaves on Barbados had been born on the island (Handler and Lange, 1978). British parliament records show that in twenty-two plantations that were examined in the late 1780s, 86% of the total 3,112 slaves on those plantations were born on Barbados, the remainder were born in Africa (Handler and Lange, 1978). Slave data from Newton Plantation indicate that in 1796, 98% of the slaves were born at Newton and three slaves were born elsewhere on Barbados. Only three slaves, an older man and two old women, were born in Africa (Handler and Lange, 1978). From 1805 until slavery was abolished on Barbados in 1834, Newton reported that there were no African-born slaves on the plantation (Handler and Lange, 1978).

Newton Plantation

Newton Plantation was one of two Barbadian plantations owned by Samuel Newton. Newton was one of the foremost planters on Barbados and also held a position on the Barbados Council, the upper house of the legislature of Barbados, from 1672-1684. While not the largest landowner on the island, Newton is noted to have held at least 400 acres in 1673 (Handler and Lange, 1978).

Newton Plantation grew with the demand for sugar and became one of the larger plantations on the island (Handler and Lange, 1978). According to plantation records, the physical size of the plantation varied over time, though it remained at roughly 458 acres from 1796 until the 20th century. Records also indicate that during the mid-18th century, Newton had an average of 171 slaves. The number of slaves climbed to 267 in 1776 and generally stayed between 250-300 from the late 18th century until emancipation on August 1, 1834. The slave population of Newton reached over 300 only once, in 1825, and at emancipation had a total slave population of 261 (Handler and Lange, 1978).

In the 1970s, Jerome Handler and colleagues undertook a large-scale project that included the examination of historical documents of the Barbadian plantations as well as an archaeological survey of some of those plantations, including Newton (Handler and Lange, 1978). Their goal was to use the findings from the historical and archaeological investigations to explore the daily lives of the enslaved laborers on Caribbean plantations. Although living structures (the original goal) were not encountered, oral histories and the archaeological survey revealed the location of an unmarked slave cemetery on Newton Plantation. Portions of the cemetery were subsequently excavated over the course of field seasons in 1971-72 and 1973

(Handler and Lange, 1978), revealing approximately 100 burials. After the first excavations at Newton Cemetery, Handler and colleagues reinterred the post-cranial remains and delivered only the cranial and dental elements back to Southern Illinois University, Carbondale for study (Handler and Lange, 1978). The recovered elements were studied extensively by RS Corruccini and his students (see Atz, 2002; Corruccini and Handler, 1980; Corruccini et al., 1982; Corruccini et al., 1985; Corruccini et al., 1987a; Corruccini et al., 1987b; Corruccini et al., 1989; Handler and Corruccini, 1983; Handler and Corruccini, 1986; Ritter, 1991). These studies produced a wealth of information on this previously unknown population. Handler and Lange (1978) reported a total of 92 individuals recovered from the cemetery, though later osteological examination adjusted that number to 101 individuals (Corruccini et al., 1982). Handler and Lange (1978) dated the cemetery to approximately 1660-1820 and all remains were determined to be of African descent based on cranial and dental features (Corruccini et al, 1982). Subsequent excavations by Kristrina Shuler (Herndon) in 1997 and Raymond Pasquariello in 1998 recovered an additional 49 individual, articulated skeletons of varying degrees of preservation (Shuler, 2005).

Biodistance Studies

European genetic admixture has been investigated in populations of African descent in the New World. These studies have used different methodologies to arrive at estimations of the European genetic contribution to these populations. These methods include examination of genetic markers (DNA) (Benn-Torres et al., 2007, 2008; Brucato et al., 2010; Miljkovic-Gacic et al., 2005; Parra et al., 1998, 2001; Tishkoff et al., 2009), serology (Pollitzer, 1958; Pollitzer et al., 1964; Wienker, 1987), skin pigmentation and reflectometry (Harrison et al., 1967; Lees and Relethford, 1978; Shriver et al., 2003; Wienker, 1987), and dental and craniometric studies (Corruccini et al., 1982; Edgar, 2007, 2009; O'Rourke and Crawford, 1980; Stojanowski 2003, 2005).

Results of these biodistance studies found the European genetic component to African-descended populations in the New World to range from less than 3% to greater than 30% (Benn-Torres et al., 2007; Brucato et al., 2010; Glass and Li, 1953; Kayser et al., 2003; Miljkovic-Gacic et al., 2005; Steinberg et al., 1960). Though the percentage of European admixture in varies widely by location, most estimates of admixture are between 10-20% (Corruccini et al., 1982; Tishkoff et al., 2009; Wienker, 1987; Zakharia et al., 2009). In the United States, African American populations tend to vary by rural versus urban locations in their relative European genetic component; populations of African descent generally exhibit higher European admixture in more urban areas (Glass and Li, 1953; Parra et al., 1998; Pollitzer, 1958; Steinberg et al., 1960). Investigations in urban centers such as Chicago, Illinois; Pittsburgh, Pennsylvania; and Detroit, Michigan found European admixture rates at 26%, 25.2%, and 26%, respectively (Chakraborty et al., 1992; Destro-Bisol et al., 1999; Reed, 1969). Even smaller urban centers like Columbia, South Carolina and Winston-Salem, North Carolina still showed a relatively high percentage of European admixture at 17.7% and 17.0%, respectively (Miljkovic-Gacic et al., 2005; Parra et al., 2001).

Conversely, African-descended populations in rural areas have generally exhibited much lower rates of European admixture. Pollitzer (1958) estimated less than 10% European admixture in rural areas of the American South. Admixture studies in more rural areas of South Carolina and Georgia have shown rates ranging from 6.8% to 15.3%, still well below rates seen in urban areas (Adams and Ward, 1973; Blumberg et al., 1964; Long, 1991; Workman et al., 1963). Outstanding among African-descended populations in the United States are a population in McNary, Arizona and the Gullah/Geechee of South Carolina and Georgia. Wienker (1987) found a <5% admixture rate in the African American population of McNary, Arizona – considerably less than most other populations. Similarly, the Gullah/Geechee have been shown to exhibit a 3-3.5% rate of European admixture (Brucato et al., 2010; Parra et al., 2001).

Few biodistance studies have been conducted in Caribbean populations (Benn-Torres et al., 2008). Parra et al. (1998) investigated European admixture in an African-descended population from Jamaica and found a 6.8% admixture rate. This estimate is slightly lower than that found by Benn-Torres et al. (2008) who estimated European admixture in a Jamaican population at 12.4%. Other Caribbean locations such as St. Thomas present admixture rates of 10.6% (Benn-Torres et al., 2008). The lowest rate of admixture found in the Caribbean was on the island of Tobago where it was estimated that 3.4% of the genetics of the African-descended population was from a European source (Miljkovic-Gacic et al., 2005).

Biodistance studies on Barbados, specifically, have revealed that the primary contributors to the gene pool are African, European, and to a much lesser degree, Native American (Benn-Torres et al., 2008; Miljkovic-Gacic et al., 2005). Benn-Torres et al. (2008) determined that the Barbadian population exhibited gene frequency rates of 89.6% West African, 10.2% European, and 0.2% Native American. Among the Caribbean islands investigated by Benn-Torres et al. (2008) (Barbados, Jamaica, and St. Thomas), Barbados had the highest level of West African genetic contribution and the lowest levels of both European and Native American genes. Corruccini et al. (1982) estimated European admixture from the dentition of the Newton cemetery population to be approximately 5%, a rate that was considered liberal based on known admixture rates in African American populations and in consideration of the population history of African-derived populations in the Caribbean. The Newton remains were subsequently examined by Ritter (1991) who compared mean odontometric data of multiple African and derived and European and derived collections to determine a 12% admixture rate for Newton; this was considerably higher than expected. Both Corruccini et al. (1982) and Ritter (1991) attributed this unexpected high rate of admixture to environmental parallelism between the American White and Black samples used in the comparison. Environmental parallelism in the New World, they argued, affects the underlying genetic factors, creating unpredicted high rates of admixture when compared to one another (Ritter, 1991).

As Benn-Torres et al. (2007:6) note, "the distribution of African genetic contributions to each [Caribbean] island population is likely tightly linked to the respective colonial histories." In light of the subsequent genetic studies on African-derived populations in the Caribbean in general and Barbados in particular, it seems that an admixture rate of 5% is a reasonable, and likely generous, estimation for Newton Plantation.

The Human Dentition

The human dentition has long been a primary focus of biodistance studies of past populations (Dahlberg, 1991; Kieser, 1990; Lease, 2003; Turner, 1969). Teeth are widely used because they are the most durable, and thus the most widely recovered, component of the human skeleton from archaeological contexts. Tooth enamel is the hardest element in the body; some have likened its hardness to mild steel (Eisenmann, 1994). Moreover, enamel has little organic component; it is primarily composed of the mineral hydroxyapatite (Hillson, 1996). Due to the lack of organic material in the enamel, teeth tend to preserve archaeologically even when other skeletal material may be in poor condition or even completely deteriorated (Kieser, 1990; Larsen and Kelley, 1991; Lease, 2003; Scott and Turner, 1997). The strength of the enamel allows the tooth to withstand the forces of mastication during an individual's life as well as post-depositional conditions such as soil pressure, soil chemistry, and water movement after death (Lease, 2003).

Human dental crowns are complex structures that have no simple genetic or environmental determinants (Dempsey and Townsend, 2001). However, studies have shown that teeth are highly heritable in regards to such characteristics as tooth size, number, and morphology (Larsen and Kelley, 1991; Lease, 2003). The "heritability" of a dental character is defined as the portion of the variation within a population that is a result of genetic differences between individuals (Townsend and Brown, 1978b).

There have been a number of studies undertaken in an attempt to investigate the heritability of tooth size (e.g., Alvesalo and Tigerstedt, 1974; Di Salvo et al 1972; Farmer and Townsend 1993; Garn et al., 1966, 1968; Garn et al., 1967b; Garn et al., 1979; Garn et al., 1980; Goose 1967, 1971; Hunter 1959; Lundström 1948; Moorrees and Reed 1964; Osborne et al., 1958; Potter et al., 1976; Sofaer et al., 1971; Townsend and Brown 1978a, b). Though results are variable, it is generally agreed that tooth size has a strong genetic component (Lease, 2003). Osborne et al. (1958) conducted a twin study that compared phenotypic tooth size within and between related individuals in order to produce non-numerical estimates of tooth size heritability and found high heritability in the mesiodistal dimensions of the anterior permanent teeth. Similar results were obtained by Goose (1971) and Lundström (1964) who found high genetic control of dimensions; both buccolingual and mesiodistal dimensions were highly heritable, while mesiodistal dimensions appeared to be slightly more strictly under genetic control.

The human dentition is also subject to environmental factors that may influence growth and development (Bishara et al., 1989; Dempsey and Townsend, 2001; Lease, 2003; Scott and Turner, 1988). These environmental effects include the *in utero* environment, such as maternal health and nutrition during fetal development, as well as the post-uterine environment, including nutrition, disease, and trauma (Lease, 2003). Though environmental effects do play a role in tooth development, Goose (1971) argues these environmental effects are minimal. It has been the goal of some research to assess the relative importance of genetic and environmental effects on human tooth size (Biggerstaff, 1979; Garn, 1977; Lundstrom, 1977; Mizoguchi, 1977, 1980; Nakata, 1985). Among studies that have attempted to quantify a percentage of variability due to either genetic or environmental factors, estimations of genetic components range from 52-92% while environmental factors were estimated at between 6-29% (Dempsey and Townsend, 2001; Townsend and Brown, 1978b). Heritability is a population specific measure (Goose 1971; Lease, 2003; Osborne, 1967), but it has been shown to be stable within a population (Hillson, 1996). Scott and Turner (1988) contend that tooth size heritability has been shown to be strong enough to make the study of biological relationships and microevolutionary trends appropriate.

While a strong genetic component for tooth size has been identified the exact mechanics are not well-understood (Kieser, 1990; Lease, 2003; Scott and Turner, 1988). Tooth size appears to be the result of a polygenic model of inheritance (Bailit 1975; Harris, 1975; Stojanowski, 2004; Townsend and Brown, 1978a, b). Additionally, the genetic control of tooth size seems to systematically vary with tooth type and location (Alvesalo and Tigerstedt, 1974). Teeth are arranged in morphogenetic fields that regulate the type of tooth that occurs within the field (i.e., incisors, canines, premolars, molars) (Ghose and Baghdady, 1979; Harris and Harris, 2007; Townsend et al., 2009). Within each morphogenetic field, heritabilities of the distal members of each tooth group are generally lower than the most mesial (polar) tooth of the group (Alvesalo and Tigerstedt, 1974; Garn et al., 1965; Harris and Harris, 2007). Thus, "polar theory" holds that the pole (i.e., most mesial) tooth within a field is more stable in size than the distal teeth within the same field, though it is noted that an exception to this observation is in the maxillary incisors (Alvesalo and Tigerstedt, 1974).

Tooth Crown Diameters and Geographic Populations

Because of their excellent preservation, strong heritability, and evolutionary stability, teeth are good for examining macro- and microevolutionary changes (O'Rourke and Crawford, 1980; Stojanowski, 2004; Turner, 1969). Tooth size investigations have been conducted on many geographic populations to discern a pattern of tooth size within and among the populations (see Bishara et al., 1989; Brace et al., 1981; Campbell, 1925; Drennan, 1929; Goldstein, 1948; Hanihara, 1977, 1979; Hanihara and Ishida, 2005; Harris and Nweeia, 1980, Kirveskari, 1978; Moorrees, 1957; Nelson, 1938; Perzigian, 1984; Shaw, 1931; Smith et al., 1981). Results of these studies indicate that odontometric and morphological variation are reasonably accurate in discriminating between geographic populations (Lease, 2003).

O'Rourke and Crawford (1980) suggest that odontometric analysis is not only an appropriate method of investigating population microdifferentiation but is even somewhat conservative in its evaluation of differences. O'Rourke and Crawford (1980) investigated the tooth size of four related contemporary Cuanalan and Saltillo populations in Mexico. Two populations remained in their ancestral home area and two populations migrated to an urban area. Transplanted populations exhibited significant microdifferentiation in tooth size relative to the groups that remained in their ancestral region, which O'Rourke and Crawford (1980) suggest reflects microdifferentiation in African and European genetic admixture between the Mexican populations.

Odontometric studies focused on the dentition of African and African-derived populations show that despite the wide range of variation present in the human dentition worldwide, these populations generally exhibit larger overall tooth size than most other populations (Farmer, 1990; Hanihara 1976, 1998; Hanihara and Ishida, 2005; Harris, 2001, 2003; Irish 1994, 1995; Keene, 1979; Lease and Sciulli, 2005; Macko et al., 1979; Merz et al., 1991; Moss and Chase, 1966; Moss et al., 1967; Richardson and Malhotra, 1975; Shaw, 1931; Vaughan and Harris, 1992). European and derived populations, conversely, have relatively smaller teeth (Lease, 2003; Harris, 2001). However, the merit of using overall tooth size to classify geographic populations has been called into question (Falk and Corruccini, 1982; Harris and Rathbun, 1989, 1991); there is general consensus that absolute tooth size is not the most reliable indicator of worldwide population relationships (Hanihara, 1977, 1979; Harris and Nweeia, 1980, Kirveskari, 1978, Moorrees, 1957; Scott and Turner, 1988). Attempts to find a more useful odontometric indicator with which to characterize geographic populations resulted in the formulation of shape analysis studies. Penrose (1954) recognized the fact that when classifying objects of any sort, it was usually the shape and morphology of the object that led to the classification not the size of the object, unless size difference was particularly extreme. Shape analyses, it was argued, result in relationship patterns that more closely correspond to the realities of the population histories in question (Perzigian, 1984; Scott and Turner, 1988). Penrose (1954) developed an odontometric analysis of shape that measures relative proportions between teeth, a type of odontometric analysis analogous to morphological analyses (Irish and Hemphill, 2004). This "Penrose shape analysis" was used in subsequent studies such as Perzigian (1984) who used shape analysis to compute the size and shape of the dentition in 42 human populations (fossil, recent, and living) from around the world. Dendrograms created using the resulting tooth shapes discriminated populations with a higher level of taxonomic accuracy than those created using overall tooth size (Perzigian, 1984; Scott and Turner, 1998).

Harris and Rathbun (1989, 1991) provided a new approach to shape analysis. Earlier studies, they argued, focused too heavily on individual teeth as the units of study. Though individual tooth measurements are very practical to perform, Harris and Rathbun (1991) questioned whether those measurements were actually the most biologically relevant variables available. Using principal components analysis on tooth crown diameters, Harris and Rathbun (1991) examined population relationships among human populations around the world. Their study indicated that the manner in which tooth mass is arranged among the morphogenetic fields is intrinsically different between populations (Harris and Rathbun, 1991). Lukacs and Hemphill (1993) used this type of analysis, known as tooth size apportionment analysis, to determine biological affinity of three populations in South Asia. Irish and Hemphill (2004) used this analysis to investigate the peopling of the Canary Islands and found that the pre-contact Canary Islanders exhibited the closest affinities with Northwest Africans, which supported earlier research based on both dental and non-dental elements (Irish and Hemphill, 2004).

While shape analysis may be the most accurate method of discerning geographical populations, for the purpose of this study overall tooth dimensions will be utilized to estimate European genetic admixture in the Newton skeletal population. Corruccini et al. (1982) found that admixture rates estimated from odontometric traits showed more agreement with genetic data of admixture than dental and cranial nonmetric traits. This was subsequently supported in another subsample from Newton by Ritter (1991).

The current study is an update to the previous admixture estimations made in the Newton population. The addition of the dental measurements of 49 additional individuals provides a larger Newton sample size with which to calculate admixture estimates. Furthermore, the inclusion of incisor measurements, previously excluded by Corruccini et al. (1982) due to preservation problems and cultural modification to the teeth, present an opportunity to more fully investigate admixture patterns in all tooth types.

This biodistance study in the enslaved African population at Newton adds to our knowledge of European genetic admixture in the enslaved populations on Barbados, specifically, and the Caribbean, in general. In addition, it increases our understanding of the lived experiences of enslaved populations and our knowledge of the African Diaspora.

CHAPTER 3

METHODS AND MATERIALS

This study utilizes most of the dental material recovered from Newton Plantation Cemetery. The commingled dental material recovered by Handler and Lange (1978) is curated at Southern Illinois University, Carbondale. Many of these teeth were measured for a study by Corruccini et al. (1982) and those existing measurements will be used in this study. However, incisor measurements were not taken during that study; these measurements were taken by the author in July, 2011. The dental material recovered by Shuler in 1997 and Pasquariello in 1998 is currently curated by Dr. Kristrina Shuler at facilities at Auburn University, Alabama. The author visited these facilities in June, 2011 to collect dental measurement data.

Comparative sample data include buccolingual (BL) and mesiodistal (MD) measurements for 19 sample populations utilized by Ritter (1991). Table 1 presents each comparative sample and the corresponding sample label used in statistical analyses. Samples include African and derived and European and derived populations. Two plantation samples, Clifts Plantation, Virginia, dated 1705-1730 (Aufderheide et al., 1981) and Rae's Hall Georgia, 1761 (Caldwell et al., 1941) are used to create a North American Colonial Euro-American sample population. The slave sample from Clifts Plantation, Virginia was also used and along with Catoctin Furnace, Maryland, dated 1790-1840 (Burnston, 1981; Kelley and Angel, 1983, 1987) makes up the North American comparative slave sample. Additional slave samples are from plantations in South

Table 1. Description of comparative samples used from Ritter (1991) with sample name used in current study in parentheses.

Collection Name (Study Sample Name)	Source
African-derived samples	
North American Slaves (NAmSlave)	
Clifts Plantation, Virginia	Ritter (1991)
Catoctin Furnace, Maryland	Ritter (1991)
West Indian Slaves (WISlave)	Ritter (1991)
19th Century African Americans (19thAfAm)	
Army Medical Museum	Ritter (1991)
Cedar Grove Cemetery, Arkansas (CGAfAm)	Ritter (1991)
20th Century African Americans (20thAfAm)	Ritter (1991)
Terry Collection	
US African Americans (USAfAm)	Henderson (1975)
South Carolina Slaves (SCSlaves)	Harris and Rathbun (1989)
American Negro (AmNe)	Moss et al. (1967)
Comparative European American Samples	
North American Colonial Euro-Americans (ColonialEuro)	
Clifts Plantation, Virginia	Ritter (1991)
Rae's Hall, Georgia	Ritter (1991)
19th Century European Americans (19thEuroAm)	
Army Medical Museum	Ritter (1991)
20th Century European Americans (20thEuroAm)	
Terry Collection	Henderson (1975); Ritter (1991)
American Whites (AmWhite)	Black (1902)
American Whites (AmWhite2)	Moss et al. (1967)
Comparative African Samples	
Sub-Saharan Africans (SubSahAf)	
Liberia, West Africa	Ritter (1991)
Cameroon, West Africa	Ritter (1991)
Gabon, West Africa	Ritter (1991)
Kenya, East Africa	Ritter (1991)
Protohistoric Sanga, Congo (Sanga)	Brabant (1963, 1965)
Hutu, Rwanda (Hutu)	Brabant (1963)
Mum, Cameroon (Mum)	Abel (1933)
Bantu, Cameroon (Bantu)	Abel (1933)
Comparative European Samples	
17th-19th century English (17-19Eng)	
British Museum of Natural History	Goose (1963)
Duckworth Laboratory at Cambridge	Goose (1963)
European White (EuroWhite)	Brabant and Twiesselmann (1964); Brabant (1965)

Carolina and the West Indies. The measurements of the West Indian Slave sample are the means of the Newton Plantation dental material recorded by Corruccini et al. (1982). It is used in this study primarily to compare the means from the current, larger sample of Newton measurements to the previously reported means.

Comparative samples also include 19^{th} and 20^{th} century African American and European American populations including the Terry Collection, Cedar Grove Cemetery (Rose and Santeford, 1985), Army Medical Museum, and others recorded in the late 1800s to mid-1900s. So that the African- and European-derived samples can be compared to parental populations, five African samples (Sub-Saharan, Protohistoric Sanga, Hutu, Mum, and Bantu) and two European samples (17^{th}-19^{th} century English and European Whites) are also used in the admixture estimations.

Maximum buccolingual and mesiodistal measurements were recorded using Mitutoyo sliding calipers calibrated to .01 mm and a data cord to transmit the measurements to an Excel spreadsheet. Measurements were made using conventional methods as described by Corruccini et al. (1982) where length is measured in the mesiodistal axis as the maximum between mesial and distal contact facets in normal occlusion and the breadth is the maximum in the perpendicular (i.e., buccolingual) axis. Each tooth was identified and recorded and each measurement (MD and BL) was taken twice. The average of those two measurements was then used in the analysis. Some interobserver error is expected since the maximum diameters on the dental material recovered by Handler and Lange (1978) were measured by R.J. Mutaw in the osteological study by Corruccini et al. (1982). However, this error is likely greater in the MD measurements than in the BL measurements as it has been shown that MD measurements are more susceptible to interobserver error than BL measurements (Kieser et al., 1990).

Ideally, in this type of study, sexes would be analyzed separately. Due to the largely disarticulated and commingled nature of the collection, this was not possible. Deciduous dentition was also omitted from the current study as their small sizes and low numbers in the sample would not serve the statistical analyses well.

In this study, all measurements on disarticulated teeth are from the left side dentition. When teeth were articulated, the left side was used when present and in good condition; when the left was not available, the antimere was used. It is noted that the Newton dental sample is from an enslaved population and that this population was under a great deal of physiological stress (Corruccini et al., 1982; Shuler, 2005). Populations under stress can exhibit increased fluctuating asymmetry in the dentition, that is, a side difference in dimensions between left and right antimeres with no side preference (Scott and Turner, 1997). However, Corruccini et al. (1982) found no remarkable levels of fluctuating asymmetry in the Newton dental sample, and that sample is included with the newer Newton dental measurements in the current study. The measurements from the Newton sample used in this study (for individual teeth N=859) approximately 66.5% of the teeth used were from the left side (N=571). Teeth with carious lesions or attrition that obscured either the MD or the BL maximum diameters were not included in the study. Some individuals from the Newton Cemetery exhibit cultural dental modification such as pipe wear or dental mutilation such as filing (Corruccini et al., 1982; Handler and Lange, 1978; Handler et al., 1982). These teeth were also excluded from the current study.

Using all available odontometric data from the Newton population, mean size was calculated for each tooth type and location (e.g., I^1, I_1, C^1, C_1, etc.) and then plotted with the means of the corresponding teeth from the 19 comparative skeletal samples. All measurements from these samples were collected from Ritter (1991). All of the means utilized by Ritter (1991) and in this study were calculated based on tooth measurements performed by a number of different individuals; this again introduces the possibility of interobserver error. Mean size of each tooth type and location were also plotted along with the individual Newton dental measurements of that tooth type and location to examine the range of variation present in the Newton dentition.

The mean sizes of each tooth type and location were then plotted in line graphs to highlight the location of Newton odontometric means relative to other African, African-descended, European, and European descended groups. Additionally, the mean sizes were used to perform a principal components analysis (PCA). Principal components analysis is a statistical technique applied to a group of variables in order to discover relatively independent subgroups. This can highlight patterns of intercorrelation or underlying relationships among the variables and also serves to reduce a large number of variables into a smaller number of potentially meaningful clusters (Tabachnick and Fidell, 1983). Principal components scores can also suggest the source(s) of the range of variation exhibited in a group of variables (Tabachnick and Fidell, 1983).

Mean mesiodistal and buccolingual crown dimensions from the populations were compared in order to estimate European genetic admixture in the African-descended populations of Newton and the African American individuals in the Terry Collection. The following method (after Corruccini et al., 1982:452) was used to estimate the percent of admixture:

$$X_1 - X_3 = a \qquad X_1 - X_2 = b \qquad (b/a) \times 100 = \text{percent admixture}$$

Where: X_1 represents the parental African population

X_2 represents the population in question (e.g., Newton)

X_3 represents the parental European population

The Newton sample is thus expected to be intermediate between the African and the European samples, and likely closer to the former.

It is hypothesized that there is relatively little European genetic admixture in the enslaved African cemetery population from Newton Plantation. This is based on the two primary factors: first, the rate of European admixture detected in DNA studies on 20th century Barbadians was approximately 10% (Benn-Torres et al., 2008) and it would be reasonable to assume that European cumulative admixture was much less during the period of slavery in Barbados than it is in a modern-day population. Second is the fact that the historic African and African-descended population of Barbados ranged from approximately 50% of the total population in the 1670s to over 80% in the early 1800s (Handler and Lange, 1978). Based on these circumstances, it seems unlikely that there would have been a great deal of European admixture in the Newton slave population if for no other reason than because there were simply much fewer Europeans to contribute genetic information. This is supported by Higman (1984) who found extremely high mortality rates and low fertility in the enslaved populations on Caribbean sugar plantations reported archivally. Still, historic documents from Newton Plantation indicate that there was admixture in the enslaved African population. In the late 18th century, 10.1% of the slaves at Newton were listed as “Colored/Mulatto” (as opposed to “Black”) and this percentage ranged from 15.1-15.4% in the early 19th century (Corruccini et al., 1982; Handler and Lange, 1978).

The slave cemetery at Newton Plantation, Barbados, offers a unique opportunity to investigate biodistance in enslaved Africans and their descendants in the New World. Specifically, this study addresses two areas in which there have been relatively few studies, enslaved Africans on the island of Barbados, for one, and secondly, the study of European genetic admixture within an enslaved population. Not only will this examination add to the growing body of work on the African Diaspora and biodistance in general, but it also will serve to help illuminate the experience of enslaved Africans in the Caribbean.

CHAPTER 4

RESULTS

Mean Dimension Plotting

The mean BL and MD measurements of each tooth type from the Newton collection were plotted with the mean measurements of each tooth type from all the comparative samples from Ritter (1991). The individual tooth measurements of each tooth type from the Newton sample were then plotted with the means of Newton and the comparative samples in order to observe the range of variation seen in the Newton dentition. Not all tooth types were available for each of the utilized samples. Though posterior dental measurements were available for all groups, anterior tooth measurements were only available for nine of the twenty-two samples. Even when anterior measurements were available, generally speaking, only I^1/I_1 and/or C^1/C_1 were present. The only measurements for I^2/I_2 were those taken by the author; thus, data for I^2/I_2 were omitted from this analysis.

Note that not all graphs will be discussed in this section. The graphs of the teeth discussed here exhibit the most distinct differentiation between African and European groups and/or best illustrate Newton's expected intermediate position between the two and closer to African groups. See Appendix A for graphs of each tooth type.

Upper I1

Mean measurements of I^1 are shown in Figure 1. The mean MD measurements of the African-descended groups are larger than the European-descended group, and Newton is the largest of the African-descended populations with a mean diameter of 9.10 mm. The mean BL measurements show a similar pattern as far as the measurements of the African-descended populations being larger overall than the one European-descended group represented. In this case, however, the Newton mean (7.40 mm) is slightly smaller than the modern African-descended population (7.46 mm).

In Figure 2, the MD and BL measurements of the individual Newton teeth are added to the mean measurements of the comparative samples (and Newton). When the individual tooth measurements from Newton are added to the graph, it is clear that the range of both MD and BL measurements observed in the Newton population is large enough to include the means of each of the comparative samples.

Upper C1

Figure 3 shows the plotted mean measurements of C^1. US African Americans and 20^{th} century Euro-Americans are similar in mean MD dimensions. However, the European and African groups still separate along MD mean measurements. The Newton MD dimension (8.06 mm) is larger than all other mean MD dimensions, including Sub-Saharan Africans (7.84 mm). The mean BL diameters also separate the European and descended groups from the African and descended groups with Newton mean BL diameter (8.60 mm) falling between the Sub-Saharan Africans and European-derived groups. Figure 4 illustrates that the range of dimensions of the Newton individuals contains all of the mean dimensions for all other samples.

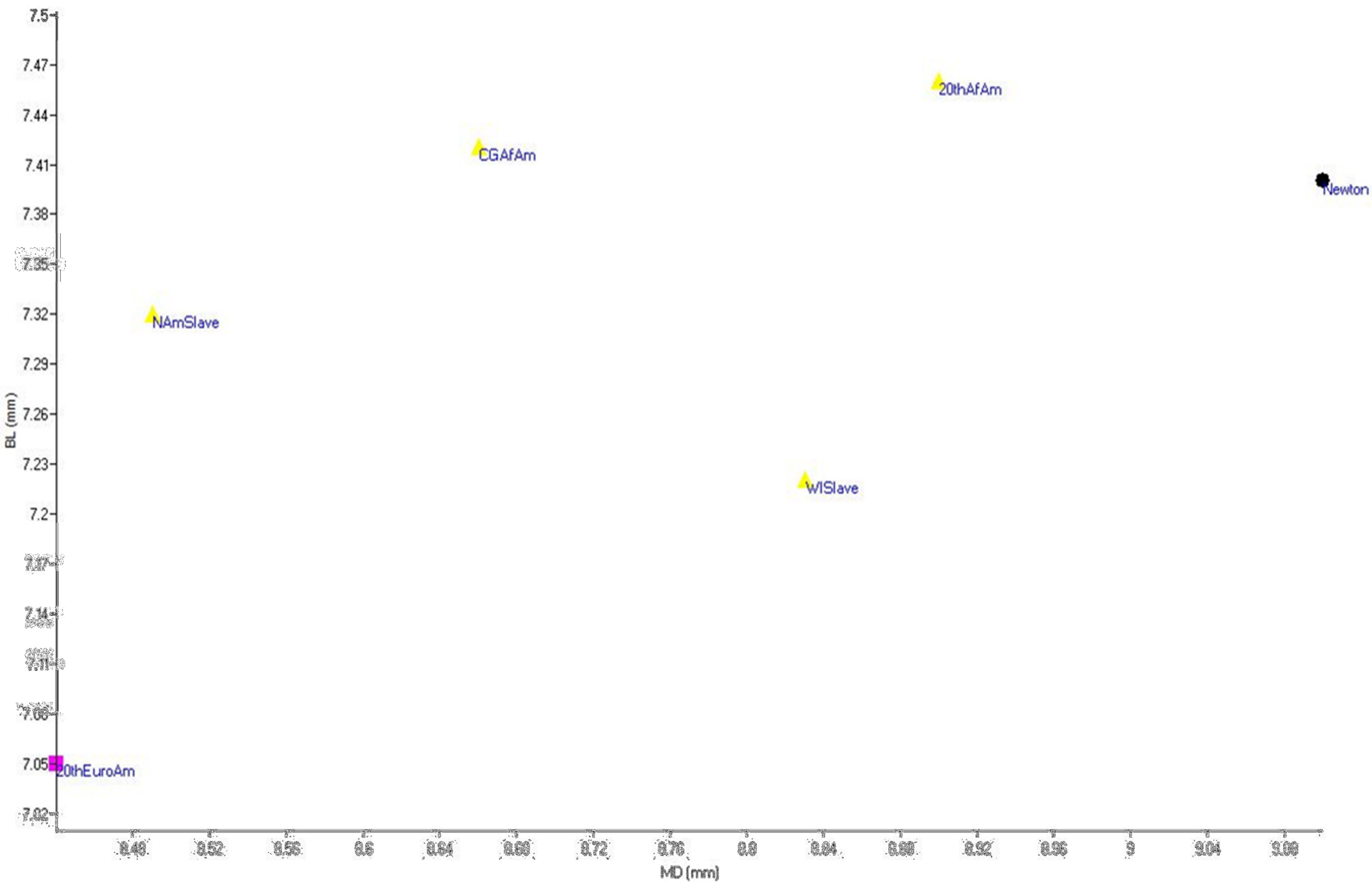

Figure 1. Mean mesiodistal (MD) and buccolingual (BL) diameters of I^1.

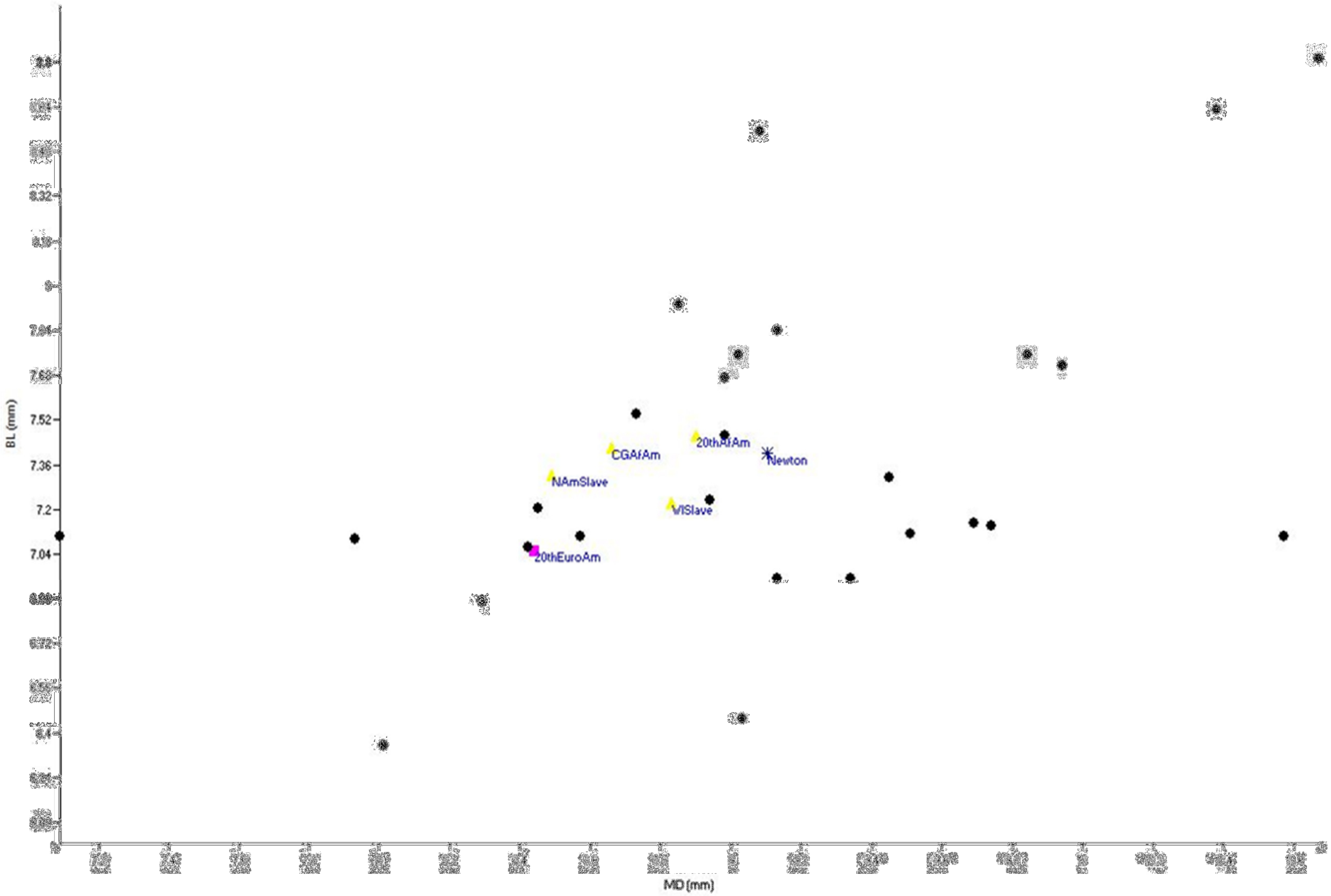

Figure 2. Mean mesiodistal (MD) and buccolingual (BL) diameters of I[1] with individual measurements from the Newton sample.

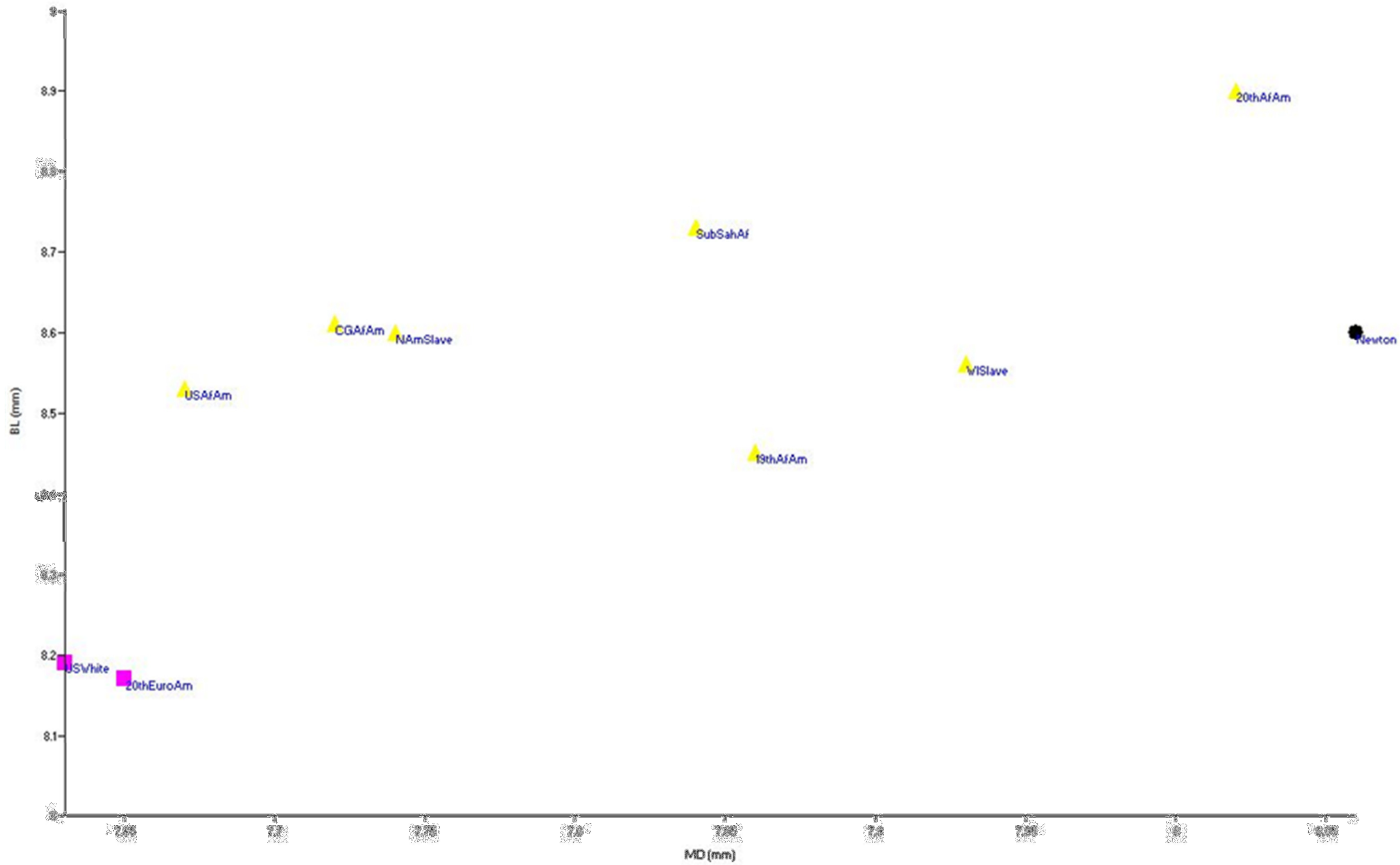

Figure 3. Mean mesiodistal (MD) and buccolingual (BL) diameters of C^1.

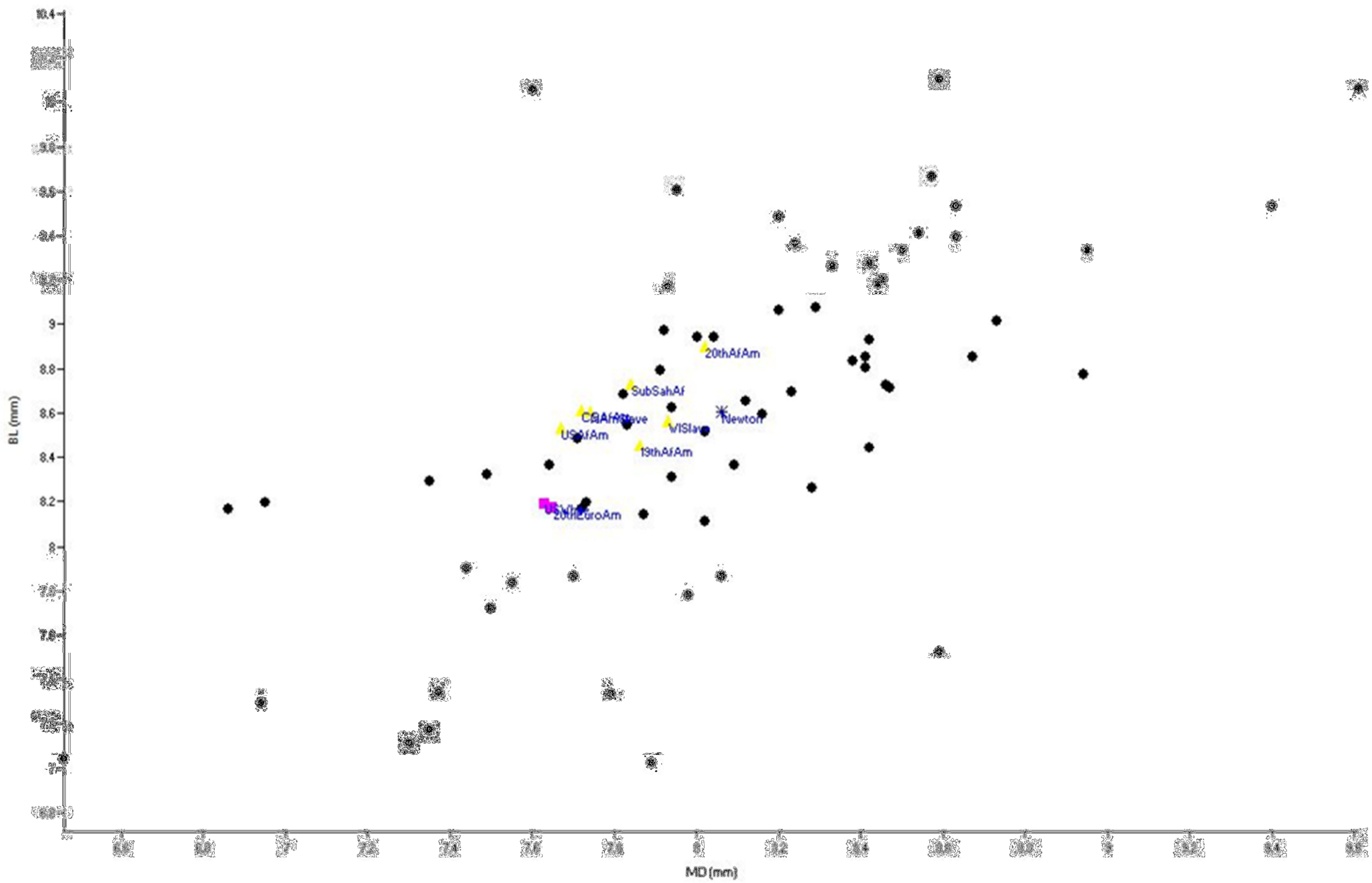

Figure 4. Mean mesiodistal (MD) and buccolingual (BL) diameters of C[1] with individual measurements from the Newton sample.

<u>Upper M2</u>

M^2 mean dimensions are shown in Figure 5. Mean MD diameters generally separate into two groups, African and European, though there is a slight overlap. The Newton mean MD diameter, 10.09 mm, is similar in size to that of the Sub-Saharan African group which has a mean MD diameter of 10.08 mm; Newton is larger than all European-derived groups except for American Whites 2, which has a diameter of 10.40 mm.

Mean BL dimensions also split European and African samples into two groups, with the exception of the South Carolina Slave population. Newton (11.83 mm) falls between Sub-Saharan Africans (12.03 mm) and the European populations; the largest mean diameter in the European samples is 11.50 mm. When Newton individual measurements are added to the mean diameters (Figure 6) all mean diameters fall into the range of Newton measurements.

<u>Lower C1</u>

Figures 7 and 8 show C_1 mean measurements with and without the Newton individual measurements. Newton means are the largest for MD measurements while Colonial Euro-Americans are the smallest. Though 19th century Euro-Americans and US African Americans are very close in size, overall there is no overlap in the mean measurements for European and descended groups and African and descended groups. The mean BL measurements show the same separation of European and descended populations from African and descended populations. However, the Newton mean measurement is smaller than that of the 19th and 20th century African Americans. Again, the Newton individual measurements show that the range of tooth size within the Newton population includes measurements larger and smaller than the mean measurements of each population.

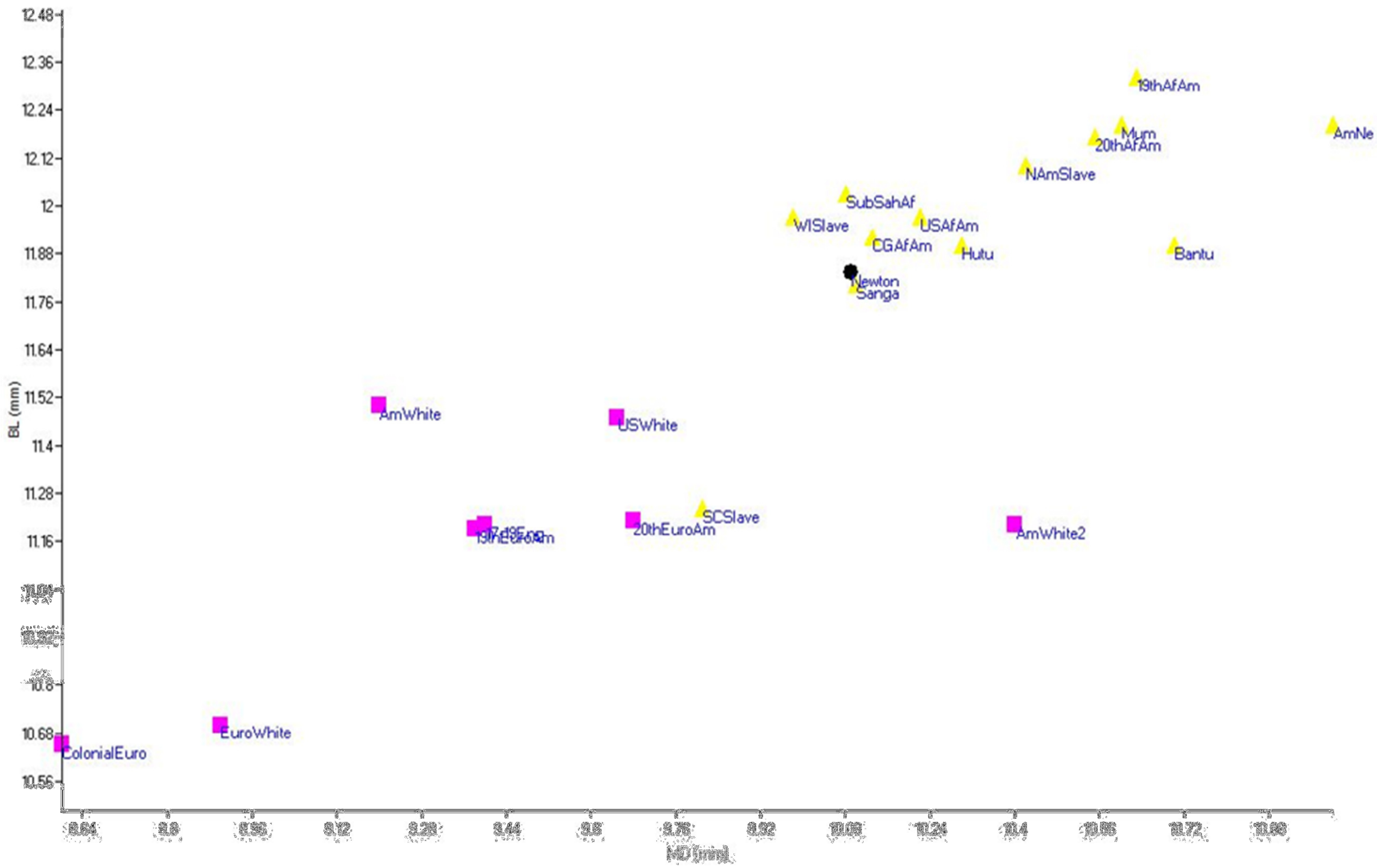

Figure 5. Mean mesiodistal (MD) and buccolingual (BL) diameters of M^2.

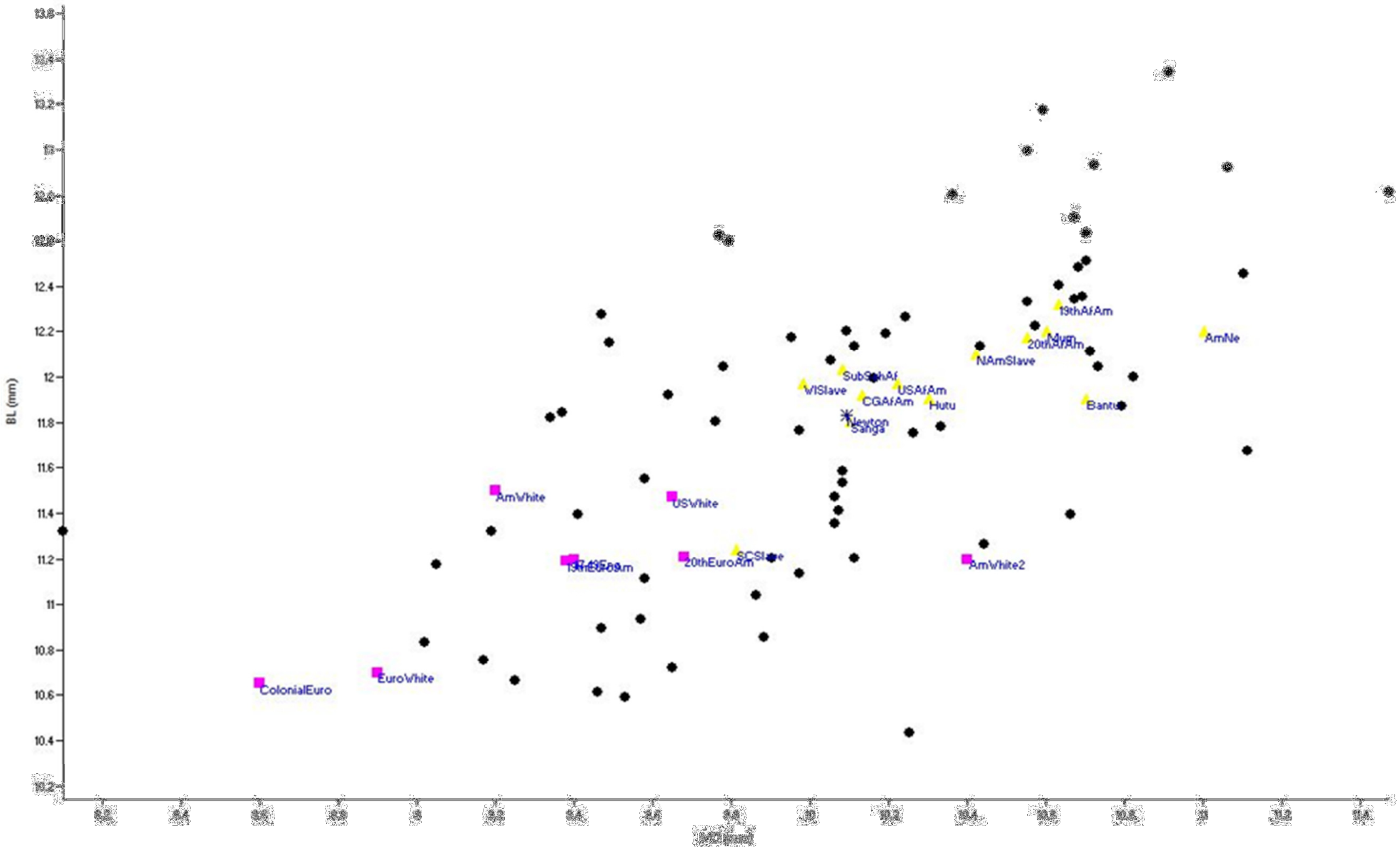

Figure 6. Mean mesiodistal (MD) and buccolingual (BL) diameters of M^2 with individual measurements from the Newton sample.

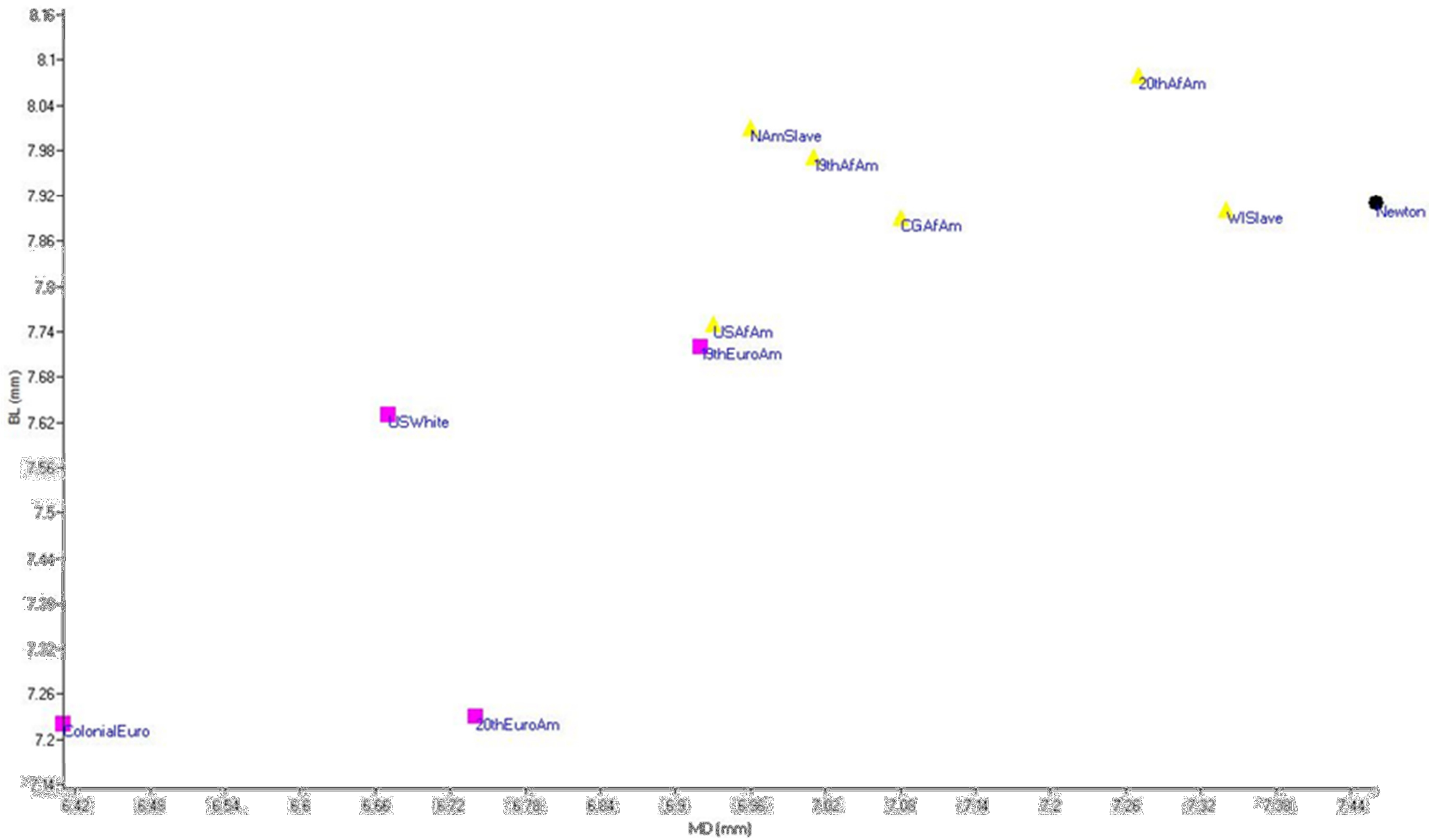

Figure 7. Mean mesiodistal (MD) and buccolingual (BL) diameters of C_1.

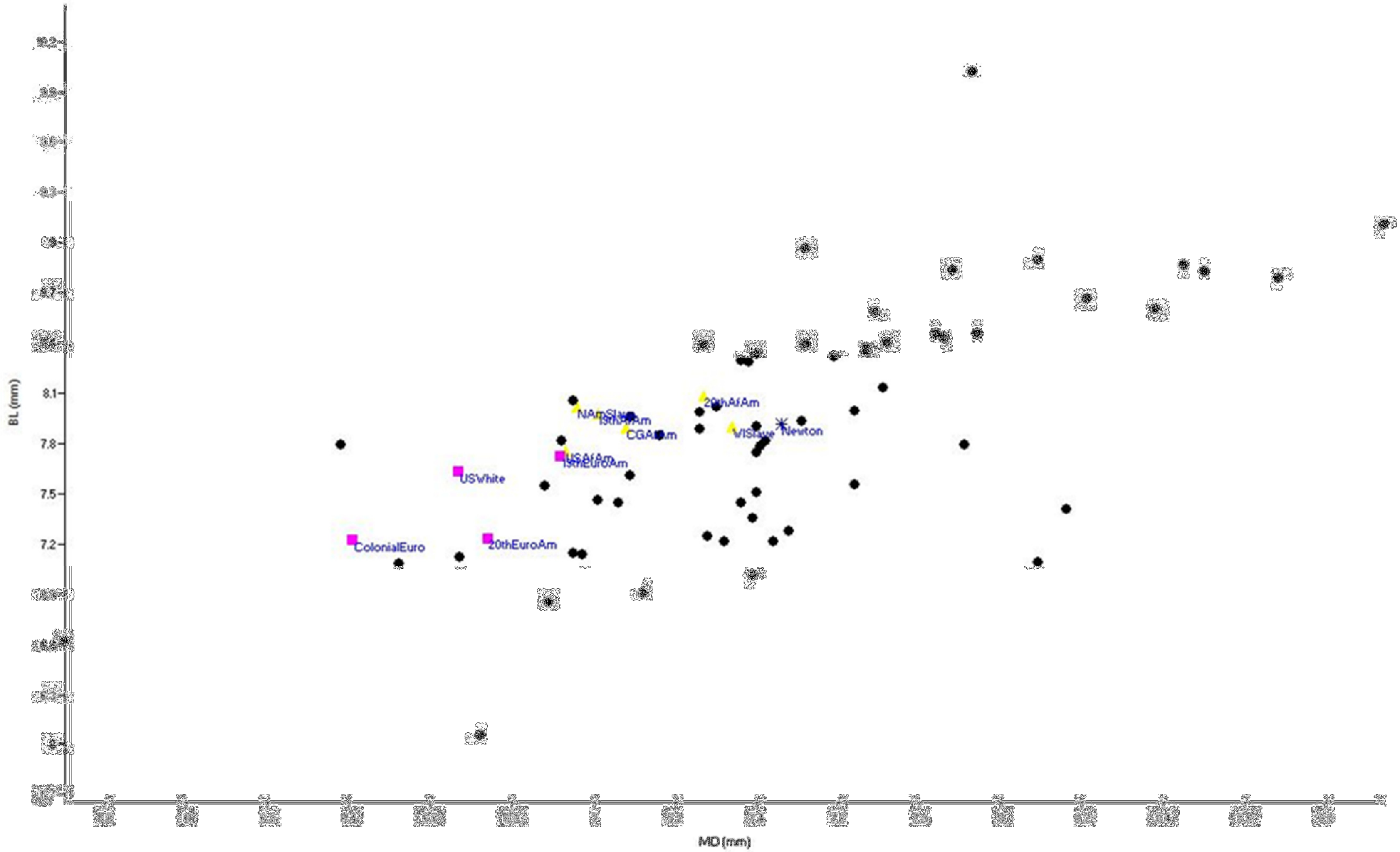

Figure 8. Mean mesiodistal (MD) and buccolingual (BL) diameters of C_1 with individual measurements from the Newton sample.

Lower M1

Figure 9 shows the mean MD and BL diameters of M_1. The African American mean MD diameter from Cedar Grove (11.25 mm) is similar in size to those of 19th century Euro-Americans (11.23 mm). Generally, the European and African groups separate into two groups along mean MD diameters, though American Whites 2 seems to have an exceptionally large mean MD diameter compared to all of the other European and derived groups and even compared to many of the African and derived populations. In mean BL diameters (Figure 10), the same separation is seen somewhat, though there is some overlap between the groups with the mean measurement of South Carolina Slaves grouping with the European and derived groups and American Whites 2 grouping with the African and derived groups.

Admixture Estimation

Table 2 provides admixture estimates for Newton based on mean crown dimensions. This was accomplished using Sub-Saharan Africans as one parental population and North American Colonial Euro-Americans, 17th-19th century English, and 20th century Euro-Americans as the second parental population, respectively. The earlier European and derived groups were selected as parental populations in order to compare the Newton population to European groups from the same general time period. A third estimation was included using 20th century Euro-Americans as the European parental population. Even though this population was clearly not contemporaneous with Newton Plantation, this was included for comparison with the two other estimations.

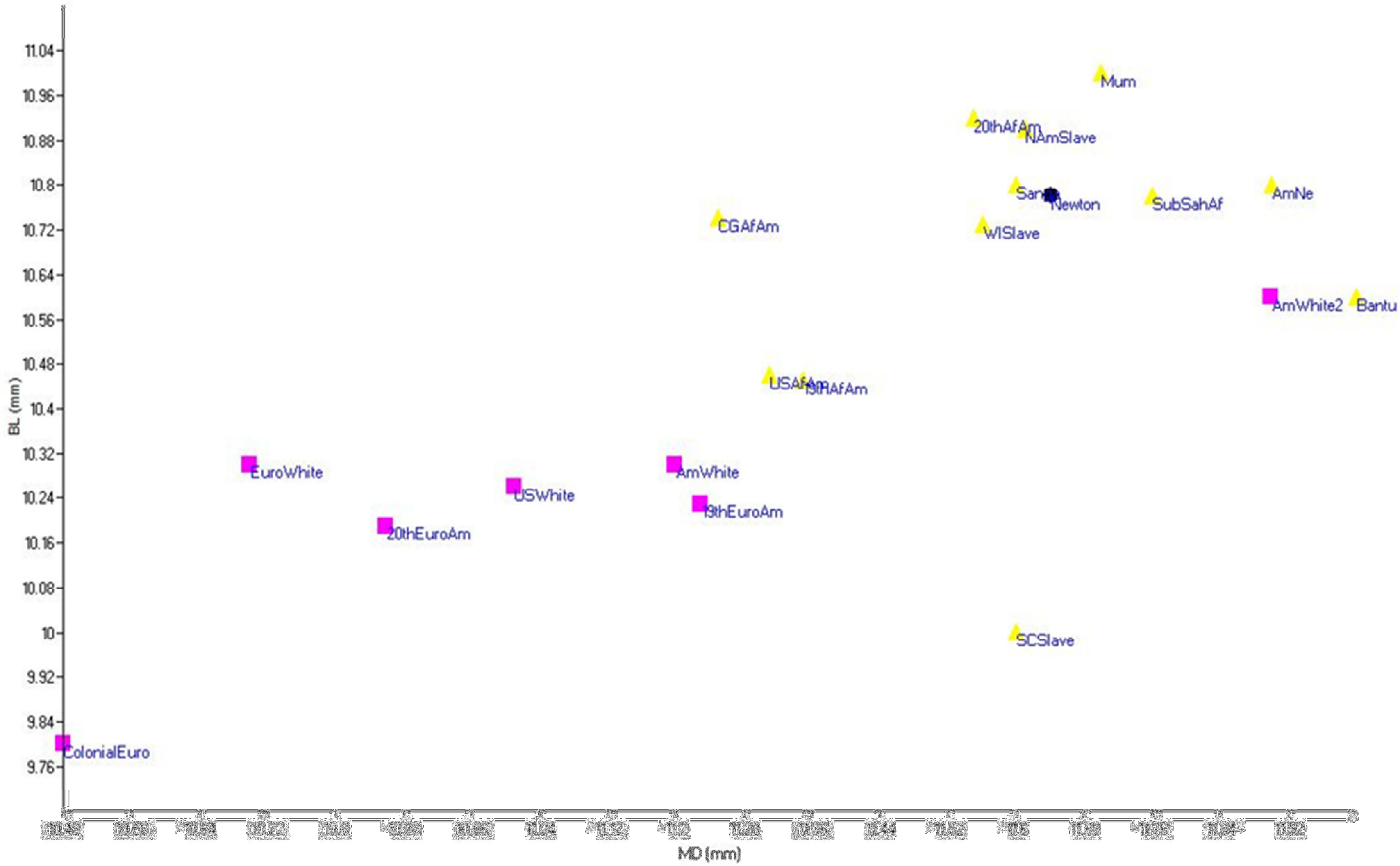

Figure 9. Mean mesiodistal (MD) and buccolingual (BL) diameters of M_1.

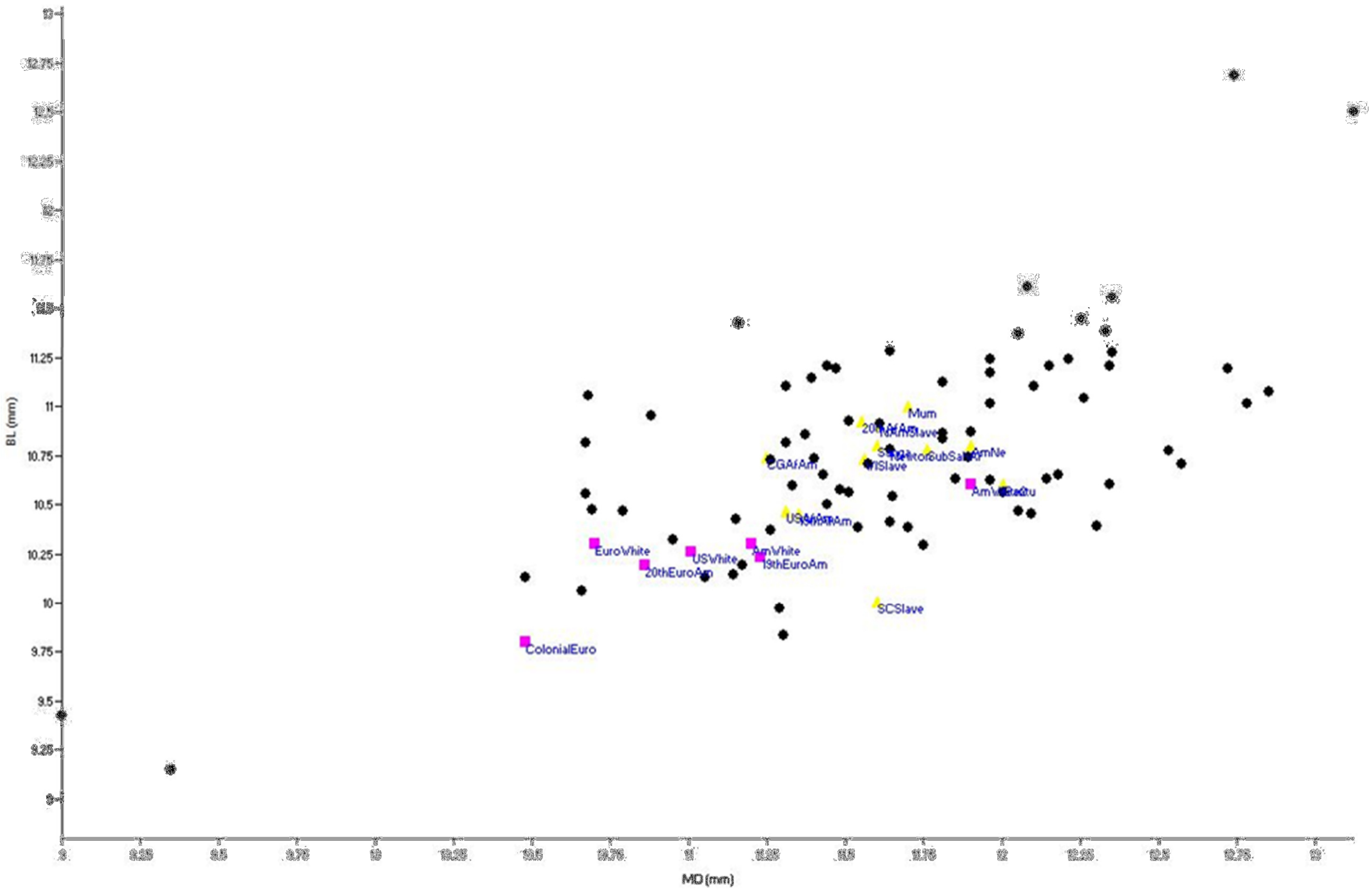

Figure 10. Mean mesiodistal (MD) and buccolingual (BL) diameters of M_1 with individual measurements from the Newton sample.

Table 2. Admixture estimates for Newton population based on mean tooth crown dimensions. The average counts admixture as zero (shown here as 0+) when X_2 is greater than X_1 or smaller than X_3.

Tooth Measurement			SubSahAf (X_1)	Newton (X_2)	ColonialEuro (X_3)	Admixture
Upper	I1	MD	--	9.10	8.43	--
		BL	7.10	7.40	7.01	0+
	C1	MD	7.84	8.06	7.52	0+
		BL	8.73	8.60	8.38	0.37
	P3	MD	7.29	7.48	6.48	0+
		BL	9.70	9.79	8.84	0+
	P4	MD	6.97	7.09	6.26	0+
		BL	10.38	9.64	8.68	0.44
	M1	MD	10.63	10.75	10.02	0+
		BL	11.61	11.69	11.04	0+
	M2	MD	10.08	10.09	8.60	0+
		BL	12.03	11.83	10.65	0.14
Lower	I1	MD	--	5.54	5.14	--
		BL	--	5.80	5.71	--
	C1	MD	5.79	7.46	6.41	0+
		BL	7.60	7.91	7.22	0+
	P3	MD	7.37	7.49	6.56	0+
		BL	8.29	8.44	7.23	0+
	P4	MD	7.17	7.62	6.57	0+
		BL	8.34	8.62	7.60	0+
	M1	MD	11.76	11.64	10.48	0.09
		BL	10.78	10.78	9.80	0
	M2	MD	10.85	11.22	10.02	0+
		BL	10.69	10.58	9.53	0.09
					Average	0.0538
					Adjusted average	0.188

Table 2. Admixture estimates for Newton population based on mean tooth crown dimensions. The average counts admixture as zero (shown here as 0+) when X_2 is greater than X_1 or smaller than X_3.

Tooth Measurement			SubSahAf (X_1)	Newton (X_2)	17-19Eng (X_3)	Admixture
Upper	I1	MD	--	9.10	--	--
		BL	7.10	7.40	--	--
	C1	MD	7.84	8.06	--	--
		BL	8.73	8.60	--	--
	P3	MD	7.29	7.48	6.50	0+
		BL	9.70	9.79	8.70	0+
	P4	MD	6.97	7.09	6.40	0+
		BL	10.38	9.64	9.10	0.58
	M1	MD	10.63	10.75	10.40	0+
		BL	11.61	11.69	11.20	0+
	M2	MD	10.08	10.09	9.40	0+
		BL	12.03	11.83	11.20	0.24
Lower	I1	MD	--	5.54	--	--
		BL	--	5.80	--	--
	C1	MD	5.79	7.46	--	--
		BL	7.60	7.91	--	--
	P3	MD	7.37	7.49	--	--
		BL	8.29	8.44	--	--
	P4	MD	7.17	7.62	--	--
		BL	8.34	8.62	--	--
	M1	MD	11.76	11.64	--	--
		BL	10.78	10.78	--	--
	M2	MD	10.85	11.22	--	--
		BL	10.69	10.58	--	--
					Average	0.1025
					Adjusted average	0.41

Table 2. Admixture estimates for Newton population based on mean tooth crown dimensions. The average counts admixture as zero (shown here as 0+) when X_2 is greater than X_1 or smaller than X_3.

Tooth Measurement			SubSahAf (X_1)	Newton (X_2)	20thEuroAm (X_3)	Admixture
Upper	I1	MD	--	9.10	8.44	--
		BL	7.10	7.40	7.05	0+
	C1	MD	7.84	8.06	7.65	0+
		BL	8.73	8.60	8.17	0.23
	P3	MD	7.29	7.48	6.75	0+
		BL	9.70	9.79	9.00	0+
	P4	MD	6.97	7.09	6.52	0+
		BL	10.38	9.64	9.06	0.56
	M1	MD	10.63	10.75	10.53	0+
		BL	11.61	11.69	11.18	0+
	M2	MD	10.08	10.09	9.68	0+
		BL	12.03	11.83	11.21	0.24
Lower	I1	MD	--	5.54	5.25	--
		BL	--	5.80	5.83	--
	C1	MD	5.79	7.46	6.74	0+
		BL	7.60	7.91	7.23	0+
	P3	MD	7.37	7.49	6.81	0+
		BL	8.29	8.44	7.57	0+
	P4	MD	7.17	7.62	6.83	0+
		BL	8.34	8.62	8.13	0+
	M1	MD	11.76	11.64	10.86	0.13
		BL	10.78	10.78	10.19	0
	M2	MD	10.85	11.22	10.64	0+
		BL	10.69	10.58	9.97	0.15
					Average	0.0624
					Adjusted average	0.218

Table 3 contains admixture estimates calculated for the African Americans from the Terry collection housed at the National Museum of Natural History. The same parental populations were used for this estimation as were used for the Newton estimates. This was included in order to compare the amount of European genetic admixture in the Newton Plantation population with the amount in a modern African American population. Because the Terry collection largely represents African Americans from a contemporary urban area (St. Louis, Missouri), the European genetic admixture in this population is estimated at approximately 20%.

Again, admixture estimates for each tooth were found using the following method (after Corruccini et al., 1982:452):

$$X_1 - X_3 = a \qquad X_1 - X_2 = b \qquad (b/a) \times 100 = \text{percent admixture}$$

Where: X_1 represents the parental African population

X_2 represents the population in question (e.g., Newton)

X_3 represents the parental European population

When the mean crown diameters for Newton are intermediate between the mean dimensions of the parental populations, an admixture estimate from 1%-99% is obtained. However, if the mean diameters of Newton are larger or smaller than the means of both the parental populations, the resulting admixture estimates are either 0% or 100%. Using this formula, admixture estimates were made for each individual tooth, then averaged together to arrive at an estimation of overall admixture.

The average admixture estimate for the Newton population using Colonial Euro-Americans to represent the Euro-American parental population is 5.4%, 10.3% using 17^{th}-19^{th} century English, and 6.2% with modern Euro-Americans. In comparison, admixture estimates

Table 3. Admixture estimates for Terry collection African American population based on mean tooth crown dimensions. The average counts admixture as zero (shown here as 0+) when X_2 is greater than X_1 or smaller than X_3.

Tooth Measurement			SubSahAf (X_1)	TerryAfAm (X_2)	ColonialEuro (X_3)	Admixture
Upper	I1	MD	--	--	8.43	--
		BL	7.10	--	7.01	--
	C1	MD	7.84	7.67	7.52	0.53
		BL	8.73	8.53	8.38	0.57
	P3	MD	7.29	7.29	6.48	0
		BL	9.70	9.64	8.84	0.07
	P4	MD	6.97	6.85	6.26	0.17
		BL	10.38	9.71	8.68	0.39
	M1	MD	10.63	10.41	10.02	0.36
		BL	11.61	11.42	11.04	0.33
	M2	MD	10.08	10.22	8.60	0+
		BL	12.03	11.97	10.65	0.04
Lower	I1	MD	--	--	5.14	--
		BL	--	--	5.71	--
	C1	MD	5.79	6.93	6.41	0+
		BL	7.60	7.75	7.22	0+
	P3	MD	7.37	7.36	6.56	0.01
		BL	8.29	8.24	7.23	0.05
	P4	MD	7.17	7.46	6.57	0+
		BL	8.34	8.55	7.60	0+
	M1	MD	11.76	11.31	10.48	0.35
		BL	10.78	10.46	9.80	0.33
	M2	MD	10.85	11.24	10.02	0+
		BL	10.69	10.59	9.53	0.09
					Average	0.1645
					Adjusted average	0.235

Table 3. Admixture estimates for Terry collection African American population based on mean tooth crown dimensions. The average counts admixture as zero (shown here as 0+) when X_2 is greater than X_1 or smaller than X_3.

Tooth Measurement			SubSahAf (X_1)	TerryAfAm (X_2)	17-19Eng (X_3)	Admixture
Upper	I1	MD	--	--	--	--
		BL	7.10	--	--	--
	C1	MD	7.84	7.67	--	--
		BL	8.73	8.53	--	--
	P3	MD	7.29	7.29	6.50	0
		BL	9.70	9.64	8.70	0.06
	P4	MD	6.97	6.85	6.40	0.21
		BL	10.38	9.71	9.10	0.52
	M1	MD	10.63	10.41	10.40	0.96
		BL	11.61	11.42	11.20	0.46
	M2	MD	10.08	10.22	9.40	0+
		BL	12.03	11.97	11.20	0.07
Lower	I1	MD	--	--	--	--
		BL	--	--	--	--
	C1	MD	5.79	6.93	--	--
		BL	7.60	7.75	--	--
	P3	MD	7.37	7.36	--	--
		BL	8.29	8.24	--	--
	P4	MD	7.17	7.46	--	--
		BL	8.34	8.55	--	--
	M1	MD	11.76	11.31	--	--
		BL	10.78	10.46	--	--
	M2	MD	10.85	11.24	--	--
		BL	10.69	10.59	--	--
					Average	0.285
					Adjusted average	0.326

Table 3. Admixture estimates for Terry collection African American population based on mean tooth crown dimensions. The average counts admixture as zero (shown here as 0+) when X_2 is greater X_1 or smaller than X_3.

Tooth Measurement			SubSahAf (X_1)	TerryAfAm (X_2)	20thEuroAm (X_3)	Admixture
Upper	I1	MD	--	--	8.44	--
		BL	7.10	--	7.05	--
	C1	MD	7.84	7.67	7.65	0.89
		BL	8.73	8.53	8.17	0.36
	P3	MD	7.29	7.29	6.75	0
		BL	9.70	9.64	9.00	0.09
	P4	MD	6.97	6.85	6.52	0.27
		BL	10.38	9.71	9.06	0.51
	M1	MD	10.63	10.41	10.53	0+
		BL	11.61	11.42	11.18	0.44
	M2	MD	10.08	10.22	9.68	0+
		BL	12.03	11.97	11.21	0.07
Lower	I1	MD	--	--	5.25	--
		BL	--	--	5.83	--
	C1	MD	5.79	6.93	6.74	0+
		BL	7.60	7.75	7.23	0+
	P3	MD	7.37	7.36	6.81	0.02
		BL	8.29	8.24	7.57	0.07
	P4	MD	7.17	7.46	6.83	0+
		BL	8.34	8.55	8.13	0+
	M1	MD	11.76	11.31	10.86	0.50
		BL	10.78	10.46	10.19	0.54
	M2	MD	10.85	11.24	10.64	0+
		BL	10.69	10.59	9.97	0.14
					Average	0.195
					Adjusted average	0.3

for the Terry collection African Americans are 16.5% using Colonial Euro-Americans, 28.5% with 17-19th century English, and 19.5% using 20th century Euro-Americans.

Line Graphs

Line graphs for each mean diameter were created for both upper and lower teeth, C1-M2. The location of the Newton measurement was then compared to the measurements all of the samples, with special respect paid to the Newton measurements relative to those of the Sub-Saharan African and Colonial Euro-American samples. Figures 11 and 12 show the mean measurements of the upper teeth. For MD measurements (Figure 11), the Newton mean diameters grouped with the other African and derived samples with larger mean diameters. The North American Colonial Euro-American mean diameters were smaller than every other population sample in almost every tooth type. European and derived populations generally grouped with each other. For the BL mean measurements, the Newton mean measurements again grouped with African and derived mean BL measurements. Sub-Saharan means were larger than Newton means in each tooth type, and North American Colonial Euro-Americans were again among the smallest means.

Figures 13 and 14 show the mean diameters for the lower dentition. Newton MD means (Figure 13) fall into the group of African and descended samples and once more, Colonial Euro-American means were smaller than every other sample mean for almost all of the teeth. With respect to BL mean measurements (Figure 14), North American Colonial Euro-American measurements were smaller than every other population for every tooth type. Again, Newton mean measurements group with the African and derived populations.

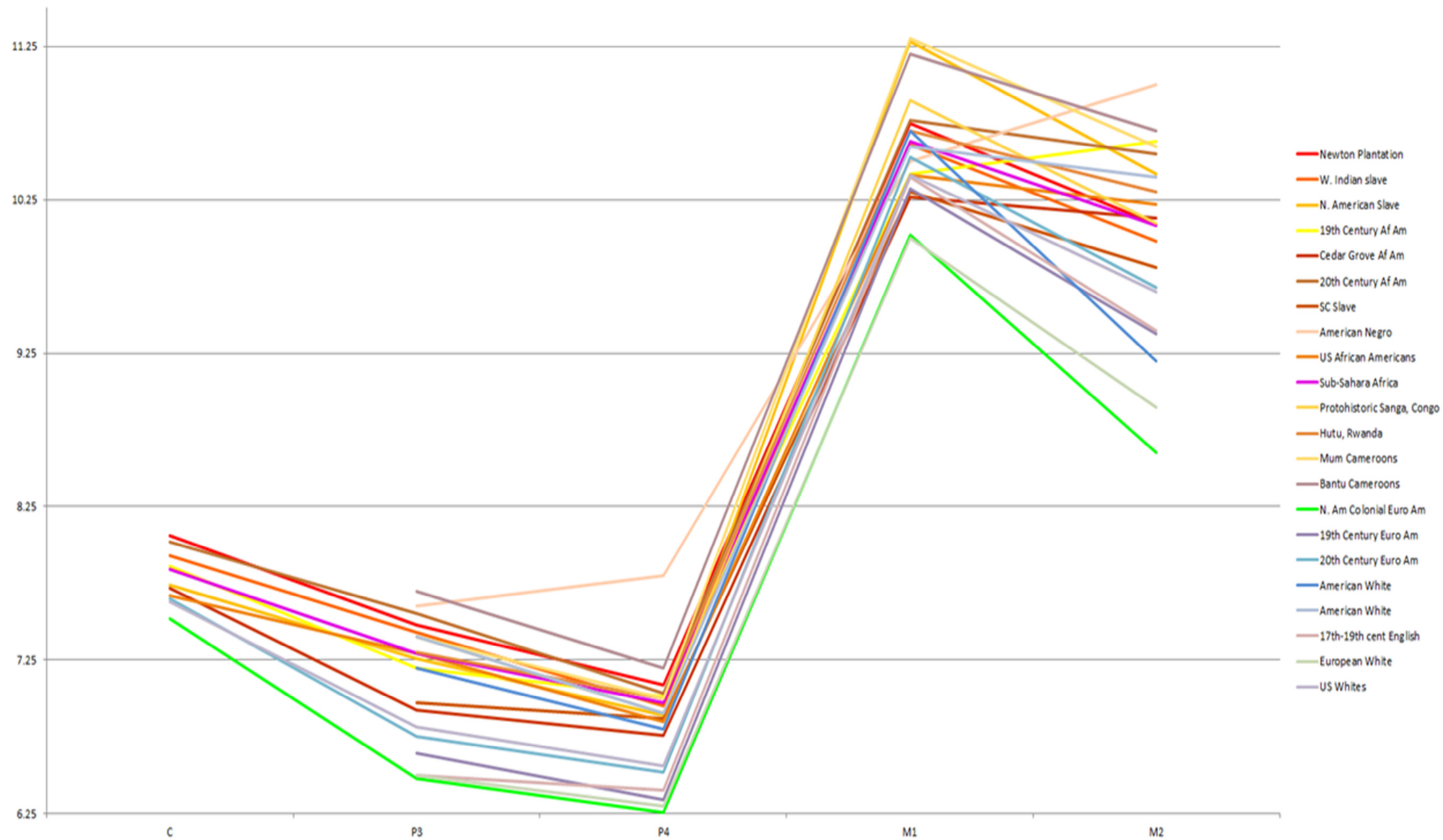

Figure 11. Line graph of mean mesiodistal (MD) diameters of each population for teeth C^1-M^2.

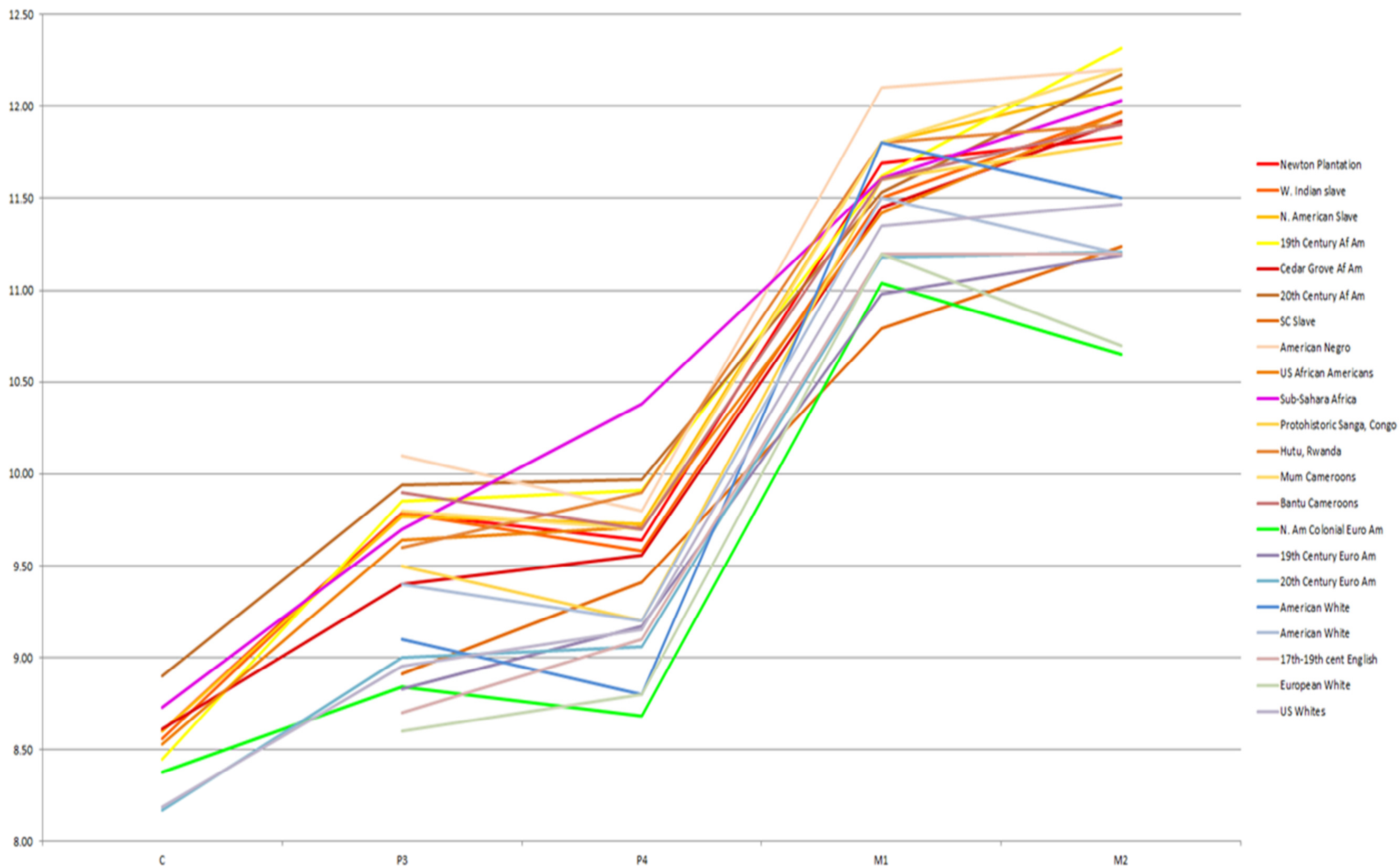

Figure 12. Line graph of mean buccolingual (BL) diameters of each population for teeth C^1-M^2.

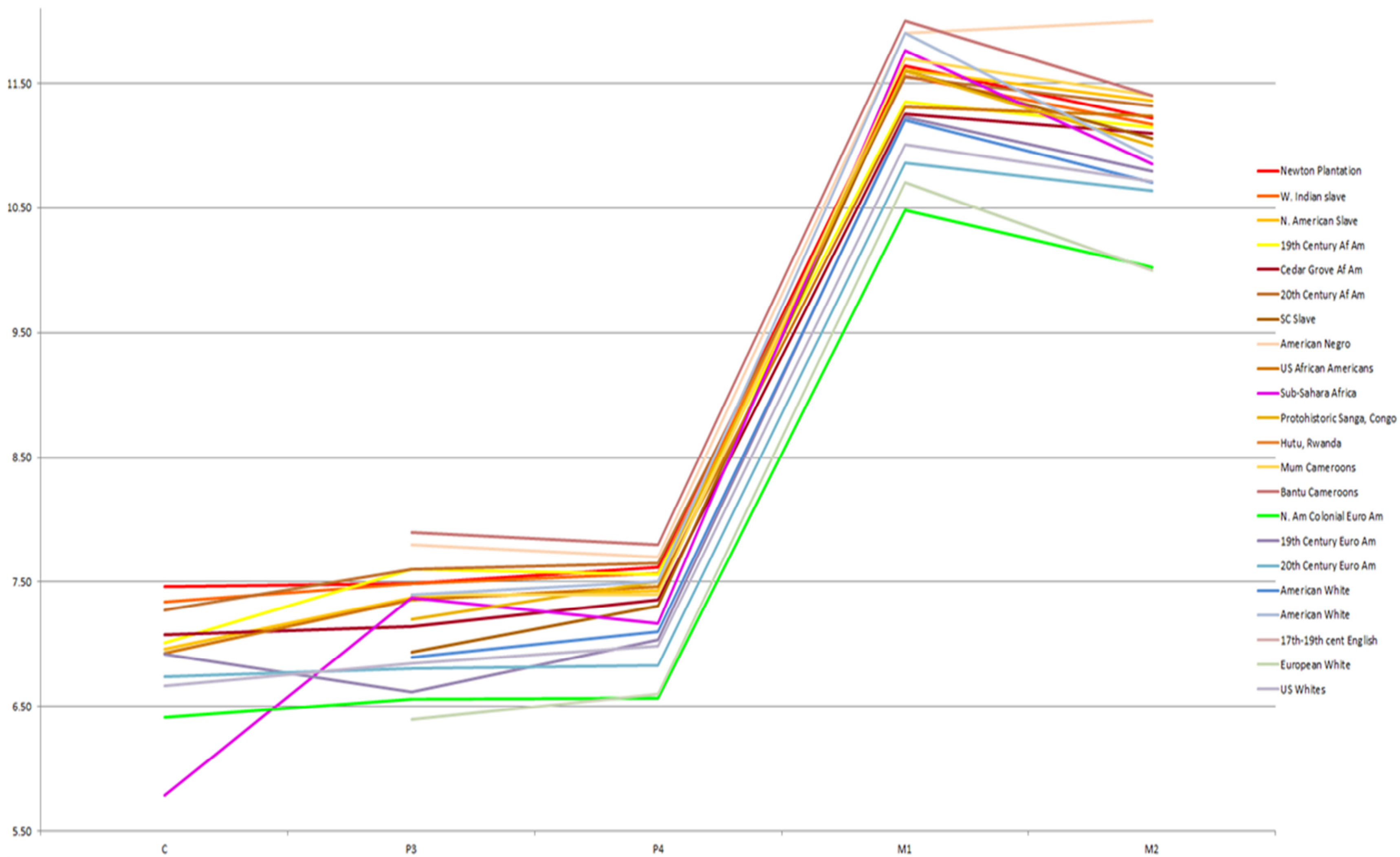

Figure 13. Line graph of mean mesiodistal (MD) diameters of each population for teeth C_1-M_2.

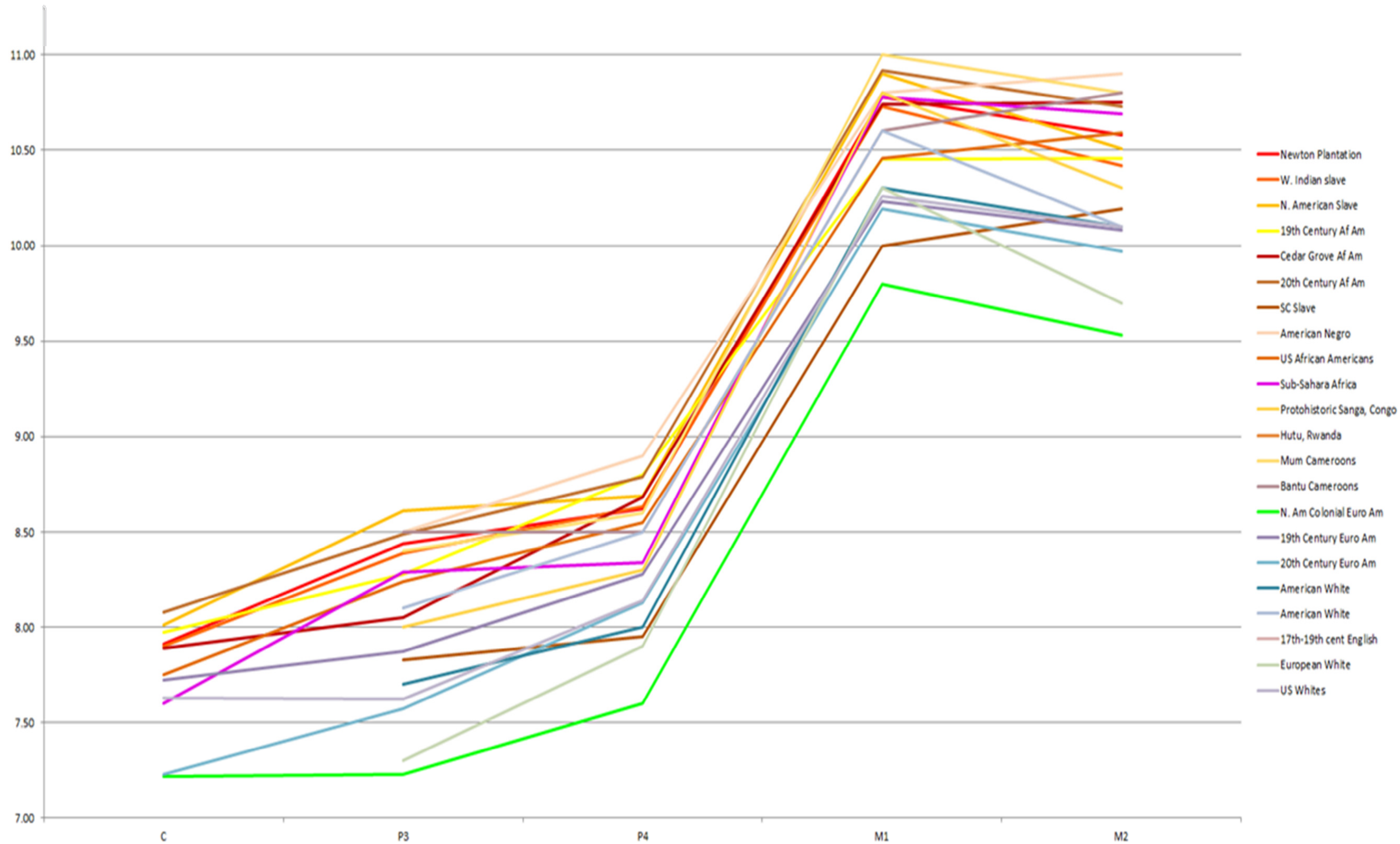

Figure 14. Line graph of mean buccolingual (BL) diameters of each population for teeth C_1-M_2.

Principal Components Analysis

A principal components analysis (PCA) was also performed with the mean MD and BL data. Figure 15 shows the resulting scatter plot. Principal Components Analysis summarizes underlying trends reflected in shared correlated "components." In this case, 82.23% of the total statistical variation in the mean diameters is reflected in PC1; this variation is in the overall size of the tooth. PC1 separates the African and descended populations and the European and descended populations into two fairly distinct groups. Based on the loadings, the driving force behind this distinction is primarily in both the MD and BL measurements of the M^2. PC2 accounts for only 4.48% of the observed variations and there is no real separation between the two groups along this axis.

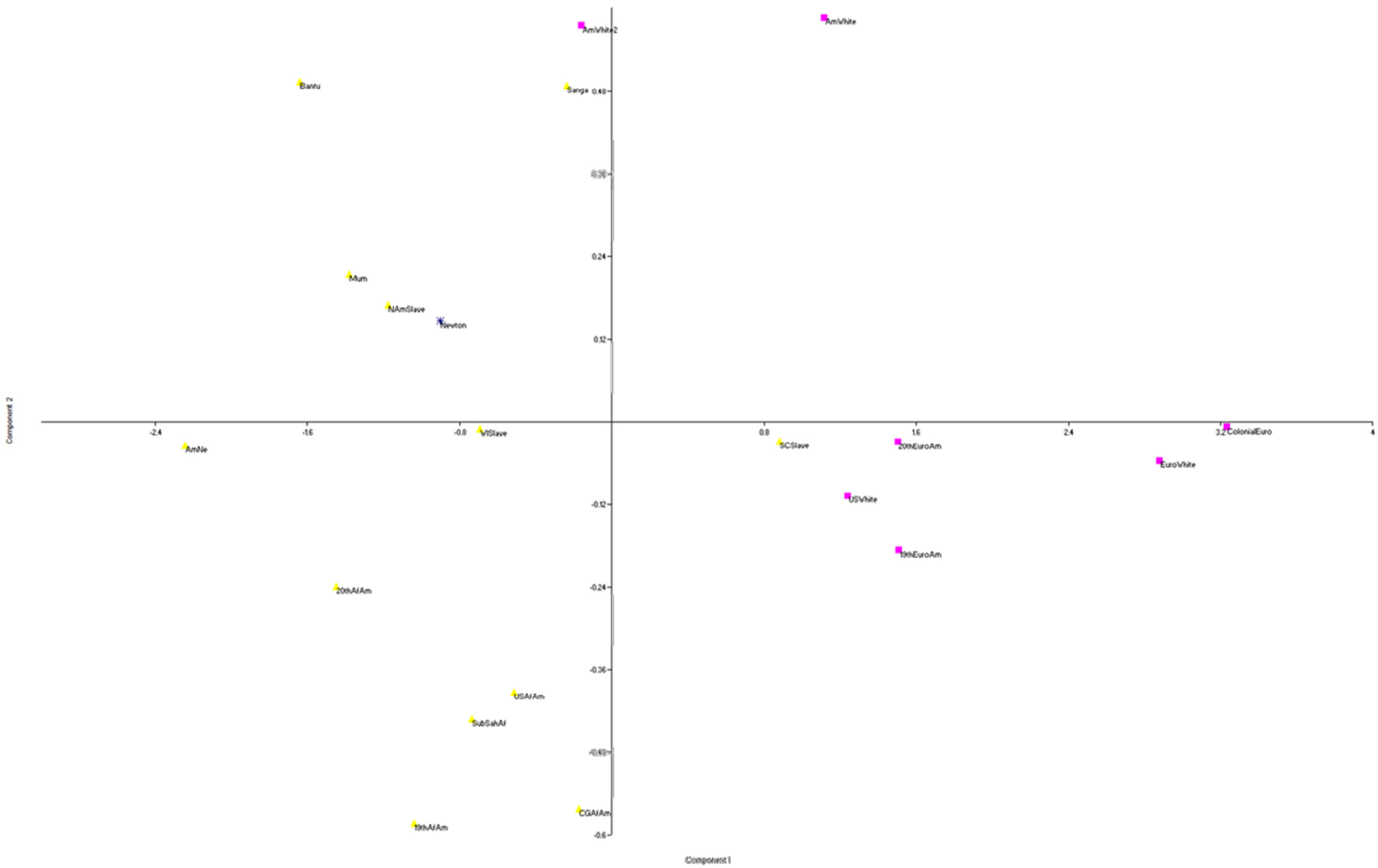

Figure 15. Results of Principal Components Analysis (PCA) of the mean tooth diameters of all samples.

CHAPTER 5

DISCUSSION

Mean Dimension Plotting

When mean MD and BL diameters were plotted, several patterns emerged in regard to the Newton populations. The first pattern is that the African/African-derived populations separated from the European/European-derived populations based on size. The African populations generally exhibit larger tooth diameters than those of the European populations. This is not unexpected, as it has previously been shown that African populations tend to have larger overall tooth size than Europeans (Farmer, 1990; Hanihara 1976, 1998; Hanihara and Ishida, 2005; Harris, 2001, 2003; Irish 1994, 1995; Keene, 1979; Lease and Sciulli, 2005; Macko et al., 1979; Merz et al., 1991; Moss and Chase, 1966; Moss et al., 1967; Richardson and Malhotra, 1975; Shaw, 1931; Vaughan and Harris, 1992).

Newton mean diameters consistently group with the other African populations. In many of the cases (I^1 MD, C^1 BL, M^2 MD and BL, C_1 MD, M_1 MD and BL) Newton mean diameters fall intermediately between Sub-Saharan Africans and the European groups. When Newton falls in between these two populations, it generally falls closer to the Sub-Saharan African sample than to the European groups. This is expected if the Newton Plantation slave population experienced low-levels of European genetic admixture. Newton's position is generally near that of Sub-Saharan Africans and distant from the European groups, also supporting the interpretation that if the Newton population experienced European genetic admixture, it was at very low levels Anterior tooth mean measurements were not available for all populations, including Sub-Saharan Africans. In these instances, investigating Newton and its relation to the African and European populations would benefit from having more comparative samples that include anterior measurements.

In some cases, there are African groups that cluster with the Europeans, namely the South Carolina enslaved African population (Figures 5, 9). This population was noted by Harris and Rathbun (1989) to have exceptionally small teeth for an African population. The reduced size of the dentition in this population causes a skew towards the European and derived groups as they also have small diameters relative to the African and derived populations. American Whites 2 also exhibits relatively large tooth diameters for a European population (Figures 5, 9). This may be an artifact of the sample size of American Whites 2 as this collection represents fewer than 10 individuals for both M_1 and M^2 (Moss et al., 1967).

Figures 3 and 4 (and Appendix A) show that in some instances Newton mean diameters are larger than those of Sub-Saharan Africans. The Sub-Saharan African sample is composed of individuals from West, East, and South Africa (Ritter, 1991). The East and South African groups have smaller dentition than the West African groups represented in the sample (Ritter, 1991). This may account for the fact that the Newton and some modern African American populations exhibit larger tooth diameters than Sub-Saharan Africans, a group that is considered a parent population. Additionally, populations of African descent in the New World experienced admixture with other groups of people besides Europeans. African-descended populations in North America have genetic admixture with Native American populations and in the Caribbean there was certainly admixture between the African-descended groups and the native populations of the West Indies (Ritter, 1991). Admixture with these groups would also influence tooth diameters observed in the population.

In each case, the range of variation in the MD and BL diameters exhibited in the Newton individuals include all mean diameters for the comparison samples. Some Newton individuals displayed extremely large teeth while others had very small teeth, even in comparison with the European and derived populations. This wide range of Newton individual variation when compared to the means of the comparative samples may appear artificially large due to the fact that these means were presented by Ritter (1991) without standard deviation or other information that would at least partially reveal the range of variation within each comparative sample.

Admixture Estimation

Admixture estimations made using the methods of Corruccini et al. (1982:452) also supports the theory that Newton had very little European genetic admixture. In the current study, Newton admixture estimates ranged from 5.4-10.3%. When compared to the contemporaneous North American Colonial Euro-American population Newton exhibits 5% European admixture; this supports the subjective estimation made by Corruccini et al. (1982) who gave an offhand estimate of Newton European admixture at approximately 5%. However, Corruccini et al. (1982:Table 10) did not use any native African samples in their actual admixture figures. Ritter (1991) found admixture rates of 12% in the Newton population when compared to Sub-Saharan Africans and Colonial Euro-Americans. This estimation is higher than that found by Corruccini et al. (1982) and in the current study. Ritter's (1991) study did not include the additional measurements of the 49 Newton individuals excavated in the 1997 and 1998 field seasons

(Shuler, 2005) and thus the estimation found in the current study should provide a more accurate reflection of the admixture in the Newton population. Mean diameters of each tooth type in the original Newton group analyzed by Ritter (1991) were generally smaller than those calculated after the addition of the more recently excavated Newton material. In addition, Corruccini et al. (1982:Table 4) showed that the estimated admixture seems much higher for dental nonmetric traits than for these metrics, thus casting some doubt on the direct genetic interpretation of nonmetric dental traits.

Based on previous studies of European admixture in modern African-descended populations in the Caribbean, Barbados exhibited European gene frequency rates of 10.2% (Benn-Torres et al., 2008). This rate is higher than that determined in the current study, but because Benn-Torres et al. (2008) performed their study on modern, living Barbadians, the amount of European genetic admixture would be expected to be higher than that of African-descended slaves that lived on the island hundreds of years earlier.

Admixture estimates made using the African Americans from the Terry collection were done in order to determine admixture in a more modern African-derived population from the US and compare the results against the Newton estimates and estimates made by other studies regarding European genetic admixture in modern African American populations. In the current study, admixture rates in the Terry collection were found to be 16.5-28.5%; the rate found using a contemporaneous European-descended population as a parental population was 19.5%. This range is quite consistent other studies that have found a general admixture rate of approximately 20% in urban, African American populations (Chakraborty et al., 1992; Destro-Bisol et al., 1999; Glass and Li, 1953; Parra et al., 1998; Pollitzer, 1958; Reed, 1969; Steinberg et al., 1960).

It should be noted that the highest average and adjusted average percentages for both Newton and the Terry African Americans are found using the 17th-19th century English as a parental population. Only the maxillary teeth are represented in the 17th-19th century English sample. This reduced number of measurements compared to the other European parental populations that are used in this analysis may inaccurately inflate the admixture estimate. Without the addition of the admixture estimates resulting from using 17th-19th century English as a parental population, Newton's range of admixture is 5.4-6.2% and that of the Terry collection is 16.5-19.5%. These estimates are within the expected ranges of admixture in their respective populations.

Line Graphs

In all the line graphs that were produced using the mean MD and BL diameters of the samples (Figures 11-14), Newton always groups with the other African and descended populations; these groups generally separated from the European populations due to the difference in their overall sizes. Newton mean diameters group much closer to the Sub-Saharan African parental population than to the North American Colonial Euro-Americans, especially in the BL diameters of the posterior dentition. The position of Newton nearer to the Sub-Saharan African population is expected given the apparent low European genetic admixture in the Newton Plantation slave population.

Principal Components Analysis

PCA results show similar groupings of African and European populations as the other analyses. There is a clear distinction between the descendant groups, though again there is a slight overlap with the South Carolina slave population grouping with the Europeans and the American Whites 2 population clustering more closely with the African populations. This is likely an artifact of the anomalous sizes of the teeth in these populations since PC1 separates the groups by size. Newton's position near the Sub-Saharan Africans and with North American Colonial Euro-Americans furthest away illustrates the low levels of European genetic admixture within the Newton population. Subjectively, the Newton centroid is further from European samples than some of the African samples are (Figure 11), reinforcing the appearance of very limited (in some cases, null) admixture.

That the Newton Plantation enslaved African population experienced little European genetic admixture is also supported by the historical studies of Barbadian slave practices by Handler and Lange (1978) and Higman (1984). Though Barbados had a much larger European population relative to the other sugar colonies, Barbados was also unique in attempting to prohibit "improper intercourse" between white servants and African slaves. Evidence shows that there was an actual impact of this regulation. Through the concept of hypodescent, children born with both African and European ancestry were classified as members of the African population, though their European genetics were recognized in the term "colored" as opposed to African or Creole. According to Higman (1984), the proportion of "colored" births on Barbadian plantations was smaller than on other sugar islands; some Barbadian planters even boasted to one another of the low numbers of "colored" births on their respective plantations (Higman, 1984).

The registration returns from these plantations show that plantations with larger numbers of slaves, 100 or more, had a percentage of "colored" births of ranged from 1.7-10.6% (Higman, 1984); Newton maintained a slaveholding of 250-300 slaves for most of its history (Handler and Lange, 1978) and thus, according to Higman (1984) would have experienced a "colored" birth rate of 10.6%. The low percentage of "colored" births was also a result of the plantation not being in a town. Higman (1984) found that the number of "colored" slaves on a plantation or farm declined with the ratio of African slaves to European-descended servants. In towns there were more white servants in the population, but in rural areas on large plantations the only white workers were small groups of supervisors. Thus, on larger plantations like Newton there was less opportunity for the introduction of European genes into the enslaved African population as there were just fewer Europeans in the area to incorporate their genes. According to Newton Plantation historic records, many of the slaves held there were "creole," the term for slaves of African descent born in the New World; as of 1817, 16.0% of the creole slaves on the island of Barbados were also classified socially as "colored" (had one white parent). This small percentage of European admixed slaves would seem to corroborate the small percentages of genetic admixture observed at Newton Plantation.

On many Caribbean sugar islands, the category "colored" was further delineated into terms that reflected the percentage of African ancestry within each individual. Terms like "octoroon," "quadroon," "yellow," and "red," among others, described varying amounts of European and African ancestry. Stereotypes about the physical strength, intelligence, and temperament of each of these delineated groups were then used as a guideline about how to treat the person in question and where individuals were placed to work (e.g., as a field laborer or house servant) (Higman, 1984; Madrigal, 2006).

Socially, being "colored" had unquestionable consequences. Children born to slave mothers and European fathers were born with the enslaved status of their mother. However, these individuals had a greater chance of being manumitted than slaves with no European parentage (Higman, 1984; Madrigal, 2006). Those who remained enslaved generally received more benefits than their counterparts who had no European ancestry. It is apparent in the literature that individuals who exhibited lighter skin color were treated preferentially as lighter skin was considered "aristocratic" (Higman, 1984). Additionally, in some locations, slaves born to an African and a European parent were believed to be less physically strong than Africans or Amerindians and thus were rarely placed into the plantation field labor gangs. Instead, they were frequently placed in such preferential positions as house servants and drivers, or skilled laborers such as carpenters, seamstresses, nurses, and fishermen (Higman, 1984; Madrigal, 2006). It is noted that sometimes placement into these preferred stations was also an acknowledgement of parental responsibility on the part of the European father (Higman, 1984).

Records indicate that "colored" slaves were underrepresented in hard labor positions (e.g., field labor) and were overrepresented in skilled labor and domestic positions (Higman, 1984). This disparity between the types of jobs that "colored" slaves performed and those performed by creole or African slaves resulted in not only economic differences but also physical and health differences (Higman 1984; Madrigal, 2006). Domestic and skilled laborers were sometimes allowed luxuries unknown to the field laborers. Some of the most obvious benefits of being a domestic or skilled laborer came in the form of better housing and clothing. In addition, because the domestics were in the house, it was possible for them to have access to more and better food, even if it was only to eat the food leftover by the owner and their family (Madrigal, 2006). The labor required of these preferred positions was not necessarily as physically demanding as that of the field laborer. Many stresses, injuries, and diseases that were hazards of field labor were not experienced by the slaves that held more desirable positions. Because these less strenuous jobs were disproportionately given to “colored” slaves, it follows that the “colored” slaves may have generally enjoyed a less strenuous, somewhat healthier life than their African and creole counterparts. Indeed, the improved life of the “colored” slave must have been substantial as resentment towards them and their favored positions grew in the slave population (Madrigal, 2006).

It is with these historical realities in mind that the investigation of European genetic admixture in the Newton population is examined. In the Newton individuals that have so far been recovered, the study shows that there is very little European admixture in the enslaved population. Based on historical records from Newton and other Barbadian plantations, this is not an unexpected result. This low level of European admixture would have likely resulted in few to none of these individuals being preferentially placed into less physically intense labor positions. This is at least somewhat substantiated by Shuler (2005) who found high levels of disease, poor nutrition, and physical stress in the same Newton population.

The admixture results achieved using the equation after Corruccini and colleagues (1982) appear to fall most in line with the results from previous admixture studies in the Newton population and more modern African American population as represented by the Terry Collection African Americans (Corruccini et al., 1982; Ritter, 1991). In order to do a more complete investigation of European admixture in the Newton Plantation enslaved African population, a study that utilizes the shape of the teeth should be attempted. Harris and Rathbun (1991) found that the apportionment of enamel along MD or BL dimensions was very effective in discriminating geographic populations – more so than overall tooth size. Dental measurements from the same parental populations utilized in the current study could be used in conjunction with the Newton dental measurements for the purpose of determining the percentage of European admixture exhibited in the Newton population.

With every biodistance study conducted with Caribbean enslaved populations we get closer to a more accurate understanding of not only the diversity of the populations of the African Diaspora, but also of the lived experiences and biological realities of the people who were enslaved. As we uncover more historical silences, we can finally begin compiling a more precise history of the people who were exploited to bring prosperity to the New World.

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