Imperialism and Physiological Stress in Rome, First to Third Centuries A.D.

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Rome during the Imperial period (27 B.C.–A.D. 476) is easily identifiable as an urban center in the archaeological and historical records. By virtue of Rome’s central geographical position in the empire and because it served as the home of the emperors, it was long viewed as the imperial core, with the provinces seen as the periphery. For over a century, abundant scholarship on “romanization” was based on a modern, Western, colonialist perspective through which archaeologists, historians, and other scholars sought to understand how Rome civilized the “barbarians” in the provinces. More recently, the core/periphery and civilized/barbarian dichotomies have been jettisoned in favor of reframing the phenomenon of population interaction as a bidirectional negotiation among groups that shared significant culture and history (e.g., Terrenato and Keay 2001; Webster 2001). Imperialism in the Roman world was not merely a function of population or geographic magnitude; it represented a cultural undertaking by a variety of people, a multidimensional idea that involved environmental, social, and economic stressors. These dimensions can be empirically measured in modern populations and are known to be causally related to one another (Schwirian et al. 1995). Previous approaches to understanding the results of the urbanization of Rome and its imperial domination focus on demography but tend to sideline topics such as migration, diet, and disease in the absence of strong skeletal data sets (e.g., Lo Cascio 2006; Paine and Storey 2006). This chapter therefore contributes a bioarchaeological perspective to the character of urban Rome in the middle of the Imperial period (first–third centuries A.D.).

The extended reach of Rome began during the Republic, and by the late first century B.C. the Roman world stretched from France to North Africa
and from Spain to Syria (Keppie 1998). At the end of the third century A.D. the imperial territory was interconnected by a massive road network that facilitated transportation of goods, movement of people, and exchange of ideas between Rome and the Empire (Laurence 1999). Towns, cities, and peoples could choose to distance themselves from Rome culturally, often in opposition to their common perceptions of the city and its culture, but the extension of Roman citizenship to every person in the Empire became the primary means by which people organized and conceived of themselves as Roman (Laurence and Berry 1998). The population of Italy in the third century A.D. was no longer more politically influential than that of the provinces, save the Emperor, and the people of the Empire became more geographically dispersed.

The sheer breadth and depth of interaction among people of the Roman Empire require a nuanced approach to imperialism. Raising questions of “entanglements” between various groups is preferable to imagining unidirectional acculturation. Anthropological approaches to colonialism and imperialism used in this volume illustrate the complications inherent in understanding these important relationships. Buzon and Smith, for example, point to a familiarity between Egypt and Nubia that does not match with the traditional colonialist model of European invasion of the New World, and Perry questions the utility of the colonizer/colonized dichotomy in Byzantine Jordan. In both of these Old World cases, a history of interaction belies a clear difference between colonizing population and colonized population, in spite of an apparent power differential. Similarly, Murphy and her colleagues find that the traditional ways of conceiving of Spanish-Inca interaction as either active resistance or passive acceptance elide the potential “in-betweenness” in indigenous responses to colonialism.

It is no longer tenable to conceive of Rome as the “core” and the provinces as the monolithic “periphery,” so a similar shift needs to be made in approaching the prevailing dichotomy that governs the understanding of health in Imperial Rome. On the one hand, public health concerns were paramount, and the Roman government created considerable infrastructure and laws to ensure access to basic resources. The aqueducts, which channeled 115 million gallons of water per day into Rome from springs in the rural outskirts, fed flushable toilets, city fountains for drinking water, and large bath complexes (Taylor 2000). Roman medicine and dentistry were quite advanced for the time. The Roman doctor’s toolkit included a variety of instruments, like a modern-looking speculum and metal catheters, and there are historical accounts of intricate cataract surgeries (Cruse
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2004). Bioarchaeological evidence shows skillful extraction of teeth by a dentist practicing in the Roman Forum along with palliative care for carious lesions (Becker 2014; Fejerskov et al. 2012). The link between dead bodies and disease was sufficiently understood that burial within the city was forbidden (Hope and Marshall 2000; Toynbee 1971). Finally, the food dole—first of wheat and later of bread, pork, olive oil, and wine—was a by-product of Rome’s ability to extract resources from provinces like Egypt and was made available for free or at a heavily subsidized cost to Roman male heads of households (Garnsey 1988, 1999; Garnsey and Rathbone 1985; White 1976). Viewed in this way, Rome was the wealthy center of the Empire, replete with natural and cultural resources that provided a good way of life for those fortunate enough to live and work in the greater Rome area.

On the other hand, Rome has also been viewed as a “pathopolis,” an urban jungle teeming with disease and poor living conditions (e.g., Mumford 1961; Scobie 1986). At the height of the Empire in the first century A.D., Rome had a population density higher than modern-day Manhattan or Mumbai, with around one million people living in fourteen square kilometers (Hopkins 1978; Scheidel 2001; Storey 1997b; Wiseman 1969). The suburbium outside the walls was also densely settled, with close to half a million people living among marginal businesses—slaughterhouses, brick-making facilities, quarry pits, landfills, and cemeteries—excluded from the city for religious or public safety reasons (Carafa et al. 2005; Champlin 1982; Morley 1996; Witcher 2005). Rome and its suburbium existed in a web of interdependent urban and suburban development, and many accounts call life in the city crowded, unsanitary, violent, and impoverished (Champlin 1982; Morley 2005; Parkin 1992; Scheidel 2003; Scobie 1986), particularly for the lower classes—urban commoners (plebs urbana), rural peasants (plebs rustica), and slaves (servi). In an often-cited article on sanitation in the Roman world, Scobie (1986) concluded from a textual and archaeological assessment of lower-class Roman living conditions that high frequencies of diseases such as cholera, typhoid, dysentery, gastroenteritis, leptospirosis, and infectious hepatitis could be attributed to food and water contamination by fecal material, open latrines in the kitchen, and defecation and urination in the streets. There is also ample historical evidence from such ancient authors as Celsus and Pliny the Younger attesting to the presence of diseases like malaria, leprosy, and tuberculosis in the population (Grmek 1989; Meinecke 1927; Patrick 1967).

These two opposing views of health in an imperial capital developed
without inclusion of bioarchaeological data because, until about thirty years ago, there was great inconsistency in the practice of saving and analyzing human skeletal remains from Rome. The scant skeletal record has provided some evidence of infectious disease in ancient Italy: malaria is assumed to have been endemic (Angel 1966; Sallares 2002); leprosy is found as early as the fourth century B.C. (Mariotti et al. 2005); and tuberculosis is known from a handful of sites (Canci et al. 2005; Ricci et al. 1997; Roberts and Buikstra 2003). Within the greater suburban area of Imperial Rome (roughly a 12 km radius from the walls), though, there is a limited amount of bioarchaeological data available. Three cemeteries from the suburbium have been relatively well published in terms of osteological demographics, methods, and results. Basiliano/Collatina represents a cemetery with over 2,200 individuals, but 142 have been studied (Buccellato et al. 2003; Buccellato, Caldarini, et al. 2008). Vallerano has just 26 individuals but has produced high-quality data (Cucina et al. 2006; Ricci et al. 1997). Finally, Osteria del Curato II contained 71 individuals (Catalano 2001; Catalano and Di Bernardini 2001; Egidi et al. 2003). In total, just 239 individuals from three cemeteries in Rome have been thoroughly investigated. Very limited osteological data from additional cemetery samples can be found in the aggregate (Catalano 2001; Catalano and Di Bernardini 2001; Catalano et al. 2012; Ottini et al. 2001). Further from Rome (25 km or more), data can be found from the Imperial-era cemetery of Isola Sacra associated with urban Portus Romae (Manzi et al. 1991; Prowse 2001; Prowse et al. 2004, 2005, 2007) and the rural sites of San Vittorino (Catalano et al. 2001; Ottini et al. 2001) and Lucus Feroniae (Manzi et al. 1999; Salvadei et al. 2001; Sperduti 1997).

Many of these archaeological samples from Rome have been investigated with the hypothesis that “ancient empires with high population density and highly developed trading systems were ideal for the cultivation of such diseases and the ravages of epidemics” (Acsádi and Nemeskéri 1970:217). It is equally important, though, to test and refine this hypothesis with new data. This chapter presents demographic and skeletal pathology data drawn from two Imperial-era cemeteries—Casal Bertone and Castellaccio Europarco—in order to broaden our understanding of physiological stress among the lower classes buried in the Roman suburbium. Where possible, inter-site and inter-sex variation in disease frequency is assessed, and comparisons are made between the study sites and other published Imperial Roman cemeteries. Some of the previously published data sets, however, do not present enough information for statistical comparisons to
be made, so these data and interpretations are used with caution. Finally, in order to set a new precedent in pathological analyses of Imperial Rome, all data used in this chapter are available in a full online relational database, as are photographs of all porotic hyperostosis lesions, at https://github.com/killgrove/RomanOsteology. The picture that results from investigating multiple cemeteries in ancient Latium is complex and belies sweeping conclusions often made about health and disease in Imperial Rome.

EVALUATING THE HEALTH STATUS OF IMPERIAL ROMANS

The two most commonly recorded pathological conditions on Imperial Roman skeletons are porotic hyperostosis (PH) and dental enamel hypoplasia (DEH). J. L. Angel (1966) first used the term *porotic hyperostosis* to refer both to lesions of the orbital roof (also known as cribra orbitalia, or CO) and to lesions on the skull vault (also known as cribra cranii, or CC). There is considerable debate as to whether these two conditions have the same etiology (Lewis 2007; Rothschild et al. 2004; Stuart-Macadam 1989), but the changes to the orbital and vault bones are similar: a cycle of loss and overproduction of red blood cells in the bone marrow causes expansion of the inner, diploic tissue of the skull and thinning of the outer, compact bone matrix (Angel 1966). Porotic hyperostosis appears macroscopically (Figure 9.1) as abnormal holes or networks of furrows and is easily recorded using a variety of grading systems (Buikstra and Ubelaker 1994; Hengen 1971; Nathan and Haas 1966). Whereas palaeopathologists used to contend that the most common cause of PH was diet-related iron deficiency, recent literature cautions against this interpretation (Waldron 2009; Walker et al. 2010), and researchers suggest a variety of mechanisms that could cause these lesions, most notably hemolytic forms of anemia (e.g., thalassemia, G6PD deficiency, lead poisoning) and megaloblastic forms of anemia (e.g., dietary insufficiency of iron, vitamin C, or vitamin B12; parasites; infection) (Crandall and Martin 2012; Oxenham and Cavill 2010). Since there are numerous possible etiologies to PH, it is used as a nonspecific indicator of overall health status within a population that generally reflects childhood metabolic health in the form of some kind of chronic anemic stress (Goodman and Martin 2002). Dental enamel hypoplasia results from a disturbance in normal enamel production (amelogenesis) and is macroscopically evident as lines or pits on the adult dentition. The pause in dental enamel formation during childhood is likely related to a prolonged episode of health stress—such as weaning, malnutrition, or illness—so DEH is also
generally considered a nonspecific health indicator (Goodman and Rose 1990; King et al. 2005) and provides complementary information to PH (Goodman and Martin 2002).

Scholars of the ancient world have attempted to identify and interpret the frequencies of PH and DEH seen in individual skeletal samples in the Imperial Roman suburbium (Buccellato et al. 2003; Catalano et al. 2001; Cucina et al. 2006; Facchini et al. 2004; Manzi et al. 1999; Ricci et al. 1997; Salvadei et al. 2001), but syntheses of these data have only been published since 2010. Interestingly, the most recent attempts at synthesis of the skeletal evidence of PH, DEH, and stature as avenues to investigate systemic health stress have been accomplished by Roman historians interested in ancient demography (e.g., Pilkington 2013; Scheidel 2014), pointing to the growing need for Roman bioarchaeologists to present and interpret data in a way that aids interdisciplinary research in the Roman world. The most thorough treatment of the skeletal evidence and the multifactorial causes of systemic health stress in Rome, however, is Gowland and Garnsey’s (2010) synthesis of the PH and DEH data published up to that point. Surveying many of the same populations employed in this analysis, Gowland and Garnsey note the very high prevalence of CO and DEH within the cemeteries from Imperial Rome and suggest that “the clinical and bioarchaeological evidence strongly points to the significance of malaria in terms of the presence of a high prevalence of cribra orbitalia” (2010:149). Nevertheless,
they note that “it is quite likely—indeed, to be expected—that a more complex pattern will emerge than is suggested by the evidence that is currently available,” particularly considering the difficulties they encountered in using published Imperial Roman studies that lack detailed methods and data (2010:131; Gowland and Redfern 2010).

The data presented in this chapter contribute to the more complex pattern that Gowland and Garnsey (2010) foresaw. Imperial Rome was composed of a huge variety of people who differed in their geographic origins (Killgrove and Montgomery 2016), in their diet (Killgrove and Tykot 2013), in their exposure to toxins (Montgomery et al. 2010), and in the location of their residence. All of these differences could have affected their susceptibility to disease and their health outcomes. While we cannot yet identify from skeletal data where in the urbs or suburbium a person lived, previously published biochemical data from the two cemeteries presented here can be examined as complementary data sets to help explicate the PH frequencies, and possible causes for the heterogeneity of health status in Imperial Rome will be detailed in the Discussion section below.

**Materials and Methods**

Roman cemeteries were almost always placed outside the city walls for both religious and hygienic reasons. Located less than 2 km east of the walls along the ancient Via Praenestina, the cemetery of Casal Bertone was closely associated with Rome (Figure 9.2). Excavations by the Soprintendenza Archeologica di Roma took place between 1989 and 2007 and were largely salvage in nature (Calci and Messineo 1989; Musco et al. 2008; Nanni and Maffei 2004). Skeletons were recovered from the cemetery between 2000 and 2003, and in 2007 a residential villa and a large industrial complex were found nearby. The cemetery was in use from the second to the third century A.D., based on pottery and coins found with the burials (Musco et al. 2008). In total, 139 skeletons were available for osteological analysis from Casal Bertone. Castellaccio Europarco, located 11.5 km south of Rome along the ancient Via Laurentina, was excavated by the Soprintendenza Archeologica di Roma between 2003 and 2007 (Buccellato 2007; Buccellato, Catalano, and Pantano 2008). Although archaeologists found architectural remains in the area, it is unclear if they are directly associated with the Imperial-era burial context, which yielded 47 inhumations dated by grave goods to A.D. 50–175 (Buccellato, Catalano, and Pantano 2008). In total, the sample analyzed includes 186 Imperial-period skeletons, most
of which were from simple inhumations—pit, amphorae, or *a cappuccina* styles (Toynbee 1971). Not every individual could be assessed for PH and DEH, so the total number of individuals, teeth, or bony elements examined is reported in the pertinent tables.

Demographic data were collected from the skeletons based on the guidelines established by Buikstra and Ubelaker (1994). Pubic symphysis morphology (Brooks and Suchey 1990; Todd 1921a, 1921b), auricular surface changes (Lovejoy et al. 1985), and cranial suture closure (Meindl and Lovejoy 1985) were used to assess age at death of adults, who were placed in categories as per Buikstra and Ubelaker (1994): Young Adult (YA: 20 to 35 years), Middle Adult (MA: 35 to 50), and Older Adult (OA: 50 and older). Subadult age at death was estimated using tooth formation and eruption (Anderson et al. 1976; Gustafson and Koch 1974; Moorrees et al. 1963a, 1963b) as well as epiphyseal union and long bone length (Baker et al. 2005; Johnston 1962). Subadults were placed in age-at-death categories as follows.

Figure 9.2. Locations of cemetery sites mentioned (base map tiles © OpenStreetMap.org contributors, available for use under the Open Database License [CC BY-SA 2.0]).
per Baker et al. (2005): Infant (0–12 months), Young Child (YC: 1–6 years), Older Child (OC: 7–12), and Adolescent (Adol: 12–20). Sex of adults and older adolescents (16–20 years) was estimated based on pelvic morphology (Buikstra and Ubelaker 1994; Phenice 1969), cranial features (Acsádi and Nemeskéri 1970), and long bone measurements (Ousley and Jantz 1996) where appropriate.

Macroscopic identification of pathological conditions on the skeletons was made based primarily on Ortner (2003). Porotic hyperostosis of the orbit (CO) and the vault (CC) was scored based on severity criteria in Hengen (1971) and is reported as crude prevalence rates—CPR%, of the number of individuals exhibiting the condition (n) divided by the number of individuals examined (N) × 100. Cribra orbitalia is further reported as true prevalence rates—TPR%, or the number of eye orbits exhibiting the condition (n) divided by the number of orbits examined (N) × 100. Macroscopic identification of DEH on the permanent dentition was made based on Standards for Data Collection from Human Skeletal Remains (Buikstra and Ubelaker 1994). Frequency data for DEH are reported here as true prevalence rates—TPR%, or the number of teeth exhibiting the condition (n) divided by the number of teeth examined (N) × 100—to facilitate comparison with other Imperial Roman cemetery samples.

**Results**

**Demographics**

The age-at-death profile for the two sites can be seen in Figure 9.3. The high number of subadult deaths and peak in adult death in the Middle Adult age range is consistent with the work of historical demographers of Rome (Acsádi and Nemeskéri 1970; Frier 2001; MacDonnell 1913; Parkin 1992; Scheidel 2001; Storey 1997a, 1997b), with the exception of the high number of deaths in the Adolescent age category. Individuals of this age were generally at a lower risk of mortality than were infants (Parkin 1992), but life-stage transitions—young Roman women could marry and become pregnant, and young men would start new occupations or apprenticeships—are possible explanations for the rise in death in this age category. Both sites, however, suffer from a statistically significant underrepresentation of females (Casal Bertone—χ² = 11.538, p < .001; Castellaccio Europarco—χ² = 9.323, p < .01), making sex-based comparisons in pathology frequencies difficult.
POROTIC HYPEROSTOSIS

Table 9.1 presents all the raw PH data for individuals, and the CO data are broken down by age and sex in Table 9.2. Hengen’s (1971) PH scoring system was employed to facilitate comparisons with other published studies from Imperial Rome. Photographs of all scored lesions from Casal Bertone and Castellaccio Europarco can be found in the online repository, labeled with individual burial number (e.g., ET31 for Castellaccio Europarco Tomb 31).

Two-tailed Fisher’s exact tests were used to compare frequencies of CO and CC between the two samples, between subadults and adults in both populations, and between males and females from Casal Bertone. Significant differences in pair-wise comparisons include the frequency of CC in the two populations \( (p = 0.006) \), with Castellaccio Europarco having 15.6 percent and Casal Bertone just 1.2 percent, and the frequency of CO between subadults and adults of the combined samples \( (p = 0.018) \), with 44.4 percent of examined subadults affected by CO and 9.3 percent of adults affected. This latter result is unsurprising, however, given the etiology of PH. No significant differences were found in the other comparisons of CO frequency (CB-CE \( p = 1.0 \); CB subadult-CB adult \( p = 0.054 \); CE subadult-CE adult \( p = 0.227 \); CB male-CB female \( p = 0.557 \)) nor in comparing CC...
Table 9.1. Porotic hyperostosis data for Casal Bertone and Castellaccio Europarco by individual

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Condition</th>
<th>Hengen (1971)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET31</td>
<td>Subadult (3–4 yrs. old)</td>
<td>CC</td>
<td>2</td>
<td>H</td>
</tr>
<tr>
<td>ET45</td>
<td>Adolescent</td>
<td>CC/CO</td>
<td>3/2</td>
<td>H/H</td>
</tr>
<tr>
<td>ET63</td>
<td>Subadult (7–9 yrs. old)</td>
<td>CC/CO</td>
<td>2/4</td>
<td>H/H</td>
</tr>
<tr>
<td>ET67</td>
<td>Subadult (c. 12 yrs. old)</td>
<td>CC/CO</td>
<td>1/3</td>
<td>H/H</td>
</tr>
<tr>
<td>ET69</td>
<td>Young adult</td>
<td>M</td>
<td>CC</td>
<td>2</td>
</tr>
<tr>
<td>F10B</td>
<td>Subadult (c. 7 yrs. old)</td>
<td>CO</td>
<td>5</td>
<td>A</td>
</tr>
<tr>
<td>F11C</td>
<td>Subadult (c. 12 yrs. old)</td>
<td>CO</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>F13A</td>
<td>Subadult (c. 7 yrs. old)</td>
<td>CO</td>
<td>1</td>
<td>H</td>
</tr>
<tr>
<td>F1D</td>
<td>Adolescent (16–18 yrs. old)</td>
<td>M</td>
<td>CO</td>
<td>3</td>
</tr>
<tr>
<td>F5A</td>
<td>Subadult</td>
<td>M</td>
<td>CO</td>
<td>3</td>
</tr>
<tr>
<td>F7B</td>
<td>Adult</td>
<td>M</td>
<td>CC</td>
<td>2</td>
</tr>
<tr>
<td>T22</td>
<td>Young adult</td>
<td>M</td>
<td>CO</td>
<td>4</td>
</tr>
<tr>
<td>T23</td>
<td>Young adult</td>
<td>M</td>
<td>CO</td>
<td>4</td>
</tr>
<tr>
<td>T32</td>
<td>Adolescent</td>
<td>CO</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>T36</td>
<td>Adolescent (14–16 yrs. old)</td>
<td>CO</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>T70</td>
<td>Subadult (c. 7 yrs. old)</td>
<td>CO</td>
<td>4</td>
<td>A</td>
</tr>
</tbody>
</table>

Note: ET = Castellaccio Europarco; F = Casal Bertone; T = Casal Bertone.

frequency between males and females from Casal Bertone ($p = 1.00$). The samples from Casal Bertone and Castellaccio Europarco were, on the whole, affected by PH in similar ways.

In order to situate the Casal Bertone and Castellaccio Europarco samples within the context of the Roman suburbium, skeletal pathology frequencies from published cemeteries in the area dating to the Imperial period are listed in Table 9.3 along with distance from Rome. Information on both

Table 9.2. Cribra orbitalia frequencies from two Imperial Roman cemeteries (calculated as number affected/number examined)

<table>
<thead>
<tr>
<th></th>
<th>Casal Bertone</th>
<th>Castellaccio Europarco</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Orbits</td>
<td>Individuals</td>
</tr>
<tr>
<td>Male</td>
<td>6/60 (10%)</td>
<td>4/33 (12.1%)</td>
</tr>
<tr>
<td>Female</td>
<td>0/17 (0%)</td>
<td>0/11 (0%)</td>
</tr>
<tr>
<td>Subadult</td>
<td>10/33 (30.3%)</td>
<td>6/19 (31.6%)</td>
</tr>
<tr>
<td>Total</td>
<td>16/110 (14.5%)</td>
<td>10/63 (15.9%)</td>
</tr>
</tbody>
</table>
Table 9.3. Individuals affected and crude prevalence rates (CPR) of porotic hyperostosis among comparative Imperial populations

<table>
<thead>
<tr>
<th>Distance from Rome (km)</th>
<th>Cribra orbitalia</th>
<th>Cribra cranii</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CPR (n/N)</td>
<td>CPR (n/N)</td>
</tr>
<tr>
<td>Casal Bertone</td>
<td>15.9% (10/63)</td>
<td>1.2% (1/83)</td>
</tr>
<tr>
<td>Basiliano/Collatina</td>
<td>c. 65%</td>
<td>50%</td>
</tr>
<tr>
<td>Quadraro</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Osteria del Curato II</td>
<td>79.2% (3/22)</td>
<td>53.6%</td>
</tr>
<tr>
<td>Castellaccio Europarco</td>
<td>13.6% (18/26)</td>
<td>15.6% (5/32)</td>
</tr>
<tr>
<td>Vallerano</td>
<td>69.2% (46/93)</td>
<td>10.7% (14/131)</td>
</tr>
<tr>
<td>Lucus Feroniae</td>
<td>49.5% (14/131)</td>
<td></td>
</tr>
<tr>
<td>San Vittorino</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

\(a\) Data from Buccellato et al. 2003.
\(b\) Data from Ottini et al. 2001.
\(c\) Data from Egidi et al. 2003.
\(d\) Data from Ricci et al. 1997, Cucina et al. 2006.
\(e\) Data from Salvadei et al. 2001.

Data-collection methods and number of individuals examined is available only for the larger populations of Vallerano and Lucus Feroniae, however.

Two-tailed Fisher’s exact tests were used to compare the frequencies of CO among cemeteries near Rome, and the results are presented in Table 9.4. Clearly, Vallerano and Lucus Feroniae have high CO frequencies compared to Casal Bertone and Castellaccio Europarco, but the two sites with high PH frequencies are not significantly different from one another. In addition, a statistical difference was found between frequencies of CC at Casal Bertone and Lucus Feroniae \((p = 0.0108)\) but not between the frequencies of this condition at Castellaccio Europarco and Lucus Feroniae. Whereas two Roman cemeteries—one suburban and one rural—have high PH frequencies, two others—one periurban and one suburban—have comparatively low PH frequencies.

Table 9.4. Comparative Imperial Roman populations—Fisher’s exact test of cribra orbitalia frequencies (two-tailed \(p\) values)

<table>
<thead>
<tr>
<th></th>
<th>Casal Bertone</th>
<th>Castellaccio Europarco</th>
<th>Vallerano</th>
<th>Lucus Feroniae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casal Bertone</td>
<td>—</td>
<td>1.00</td>
<td>(&lt; 0.0001)</td>
<td>(&lt; 0.0001)</td>
</tr>
<tr>
<td>Castellaccio Europarco</td>
<td>—</td>
<td>(0.0001)</td>
<td>(0.0033)</td>
<td>—</td>
</tr>
<tr>
<td>Vallerano</td>
<td></td>
<td></td>
<td>(0.0806)</td>
<td>—</td>
</tr>
<tr>
<td>Lucus Feroniae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DENTAL ENAMEL HYPOPLASIA

Every permanent tooth was assessed for evidence of DEH of the linear or pit variety. In all, 2,525 permanent teeth were examined from the two samples, with a total of 109 individuals at Casal Bertone and 34 individuals at Castellaccio Europarco. True prevalence rates of DEH are presented in Table 9.5. Differences in DEH frequencies in the Casal Bertone and Castellaccio Europarco samples were investigated using Fisher’s exact test, but no statistically significant differences ($p = 1.00$) were found between the two samples. Two-tailed Fisher’s exact tests between every other pairing of Casal Bertone, Castellaccio Europarco, Vallerano, and Isola Sacra, however, were significant, all with $p$ values less than 0.0001. Imperial Roman samples appear to vary significantly in the TPR of DEH, but the Casal Bertone and Castellaccio Europarco samples are unique in having significantly lower frequencies than the other three groups for which TPR is reported.

REPUBLICAN PHASES AT CASTELLACCIO EUROPARCO

At the present time, examining diachronic change in osteological data from Rome is nearly impossible because of the paucity of immediately pre- and post-Imperial data sets. During the Republican era that preceded the Empire, roughly 510–27 B.C., the dominant burial rite was cremation (Toynbee 1971). As Roman art collectors over the past several centuries have prized intact examples of ceramic vessels, marble sarcophagi, and statues, a vast number of cremated remains have certainly been discarded and destroyed. Cremations and inhumations have been found side-by-side at sites like Osteria del Curato (Egidi et al. 2003) and Castellaccio Europarco (Buccellato

<table>
<thead>
<tr>
<th>Site</th>
<th>Number affected ($n$)/ Number examined (N)</th>
<th>True prevalence rate ($n/N$ %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casal Bertone</td>
<td>52/1962</td>
<td>2.2%</td>
</tr>
<tr>
<td>Basiliiano/Collatina$^a$</td>
<td>—</td>
<td>42.0%</td>
</tr>
<tr>
<td>Castellaccio Europarco</td>
<td>14/563</td>
<td>2.5%</td>
</tr>
<tr>
<td>Vallerano$^b$</td>
<td>502/790</td>
<td>63.5%</td>
</tr>
<tr>
<td>Isola Sacra$^c$</td>
<td>281/791</td>
<td>35.5%</td>
</tr>
</tbody>
</table>

$^a$Data from Buccellato et al. 2003 report a (possibly rounded) TPR but not sample size.


$^c$Data from Manzi et al. 1999.
2007; Buccellato, Catalano, and Pantano 2008), but there have been no large-scale studies of cremations from Rome to date.

The Castellaccio Europarco necropolis, however, has two earlier phases of burial: fourth–third centuries B.C. (Phase 1, inhumation MNI = 17) and second–first centuries B.C. (Phase 2, inhumation MNI = 11) (Buccellato 2007; Buccellato, Catalano, and Pantano 2008). These are very small sample sizes, made even smaller when only individuals who could be scored for pathological lesions are considered, so statistical analysis is not possible. The PH and DEH data from Republican Castellaccio Europarco are presented here in the hopes that as more data from these time periods become available,³ a diachronic examination of health at the Republic-to-Imperial transition can be made.

Of the 17 inhumed individuals who date to Phase 1 of Castellaccio Europarco, 10 could be scored for CO and 10 could be scored for CC. No instances of either condition were found, however. In Phase 2, 1 out of the 6 scorable individuals displayed CC, and 1 out of the 4 scorable individuals displayed CO. Calculating the CPRs for CO for the various phases gives 0 percent in Phase 1, 25 percent in Phase 2, and 13.6 percent in Phase 3. CPR for CC is 0 percent in Phase 1, 16.6 percent in Phase 2, and 15.6 percent in Phase 3. It is possible that a decline in health is occurring between the middle Republic (Phase 1) and the late Republic/beginning of the Empire (Phase 2), but the sample sizes are too small to say anything definitive.

Of the 17 Phase 1 burials at Castellaccio Europarco, 7 individuals presented a total of 135 adult teeth for assessment of DEH. No hypoplastic lesions were found in these individuals, however. Of the 11 Phase 2 burials, 4 individuals presented a total of 68 adult teeth for assessment. No hypoplastic lesions were found in these individuals either. The TPRs for the various phases are therefore 0 percent (Phase 1), 0 percent (Phase 2), and 2.5 percent (Phase 3). The trend in DEH frequency through time at Castellaccio Europarco, then, appears to increase in the Imperial period.

**Discussion**

**General Health in Imperial Rome**

The demographic and pathological data collected from the periurban Casal Bertone sample and the suburban Castellaccio Europarco sample suggest that lifestyle, health, diet, and disease ecology at these sites were similar in the Imperial period. Nevertheless, the age distribution and the composition
of these cemetery samples were both certainly affected by a number of variables in antiquity, including epidemic diseases, migration, and living conditions (Wood et al. 1992). Although Casal Bertone and Castellaccio Europarco are similar in terms of health stress, comparing PH and DEH frequencies with other published sites from the Roman suburbium paints a significantly more complicated picture of population heterogeneity and defies easy interpretation.

Both Casal Bertone and Castellaccio Europarco have significantly lower frequencies of PH than do the populations from Basiliano/Collatina, Osteria del Curato II, Vallerano, and Lucus Feroniae; they are comparable, however, to the lower frequencies of PH in the small samples at Gabii, Quadraro, and San Vittorino (Catalano et al. 2001; Ottini et al. 2001). In all the studies that refer to Hengen (1971) grades, the vast majority of the individuals with PH have lesions between grades 1–4 (Buccellato et al. 2003:347; Ottini et al. 2001:365; Ricci et al. 1997:119), with only a few individual mentions of the more severe PH grades 5 and 6.

The number of individuals examined for PH in these reported cemetery samples is quite small, generally numbering fewer than 25 individuals, and this could be biasing the data. The two larger samples—Casal Bertone with 63 individuals and Lucus Feroniae with 93 individuals—have significantly different frequencies of PH. They are also, however, located in very different parts of Imperial Rome. The few statistical tests that could be performed suggest that the populations buried at suburban Vallerano and rural Lucus Feroniae were under greater disease loads and therefore had worse overall health than the populations buried at periurban Casal Bertone and suburban Castellaccio Europarco.

Without additional information about the context of the cemetery samples, however, we can simply say that PH frequencies vary widely, from none seen in a small sample from rural Latium to over three-quarters of the population affected in a sample from the Roman suburbium. Different areas of the greater Rome area likely had different population attributes, different disease ecology, and different access to a wide variety of resources, like food, water, medicine, and flush toilets, any combination of which could explain variation in PH frequencies.

As with PH frequencies, the frequencies of DEH at Casal Bertone and Castellaccio Europarco were significantly lower than at any other reported site, each with under 3 percent of teeth exhibiting a hypoplastic lesion, an order of magnitude lower than frequencies reported at periurban Basiliano/Collatina, suburban Vallerano, and urban Isola Sacra. Differences in DEH
frequencies point to variation in physiological stress during childhood for these populations.

The population of Vallerano deserves additional consideration because of its high frequencies of PH and DEH and because of its proximity to Castellaccio Europarco (see Figure 9.2), which had low frequencies of these pathological lesions. Vallerano is also the sample most easily compared to the study sites, because Cucina et al. (2006) describe in detail their methods of data collection and report both the number of individuals or teeth examined and the total sample examined for pathological lesions. It is clear that the population buried at Vallerano, associated with a villa in the Roman suburbium, was systemically stressed, both in childhood (DEH) and as adults (PH). Considering the close proximity of Vallerano and Castellaccio Europarco, the vast difference in CO and DEH frequencies suggests that factors other than geographic location affected health. Although it is roughly contemporaneous with Castellaccio Europarco, Vallerano dates to the second–third century A.D., while archaeologists report dates of A.D. 50–175 for Castellaccio Europarco (Buccellato, Catalano, et al. 2008). Changes in the population of the Roman suburbium between the times of these two sites could have affected health, as could have changes in the infrastructure of Rome. Ricci et al. (1997:126), in attempting to explain the PH and DEH frequencies and life expectancy at Vallerano, point to the so-called Imperial Crisis of the third century A.D., which devastated Rome’s transportation infrastructure and thereby the ability to move crops and other foodstuffs around. The population buried at Casal Bertone, however, also dates to the second–third centuries but has far lower frequencies of PH and DEH. It is possible the people buried at Casal Bertone were socioeconomically insulated from the crisis, but it would be useful to have more specific dates (i.e., radiocarbon dates) for cemeteries around Imperial Rome in order to combine the historical and palaeopathological records.

Finally, in spite of an attempt to control in this study for similar data-collection methods, it is possible that differences in inter-observer identification or recording practices contributed to the disparities in frequencies. It is additionally possible that factors intrinsic to the population samples, such as nutrition, water sources, and disease ecology, differentially affected the health of individuals buried in these cemeteries. Until more data are published, we need to use alternative methods to investigate the possible factors involved in systematic health stress within the Imperial Roman population.
POSSIBLE FACTORS AFFECTING ROMAN HEALTH

As illustrated in other contributions to this volume, the consequences of colonialism and imperialism are diverse. Specific to the Old World, Perry finds that Byzantine involvement in Jordan had little impact on local health, but Buzon and Smith find that the high frequency of active cribra orbitalia in colonial-era Tombos suggests significant stress on children’s health. Clearly, variables like geographic location, diet, population change, environmental conditions, and socioeconomic buffering are instrumental in affecting people’s health, and these variables need to be teased out of bioarchaeological data sets as best as possible.

The sheer amount of biochemical data produced from Casal Bertone and Castellaccio Europarco is currently unparalleled in Rome (Killgrove 2010), and these data can be combined in numerous ways to investigate questions of diet, migration, and disease. Relevant to the etiology of PH are carbon and nitrogen isotopes to look for potential dietary causes (Killgrove and Tykot 2013); strontium and oxygen isotopes to investigate PH in people who immigrated to Rome (Killgrove and Montgomery 2016); and lead concentration data to see if they correlate with presence of PH (Montgomery et al. 2010). These preliminary investigations, detailed below, cannot confirm an etiology of PH but do show the potential of biochemical data to inform palaeopathological analysis of a complex population.

Diet

As noted above, an early assumption of PH etiology was dietary insufficiency of iron. More recent studies, though, have suggested that vitamin B12 deficiency resulting from lack of meat in the diet is a possible cause of PH (Domínguez-Rodrigo et al. 2012; Walker et al. 2010). Forty-eight individuals from Casal Bertone and Castellaccio Europarco were previously tested for carbon and nitrogen isotopes (Killgrove and Tykot 2013), and seven of those individuals had evidence of PH (see Table 9.6). As nitrogen isotopes give a general idea of the proportion of meat that made up the ancient diet (Katzenberg 2008), individuals with PH lesions and low δ15N values may be suffering from a dietary insufficiency. Of the individuals in Table 9.6, however, only ET69 had a δ15N value more than one standard deviation lower than the mean for the site (9.8 percent; SD 1.5). At least in this small sample, a low-meat diet does not sufficiently explain the distribution of PH in these two samples.
Table 9.6. Paleodietary data from individuals with porotic hyperostosis

<table>
<thead>
<tr>
<th>Individual</th>
<th>PH</th>
<th>δ¹³C ‰ VPDB</th>
<th>δ¹⁵N ‰ AIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET31</td>
<td>CC</td>
<td>-18.3</td>
<td>11.8</td>
</tr>
<tr>
<td>ET69</td>
<td>CC</td>
<td>-19.5</td>
<td>7.8</td>
</tr>
<tr>
<td>F5A</td>
<td>CO</td>
<td>-17.5</td>
<td>9.3</td>
</tr>
<tr>
<td>F7B</td>
<td>CC</td>
<td>-17.7</td>
<td>10.8</td>
</tr>
<tr>
<td>T23</td>
<td>CO</td>
<td>-18.1</td>
<td>11.6</td>
</tr>
<tr>
<td>T36</td>
<td>CO</td>
<td>-18.1</td>
<td>10.8</td>
</tr>
<tr>
<td>T70</td>
<td>CO</td>
<td>-18.5</td>
<td>10.2</td>
</tr>
</tbody>
</table>

Note: Data from Killgrove and Tykot 2013.

Migration

The Roman population was also very heterogeneous in its origins, with millions of slaves and other immigrants flooding into Rome every year (Noy 2000; Scheidel 2005). Researchers such as Hengen (1971:66) have noted an association between PH frequency and geographic latitude, with populations living closer to the equator having higher PH frequencies than those living closer to the poles. Figure 9.4 shows immigrants to Rome (based on both oxygen and strontium isotopes), with a box indicating the local limits expected for both carbon and oxygen (see Killgrove and Montgomery 2016 for full explanation of the data). Individuals with higher δ¹⁸O values are likely from areas hotter and drier than Rome.

None of the individuals with suggested geographic origins similar to Rome (within the box) and from areas cooler and wetter than Rome (lower δ¹⁸O values) were found to have evidence of PH. Several individuals, however, with oxygen isotope values that place their origin in warmer, drier parts of the Roman world do have PH. Although these small sample sizes cannot lend definitive explanations to the cause of PH, these data suggest that further investigation into the relationship between migration and parasitic infection, malaria, and other diseases present in the southern parts of the Roman Empire is warranted.

Disease

Figure 9.4 has a bit more to tell, however. The Roman Empire is notorious for its abundant use of lead in weaponry, jewelry and makeup, aqueduct pipes, pottery glazes, and even food seasonings (sapa or defrutum was grape must boiled in lead or pewter pots until it absorbed some of the lead sugar). The Romans themselves knew of the ill effects of lead (e.g., Vitruvius 8.6.1–11), and scholars have wondered whether lead caused large-scale
Porotic hyperostosis and lead concentration in immigrants to Rome.

Figure 9.4.
Table 9.7. Lead concentrations and porotic hyperostosis from Castellaccio Europarco and Casal Bertone

<table>
<thead>
<tr>
<th>Individual</th>
<th>Pb mg/kg</th>
<th>PH</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET58</td>
<td>0.24</td>
<td>None</td>
</tr>
<tr>
<td>ET27</td>
<td>0.32</td>
<td>None</td>
</tr>
<tr>
<td>ET72</td>
<td>2.52</td>
<td>None</td>
</tr>
<tr>
<td>ET67</td>
<td>2.68</td>
<td>CO</td>
</tr>
<tr>
<td>ET42</td>
<td>3.61</td>
<td>Unobservable</td>
</tr>
<tr>
<td>ET31</td>
<td>6.97</td>
<td>CC</td>
</tr>
<tr>
<td>ET69</td>
<td>9.50</td>
<td>CC</td>
</tr>
<tr>
<td>T70</td>
<td>1.06</td>
<td>CO</td>
</tr>
<tr>
<td>T18</td>
<td>1.68</td>
<td>None</td>
</tr>
<tr>
<td>T36</td>
<td>2.73</td>
<td>CO</td>
</tr>
<tr>
<td>T23</td>
<td>3.11</td>
<td>CO</td>
</tr>
<tr>
<td>T30</td>
<td>5.17</td>
<td>None</td>
</tr>
<tr>
<td>F12A</td>
<td>5.64</td>
<td>None</td>
</tr>
<tr>
<td>F11A</td>
<td>8.85</td>
<td>None</td>
</tr>
<tr>
<td>T33</td>
<td>13.0</td>
<td>None</td>
</tr>
<tr>
<td>T32</td>
<td>21.9</td>
<td>CO</td>
</tr>
</tbody>
</table>

Note: Data from Montgomery et al. 2010.

health issues in the Empire (e.g., Nriagu 1983; Waldron 1973). Lead poisoning can cause hemolytic anemia, which can in turn result in PH lesions on skeletons. Using data from Montgomery et al.’s (2010:206) study of 7 individuals from Castellaccio Europarco and 10 individuals from Casal Bertone, it is possible to correlate lead concentration with presence of PH (see Table 9.7). Considering a safe limit for lead in the blood is about 0.5 mg/kg (Montgomery et al. 2010:207), Figure 9.4 shows that 4 of the 5 individuals with PH were likely exposed to high levels of lead as children, possibly in addition to a different pathogen load in their home environment. Further, all 7 individuals who had PH and who were tested for lead concentration (ET67, ET31, ET69, T70, T36, T23, and T32) had unsafe levels of lead in their teeth, ranging from 1.06 mg/kg to 21.9 mg/kg, suggesting that hemolytic anemia caused by lead poisoning could have resulted in PH lesions. However, there is an equal split between individuals with high (greater than 1 mg/kg) lead concentrations: 7 of those individuals have PH, while 7 others (ET72, T18, T30, F12A, F1A, F11A, and T33) had no evidence of PH. While lead poisoning is likely a factor in development of PH in the population of Imperial Rome, it is not the only etiology. Perry (this volume) similarly found that colonialism in early Byzantine Faynan and Aila in Jordan cannot be the only explanation for health outcomes, but that other factors such as
environmental pollution from mining activities likely contributed to childhood stress and poor health.

**Stress and the Suburbium**

It is likely that the disease ecology of the seven hills of Rome and the *suburbium* was strikingly varied. Poorer inhabitants tended to live and work in the marshier, lower-lying areas of Rome without as good access to clean water (Sallares 2002). These individuals would have been at high risk of contracting malaria or another parasitic infection, and many may have suffered from nutritional deficiencies owing to inconsistent access to food (Garnsey 1991). Immigrants to the Imperial capital introduce another level of complexity to the question of overall health. An additional factor in the development of anemia and therefore PH is the metabolic imbalance and consequential hemolytic anemia caused by ingesting too much lead.

Many of the individuals buried in the Roman *suburbium* were obviously systemically stressed. Consistently, the previous interpretation of indicators of physiological stress in Imperial Rome has been malaria and poor diet (Buccellato et al. 2003; Catalano et al. 2001; Cucina et al. 2006; Facchini et al. 2004; Gowland and Garnsey 2010; Gowland and Redfern 2010; Salvadei et al. 2001), but it is clear that significant diversity exists within the bioarchaeological remains of the Roman *suburbium* and that discerning the interrelated causes of that diversity will be challenging. Compared to contemporary health outcomes, it is possible to conclude that life in Rome was nasty, brutal, and short, but the reality is much more complex, and additional bioarchaeological analyses of PH and DEH, as well as other pathological indicators, are necessary to better understand health in Imperial Rome.

**Conclusions**

With its high population density and lack of proper hygiene, Rome during Imperial times has long been considered a *pathopolis*, a city of mortal suffering in which the *plebs urbana* was disproportionately affected (Mumford 1961). This palaeopathological and demographic assessment of individuals buried at periurban Casal Bertone and at suburban Castellaccio Europarco, however, has shown that some people did live short lives, some suffered significant health stress, but some lived beyond their fifties and others had seemingly good health until their death. This heterogeneity in health outcomes means that the common perception of life in urban Rome as one
full of violence, stress, and disease is simply not the only story given the osteological evidence. Understanding the variation in health and the disease load of the population of this massive preindustrial urban center is complicated by geography, disease ecology, diet, and genetic variation, as well as by inconsistent reporting of osteological data in the bioarchaeological literature.

The lives of the lower classes were complex, and people living in Rome and its suburbs had wide-ranging, heterogeneous experiences in the urban center. To the extent that these experiences are written on their bodies, we can start to explore questions of differential exposure to pathogens, levels of physiological stress, and health outcomes through the palaeopathological record of Rome. Future studies of both Republican and Imperial cemetery samples would therefore benefit from more complete palaeopathological analyses and reporting of the indicators of stress found in human skeletons from the suburbium of Rome. Additionally, further information on lead usage and its effects on Roman bodies, the distribution of fresh water via aqueducts, the topography and disease ecology of Rome, and the genetic background of the Roman population may contribute to a better understanding of the quality of life of all residents of this important Imperial capital.

Acknowledgments

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Notes

1. Ongoing research into large amounts of feces found in sewers at Pompeii and Herculaneum (e.g., Sullivan 2010), however, may soon generate a new line of information about pathogens and diseases that were present in Imperial Italy.

2. See, however, examples from around Italy such as Salvadei et al. 2001, Macchiarelli and Salvadei 1994, and Fornaciari et al. 1989.

3. See Killgrove 2013 for strontium and oxygen isotope results from the Republican phases of burial.

4. New research is forthcoming from the recently excavated Imperial cemetery in the city center of Gabii, which similarly has a low frequency of pathological conditions (Killgrove 2012).

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