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The Invisible Hunger: Is Famine Identifiable from the Archaeological Record?

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Abstract

Famine, as defined by an acute (short-term) or chronic (long-term or cyclical) period of starvation, is identifiable in the historical period from written records and potentially with archaeological corroboration, but in prehistory other approaches must be employed. Several of these are discussed including studies of diet and nutrition, paleodemography, environmental catalysts, and funerary ritual. Despite a multifactorial analysis integrating palynology, dendrochronology, stable isotope analyses, osteoarchaeology, and social archaeology, difficulties in contemporizing paleodemographic events them with osteological assemblages are substantial enough that the detection of a famine is not possible solely from the archaeological record. More significant is the conclusion that all apparent indicators for acute or chronic starvation are also representative of epidemic disease. Because of this uncertainty, it is not possible to identify famine in prehistory.

Keywords

palaeodiet, prehistory, bioarchaeology, palaeodemography, palaeopathology

Introduction

Few circumstances affect a population as completely as a famine: social structure and behaviors are subjected to intense pressure as individual and collective health is compromised (Chamberlain 2006; Scrimshaw 1987; Torry 1984). Individuals and groups abandon what is typical and familiar to change diets and emigrate, thereby experiencing additional physical and psychological stress (Dirks 1993; Mokyr and Ó Gráda 2002; Scrimshaw

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1987). Even isolated from the socially disruptive precursors to a period of starvation, historically often a result of political upheaval, such an event puts severe stress on the affected population and its neighbors, on social and biological processes (Scrimshaw 1987; Torry 1984).

Although a potential source of information regarding human adaptation to a dynamic environment, as a distinct event famine is difficult to define and identify even in modern populations. At what point does malnourishment, hunger, or starvation become famine? For the purposes of this article, famine has been categorized into two types based primarily on biological processes: acute and chronic. Acute famine occurs over a brief period of up to several months as a single occurrence; the chronic form is exemplified by regular starvation over more than a year, either a steady period of dearth throughout or exacerbated by cyclical seasonal insufficiencies (aka hungry seasons), socio-political unrest, *et cetera* (Newman 1962; Scrimshaw 1987). Note that this may but does not necessarily include malnutrition: a malnourished individual is not necessarily undernourished (Mokyr and Ó Gráda 2002). Whereas malnutrition is a deficiency in vitamin or mineral requirements, undernutrition is a deficiency in caloric requirements; an undernourished individual is very likely to be malnutrient but this is not necessarily true for the opposite. In addition, although others have specified the cause(s) of starvation as a part of their classifications (Dirks 1993, Scrimshaw 1987), here evidence for some natural stimuli will be examined but famine has been largely characterized by its effects rather than its causes. This is because this paper is intended as a survey examining the biological effects of prolonged starvation upon societal and individual behaviors and environmental interactions.

The identification of past periods of famine is simplest from documentation. Parish records, personal or public accounts, tax records, grain prices, immigration lists, and other sources serve to identify periods of extreme dearth, either throughout a population or restricted to specific socio-cultural groups (Appleby 1973). Prehistoric investigation must be derived from the archaeological record: changes in foodstuffs or funerary ritual, the presence of growth-arrest lines or malnutrition markers on the skeleton, and fluctuating demographic profiles are representative of systemic stressors. Expected rates for some types of evidence (such as an increased attritional mortality profile) may be compared to more recent and clearly famine-afflicted populations as an ethnoarchaeological approach (Chamberlain 2006; Razzaque et al. 1990; Scrimshaw 1987).

Forms of Evidence

How is famine identified in historical contexts except from documentation? There are a number of known social and biological reactions which can be examined in a prehistoric population including malnutrition, undernutrition, stunted growth, epidemic disease, drastic changes in foodstuffs and funerary rituals, and fluctuating demographic profiles (Chamberlain 2006; Chandra and Newberne 1977; Dirks 1993; Mokyr and Ó Gráda 2002; Scrimshaw 1987; Torry 1984). The breakdown of social norms affects everything from hygiene and food preparation to the incidence of suicide and interpersonal violence as individuals become more desperate for sustenance (Dirks 1993; Mokyr and Ó Gráda 2002; Scrimshaw 1987). Prehistoric sources have been divided into environmental stimuli (affecting the natural availability of foodstuffs), diet (what is consumed), osteology (skeletal effects of what is consumed and related pathologies), demography (how these affect population dynamics), and funerary ritual (the social response to an increase in mortality). Definite socio-political precursors are rarely identifiable from the archaeological record and do not necessarily result in starvation; they have therefore not been considered here.

Environmental Impetus

Sudden environmental change can induce social, biological, and ecological upheaval and greatly influence human and animal food sources (Newman 1962; Scrimshaw 1987). Famines in Ethiopia and the Sahel resulted from drought, in medieval England from excessive rainfall, and in Scotland from low ocean temperatures, but flood, earthquake, volcanic eruption, and extreme or unseasonable temperature fluctuations can also severely affect flora and fauna, potentially provoking a period of starvation (Dirks 1993; Roberts and Cox 2003; Scrimshaw 1987). Climate changes can also induce pest infestation which can affect hygiene as well as food sources or stores (Scrimshaw 1987).

Tree rings, ice cores, fluvial and lava deposits, and char lines may permit the contemporization of flood, drought, fire, or volcanic eruption with an assemblage but neither crop failure nor starvation are dependent solely on natural catastrophic stimuli (Dincauze 2000; Scrimshaw 1987). Indeed the social reaction to such events (among others) is exceedingly variable from one population to the next and this likely plays a far more substantial role than that of the event itself.

Diet

Although affected by socio-political, environmental, pathological, and other stimuli, famine is characterized by a deficiency in food intake and so diet is the key point of investigation. Prehistoric diet is assessed with a number of archaeological foci, chiefly palynology, zooarchaeology, paleocoprology, and stable isotope (see below) and residue analyses (Dincauze 2000; Edwards 1998; Legge et al. 1998; Outram 2000). The fundamental aim in considering such studies in this context is to identify a drastic change in diet as a reflection of the collapse of social tenets due to the inability of an individual to meet the biological imperative to sustain itself and its offspring (Torry 1984). Such circumstances have resulted in cannibalism, infanticide, and the consumption of biologically toxic and/or socially prohibited foodstuffs (Dirks 1993; McKeown 1985; Mokyr and Ó Gráda 2002; Scrimshaw 1987; World Health Organization 1991). In 1920-1 starving Russians made bread "*from leaves, the barks of the birch and elm, sawdust, nut shells, rhubarb, rushes, peanuts, straw, potato peels, cabbage, beet leaves, and even horse manure,*" followed by "*eating dogs, cats, rats, roots, skins, bones, and all manner of refuse;*" surplus corpses from typhus outbreaks were stolen, boiled, and consumed (Scrimshaw 1987:12). During the Great Potato Famine in Ireland those affected "*ate decomposing carrion as well as nettles, carrageen moss, and corn-weed*" (Mokyr and Ó Gráda 2002:341). Dando asserts that famine in Pharaonic Egypt was so severe "'*that everyone had come to eating his children*'" (Scrimshaw 1987:3). Although many of these substances are in fact quite nutritious, they were not conventionally classed as foods by the respective societies under usual circumstances.

Unfortunately archaeological contexts do not provide such detailed information. Paleocoprology produces the most realistic evidence and so latrine fills, especially those shared by large groups, should be analyzed in great detail; where intestinal contents are preserved they should be subject to similar scrutiny (Roberts and Manchester 2005). Specific components may be identified and compared with known availability although the presence of atypical foods – such as uncommon plants which may be designated as weeds – may be more indicative of contamination or spicing rather than inclusion of these components into the diet as emergency resources (Robinson 1987). The best-preserved samples are often carbonized or charred but these are unlikely to realistically gauge the prevalence of a species; moreover, if starvation has resulted in the processing and consumption of vegetation usually used for fuel or animal fodder, this will of course be indistinguishable (Dincauze 2000; Legge et al. 1998; Scrimshaw 1987).

Residue analyses from objects involved in food processing, although in greater abundance than coprolite samples, can present only tentative conclusions at best because the processing of a substance does not ensure that it was consumed by the individuals or population under consideration (Dincauze 2000; Rice 1996). Floral and faunal remains, even in midden and food processing contexts, have similar restrictions. It is therefore of utmost importance that the fullest possible picture be derived from several independent sources and methods in order to avoid conflict between interpretations. A lack of awareness of the shortcomings of various methods and reconciliation of their myriad results can easily produce schisms between isotopic approaches and contextual archaeological conclusions; disagreement between different forms of evidence has led to issues worldwide, notably for studies regarding maize dependence in the Mississippi valley (Buikstra and Milner 1991) as well as marine food sources in South Africa (Parkington 1991).

Pollen, seeds, and other micro- and macroscopic plant remains have been used to map woodland clearance and the development of agriculture (Dincauze 2000; Edwards 1998). The presence or absence of domesticated plants as a primary food can have distinct effects on indicators of under- and malnutrition within a population (see below) and so indicate whether the diet consumed at certain periods in vivo was sufficient or not (Roberts and Manchester 2005). In addition, although nomadic hunter-gatherers may have access to a more diverse pool of available resources than stationary agriculturalists (despite domestication to some degree by the latter providing more stable food resources), neither lifestyle may supply all nutritional requirements (Bollet and Brown 1993; Roberts and Manchester 2005; Scrimshaw 1987). This is well-demonstrated by the nomadic population of the Sahel: prior to the end of their itinerant lifestyle regular droughts were handled "*by migrating from one region to another and thereby avoiding overgrazing their herds,*" but drought following political divisions restricting movement resulted in famine in 1984-5 as new subsistence technologies had not yet progressed to the degree required for resource stability (Scrimshaw 1987:6-7). Where self-sufficient systems are in place however the risk of susceptibility to a food crisis in general is approximately equivalent between nomadic hunter-gatherers and stationary agriculturalists (Benyshek and Watson 2006).

Zooarchaeological analysis can yield additional details. Butchery and defleshing cuts on bone from midden or food processing contexts are potential sources of domestic and wild food animal assemblages (Legge et al. 1998).

The most information may be gleaned from domesticated assemblages: atypical dental microwear, growth-arrest or malnourishment indicators (as in humans, see below), low robusticity, and premature butchering during an isolated period may be diagnostic of an increased need for immediate provisions of the associated human population (Cachel 2000; Chandra and Newberne 1977; Legge et al. 1998; Scrimshaw 1987). Perimortem fractures well-suited for marrow recovery in both animals and humans, if unusual, may imply an additional emergency measure for obtaining protein (McKeown 1985; Outram 2000).

In addition disease is a consideration for local flora and fauna as well as humans: epidemic disease will affect a mal- or undernourished animal the same as a human (McKeown 1985). Dependency upon affected animals for food may induce a famine incident in a human population: this occurred with a fatal cattle plague (Rinderprest) in Ethiopia in 1882-92, which affected approximately ninety percent of cattle and wild animals, severely limiting the primary food resources for human populations in the region (Scrimshaw 1987). The Great Potato Famine of Ireland (1846-7) is a similar example of dependence upon a food source suffering from epidemic disease, albeit floral (Mokyr and Ó Gráda 2002; Scrimshaw 1987). Aside from dependency there is also the possibility of zoonotic (animal-vector) disease which may not only deplete food animal stocks but also induce significant illness in humans, itself potentially resulting in a period of starvation due to decreased productivity and increased nutritional need (Dincauze 2000; Dirks 1993; Newman 1962; Roberts and Cox 2003).

In short, where there is an apparent considerable deviation from the typical diet for a distinct brief period it may be possible to interpret this period as one of acute famine. This is not inclusive of a regular but malnutrient diet: food and food ritual are subject to socio-cultural conventions and the nutrition requirements identified by modern medicine are not necessarily those acknowledged by past populations or even universally by modern ones (World Health Organization 1991). Lack of consideration for such social behaviors could easily result in the misdiagnosis of chronic famine identified from long-term malnutrition without representing the devastating social impact epitomized by the term.

Osteology

Physical and psychological stress is manifest on the system of an individual in life and can be assessed after death and skeletonization; starvation on individual and population-wide scales is responsible for both forms (Dirks 1980 and 1993; Hart 1993; Humphrey 2000; Mokyr and Ó Gráda 2002; Newman 1962; Roberts and Manchester 2005; World Health Organization 1991). Anemia, scurvy, rickets and osteomalacia, and osteopenia and osteoporosis are all evidence for malnourishment although they are somewhat prevalent even in modern populations with sufficient caloric intake (Bollet and Brown 1993; Chandra and Newberne 1977; French 1993; Humphrey 2000; Keenleyside and Panayotova 2006; Newman 1962; Roberts and Manchester 2005; Steinbock 1993; World Health Organization 1991). More generic indicators of systemic stress include enamel hypoplasia, Harris (retarded growth) lines, decreased robusticity and stature, and nonspecific periostitis, all of which can contribute to an understanding of the overall health of an individual but are too ambiguous for etiological diagnosis (Humphrey 2000; Newman 1962; Roberts and Manchester 2005; World Health Organization 1991).

Severe caloric deprivation is often accompanied by opportunistic epidemics which may themselves produce osteological reactions; unfortunately the most common of these (typhus, dysentery, and malaria) are osteologically invisible (Carmichael 1985; Chandra and Newberne 1977; Dirks 1993; Roberts and Manchester 2005; Scrimshaw 1987).

Overshadowing such speculation is the osteological paradox: a particularly potent stress (e.g., trauma or infection) will result in either a successful or unsuccessful reaction by the system (Wood et al. 1992). The stress will either overcome (death), be maintained (chronic or prolonged illness or stress), or be overcome (recovery) by the system; the first will not be identifiable osteologically whereas the latter two can produce reactions such as periostitis (Roberts and Manchester 2005; Wood et al. 1992). Thus those individuals assumed to be more diseased maintained or recovered from their stressors whereas those without such indicators may have died either from a stress not reflected by the skeleton or too quickly for an osteological reaction to occur (Wood et al. 1992). Thus it is virtually impossible to distinguish between a rapid death from soft tissue trauma and that from plague.

Nutritional deficiencies are dependent upon absorption during digestion and consumption as determined by environmental and social availability. For instance, cribra orbitalia and porotic hyperostosis are recognized signs of anemia but this can be a result of dietary iron deficiency, thalassemia, sickle-cell anemia, parasitic infestation, or neoplastic and genetic disorders affecting iron or vitamin B12 absorption; anemia is also not uncommon in recently-weaned infants, women (due to menstruation), or stationary agriculturalists (Bollet and Brown 1993; Keenleyside and Panayotova 2006; Newman 1962; Roberts and Manchester 2005; Stuart-Macadam 1998; Walker et al. 2009; World Health Organization 1991). Due to such a broad range of etiologies, it is unrealistic to presume that malnutrition is the result of an unavailability of sufficient calories in addition to that of the specific vitamin or mineral.

Finally, comprehensive studies of human remains themselves include stable isotope analysis. Strontium, carbon, nitrogen, oxygen, and sulfur isotopes are used to track migration (discussed below) and consumption of vegetation types and levels and sources of protein (Dincauze 2000; Edwards 1998; Richards et al. 2001; Roberts and Manchester 2005). Carbon, nitrogen, and sulfur isotope ratios can elucidate whether an individual or population was dependent on marine or terrestrial, freshwater or saltwater protein and C3 or C4 plants (Dincauze 2000; Richards et al. 2001). Although the most accurate method for portrayal of dietary composition, isotopic study is not suited for assessment of starvation: an insufficient or comparatively low protein intake, for instance, does not necessarily indicate chronic starvation. Instead such results are more likely to reflect the substantial social component inherent in food and nutrition without being able to classify a depressed ratio as the result of starvation.

Specific attempts to identify carbon and nitrogen abundance ratio differences for famished individuals from the 30 Years' War was unsuccessful as it was not possible to distinguish famine from pre-famine levels (Nehlich 2006). Bone reflects long-term patterns: perhaps in shorter-term deposits (such as hair or fingernails) abundance levels reflecting a period of starvation could be isolated (Nehlich, letter to author, May 7, 2009). One of these very few studies utilizing hair identified patterns of high levels of nitrogen with low levels of carbon followed by low levels of nitrogen with high levels of carbon in severely anorexic individuals prior to and then following the onset of nutritional therapy, respectively (Neuberger et al. 2009). These levels were due to catabolism of first protein cells (such as muscle) after the body's fat deposits were exhausted followed by the restoration of a balanced diet and replenishment of fat stores (Neuberger et al. 2009). In a different context however, one without knowledge of soft tissue changes or dietary history, this fluctuation could be similarly explained simply as a diet with variably dominant foodstuffs and not necessarily as undernutrition severe enough to result in protein catabolism, which occurs in both acute and chronic events.

Demography

Paleodemography reconstructs the age and sex structure of a population and can estimate dynamic population reactions to known stimuli such as a baby boom or mass migration (Chamberlain 2006). Despite this, using it to help identify a prehistoric period of extreme hunger is improbable, primarily due to imprecise dating techniques. In the unlikely instance that a pinpointed demographic profile is possible, there are several identifiable patterns exhibited by the mortality profile and birth and conception rates (Boyle and Ó Gráda 1986; Chamberlain 2006; Kidane 1989; Razzaque et al. 1990).

The mortality profile is the most obvious starting point when working with an osteological assemblage. Instead of a catastrophic mortality curve (high rates of death for young adults) famine tends to produce an increased attritional curve (peaks in the youngest and eldest groups), although those of young children and the elderly may be either artificially protected or comparatively excessive (Chamberlain 2006; Dirks 1993; Grayson 96; Scrimshaw 1987). In the Punjab in 1939, for instance, child mortality rates rose by 192 percent and the elderly by 288 percent whereas morbidity for those aged between 10 and 60 dropped 14 percent (Dirks 1993). Conversely, famines in 1984-5 Darfur and late 19th century India showed a comparatively lower curve for juveniles (Chamberlain 2006). Sex may also be a factor, with males usually at a disadvantage, although this is not always the case: famines in Russia (1892) and Ireland (1846-7) caused no such distinction, and women in Finland (1868) were slightly more susceptible (Mokyr and Ó Gráda 2002). Increased female survival may be attributable to their greater stores of subcutaneous fat allowing them to survive starvation for a longer period of time (Grayson 1996).

Conception and birth (fertility) ratios are valuable indicators of health in breeding-age females: a healthy rather than malnourished mother is far more likely to produce and maintain a healthy baby (Dirks 1980; Hart 1993; Newman 1962; Razzaque et al. 1990). Infants conceived or weaned during a period of famine are at the highest risk of mortality post partum, and those carried to term in severely undernourished mothers may not survive birth (Newman 1962; Razzaque et al. 1990). Fertility rates drop roughly one year into the famine period resulting from a decline in spermatogenesis, the onset of amenorrhea, and the inability to sustain a fetus to term; this decline continues until approximately one year after the end of the crisis (Boyle and Ó Gráda 1986; Chamberlain 2006; Kidane 1989). After this point there is usually a considerable increase, as occurred following the Dutch

Hunger Winter, 1985 in Ethiopia, and famines in medieval England (Chamberlain 2006; Kidane 1989; Roberts and Cox 2003; Scrimshaw 1987). Such increase may be biological insurance against a similar emergency but also results from the redistribution of social pairs (i.e., remarriage) and the recovery of health which includes an increase in spermatogenesis and an end to amenorrhea (Dirks 1980 and 1993; Kidane 1989; Roberts and Cox 2003).

A crucial factor in the generation of demographic tables is migration, the only way for individuals to enter or leave a defined system (population or assemblage) apart from birth and death. Although strontium, oxygen, and sulfur isotope analyses can sometimes identify the immigrants within an assemblage, not all immigrants are from an area with different background isotope ratios (Richards et al. 2001; White et al. 1998). In addition, not only is it virtually impossible to identify emigrants from the archaeological record, emigration is common in a famished population as part of the search for resources (Chamberlain 2006; Kidane 1989; Mokyr and Ó Gráda 2002; Scrimshaw 1987). Settled populations become nomadic, rural become urban, and individuals and groups travel great distances in the pursuit of sustenance (Scrimshaw 1987). Forced emigration or deportation was also used in ancient Rome and more recently in Nigeria as a response to food crises; medieval Europeans traversed the continent following (or being followed by) the plague; Russians and the Irish fled to the United States (Mokyr and Ó Gráda 2002; Roberts and Cox 2003; Scrimshaw 1987). Because emigration is more likely to occur in starvation circumstances (and in greater numbers) than when there are no constraints on communal resources, it would behoove any paleodemographic study to be alert for unexpected increases in neighboring populations.

Funerary Ritual

Funerary ritual is a valuable source of information because it is investigated with both biological and cultural anthropological approaches. This particular context also requires a practical perspective: epidemic starvation (and affiliated disease) produces an excess of corpses which must be disposed of quickly lest hygiene further deteriorate, and frequently by those in similarly energy-deficient states themselves. A less energy-intensive ritual or disposal pathway is the most efficient way of handling a sudden increase in mortality: during the Athenian plague (430-426 BC) for example, cremation overtook inhumation as the predominant method of disposal and traditional funerary monuments and rituals were greatly restrained in order to save time, space, and resources (Garland 1985; Humphreys 1980). In addition mass graves, a period of intensive burial, conservation of space or overcrowding, and/or an absence of the usual personal effects or grave goods are also common indicators of such events. These features are commonplace in English plague burials as well as those in famished Russia (Appleby 1973; Scrimshaw 1987). A change in burial ritual may also result in a significantly increased rate of neonates and infants – these are often uncommon in recovered assemblages due to an estimated variation in funerary ritual and greater susceptibility to taphonomic damage – which may itself be misinterpreted as a substantially higher morbidity for these age groups even after accounting for the increased attritional rate typical of an acute famine event (Hart 1993; Razzaque et al. 1991).

Socio-cultural pressures separate from a sudden increase in corpses may also be expressed via funerary ritual. Unfortunately the interpersonal violence and increase in suicide often recorded in historical famine contexts is only speculative in prehistoric populations, but as either a chronic or acute event famine affects social ritual, of which funerary practices are a part (Dirks 1993; Torry 1984).

Case Study: Neolithic Japan

Prehistoric Japan has been extensively studied and published (Habu 2004; Imamura 1996; others) with a major focus on reconstruction of diet (Akazawa 1982; Yoneda et al. 2004; others). A multidisciplinary approach relying on settlement and landscape archaeology, paleoclimate, osteology, isotopic analyses, and paleodemography has produced a picture of dynamic subsistence strategies in response to a varying landscape and resources in the Jomon period prior to the introduction of rice agriculture (Hoover and Matsumura 2008; Temple 2007). In particular the population crash in the Late/Final Jomon period (c. 4,000-2,000 BP), concurrent with climate change and a shifting coastline, has spawned intensive investigation into contemporary subsistence and nutrition changes (Hoover and Matsumura 2008; Temple 2007). Two studies (Hoover and Matsumura 2008 and Temple 2007) have performed in-depth and comprehensive assessments of this and the previous and following periods with regard to nutrition and subsistence. Both utilize linear enamel hypoplasia (LEH) as an indicator of nutritional stress, with Hoover and Matsumura (2008) also including fluctuating asymmetry as evidence of pathological developmental instability and Temple (2007) using caries rates to better understand the change in diet. Temple's (2007) findings indicate increased systemic stress in a population more reliant on floral resources in comparison to a marine-dependent population (indicative of periods of chronic resource inadequacy), and Hoover and Matsumura (2008) found a decrease in nutritional stress throughout the population crash (indicating an end to a period of chronic resource insufficiency).

Both papers make convincing arguments for their cases albeit with a fatal flaw: the consideration of LEH as an indicator of nutritional stress. Although studies do indicate that LEH can occur as a result of nutritional deficiency, pathological, psychological, and traumatic systemic stress may also be the culprit (May et al. 1993; Nikiforuk and Fraser 1981; Roberts and Manchester 2005). In such a light Hoover and Matsumura's (2008) results indicate only that cumulative developmental systemic stress, not necessarily nutritional stress, was unchanged throughout this transitional period.

Temple (2007) goes further to conclude that higher rates of LEH in the plant-dependent population indicate (likely seasonal) chronic resource inadequacy in comparison to the marine-dependent population in the Middle/Late Jomon period. The subsequent Late/Final Jomon period assemblages (still prior to the introduction of wet-rice agriculture) however present significantly higher caries rates than the previous era (10.1% compared to the Middle/Late 3.7%), suggesting an increase in carbohydrate dietary components following changes in climate and coastline (and so reduced accessibility to marine resources), but the frequency of LEH remains constant (Temple 2007:1040). This contradicts the conclusion that floral-dependency is a less stable subsistence strategy than marine-dependency and reaffirming that LEH does not result solely from nutritional stress. As such it is still not possible to achieve a comprehensive understanding of nutritional sufficiency in this case despite long-term and large-scale interdisciplinary research.

Discussion

Consider a population which apparently represents (with the use of fantastic dating techniques) a discrete period of starvation as defined by the above criteria: its individuals are characterized by malnutrition, a diminished stature compared to earlier and later generations, growth-arrest signs, and a high attritional mortality. This population also briefly abandoned their elaborate funerary rituals at approximately the same time as a natural disaster, and there are signs of a change in diet and less efficient husbandry techniques. What, other than famine, could explain such a pattern? Unfortunately epidemic disease also fits these criteria: survivors may not achieve their full physiological potential, there is still an increase in deaths, and the desire to cure the sick and protect the healthy can provoke changes to diet and rituals associated with food and eating. Aside from disease alone there are also frequent associations between famine, warfare, disease, and mass migration with one another, and all may appear similarly in the archaeological record (Keenleyside and Panayotova 2006; Scrimshaw 1987).

Populations and Dating

Aside from the interchangeability of starvation and highly contagious disease in the archaeological record, the imprecision of dating in prehistory nullifies any attempt to contemporize incidents or processes; pinpointing dates in archaeology, with the exceptions of ice core and tree ring data, is only possible in very few select circumstances. This most affects demographic analysis: assemblages from prehistoric contexts are usually small and (except where representative of a catastrophic mortality pattern, which starvation does not directly cause) accumulated over a vague time period. In addition, even reasonably conclusive evidence associated with 20 percent of a cohort would not be confirmation of an epidemic crisis. Supplementing this disclaimer is the invisibility of certain groups, specifically children. Preservation is often responsible as is bias by funerary ritual: a 500 percent increase in stillborns will never be identified if each is simply laid out on a hillside. Older age groups are also not always correctly represented often due to modern bias (e.g., that the eldest individuals should be older than 60) and less accurate aging techniques leaving many such individuals assessed as adults of indeterminate age.

Even with a fully representative sample, contemporization is an obstacle. Dendrochronology and ice core analyses may differentiate between as little as one year or season but contextual and chemical dating in graves is not so precise. It is difficult if not impossible to contemporize the date of death with environmental occurrences when the latter occurred at some point within a given century. Acute famine requires still greater precision and yet is even less likely to be identified from other forms evidence.

Considerations of dating lead to additional questions: which deaths are the results of a food crisis? How long after the end of the crisis should deaths no longer attributed to it? Even infants conceived during such an event maintain a higher-than-average mortality rate for the two years following birth (Razzaque et al. 1990). Inhibited growth rates and an increase in adolescent disease are also linked with younger ages-at-death without interference from starvation (Roberts and Manchester 2005). Even social adaptations to famine can conceivably persist beyond living memory, long after they are a necessity for survival (Torry 1984). Is it reasonable to assume that there is ever an end point?

Other Interpretations

Chronic starvation is most likely to occur in populations with endemic malnutrition and so a discrete period of epidemic emaciation is often inseparable from this prolonged state (Chandra and Newberne 1977; Scrimshaw 1987). Despite the distinction both are often antecedents of opportunistic infectious diseases: a system weakened by mal- or undernutrition is simply more susceptible to disease and parasitic infection than a healthy one (Brothwell 1993; Carmichael 1985; Chandra and Newberne 1977; Dirks 1993; Scrimshaw 1987; World Health Organization 1991). Indeed the deaths associated with a specific famine are more often from the subsequent epidemics than the starvation itself (Mokyr and Ó Gráda 2002, Scrimshaw 1987).

Disease can itself cause an acute famine event should it affect the workforce responsible for food acquisition and processing: this instigates a downward spiral whereby there is less food for those with the highest need for sustenance and who therefore become weaker (Dirks 1993; Newman 1962). Chronic famine may in turn result not from fluctuating resource availability but rather fluctuations in parasite or infectious disease prevalences, which are often seasonal. Individuals fleeing such a situation frequently transport such illness with them and so migration becomes a vector for the spread of both disease and starvation without necessarily being identifiable paleodemographically (Appleby 1973; Stannard 1993). Illness can also be the result of substances sought out as dietary substitutions for inaccessible primary foods: rotting or diseased meat is often riddled with parasites and an additional vector for contagion; vegetation not usually consumed may not be so because it is toxic (Dirks 1993; Scrimshaw 1987; World Health Organization 1991). The end result is that deaths from starvation appear remarkably like those from widespread infection or poisoning because that is often the actual cause of death (Mokyr and Ó Gráda 2002; Scrimshaw 1987). As such there is no efficient way to distinguish the former from the latter.

Conclusions

Famine, chronic or acute, is not currently identifiable solely from the archaeological record: only where historical sources clearly identify widespread emaciation is such an assertion possible (Appleby 1973; Dirks 1993). Should the dating predicament be resolved with future technological advances, and in cases where diet is generally known for prehistoric societies, such as where there is evidence for large-scale agriculture or processing for the purposes of food production with concurrent evidence from isotopic analyses, etc., the identification of seasonal oscillation is not necessarily indicative of chronic famine, simply of cyclical dietary variation.

Possibly the most significant problem regarding dating, even with hypothetically perfected methods, is that deaths directly related to starvation may not take place during the period associated with it: a population socially and biologically affected as severely as to be identifiable in prehistory is unlikely to completely recover to pre-famine health, fertility, and practices in less than several years, and this predicament is insurmountable even by perfect dating methods. A multifactorial analysis considering numerous variables is also insufficient because of the very real possibility that disease, instead of or in addition to famine, induced the effects.

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