Supplemental Information

Revisiting Hohokam Paleodemography

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Dependency Ratios

In living populations, the dependency ratio is often conceived of as the ratio of nonworkers (consumers) to workers (producers), with the working age population typically counted as those between 15 and 60 or 65. It is acknowledged that the dichotomy is imperfect, as there is evidence from ethnographic studies in foraging and agricultural subsistence societies that juveniles under 15 do contribute at least in part to production (Bird and Bird 2000; Bock and Johnson 2004; Hawkes et al. 1995; Kramer 2005; Nag et al. 1978; Weisner and Gallimore 1977). Some archaeological studies have also explored the potential contribution of juveniles in craft production (Högberg 2008; Kamp 2001). Older community members can also play a significant role in childcare, likely enhancing group fitness. This phenomenon has been proposed as one explanation for the evolution of a lengthy post-fertile lifespan in humans (Levitis et al. 2013). Consequently, consigning the young and old to the category of consumers may overstate the burden placed on "working-age" adults, especially in traditional subsistence economies.

An adjustment to the definition of the dependency ratio is justified when applying this measure to skeletal samples rather than living populations. Weiss (1973:40–41) set the upper limit of producers at 50 years rather than 60 or 65 to compensate for the fact that standard osteological methods often underestimate the age of older adults. Therefore, the ratio likely does include some adults over the age of 50 who remained productive in past subsistence economies.

Life Tables and Hazards Analysis

Life tables were originally developed for use with census data to track the mortality experience of a cohort of individuals in equal age intervals from birth to death. Paleodemographers cannot assemble data on a true cohort of individuals born in the same year, but construct a virtual or instantaneous cohort represented by the numbers of individuals dying at specific ages in a cemetery sample (Chamberlain 2006:28). Yaukey (1985:112) uses the term *hypothetical birth cohort* and notes that the mortality schedule probably does not represent the experience of any actual cohort. This is especially useful to keep in mind when we employ archaeological samples that are aggregate collections extending over many lifetimes.

It should also be understood that statistics generated from life tables, such as life expectancies, are not estimates with associated ranges of error. They are simple mathematical values derived from the age-at-death information. Life tables will produce accurate assessments of past life experience assuming that certain assumptions can be met. First, it is assumed that the cohort includes all the individuals who died during a defined interval, or is a representative sample (Ubelaker 1989). In many cases, there is a possibility that certain age groups may be underrepresented in skeletal collections due to differential preservation. Second, it is assumed that the population growth rate is zero or at least the growth rate is uniform during the period in question (Chamberlain 2006). Accommodations can be made in a life table if the growth rate is known, but growth rate is usually a factor that we wish to discover.

One way to compensate for uneven representation of age groups in a skeletal collection and explore the effects of different growth rates is to use model tables derived from known cases in documented populations. In this approach, the skeletal data are matched with the closest curve and this essentially fills in the individuals in the missing age groups (Chamberlain 2006). One of the difficulties with this approach is that there is no rigorous method for selecting the most appropriate model table (Wood et al. 2002).

Hazards analysis is another type of model-bound approach that has gained the favor of paleodemographers. This method is based on a maximum likelihood probability density function produced from the skeletal age-at-death distribution (Frankenberg and Konigsberg 2006; Hoppa and Vaupel 2002; Wood et al. 2002; Wood et al. 1992). The estimated parameters from the probability density function can then be applied to a mortality model to develop familiar demographic estimates, such as hazard of death or survivorship at specific ages. Life expectancy at birth is estimated by integrating the survivorship function. Several different mortality models have been proposed. Wood et al. (2002) discuss the advantages of each model, which vary in the number of parameters used to fit age-at-death data. One of the prime advantages of hazards analysis is that it takes advantage of prior knowledge about the age distribution of human populations, applies this directly to the age distribution of the sample, and generates familiar demographic estimates.

A common problem encountered when constructing a life table from archaeological skeletal collections is that ages can rarely be estimated in the uniform, narrow age intervals required. Due to the vagaries of preservation, many individuals can only be assessed in broad ranges, such as 35–50 years. Consequently, intervals must be adjusted or individuals must be allotted in proportion to those with more specific age estimates, possibly magnifying error. An advantage of hazards analysis is that age ranges of differing precision can easily be accommodated in maximum likelihood estimation.

The model chosen for this study is the Mixed-Makeham model, which Wood et al. (2002) have demonstrated to be a good fit for paleodemographic mortality. The probability density function for the mixed-Makeham model is given by

$$f_0(a) = p \exp\left[-\alpha_1 a + \frac{\alpha_3}{\beta_3}\left(1 - e^{\beta_3 a}\right)\right]\left[\alpha_1 + \alpha_3 e^{\beta_3 a}\right]$$

$$+(1-p)exp\left[-\alpha_2 a + \frac{\alpha_3}{\beta_3}\left(1 - e^{\beta_3 a}\right)\right]\left[\alpha_2 + \alpha_3 e^{\beta_3 a}\right]$$

and the survivorship function by

$$S(a) = p\ exp\left[-\alpha_1 a + \frac{\alpha_3}{\beta_3}\left(1 - e^{\beta_3 a}\right)\right]$$

$$+(1-p)exp\left[-\alpha_2 a + \frac{\alpha_3}{\beta_3}\left(1 - e^{\beta_3 a}\right)\right]$$

where $f_0(a)$ is the age-specific probability density function, p is the proportion of the population in the high-risk group, 1-p the proportion in the low-risk group, and $S(a)$ is age-specific survivorship. Parameters α and β define the magnitude and shape of the curve, respectively. Parameters and life expectancies were estimated with Holman *mle*, version 2.1 (Holman 2003).

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