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Author(s): Robert S. Corruccini, Elizabeth M. Brandon, Jerome S. Handler

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INFERRING FERTILITY FROM RELATIVE MORTALITY IN HISTORICALLY CONTROLLED CEMETERY REMAINS FROM BARBADOS

Robert S. Corruccini, Elizabeth M. Brandon, and Jerome S. Handler

Fertility (crude birth rate) was estimated from skeletal and corresponding historical relative mortality ratios for a seventeenth- to eighteenth-century Barbados slave population. The estimates varied widely among themselves according to which data source and mortality ratio was used; they also varied from the actual historical fertility rate. In addition, we have raised logical objections to the use of stable model life tables for inferring nonstable vital rates in archaeological populations. These points are problematic for the broad use of relative mortality to infer relative fertility.

La fertilidad (índice de natalidad bruta) de una población de esclavos en la Barbada, para los siglos XVII al XIX, fue calculada por los esqueletos y por la proporción de mortalidad histórica relativa correspondiente. Los cálculos varían mucho entre sí mismos, según la fuente de datos y la proporción de mortalidad usada; también varían del índice real de nacimientos. Además, hemos hecho objeciones lógicas contra el uso de tablas de modelos de vida estables para inferir índices vitales no estables en las poblaciones arqueológicas. Estos son aspectos problemáticos ante el amplio uso de mortalidad relativa para inferir fertilidad relativa.

Bocquet-Appel and Masset (1982) have strongly challenged the feasibility of conventional skeletal paleodemographic studies. They especially note the probably ubiquitous problem of differential proportions of misclassified ages (which negates the interpretability of inferred vital rates), rather than attacking the general value of aging individual remains. They also suggest that *historical* demography provides the only objective check on skeletal demographic findings, and that it is the proper basis for validation; they cite some historical/skeletal comparisons showing disparity. These points are not addressed in an entirely direct manner by van Gerven and Armelagos (1983) in their hasty reply in defense of this type of study (see Bocquet-Appel and Masset 1985).

Buikstra and Konigsberg (1985) also present a diverse array of analyses addressing paleodemography's critics, basically finding evidence that could serve both camps in different ways. Buikstra and Konigsberg are optimistic regarding new skeletal/dental aging methods that still are being validated. Buikstra et al. (1986) are especially optimistic regarding fertility estimation. This follows earlier comments made by Bocquet-Appel and Masset (1982) and by Sattenspiel and Harpending

Robert S. Corruccini, Elizabeth M. Brandon, and Jerome S. Handler, Department of Anthropology, Southern Illinois University, Carbondale, IL 62901

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(1983) that average skeletal age at death (and age-specific death-rate profiles) are, rather contradictorily, more predictive of birth rates (fertility) than of death rates or patterns.

Our analysis (Corruccini et al. 1982) of slave cemetery remains from Barbados has gone unnoticed in these debates. We were able to contrast skeletally inferred vital rates for 101 slaves interred over about 160 years, with adequate records of actual deaths by age from the later period of slavery at Newton Plantation. As far as we are aware, this is the only instance of very specific historical records pertaining to recovered and demographically analyzed skeletal remains (Bocquet-Appel and Masset [1982] cite the contrasts between less specifically associated historical/skeletal data from Europe). Our results do not promote paleodemographic optimism. Age-specific mortality is underestimated very heavily for infant and child categories while young-to-middle-adult age classes yield excessive mortality estimations. While these are the usual problems with skeletal paleodemography (e.g., Weiss 1973), conscious efforts to adjust for expected underaging of older remains do not suffice to correct the bias. African ethnographic analogy helps account for some of the missing younger remains (although without historical confirmation from Newton Plantation itself; see Corruccini et al. [1982: 455–456]; Handler and Lange [1978]). This is not the perfect osteological series for correlation with these historical data, because preservation is poor. The copious dental remains, however, allow good age estimation within the 5–14 age group that is critical to comparison of the Bocquet-Appel/Masset and Buikstra et al. techniques.

In this report we apply historical data from Newton Plantation to an examination of fertility inference from the mortality profile of the associated skeletal remains. This analysis will provide some perspective on select portions of Buikstra et al.'s (1986) rationale.

NEWTON SLAVE DEMOGRAPHY

For 23 of the years from 1796 to 1825, we have complete manuscript records for slave births, deaths, and total population at Newton sugar plantation (Newton Plantation 1796–1801, 1808–1825). Previously published age-specific mortality data (Handler and Lange 1978:Table 26) do not correspond precisely with birth and death data employed in this paper because we have used additional manuscript materials. These records probably are very accurate because the resident managers of Newton emphasized recording vital statistics for the benefit of absentee owners who were concerned economically (as were many other slaveowners in Barbados) with the stability and natural increase of their slave labor force. Although interments in Newton's slave cemetery probably extended from about the 1660s until the 1820s, we believe that most of the recovered skeletal remains date from the later part of the slave period. This conclusion is suggested by various interpreted trends in the growth and development of Newton cemetery (Handler and Lange 1978: 168–170), by the low frequency of inferred African-born individuals (Corruccini et al. 1987a, 1987b; Handler et al. 1982, 1986) when a higher ratio would be expected from the earlier periods, and by preservational factors favoring recovery of later burials in this shallow, commingled burial ground. The proportion of adults in the living slave population was 64.9 percent in the one early year with available records (1740), which does not differ significantly ($p > .10$) from the 56.1 percent shown from 1786 to 1795 and from 1796 to 1825. If we are reasonably correct about the relative lateness of most of the recovered skeletal remains, then they justifiably are comparable with the available historical data derived from manuscript materials of the late eighteenth and early nineteenth centuries.

These historical data indicate an average crude birth rate (CBR—the number of births within one year divided by that year's average population size) of about .037, whether calculated over the entire period or by yearly averages. This actual CBR is low—in fact, as in the Caribbean in general, historically too low for population replacement given the high mortality (Campbell 1984; Craton 1971, 1975, 1978; Eblen 1972; Farley 1965; Higman 1984; Kiple 1984; Kiple and Kiple 1980; Roberts 1952; Sheridan 1975). Observed CBR was contrasted with CBR predicted from two skeletal age-at-death indices: the number dying at age 30+ compared to those 5+ (Buikstra et al. 1986), and the number aged between 5 and 14 years compared to the total aged 20+ (Bocquet-Appel and Masset 1982). These indices are used because the calculation of mean ages of entire skeletal series is too fraught with inaccuracy.

Table 1. Crude Birth Rate (CBR) for Newton Slaves as Calculated from Historical Records and Estimated from Historical and Skeletal Mortality Ratios.

Method	CBR	Standard Error
Historically observed (overall)	.0370	.0024
Historically observed (annual average)	.0367	.0031
Historical D5-14/D20+	.0321	.0061
Historical D30+/D5+	.0523	.0059
Skeletal D5-14/D20+	.0242	.0061
Skeletal D30+/D5+	.0729	.0059

Note: A correlation of $\pm .83$ accompanied regressions of CBR on both types of relative mortality.

A predictive negative correlation between the death index (specifically, the proportion dying at a later age) and fertility rate or CBR is the basis of Buikstra et al.'s inference (based on 312 model life table rates from Coale and Demeny 1966). An analogous negative relation holds over time within the Newton slave population; $r = -.51$ among annual relative adult death and total birth rates. From 1817 to 1825, there was relatively less mortality among those in the 20+ group and higher fertility than obtained previously ($p < .002$). To gauge the entire period's mortality/fertility proportion, we extracted model life data from Weiss's (1973) 18 anthropologically based tables for life expectancy of 15-30 years and survivorship of .30-.40 at age 15. These were the only model tables that conceivably could fit the known Newton parameters. The proportions dying at ages 5-14, 5+, 20+, and 30+ were input along with D5-14/D20+ and D30+/D5+ ratios and CBR. Linear and log-transformed regressions and principal components analysis were calculated.

As an aside, two minor observations can be made. First, the major principal component (accounting for 79.4 percent of total variance) shows D30+/D5+ has the worst fit to the common axis with other variables (i.e., the lowest correlation with the major component: $r = -.54$) and the largest residual loading on the second component ($r = +.74$). In these data at least, that particular ratio does not coalign well with the joint variance of all others. Second, the nonlinearity of regression is significant for CBR on D5-14/D20+ (log-log slope = .756, significantly different from 1.0 at $p < .02$). This was not the case for regression on D30+/D5+. Thus the log-log regression model is slightly more appropriate in the D5-14/D20+ case for predicting CBR.

The two death-category ratios are calculated for the entire diachronic Newton population from historical data (Handler and Lange 1978:Table 26, and the additional data) and skeletal data (Corruccini et al. 1982:Figure 1), and are used to predict CBR according to the computed regressions (see Table 1). Notable discrepancies are seen on various levels of comparison. Skeletal and historical mortality data using D5-14/D20+ predict CBR values that are 35 percent and 14 percent underestimated, respectively, relative to the actual figure. The D30+/D5+ variable predicts CBR that is 97 percent overestimated for skeletal and 41 percent overestimated for historical data. Paucity of historical deaths between age 6-20 is a major reason for the discrepancies.

That the predicted CBR values are literally incorrect does not reflect negatively on the approach taken by Buikstra et al. (1986), which was to use the D30+/D5+ proportion on its own comparative grounds as an unspecified correlate of fertility. Also, the discrepancy between historically actual and historically predicted CBR is purely a function of the appropriateness of the model (i.e., the predictive relation contained within Weiss's [1973] particular model tables). Other aspects of the results, however, are more troublesome to the mortality-fertility predictive model. First, there is substantial discrepancy among skeletally and historically predicted CBR. Further, the discrepancy changes according to the two different mortality ratios. The skeletal CBR prediction is higher than that based on the actual D30+/D5+ mortality proportion, but lower than that based on D5-14/D20+. Second, for both skeletal and historical predictor data, the different mortality ratios give very different results, one slightly underestimating and the other gravely overestimating actual CBR. These variations

suggest problems for future paleodemographic fertility studies if they depend on varying model table bases, preferred mortality ratios, preservational and recovery situations, and, perhaps, different observers and aging techniques. Since Buikstra et al.'s (1986) test case is a carefully controlled series, it is exempt from most of these concerns.

MODEL TABLES AND REAL POPULATIONS

When inferring fertility from mortality, the theoretical underpinning is the stable model life table. The incorporated stability assumption allows life tables to be computer generated by balancing fertility and mortality rates (hence creating a strong correlation) such that no growth or small, constant growth occurs. Thus the negative relation between fertility and relative adult mortality is automatic in creating stable models; as longevity increases, fertility must decline mathematically to keep resulting model populations from changing. In other words, in stable or stationary closed model life tables, the predictive correlation between fertility and mortality is a fixed feature, neither a necessarily real biological feature nor a generalization justifying fertility estimation from real population data. Previous workers have recognized this point, of course, yet we feel they have not emphasized it enough. Whether living anthropological populations are ever truly stable is highly questionable. Perhaps over time these populations converge on such stability, at least to an extent allowing simulations of population structure (Weiss 1975), yet the temporal fluctuations would invalidate the fertility-mortality balance (and the associated predictive model) within a temporally finite cemetery to an undetermined extent.

The Newton slave population was undeniably nonstable in a demographic sense. That is, we know there was some immigration as well as population size change. To some extent this accounts for the failure to match mortality/fertility proportions among historical, skeletal, and model table-based rates; however, it does not account for the eccentric varieties of that failure. Other scholars have documented the considerable difficulties in fitting slave historical demography to stable model tables: either vital rates were changeable (Zelnick 1966) or the models do not fit (Eblen 1972, 1975; Steckel 1986).

The Late Woodland and Mississippian societies constituting Buikstra et al.'s (1986) examples similarly were admittedly demographically unstable. Those authors ascribe increased population through time to increased fertility, which was inferred, in turn, from the stable model (which allows for no change in fertility!). Aggregating Mississippian populations, following the model of Kunstadter (1972), would (somewhat like Barbados slaves) have been low-fertility areas of accretion from high-fertility rural hinterlands. Furthermore, first-generation immigrants might have experienced relatively higher mortality than those adapted in place to the increased density. As perhaps is the case with most populations, the Mississippian samples hardly can be considered as deriving from stable (or stationary) parent populations, unlike the computer populations used to model their fertility trends.

The method for prehistoric fertility inference developed by Buikstra et al. following Sattenspiel and Harpending is the most promising recent innovation in paleodemography. Until independent data on actual fertility somehow can be found and used for validation, other systematic biases in mortality ratios such as interment practices, migration, or the time factor in preservation cannot be eliminated entirely. Although we would like to reason otherwise, our brief analysis leads us at present to share the general scepticism toward paleodemographic vital rates expressed by Bocquet-Appel and Masset (1982).

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FERTILITY IN THE PREHISTORIC MIDWEST: A CRITIQUE OF UNIFACTORIAL MODELS

Thomas D. Holland

Cultivation of starchy seeds must be recognized as a complex of variables upon which selection operates and of which population growth is the inherent measure of success. Early weaning through the use of starchy-seed gruels, though recently proposed as the principal factor in the increase of fertility, is insufficient as a prime mover for population growth in west-central Illinois during the Middle and Late Woodland periods.

El cultivo de semillas ricas en féculas debe ser reconocido como un complejo de variables sobre las cuales opera la selección, de estas variables, el crecimiento poblacional es una buena medida del logro reproductor. Se ha propuesto que el principal factor del incremento de la fertilidad se debe al destete temprano de los niños, por el uso de coladas elaboradas a partir de semillas con alto contenido de almidón; sin embargo, consideramos que tal argumento no es suficiente como para explicar el aumento poblacional en la región centro-occidental del estado norteamericano de Illinois, durante los períodos Middle Woodland y Late Woodland.

The success of the food-producing revolution is measured not by the ability of agriculturists to produce more food but rather by agriculture's ability to produce more agriculturists: Gross population growth is the ultimate expression of agriculture's fitness. Population growth often has been used (and, more often, misused) to explain the origins of agriculture. For the most part, these explanations take the form of a unicausal model: Either population growth initiates an innovation in subsistence (e.g., Binford 1968; Cohen 1977) or innovations in subsistence strategy or favorable conditions prompt subsequent population growth (e.g., Braidwood 1967; Childe 1951). Unfortunately, these unicausal models tend to become static and dead-ended. Therefore, when a new variable is introduced into the equation it deserves critical attention.

Buikstra et al. (1986; see also 1987) have introduced such a variable. Using a biocultural fertility model they believe applicable to prehistoric populations of west-central Illinois, they argue (Buikstra et al. 1986:539) that "the key variable associated with fertility is dietary change," specifically the cultivation of the starch-seed complex of *Chenopodium bushianum* (goosefoot), *Polygonum erectum*

Thomas D. Holland, Department of Anthropology, University of Missouri-Columbia, Columbia, MO 65211.

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