ROMAN AGE STRUCTURE: EVIDENCE AND MODELS*

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For Keith Hopkins

I. THE SEARCH FOR ROMAN AGE STRUCTURE

For many Romans, life was short. In consequence, the young greatly outnumbered the elderly. Historians have long accepted these basic truths, even if they are only beginning to come to terms with the social implications of an alien demographic regime.[1] But how short is 'short', and how many Romans were children, how many adults? Does it matter, and can we know?

The importance of demographic structure is not in doubt. High mortality causes scarce energy resources to be wasted in pregnancies and nursing, and poses a disincentive to investment in education. It destabilizes families and households, exposes orphans and widows to risk and potential hardship, and shortens the time-horizons of economic activity. In the long term, average life expectancy is the principal determinant of fertility. Poor chances of survival trigger high birth rates to ensure genetic survival. High fertility, in turn, is negatively correlated with the status and well-being of women, and constrains female participation in economic and public affairs. Overall age structure, in conjunction with cultural practices from marriage to child care, determines the prevalence of orphans and widows, and affects the age-specific distribution of fertility.[2] In sum, age structure is instrumental in framing and shaping expectations and experiences. For this reason alone, our understanding of life in the Roman world is critically dependent on our knowledge of demographic conditions.

Any appreciation of ancient demography is complicated by the fact that life expectancy and age structure are independent variables that do not always move in tandem. Thus, a given level of mean life expectancy at birth does not automatically translate to a fixed age distribution. Changes in fertility and population transfers introduce further uncertainty: for example, a parallel increase in both longevity and fertility may leave the overall age structure unchanged. It is only in a very broad sense that average life expectancy is correlated with the overall shape of the age distribution. A drop in mortality will eventually change the balance between young and old in favour of the latter. Visually represented, this development gives the impression of a gradual 'rectangularization' (Robert Fogel's term) of the age distribution. Today's 'age pyramids' have already assumed the shape of bells, and — ideally — strive to perfect themselves into proper squares (Figs 1–2).[3]

Beyond this basic tendency, however, a fair amount of variation is possible. Roman historians are poorly equipped to establish demographic facts. No direct records of ancient life expectancy are currently known, and it is unlikely that they ever existed. Instead, life expectancy rates have usually been calculated from age distributions

* This paper is meant as a *reprise* of Keith Hopkins' critique of earlier attempts to explore Roman age structure (see below, n. 6). Hopkins' pioneering study of 1966 encouraged a renaissance of Roman population studies without which contributions such as my own would have been impossible. His retirement as Professor of Ancient History in the University of Cambridge provides a fitting occasion for my dedication. I wish to thank Peter Garnsey, Richard Saller, and the journal's referees for comments on an earlier draft of this paper.

[1] For some first attempts, see R. P. Saller, *Patriarchy, Property and Death in the Roman Family* (1994); 'Legal institutions, population structure and investment in the Roman Empire', paper delivered at the Conference on Institutions and Markets in Comparative-Historical Perspective (Stanford, 1999).

[2] The Roman kinship simulations in Saller, op. cit. (n. 1), 43–69, seek to capture the essence of Roman domestic experience. For patterns of fertility, see B. W. Frier, 'Natural fertility and family limitation in Roman marriage', *CP* 89 (1994), 318–33.

[3] Figs 1–2: A. J. Coale and P. Demeny, *Regional Model Life Tables and Stable Populations* (1983), 57, 79.

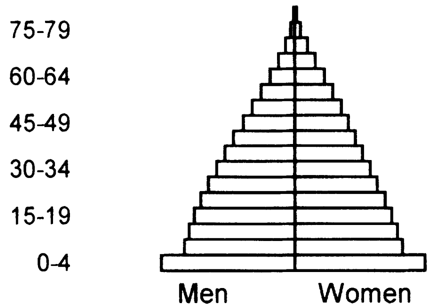

FIG. I. IDEALIZED STATIONARY POPULATION: 'ANCIENT' (COALE/DEMENY MODEL WEST LEVEL 3: MEAN LIFE EXPECTANCY AT BIRTH: 24 YEARS).

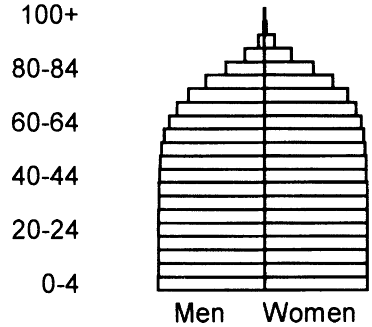

FIG. 2. IDEALIZED STATIONARY POPULATION: PRESENT (COALE/DEMENY MODEL WEST LEVEL 25: MEAN LIFE EXPECTANCY AT BIRTH: 78.3 YEARS).

constructed from samples of textual or physical source material, such as census documents, epitaphs, or skeletons. This process involves a series of epistemological problems. First of all, for this type of evidence to be of any relevance for our understanding of demographic structure, the attested age distribution has to be a random or near-random sample that reflects the actual composition of the underlying population. Recording or commemorating biases must either be absent or known and controlled for. Second, the quantitative properties of confounding variables such as natural growth or migration must be known (or known to have approximated zero) with reasonable precision. In the absence of such information, it is impossible to distinguish between a large proportion of young individuals caused by high mortality at mature ages and a large proportion of young individuals brought about by strong net growth. A large share of adults may be equally well interpreted as a sign of low mortality or of substantial immigration at mature ages. In principle, the accumulation and averaging of large numbers of local datasets help mitigate these problems of interpretation. Ultimately, however, any reliable reconstruction of demographic structure must be grounded in a combination of evidence created by different recording mechanisms (such as censuses and birth or death registers).[4] Neither of these options is available to the student of Roman populations.

For the past thirty-five years, scholars have dealt with this predicament in two different ways.[5] According to what has now become the majority position, ancient data are too deficient and unreliable to support reconstructions of actual age distributions and consequently do not permit us to establish likely average rates of life expectancy. Rather, we ought to fall back on comparative information about more recent high-mortality regimes and especially on idealized model life tables extrapolated from reliably documented populations. These proxy data are thought to demarcate the limits of the plausible with regard to the otherwise unknown and unknowable ancient population structure.[6] Since the early 1980s, Bruce Frier has adopted a somewhat less sceptical stance.[7] In his view, model life tables can help determine which ancient evidence has some *prima facie* claim to coherence and plausibility, and some measure of credibility may therefore be accorded to data that can be shown to be consistent with the predictions generated by these models. This perspective also informs his survey of Roman demography in the new edition of the *Cambridge Ancient History* which has the potential

[4] Coale and Demeny, op. cit. (n. 3), 4.

[5] I omit reference to straightforward readings of the extant sources as a faithful mirror of reality, which lack intellectual warranty and have deservedly been in decline since the 1960s.

[6] This approach was first advocated by K. Hopkins, 'On the probable age structure of the Roman population', *Population Studies* 20 (1966), 245–64, re-iterated in his 'Graveyards for historians', in F. Hinard (ed.), *La mort, les morts et l'au-delà dans le monde romain* (1987), 113–26, and endorsed by T. G. Parkin, *Demography and Roman Society* (1994), chs 1–2. Cf. also Saller, op. cit. (n. 1), 22–3. For the nature of model life tables, see below, Section II.

[7] B. W. Frier, 'Roman life expectancy: Ulpian's evidence', *HSCP* 86 (1982), 213–51; 'Roman life expectancy: the Pannonian evidence', *Phoenix* 37 (1983), 328–44; R. S. Bagnall and B. W. Frier, *The Demography of Roman Egypt* (1994), chs 4–5.

to shape perceptions of Roman age structure for the foreseeable future and therefore merits particular attention.[8] In this paper, I hope to show that both approaches require considerable revision.

The use of model life tables is central to either position. The 'pessimistic' camp employs them as an independent standard that can be used to invalidate ancient source material. Frier's method differs only in as much as he puts more emphasis on positive matches between evidence and models. Thus, both sides critically rely on models as the ultimate arbiters of demographic plausibility. A genuine contrast arises from the fact that Frier's method also requires samples that match model predictions to reflect reality, a precondition that is irrelevant to determined sceptics merely concerned with falsification. As a consequence, predicated as they are on both the predictive value of model life tables *and* the representative character of the empirical data, attempts to identify demographically plausible evidence are doubly vulnerable *a priori*.

These circumstances invite a series of questions. (1) Can standard model life tables bear the weight put on them by 'pessimists' and 'optimists' alike? Can they reasonably be expected to cover the whole range of demographic conditions in the Roman world? A negative answer would undermine both rival approaches. (2) Can we reasonably expect isolated local samples of ancient age data to conform to the predictions of model life tables if the general age structure of the underlying populations did in fact match these predictions? In other words, can isolated local data sets be regarded as true random or near-random samples of an unrecorded larger whole? Is generalization from local data feasible? If the answer is no, the second approach loses much of its appeal. (3) Can we reasonably expect local data samples to mirror *local* age structure? A positive answer would seem a minimal precondition for the validity of Frier's approach. (4) Are there indeed reported age distributions that can be shown to be compatible with model life tables? This issue is relevant only inasmuch as the preceding questions can be answered in the affirmative. Otherwise, any such matches would perforce remain of dubious value.

I will argue that the answers to the three main questions must be largely negative. There is no compelling reason to believe that model life tables cover anywhere near the whole range of demographically plausible age structures, nor is there any compelling reason to believe in the representative nature of local data samples with regard to whole regions or the entire Roman world *even if* they could somehow be shown faithfully to mirror local conditions. To make matters worse, it is usually impossible to rule out reporting biases even if attested patterns happen to conform to model predictions. Finally, most of the few reported matches between evidence and models can be shown to be fortuitous or the result of observer preference. In Sections II to V, I will deal with each of these questions in the sequence set out above.

II. DEMOGRAPHIC MODELS AND THE CHANGING NATURE OF HUMAN MORTALITY

Model life tables are algorithmic extrapolations from empirical demographic evidence for historical and contemporary populations. The most widely used set of models was produced by the American demographers Ansley Coale and Paul Demeny in 1966 and revised in 1983.[9] Their calculations created idealized age distributions of stable populations characterized by different levels of mean life expectancy at birth (e_0).[10] Twenty-five mortality levels, set at 2.5 year intervals, cover a total range of e_0 from approximately twenty to eighty years. Separate tables are provided for women and men, and for four 'families' of models termed 'West', 'South', 'North', and 'East' that reflect broad differences between geographical clusters of data samples. Ancient

[8] B. W. Frier, 'Demography', in *CAH*[2] XI (2000), 787–816, esp. 788–97.

[9] Above n. 3.

[10] A 'stable population' is a (hypothetical) population with fixed birth and death rates that will therefore grow or shrink at an unchanging rate (or not change at all). See, e.g., C. Newell, *Methods and Models in Demography* (1988), 120–2.

historians usually use tables from the 'West' family (a generic default position) or the 'South' group (based on material from the western Mediterranean).

In all these categories, tables for low-mortality environments are the ones most solidly anchored in recent empirical evidence. Conversely, the lower the level of life expectancy, the more the corresponding tables rely on retrapolation from the known to the unknown. This poses serious epistemological problems for Roman historians who need to concentrate on the bottom end of the range of available models. Levels of e_0 of the order of twenty to thirty years (and the predicted age structures) are not covered by the demographic data used for the construction of these model life tables. None of the sources underlying Coale and Demeny's calculations go back farther than 1851 (for the 'North' family, typical of Scandinavian populations and not used by ancient historians); for 'West' models, they start in 1870. The overwhelming majority of the evidence is European and comes from the twentieth century. No samples from populations with a mean life expectancy at birth below the mid-thirties could be included.[11] Coale and Demeny avoided earlier data or material from high-mortality populations mainly because they appeared to have been marred by reporting inadequacies. Only populations covered by periodic censuses and continuous registration of vital events were considered sufficiently well documented to provide a reliable basis for model extrapolation. Due to historical circumstances, evidence of this kind only became available from the late nineteenth century onwards.

These strict standards cause an irresolvable dilemma: in shielding the resultant models from contamination with potentially deficient and therefore misleading data input, they cannot take account of the full amount of variation in the demographic experience of underdeveloped, high-mortality populations.[12] Coale and Demeny stress 'the uniqueness of the accurate records — mostly those of European countries before World War I — that reflect relatively high levels of mortality'. For Roman historians, it is important to remember that Coale and Demeny did not intend to re-create the demographic realities of high-mortality populations in the distant past. In their own words,

> there is no strong reason for supposing that the age patterns of mortality exhibited in these four families [of life tables] cover anything like the full range of variability in age patterns in populations under different circumstances. (. . .) The question of what is the pattern of mortality in a population of an underdeveloped area is essentially unresolvable. (. . .) By the time a population has reached the stage where age-specific mortality rates can be measured with confidence, the level and age pattern of mortality may have changed, so that the pattern of mortality during the underdeveloped period may never be known.[13]

In earlier centuries, Europeans would pray for deliverance from war, pestilence, and hunger (*a bello, fame et peste libera nos, Domine*). For the societies that furnished the raw data for our model life tables, this wish had come true. Except for the worldwide influenza outbreak of 1918/19, they were spared major pandemics of deadly disease. There had been no catastrophic famine in Europe since the Irish Potato Blight of the 1840s, well before Coale and Demeny's cut-off date. Moreover, 'tables covering years in which a country was in a major war were eliminated' from their database.[14] By the late nineteenth century, the general pattern of mortality had already undergone dramatic changes. Between the mid-eighteenth century and 1900, interannual variation in national death rates in Sweden and France dropped by two-thirds. This narrowing band

[11] Coale and Demeny, op. cit. (n. 3), 12, 24–5.

[12] Coale and Demeny 'exclude the possibility of using these life tables for the purpose of generalizing on mortality conditions unless the validity of each table is carefully analyzed' (op. cit. (n. 3), 4). However, as long as life tables based on more highly developed populations provide the only practical standard of reference, the circular character of any such 'analysis' is obvious.

[13] op. cit. (n. 3), 25. Model life tables for non-Western countries draw on recent sources that resemble Western data: e.g., *Unabridged Model Life Tables Corresponding to the New United Nations Model Life Tables for Developing Countries* (1982). For more unconventional attemps to exploit non-Western material, see S. Ledermann, *Nouvelles tables-types de mortalité* (1969); L. Petrioli, *Nouvelles tables-types de mortalité* (1982).

[14] Coale and Demeny, op. cit. (n. 3), 5.

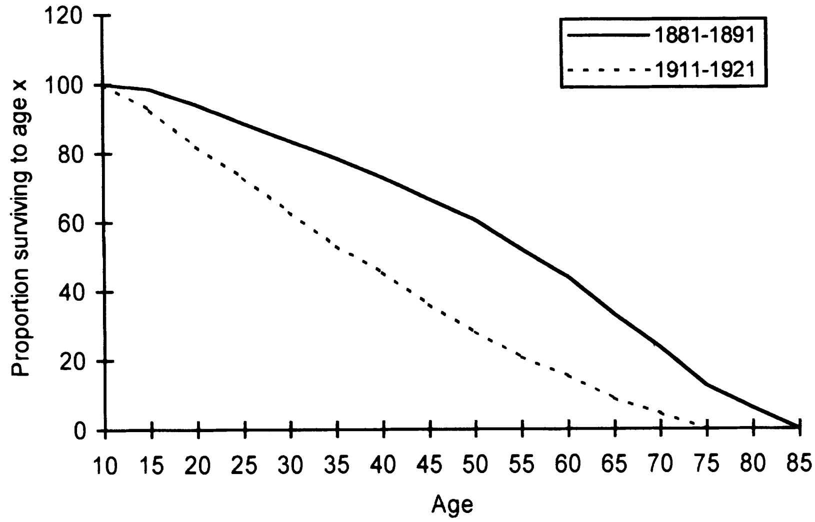

FIG. 3. CHANCES OF SURVIVAL BY AGE IN 'GOOD' AND 'BAD' DECADES, UNITED PROVINCES (NORTH INDIA), WOMEN, 1881–1891 AND 1911–1921.

of oscillation testifies to a gradual but cumulatively massive attenuation of risk and mortality crises.[15]

The Romans found themselves in a less enviable position. During the Republican period, military manpower losses must have skewed male age structure.[16] But it need not have been the Roman state that suffered most: for small communities in particular low-level warfare is often of considerable demographic consequence.[17] It is true that famine may have been rare, while periodic food crises need not have had any major impact on age structure.[18] Epidemics have the potential of causing far greater havoc, and appear to have recurred fairly frequently throughout the Roman period.[19] As Herlihy and Klapisch-Zuber discovered in their study of Florentine demography in the late Middle Ages, such events may distort age patterns for decades. This led them to conclude that 'the assumption behind model life tables, that death and birth rates have remained constant over the life of the oldest members, is unrealistic when applied to a population molded by catastrophes'.[20] Although catastrophic events on the scale of the Black Death were uncommon, the convergence of less dramatic instances of epidemics and hunger across a large region is equally capable of shaping patterns of death and age. This is well illustrated by census data from British India (Fig. 3).[21]

In all this, the prevalence of infectious disease is the key factor. The population data harnessed for the construction of model life tables post-date the 'epidemiologic transition', a tidal shift in the causes of death from infectious to chronic and degenerative disease. Prior to this transition, infectious disease ran largely or wholly unchecked and epidemic flare-ups were sufficiently frequent to contribute significantly to the overall death rate, creating what Perrenoud, in his study of early modern Geneva, labels the

[15] M. Livi-Bacci, *A Concise History of World Population* (1992), 108.

[16] P. A. Brunt, *Italian Manpower 225 B.C.–A.D. 14* (1971, repr. 1987), ch. 5.

[17] Athens in the Peloponnesian War is a case in point: M. H. Hansen, *Three Studies in Athenian Demography* (1988), 14–28. L. H. Keeley, *War Before Civilization* (1996), 88–94, illustrates the huge demographic impact of war deaths in small pre-state societies.

[18] P. Garnsey, *Famine and Food Supply in the Graeco-Roman World* (1988), 6–39. For the comparatively moderate demographic impact even of genuine famines, see S. C. Watkins and J. Menken, 'Famines in historical perspective', *Population and Development Review* 11 (1985), 647–75.

[19] R. P. Duncan-Jones, 'The impact of the Antonine plague', *JRA* 9 (1996), 109–11.

[20] D. Herlihy and C. Klapisch-Zuber, *Tuscans and their Families: a Study of the Florentine Catasto of 1427* (1985), 195.

[21] A. W. Clark, 'Mortality, fertility, and the status of women in India, 1881–1931', in T. Dyson (ed.), *India's Historical Demography* (1989), 134–5.

'archaic' mode of mortality and age structure.[22] In quantitative terms, endemic infections were the principal determinant of mortality. The spread and virulence, and thus the potency, of infectious disease are functions of the interplay of ecological conditions, ranging from climate, altitude, and population density to the mutation rates of infective agents and the history of host-pathogen relationships, all of which are intertwined with cultural practices and responses such as farming techniques, the domestication of livestock, settlement preferences, hygiene, and medical knowledge.

There can be no doubt that, by recent standards, Romans were often in ill health and died early. However, this basic truth does not automatically imply the existence of an 'ancient' pattern of morbidity and death with an attendant life expectancy or age structure. Likewise, there is no reason to believe that the age distributions predicted by model life tables at the bottom of the range somehow account for 'ancient' patterns of infection and disease simply because they put mean life expectancy at birth at very low levels. Model life table extrapolation is governed by the strongly uniformitarian principle that age-specific mortality rates co-vary in predictable ratios across a wide spectrum of life expectancy at birth. Put simply, if e_0 drops by x, mortality between birth and age one is thought to rise by y while deaths between ages twenty and forty increase by z, and so forth. Otherwise, mathematical extrapolation from known to unknown age structures would be impossible.[23]

This assumption, albeit convenient, is dubious for two reasons. First of all, it has been demonstrated time and again that model life tables fail to predict the ratio of infant mortality to adult death rates when life expectancy is low.[24] Data from early modern England show that the former could vary independently of the latter.[25] In general, mortality at mature ages tends to be higher (and/or child mortality lower) than predicted. Standard models overestimate mortality up to age five in India; as a consequence actual mean life expectancy at birth appears to have been one or two years higher than expected. A greater discrepancy of this kind is found in Chinese evidence from the early twentieth century.[26] Indeed, Benedictow claims that it is possible to link empirically the same level of life expectancy at age twenty to infant mortality rates varying from 15 to 35 per cent.[27] Schematic extrapolation from adult death rates may underpredict mean life expectancy at birth by as much as ten years.[28] Recently analysed early modern Chinese data of very high quality reveal even more striking divergence. Among male members of the Qing nobility in Beijing in 1700, e_0 stood at 22 years although only one in eight infants died during the first year of life. However, models associate an infant mortality rate of 12.5 per cent with a value of e_0 of 49.5 years (Model West Level 14 Males), more than twice as high as in reality. In this case, deaths from smallpox between ages one and five were responsible for this pattern (see below). Yet even after the eradication of endemic smallpox in élite circles, by 1800 e_0 had risen to 36 years while infant mortality now stood at 10 per cent, equivalent to Model West Level 16 Males ($e_0 = 54$). During the same century, mean life expectancy at age thirty had not changed at all.[29] In the orderly world of model life tables, needless to say, there is no

[22] A. R. Omran, 'The epidemiological transition: a theory of the epidemiology of population change', *Milbank Memorial Fund Quarterly* 49 (1971), 509–38, esp. 516; A. Perrenoud, *La population de Genève du seizième au début du dix-neuvième siècle* I (1979), 429.

[23] e.g., N. Howell, 'Demographic anthropology', *Annual Review of Anthropology* 15 (1986), 219: 'When the parameters are known (. . .), the population structure that will result is highly predictable and can be projected backward and forward in time to examine the implications of sets of parameters'.

[24] R. I. Woods, 'On the historical relationship between infant and adult mortality', *Population Studies* 47 (1993), 195–219, esp. 204–12.

[25] E. A. Wrigley *et al.*, *English Population History from Family Reconstitution 1580–1837* (1997), 284, find that in England in the 1680s, mortality up to age fifteen corresponded to Coale/Demeny Model North Level 8 (implying a mean life expectancy at birth [e_0] of 36 years) while adult mortality was closest to Level 2 ($e_0 = 21.2$). Although they consider this a transitional period, it deserves notice that even at the end of that transition mortality up to age fifteen resembled Level 11 ($e_0 = 43.4$) while adult mortality was closer to Level 9 ($e_0 = 38.4$). In both cases, adult mortality relative to child mortality was higher than predicted.

[26] P. N. Mari Bhat, 'Mortality and fertility in India, 1881–1961: a reassessment', in Dyson, op. cit. (n. 21), 73–118 (discussing China as well as India).

[27] O. J. Benedictow, *The Medieval Demographic System of the Nordic Countries* (1993), 26.

[28] R. M. Smith, 'Demographic developments in rural England, 1300–48: a survey', in B. M. S. Campbell (ed.), *Before the Black Death* (1991), 59.

[29] J. Z. Lee, F. Wang and C. Campbell, 'Infant and child mortality among the Qing nobility: implications for two types of positive check', *Population Studies* 48 (1994), 398, 401.

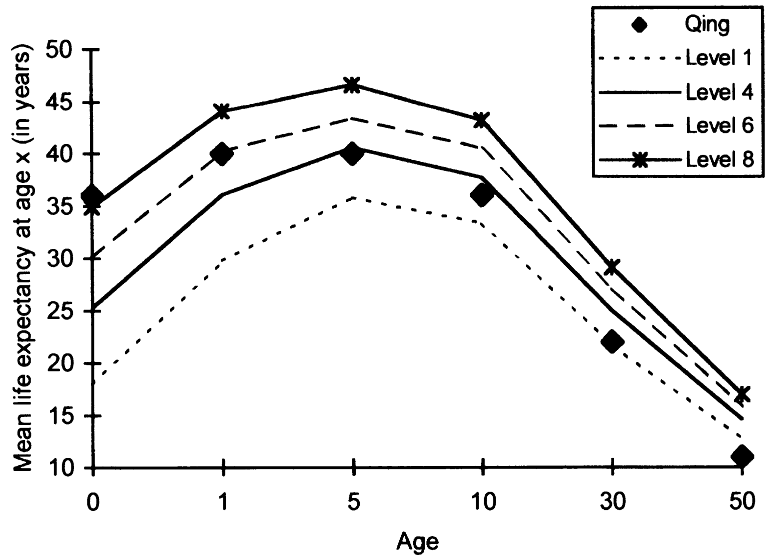

FIG. 4. AGE-SPECIFIC LIFE EXPECTANCY IN THE QING NOBILITY OF BEIJING IN 1800 AND ACCORDING TO MODEL LIFE TABLES (MODEL WEST MALES).

room for a dramatic shift in e_0 without a concomitant shift in e_{30}. Moreover, age-specific mortality at mature ages in these sources is similarly incompatible with model predictions (Fig. 4).

In cases like these, it is patently impossible to predict infant mortality or calculate mean life expectancy at birth on the basis of adult death rates. Mortality at mature ages may have been raised by disease or violence, encouraging erroneous assumptions about even higher child mortality; conversely, death in childhood could be more frequent than indicated by subsequent attrition rates. Infant mortality rates have repeatedly been shown to vary with altitude.[30] To complicate matters further, cultural practices such as breastfeeding and weaning patterns also affect the chances of child survival. Roman historians need to allow for substantial variation in this regard: after all, ancient sources not only preserve wetnursing contracts for up to three years but also hint at misguided attempts to force solid food on six-week-old babies.[31] More recent comparative evidence points to enormous differences in infant mortality depending on nursing customs.[32] Even though the apparent absence of bottle-feeding in Roman times may have reduced the demographic impact of child care (at least compared to modern Europe), local or class differences in weaning norms or birth spacing could well have translated to significant variation in overall life expectancy.

A single demographic model cannot possibly account for the probable range of epidemiologic and cultural circumstances. This is particularly unfortunate given that there is no usable evidence for childhood mortality from classical antiquity. Equally unfortunately, premature death was a crucial determinant of overall life expectancy (and thus fertility): because a substantial share of all deaths must have been concentrated in the first few years of life, even comparatively minor differences in this age bracket would have a significant impact on demographic conditions in general.

[30] e.g., M. J. Dobson, *Contours of Death and Disease in Early Modern England* (1997), 175–8.

[31] Feeding and weaning: P. Garnsey, *Cities, Peasants and Food in Classical Antiquity* (ed. W. Scheidel) (1998), 261–70. Cereal food given forty days after birth ('as do those for the most part <who> find nursing a burden'): Soran., *Gyn.* 2.46. Duration of wetnursing contracts: M. M. Masciadri and O. Montevecchi, *I contratti di baliatico* (1984), 32–5. Isotope analysis of skeletal remains has the potential to illuminate differences in weaning practices: for a first attempt, see T. L. Prowse *et al.*, 'Chemical analysis of infant feeding practices from the imperial Roman site of Portus Romae, Italy', *American Journal of Physical Anthropology* suppl. 30 (2000), 254.

[32] e.g., J. C. Knodel, *Demographic Behavior in the Past* (1988), chs 3–4. There are likewise great differences in the mean duration of breastfeeding (and thus birth intervals): e.g., J. W. Wood, *Dynamics of Human Reproduction* (1994), ch. 8.

The second weakness of the uniformitarian position is the fact that it is predicated on observed differences in age structure between medium- and low-mortality populations of recent history but artificially extends this relationship into the more distant past in order to describe high-mortality regimes as well. This neglects the possibility that following the 'epidemiologic transition', medium- and low-mortality populations may be structurally different from pre-transitional groups. High mortality is now widely considered to be a function of a strong incidence of endemic infectious disease rather than primary malnutrition.[33] Since many of the most potent endemic infections differ in their age-specific impact, their relative prevalence in any given population is a critical determinant of its overall age distribution. In brief, different disease environments will create different age structures.

Historical demographers have documented this phenomenon in a variety of ways.[34] Death from pulmonary tuberculosis, for example, used to peak in the early twenties, and generally at ages at which model life tables predict a trough in mortality.[35] This discrepancy may be partly due to the fact that Coale and Demeny excluded populations that were strongly affected by tuberculosis from their database.[36] High probabilities of dying between ages five and twenty in early twentieth-century Chinese data have been tentatively associated with tuberculosis. In cases like this, model life tables need to be 'spliced' (i.e., refashioned from segments associated with different levels of life expectancy) to be of any use at all.[37] The demographic consequences of tuberculosis are potentially of considerable relevance to Roman historians. Ancient medical and other literary sources as well as skeletal evidence point to a significant presence of tuberculosis in the Mediterranean.[38] Urbanization in the Roman period must have accelerated its dissemination.

Owing to higher infection rates, malaria was an even more powerful agent in shaping mortality and age structure. In general, malaria infection tends to result in higher death rates at mature ages relative to early mortality than predicted by model life tables. The best evidence comes from the coastal marsh parishes of South-East England two hundred years ago, when *Plasmodium vivax* (benign tertian fever) was still endemic at low altitudes. In the most affected areas, adults aged twenty to sixty suffered from significantly higher mortality than expected: while model distributions are compatible with reported age structure up to age twenty, the two progressively diverge from that point onwards.[39] Much more serious effects of this kind can be observed in the case of endemic *P. falciparum* (malignant tertian fever), by far the most dangerous type of malaria. Child mortality would rise to the highest levels found in standard projections while the adult death rate exceeded anything envisaged by model life tables. In the town of Grosseto in coastal Tuscany in the 1840s, for example, mortality reached 34 per cent between ages one and five and 60 per cent from ages twenty to fifty, compared to 34.7 and 46 per cent in Model South Level 1.[40]

[33] e.g., M. Livi-Bacci, *Population and Nutrition* (1991); S. R. Johansson, 'Food for thought: rhetoric and reality in modern mortality history', *Historical Methods* 27 (1994), 101–25.

[34] Retrospective medical diagnosis from inadequate data is a hazardous business. In the following, I will focus on major diseases whose distinctive symptoms are reasonably well described in pre-scientific and even ancient sources. In addition, skeletal data (from bone lesions to pathogen DNA) increasingly contribute to our knowledge of medical conditions in early societies. M. D. Grmek, *Diseases in the Ancient Greek World* (1989) provides a masterful account; for a state-of-the art survey of the physical evidence, see A. C. Aufderheide and C. Rodríguez-Martín, *The Cambridge Encyclopedia of Human Paleopathology* (1998). Dobson, op. cit. (n. 30), ch. 5, discusses more recent textual evidence; cf. also in general G. Alter and A. Carmichael, 'Studying causes of death in the past: problems and models', *Historical Methods* 29 (1996), 44–8.

[35] e.g., B. Puranen, 'The decline of mortality in Sweden', in R. Schofield *et al.* (eds), *The Decline of Mortality in Europe* (1991), 84 fig. 4; Woods, op. cit. (n. 24), 213 fig. 13.

[36] Coale and Demeney, op. cit. (n. 3), 11–12.

[37] G. W. Barclay *et al.*, 'A reassessment of the demography of traditional rural China', *Population Index* 42 (1976), esp. 621. As a result, the Chinese mortality pattern is 'different from the structure of any model life tables' (624).

[38] Grmek, op. cit. (n. 34), 183–94. For tuberculosis in ancient Egypt, see W. Scheidel, *Death on the Nile: Disease and the Demography of Roman Egypt* (in press), ch. 1.3.6.

[39] Dobson, op. cit. (n. 30), 133–220, esp. 168–72.

[40] L. Del Panta, *Malaria e regime demografico* (1989), 22. Cf. also P. Arlacci, *Mafia, Peasants and Great Estates* (1983), 182 (Crotonese).

Once again, these findings are of considerable relevance to our understanding of Roman age structure. In his new study of malaria in central Italy, Robert Sallares demonstrates that from the Roman period onwards endemic falciparian malaria was commonly found in low-lying parts of Latium and Tuscany and other parts of the peninsula. The city of Rome itself appears to have been a veritable hotbed of all known Mediterranean types of malaria infection.[41] In this context, malaria was not only an important clinical cause of death but also exacerbated other illnesses. The resultant age patterns are likely to have borne little resemblance to the schedules of standard models.

According to the Chinese sources cited above, endemic smallpox could have an extremely powerful impact on child mortality and thus overall life expectancy, dissociating death rates early in life from those at mature ages. In 1700, among the Qing élite, the probability of dying between ages one and five amounted to 40 per cent, fully one and a half times as high as in the most pessimistic model life tables.[42] If the 'Antonine plague' of the late second century A.D. was indeed smallpox, it may well have become endemic in the largest conurbations of the Roman Empire, above all in Rome and Alexandria, and distorted local age distributions accordingly (see below, Section IV).

In addition, the demographic repercussions of traditionally ubiquitous diseases can be expected to have differed from their more modest manifestations in the modern West. Even basic medical treatment can greatly reduce the dangers of bacillary dysentery. In Egypt up to the early twentieth century, it was associated with fatality rates of 20 to 30 per cent, at a time when it had already been tamed in Europe.[43] Aretaios' claim (4.9.15) that dysentery struck adults rather than children is corroborated by data from nineteenth-century Egypt.[44] Typhoid, which in developing countries today still targets individuals between ages five and thirty and is rare under two and over fifty, used to be lethal in 20 to 30 per cent of all cases, and could be put on a par with smallpox or measles. Again, Western fatality rates had already dropped by the late nineteenth century. Both infections, by disproportionately affecting a particular age cohort, would increase mortality in late childhood and early maturity relative to deaths in infancy and old age.[45] Presumably common in antiquity,[46] these hazards also contributed to the shaping of overall age structure.

So far, we have only looked at clearly defined medical conditions and their demographic ramifications. Sometimes, it is only the symptoms of unspecified environmental stress (infection and/or malnutrition) that can be linked to a particular mortality profile. A study of 334 crania from two medieval Upper Nubian cemeteries in Kulubnarti reveals a striking correlation between the incidence of cribra orbitalia and age-specific death rates. Cribra orbitalia, porotic bone lesions on the skull, is associated with iron deficiency anaemia caused by malnutrition and/or parasitism, typically in childhood. In the Nubian sample, this condition can be observed in 46 per cent of all skulls but in 78 per cent of those individuals who died at ages four to six, compared to 30 per cent beyond age seventeen. Thus, the same factors that created the bone lesions significantly reduced chances of survival. Mean life expectancy differed accordingly: at ages four to six, it was fifteen years higher for those who were free fom cribra orbitalia than for those affected. It was only from the late teens onwards that those suffering from lesions were no longer put at a demographic disadvantage (Fig. 5).[47]

[41] R. Sallares, *Malaria and Rome: a History of Malaria in Central Italy in Antiquity* (in press). On the city of Rome, see also W. Scheidel, 'Germs for Rome', in C. Edwards and G. Woolf (eds), *Rome the Cosmopolis* (in press).

[42] Lee, Wang and Campbell, op. cit. (n. 29), 398 fig. 1; Coale and Demeney, op. cit. (n. 3), 42.

[43] L. Rogers, *Dysenteries* (1913), 114–15, 284–5; H. O. Lancaster, *Expectations of Life* (1990), 74.

[44] M. B. Schnepp, 'Considérations sur le mouvement de la population en Egypte', *Mémoires ou travaux originaux presentés et lus à l'Institut Egyptien* 1 (1862), 552–3; D. Panzac, 'Endémies, épidémies et population en Egypte au XIXe siècle', in *L'Egypte au XIXe siècle* (1982), 89 tab. 7. See also below, Section IV.

[45] R. L. Huckstep, *Typhoid Fever and other Salmonella Infections* (1962), 49; R. B. Hornick, 'Typhoid fever', in A. S. Evans and H. A. Feldman (eds), *Bacterial Infections of Humans* (1982), 660, 667; Lancaster, op. cit. (n. 43), 71.

[46] For typhoid, see Grmek, op. cit. (n. 34), 89, 346–7.

[47] D. M. Mittler and D. P. van Gerven, 'Developmental, diachronic, and demographic analysis of cribra orbitalia in the medieval Christian populations of Kulubnarti', *American Journal of Physical Anthropology* 93 (1994), 287–97.

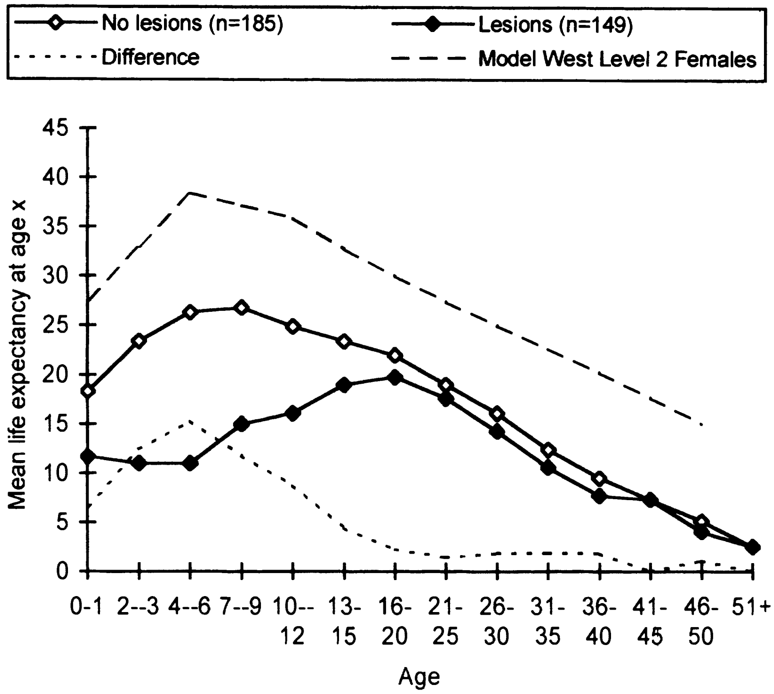

FIG. 5. AGE-SPECIFIC LIFE EXPECTANCY IN THE CEMETERY POPULATION OF KULUBNARTI, NUBIA.

In this case, it is the shape of the curve that tracks age-specific life expectancy rather than the indicated levels of e_x that matter: whereas the curve for those free of lesions appears consistent with model predictions, the one for cribra orbitalia sufferers is not. As a result, the aggregate age structure of this group — in as far as the actual population is represented in this sample — must have been markedly different from any standard model. Leaving the specifics aside, these findings gain especial weight thanks to the high incidence of cribra orbitalia and related conditions in skeletal samples from different parts of the Roman world.[48] If bone lesions predict anomalous mortality patterns, the latter must have been common. Model life tables reckon with low mortality (relative to other age brackets) between ages five and twenty, when those suffering from cribra orbitalia were most likely to die. Unlike ancient Romans, the members of modern populations on whose experience these models are based were not (or in any case no longer) exposed to the high rates of parasitism and chronic malnutrition associated with bone lesions. Once again, the implication is clear: actual mortality patterns and age distributions were likely to diverge significantly from model life tables.

It would be easy to continue this survey of confounding variables. Additional non-standard age distributions could be gleaned from the historical record. Some of the most striking evidence comes from a well-attested population in rural Manchuria in the first half of the nineteenth century in which mortality rates can be shown to have fluctuated by up to twenty Coale/Demeny levels across the human lifespan.[49] The role of cultural practices could also be taken into account. On average, modern women outlive men, as they do in model life tables. They do not always do so in some non-Western cultures with a strong male bias, which was also present in antiquity.[50] Femicide and 'benign

[48] Garnsey, op. cit. (n. 31), 249, and *Food and Society in Classical Antiquity* (1999), 56–7. Cf. Grmek, op. cit. (n. 34), 276, for Greece.

[49] J. Lee and C. Campbell, *Fate and Fortune in Rural China* (1997), 63 tab. 4.2. For instance, male mortality between ages twenty-one and thirty-five corresponded to Model North Level 12 Males but matched Levels 3 to 5 after age fifty-one. Among women, death rates in the late teens went right off the chart, implying a mortality level of minus 8 (i.e., eight levels worse than the most pessimistic model life table), but oscillated between Levels 2 and 7 for most other age brackets.

[50] See Garnsey, op. cit. (n. 48), 100, for the probable effects on longevity.

neglect' may have distorted age patterns even further, in ways unknown to the populations underpinning the standard models.

I conclude that model life tables cannot reasonably be expected to capture or even credibly approximate the demographic experience of high-mortality populations. It would therefore be unreasonable to expect any particular model life table (or any combination of several of them) to reflect age structure in any particular part of the Roman world, or even of the Empire as a whole. One may suspect that global averages — could they be established — would tend to smooth local and regional variation, and perhaps even that they would deviate less strongly from model standards. This is well brought out by a large sample of age data from an extended clan population in China ranging from A.D. 1 to 1750 which supports a partial fit with a Model East life table.[51] However, no comparable data aggregations are available from the ancient world.

III. PROBLEMS OF REPRESENTATION

Do extant bodies of Roman age data reflect demographic realities? In this context, even 'reality' is hard to define. Such sources as do exist are one or more steps removed from underlying age structures. For instance, all skeletons in a given cemetery may somewhat tautologically be taken to represent the age pattern of all those buried in that location. At the same time, the extent to which they reflect the demographic experience of those who had once lived nearby necessarily remains unclear because (1) considerations of class, gender, or age may have determined the probability of receiving a proper burial in a particular cemetery and (2) the composition of the local population may have been affected by migration. Thus, we are dealing with two layers of 'reality': the age structure of the local residents at any given moment in time, and the local age structure that would have been created by local rates of mortality and fertility in the absence of population transfers. These two patterns might coincide but just as likely diverge widely; there is no way of distinguishing between them. This problem alone effectively forestalls the application of stable population predictions to empirical data from graveyards. Standard model life tables are monofactorial schedules that allow for only one type of input (births) and one attrition factor (death). Consequently, stable population analysis requires a group to be closed (or the rates of exchange to be known). It also requires the intrinsic rate of natural growth (the average surplus or deficit of births over deaths) to be known. Neither precondition is met for any skeletal sample. In practice, moreover, abiding difficulties in the ageing of adult bones introduce further uncertainty. Cumulatively, these factors render 'palaeodemographic' investigations a fairly fruitless exercise and stable population analysis of skeletal samples a flagrant misapplication of demographic method.[52]

Age records on Roman tombstones are one more step removed from either 'reality'. Not only do all of the above problems apply in much the same way (including the hazard of mis-ageing through ignorance, number stylization, or age exaggeration). In addition, while a cemetery contains the physical remains of everyone buried there, epitaphs are selective in recording death. Again, age, gender, and class can be shown to determine the likelihood of epigraphic commemoration. And once more, model life tables provide the only standard against which to measure the credibility of age distributions calculated from reported ages at death. However, due to the questions about the representative nature of standard models in general (see above, Section II) and of their convergence with local conditions in particular (see below, Section IV), these models can only be used to invalidate pertinent source material by showing implied age patterns to be wildly

[51] Z. Zhao, 'Long-term mortality patterns in Chinese history: evidence from a recorded clan population', *Population Studies* 51 (1997), 117–27. But contrast the Chinese data discussed above, n. 49.

[52] For a similarly sceptical overview, see Parkin, op. cit. (n. 6), 41–58. For detailed bibliography covering the debate over the past twenty years, see W. Scheidel, 'Progress and problems in Roman demography', in W. Scheidel (ed.), *Debating Roman Demography* (2001), 19 n. 66.

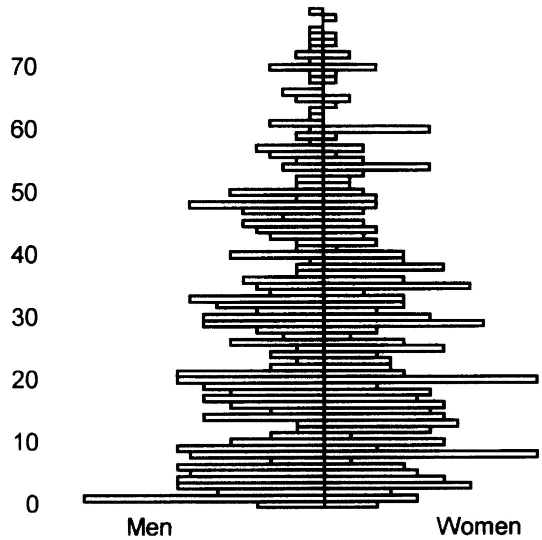

FIG. 6. AGE DISTRIBUTION IN THE CENSUS RETURNS OF ROMAN EGYPT.

implausible or indeed demographically impossible.[53] They cannot ever be used to validate any particular sample beyond a general confirmation of plausibility (cf. below, Section v).

This leaves demographic information derived from surviving census returns and tax lists from Roman Egypt, commonly taken to constitute the most reliable body of population data from classical antiquity.[54] These documents are the remnants of provincial population counts that were conducted every fourteen years during the first three centuries A.D. On these occasions, each declarant had to list all members of his or her household, including lodgers and slaves, with their names, filiations, ages, and other specifics. Close to three hundred of these texts have been published, recently supplemented by a lengthy extract of material copied from individual census returns. Several lists of men aged fourteen to sixty-two who were liable to pay poll tax also preserve information from (now lost) census declarations.[55] In their study of the demography of Roman Egypt, Bagnall and Frier subjected the age data from the three hundred core texts to stable population analysis in a bid to reconstruct the probable age structure of the underlying population. By now, 747 ages have become known, 351 for women, 372 for men, and 24 for persons of unknown gender. 403 of these references come from villages and 344 from district capitals.[56] As is clear from Fig. 6, the raw data require smoothing and weighting procedures to produce a meaningful pattern.

By converting the raw data into seven-year moving averages and rebalancing them to take account of the likely urban-rural split in Roman Egypt, Bagnall and Frier arrive

[53] Demographic analysis of epitaphs is now largely discredited, thanks to Hopkins, op. cit. (n. 6, 1966) (and again op. cit. (n. 6, 1987), 121–6); see also briefly R. Duncan-Jones, *Structure and Scale in the Roman Economy* (1990), 101–3, and in more detail Parkin, op. cit. (n. 6), 5–19. Scheidel, op. cit. (n. 52), 17 n. 59, provides further references. M. Clauss, 'Probleme der Lebensalterstatistik aufgrund römischer Grabinschriften', *Chiron* 3 (1973), 395–417, documents extreme local variation in implied age structures. For changing patterns of commemoration, see B. D. Shaw, 'The cultural meaning of death: age and gender in the Roman family', in D. I. Kertzer and R. P. Saller (eds), *The Family in Italy from Antiquity to the Present* (1991), 66–90.

[54] e.g., Frier, op. cit. (n. 8), 790 ('what is generally conceded to be by far the best surviving demographic source for ordinary subjects of the Roman empire'). Parkin, op. cit. (n. 6), 21, 59, is more sceptical. For a more detailed demographic re-appraisal of these documents, readers are referred to ch. 2 of my book cited above, n. 38.

[55] Bagnall and Frier, op. cit. (n. 7); R. S. Bagnall, B. W. Frier and I. C. Rutherford, *The Census Register P.Oxy. 984* (1997). Tax lists: Bagnall and Frier, 102–3.

[56] All my calculations are based on the age data compiled by Bagnall and Frier, op. cit. (n. 7), 334–6, with Frier's corrections in Bagnall *et al.*, op. cit. (n. 55), 113, and supplemented by thirty-seven additional references in Bagnall and Frier, 309–12; C. A. Nelson, 'Four papyri from the Berlin collection', *BASP* 32 (1995), 123–32; P. J. Sijpestein, 'Three papyri concerning census', *ZPE* 107 (1995), 271–6; R. Duttenhöfer, 'Five census returns in the Beinecke Library', *BASP* 34 (1997), 53–78; P. Prag II 127.

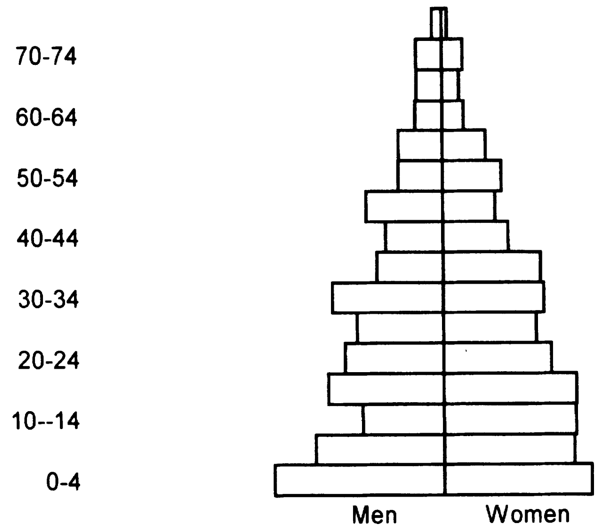

FIG. 7. SMOOTHED AND WEIGHTED AGE DISTRIBUTION IN THE CENSUS RETURNS OF ROMAN EGYPT.

at female and male age distributions that can be reconciled with the predictions of plausible Coale/Demeny models (Fig. 7). Due to the conspicuous underreporting of infants, mortality in the first year of life had to be extrapolated from these models. The best fit between evidence and models points to a mean life expectancy at birth of 'probably between 22 and 25 years' together with an adult age structure that is reasonably well consistent with the model schedules.[57]

My critique of this approach extends over Sections II to V. The pitfalls inherent in the schematic extrapolation of infant mortality rates from adult age structure have already been addressed in Section II. Next, the issue of the representative nature of these data also merits attention. Bagnall and Frier implicitly take them to approximate the specifics of the actual Egyptian age distribution and, more loosely, that of Roman populations in general.[58] This contention places a heavy burden on these three hundred papyri, and entails three preconditions. (1) For the age references in the census returns to mirror the age structure of the *census population* (i.e, the individuals covered by the extant texts), every member (or an identical proportion of members) of each age cohort would have to be reported. Systematic biases (as opposed to random fluctuations arising from small sample size that may be alleviated by smoothing techniques) would undermine this equation. (2) The census population would have to be broadly representative of the entire population of Roman Egypt, and (3) the Egyptian age pattern would have to be broadly typical of Roman age structure in general. Each of these assumptions can be shown to be doubtful. I will deal with the problem of representation in the remainder of this section before considering the validity of generalizations in Section IV. In Section V, I will investigate the claim that the census data match model patterns, and suggest an alternative reading of the evidence.

Bagnall and Frier follow model life tables in disaggregating the census data according to gender. Whilst stressing the supposedly superior quality of the references to female ages and expressing doubts about the validity of their demographic interpretation of the male data set, they accord a fair measure of demographic credibility to the resultant adult male age distribution.[59] In my view, this belief is unwarranted and

[57] Bagnall and Frier, op. cit. (n. 7), 75–110 (quote: 109). Cf. 34 n. 10 for a disclaimer concerning infant mortality.

[58] ibid., 109 (Egypt), 110 ('the returns provide solid support for the emerging picture of life expectancy in the early Roman empire').

[59] ibid., 106–9. 'We are much less confident about our restored male life table [sc. than about the female table], although we believe that it may not be far off in approximating the true level of male mortality, particularly among adults' (109).

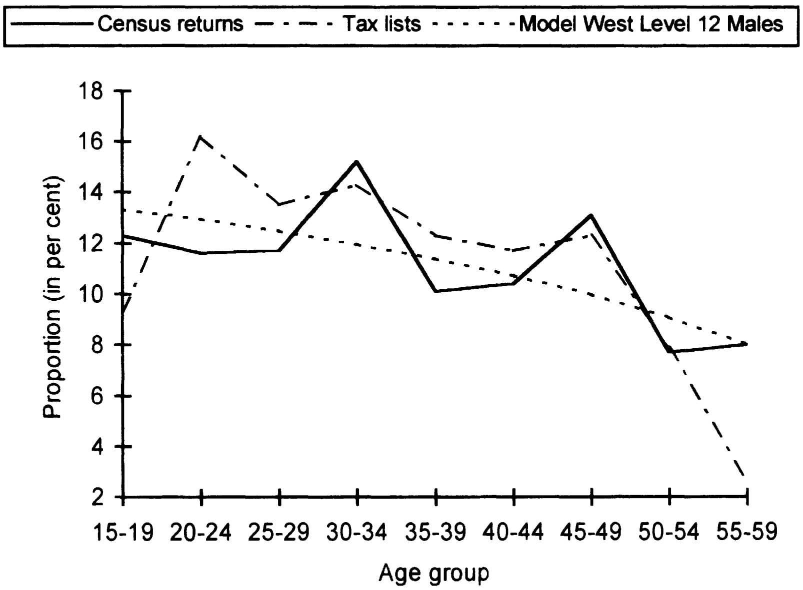

FIG. 8. MALE AGE STRUCTURE IN THE VILLAGE CENSUS RETURNS AND TAX LISTS OF ROMAN EGYPT, COMPARED TO A MODEL LIFE TABLE (CENSUS RETURNS: SEVEN-YEAR MOVING AVERAGES; TAX LISTS: RAW DATA).

the adult age data are fundamentally flawed. It is readily apparent that the reported ages of male villagers fall into an impossible pattern (Fig. 8).[60]

Hardly any men appear to have died between ages fifteen (or indeed five) and fifty, which, if true, would put villagers on a par with the most advanced Western populations today.[61] The extant tax lists, based on different village declarations for men, exhibit a similar though marginally less extreme pattern. This specious impression of longevity is created by the attempted concealment and/or absence of male taxpayers. Liable to pay poll tax from ages fourteen to sixty-two, some village men continued to be invisible well into their forties.[62] The flattened shape of these curves results from a gradual decrease in the frequency of concealment and/or absence. Comparative evidence strongly supports this interpretation. Similar levels of underreporting mar census documents from several villages in early medieval Japan.[63] Chinese census returns from the T'ang period likewise resemble Egyptian village records in that listed women outnumber men from ages sixteen to forty and no men appear to have died between ages thirty and sixty. Just as in Roman Egypt, adult men were then subject to a poll tax that appears to have encouraged systematic attempts at evasion.[64]

The female age data do not appear to suffer from comparable deficiencies. However, as I will show in Section v, the process of disaggregating the references based on gender obscures significant differences within the census population. For this reason, the record for women does not yield reliable information about the general age structure either.

[60] The tax list pattern in Bagnall and Frier, op. cit. (n. 7), 103, is based on a garbled sample of evidence. For this graph, see Scheidel, op. cit. (n. 38), ch. 2.3.1.

[61] The age data up to age sixty are broadly consistent with Model West Level 12 Males, with an implied mean life expectancy at birth of 44.5 years, a rate Egypt did not reach until the mid-twentieth century. This model is used for comparative purposes only.

[62] For consideration of the possibility that they migrated to cities, see below, Section v.

[63] W. W. Farris, *Population, Disease, and Land in Early Japan, 645–900* (1985), reporting low sex ratios similar to those found in Egyptian villages (Bagnall and Frier, op. cit. (n. 7), 163). Farris, 34, attributes this imbalance to attempted tax evasion. Just like in Egypt, this practice creates the specious impression of higher male life expectancy (ibid., 43; cf. Bagnall and Frier, 101).

[64] T. F. Liao, paper given at the 25th Anniversary Meeting of the Social Science History Association (Pittsburgh, 2000).

IV. PROBLEMS OF GENERALIZATION

Variation in Space

To the extent to which mortality is determined by endemic infectious disease, age structure depends on location in the same way as do the diseases themselves. Malaria is a choice example. *P. vivax* and *P. falciparum* require minimum ambient temperatures of 16 and 19 degrees Celsius, respectively, to reproduce successfully. For this reason, malaria does not thrive in Italy at altitudes of more than 500 m. *Ceteris paribus*, the demographic regimes of malarial and malaria-free zones may differ on an impressive scale. Del Panta compared conditions in two Italian towns in the 1840s: Grosseto, heavily beset by falciparian malaria, where mean life expectancy at birth was as low as twenty years, and Treppio, a much healthier community higher up, with a corresponding rate of thirty-seven years.[65] Similar discrepancies could be observed in Kent, where the Crude Death Rate (the annual number of deaths per 1,000 population) varied from 70 per 1,000 at sea level to 24 per 1,000 above 100 m altitude.[66] Malaria has the power to pattern the land in what Dobson calls geographical 'contours of death'. It thrives in fertile lowlands which are capable of supporting higher population densities than healthier upland regions. Cities were likely to be situated in the same low-lying areas. In his study of malaria in Roman Italy, Sallares draws attention to Pliny's observations on the differences between the malarial coast of Tuscany and his estate in Tifernum Tiberinum in Umbria, which must have been free of malaria. Pliny commented on the ubiquity of grandfathers and great-grandfathers in the latter community and noted that during one of his stays there none of his slaves had died, both of which occurrences seem to have struck him as unusual.[67] Yet even if we allow for some rhetorical hyperbole, there is no obvious reason why a town like Tifernum Tiberinum should not have enjoyed levels of life expectancy similar to that attested for Treppio in the mid-nineteenth century.[68]

As is well known, the inhabitants of premodern cities commonly experienced higher mortality than the rural population.[69] Urban excess mortality triggered immigration, affecting the age structure of both feeding and receiving groups.[70] Moreover, it may have offset demographic benefits accruing from socio-economic privilege. Evidence for the probable length of life of Roman emperors, senators, and city-councillors points to levels of life expectancy that cannot have been significantly higher than for commoners.[71] In fact, comparative findings suggest that location used to have a greater impact on longevity than access to material resources.[72] This picture only began to change in eighteenth-century Europe and China when more efficient medicine and hygiene first became available to the wealthy.[73]

These points about altitude and settlement style are both of immediate relevance for any demographic appraisal of the Egyptian census returns. Almost two-thirds of the

[65] Del Panta, op. cit. (n. 40), 22.

[66] Dobson, op. cit. (n. 30), 148 fig. 3.18; cf. also 153.

[67] Sallares, op. cit. (n. 41), drawing on Plin., *Ep.* 5.6.1, 6, 46.

[68] I should stress that these examples should best be understood as demarcating opposite ends of a spectrum: not every malarial locale was as lethal as the Maremma, and some malaria-free areas could be unhealthy for other reasons.

[69] For a judicious discussion, see esp. J. De Vries, *European Urbanization 1500–1800* (1984), 175–98; more recent contributions include the articles in *Annales de Démographie Historique* 1990, 5–151, and C. Galley, 'A model of early modern urban demography', *Economic History Review* 48 (1995), 448–69. For references to scholarship before 1984, see Scheidel, op. cit. (n. 52), 28 n. 106.

[70] The classic analysis is E. A. Wrigley, 'A simple model of London's importance in changing English society and economy 1650–1750', *Past and Present* 37 (1967), 44–70 (various reprints). N. Morley, *Metropolis and Hinterland* (1996), 33–54, applies this model to the ancient city of Rome.

[71] W. Scheidel, 'Emperors, aristocrats and the Grim Reaper: towards a demographic profile of the Roman élite', *CQ* 49 (1999), 254–81.

[72] e.g., Livi-Bacci, op. cit. (n. 33), 63–7; Johansson, op. cit. (n. 33), 113–14.

[73] T. H. Hollingsworth, 'Mortality in the British peerage families since 1600', *Population*, numéro spécial (1977), 327–8; Lee, Wang and Campbell, op. cit. (n. 29), 401.

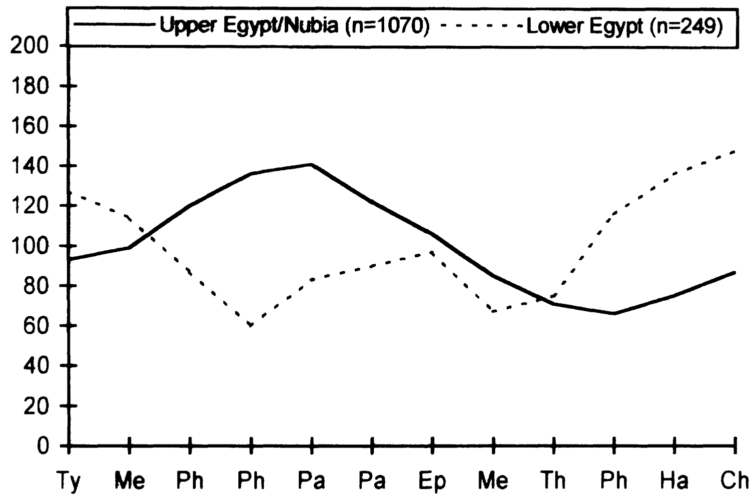

FIG. 9. SEASONAL MORTALITY IN ROMAN AND EARLY MEDIEVAL EGYPT AND NUBIA (SMOOTHED DATA).

extant declarations come from the Fayum, an oasis in a large depression whose ecology would have differed from that of the Nile valley or the Delta.[74] Its large lake and once extensive marshes supported endemic malaria. In the early twentieth century, even after some improvement measures, the Fayum was still the most malarial part of Egypt outside the northern Delta. Malaria is also attested for antiquity.[75] As late as the 1920s, Crude Death Rates in the Fayum were higher than anywhere outside Cairo and the (malaria-ridden) oases.[76] Other ancient data indicate considerable variation in the main causes of death in different parts of Egypt (Fig. 9).[77]

While these differences do not strictly speaking tell us anything about relative levels of mortality, they raise the serious possibility that death rates varied together with the underlying causes. Even though pathogens compete for hosts and one disease may therefore have killed people who would otherwise have succumbed to a different infection had it been present, it would be surprising if causes of death that generated mutually incompatible seasonality profiles had resulted in identical death rates. It is also important to note that teenagers and young and middle-aged adults are overrepresented in the epitaphs on which these profiles are based.[78] In standard models, this group is least heavily affected by mortality and physiologically best equipped to resist endemic infections. Nevertheless, the strong seasonal swings in mortality leave little doubt that endemic infections killed them in large numbers. Seasonality data from Italy reveal the

[74] Provenance of census texts: Bagnall and Frier, op. cit. (n. 7), 8.

[75] A charm from the Fayum village of Tebtunis targeted various types of malaria (*PMG* 33.1–25); for other ancient data, see, e.g., A. Cockburn, 'Ancient parasites on the west bank of the Nile', *The Lancet* 8252 (1981), 938; R. Miller *et al.*, 'Diagnosis of Plasmodium falciparum infections in mummies using the rapid manual *Para*Sight™-F test', *Transactions of the Royal Society of Tropical Medicine and Hygiene* 88 (1994), 31–2; Hdt. 2.95. Thirteenth century: Nabulsi' description in A. Zeki, 'Une description arabe du Fayoum au VIIe siècle de l'hégire', *Bulletin de la Société Khédivale de Géographie*, ser. 5, 1 (1898), 264–9. Early twentieth century: *Preliminary Report of the Anti-Malarial Commission* (1919), 33–4; *Report No. 1 of the Anti-Malarial Commission for the Period from 1919 to March 1925* (1928), 37–8; *Report No. 13 on the Anti-Malarial Work in Egypt, 1936* (1939), 3. For a comprehensive discussion of malaria in Egypt from antiquity to the present, see Scheidel, op. cit. (n.38), ch. 1.3.5.

[76] *Annuaire statistique 1926–1927* (1928), 61. I am grateful to B. D. Shaw for providing me with a copy of this text.

[77] The graphs in Fig. 9 are derived from the incidence of mortality reflected in Greek and Coptic tombstones and Greek mummy labels; see Scheidel, op. cit. (n. 38), Appendix 1, for full references. A discussion of seasonal mortality in Roman Egypt can be found ibid., ch. 1.

[78] B. Boyaval, 'Remarques à propos des indications d'âges des etiquettes de momies', *ZPE* 18 (1975), 63–6; 'Remarques à propos des indications d'âges de l'épigraphie funéraire d'Egypte', *ZPE* 21 (1976), 219, 221, 238–40; 'Datation du décès dans l'épigraphie funéraire de l'Egypte gréco-romaine', *Kentron* 4, 3 (1988), 68–70.

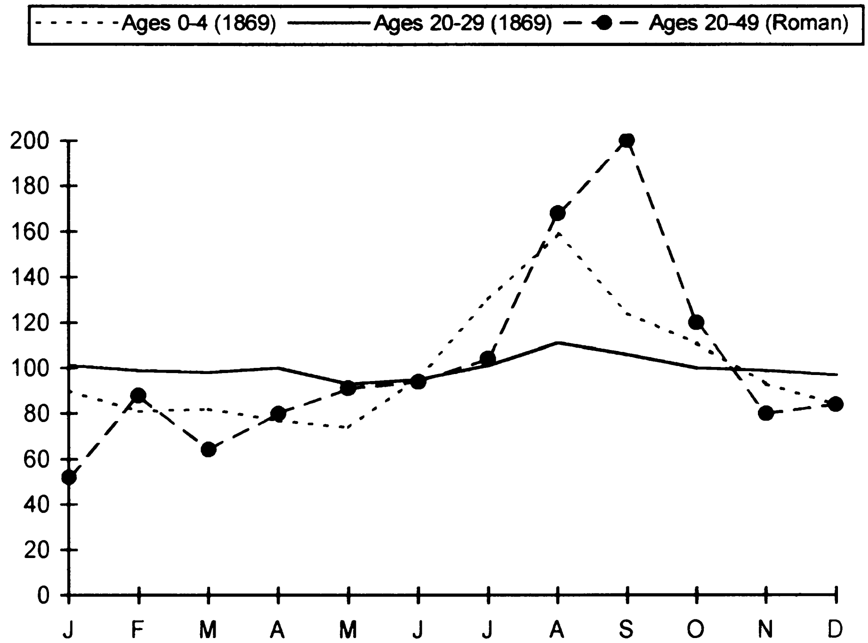

FIG. 10. SEASONAL MORTALITY AT SPECIFIC AGES IN ITALY, 1869, AND IN LATE ANTIQUE ROME.

width of the gap between ancient and modern (Fig. 10).[79] This observation once again raises the suspicion that in the distant past adult mortality may have significantly exceeded the predictions of model life tables, a suspicion that is corroborated by the properties of most of the principal fatal diseases discussed in Section II.

Ecological and epidemiological divergence between Egypt (or any of its constituent regions) and other parts of the Roman world would further diminish the representative value of the census records even if they could be shown to furnish reliable documentation. Above all, Roman Egypt was much more densely populated than any other province, at least ten times as much as the Empire as a whole.[80] The unifying communications artery of the Nile facilitated the transmission of disease, and the annual inundation (unique to that part of the Mediterranean) would also interfere with epidemiological conditions. Certain diseases were said to be particularly prevalent in that country, such as leprosy, which had been unknown outside Egypt prior to the first century B.C.[81] Bubonic plague was first reported in Libya, Egypt, and Syria in the Hellenistic period.[82] In Egypt proper, schistosomiasis and dracunculiasis also contributed to local morbidity patterns.[83]

According to the historical demographer Sheila Ryan Johansson, 'early modern Europe was characterized by extreme variability with respect to its mortality patterns'. In seventeenth-century England alone, local rates of mean life expectancy at birth would range from twenty to fifty years, and annual growth rates of 1 to 2 per cent were feasible under the most favourable conditions.[84] In nation-sized samples, local fertility imbalances would largely cancel each other out: no premodern population could have sustained growth on that scale. However, these comparisons show that the plausible estimate of average annual long-term growth of 0.15 per cent in the Roman Empire as a

[79] G. Ferrari and M. Livi-Bacci, 'Sulle relazione tra temperatura e mortalità nell'Italia Unita, 1861–1914', in *La popolazione italiana nell'ottocento* (1985), 280 tab. 5; B. D. Shaw, 'Seasons of death: aspects of mortality in imperial Rome', *JRS* 86 (1996), 120 fig. 11.

[80] Frier, op. cit. (n. 8), 814 tab. 6.

[81] Lucr. 6.1114–15.

[82] Rufus of Ephesus in Oreib., *Coll. med.* 44.14 (*CMG* 6.2.1).

[83] G. Contis and A. R. David, 'The epidemiology of bilharzia in ancient Egypt: 5000 years of schistosomiasis', *Parasitology Today* 12 (1996), 253–5; P. B. Adamson, 'Dracontiasis in antiquity', *Medical History* 32 (1988), 204–9.

[84] S. R. Johansson, review of Benedictow, op. cit. (n. 27), *Population Studies* 48 (1994), 528, 531, also emphasized by Sallares, op. cit. (n. 41).

whole[85] has little bearing on local conditions and is of no obvious relevance for the study of any particular local data sample.

In demographic terms, the plains of Latium were very different from the hills of Umbria; Upper Egypt was different from the Delta or the Fayum; Egypt as a whole was different from Italy or Greece; and Britain or Pannonia may have been different again; arid land differed from marshland, mountains from lowlands. That the resultant kaleidoscope of local demographic regimes is irrevocably lost does not mean that it did not matter.[86] In their sweeping Braudelian survey, Horden and Purcell emphasize the ecological fragmentation of the Mediterranean, with its manifold micro-climates and ecological niches.[87] Demographic fragmentation needs to be added to this picture. Coale and Demeny built their model life tables from large, preferably national, samples of data. Modern expectations to find a close and genuine match between any one local data sample from the Roman world and any such model would seem to require a remarkable and probably unwarranted suspension of disbelief.

Variation in Time

Demographic change also needs to be taken into account. It would be wrong to envision static micro-regimes, frozen in time. Instead, the Roman period witnessed significant shifts in the presence of disease and hence mortality. The progressive 'confluence of the civilized disease pools of Eurasia'[88] enriched the epidemiologic landscape of the Mediterranean. Increases in population density and the expansion of exchange networks facilitated the flow of pathogens over great distances and helped ensure their endemicity. The slow spread of leprosy from Egypt to Italy and into Western Europe is a classic example.[89] More dramatically, the 'Antonine plague' of the late second century A.D. appears to have been the first true pandemic of smallpox in the Mediterranean basin.[90] In his forthcoming dissertation, Yan Zelener argues, on the basis of epidemiologic models, that on this occasion smallpox ought to have established itself permanently in the main population centres of the Empire. The number of residents of Rome and Alexandria, in any case, well exceeded the endemicity threshold. In its endemic form, smallpox would have killed children in the metropolises but also periodically escaped and caused epidemic outbreaks in the surrounding regions.[91] By the late first millennium A.D., measles, never clearly described by Greek or Roman authors, had likewise become endemic in the eastern Mediterranean. Its introduction in the Roman period seems at least plausible, conceivably in the third century A.D.[92] In the sixth century A.D., bubonic plague first entered Europe from Asia or Africa, ravaging it for over two centuries.[93] Sallares traces the gradual dissemination of malaria in various parts of Roman Italy. The Pontine Marshes are the most impressive example: a region considered fertile and worth fighting for during the early Republican period had, by the first century A.D., turned into a largely uninhabitable malarial death-trap. Human interference in the form of failed drainage projects and changes in the water table caused

[85] Frier, op. cit. (n. 8), 813. However, contrary to ibid., 813 n. 104, 'a rate of that order' is *not* 'supported by the Egyptian census returns', if only because it is impossible for a regional data set — regardless of its quality — to provide any corroboration or falsification of a general assumption about the Roman Empire as a whole. See below, n. 124.

[86] Seasonal mortality patterns derived from dates of death recorded on epitaphs afford us rare glimpses of the true scale of epidemiologic and thus demographic variation in the Roman world: see W. Scheidel, *Measuring Sex, Age and Death in the Roman Empire* (1996), ch. 4; Shaw, op. cit. (n. 79).

[87] P. Horden and N. Purcell, *The Corrupting Sea* (2000).

[88] W. McNeill, *Plagues and Peoples* (1977), ch. 3.

[89] Grmek, op. cit. (n. 34), 168–73.

[90] R. J. Littman and M. L. Littman, 'Galen and the Antonine plague', *AJP* 94 (1973), 245; R. Sallares, *The Ecology of the Ancient Greek World* (1991), 248. On the scale of the epidemic, see Duncan-Jones, op. cit. (n. 19). Thuc. 2.48 might point to a previous smallpox incursion.

[91] Y. Zelener, PhD thesis, Columbia University (in preparation). I am grateful to Y. Zelener for sending me a copy of his draft.

[92] cf. McNeill, op. cit. (n. 88), 132, for a guess that the massive pandemic in the 250s and 260s A.D. may have been measles; cf. also A. Cliff *et al.*, *Measles* (1993), 49.

[93] J.-N. Biraben, *Les hommes et la peste en France et dans les pays européens et méditerranéens, I* (1975), 25–48; L. Conrad, *The Plague in the Early Medieval Middle East* (1981).

by road construction may have contributed to the spread of malaria. In other cases, progressive alluviation reduced the salinity of coastal marshes and provided new breeding grounds for anopheline vectors.[94] In general, therefore, there is reason to believe that the Roman period coincided with a gradual exacerbation of the disease environment and concomitant increases in overall mortality. While limited economic and demographic growth expressed in urbanization, improved communications, and more intensified land use encouraged the exchange of infective agents, corresponding progress in the stock of medical knowledge that could have countervailed this development did not occur.

Finally, and again with an eye to the application of model life tables to the more distant past, it deserves attention that less developed but well-documented countries permit us to glimpse epidemiologic change under more 'archaic' conditions. The disease environment of Egypt, for instance, underwent major transformations both within the nineteenth century and between the nineteenth and the early twentieth centuries. Either regional seasonality pattern charted in Fig. 9 differs from the distribution found in the 1920s, at a time when mean life expectancy at birth was still hovering around thirty years and the country was a long way from a 'modern' demographic regime.[95] Even so, important shifts had occurred in the preceding generations.[96] As recently as the early nineteenth century, smallpox was endemic among small children while quasi-endemic plague killed large numbers of adults. Conditions changed with the departure of the plague in the 1840s and the gradual eradication of smallpox through Jennerian vaccination. Measles temporarily replaced smallpox as a leading cause of death in childhood while diarrheal diseases struck those who would earlier have succumbed to smallpox and plague. In the 1860s, around 70 per cent of all deaths in Cairo were attributed to gastro-intestinal disorders, compared to 35 per cent in the 1920s. During the same interval, the share of deaths from pulmonary diseases doubled from 14 to 28 per cent.[97] What matters here is that these complementary shifts do not appear to have been accompanied by significant changes in mean life expectancy. Rather, different diseases competed for prey. However, due to the age-specific impact of diseases such as tuberculosis, Egyptian age structure may arguably have been more strongly affected than life expectancy. In the absence of human intervention (which played a major role in these changes), ancient populations would not experience similarly dramatic shifts in the relative prevalence of different causes of death. Yet the Egyptian case is relevant in so far as it confirms that low levels of life expectancy can be associated with markedly diverse disease environments and thus age distributions. There was no such thing as a premodern demographic regime or a premodern age structure beyond the obvious point that mortality and fertility must have been high in any case. This general principle accommodates considerable epidemiologic variation with consequent effects on age structure. Under these circumstances, whenever samples of Roman age data do appear to square with the predictions of model life tables, they may well do so by chance, and not because of some basic demographic uniformity across millennia.

V. PROBLEMS OF CONVERGENCE

Given a sufficiently large number of specimens, coincidental matches between evidence and models will eventually be observed. Frier's analysis of a cemetery population from late Roman Pannonia that appears to fit model schedules may belong

94 Sallares, op. cit. (n. 41).

95 See above, Fig. 9, and compare Shaw, op. cit. (n. 79), 124 figs 15–16. For life expectancy in the 1920s, see *The Estimation of Recent Trends in Fertility and Mortality in Egypt* (1982), 12 tab. 2.

96 The following summary draws on L. Kuhnke, *Resistance and Response to Modernization* (1971); D. Panzac, op. cit. (n. 44) and 'The population of Egypt in the nineteenth century', *Asian and African Studies* 21 (1987), 11–32; S. Jagailloux, *La médicalisation de l'Egypte au XIXe siècle* (1986).

97 Causes of death: Schnepp, op. cit. (n. 44), 552–3; Panzac, op. cit. (n. 44), 85 tab. 2. In these early datasets, only the most basic classifications (e.g., gastro-intestinal vs. pulmonary diseases) may be taken at face-value.

in this category.[98] In that case, multiple statistical tests confirm a close fit between the age distribution derived from a skeletal aggregation of ninety-nine individuals aged five and over (out of a total of 120) from a community in Keszthely-Dobogó on Lake Balaton. Yet while the statistics are beyond reproach, it is impossible to tell to what extent this small sample reflects the intrinsic age structure of the (local? Pannonian? Roman?) population in general. As long as it remains unclear for how long this cemetery remained in use, it is difficult to relate the number of burials to the size of the settlement. If all these bodies had been interred within a few decades, the whole community need not have numbered more than one hundred residents.[99] This is possible; however, if the settlement had been larger, how can we tell whether the remains of the 'invisible' deceased would have produced a similar age distribution? Conversely, if the community had indeed consisted of no more than a few dozen households, migration on a relatively modest scale could have had a significant impact on overall age structure. Frier notes that the local population 'was made up of peoples from adjacent provinces, together with an admixture of settlers from beyond the frontier'.[100] I fail to see how stable population analysis (which presupposes a closed population or requires rates of migration to be known) can profitably be applied to a sample of this size and background. Indeed, the fact that, among local skeletons aged twenty and over, men outnumber women three to two all but proves that this aggregation does not reflect the structure of a 'normal' population.[101] This skewed sex ratio must be the result of differential burial practices (which would inevitably cast doubt on the representative nature of the male remains as well) or considerable immigration of single adult men, or both. And, as usual, all the other Roman skeletal samples that do not meet this standard must necessarily be excluded from consideration. In general, owing to the multiple refractions of the sampling process discussed in Section III, a local population with an age structure that happens to be consistent with the predictions of model life tables cannot simply be expected to generate a skeletal sample that gives the same impression. Conversely, a cluster of age data derived from often deficient estimates of skeletal age that happens to fall into an age distribution that conforms to model standards is unlikely to reflect past 'realities'.[102]

Frier's recent attempt to exploit epitaphs from Roman North Africa for a reconstruction of regional age structure raises similar questions. He is able to show that a segment of the male age data precisely replicates the pattern predicted by a plausible model life table.[103] Yet again, the problems of representation summarized above (Section III) undermine any simplistic equation of the commemorated with all deceased. Once more, since all epigraphic samples from other parts of the Roman world need to be discarded, the risk of circularity looms large.[104] Further doubts arise from the observation that the female distribution diverges from model predictions. It is impossible to tell whether this apparent discrepancy reflects sex variation in mortality or funerary recording preferences.[105] Were only women affected by 'non-standard'

[98] Frier, op. cit. (n. 7, 1983), esp. 331–4 for the statistical tests. The data were provided by G. Acsádi and J. Nemeskéri, *History of Human Life Span and Mortality* (1970), 296–7.

[99] An early report assigned these burials to the period from A.D. 340 to 374: according to Frier, op. cit. (n. 7, 1983), 332 n. 9, this implies a total population of around 125 persons. However, a later study re-dated this site to the reign of Constantine I: see V. Lányi, 'Die spätantiken Gräberfelder von Pannonien', *AArchHung* 24 (1972), 138.

[100] Frier, op. cit. (n. 7, 1983), 331. Acsádi and Nemeskéri, op. cit. (n. 98), 227, distinguish between two cranial types in this group.

[101] See Acsádi and Nemeskéri, op. cit. (n. 98), 298–301 (49.5 men and 33.375 women aged 20+). Frier omits this telling bit of information.

[102] For the problem of dual demographic 'realities', see above, p. 11. Frier's contribution of 1983 coincided with the onset of a wave of criticism of the feasibility of 'paleodemography': see esp. J.-P. Bocquet-Appel and C. Masset, 'Farewell to paleodemography', *Journal of Human Evolution* 11 (1982), 321–33 (cf. also their 'Paleodemography: expectancy and false hopes', *American Journal of Physical Anthropology* 99 (1996), 571–83, and above, n. 52). Thus, the belief in the reliability of the demographic analysis of skeletal remains expressed by Frier, op. cit. (n. 7, 1983), 343, while common at the time, now seems rather outdated. Unfortunately, his use of paleodemographic results in op. cit. (n. 8), 790, takes no account of these intervening developments.

[103] Frier, op. cit. (n. 8), 791–2 and tab. 2 (Model South Level 2 Males).

[104] Hopkins, op. cit. (n. 6, 1987), 121–2 raises methodological objections to this process.

[105] As I first pointed out in Scheidel, op. cit. (n. 52), 18 n. 61, the female age pattern matches Model South Level 2 Females for ages ten to twenty but increasingly deviates at later ages, especially between twenty-five and forty when implied mortality is higher even than in Level 1.

mortality and/or commemoration, or not?[106] How could we possibly know? Hopkins confronted this conundrum thirty-five years ago, warning us against the temptation of accepting ancient 'evidence which confirms the hypothesis merely because it confirms it', and calling for independent confirmation, which is not available here.[107]

The Egyptian census returns are all that remain.[108] Bagnall and Frier's disaggregation of the age data according to gender yields two separate matches between the data and model life tables. Since the male data can now be shown to be too distorted to be of much use for demographic purposes (see above, Section III), the burden of proof rests squarely on the reported ages of women. Surviving in sufficiently large numbers to ensure statistical significance of the observed convergence, the female data gain some *prima facie* credibility by plausibly implying a mean life expectancy at birth of about twenty-two years (as extrapolated from adult age structure).[109] However, it is not at all obvious that the data should be separated along gender lines. In the absence of frequent warfare and under conditions of high mortality overall, sex differences in age structure are unlikely to be dramatic and need not even be discernible in imperfect data.[110] In view of the pivotal role of endemic infection in shaping mortality patterns and its contingency on ecological conditions such as population density (see above, Section IV), location can reasonably be expected to be a more significant determinant of age structure than gender. Almost half of the age records originate from urban settings, above all from Arsinoe, one of the largest cities in Roman Egypt with a population of 40,000 or more. Most of the other urban returns were filed in Oxyrhynchus and Hermopolis Magna, centres of several tens of thousands of residents each. District capitals of this kind were maybe twenty to thirty times as populous as the average Egyptian village (or close to ten times as populous as the largest villages), and could easily have created their own distinct epidemiologic regime.[111] This assumption is consistent with the census evidence (Fig. 11).

On the face of it, the urban age distribution implies higher attrition rates at mature ages than the rural data (which underreport young adults and are therefore unrepresentative) and Bagnall and Frier's model for the total census population.[112] One might suspect that the urban records reflect temporary migration of individuals in their late teens and early twenties. It would even be possible to speculate that these young city-dwellers are the very men missing from the villages. However, for this explanation to be valid, temporary migrants had to be covered by the census. Even if some of the 'missing' villagers had indeed moved to the cities,[113] it is far from clear that their presence would

[106] According to the tabulations by J. Szilágyi, 'Die Sterblichkeit in den nordafrikanischen Provinzen', *AArchHung* 17 (1965), 309–34, 18 (1966), 236–77, 19 (1967), 25–59, men were 1.37 times as likely as women to be commemorated in North African epitaphs (n = 17,793). For this reason alone, a significant amount of reporting bias is certain to have prevailed. Hopkins, op. cit. (n. 6, 1987), 125–6, raises the same point regarding a smaller sample from Roman Africa. Duncan-Jones, op. cit. (n. 53), 102 and n. 26, notes that age-rounding may have introduced additional distortions.

[107] Hopkins, op. cit. (n. 6, 1966), 264: 'We have to show instead some other grounds for its validity; for example, that in Africa all people who died were commemorated, hence the reasonable demographic levels of mortality at certain ages. But clearly we do not have enough evidence for such an assertion.' This standard has not been met: cf. Frier, op. cit. (n. 8), 791: 'In the case of the European inscriptions, no life table based on all or part of them is even remotely plausible. (. . .) Roman North Africa is altogether different. (. . .) they produce credible mortality rates for males aged 10 to 44, and for females aged 10 to 54', etc., a line of reasoning that illustrates Hopkins' principle. This approach also undermines the view that 'convergence of the best available statistics still demands a measure of respect' (Bagnall and Frier, op. cit. (n. 7), 109), given that there is no quality standard beyond goodness of fit with Coale/Demeny models. Cf. furthermore Scheidel, op. cit. (n. 52), 20–1.

[108] I am disinclined to discuss under this heading the evidence of Ulpian's so-called 'life table' (*Dig.* 35.2.68 pr.) (exploited by Frier, op. cit. (n. 7, 1982)) since it remains unclear whether this text is based on any kind of empirical evidence at all (*pace* Duncan-Jones, op. cit. (n. 53), 100–1). For scepticism, cf. Parkin, op. cit. (n. 6), 27–41, 75–8, 82–3; Hopkins, op. cit. (n. 6, 1987), 120–1; Saller, op. cit. (n. 1), 13–15.

[109] Bagnall and Frier, op. cit. (n. 7), 84–90. For the pitfalls inherent in this extrapolation process, see above, Section II.

[110] I hasten to qualify this statement with a reference to the Chinese data cited in n. 49, which show marked gender differences.

[111] For city and village population numbers, see D. Rathbone, 'Villages, land and population in Graeco-Roman Egypt', *PCPS* 36 (1990), 103–42.

[112] The latter deviation is statistically significant. In the cities, 71.1 per cent of residents aged five and over are between five and thirty-four years old, compared to 64.7 per cent in the model ($p < 0.0208$). 62 per cent of those older than fifteen are aged between fifteen and thirty-four, compared to 53 per cent in the model ($p < 0.0066$).

[113] In general, see H. Braunert, *Die Binnenwanderung* (1964).

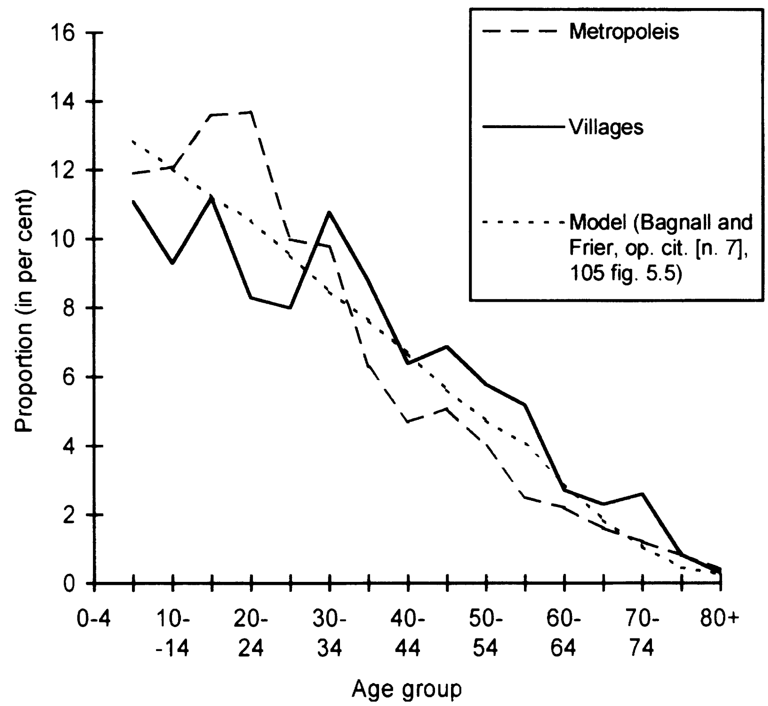

FIG. 11. AGE COMPOSITION OF THE CENSUS POPULATION OF ROMAN EGYPT (SEVEN-YEAR MOVING AVERAGES).

have been properly recorded. Population counts that took place every fourteen years were hardly a suitable instrument to keep track of mobile young men. The census' focus on households rather than individuals must have made it even easier to escape detection. Comparative evidence sheds some light on the possible scope of resultant underreporting. A demographic survey of households in Bangladesh conducted in 1961/62 established an urban sex ratio of 107.7 (i.e., 107.7 men per 100 women) and a rural mean of 106.1. By contrast, the census of 1961, which sought to include every person, found the urban sex ratio to be as high as 153.2, compared to 105 in the countryside. Local observers attributed this staggering discrepancy to the omission of messes, hostels, and similar residential units from the household survey.[114] Moreover, poor young male immigrants may also have spent their nights at their workplace or slept rough. Similar arrangements may be suspected for Roman Egypt. Moreover, the age structure of urban lodgers registered in the census returns did not differ from that of other urban residents.[115] Thus, since it appears impossible to identify temporary migrants in the census declarations, it is not feasible to explain the apparent surfeit of young adults in the cities with reference to migration.

In any case, this 'apparent surfeit' disappears once we abandon the implicit assumption that any given historical population ought to resemble one of the model populations created by Coale and Demeny. As I have tried to show in Section II, there is no compelling *a priori* reason to expect urban age structure in Roman Egypt to be consistent with model life table predictions. Hence, the alternative explanation that urban mortality at mature ages may actually have been higher than envisaged by such models cannot be dismissed out of hand. In cities of that size, some degree of urban 'excess' mortality is only to be expected.[116] The fact that both male and female ages

[114] A. N. M. Muniruzzaman, *Demographic Survey in East Pakistan, 1961–1962, part 3* (1966), 9–10.

[115] See Scheidel, op. cit. (n. 38), ch. 1.3.2 for discussion.

[116] See above, n. 69. R. S. Bagnall, *Egypt in Late Antiquity* (1993), 50, likewise assumes that cities were less healthy than villages. This possibility is not investigated in Bagnall and Frier, op. cit. (n. 7).

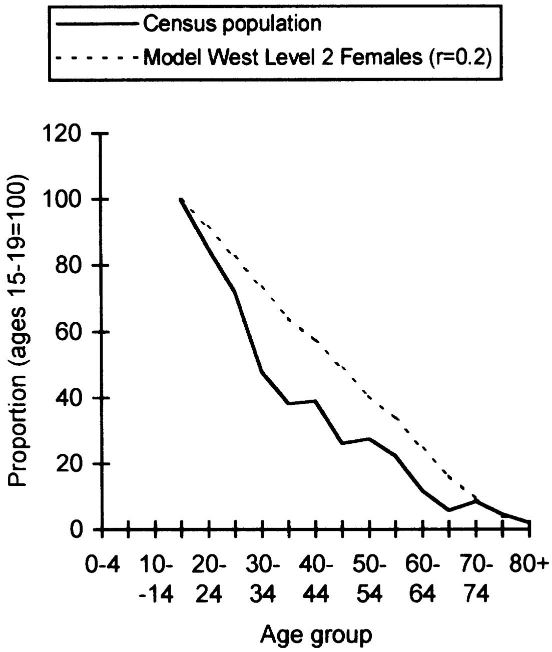

FIG. 12. FEMALE AGE COMPOSITION OF THE URBAN CENSUS POPULATION OF ROMAN EGYPT EXCLUDING LODGERS AND SLAVES (SEVEN-YEAR MOVING AVERAGES).

exhibit the same characteristics may be taken to support this new reading of the evidence (Figs 12–13).[117]

Although other explanations (involving some unknowable reporting biases or population movements) cannot be ruled out, I am inclined to regard the urban age data from Roman Egypt as the oldest surviving quantifiable evidence of urban excess mortality in world history. At the very least, the urban age distributions do not fit any plausible standard model life tables. Thus, data disaggregation according to gender obscures potentially significant differences between urban and rural demography that cannot readily be attributed to migratory flows. As a matter of fact, even if they could be explained in this way, the mere admission that these samples might be affected by discernible levels of relocation would preclude the application of stable population analysis unless we are prepared to believe that, by some striking coincidence, the number of emigré villagers who are missing from the rural census returns is identical with the number of temporary city residents reflected in the urban documents.[118]

But what about the age records of village women, which do closely match a plausible pattern (Model West Level 2 Females; $e_0 = 22.5$)? Unfortunately, after two successive disaggregations — according to location *and* gender — this sample is now too small for this match to be statistically significant. The attested age structure is equally well compatible with Model West Levels 1 to 6, with corresponding rates of e_0 of from 20 to 32.5 years (or, indeed, with any roughly comparable non-standard age distribution).[119] The only sample that still allows statistically significant comparisons is that of all urban

[117] Temporary migration would tend to be sex-specific. In the absence of obvious concealment of village women, there is no reason to believe that the ranks of young adult women in the cities were boosted by temporary migrants. In the villages, women at these ages consistently outnumber men: Bagnall and Frier, op. cit. (n. 7), 163 fig. 8.2.

[118] However, this is the implicit assumption logically underlying the weighting procedure in Bagnall and Frier, op. cit. (n. 7), 82, where they recalculate figures on the assumption that the ratio of urban to rural population was 1:2 (i.e., giving village data twice the weight of urban data), in the apparent belief that this would restore a representative sample of the actual population.

[119] If the sample of 141.1 female villagers (based on seven-year moving averages) aged fifteen to sixty-nine is divided into two roughly equal halves, 51.45 per cent are younger than thirty-five. In terms of statistical significance, this proportion is compatible with corresponding shares predicted by Model West Females Levels 1 ($p < 0.4$) through 6 ($p < 0.516$).

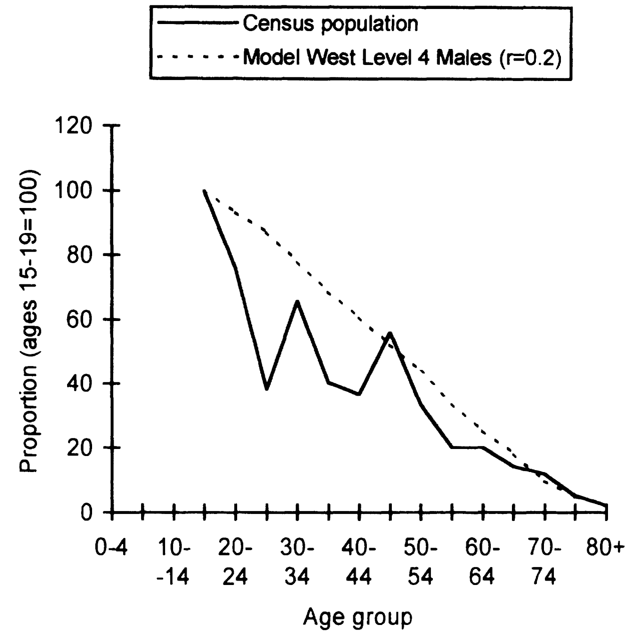

FIG. 13. MALE AGE COMPOSITION OF THE URBAN CENSUS POPULATION OF ROMAN EGYPT EXCLUDING LODGERS AND SLAVES (SEVEN-YEAR MOVING AVERAGES).

residents, which does not match any plausible standard model life table.[120] However, there is no good reason to consider the urban age structure in any way representative of Egyptian conditions in general. The urban population may well have been incapable of fully reproducing itself (a common pattern in premodern high-mortality settings[121]), relying on immigration to maintain or expand its size.[122] This situation cannot in the long term have applied to the country as a whole. As a consequence, it is impossible to reconstruct the 'average' age structure of the population of Roman Egypt from the extant census returns.

VI. CONCLUSION

Two distinct issues are at stake. First of all, is it possible, with the help of model life tables, to guess at the 'average' age structure of the population of the Roman Empire as a whole? In view of the origins of standard mortality models and the impact of more 'archaic' disease patterns on age-specific chances of survival, it seems doubtful whether any model life table is capable of giving even 'an approximate notion of normal Roman mortality experience', as suggested by Frier. Not only is the very notion of 'normal' mortality an untenable concept (see above, Section IV) but Frier's concession that, because of the likelihood of considerable variation in space, time, and class, 'normal Roman life expectancy at birth is perhaps more satisfactorily set in a broad range from twenty to thirty years', does not fully take account of the very real possibility that model extrapolations may not do justice to the full scale of premodern variation in age structure *per se* (as opposed to mean life expectancy).[123] Thus, local and regional age distributions would not merely have oscillated within a band of Coale/Demeny levels of mean life expectancy but may more conspicuously have deviated from the age-specific mortality

[120] See above, n. 112.

[121] See above, nn. 69–70.

[122] It should be noted that permanent immigration at the onset of maturity would have had no palpable impact on the urban distributions in Figs 12–13, except for the possibility that recent immigrants were particularly vulnerable to unfamiliar urban disease environments.

[123] Frier, op. cit. (n. 8), 789.

matrices associated with particular averages of life expectancy. There is now no good reason to believe that the correlation between mean life expectancy at birth (or any other age) and the overall age structure was anywhere near as solid as predicted by Coale and Demeny's algorithm (see above, Section II).

General references to the probable margins of demographic variation in ancient populations sit uneasily with elaborate attempts to match samples of age data with particular levels of life expectancy or growth rates. This leads to the second major question: is it possible to link probabilistic assumptions about Roman age structure to empirical evidence from that period? I submit that, taken together, my observations in Sections III to V compel us to reject this assumption. It seems incongruous to affirm the general principle of ancient mortality variation before proceeding to match age distributions derived from raw data to one particular model life table or to make them yield precise intrinsic growth rates down to two decimal points for far-flung populations numbering in the millions.[124] The 'modern consensus that average life expectancy of Romans at birth was normally about 25 years, or perhaps even slightly lower' may well be correct, all the more so as it appears consistent with comparative evidence from the more recent past.[125] However, while empirical data from the Roman period cannot be shown to 'support' this consensus in any meaningful sense of the term (see above, Sections III and V), model life tables on their own are likely to underestimate local and regional variation in age structure (as opposed to mean life expectancy at birth).[126]

Over the past twenty years, hopes have been growing that it might indeed be possible to anchor modern estimates of Roman age structure and life expectancy in model approximations or, preferably, even in primary evidence. It has been my aim to show that these hopes are deceptive. Thirty-five years after the publication of Keith Hopkins' seminal critique of earlier attempts to reconstruct Roman age structure, we have not been able to advance beyond his guesstimate that mean life expectancy at birth in the Roman world probably fell in a range from twenty to thirty years.[127] If anything, these bounds seems unnecessarily restrictive. Given the scope of variation in other premodern societies, it is perfectly possible that in the most hazardous environments (quite possibly including the city of Rome itself) this mean may have dropped below twenty years, or that in the most favoured locales it could have exceeded thirty years by a palpable margin (cf. above, Section IV). It might be tempting to underestimate the significance of such differences: after all, mean life expectancy at birth even in the worst-off countries today barely dips below forty years.[128] But not all high-mortality regimes are alike. Hopkins' paper came out in the year of my birth. Relying (*nolens volens*) on model life tables for this calculation, a mean life expectancy at birth of eighteen years

[124] e.g., Frier, op. cit. (n. 7, 1983), and Bagnall and Frier, op. cit. (n. 7), esp. 84–90. Attempts to derive typical rates of population growth from small data samples are particularly hard to defend. Natural growth rates need to be known from independent sources (such as successive population counts) *before* attested age distributions can be converted into life tables. It is technically impossible to derive both age-specific mortality rates and growth rates from the *same* body of data: for instance, high mortality and strong growth will shape age structure in the same manner (by increasing the proportion of young people). This insuperable problem invalidates the claim that the (entirely plausible) estimate of an average long-term annual growth rate of 0.15 per cent in the early Roman Empire 'is supported by the Egyptian census returns' (Frier, op. cit. (n. 8), 813 n. 104), a claim based on the interpretation of subtle differences between the adult age distribution of women in these documents and one particular model life table (Bagnall and Frier, op. cit. (n. 7), 86). This claim is predicated on the notions that (1) the female age data in the census texts can be shown to be representative of the Egyptian population (which is not the case: see above, Section V); (2) the chosen model life table provides a normative standard (which is unlikely: see above, Section II); (3) local growth rates coincide with global averages (which is even more unlikely: see above, Section IV). The assertion that 'the age-distribution at Keszthely-Dobogó is generally consistent with a population declining at a rate of somewhat less than .5% per year' (Frier, op. cit. (n. 7, 1983), 331 n. 5) is also voided by this bundle of problems. In fairness, I ought to point out that some of my own earlier work is vitiated by an overly optimistic application of model life tables to inadequate data samples (see esp. Scheidel, op. cit. (n. 86), 117–24).

[125] Frier, op. cit. (n. 8), 791.

[126] Outright scepticism about the relevance of model life tables has been rare among ancient historians: see, however, M. Golden, 'A decade of demography: recent trends in the study of Greek and Roman populations', in P. Flensted-Nielsen *et al.* (eds), *Polis and Politics* (2000), 32; Sallares, op. cit. (n. 41).

[127] Hopkins, op. cit. (n. 6, 1966), 264.

[128] According to the *Human Development Report 1999* (1999), 137, e_0 in war-torn Sierra Leone was 37.2 years in 1997, the only country with a reported rate of under 40. By now, the worst AIDS-affected countries such as Zambia are about to drop below 40 years.

would have given me a one in four chance of living long enough to write this article; at twice that rate, the odds would have been twice as good.[129] Thus, the relative difference between these two environments is as great as between the top end of that range and life today, an enormous gap by any standard. If mean life expectancy at birth is twenty years, the average woman surviving to menopause has to give birth to 6.3 children to replace herself and her spouse; at thirty-five years, 3.7 suffice. Romans must have felt the difference, even if they were unaware of the true range of demographic variation in their own day, as most of them must have been. Unfortunately, so are we. Beyond divergence in average life expectancy, the impact of particular diseases on local age structure may have mattered even more. Identical rates of mean life expectancy would have been compatible with exceptionally high mortality at different ages (cf. above, Section II). Diseases that struck adults rather than small children would arguably have been the most pernicious: the distortion of contemporary African age distributions by AIDS that is about to turn millions of children into orphans provides a powerful if extreme example.[130]

This is not to say that model life tables serve no practical purpose. In the absence of empirical information, they will always be 'good to think with'.[131] Hypothetical 'one-fits-all' averages can still be useful for schematic calculation along the lines of Saller's simulation of Roman kinship structures,[132] even though the margins of probability may need to be spaced more generously than previously realized. Yet whenever we are concerned with conditions in a particular place and time, notional averages lose much of their heuristic utility. Instead, we must consider ecological specificity. Modern guesses about local life expectancy and age structure critically depend on our knowledge of local geomorphological, climatic, and epidemiologic conditions in the Roman (or at least the more recent) past. It is only through a systematic, scientific assessment of ecological context that we can hope to appreciate demographic structure and variation in the Roman world.

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[129] Based on Model West Levels 1 and 8/9 Males, respectively. Of course, this calculation depends on the age structure predicted in these models.

[130] As a consequence, the number of orphans in South Africa may rise to 2 million by 2010 (*The Economist*, 24 February–2 March 2001); this implies that the proportion of minors without living parents will be roughly twice as large as in Saller's Roman kinship simulation based on Model West Level 3 Females (Saller, op. cit. (n. 1), 49), even though mean life expectancy at birth in South Africa will be forty years instead of twenty-five as in the model.

[131] Golden, op. cit. (n. 126), 32.

[132] Saller, op. cit. (n. 1), ch. 3.