

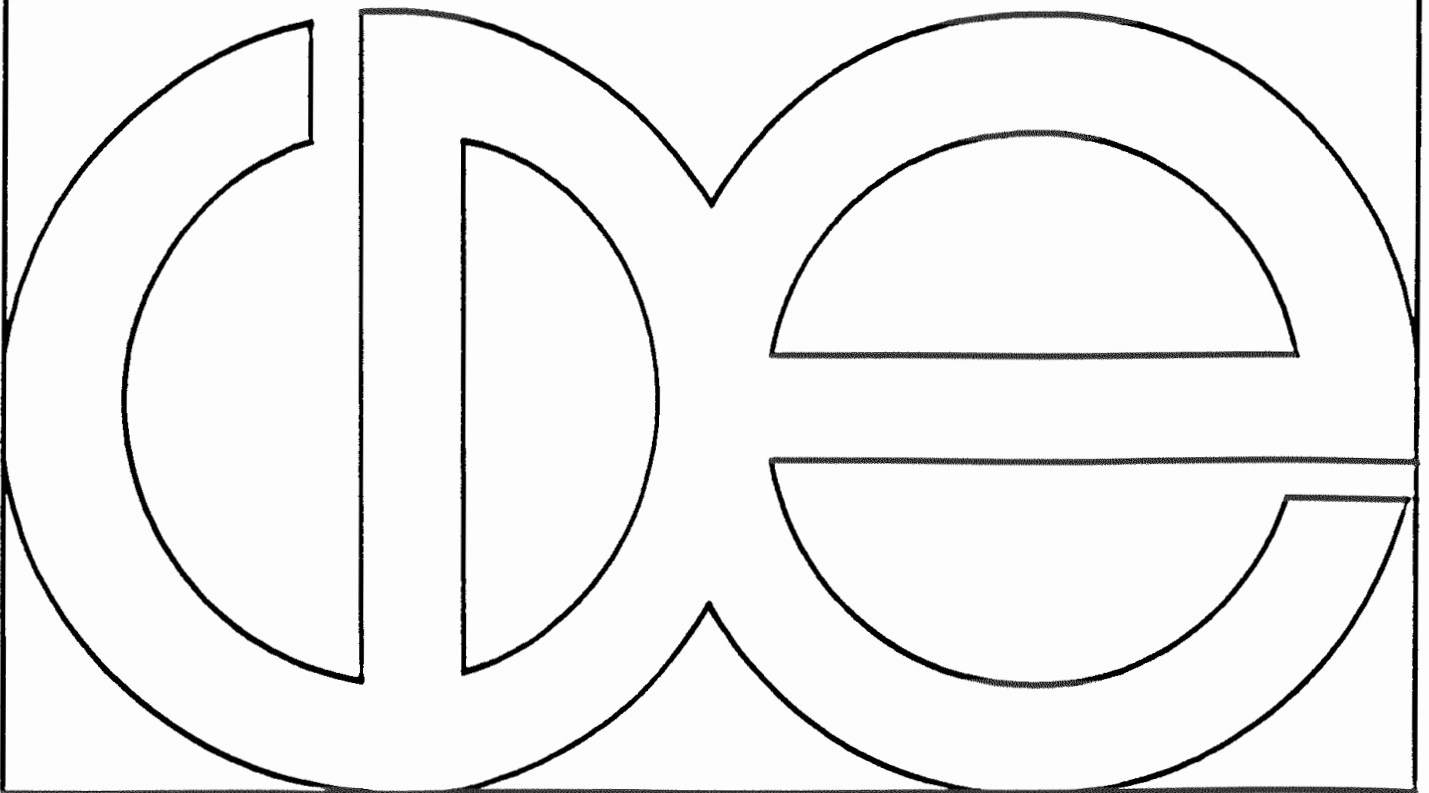
Center for Demography and Ecology

University of Wisconsin-Madison

**DID FOOD INCREASE FERTILITY?
AN EVALUATION OF !KUNG AND HERERO HISTORY**

Renee Pennington

CDE Working Paper 91-29



Did food increase fertility? An evaluation of !Kung and Herero history

Renee Pennington
University of Wisconsin—Madison ¹

¹This research was supported by the National Institute of Child Health and Human Development through a grant for core support of population research (HD-05876) and a training grant (HD-07014) to the Center for Demography and Ecology, University of Wisconsin. Original field work among Herero was supported by grants for dissertation research from the Wenner-Gren Foundation for Anthropological Research and the Hill Fund of the Pennsylvania State University. A grant from the National Institutes on Aging (AG03110) to Jennie Keith and Christine Fry also provided support. I thank Henry Harpending for helpful comments.

Abstract

Considerable attention has been given to hypotheses explaining the low fertility rates observed among nomadic !Kung hunter-gatherers of the northern Kalahari Desert of Botswana as an adaptation to scarcity of food. However, comparisons of their fertility before and after a transition to sedentariness indicate that fertility did not increase in response to more food. Moreover, a study of the fertility of a neighboring group of sedentary Bantu-speaking Herero pastoralists shows that low female reproductive rates in this geographic area were not unique to !Kung. Herero women who were postreproductive in 1968 had substantially lower reproductive rates than their !Kung counterparts. Although they have undergone little or no social change, Herero total period fertility rates have increased by more than four births per woman in the last three decades, probably in response to control of sexually transmitted diseases in this region. In contrast, reproductive success of !Kung women has increased dramatically since 1950 as a result of declining infant and childhood mortality. More food appears to be responsible for significant decreases in offspring mortality among !Kung since only small declines in mortality were observed among Herero. This study emphasizes the need for a more rigorous comparative perspective in anthropology to understand better the significance of findings from restricted populations and suggests that evolutionary ecology would benefit from shifting some of its current focus on fertility to mortality.

Introduction

Throughout the last two decades a considerable amount of research has examined the regulatory role of food on fertility. The general idea is that low fertility is a response to scarce resources. Both behavioral and biological mechanisms of regulation have been proposed. Behaviorally, individuals may achieve lower fertility by marrying late or by breastfeeding for a long time to increase the spacing between births. Impaired reproductive functioning such as that from delayed reproductive maturity or ovulatory failure associated with seasonal food stress and work load and activity levels have also been examined (Frisch and McArthur, 1974; Bentley, 1985; Ellison, 1990). Permutations and combinations of these ideas are easy to find.

Low reproductive rates observed among !Kung hunter-gatherers of southern Africa led to an abundance of research in the 1970s with the aim of understanding the hunter-gatherer adaptation. Many human ecologists have come to believe that foraging populations adapt to low energy environments by regulating their fertility at low levels (Dumond, 1975). The Darwinian fitness of individuals may be viewed as the result of compromises between extreme reproductive strategies in which parents invest heavily in a few children that survive well versus ones in which parents invest less in more children that die at a higher rate (Pennington and Harpending, 1988). !Kung were thought to maximize the number of offspring that survived to reproduce themselves by having small families. Although a number of interesting hy-

potheses have been proposed to explain how and why hunter-gatherers have low fertility, empirical support for an association between subsistence mode and fertility is weak (Campbell and Wood, 1988), and the underlying premise that !Kung had low reproductive rates because they were foragers has never been established.

This paper challenges the assumption that the low fertility is unique to foraging populations of the Kalahari. The reproductive rates of !Kung are contrasted with a neighboring group of sedentary Bantu-speaking Herero and with overall reproductive rates in Botswana. Fertility rates before and after the !Kung began settling among Bantu are also examined. Although there is no positive association between !Kung sedentariness and fertility change, reproductive success of !Kung women has increased dramatically since 1950 as a result of declining mortality among children, apparently in response to increases in the availability of food.

Background

Geographic History

The !Kung and Herero in this study co-reside in an area of the Kalahari Desert of northwestern Botswana west of the Okavango Delta (see map in Figure 1). This area is roughly equal to the western half of Ngamiland, the northwest district of Botswana. The two groups are genetically and culturally distinct. Regular contact between them is recent.

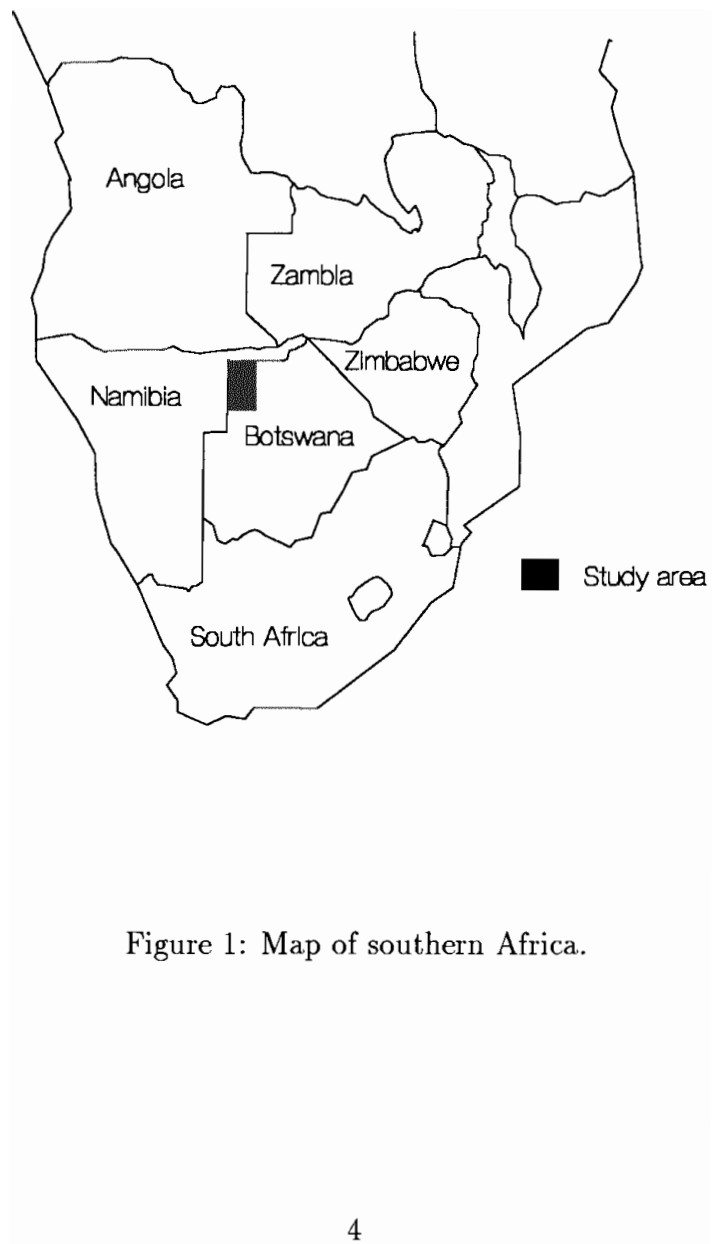


Figure 1: Map of southern Africa.

The !Kung belong to a larger group of Khoisan speakers who are believed to have subsisted in southern Africa as hunter-gatherers for the last 24,000 years (Brooks, 1989). At the time of European contact, the !Kung in this study ranged in northwestern Botswana, Namibia, and southern Angola. Group movement was seasonal, depending on the distribution of water and the availability of bush foods and game. At the end of the dry season, most congregated at a few permanent water holes. !Kung move in smaller groups during the rainy season.

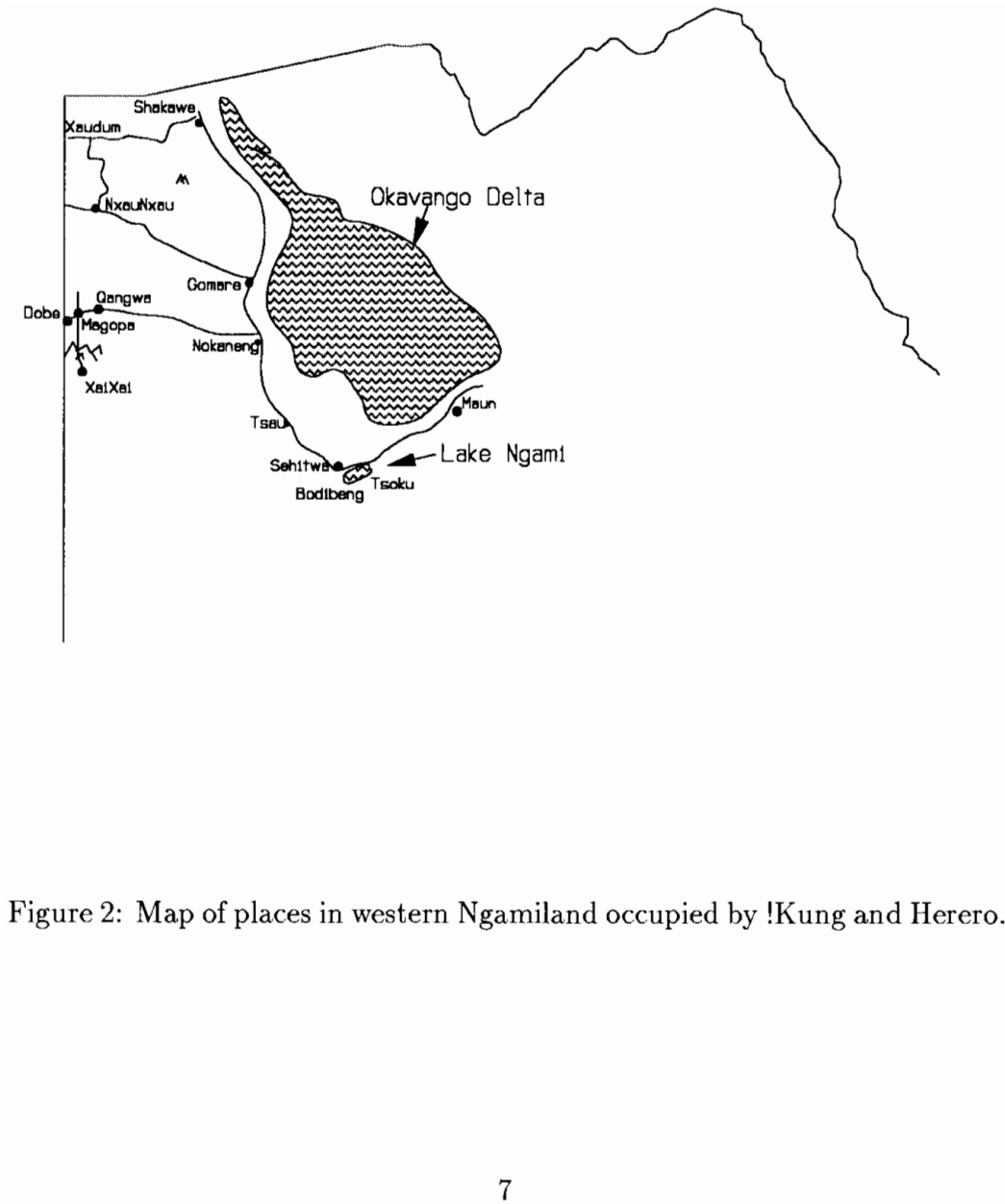
The Bantu expansion from West Africa that started at least 3,000 years ago probably reached southern Africa early in the Christian era. Herero-speakers are thought to have migrated into what is now Namibia from the East during the 16th century where they have grazed cattle for several hundred years (Pennington and Harpending, 1992). Herero is used herein to refer to two politically distinct groups of Herero-speaking pastoralists in Botswana, the Herero proper and the Mbanderu. Since they speak the same language, share culture and intermarry, useful distinctions between members of the two groups cannot be made in this paper.

During the Herero-German War of 1904-1907, many Herero fled South-West Africa (now Namibia) to the Bechuanaland Protectorate (now Botswana) to escape German slaughter. Most settled around Lake Ngami, where they built semi-permanent patrilineal homesteads. Although cattle may be herded in various locations, cattle posts are typically close to the

homestead so that, for all practical purposes, the Herero are a sedentary population.

In the mid-1920s, Herero, as well as members of other Bantu groups in Botswana, began expanding northwest into the Dobe, XaiXai, NxauNxau and Xaudum areas previously occupied almost exclusively by !Kung (Howell, 1979; Lee, 1979; Solway and Lee, 1990). These locations are shown in Figure 2. Contact among Bantu and !Kung accelerated in the 1950s when many more Herero moved into these areas. Many !Kung, attracted by employment opportunities and more plentiful food, settled at the Herero homesteads. Other large settlements of Herero in Botswana are in Ghanzi, Rakops and Mahalapye. Most of the !Kung in Botswana live in Ngamiland but range south as far as Ghanzi.

There are probably about 15,000 Herero in Botswana (Pennington and Harpending, 1992). The number of !Kung is probably less than 2,000 (H. Harpending personal communication May 1991). In 1981, there were about 70,000 people living in Ngamiland and one million people living in all of Botswana (Central Statistics Office, 1981) so that these two groups comprise about one-fourth the population of Ngamiland and about 2% of the population of Botswana. For various reasons, few !Kung, if any, presently hunt and gather full-time. Many also raise livestock of their own.



Previous Research

In the 1960s, the !Kung became the focus of a large anthropological research project (Lee and DeVore, 1976). One of the notable findings of the research was that the !Kung appeared to be characterized by unusual demographic rates. Foremost, they appeared to have unusually low fertility and, in 1963-1973, unusually low mortality. These findings generated other research with the aim of understanding the hunter-gatherer demographic adaptation.

A large, recent survey involving interviews of over 700 Herero men and women has yielded data suitable for reconstructing Herero demographic history that can be used to view the !Kung findings in a regional perspective. The Herero data were collected by Henry Harpending and me in two-person years of field work in 1987-1989. The field work focused on Herero living in Ngamiland, including Herero living in the well-known Dobe area occupied by !Kung. Exact ages of Herero were obtained using traditional Herero and Mbanderu year names that have been sequenced and aligned with Gregorian years (Vedder, 1966; Almagor, 1980; Pennington and Harpending, 1992). Altogether we ascertained over 3,000 living individuals. Details of our research methods and analyses of Herero fertility, mortality, and parenting are in Pennington and Harpending (1991a, 1991b), Harpending and Pennington (1991), Pennington (1991) and Pennington and Harpending (1992)..

Most of the !Kung data is taken from Howell (1979), whose study took place in the Dobe area. !Kung did not know their years of birth so Howell

estimated their ages by age ranking individuals and then assumed that the proportions of population at each age fit a stable age distribution. Although Howell's method was suitable for comparisons within the !Kung population, the age estimates of some !Kung may be inaccurate if the assumption that the !Kung population was stable is inappropriate or if Howell chose the wrong stable age distribution. On the other hand, she was able to obtain exact ages of children born in 1963–1973. Her population consisted of over 500 !Kung who had lived in the Dobe area during her study.

The results of the larger but less detailed demographic survey of !Kung by Henry Harpending (Harpending, 1976; Harpending and Wandsnider, 1982) in 1967–1968 is also contrasted. Harpending obtained reproductive histories of about 500 !Kung women living in Ghanzi and throughout Ngamiland. Many of the !Kung living in Ghanzi were settled on cattle ranches and had been sedentary most of their lives. The !Kung ascertained throughout Ngamiland lived much the same way as those in the Dobe area. Harpending did not attempt to age !Kung, but because he distinguished between pre- and post-reproductive women and between infants and children, comparisons among all three data sets are possible.

Fertility

Popular explanations for low !Kung fertility

The quality of parental care

For the last two decades the !Kung have been the focus of a great deal of speculation because they had completed family sizes of less than five births per woman (Howell, 1979; Harpending and Wandsnider, 1982). A number of hypotheses have been tendered as explanations. Low fertility has been attributed to wide birth spacing thought to be an adaptation to excessively high mortality among offspring whose births are spaced more closely than several years (Blurton Jones, 1986) or because foraging women can care only for one small child at a time (Bleek, 1928; Lee, 1979). However, in a test of the Blurton Jones hypothesis, Pennington and Harpending (1988) found no relationship between offspring survivorship and the number of children a woman bears. Blurton Jones and Sibly (1978), Lee (1979), and Blurton Jones (1986) have emphasized increasing work loads of mothers with closely spaced births as fertility limiting factors.

Breastfeeding and the pace of childbearing

Late age at weaning of children has also been suggested as a factor contributing to low fertility of !Kung women. Resumption of menstrual cycling postpartum is known to be delayed among lactating women. Prolonged breast-

feeding leads to longer interbirth intervals, thereby reducing the number of births a woman can fit into her reproductive span. Ovulation is thought to be inhibited most in mothers whose infants suckle frequently and intensely.

!Kung women breastfeed their babies on demand for several years, contributing to substantial delays in the return of ovulation following parturition (Konner and Worthman, 1980). Unfortunately, we do not have data on Herero with which to compare the contribution of breastfeeding to the spacing of their births. However, the Herero also breastfeed their babies on demand. They carry their babies tied to their backs throughout the day. The babies are removed and breastfed whenever they cry or become restless. Both the Herero and !Kung begin introducing supplementary foods at about the same time. Herero children are typically weaned in their second year of life, at which time many of them are fostered either permanently or temporarily to relatives (Pennington, 1991). No relationship between fostering and fertility was found among Herero. In contrast, the !Kung, who apparently do not foster their children, have been observed breastfeeding offspring as old as four years.

Extremely prolonged breastfeeding was thought to explain extremely wide birth spacing in !Kung women. Lack of suitable weaning food has been suggested as the reason !Kung wean their children so late. These arguments hold to a certain degree, but because both the contraceptive effects of lactation and the proportion of calories children obtain from their mothers' breasts

decreases sharply during the second year postpartum, prolonged breastfeeding would not explain average birth spacing of four years in a population. It is important to realize that pregnancy is a reason !Kung wean their children, so the effect of lactation on birth spacing cannot be measured from observational data. That is, prolonged breastfeeding may be an effect of subfecundity rather than a cause of it.

The possibility that !Kung reproductive function is impaired by undernutrition has also been raised (Howell, 1979; Lee, 1979; Bentley, 1985). Low caloric intakes coupled with high energy outputs may cause !Kung women to ovulate irregularly or resume ovulation later postpartum. To what extent these mechanisms, if they exist, affect !Kung fecundity has not been measured.

Does more food lead to higher fertility?

Fertility !Kung and Herero in the past

Age-specific fertility A popular theme in anthropology is that sedentariness leads to higher fertility (Dumond, 1975; Lee, 1979; Roth, 1985; Handwerker, 1983). Campbell and Wood (1988), however, found that there was not a strong correlation between subsistence base and fertility levels. There is also very little empirical support for this theme for !Kung. Harpending and Wandsnider (1982) originally showed that contemporary populations of settled and nomadic women had identical levels of fertility, having an average

of 4.03 and 4.08 births, respectively, at the end of childbearing. Estimates from Howell's data of age-specific fertility from !Kung women who spent the majority of their reproductive years as nomadic foragers are in fact higher than for younger women, although many of the younger women were settled on ranches. Moreover, a comparison of !Kung and Herero fertility also shows that !Kung fertility is not unusually low when compared to other populations in this region and that sedentary populations, in fact, have lower fertility than !Kung.

Figure 3 shows the age-specific fertility rates for Herero and !Kung calculated for the cohort of women who were postreproductive in 1968 and for women reproducing in the period 1963-1973. Age-specific fertility rates (ASFRs) are computed by dividing the number of live births to women in each age-class by the number of years at risk. The total fertility rate (TFR) is the sum of the age-specific fertility rates times five years (the width of the age-class). The cohort TFR is computed for women born in a defined period (women born before 1968 in this case) who have reached menopause. The Herero and !Kung cohort TFRs are based on births retrospectively reported by women. The period TFR is computed for all women who were of reproductive age at any time during 1963-1973, regardless of when they were born. The !Kung period rates are based on observed births while the Herero rates are based on retrospective reports. The period TFR may be interpreted as the expected number of live births a woman would have at the end of child-

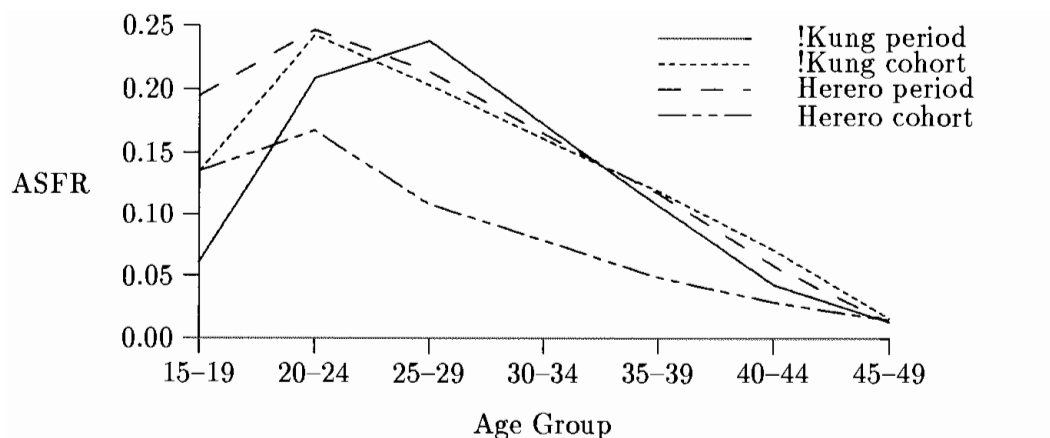


Figure 3: !Kung and Herero period and cohort age-specific fertility. !Kung rates are taken from Howell (1979).

bearing for a set of ASFRs. If fertility is constant through time, cohort and period TFRs will be equal.

The cohort TFR of Herero women who were postreproductive in 1968 was only 2.7 compared to 4.7 among !Kung. In 1963-1973, the Herero were characterized by a period TFR of 4.9, while the period TFR for !Kung was 4.3. The !Kung period rate reflects the experience of many women who had become relatively settled on Bantu (e.g. Herero) cattle ranches while the cohort rate reflects the experience of women who had spent most of their lives as nomadic hunter-gatherers. The plot of fertility rates (Figure 3) and TFRs that summarize them clearly show that fertility did not increase in response to sedentariness and the concomitant increase in food. Nomadic postreproductive !Kung have higher fertility than sedentary postreproductive Herero, and !Kung fertility did not increase in response to sedentariness. If

anything, it appears that sedentariness caused lower fertility.

It is possible that the !Kung period rates are affected by age estimation errors as the age-specific fertility rates peak at an unusually late age. In natural fertility populations, the ASFRs typically peak among women aged 20–24 (Henry, 1961; Wood, 1989). It is clear, however, that the !Kung did not experience a transition to higher fertility after settling on Bantu cattle ranches, although Herero fertility increased dramatically during this period.

It is also worth noting that the oldest !Kung women ascertained by Howell (1979:125) had higher completed fertility than those who had become postreproductive more recently. Women aged 45–49, 50–54, 55–59, 60–64 and 65 or more had an average of 4.1, 4.2, 5.0, 5.0 and 5.3 births, respectively. This trend indicates that fertility had been declining among !Kung throughout the century, possibly in response to the increasing degree of contact between Herero and !Kung. This finding is especially interesting because it is more commonly observed that the older women report fewer births than younger women, further indicating that low !Kung fertility is more recent than previously believed.

Regional variation in Botswana The reproductive rates of !Kung and Herero can also be compared to estimates based on the 1971 national census of Botswana, which included regional summaries of fertility rates (Central Statistics Office, 1972). The TFR for Ngamiland in 1970 was 4.7, slightly lower than our period estimate of Herero. Only Orapa, Selebi-Pikwe, Ghanzi

and Gaborone had TFRs lower than Ngamiland. Orapa and Selebi-Pikwe are mining communities only recently settled at the time of the census. Ghanzi is a district bordering on the South of Ngamiland in which significant numbers of Europeans, Herero and Bushmen (!Kung and other Khoisan speaking groups) reside. The estimates of these three regions are based on small numbers. Gaborone is the capital of Botswana.

The average TFR in Botswana was 5.8. For various reasons, this estimate based on the raw data was “adjusted” to 6.5 or more (Central Statistics Office, 1972; Finch and Way, 1981). Similar adjusted figures by region were not given. Each of the three studies (of the Herero, !Kung, and population of Botswana) were conducted differently and subjected to different sources of bias. For example, the ages of Herero are certainly more accurate than the age estimates of !Kung and the population of Botswana. The !Kung estimates of period fertility are based on actual observations and are less likely to be biased by reporting errors that can occur in retrospective studies, such as omission of births or confusion about the reference period. Both the Herero and !Kung figures are based on wide time periods and are less sensitive to annual stochastic fluctuations, although they are based on observations of fewer women. Nevertheless, all three studies estimate low levels of fertility in Ngamiland at the same time.

Estimates of past fertility reported in the 1971 census are also low. For all of Botswana, women aged 45–49 reported having 5.6 births in their lifetime

compared to an average of 5.2 births to women aged 50 or more. Except for Orapa, Ngamiland had the lowest averages in all of Botswana, being 4.0 and 3.8 to women 45–49 and 50 or more, respectively.

!Kung and Herero fertility transition in perspective Although a thorough analysis of current !Kung fertility is lacking, one small study by Wilmsen (1986) reports that !Kung total fertility was 6.9 for the period 1976–1980. Wilmsen argues that the increase is due to stabilization of the !Kung diet, but a similar if not more dramatic increase in fertility has been documented in the already-sedentary Herero (Pennington and Harpending, 1991b). Herero period TFRs increased from a low of 2.7 in the first half of this century to 7.0 during the last decade. Wilmsen criticized a model of fertility proposed by Bongaarts (Bongaarts, 1982) because it did not appear to fit Howell's estimates of !Kung fertility. Unfortunately, as Bongaarts pointed out in his rejoinder, Wilmsen failed to recognize the magnitude of primary and secondary of sterility in the !Kung related to sexually transmitted diseases (STDs). Bentley (1985) also discounted the contribution of STDs in her examination of the components of !Kung fertility when using Bongaarts' model.

Abnormally low rates of fertility are known throughout sub-Saharan Africa (Coale, 1968; Caldwell and Caldwell, 1983; Frank, 1983), comprising the well-known African infertility belt. As a secondary effect of anti-yaws campaigns in many parts of Africa involving widespread use of antibiotics

(Guthe et al., 1972), the incidence of STDs declined, slowing the pace of infertility in those areas. In northern Botswana, the increase in fertility among Herero coincides with the introduction of mobile medical dispensaries. The pathologically low levels of fertility appear to have been due to the sterilizing effects of pelvic infections in women, such as from the sequelae of gonorrhea that can cause pelvic inflammatory disease and blockage of the Fallopian tubes.

Because of the frequency of intermatings between !Kung and Bantu, it is likely that the !Kung also suffered from the devastating effects of sexually transmitted diseases. Howell (1979) remarked upon the epidemic of STDs they experienced following the movement of Bantu into the Dobe area in the 1950s. Even before Bantu moved into the northern valleys of Ngamiland, !Kung no doubt had opportunities for contracting STDs. Along the perimeters of their range in Angola, Botswana and northern Namibia they have been in contact with peoples known to have a history of subfertility that has been attributed to STDs (Pennington and Harpending, 1991b; Frank, 1983; Caldwell and Caldwell, 1983). The !Kung have a word for venereal disease in their own language ($\neq$ *unini*, H. Harpending pers. comm. May 1991) indicating that it is not a new affliction. Interestingly, Howell dismissed STDs as being a complete explanation for low !Kung fertility. She estimated that STDs cost !Kung 3% of their reproductive capacity per year during 1963–1973 in comparison to the older women she studied. However,

the older women also had low fertility, and it apparently declined throughout the early part of this century as contact between !Kung and Bantu increased (see above). Since the older women were also probably afflicted by STDs, the total cost of STDs would be much higher.

In sum, low fertility was prevalent in Ngamiland at the same time it was observed among !Kung. Explanations for changing !Kung fertility do not account for concomitant changes in fertility among other populations in the same region.

The length of birth intervals

One of the most convincing pieces of evidence for an association between sedentariness and transition to higher fertility was reported by Richard Lee who found that women he classified as “more sedentary” had shorter interbirth intervals than women who were “more nomadic” (Lee 1979:322). However, there are several reasons to doubt Lee’s conclusions.

In his analysis, Lee estimated the mean number of months between live births to about 90 women who had at least two live births between 1963-1973. More sedentary women had shorter interbirth intervals than more nomadic women. The mean number of months between births to women who had the two births in 1963-1968 was compared to the mean for births in 1968-1973. In both groups there is a temporal decrease in the length of interbirth intervals which Lee believed reflected an increasing reliance on milk and cultivated

grains.

In view of the Herero findings, Lee's conclusions are subject to an alternative interpretation. Because we know only the years in which Herero women had their births, we do not have comparable estimates of the length of interbirth intervals for Herero. However, since shorter birth intervals lead to higher fertility than longer birth intervals, we can compare trends in fertility between 1963–1973. Although differing levels of infant mortality can affect fertility levels, it is shown below that both !Kung and Herero had comparable levels of infant and child mortality during this period. Herero fertility increased steadily in 1963–1973, and the temporal decrease in the length of !Kung birth intervals is probably due to the same factors contributing to increases in Herero fertility. Differences between more nomadic and more sedentary women may be due to the more sedentary women being better able to seek treatment for STDs because of their closer proximity to health posts, as well as the medicines of anthropologists studying them. The presumably lower infection rates among Bantu in these areas (Pennington and Harpending, 1991b) also reduced the proportion of potential infectious contacts at the cattle posts.

The study by Lee also failed to prove the causal direction of short birth intervals and sedentariness. He assumed that women became sedentary before their fertility increased when it is perhaps more plausible to assume that high fertility causes women to become sedentary. In other words, !Kung

women who find themselves with closely spaced births have more incentive to become “more sedentary” than women with fewer or more widely spaced births. This phenomenon was observed by Howell (1979:50), who remarked, “Families who are burdened with...many children...tended to congregate at the cattle posts in the 1960s, and the healthy members of the groups tended to gain weight on the high calorie diet available there.” Later (p. 210), in an analysis similar to Lee’s, she noted that the most fecund women may be “forced” to settle at the cattle posts because of their closely spaced births. This would result in a selective sample of the most fecund women being classified as “less nomadic.” As I will show below, women with small children have the most to gain from settling as their children appear to survive better than the children of more traditional !Kung.

Lee’s analysis can also be criticized on methodological grounds. First, he did not control for the effects of maternal age on birth spacing. The effect of age on fertility is obvious from Figure 3, which shows that fertility declines steadily after peaking in the mid-20s. It is possible that Lee’s results are biased by unequal age structures in the groups of women. Finally, Lee analyzed only interbirth intervals that were completed during his study period. Excluding censored birth intervals (intervals whose outcome was still unknown at the conclusion of the study) can seriously bias estimates of means, since only short durations are included. This effect is obvious from the table presented by Lee in which the mean length of interbirth intervals that occurred

throughout 1963-1973 was substantially longer than those that began and finished in the two five-year periods. Lifetable analyses are more appropriate for comparing sets of duration data since lifetables can accommodate censoring (Kalbfleisch and Prentice, 1980). It remains to be seen whether Lee's results will be substantiated by more rigorous statistical analysis. Although Howell (1979) computed probabilities of closing birth intervals for different classes of women by weight and diet, she did not establish that the groups of women had statistically different probabilities of having next births and did not consider the affects of age.

The estimates of completed family size (CFS, the average number of births to women at the end of childbearing) from Harpending and Wandsnider (1982) also do not support Lee's interpretation. Harpending and Wandsnider describe two contemporary !Kung populations living under different subsistence regimes who had identical levels of fertility of about four births per woman. Harpending and Wandsnider's estimates are based on reproductive histories of more than 200 postreproductive women collected by Harpending (1976) at about the same time Howell and Lee collected their data. The !Kung women classified as nomadic by Harpending lived throughout Ngami-land, including the Dobe area, and had spent their reproductive years as hunter-gatherers. The sedentary !Kung were women who had spent their reproductive years on Ghanzi cattle ranches. When the entire birth history of !Kung women is taken into account, there is no evidence that lower activity

levels and higher caloric intakes of sedentary women led to higher fertility.

The majority of the postreproductive !Kung women ascertained by Harpending and Howell had also completed reproduction before antibiotics became widely available in rural Botswana (Pennington and Harpending, 1991b). In contrast, Lee examined birth intervals of women who had differential access to health care during a period in which fertility was on the rise throughout northwestern Botswana.

Harpending and Wandsnider's CFS estimates are somewhat lower than Nancy Howell's. This is probably due to Harpending's less precise definition of a live birth and the lack of sterile women in Howell's data. Harpending defined only children who lived long enough to receive a name (a few days) as live births. Although comparisons within the Harpending data can be made, some children die in the first few days of life so that the fertility of all !Kung women was slightly underestimated. On the other hand, Howell overestimated the CFS because she failed to ascertain any women who had no births. The primary sterility rate reported by Harpending and Wandsnider was about 10%. If Howell's estimate is adjusted to accommodate a reasonable proportion of women with primary sterility, the agreement between the two data sets is quite good.

Howell speculated that the reason she failed to ascertain any sterile postreproductive women was that sterile women selectively migrated to the cattle ranches (Howell 1979:127). However, Harpending and Wandsnider (1982:38)

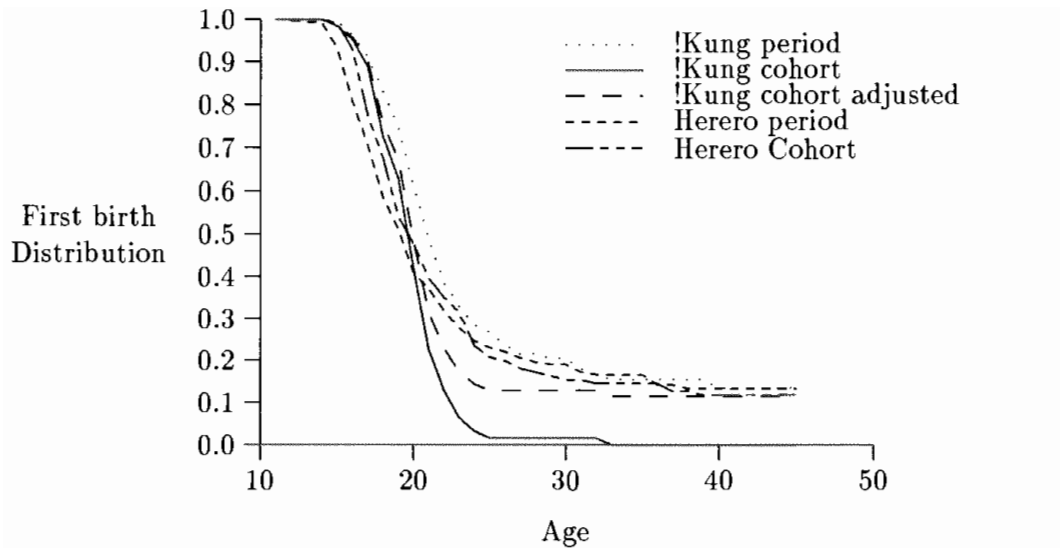


Figure 4: Cohort and period survivor curves of age at first birth for !Kung and Herero. *Cohort* refers to women who were aged 45 or more in 1968. *Period* refers to women who were aged 15 to 44 at any time in 1963-1973. The *adjusted* curve has 8 sterile women added. !Kung data comes from Howell (1979).

report that sterile women were ascertained in approximately equal proportions throughout Ngamiland. They suggested that sterile women were more mobile than women with children and were therefore classified as “visitors” by Howell when she encountered them in the Dobe area. This also supports the interpretation that higher fertility causes women to become “more sedentary” rather than Lee’s interpretation.

The length of the reproductive span

Age at first birth Variation in levels of fertility has also been attributed to later age at sexual maturity among marginally nourished women. Since

the number of births a woman can have is affected by the number of years she has to reproduce, females who mature later may be able to fit fewer births into their reproductive spans. In contrast to the apparently lean !Kung of the 1960s, Herero are heavy and frequently suffer from obesity (O'Keefe et al., 1988) and are less likely to experience delayed sexual maturity due to nutritional stress. As pastoralists who maintain large herds of cattle and goats, they are relatively buffered against seasonal food shortages as well as drought. Therefore, if food affects fecundity (the biological ability to conceive) and the onset of sexual maturity, Herero women should begin reproduction earlier than !Kung. In addition, !Kung women living at cattle posts should reproduce at younger ages than foragers because they are heavier (Lee, 1979; Howell, 1979; Truswell and Hansen, 1976).

It is standard practice to compute things such as the mean age at first birth but, for several reasons, this is not a meaningful statistic for making comparisons between populations or between women who are at different points in their reproductive spans. First, even women in natural fertility populations (populations in which birth control is not parity dependent) have first births at old ages. Comparing the mean age at first birth among women who are postreproductive with those who are still reproducing can give the wrong impression that the age at sexual maturity has declined. This observation is often due to censoring women who eventually have a first birth but not until they are old. The mean is underestimated because only

young women are included in the statistic. In addition, not all women have first births, ever, and differences in primary sterility rates (the proportion of women who never have a live birth) between populations or cohorts of women can bias the estimate of the mean, since the population at risk is ill defined.

The first problem can be avoided by computing the probabilities of having a first birth at each age and converting them into survivor curves. These are shown for the !Kung and Herero in Figure 4. The curves are computed using the product-limit lifetable method (Kaplan and Meier, 1958) given by the equation (Kalbfleisch and Prentice, 1980)

$$\hat{F}(t) = \prod_{j|t_j < t} \frac{n_j - b_j}{n_j}.$$

where $\hat{F}(t)$ is the survivor function, n_j is the number of women at risk of having a first birth at age j , and b_j is the number of first births occurring to women aged j . This yields the probability of not having a first birth by age t , conditional on the probability that a first birth has not already occurred. The product-limit lifetable method is similar to the more conventional actuarial method of estimating survivorship (usually denoted l_x in mortality studies) except that estimates are computed for every point at which a birth occurs rather than using arbitrary intervals, such as five-year age-classes.

A comparison of the !Kung and Herero survivor curves for age at first birth for the cohort of women who were postreproductive in 1968 reveals that Herero women begin reproduction sooner, but that !Kung women “catch

Comparison	Log-rank statistic	df	p-value
Herero cohort vs !Kung cohort	1.39 + 16.84	2	0.00
Herero cohort vs !Kung cohort (adj.)	0.04 + .033	2	0.96
!Kung cohort (adj.) vs !Kung period	3.70	1	0.05
!Kung period vs Herero period	7.02	1	0.01
Herero cohort vs Herero period	0.09	1	0.77

Table 1: Log-rank statistics for comparing equality of survivor curves. Scores for comparisons of Herero with !Kung cohort curves were stratified at the cross-over points. !Kung data is from Howell (1979).

up” and outpace Herero. As a whole, !Kung finish giving birth sooner than Herero, which is the opposite of what was expected. Log-rank scores provide statistics for testing the equality of survivor curves. The Mantel log-rank test in SYSTAT on a microcomputer was used. The results are in Table 1. Because the curves cross, the time axis was stratified at the points where the curves cross. X^2_1 statistics were computed for each portion of the curves (Kalbfleisch and Prentice, 1980). The degrees of freedom are equal to $r - 1$, where r is the number of curves being compared. The X^2 statistic for the portion before the cross-over is small, indicating that the differences between the populations are not significantly different. However, the statistic for the last portion of the curve is quite large, and the two scores summed together $X^2_2 = 18.23$ suggest that the !Kung reproduce at a younger age at a high significance level. The number of degrees of freedom for the stratified X^2 statistic is $r - 1$ times the number of stratifications.

Much of the difference is because there were no sterile women in Nancy Howell’s group of postreproductive women, a finding that is unusual even

in populations with high levels of fertility. To make the populations more comparable, the !Kung curve was adjusted by assuming that the !Kung, like the Herero, had an 11.5% primary sterility rate (equivalent to 8 sterile women). The results of applying the log-rank test to the adjusted data are in Table 1. The statistic is small, indicating that the survivor curves for age at first birth in the two populations cannot be distinguished from one another.

Figure 4 also shows the survivor curve for first births among women aged 15 through 44 in 1963 to 1973. Some of the first births occurred before 1963. On the average, the !Kung cohort survivor curve reflects the experience of women who were older than women reproducing during 1963-1973, after !Kung began settling among Bantu. Again, the effect is in the direction opposite the one expected. The period curve is higher than the cohort curve across all ages. The log-rank statistic using the adjusted data is 3.7 (1df, $p = 0.05$). This means that women in 1963-1973 had first births at older ages than the cohort of older, postreproductive women.

Similarly, the comparison between the two period curves indicates that younger !Kung women also have a later age at first birth than younger Herero, and this difference is significant. In contrast, the difference between the period and cohort curves for Herero is small and is statistically indistinguishable from zero. The log-rank statistic comparing the survivor curves is 0.090, 1df, $p = 0.77$. Stratifying the time axis at the two cross-over points results in a X^2_3 of 0.34, $p = 0.95$.

Although the age at first birth of !Kung may have truly increased, the shift is more likely due to age estimation errors. I noted above that the age-specific fertility rates during 1963-1973 peaked at an unusually late age.

In sum, there is no evidence that the age of sexual maturity of !Kung has increased in response to more food or declining activity levels associated with sedentariness. Postreproductive !Kung women, who for the most part began their reproductive careers as nomadic foragers, began reproduction at the same ages as sedentary Herero. In addition, postreproductive !Kung women began reproducing at *earlier* ages than !Kung reproducing in the period 1963-1973. If anything, the evidence suggests that sedentariness has caused an increase in the age at sexual maturity. No temporal change in the age at which Herero women begin giving birth was observed.

Age at last birth Most of the difference in the level of fertility between the two populations is probably due to the age at which women cease child-bearing. Postreproductive Herero women (in 1968) ceased reproducing at earlier ages, having their last births at 27 years of age, compared to 34 years for !Kung. The age at last birth for women who have completed reproduction more recently has increased. Seventy-four Herero women aged 45-54 in 1986 who had at least one birth had their last birth on the average at age 32. Although there was no difference in the age at which these younger women began reproducing, the average number of births per woman (including 8 women who reported having no births) was 4.4. It appears that if Herero

women continued to reproduce as long as !Kung, they would have about the same levels of fertility.

The low fertility of Herero is attributable to women ceasing childbearing early in their reproductive span. After considering a number of possible causes, Pennington and Harpending (1991) concluded that the best explanation for low rates in the early part of this century was the sterilizing effects of pelvic infections in women (see above). The TFR for the period 1977-1986 was estimated at 7.0 compared to 2.7 among the cohort of Herero postreproductive in 1968. While there is no evidence that less work and more food affects fertility of !Kung, the diminution of a single disease means that the average Herero woman can expect to have four more births than she could only 30 years ago.

How food matters

In this section, the relationship between food and survivorship is examined. Following Howell, mortality of !Kung offspring before and after about 1950 is compared. The year 1950 marks the acceleration of contact by !Kung with Bantu. The significance of more food on survivorship can be identified by comparing the magnitude of change in !Kung with Herero.

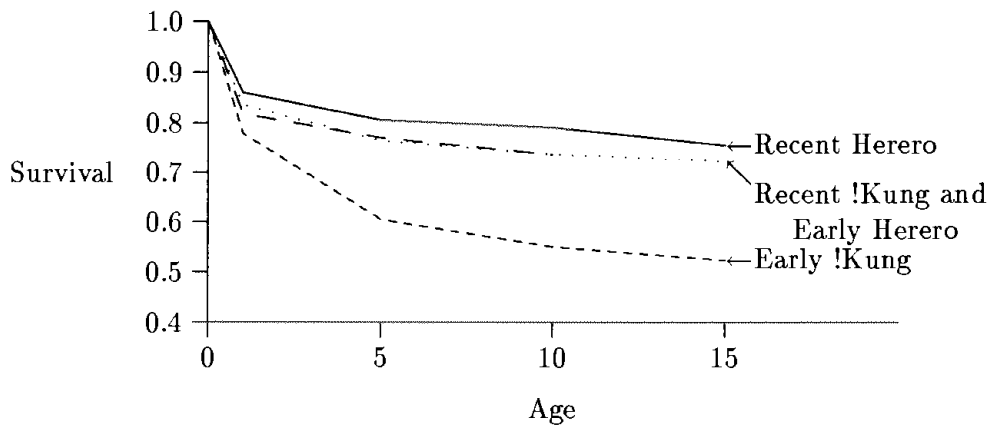


Figure 5: Survivorship of !Kung and Herero offspring to age 15 before 1949 (early period) and after 1948 (recent period). !Kung data is from Howell (1979).

Pre-adult mortality

A look at Herero and !Kung mortality estimated from offspring mortality reported in fertility histories during two time periods indicates that mortality in both populations was higher in the past. Figure 5 shows the survivorship, l_x , of the two groups for early and recent birth cohorts of children to age 15. l_x is the probability of surviving to age x . The early !Kung period includes children born in the years 1919 to 1948, and the early Herero period includes children born in 1917 to 1948. The curves for the recent period are based on births occurring in 1949 to 1968. Survivorship was computed for the first year of life (infancy) and for the age classes 1–4, 5–9, and 10–14. Howell observed no deaths in the age class of children aged 10–14, so l_{15} is not estimated.

The figure shows that Herero had lower mortality than !Kung in both

periods but that recent !Kung mortality declined to the low level of early Herero. Survivorship of !Kung children to age 10 in the recent period is .74 compared to only .55 in the early period. Although !Kung mortality decreased dramatically in the recent period, the drop in Herero mortality is substantially smaller, although the change is statistically significant.

The data from which the curves in Figure 5 were calculated are in Table 2. This table also gives the lifetable estimates l_x and 95% confidence intervals. l_x is computed in the same way the survivor curves for age at first birth were except that l_x is estimated only every five years, since this is the form in which the !Kung data were published. The formula is

$$l_x = \prod_{j|x_j < x} \frac{n_j - d_j}{n_j}$$

where n_j is the number at risk of dying during interval j , and d_j is the number of deaths to individuals in interval j .

Children who were not old enough to survive an age class were assumed to be censored (i.e., information about them was discarded) at the beginning of the age interval, even if they died during the interval. The confidence intervals were estimated by applying the asymptotic normal distribution to a transformation of l_x as described by Kalbfleisch and Prentice (1980:14–15). The confidence intervals are given by

$$l_x^{\exp(\pm 1.96 s_x)}.$$

s_x^2 is the asymptotic variance of $\log[-\log l_x]$ and can be estimated by

$$s_x^2 = \frac{\sum \frac{d_j}{n_j(n_j - d_j)}}{[\sum \log(\frac{n_j - d_j}{n_j})]^2}.$$

Log-rank tests are more concise statistics than confidence intervals for comparing survivor curves since they produce a single number rather than series of point estimates. Nevertheless, the confidence intervals still tell much of what we need to know. There is no overlap between the confidence intervals of the two early mortality periods, and the two !Kung curves overlap at only one point. Early Herero and recent !Kung are probably the same. Of the other two-way comparisons of interest (early Herero vs recent Herero and recent Herero vs recent !Kung), the overlap is at the extreme ends of the confidence intervals. Since the probability that all the true values of the point estimates fall at the extreme ends is less than 5%, we can be reasonably certain that a decrease in mortality has occurred in both populations and that the Herero have lower mortality than !Kung.

Each Herero age class appears to have experienced increases in survivorship of roughly equal magnitude, with mortality being highest during infancy. In the early !Kung period, mortality during infancy and during the ages 1 to 4 were nearly equal. Interestingly, the large decline in !Kung mortality during the recent period occurred mostly among children aged 1 to 4. In this interval, the probability of dying declined from 0.22 to 0.06. This is nearly a four-fold decrease in mortality during the period of weaning and is probably due to the availability of milk.

Population	Age-class	At risk	Deaths	l_x	Lower Limit	Upper Limit
Early Herero	0	293	48	1.00	1.00	1.00
	1-4	245	21	0.84	0.80	0.87
	5-9	224	8	0.76	0.71	0.81
	10-14	216	4	0.74	0.68	0.78
	15-19	–	–	0.72	–	–
Recent Herero	0	500	70	1.00	1.00	1.00
	1-4	303	19	0.86	0.83	0.89
	5-9	167	3	0.81	0.77	0.84
	10-14	66	3	0.79	0.74	0.85
	15-19	–	–	0.76	–	–
Early !Kung	0	258	57	1.00	1.00	1.00
	1-4	201	45	0.78	0.74	0.81
	5-9	156	14	0.60	0.55	0.66
	10-14	142	7	0.55	0.49	0.61
	15-19	–	–	0.52	–	–
Recent !Kung	0	231	42	1.00	1.00	1.00
	1-4	189	11	0.82	0.77	0.86
	5-9	68	3	0.77	0.71	0.82
	10-14	65	0	0.74	0.67	0.80
	15-19	–	–	–	–	–

Table 2: Offspring mortality through age 15 by period. Recent period is after 1948. Early period is before 1949. !Kung data is from Howell (1979).

The decline in !Kung mortality coincides with their settling among Bantu. Harpending and Wandsnider (1982) found a similar mortality differential between contemporary sedentary and nomadic !Kung. Infant mortality among the nomadic population was twice that of the sedentary groups, and preadult mortality was about three times higher. The marked decrease in mortality among 1 to 4 year-old !Kung indicates that getting enough to eat is especially crucial during weaning. This may mean that nutritional stress is greatest among small children but does not imply an advantage to extremely wide birth spacing among foragers since no duration of breastfeeding can procure milk from domestic livestock.

The mortality of Herero and !Kung during early life can also be compared with estimates from the 1971 Botswana census. Finch and Way (1981) estimated the infant mortality rate for both sexes to be 97 per 1000 between 1964 and 1971. This compares with 140 per 1000 for Herero and 182 per thousand for !Kung during 1949-1968. Estimates of l_{10} for males and females between 1964 and 1971 in Botswana were 0.81 and 0.84 (Finch and Way, 1981; Central Statistics Office, 1972) compared to 0.79 and 0.74 for Herero and !Kung for the sexes combined.

The higher estimates of mortality among !Kung and Herero are probably primarily due to higher overall levels of mortality in Ngamiland. Geographic breakdowns in survivorship reported by the 1971 census indicate that this region has the highest mortality in the country (Central Statistics Office,

1972). Some variation may be due to differences in the methods used to calculate the estimates. The comparisons also reflect estimates of mortality for slightly different time periods, and some increase in mortality since 1965 would be expected in both groups. Harpending and Pennington (1991) report an infant mortality rate of 120 per 1000 for 1960-1974.

The decrease in !Kung mortality means that the average child born after 1948 has about a 25% greater chance of surviving to age 15, about the age of adulthood. (The empirical estimate of l_{15} during the recent period is the same as l_{10} but would be 0.72 if early Herero and recent !Kung mortality is the same.) This nets a considerable increase in the reproductive success of !Kung women. A 25% increase in offspring survivorship is equivalent to a woman with four births increasing her reproductive rate by one more birth.

Mortality throughout the lifespan

A comparison of Herero and !Kung survivorship throughout the lifespan is in Figure 6. The Herero survivor curve, taken from Pennington and Harpending (1992), is estimated from parents reporting the mortality of their children and children reporting the mortality of their parents. The curve shows the experience of Herero living in the period 1894 to 1965. The !Kung survivor curve is taken from Howell (1979) and is based on deaths observed in 1964-1973. Both curves combine the experiences of both sexes and are remarkably similar.

The life expectancy at birth of a population can be used as a summary

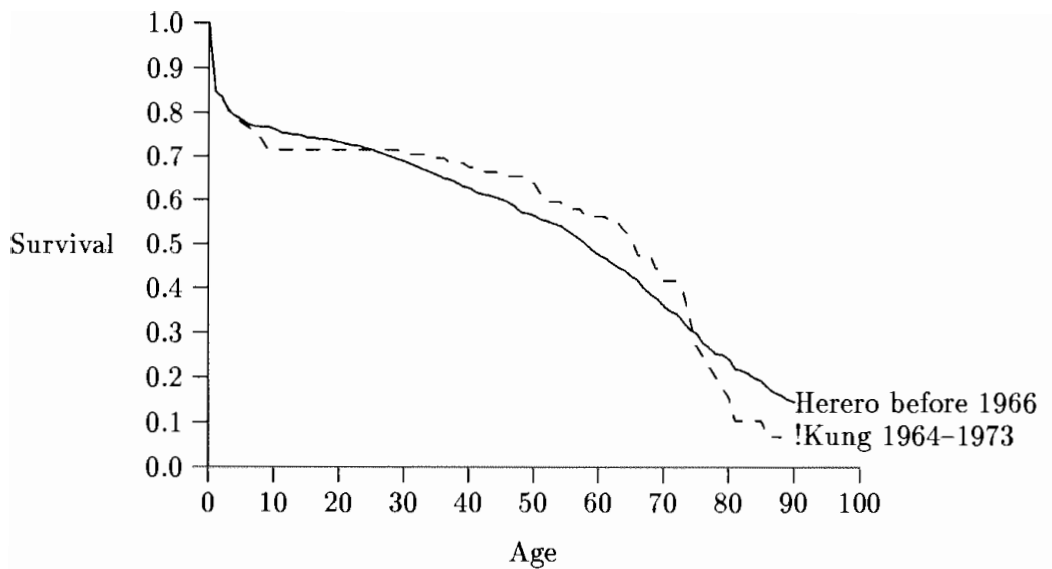


Figure 6: !Kung and Herero survivorship throughout the lifespan. !Kung estimates are from Howell (1979). Herero estimates are from Pennington and Harpending (1992).

statistic for comparing populations. Both curves reflect lifetables with life expectancies at birth of 51 years, further indicating that the Herero and recent !Kung are characterized by similar mortality schedules. Interestingly, Howell (1979) discounted her estimates of mortality, believing that !Kung mortality was much higher. At that time, however, she believed the life expectancy at birth in Botswana was only 40 (Howell 1979, p. 95) so that the !Kung appeared to survive better than the general population. Estimates based on the 1971 Botswana census indicate that the population's life expectancy at birth during 1964-1971 was 55 years (Finch and Way, 1981). When contrasted with other estimates of Botswana, her estimates of !Kung survivorship are quite reasonable.

Summary

The relationship between food and fertility in northwestern Botswana was examined. Fertility before and after transition to a more sedentary lifestyle among !Kung was compared and contrasted with already-sedentary Herero. Although sedentary !Kung women have steadier food supplies and lower activity levels than nomadic !Kung, fertility did not increase after they began settling. In fact, postreproductive !Kung who had spent most of their reproductive span as nomadic foragers had higher fertility than already-sedentary Herero. Older !Kung also had higher fertility than !Kung women reproducing in 1963-1973, although more than a decade had transpired since the !Kung started to become sedentary. In addition, there were no differences in the ages at which Herero and postreproductive !Kung women began childbearing. The comparisons indicate that low fertility is a regional attribute and is not unique to marginally nourished foragers. This conclusion is borne out by comparisons with the 1971 Botswana census in which Ngamiland had fertility rates that were among the lowest in the country. Previous explanations for low !Kung fertility are not general enough to account for sub-fertility throughout this region.

One might argue that !Kung sedentariness was too recent to effect reproductive performance. However, a comparison of their mortality before and after contact with Bantu indicates that !Kung were benefitting from sedentariness. Since about 1950, about when contact between !Kung and

Bantu began increasing dramatically, survivorship of offspring to age 10 has increased by about 25%. Most of the decrease in mortality occurred among children one to four years old, the age interval during which children are weaned. The mortality of these children declined by almost 75% from a rate of 0.22 to 0.06.

The decrease in mortality is attributed to increases in the availability of food because a decline of similar magnitude was not found among the Herero. Survivorship to age 10 among Herero increased only by about 6%. Compared to !Kung, decreases in mortality were roughly the same in all age classes. The huge decrease in mortality among !Kung children aged 1 to 4 indicates that more food has its biggest effect during the ages of weaning.

The level of survivorship of !Kung offspring in the recent period rose to the level of Herero in the early period. As a result, !Kung mortality was only slightly higher than Herero in the 1960s. Life expectancy at birth in both populations was estimated at 51 years.

Altogether, these findings indicate that more food can have a tremendous impact on reproductive success by way of its impact on survivorship. The chances that a !Kung child will survive to reproductive age appear to have increased by more than 25% as an apparent consequence of contact with sedentary peoples. There is no evidence that availability of food regulated !Kung fertility.

Conclusion

This paper shows that there is no evidence for an association between the availability of food and fertility among !Kung. Pathologically low rates of fertility are also reported for Herero, sedentary neighbors of !Kung. Ecological explanations for low fertility among !Kung do not account for low reproductive rates of other populations in this region. The causes of low reproductive rates observed among !Kung two decades ago appear to be geographic rather than ecological.

The findings presented here suggest that the !Kung benefitted from sedentariness through increases in offspring survival. Substantial decreases in early childhood mortality may have increased !Kung reproductive success by more than 25%.

The comparative perspective used in this paper emphasizes the fact that isolated findings may not be unusual when considered in a regional context. This study also makes the point that correlations do not imply cause. The expected effects on fertility due to sedentariness and improvements in health care concurrently experienced by the !Kung are in the same direction so that one cannot be considered without the other.

References

- Almagor, U. 1980. Some notes on the Mbanderu calendar. *Botswana Notes and Records*, 12:67–82.
- Bentley, G. 1985. Hunter-gatherer energetics and fertility: a reassessment of the !Kung San. *Human Ecology*, 13:79–109.
- Bleek, D. 1928. *The Naron: A Bushman Tribe of the Central Kalahari*. Cambridge University Press, Cambridge.
- Blurton Jones, N. 1986. Bushman birth spacing: a test for optimal interbirth intervals. *Ethology and Sociobiology*, 7:91–105.
- Blurton Jones, N. and R. Sibly. 1978. Testing adaptiveness of culturally determined behaviour: do Bushman women maximize their reproductive success by spacing births widely and foraging seldom?, pp. 135–155. In N. B. Jones and V. Reynolds, editors, *Human Behaviour and Adaptation*, Taylor and Francis, London.
- Bongaarts, J. 1982. The fertility-inhibiting effects of the intermediate fertility variables. *Studies in Family Planning*, 13:179–198.
- Brooks, A. 1989. Past subsistence and settlement patterns in the dobe area: an archaeological perspective. Paper Presented at the 88th Annual Meeting of the American Anthropological Association, Washington, D.C.
- Caldwell, J. C. and P. Caldwell. 1983. The demographic evidence for the incidence and cause of abnormally low fertility in tropical Africa. *World*

Health Statistics Quarterly, 36:2–34.

Campbell, K. L. and J. W. Wood. 1988. Fertility in traditional societies: social and biological determinants, pp. 39–69. In P. Diggory, M. Potts, and S. Teper, editors, *Natural Human Fertility*, MacMillan Press, London.

Central Statistics Office. *Report on the Population Census 1971*. Gaborone, 1972.

Central Statistics Office. 1981. *Population and Housing Census*. Census Administrative/Technical Report and National Statistical Tables, Republic of Botswana, Gaborone, Botswana.

Coale, A. J. 1968. Estimates of fertility and mortality in tropical Africa, pp. 179–186. In J. Caldwell and C. Okonjo, editors, *The Population of Tropical Africa*, Columbia University Press, New York.

Dumond, D. 1975. The limitation of human population: a natural history. *Science*, 187:713–721.

Ellison, P. T. 1990. Human ovarian function and reproductive ecology: new hypotheses. *American Anthropologist*, 92:933–952.

Finch, G. S. and P. O. Way. *Country Demographic Profiles. Botswana*. 1981. U.S. Department of Commerce, Bureau of the Census.

Frank, O. 1983. Infertility in sub-Saharan Africa: estimates and implications. *Population and Development Review*, 9:137–144.

Frisch, R. E. and J. McArthur. 1974. Menstrual cycles: fatness as a deter-

- minant of minimum weight for height necessary for the maintenance or onset. *Science*, 185:949–951.
- Handwerker, W. 1983. The first demographic transition: an analysis of subsistence choices and reproductive consequences. *American Anthropologist*, 85:5–27.
- Harpending, H. 1976. Regional variation in !Kung populations, pp. 152–165. In R. B. Lee and I. DeVore, editors, *Kalahari Hunter-Gatherers*, Harvard University Press, Cambridge.
- Harpending, H. and R. Pennington. 1991. Age structure and sex biased mortality among Ovaherero pastoralists. *Human Biology*, 63:327–352.
- Harpending, H. and L. Wandsnider. 1982. Population structures of Ghanzi and Ngamiland !Kung, pp. 29–50. In M. Crawford and J. Mielke, editors, *Current Developments in Anthropological Genetics*, Plenum Press, New York.
- Henry, L. 1961. Some data on natural fertility. *Eugenics Quarterly*, 8:81–91.
- Howell, N. 1979. *Demography of the Dobe !Kung*. Academic Press, New York.
- Kalbfleisch, J. D. and R. L. Prentice. 1980. *The Statistical Analysis of Failure Time Data*. Wiley, New York.
- Kaplan, E. and P. Meier. 1958. Nonparametric estimation from incomplete observations. *Journal of the American Statistical Association*, 53:457–481.
- Konner, M. and C. Worthman. 1980. Nursing frequency, gonadal function,

- and birth spacing among !Kung hunter-gatherers. *Science*, 207:788–791.
- Lee, R. B. 1979. *The !Kung San*. Cambridge University Press, Cambridge.
- Lee, R. B. and I. DeVore. 1976. *Kalahari Hunter-Gatherers*. Harvard University Press, Cambridge.
- O’Keefe, S. J. D., J. E. Rund, N. R. Marot, K. L. Symmonds, and G. M. B. Berger. 1988. Nutritional status, dietary intake and disease patterns in rural Hereros, Kavangos and Bushmen in South West Africa/Namibia. *South African Medical Journal*, 73:643–648.
- Pennington, R. 1991. Child fostering as a reproductive strategy among southern African pastoralists. *Ethology and Sociobiology*. In press.
- Pennington, R. and H. Harpending. 1988. Fitness and fertility in Kalahari !Kung. *American Journal of Physical Anthropology*, 77:303–319.
- Pennington, R. and H. Harpending. 1991a. The effect of infertility on the population structure of the Herero and Mbanderu of southern Africa. *Social Biology*. In press.
- Pennington, R. and H. Harpending. 1991b. Infertility in Herero pastoralists of southern Africa. *American Journal of Human Biology*, 3:135–153.
- Pennington, R. and H. Harpending. 1992. *Demography of Ngamiland Herero*. Kluwer. Forthcoming.
- Roth, E. 1985. A note on the demographic concomitants of sedentarism. *American Anthropologist*, 87:380–382.

- Solway, J. S. and R. B. Lee. 1990. Foragers, genuine or spurious? situating the Kalahari San in history. *Current Anthropology*, 31:109–146.
- Truswell, A. S. and J. D. L. Hansen. 1976. Medical research among the !Kung, pp. 166–194. In R. B. Lee and I. DeVore, editors, *Kalahari Hunter-Gatherers*, Harvard University Press, Cambridge.
- Vedder, H. 1966. *South West Africa in Early Times (translated and edited by C.G. Hall)*. Frank Cass & Co., London. Reprint of 1938 edition.
- Wilmsen, E. 1986. Biological determinants of fecundity and fecundability: an application of bongaarts' model to forager fertility, pp. 59–89. In W. P. Handwerker, editor, *Culture and Reproduction. An Anthropological Critique of Demographic Transition Theory*, Westview Press, Boulder.
- Wood, J. W. 1989. Fecundity and natural fertility in humans. In S. R. Milligan, editor, *Oxford Reviews in Biology, Volume 11*, Oxford University Press, Oxford.

Center for Demography and Ecology
4412 Social Science Building
1180 Observatory Drive
University of Wisconsin - Madison
Madison, WI 53706-1393
U.S.A.