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LACTATION, OVULATION, INFANTICIDE, AND WOMEN'S WORK: A STUDY OF HUNTER-GATHERER POPULATION REGULATION

Richard B. Lee 1980

How do human hunter-gatherers regulate their numbers? Most observers have agreed that some form of population regulation is essential, simply because humans share with all successful species an "inherent excessive fertility," to use Birdsell's phrase (1968), while hunter-gatherer population densities remain strictly limited. Hunter-gatherers throughout prehistory have therefore had to tread the fine line between too much regulation of fertility, which could result in extinction (Schrire and Steiger 1974), and too little regulation, which could achieve the same effect by the too rapid expansion of the population and the exhaustion of resources. We have little knowledge of those who failed, but the fact that humans expanded to occupy six continents before the advent of agriculture is testimony to the degree of their success in treading this line.

In thinking about the ways that hunters have regulated their numbers, a wide variety of mechanisms have been suggested, including warfare, migration, starvation, and, paradoxically, local extinction. Undoubtedly, each of these scenarios has been played out at various times and places in humanity's long prehistory. But to invoke these mechanisms as the major explanations is like invoking catastrophism to explain the evolution of species.* I favor the search for a mechanism or mechanisms that arise out of the basic adaptation of the hunter-gatherers, a mechanism or mechanisms that can be calibrated or fine-tuned to respond to minor fluctuations in resources long before the thresholds of disaster are reached—in other words a self-regulating system.

**Editors' Note:* Alternative views of the roles played by each of these mechanisms are offered by Cohen and by Hassan.

This line of inquiry has focused attention on two major mechanisms: systematic infanticide and the control of ovulation by lactation. Both kinds of mechanisms—one cultural, the other physiological—offer the possibility for modifying fertility in such a way that the reproductive success of the individual and the overall survival of the group are brought into congruence. Periodic warfare and starvation, by contrast, seem a more expensive and risky way in the short run of ensuring group survival in the long run.

Those who see infanticide as the primary regulating mechanism and those who credit suppression of ovulation by lactation have differed over the relative weight of each mechanism in determining family size. Birdsell (1968) has postulated a 15–50% rate of infanticide for all human births in the Pleistocene, and notes that "medical science has not yielded accurate information on the relationships between nursing and ovulation needed to fix the figure more accurately."

In the decade since Birdsell's excellent paper, a great deal of research has been conducted on the relation of lactation to ovulation and on the duration of the anovulatory period in nursing mothers. We are now in a much better position to evaluate the cultural and physiological mechanisms that regulate fertility in human hunter-gatherers and in humans in general. Recent evidence enables us now to make a clearer statement of how early human populations may have regulated their numbers, and how this situation changed dramatically with the onset of the Neolithic Revolution.

The argument is presented in the form of a case study of the !Kung San, a nomadic hunting and gathering people of northern Botswana who were in the process of settling down during the period of the research (1963–73).* The chapter starts with an analysis of the dual role of women in the productive and reproductive spheres and traces the points of articulation between the two spheres by means of a quantitative model of work. Nomadic !Kung women have an average interval between live births of almost 4 years. This shortens dramatically with the onset of sedentary life. Next, we examine the physiological

**Editors' Note:* There is considerable debate in anthropology about the use of the !Kung as a model for understanding Pleistocene hunter-gatherers. Both Lee and Cohen extrapolate !Kung data to the Pleistocene, albeit with some reservations. Ripley argues that the !Kung are atypical and cannot be used as a basis for extrapolation. She offers specific hypotheses to account for their anomalous condition.

mechanisms underlying long birth spacing and the reasons for its shortening with sedentarization.

Two main causal explanations are considered: the critical fatness hypothesis (Frisch and McArthur 1974; Howell 1976a) and the nursing stimulus hypothesis (Kippley 1975; Knodel 1977); both the !Kung evidence and the comparative data seem to favor the latter hypothesis. The conclusion briefly spells out the implications of this case study for human psychosocial development.

Production and Reproduction

Women play a dual role in !Kung society: as producers of food and the necessities of life, and as reproducers, to whom falls the major task of bearing and raising the next generation of gatherers and hunters. This dual role, which !Kung women share with women in all preindustrial societies, places them in a strategically central position, since for the !Kung the work of subsistence and of child rearing forms a very large proportion of the total work carried out by the society. This is in marked contrast to the situation in industrial societies, where women are often marginalized by being excluded from the labor force and confined to the home or concentrated in menial jobs of low productivity.

Like the men, !Kung women range widely through the countryside to find food. This necessity for mobility is a key factor in the foraging mode of production. Against this are the demands placed upon women in their other role, reproduction: pregnancy, childbirth, lactation, and the necessity to care for and carry the young infants tend to draw a woman toward the home and to reduce her mobility. Women are thus at the intersection of two critical systems within the foraging economy: the productive system and the reproductive system, each with its conflicting demands.* The one necessitates mobility and the other penalizes it. In hunting and gathering societies there is a tight articulation between these two systems, so that a change of the variables in one system leads to adjustment of the variables in the other.

**Editors' Note:* See Ripley for a further discussion of the possible consequences of focusing both productive and reproductive roles and choices on women.

Given this articulation, what are the factors that regulate !Kung fertility under traditional hunting and gathering conditions, and how might these factors be altered in a shift from a nomadic to a sedentary life? The predictive model of changing !Kung fertility was originally presented at a conference on population growth in 1970 and published 2 years later in a paper entitled "Population growth and the beginnings of sedentary life among the !Kung Bushmen" (Lee 1972). Pages 324–34 are a recapitulation of the argument in Lee 1972. Data to test the predictions of the model against actual birth statistics were collected in a restudy of the Dobe !Kung in 1973. These are presented in pages 334–38 (see also Lee 1979).

The Role of Women in the !Kung Economy

Woman's work—gathering wild vegetable foods—provides well over half of all the food consumed by a !Kung camp. Men's hunting activities and gifts of food from other camps makes up the remainder. Subsistence work occupies 2 or 3 days of work per week for each adult woman. On each workday a woman walks from 3 to 20 km (2–12 miles) round trip, and on the return leg she carries loads of 7–15 kg. Subsistence work, visits, and group moves require an adult woman to walk about 2,400 km (1,500 miles) during the course of an annual round. For at least half of this distance she carries substantial burdens of food, water, or material goods.

Of course, the major burden carried by women has yet to be mentioned. On most gathering trips and on every visit and group move, a woman has to carry with her each of her children under the age of 4 years. Infants and young children have an extremely close relationship with their mothers (Draper 1976; Konner 1976). For the first few years of an infant's life mother and child are rarely separated by more than a few paces. Although solid foods are introduced at the age of 6 months or earlier, breast feeding continues into the third or fourth year of life. For the first year or two, infants are carried on the mother's back in the special baby carrier. Then from 2–4 years of age they are carried in the kaross or straddling the mother's shoulder. For the first 2 years of life, a child is carried everywhere. In the third year some babysitting occurs, and this increases in the fourth year. For each of the first 2 years of life, a child is carried by the mother for a distance

of 2,400 km; in the third year this decreases to about 1,800 km; and in the fourth year to about 1,200 km. Over the 4-year period of dependency, a !Kung mother will carry her child a total distance of around 7,800 km (4,900 miles).

The Reproductive System

The onset of puberty in girls is late compared to western standards, usually occurring between the ages of 15 and 17. First pregnancies are further delayed for several years by postmenarcheal adolescent sterility (Howell 1976b). Thus, a woman does not bear her first child until she is between 18 and 22 years of age. The first pregnancy is followed by four to eight others spaced 3–5 years apart until menopause occurs after age 40. Howell has noted that !Kung fertility appears to be lower than among other populations (Howell 1979).

What is critical to the present analysis is not the overall fertility picture as expressed in birthrate but the frequency with which successive births occur to individual women—that is, the interval between births or birth spacing, expressed in months or years.

The Economic Consequences of Birth Spacing

Since every child has to be carried, it is fortunate that generally the birth interval among the !Kung is as long as it is. The advantage of long birth spacing to hunter-gatherers is obvious. A mother can devote her full attention to caring for an offspring for a longer period, and the older the offspring is when his mother turns to the care of the subsequent young, the better are his chances for survival.

There is also the matter of the sheer weight of an infant to be carried by the mother. A woman whose children are spaced 4 years apart will have only one child to carry at any one time. By the time the next infant is born, the older child is mature enough to walk on his own. On the other hand, a woman whose births are spaced only 2 years apart will have to carry two children at once; a newborn to 2-year-old on the back and a 3- to 4-year-old on the shoulder. No sooner is the older child "weaned" from the shoulder when yet another newborn arrives. The !Kung San of the Dobe area recognize the plight of the woman with high fertility and express it in the saying: "A woman who gives birth like an animal to one offspring after another has a permanent backache."

The actual work involved in raising young children in a hunting

Table 15.1. Average Weight in Kilograms and Pounds by Age for 40 San Children from Birth to 8 Years

	Weight of child				*Observations on individuals*	
Age (years)	*kg*	*Range (kg)*	*lb*	*Range (lb)*	*Number of observations*	*Number of individuals*
0–1	6.0	3.1–8.7	13.2	7–19	32	12
1–2	8.8	7.3–11.8	19.4	16–26	21	12
2–3	11.6	8.2–14.1	25.6	18–31	15	9
3–4	12.4	10.9–15.0	27.4	24–33	15	7
4–5	13.4	9.5–15.9	29.6	21–35	31	11
5–6	14.7	12.3–16.8	32.3	27–37	20	10
6–7	15.3	11.8–17.7	33.8	26–39	13	7
7–8	17.6	12.7–19.5	38.7	28–43	17	5
Total					164	73[a]

[a]A number of individuals appear in two or more age categories.

and gathering society is in large part a function of three variables: weight of children, the distance to be traveled, and the frequency with which children are born to a given woman. Fortunately, each of these variables can be precisely quantified, and from their interaction a simple calculus can be developed to show more precisely the relationship between birth spacing and woman's work—that is, between the reproductive system and the productive system.

Women's Work

The Weights of Infants and Children. !Kung adults are small in stature and light in weight by western standards. Birth weights and rates of infant growth for the first 6 months of life are comparable to western standands. Thereafter, children grow more slowly than do western children. The weights of the former at each age run about 75–80% of the latter. For example, a 3½-year-old American child weighs about 16.0 kg, while a !Kung child of about the same age weighs 12.5 kg (Truswell and Hansen 1976).

The average weights of !Kung infants and children from birth to 8 years are shown in table 15.1. The figures are based on 164 observations on 40 children weighed during field work in 1967–69. The values vary from 6.0 kg in the first year of life to 17.6 kg in the eighth year. Note that these figures represent average weight during the year, not

Table 15.2. Work Load of Women with Children of Various Ages

Child's Age (Years)	Average weight of child		Average annual distance to be carried		Work load for the mother (kg/km)
	kg	lb	km	miles	
0–1	6.0	(13.2)	2,400	1,500	14,400
1–2	8.8	(19.4)	2,400	1,500	21,120
2–3	11.6	(25.6)	1,800	1,125	20,880
3–4	12.4	(27.4)	1,200	750	14,880
4–5	13.4	(29.5)	—	—	—
5–6	14.7	(32.3)	—	—	—
6–7	15.3	(33.8)	—	—	—
7–8	17.6	(38.7)	—	—	—

the weight attained at the end of the year. Presenting the data in this form enables us to calculate the average burden to be carried by the mother during each year of the child's life.

In the first year children weigh from 3.1 kg at birth to a high of 8.7 kg for an exceptionally fat older infant, with the average weight of infants being 6.0 kg. In the second year of life the mother's burden is 8.8 kg, with a range of 7.3–11.8 kg. By the fourth year this average has increased to 12.4 kg, with a range of 10.9 to as high as 15.0 kg.

The Distance to be Traveled. I have estimated that a woman walks about 2,400 km during a year's activity. Apart from the food, water, and personal belongings, a woman will carry each of her children under the age of 4 for all or much of this distance. The weight she actually carries is determined by the age of the child and its rate of growth. Table 15.2 shows the different burdens of women with children of various ages. I introduce the useful, although somewhat cumbersome, measure of the "kilogram/kilometer," which is simply a product of weight times distance; that is, a load of 1 kg carried a distance of 1 km.

The Interval between Births. Given a mean birth interval among nomadic San of 4 years (for women of normal fertility), the work load of an average woman's reproductive career can be estimated. Her first baby is born in year 1, her second baby in year 5, her third in year 9, and so on. Each year she will have a variable weight of child to carry, depending on the age of the child. For a 10-year period her work effort will be as shown in table 15.3.

Table 15.3. Average Daily Burden over a 10-Year Period for a Woman with 4-Year Birth Spacing

	Year	*Kilograms to carry*
First baby	1	6.0
	2	8.8
	3	11.6
	4	12.7
Second baby	5	6.0
	6	8.8
	7	11.6
	8	12.7
Third baby	9	6.0
	10	8.8

During the 10-year period the average woman will raise three children and will have carried an average burden of 9.2 kg/day. Her burden will be least during the years when she is carrying a newborn (6.0 kg/day) and greatest when she is carrying a 3-year-old (12.4 kg/day plus the burden of being pregnant at the same time).

With shorter birth spacing, both the number of children and the weight of children to be carried will go up. Table 15.4 shows the work load required of mothers with four different birth intervals: 2, 3, 4 and 5 years. The table shows the number of babies and the weight in babies for each year of a 10-year period of the reproductive career.

As one moves from longer to shorter birth spacing, the work required of the mother progressively increases. At one extreme, a mother with 5-year spacing will at the end of 10 years have raised two children and will have carried an average daily burden of only 7.8 kg (17.2 lb). At the other extreme, a woman with 2-year spacing will, after the same time period, have five children, and her average daily burden will have been 17.0 kg (37.4 lb), and for 4 of the 10 years will have been as high as 21.2 kg (46.6 lb). Two-year birth spacing would, in fact, represent a theoretical upper limit of birth frequency for San women living under hunting and gathering conditions, since to carry more than two babies would be beyond a woman's capabilities.

For the majority of fertile women living as foragers, the intervals between live births varies between 5 and 3 years (see below). Shortening the birth interval from 5 to 4 years adds a daily burden of 1.4 kg to a woman's work load. Shortening the interval further from 4 to 3

Table 15.4. Effect of Different Birth Intervals on Work Effort of Mother

	Birth interval							
	2 years		*3 years*		*4 years*		*5 years*	
Year	*Weight (kg)*	*Baby no.*	*Weight (kg)*	*Baby no.*	*Weight (kg)*	*Baby no.*	*Weight (kg)*	*Baby no.*
1	6.0	1	6.0	1	6.0	1	6.0	1
2	8.8	1	8.8	1	8.8	1	8.8	1
3	17.6	1 & 2	11.6	1	11.6	1	11.6	1
4	21.2	1 & 2	18.4	1 & 2	12.4	1	12.4	1
5	17.6	2 &3	8.8	2	6.0	2	—	—
6	21.2	2 & 3	11.6	2	8.8	2	6.0	2
7	17.6	3 & 4	18.4	2 & 3	11.6	2	8.8	2
8	21.2	3 & 4	8.8	3	12.4	2	11.6	2
9	17.6	4 & 5	11.6	3	6.0	3	12.4	2
10	21.2	4 & 5	18.4	3 & 4	8.8	3	—	—
No. of children at end of 10 years	5		4		3		2	
Average weight of baby per annum	17.0 kg (6–21.2)		12.2 kg (6–18.4)		9.2 kg (6–12)		7.8 kg (0–12)	
No. of years carrying 2 children	8		3		0		0	
No. of years carrying 1 or 0 children	2		7		10		10	

Table 15.5. Work per Mother per Year According to Birth Spacing (kg/km)

	Birth interval			
	2 years	*3 years*	*4 years*	*5 years*
Average kg/km per year	32,064	22,824	17,808	14,256

years more than doubles the increase in burden to 3.0 kg, for a total weight of 12.2 kg.

We have noted how actual work for the mother is a product of weight carried times distance traveled. To carry a child for 1 year requires between 14,000 and 21,000 kg/km of effort by the mother. To carry one child for the full 4 years requires a total of 72,280 kg/km and the average per year of 17,820 kg/km.

Table 15.5 shows how the amount of work is affected by different lengths of birth spacing. The curve of increased work effort rises slowly as the birth interval shortens from 5 to 4 years; it rises more steeply as the birth interval reduces to 3 years, and extremely sharply as the interval is further reduced to 2 years. This table indicates some of the "costs" in work effort of raising children under nomadic hunting and gathering conditions, and it also shows the added costs of an increase in the birth rate.

A mother with 5-year birth spacing will have two children at the end of 10 years. To add a third child during the same period (by lowering the birth interval to 4 years) will add only 3,500 kg/km to a mother's work load. To add a fourth child (by further lowering the birth interval to 3 years) will "cost" 40% more than the cost of adding a third child—5,016 kg/km as opposed to 3,542 kg/km. And to add a fifth child (by lowering the birth interval even further to 2 years) would "cost" over 2½ times as much per child as adding a third.

Given these "high costs" of short birth spacing, it is not surprising that under nomadic conditions the birth intervals average close to 4 years, and this is maintained even in the absence of contraceptive measures; the !Kung practice postpartum sex taboos, but only during the first year of the baby's life. This long birth spacing is adaptive both at the individual level and at the level of population. The individual woman is better equipped to care for each of her children if births do not follow too closely one after another, and this long birth spacing

lowers overall fertility so that the population does not grow so rapidly that it threatens the food supply. Long birth spacing alone is not sufficient to keep the population in long-term balance with resources, but the modest amount of excess fertility of the !Kung is readily absorbed by infant mortality, occasional infanticide, and outmigration.*

In this context it is worth noting that the slow rates of growth of !Kung children, mentioned earlier, are also adaptive. For people who have to walk a lot, small babies are easier to carry than large babies. This is another way that smallness makes sense in terms of the nomadic foraging way of life. If the !Kung children grew as fast as they should according to western standards (see Truswell and Hansen 1976), an intolerable burden would be imposed on the parents, who would have to do the carrying, thereby reducing the survivial chances of both generations. It is also worth noting that among adult !Kung, shorter men are more successful hunters than are taller men (Lee 1979).

Mobility, Birth Spacing, and Population Growth

I have examined the implications of higher and lower fertility levels for the economic adaptation of the hunting and gathering San. More babies and/or greater distances to travel mean more work for San mothers. Similarly, work effort would decline with fewer babies and/or less walking. It is the latter possibility—less walking or reduction of mobility—that is of interest here. This is precisely what happens when hunters and gatherers shift to agriculture. Even partial agriculture allows more food to be grown closer to home, allowing the population to maintain the same level of nutrition with much less walking.†

What are the consequences for a !Kung mother's work load of a partial shift to food sources closer to home? To raise one child to the point where he can walk by himself requires four years of carrying, for an average annual work load of 17,820 kg/km. This average is based on 1,200–2,400 km/year of walking. If walking is reduced by a third—to 800–1,600 km/year—the annual work load falls to 11,880 kg/km.

Table 15.6 sketches the implications of reduced work effort for birth spacing. Formerly, the mother with 5-year birth spacing had an

**Editors' Note:* Note that Lee, Ripley, Hassan, and Cohen all agree that physiological birth spacing mechanisms are inadequate to account for low hunter-gatherer growth rates. The disagreement among them is largely one of emphasis.

†*Editors' Note:* Both Hassan and Cohen question Lee's emphasis on the reduction of physical stresses which accompanies sedentism.

Table 15.6. Effect of Reduced Mobility on Fertility

	kg/km Work per year for women with various birth intervals			
	2 years	*3 years*	*4 years*	*5 years*
Under nomadic conditions: 1,200–2,400 km/year	32,064	22,824	17,808	14,256
Under more sedentary conditions: 800–1,600 km/year	21,376	15,216	11,872	9,504

annual work load of 14,256 kg/km. Under the more sedentary conditions, this falls to 9,504 kg/km. A mother with 4-year birth spacing used to work 17,808 kg/km per year. Now she works only 11,872 kg/km, which is less than that of a mother with 5-year birth spacing under the nomadic conditions.

What this means in practical terms is that with reduced mobility a woman may shorten the interval between successive births and continue to give each child adequate care while keeping her work effort a constant. To put it another way, a mother can have more children with no increase in work effort. Table 15.6 shows how a mother may now have babies every 3 years with slightly less work effort than having babies every 4 years required under nomadic conditions (15,216 kg/km vs. 17,800 kg/km). Shortening the mean birth interval results in a general rise in the level of fertility, which, in turn, leads to an upswing in the rate of population growth.

I do not intend to imply that sedentarization alone causes population growth. In the first instance, reduction of mobility may produce a situation where the number of children remains the same but there is more leisure time. What I am suggesting here is that settling down removes the adverse effects of high fertility on individual women. Among hunters and gatherers high natural fertility is maladaptive: even with 3-year birth spacing the mother's work load may be great enough to endanger her own fitness and affect the survival chances of her offspring. With sedentary life these restraints are removed: 3-year birth spacing becomes no more strenuous to the mother than was 4-year birth spacing to mothers under nomadic conditions.

Thus, for the population as a whole, sedentarization may lead to the upsetting of the hunting-gathering low-fertility adaptation and trig-

ger population growth, even in the absence of any expansion in the food supply. The cause of the sedentarization need not be the shift to agriculture, although such a shift is occurring among the !Kung San. It is apparent that any change in the subsistence economy that allows reduced mobility may be sufficient to increase fertility. Such preagricultural examples of sedentarization as the exploitation of wild grains with a milling technology or the exploitation of coastal and riverine resources may have had a similar effect of increasing fertility by reducing mobility.

The relation between nomadism and long birth spacing has been known at least since 1922, when Sir Alexander Carr-Saunders referred to "the problem of transportation in nomadic societies." He pointed out that the necessity of carrying children for the first few years of life sharply limited the number of children a woman could successfully rear during her reproductive span (Carr-Saunders 1922). J. B. Birdsell speaks of at least a 3-year birth interval among Australian aboriginal women (Birdsell 1968). To my knowledge the first person to pinpoint live birth spacing as a key variable in the shift from hunting and gathering to sedentary life was Lewis R. Binford, as quoted by John Pfeiffer in *The emergence of man* (1969, p. 218):

> Binford suggests that one result (of a more reliable food supply at the end of the Pleistocene) may have been a increased trend toward year round settlements reducing the need to pack up and move on to new hunting grounds, and permitting an adjustment of primitive birth control measures. As long as mothers had to keep on the move, they were limited to one child every three or four years because that was all they could carry but infanticide could be relaxed in more settled times with fish and fowl to supplement basic supplies of reindeer meat.

Note that unlike the present theory, Binford points to infanticide as the key mechanism of hunter-gatherer population control. Sedentarization in his view triggers population growth through a reduction of infanticide and not through a shortening of the birth interval. Birdsell (1968) also sees infanticide as the key mechanism, arguing that "difficulties of nursing and mobility in the Pleistocene may have made necessary the killing of 15–50% of children born, since lactation alone would not have provided sufficient spacing of births to provide equilibrium" (p. 243).

My own view is that such a level of infanticide is *not* a necessary

component of hunter-gatherer population control. (It should be added, however, that this low level could easily rise should the need come about.) Under most foraging conditions the !Kung are able to maintain very low fertility through long birth spacing with a rate of infanticide of less than 2% (Howell 1976b). In fact, we are now in a position to specify precisely how long the birth intervals are under hunting and gathering conditions and how these birth intervals change when the !Kung settle down to village life.

!Kung Birth Spacing: A Test of the Hypothesis

Starting with July 1963, our research project has maintained a registry of births (and deaths) in the Dobe population. During field work birth dates were recorded by direct observation. These dates are usually accurate ±5 days. When there was no observer in the field, birth dates were reconstructed through interviews. These dates are usually accurate to ±30 days. In all we followed the reproductive lives of 256 adult women over the 10-year period 1963–73.

A process of sedentarization was going on in the Dobe area, but this had a markedly differential effect on groups at different waterholes. At one eastern waterhole (!Goshe), the San had built a village of mud huts in the early 1960s and essentially occupied this same site throughout the study period. They continued to hunt and gather on short trips, but an increasing proportion of their subsistence came from cows' milk and cultivated grains. At the other extreme of mobility were the /Du/da subpopulation 60 km south of the Dobe area, who moved camp five or six times a year in a classic foraging pattern. The remainder of the population exhibited patterns intermediate between these two poles. This varied situation offered the investigator a natural laboratory for testing hypotheses about the social, economic, and demographic effects of sedentarization.

After the original study appeared in print (Lee 1972), I returned to the Dobe area the following year to complete the 10-year record of births and deaths and to provide data for testing the hypothesis about the relationship between birth spacing and sedentarization. The 256 adult women included virtually all the resident women of reproductive age (15–59) in the population. Basically, there were two sets of cross-cutting variables characterizing the women in the sample: the stage of

Table 15.7. Women of Reproductive Age in the Dobe Area, 1963–1973

Stage of reproductive career	*Number of pregnancies 1963–73*			
	None	*One*	*Two+*	*Total women*
Early[a]	24	22	16	62
Middle[b]	63	19	73	155
Late[c]	32	2	3	37
Total	119	43	92	254[d]

[a] Women for whom menarche occurred during period 1963–73.
[b] Postmenarcheal women between the ages of 15 and 59.
[c] Women who underwent menopause during the period 1963–73.
[d] For two women of total 256, data were insufficient.

the reproductive career and the number of children born; this yielded the nine categories of women in table 15.7. Of the total, 119 women had no pregnancies during the period 1 July 1963–30 June 1973. Forty-three others had only one pregnancy, and for two women the data were insufficient, leaving 92 women with two or more births and hence with one or more measurable birth intervals.

The first step was to consider all the birth intervals while acknowledging that infant mortality could shorten the interval considerably. The average interval between successive births was 37.23 months for all 92 women (165 intervals). That means that over 3 years elapsed between births, whether or not the first baby died. This figure varied from a low of 11 months in a woman whose infant died in the first week of life and who conceived soon after, to a high of over 8 years in a woman of very low fertility. This figure is very high for a population in which no forms of contraception are practiced.

To eliminate the effects of infant mortality, I abstracted from the data those birth intervals in which the first child survived to the birth of the second. I further divided the population into two groups: women at *more nomadic* foraging camps and women at *more sedentary* nonforaging villages. Finally, I divided the 10-year run of data into two 5-year periods. This last division yielded three temporally related sets of data: (1) intervals falling within the period 1 July 1963–30 June 1968, (2) intervals falling within the period 1 July 1968–30 June 1973, and (3) intervals straddling the mid-1968 boundary. By comparing period 1 with period 2 we could discern possible secular trends through the 10-year period.

Table 15.8. Intervals in Months between Successive Live Births to !Kung Women during the Period 1963–1973

	Mean Length of Birth Interval in Months (n)			
	1963–68	*1968–73*	*1963–73*	*Mean of all three periods*
More nomadic women	42.27 (11)	36.42 (12)	47.63 (32)	44.11 (55)
More sedentary women	38.35 (17)	29.82 (22)	40.12 (26)	36.17 (65)
All women	39.89 (28)	32.15 (34)	44.26 (58)	39.81 (120)

The results are set out in table 15.8. The mean birth interval for nomadic women was 44.11 months and for sedentary women 36.17 months, indicating that throughout the period sedentary women tended to reconceive about 8 months earlier than did nomadic women. This 8-month difference would significantly increase both the birth rate and completed family size for the sedentary women.

The difference between more nomadic and more sedentary women comes into even sharper contrast when we examine the time dimension. The entire population was undergoing sedentarization during the period 1963–73, and this is reflected in the fact that the birth interval for all women dropped from 39.89 months in period 1 to 32.15 months in period 2. This shortening of the birth interval was particularly marked for more sedentary women, with a drop of 8.53 months, but the process is apparent in the more nomadic women as well, who exhibited a decrease of 5.85 months. The increase in fertility was most marked at the most settled village of !Goshe, where there were four young women each of whom in the period 1968–73 had had two successive live births spaced 22, 23, 21, and 20 months apart, respectively.

To illustrate the effects of birth spacing on actual people, here are case histories of several women, representing first the more nomadic and then the more sedentary categories.

1. /Twa (born 1933) is a married woman who alternates between !Kubi and /Xai/xai waterholes, spending a large proportion of her time with her group foraging in her husband's n!ore in the southwestern Aha hills. In 1968, /Twa had three well-spaced children: //Koka (born c.

1960), !Xam (born 2/63), and N!ai (born 3/68). She had a fourth birth 9/71 and when interviewed in 8/73 she was about 3 months' pregnant. Three of her birth intervals fall roughly within the study period:

2/63–3/68	61 months
3/68–9/71	42 months
9/71–c. 1/74	28 months

The average birth interval was 43.67 months, with clear evidence of a shortening of the interval through the 10-year period.

2. N≠isa (born c. 1941) has lived with her husband at cattle posts at Mahopa and Bate. In addition to an older son by a previous husband, N≠isa has had five pregnancies since the early 1960s, a girl //Kushe (born 1962), a boy /Tishe (born 2/65), a boy Bo (born 10/68, deceased), and another boy /Twi (born 3/71). She was in the middle stages of pregnancy when observed in July 1973. Her three birth intervals within the study period are as follows:

2/65–10/68	44 months
10/68–3/71	29 months
3/71–c. 10/73	31 months

The average birth interval was 34.67 months and there was some evidence of shortening through the period, although N≠isa does not approach the very short intervals (20–24 months) of some of the !Goshe girls.

3. An example of the latter is N!uhka (born 1947), who has spent most of her life at cattle posts north of the Dobe area and who married a !Goshe man in the mid 1960s. She had one stillbirth prior to 1968 (undated) and a pregnancy that spontaneously aborted in 9/68. She had a baby girl in 4/70 and 23 months later a boy in 3/72 for a birth interval of only 23 months and a period between birth and reconception of only 14 months.

The data presented in table 15.8 are specific to the period 1963–73, a time of increasingly rapid change for the !Kung. We have no way of knowing what the birth intervals might have been 10, 25, or 100 years ago when the !Kung were leading more nomadic lives. However, the data presented here convincingly demonstrate that the actual interval between live births continues to be well over 3 years for nomadic !Kung even under present circumstances, and that this long birth spacing is achieved without recourse to infanticide or to other forms of contraception. Howell recorded only six cases of infanticide in the 500 live births to the 165 women in the Dobe !Kung population (1976a).

In fact, methodologically the technique tends to underestimate the mean of the birth intervals. Because only a 10-year time period is considered, the cutoff of July 1973 gives us a truncated distribution of the full range of birth intervals and tends to overrepresent shorter intervals and underrepresent longer ones. For example, we do not know how many of the 43 women with only one birth in the 10-year period have ceased to be fertile and how many will give birth again after intervals of 60, 70, or 80 months (Sheps and Menken 1973; Howell personal communication). If these longer intervals were added into the sample I believe that the mean birth interval for nomadic women would fall between 4 and 5 years, as postulated by the model. Unfortunately, the termination of fertility by gonorrhea is a factor in many of the cases of women of midreproductive age who had no pregnancies during 1963–73. Gonorrhea thus could be reducing overall !Kung fertility, even as sedentarization could be increasing the fertility of nongonorrheal women (cf. Howell 1979).

A second point brought home by the data in table 15.8 is the rapidity of change during the decade. There is no statistical reason why the birth intervals in 1968–73 should be 7.75 months shorter than the intervals in 1963–68. The difference suggests that a change in the means of production toward reduced mobility can rapidly alter the balance in the system of reproduction and release, in effect, a flood of suppressed fertility. Schaefer (1971) and Freeman (1971) have observed a similar burst of fertility among the recently settled Inuit and other Canadian native people.

Lactation and Ovulation: The Causal Links

Two additional questions can now be asked. First, by what mechanism is long birth spacing maintained under foraging conditions, and second, what factors in the productive system could underlie the shortening of birth spacing when the shift to sedentary life is made? To the first question the answer is that long lactation appears to suppress ovulation in !Kung women. The mothers are observed to nurse their children for the first 2–3 years of the child's life. Nursing is vigorous, frequent, given on demand, and spaced throughout the day and night. During the latter half of the nursing period the mother's sexual life is

active, yet conception does not occur. Although the exact mechanism is still in dispute, it seems clear that it is the long period of vigorous continuous nursing that suppresses ovulation in enough women enough of the time to produce an average birth interval in Nomadic !Kung women of about 3.7 years (44.11 months).

The data on the relation between lactation and ovulation in other populations were at first difficult to interpret, but more recently the relationship has become increasingly clear. Carefuly studies have shown a marked suppressant effect in third world populations where nursing mothers show much longer birth intervals than do nonnursing mothers. These studies include Rwanda (Bonte and van Balen 1969), India (Tietze 1961; Peters et al. 1958; Potter et al. 1965), Egypt (El-Minawi and Foda 1971), and Taiwan (Jain et al. 1970) as well as among native North Americans, including Indians in New Mexico (Gioisa 1955) and Alaskan Eskimos (Berman et al. 1972). The data have led the demographer John Knodel to conclude that "There is ample evidence that lactation inhibits conception through prolonged postpartum amenorrhea" (Knodel n.d.; see also Van Ginneken 1974; Knodel 1977).

The fact that studies from urban western populations have shown the suppressant effect to be present but in a weaker form has led some western authorities to express doubts that lactation has any contraceptive value beyond the first few months of the child's life (e.g., Guttmacher 1952). In a recent study of American nursing mothers Kippley and Kippley have argued that cultural factors such as nursing schedules, the early use of pacifiers, midnight bottles, and supplementary feedings have tended to greatly reduce the effectiveness of lactation as a suppressor of ovulation in western societies (1975). For western mothers who are committed to a program of what the Kippleys call "natural mothering"—no pacifiers, bottles, or solid foods used for first 5 months, plus 24-hour feeding on demand—much longer periods of lactational infertility have been achieved. In a survey of 22 American La Leche League Mothers who breastfed their children from 12 to 37 months, the Kippleys found the mean length of breast feeding to be 22.8 months and the mean period of amenorrhea to be 14.6 months (Kippley and Kippley 1975). These values are, of course, short by !Kung standards but they are very long by western standards, where most bottle-feeding mothers are observed to resume menstrual cycles within 90 days of giving birth.

Although data on the incidence of postpartum amenorrhea are not yet available for the !Kung, we can infer from the length of the birth intervals and from the absence of evidence for the use of contraceptive devices or for postpartum sex taboos after 12 months that the !Kung women experience much longer periods of infertility following parturition and that their strong continuing lactation is probably involved in the persistence of the infertile period.

How does lactation suppress ovulation? Two kinds of related explanations have been offered. The first, called the critical fatness hypothesis, was originally developed by the Harvard biostatistician Rose Frisch to account for the timing of menarche in adolescent girls. Frisch found that the onset of menses was correlated with the attainment of a critical level of fatness, a level that was in fact a better predictor of the timing of menarche than was a girl's chronological age (Frisch 1974; Frisch and McArthur 1974). She has also suggested that a critical threshold of fatness may control the cessation and resumption of menstrual cycles in adult women (Frisch 1975). Citing evidence for amenorrhea in poorly nourished wartime populations, Frisch has directed attention to fat loss as a possible way of controlling menses and ovulation. Howell has applied this hypothesis to the !Kung data seeking to determine whether the caloric demands of lactation are so great that fat stores in nursing mothers are reduced below a critical threshold to the point where menses and ovulation cannot resume. She also considers the possibility that the gradual shift of the older nursing child to solid foods may permit the mother's fat levels to rise sufficiently to the point where menstrual cycles and ovulation are triggered (Howell 1976b, 1979; see also Kolata 1974).

There are three problems with the critical fatness hypothesis as an explanation of the !Kung womens' long postpartum infertility. First, nutritional amenorrhea is a usually serious condition of ill-health and reduced fitness; it seems unlikely that !Kung fertility would be regulated by a mechanism that routinely reproduces wartime conditions of semistarvation. Second, the clinical evidence for the nutritional status of lactating !Kung mothers indicates adequate levels of such key nutrients as vitamin B_{12}, folates, and iron (Truswell and Hansen 1976; Metz et al. 1972).* Third, Howell in a study (1979) of the weights of preg-

**Editors' Note:* Compare the treatment of the critical fat hypothesis by Cohen, who offers a hypothesis by which a critical fat threshold need not be inconsistent with good nutrition and attempts to explain why a mechanism which appears under pathological conditions among modern populations could have worked among healthy Pleistocene populations.

nant !Kung women found a wide scatter of weight levels for women around the time of conception, with thinner women conceiving as frequently as fatter women.

Other studies have also failed to show a correlation between weight gain and the timing of conception. For example, nursing mothers in a Guatemalan rural study population were actually found to be *losing* weight at reconception, not gaining it (Bongaarts and Delgado 1977).

Given these problems, attention has turned to alternative explanations. The second possible mechanism relating lactation to suppression of ovulation concerns the strength and persistence of the sucking stimulus itself. In a paper entitled "Effects of suckling on hypothalamic LH-Releasing factor and prolactin inhibiting factor," Minaguchi and Meites (1967) reported that follicular growth and ovulation were inhibited by the suckling act itself, a finding that confirmed earlier observations by other researchers (e.g., McKeown and Gibson 1954; Udesky 1950; Keettel and Bradbury 1961; Topkins 1959).* Topkins (1958; quoted in Kippley 1975, pp. 149–50) has stated:

> Recent evidence indicates that it is the stimulus of sucking of the infant rather than lactation which acts on the pituitary gland probably by way of the midbrain. The decrease in the frequency of feedings and the cessation of nursing result in the re-establishment of ovarian function, the reappearance of menstruation and ultimately ovulation. Complete breast-feeding in the early months of life is a fairly effective method of suppressing ovarian function and conception.

Subsequent research has confirmed this finding. In 1977, Mosley, drawing on the work of Tyson and Perez (1978) and others, could state (Mosley, 1977, pp. 8–9):

> It is now well-established that lactation and post-partum amenorrhea rely heavily upon the effectiveness of the nursing stimulus which in turn causes secretion of the pituitary hormone prolactin. This hormonal reflex system has even been demonstrated in normally menstruating women who induce lactation simply by nipple stimulation.

**Editors' Note:* Although suppression of ovulation by lactation is not discussed by Christian, his review of the interaction of the adrenal cortex, hypothalamus, pituitary, and gonads will provide the reader with an appreciation of the complexity and sensitivity of the endocrine systems feedback control mechanism. Lacking from Lee's discussion is consideration of other density-related or socially induced effects on lactation similar to those discussed for rodents by Christian or by Lloyd.

In other words, vigorous sucking—of a kind that is regular, frequent, and occurs round the clock—seems more likely to be responsible for the persistence of amenorrhea during lactation than does the falling of a woman's fat levels below a critical threshold (see Huffman et al. 1978, 1979). A number of studies, including work in Indonesia, Bangladesh, and among the !Kung San (Konner personal communication), are currently exploring the relative weights of these two kinds of factors, and we can look forward to some exciting results in the near future.

Whatever the mechanism (and the interactions between the two are complex; see Frisch and McArthur 1979), the !Kung appear to be able to achieve periods of lactational amenorrhea that are two to three times longer than that of other populations of breast-feeding noncontracepting mothers. The mean birth interval of 39.8 months (table 15.8) for !Kung mothers would imply a mean period from birth to conception of 30.8 months. If we assume that a woman's menstrual cycles resume on the average 3–6 months before she becomes pregnant again, that would place the mean length of the period of amenorrhea in the range 24.8–27.8 months, compared to figures of 10–12 months for native populations in India, Alaska, and Rwanda (Berman et al. 1972).

How are we to account for this persistence? If vigorous, persistent sucking stimulus is the causal mechanism, the !Kung present a good case. Observers of !Kung nursing mothers have been struck by the high frequency with which the children take the breast and the vigor with which the older children especially stimulate the nipples. In fact, the !Kung are quite striking in the degree to which they accept as the cultural norm the continued nursing of older children with full sets of teeth and fully developed sucking muscles. It is common to see 2- and 3-year-olds standing to nurse at a seated mother's breast. In fact, the primary reason for weaning appears to be a following pregnancy; when a woman becomes sure she is pregnant she quickly withdraws the breast, saying to the child: "Look this milk is no longer for you, it is for your younger sibling" (see Shostak 1976). But in the absence of a pregnancy a child may continue to nurse to age 5 or more. Only when the child is as old as 6 and the mother is still not pregnant are steps taken to wean the child with social pressure and mild ridicule ("You are too old for baby stuff like that"). This kind of late weaning is almost always confined to the last child of a mother in her forties. Here

we have the interesting (but not uncommon for the !Kung) situation of a lactating mother undergoing menopause while still nursing. We do not know how much nourishment the 3-year-old or 5-year-old child is actually getting from the breast, probably not very much; but if the sucking stimulus itself proves to be instrumental in inhibiting ovulation, !Kung child-rearing practices offer an ideal milieu to maximize its effectiveness.

Of course the 3-year-old child running with his play group does not nurse as frequently as the 1-year-old who is carried on the mother's hip, but the vigorousness of the stimulus may compensate for the decline of nursing frequency.

The emphasis the !Kung place on carrying the younger child may now be more clearly understood since the constant stimulation of the breast by the carried child may contribute significantly to the birth control effect, rather like carrying your contraceptive on your hip. If the infant were left at home with babysitters for a 6-hour working day, the contraceptive effect might be reduced.

Australian aboriginal women in Arnhem Land organize their work groups differently from the !Kung. They leave their children in camp in the charge of older cowives or other babysitters while they go out to gather. It is worth considering whether this fact alone may not account for the much shorter birth intervals and higher rates of infanticide that have been observed among Australian aboriginal women compared to !Kung women (McCarthy and McArthur 1960; Rose 1960; Birdsell 1968; Lancaster-Jones 1963).

Finally, we can ask why this system of long lactational amenorrhea breaks down when the shift to sedentary life is made. The rapidity of the change makes it unlikely that "removing the adverse effects of high fertility" will account for the change, since we see birth intervals shortening from one pregnancy to the next in the same women. It is more likely that some more proximate or immediate cause is at work. The probable mechanism is not too hard to discern. The nomadic !Kung diet, although rich in nutrients, is deficient in suitable weaning foods, that is, soft foods such as milk and porridge, which are easily digested by infants and toddlers. As a result, although infants are introduced to solid foods by 6 months of age, mother's milk continues to be an important part of the child's diet into the third year of life. At !Goshe and the other more settled !Kung villages there is a more plentiful supply

of cows' milk and cultivated grains. This availability of alternative foods lessens the child's need for breast milk, and this may lower the level of lactation and the frequency of nipple stimulation. The result of the infants' reduced demands is that a woman's lactational amenorrhea may cease and her ovulation may resume as early as 11–14 months after she has given birth, a situation that would lead to the 20- to 23-month birth intervals actually observed at !Goshe.

It must be emphasized that these are not either/or propositions. When you have a variable such as diet, it will affect different women differently. In some women it may lead to an earlier conception; in others it may not. The net statistical effect, however, would be a shorter birth interval and a rise in the birth rate.

The Emotional Economy of Reproduction

The more rapid succession of births is not an unmixed blessing. Quite apart from the long-term consequences of population growth and shrinking food supply, this sudden embarrassment of riches in terms of births is already imposing hardships on !Kung mothers and children alike. This degree of stress reveals the existence of a third system interlocked with production and reproduction, a system I will call the emotional economy of the San. Long birth spacing for the !Kung has meant that a great deal of energy, both physical and emotional, has gone into the raising of each child. For the nomadic !Kung each child got her mother's exclusive attention for 44 months, a period that included 36 months of breast feeding. By the time the child was weaned, she entered the world with the teeth, motor development, language, and social awareness of a 3-year-old. The weaning transition was not without difficulties. The child would cry for the breast and to be carried in the back pouch, and she would throw tantrums if she did not get her way. But after a few months the child usually adjusted to her new status of older sibling as her mother turned her attention to the new arrival. For the child who is weaned at 12 months instead of 36 months, the trauma of separation becomes much more severe. Remember that the year-old child under traditional !Kung circumstances was carried full time by the mother, was nursed on demand, and probably obtained a large proportion of her calories from the breast milk. From

the point of view of the culture, the year-old child was just a third of the way toward the point at which she would have to give up breast and back.

When the mother of such a young child becomes pregnant, the effects are striking. The most miserable children I have observed among the !Kung are some of the 1.5- to 2-year-old youngsters with younger siblings on the way. Their misery begins at their weaning and continues to the birth of their sibling 6–8 months later and beyond. The mother for her part has not only a demanding newborn to care for but the constant intrusions of an angry, sullen 2-year-old. A grandmother or aunt may do her best to feed and cheer up the child and to give the overworked mother some relief, but it is clear to the observer that something is out of kilter. The scene is in marked contrast to the relatively placid scenes of infant care in the nomadic camps documented by Draper (1976) and Konner (1976). In light of the emotional stress brought on by their short birth spacing, it is not surprising that several of these women have asked for birth control assistance. The Dobe area has never had a regular medical presence until the last few years, but the !Kung women had heard rumors of a European pill that would make them stop having babies and they sought this as a way out of their problems.

The unhappiness of the prematurely weaned !Kung babies and their mothers brought home to me how closely the emotional and psychological dynamics of life are tied into the productive and reproductive systems. The long birth spacing, which makes such good sense for hunter-gatherers in economic and health terms, also provides the opportunity for a high parental investment in each child, making possible the raising of what might be called fewer children of higher quality. The children's personalities were moulded by this system of exclusive attention for the first few years. The emotional security that !Kung adults display may be related to the security they experienced in early childhood. With short birth spacing the circle is broken and the emotional economy is put under stress, even though the nutritional and health needs of mother and child may be adequately met. Clearly, marked changes in the patterns of child care and maternal behavior will be required before the !Kung can adjust emotionally to their new economic and demographic realities. In the interim a generation of !Kung children may be growing up bearing the psychological scars of the rapid transition.

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