Ecology of Weaning among Nomadic Turkana Pastoralists of Kenya: Maternal Thinking, Maternal Behavior, and Human Adaptive Strategies

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Abstract   Weaning of human children is a complex process involving the introduction of non-breast-milk foods, reduction in suckling activity, and eventual termination of breast feeding. Because the choice of strategies for each component of the weaning process depends on the operating environmental constraints, reproductive demands on women, and prevailing levels of infant and weanling mortality, it is appropriate to examine weaning practices as human adaptive strategies. Here, I examine the structure of weaning and maternal attitudes toward weaning among nomadic Turkana pastoralists from the perspective of human adaptation. Using retrospective and prospective data on breast feeding, the use of non-breast-milk foods, and the cessation of breast feeding, I identify ideal strategies as those defined by Turkana women. Real behavior in relation to weaning, however, deviates considerably from the ideal, and this deviation reflects adaptive responses to nutritional and disease risks to infants. Particular attention is given to problematic aspects of weaning practices in Turkana, such as premature introduction of non-breast-milk foods and abrupt termination of breast feeding, which have been shown to contribute to high infant and weanling mortality in populations in developing countries. These practices have evolved from the dual caretaking and childbearing role of women and the necessity of reconciling the needs of the breast-feeding child with the demands of the next pregnancy. As such, they represent rational strategies for enhancing reproductive success in this and other similarly stressful environments.

Among the most important factors that contribute to population variation in breast-feeding practices is the structure of the weaning process, that is, the timing and order of the introduction of non-breast-milk foods. Non-breast-milk foods are used as either supplements to or replacements for breast milk (Quandt 1984), and their impact on the daily structure of breast feeding

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(Vitzthum 1994a) and on the duration of lactation depends on which function is intended. Both uses of non-breast-milk foods influence fertility levels through direct effects on lactational amenorrhea and indirect effects on child survival. On the one hand, replacements reduce suckling frequency, leading directly to changes in hormonal levels and resumption of ovarian function (Jones 1988, 1990; Tay et al. 1992). On the other hand, early introduction of non-breast-milk foods as supplements to human milk may affect fertility not only through effects on suckling frequency but also through increased infant exposure to contaminated foods and feeding vessels, resulting in higher infant morbidity and mortality (Cameron and Hofvander 1983; Gabriel et al. 1986; Castle et al. 1988; Latham et al. 1988; Winikoff and Laukaran 1988). Contamination and the resulting increased morbidity are often described in studies undertaken in developing countries, where poor hygiene and high prevalence of infectious and parasitic diseases are the rule. Given the health risks associated with early supplementation, it is assumed that in those populations that adopt such a strategy a significant percentage of infant deaths is directly attributable to just such questionable infant feeding practices (Latham et al. 1986; Van den Eerenbeemt 1985; Hildebrand et al. 1985).

Seemingly in direct contradiction to conventional biomedical wisdom, which emphasizes the importance of exclusive breast feeding for the first 4–6 months (World Health Organization 1984; Pipes 1989; Food and Nutrition Board 1991; Wardlaw and Insel 1993), mothers in many populations in developing countries nonetheless introduce non-breast-milk foods within the first months or weeks of an infant's life while continuing to breast-feed their children on demand for 12 months or more (Dettwyler 1986; Latham et al. 1986; Castle et al. 1988; Vitzthum 1988; Launer and Habicht 1989; Nestel 1989; Van Lerberghe 1990; Maher 1992; Panter-Brick 1992). Case studies documenting this practice understandably focus on the negative consequences for the children concerned [e.g., Castle et al. (1988), Launer et al. (1990), and Van Lerberghe (1990)]. The same studies explain early supplementation in developing countries as a consequence of modernization (Winikoff and Castle 1988a,b; Almedon 1991) and the medicalization of breast feeding by the Western health community (Bryant 1982; Entwisle et al. 1982; Ellis and Hewat 1984; Hillervik-Lindquist 1992). The ongoing debate concerning the insufficient milk syndrome documents this view of the issues involved (Gussler and Briesemeister 1980; Greiner et al. 1981; Tully and Dewey 1985). However, these explanations may at times obscure an underlying logic in maternal behavior that becomes apparent only when that behavior is situated within its larger ecological context. So situated, practices that appear to be inherently harmful to infants often acquire a more adaptive dimension.

Some time ago, several scientists suggested that infant feeding practices in general do represent adaptive strategies (LeVine 1977; Lozoff and Brittenham 1979; Lepowsky 1987). As such, they are long-standing and sound responses to ecological relationships that prevailed in the past and persist in the

present (LeVine 1977). If adaptive, they must by definition convey some advantage in terms of survival or reproduction or both. Given that early introduction of non-breast-milk foods appears to be an important component of infant feeding in populations demonstrating at most marginal exposure to or acceptance of Western culture, it seems reasonable to assume that this strategy indeed has been adaptive in some way. Furthermore, this view may have greater explanatory power than one that argues that mothers persistently and perversely pursue infant feeding strategies that have only adverse effects on their offspring and hence on their own reproductive success.

According to Maher (1992), we should expect early introduction of non-breast-milk foods in populations in which mothers experience chronic poor health and poor nutrition and where they must meet heavy labor and reproductive demands—all conditions that compromise maternal survival. In addition, these are populations in which infant and child mortality are high by world standards. Hence the opportunity for selection is great (Crow 1958). Although Maher's (1992) focus is on early supplementation as a strategy to reduce maternal energy expenditure for lactation and thus to enhance maternal survival, one should not dismiss the possibility, however problematic, that it also enhances survival of infants. If this is indeed the case, it follows that the nutritional benefits of the early introduction of non-breast-milk foods must outweigh the costs of increased exposure to disease.

This thesis is explored here in relation to patterns of breast feeding, weaning, and the feeding of non-breast-milk foods among nomadic Ngisonyoka Turkana of Kenya. The Turkana are an ideal population in which to investigate infant care and feeding as adaptive strategies. The physical environment is harsh and unpredictable. All individuals experience chronic low energy intake (Galvin 1992), and women exhibit depletion of fat stores with increasing parity (Little et al. 1992). Respiratory disease and malaria are endemic, and measles epidemics occur every 7–10 years (most recently in 1992). Heavy reproductive demands are made on women, who also may be called on to travel long distances to water or herd livestock, depending on environmental conditions and resource availability. Maternal and infant mortality (Fry and Leslie 1985; Rada Dyson-Hudson, personal communication, 1990) and infant and child morbidity (Gray 1996; Shell-Duncan 1993) are estimated to be high. The pastoralist system, however, also provides a nutritious alternative to breast milk in the form of milk from the herds and a complex social network that ensures its availability.

The study presented here was undertaken in Turkana District between 1989 and 1990 as part of a larger study of reproductive ecology initiated by members of the South Turkana Ecosystem Project. In addition to obtaining baseline data on breast-feeding and weaning practices, a major objective of the study was to develop an ecological framework in which to situate this set of behaviors among nomadic Turkana. In the course of developing such a framework, attempts were made to differentiate the ideal from the actual in

infant caretaking practices. It was hypothesized that care and feeding of young Turkana children would conform to a cultural ideal representing an optimal strategy. As a corollary to this expectation, it was hypothesized that there would be considerable deviation from the ideal as Turkana mothers negotiated the current environmental setting (N. Dyson-Hudson 1980, 1984). Descriptions of infant caretaking strategies were expected to be couched in the language of the ideal, providing insight into what mothers believed should or would occur in the most perfect of worlds. Actual behavior, both recalled and observed, was expected to reflect the precariousness of Turkana pastoralism and the degree to which everyday realities constrain the attainment of the ideal. In other words, actual behavior was expected to draw from a number of lesser options that, when considered in their entirety, represent an adaptive strategy.

Study Area and People

The Turkana are Teso-Turkana-speaking members of the Eastern Nilotic language group (Vossen 1982; Greenberg 1966) who inhabit the northwest corner of the Republic of Kenya (between 1°0 and 5°0 north latitude) (Figure 1). Turkana District is a semi-arid to arid scrub savanna and is subject to marked periodicity in rainfall. Ideally, rainfall is distributed in a bimodal pattern across the year: The rainy season lasts from the end of March to the end of May and is followed by a long, dry season, which begins toward the end of July. The dry season may be punctuated by the short rains (*erupe*) in October or November. In actuality, the timing of the rains and the amount of rainfall at any given locale in Turkana vary dramatically from year to year. Droughts are frequent and are anticipated at least once during a five-year period, although it is impossible to predict precisely when. During the last 15 years, three droughts of varying severity have occurred: from 1979 to 1981, from 1984 to 1985, and most recently, from March 1990 to 1993. Vegetation is sparse and is patchily distributed across Turkana. *Acacia* ssp. and thorn scrub are the predominant species, but various species of grasses are also found, depending on the rainfall. Water for livestock and human use is obtained from wells, which are dug in the dry washes that crisscross the region.

The members of the Ngisonyoka subsection of South Turkana are primarily nomadic pastoralists who keep mixed herds of camels, cattle, sheep, goats, and donkeys. They move their livestock and herding camps frequently in response to resource availability, rainfall patterns, the severity of the dry season, and the prevalence of livestock diseases. During the dry season, vegetation becomes increasingly scarce and water may be quite distant from forage. To distribute foraging stress more evenly throughout their territory, large herding units are broken down into smaller satellite herds, which are then sent to different parts of the range (Ellis and Swift 1988). Because longer
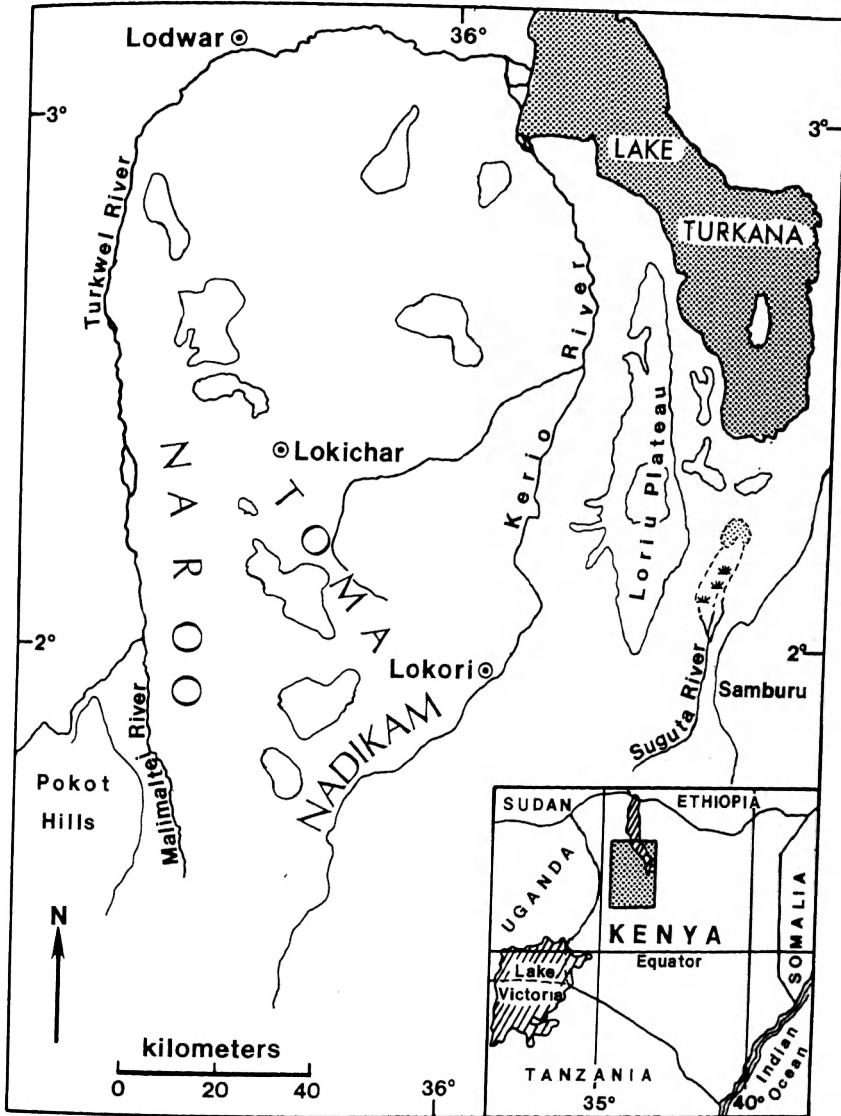
Figure 1. South Turkana.

distances must be traveled between wells and forage and because there are fewer people in each herding unit, the labor demands on individuals tend to be more intense during the dry season than during the rainy season.

The Ngisonyoka pastoral system is labor extensive, and wives and children contribute substantially to the labor pool. Successful, wealthy herders

Table 1. Age Distribution of Mothers and Infants

Mothers			Infants		
Age (Years)	Number	Mean Parity	Age (Months)	Males	Females
20–24	16	1.4	Neonates	0	2
25–29	36	2.3	1–3	14	12
30–34	27	3.3	4–6	8	11
35–39	13	4.5	7–9	11	9
40 and over	9	5.7	10–12	4	3
			13–15	10	6
Total	101		16–18	2	1
Mean age	30.4		Over 18	3	5
			Total	52	49
			Mean age	8.4	8.8

are those men who possess large herds and have many people to tend them. These may include several wives, many children of varying ages, and other members of an extended social network. R. Dyson-Hudson (1989) described the subsistence strategy as one in which both herd size and family size are optimized. In such a socioeconomic context the value placed on children is high, and Ngisonyoka women average seven live births by the end of their reproductive years (Brainard 1981; Leslie and Fry 1989; Gray 1992).

Major features of the environment and of the pastoral system have been described in detail in several publications [see Coughenour et al. (1985) and R. Dyson-Hudson and McCabe (1985)]. Health, biology, and demography of Ngisonyoka were examined in studies undertaken during the 1980s and early 1990s (Mugambi and Little 1983; Leslie et al. 1988; Little et al. 1988; Leslie and Fry 1989; Little and Gray 1990; Gray 1994b). Results of recent studies of human reproduction in South Turkana have been published by Gray (1994a), Leslie et al. (1993), and Little et al. (1993).

Methods and Materials

One hundred one Ngisonyoka women participated in the study; all of them were breast-feeding at the time the research was conducted. Age of nurslings and age and parity of mothers are shown in Table 1. Because Turkana do not keep a precise calendar, age estimates for both mothers and children were obtained by using an event calendar developed by Paul Leslie, Eliud Lowoto, and Rada Dyson-Hudson. Age of infants younger than 1 year was fairly easy to determine because their births were recent and could be linked to the location and activities of members of the South Turkana Ecosystem Project who were in the field at the time. For older children the event

calendar was used in conjunction with discussion among members of the herding group. Children were also ranked in order of their birth after the season of birth was determined for a particular child in the household. For a few children who had been born or immunized at a local health center, birth dates were available from their health cards.

The study included both retrospective and prospective components. During an interview, mothers were asked to describe breast-feeding and weaning practices, with particular attention to the introduction of non-breast-milk foods. Breast-feeding data were obtained by reconstructing maternal activity schedules for the preceding 24-hour period. Detailed discussion of the methodology, rationale, and results of the breast-feeding study are presented by Gray (1994a, 1995b). Data on the feeding of non-breast-milk foods consisted of recall of the type of food and amount fed in the preceding 24-hour period. Because children were characteristically fed from a personal feeding vessel, rough estimates of the amounts consumed were obtained by measuring the capacity of each such vessel, using a water or gruel substitute. Mothers were also asked to recall the order in which non-breast-milk foods were added to their children's diet, the season and approximate age of children at the time, and the reason the foods were introduced.

Multiparous mothers ($N = 75$) were asked to recall when (season and/or approximate age) and why they had weaned the child preceding their nursling. In addition, the same mothers were asked to speculate about when and why they would wean their nurslings, and responses for the two children were compared to obtain insight into actual versus ideal weaning behavior, as described by Turkana women. Because maternal choices relating to infant care and feeding can be influenced by past reproductive experience, analysis of weaning practices was undertaken separately for multiparas and primiparas.

The use of recall data to evaluate weaning practices presents several well-documented problems, chief among which is the problem of heaping (Holland 1987; Vitzthum 1994b). However, Quandt (1987) found that, relative to recall of other feeding transitions, recall of the timing of the weaning event (actual termination of breast feeding) had a high level of accuracy compared with prospective data ($R^2 = 0.79$). It should also be noted that weaning is an important event among nomadic Turkana. Although the precise month of weaning can be only roughly estimated, the chances that a woman will accurately recall the season and year are quite good for the simple reason that time in Turkana does not exist apart from the events that mark it: It is measured because something happens in it (N. Dyson-Hudson 1966). Seasons, for example, are named post hoc, and they are named to commemorate an important event. Hence weaning itself may become a time marker. Women reported that children were weaned in the early, mid, or late dry season or wet season. In the analyses monthly rainfall data for South Turkana were used to estimate a range of months for each of these seasons, and the timing of weaning was set at the midpoint for each range.

In addition to the recall data, focal studies of a subset of 24 mother-nursling pairs (one mother of twins) were undertaken to quantify caretaking correlates of reported weaning strategies and attitudes described during the interviews. Maternal speculation about weaning was assumed to reflect the set of culturally ideal options, which should prevail under optimal conditions. It was hypothesized that observed behavior would provide insight into those environmental and social constraints on infant care and feeding strategies that cause mothers to deviate from the ideal.

Focal pairs were observed in their herding camps for an average period of 8 hours (range 5–12 hours). To control for changes in mother-infant interactions in response to the presence of the investigator, a spot sampling strategy was implemented in which the investigator arrived unannounced and stayed for 3–6 hours during one part of the day. The day was broken into three periods based on observed activity patterns: morning (0500–1100 hours), midday (1100–1600 hours) and early evening (1600–1830 hours, approximately). Mothers were observed for some part of each of these three periods over the course of 1–3 days.

All interactions involving mothers and their children were timed to the nearest second and recorded in a diary. Observations included the time and duration of all suckling events (Vitzthum 1994a; Gray 1994a) and whether an event was terminated by the mother or the nursling; the frequency of non-breast-milk feedings, the kind of food given, and, when possible, the amount consumed; the length of time that nurslings were held by their mothers and the time they were held by others; the length of time nurslings spent in close physical proximity to their mothers and time spent outside of her immediate vicinity; the time nurslings spent napping; the frequency and duration of crying episodes and mothers' responses to their nurslings' cries; the length of time mothers spent away from their camp, leaving their nursling behind in the care of another caretaker; and the identity of all other caretakers. For the analyses behavioral variables were calculated as either a percentage of total observation time (e.g., the percentage of time infants were held by mothers) or as the average number of interactions per hour of observation (e.g., number of breast-feeding events or cries per hour).

Anthropometric examinations of nurslings were also conducted. Measurements included recumbent length and weight, head, chest, mid-calf, and upper arm circumferences, and six skinfold thicknesses (triceps, subscapular, mid-axillary, suprailiac, mid-calf, and periumbilical). Anthropometric protocol is described in detail by Gray (1992). Anthropometric data were used to determine what physical or developmental characteristics of nurslings, if any, were correlated with observed behavioral patterns.

In keeping with usage by other researchers (Almedom 1991; Vitzthum 1994b), I use the term *weaning* in this study to refer to a discrete event, as distinguished from the weaning process. Weaning is the complete cessation

of breast feeding, whereas the weaning process refers to the pattern of introduction of non-breast-milk foods and reduction in breast-feeding activity.

All analyses were run using SAS, release 6.03. PROC UNIVARIATE was used for all univariate analyses; where appropriate, variables were normalized using logarithmic and square root transformations (Sokal and Rohlf 1981). PROC FREQ was used to obtain distributions and to determine associations between row and column variables in contingency tables. Parametric analysis of variance was run using PROC GLM for unbalanced cell sizes, and nonparametric analysis of variance was run using PROC NPARIWAY. PROC CORR (Spearman and Pearson) was used for all correlations. PROC FACTOR was used to identify correlations among anthropometric variables and to select those most strongly correlated along each axis for use in other analyses.

Results

The structure of breast feeding among nomadic Turkana has been described in detail by Gray (1994a). Briefly, the pattern observed was one of constant physical contact between mothers and infants, allowing the infant to nurse on demand throughout the day. Children slept at their mother's breast and thus also had continuous access to the nipple throughout the night.

Turkana infants were regularly fed non-breast-milk foods from the middle of the first postpartum month. By the end of the second year, children's diets included most of the foods consumed by Turkana adults (Figure 2). Different categories of foods were introduced according to a culturally prescribed order, deduced from consistent maternal responses regarding when particular foods should be added to the infant diet. Butterfat made from camel milk was introduced first, a few weeks after birth, and is force-fed during breast feeding. The intake of butterfat averaged 50 ml/day, or the equivalent of 325 kcal/day for children aged 6 months or younger [calculated from composition tables given by Galvin (1985)]. Although mothers reported that nurslings older than age 6 months refused butterfat, decreases in infant intake were in fact observed to correspond with the arrival of the dry season, when less milk was available (Gray 1996).

Whole fresh milk from livestock was added to the infant diet in the first 3–4 months (see Figure 2). Camel milk was preferred for infants aged 4 months or younger, who received small portions over the course of the day in addition to breast milk. Milk from goats and cows, which was considered too rich or too fatty for very young infants, was introduced between age 5 and 6 months. After age 8 months other foods were gradually added. These included very sweet, milky tea (which was over 50% milk) and tea leaves, bits of animal fat cooked in ghee, and maize-meal porridge or gruel, which was cooked with milk and fat. From the middle of the second year children were fed blood (cooked with milk or maize-meal porridge) and bits of red
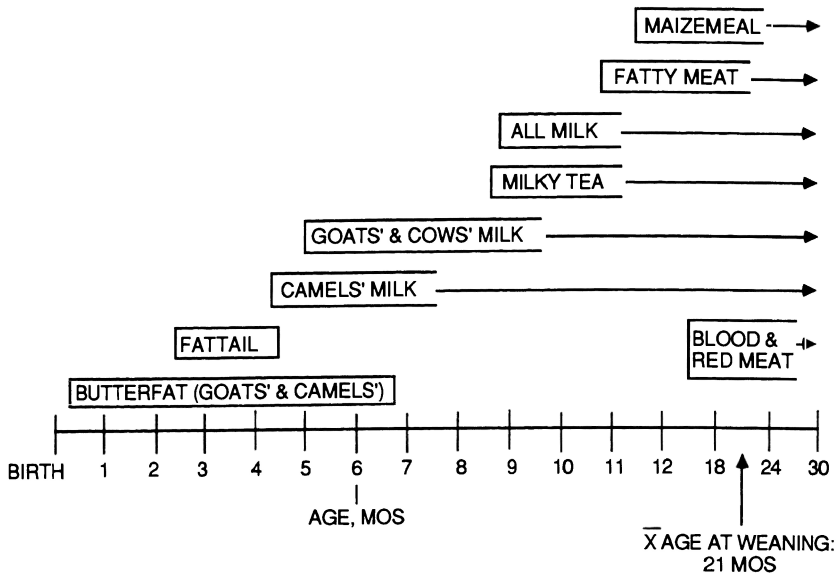
Figure 2. Order and timing of introduction of non-breast-milk foods among nomadic Turkana.

meat. Mothers agreed that nurslings required some time to acquire a taste for blood. However, they also reported that they had more confidence in their decision to terminate breast feeding if the weanling had developed this taste, because blood is an important replacement for animal milk during the dry season.

Weaning Behavior and Attitudes: Retrospective Component. Of the 75 multiparas who participated in the study, 69 women provided information about the weaning of their previous child and 62 provided speculative weaning information for their nurslings. The median age at weaning for the older children was 21 months, and most weaning events were reported to have occurred between age 15 and 24 months (Figure 3). The timing of weaning thus corresponded with mothers' reports of the timing of the introduction of blood and meat.

In Figure 4 the reasons given for weaning the two children are compared. In several instances mothers provided two reasons, and the percentages shown were computed from the total number of responses in each category. In the figure "*akero*" refers to the Turkana practice of child fostering (a child born outside a formal marriage who is subsequently adopted by an older postreproductive or barren woman in the herding unit is a child of the *akero*, or dancing floor; Gray 1995a). "Child development" refers to some devel-
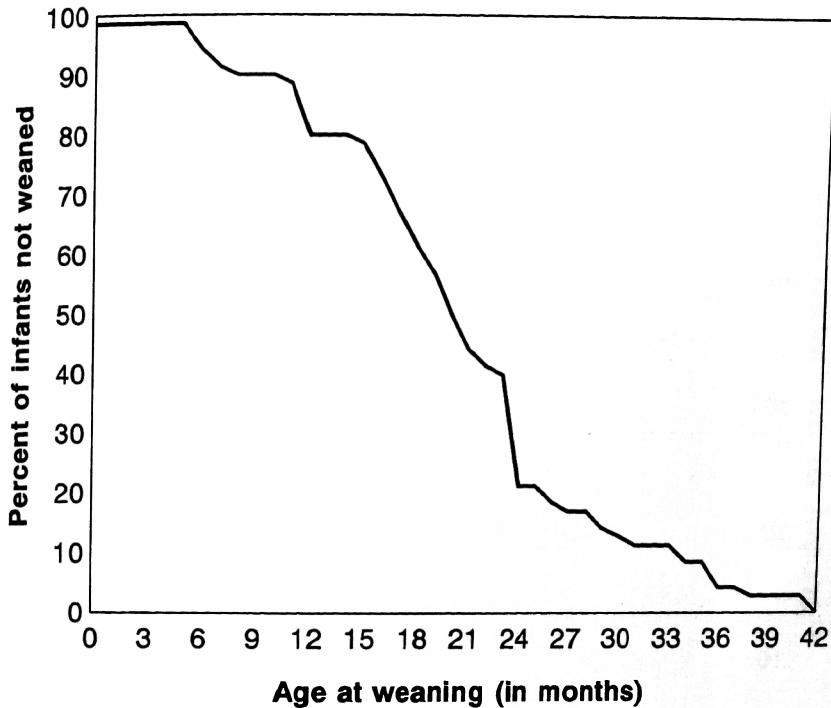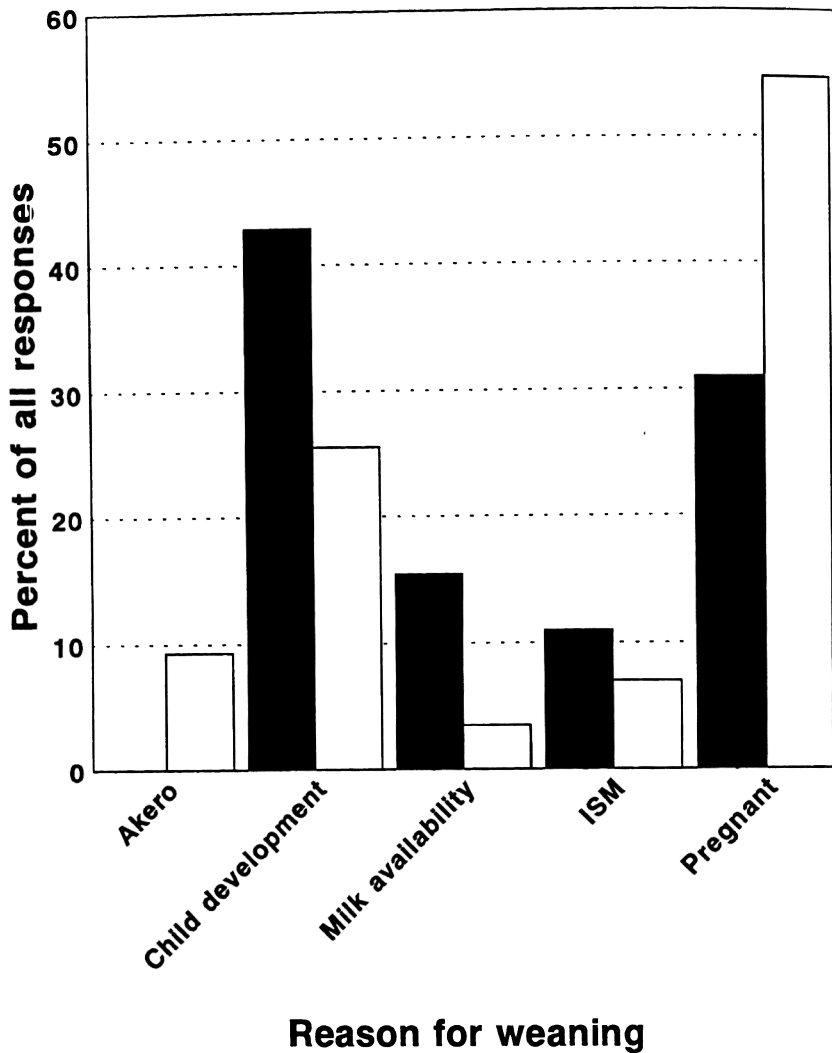
Figure 3. Age at termination of breast feeding among nomadic Turkana.

opmental landmark recognized by Turkana mothers. Landmarks included walking, running, talking, biting (the nipple), and the more general description, "big." "Milk availability" refers to animal milk, which was described as either "good" or "no milk." "ISM" refers to insufficient breast milk; specifically, it indicates some physical characteristic of the mother that she believed limited her ability to produce adequate breast milk. "Pregnant" indicates that a woman realized that she was again pregnant, which actually might have been 2 or 3 months after conception.

For the older child the most frequently cited reason for weaning was pregnancy (55% of all responses), followed by the developmental stage of the child (26%) and entrusting the child to an adoptive mother (9%). Combined, insufficient breast milk and availability of animal milk accounted for only about 10% of all responses; they were more likely to be cited as secondary reasons, after pregnancy.

Mothers were also asked to recall the season in which they had weaned their older child (Figure 5). Of the 75 multiparous women who were asked this question, 56% reported that they had weaned during the dry season (*N*

Reason for weaning

Figure 4.   Reasons for termination of breast feeding among nomadic Turkana: Comparison of the prediction for the index child (nursling) and of recall for the previous live birth. Solid bar, predicted (nursling); white bar, recalled (older child). For nurslings $N = 91$ responses from 62 mothers; for the previous child $N = 86$ response from 69 mothers.

= 42). Twenty-five mothers (33%) reported that they had weaned in the wet season. Five weaned during the short rainy season; however, because the short rains are unpredictable events falling in the middle of the dry season, those responses are included in the dry season tallies in Figure 5 and in all other
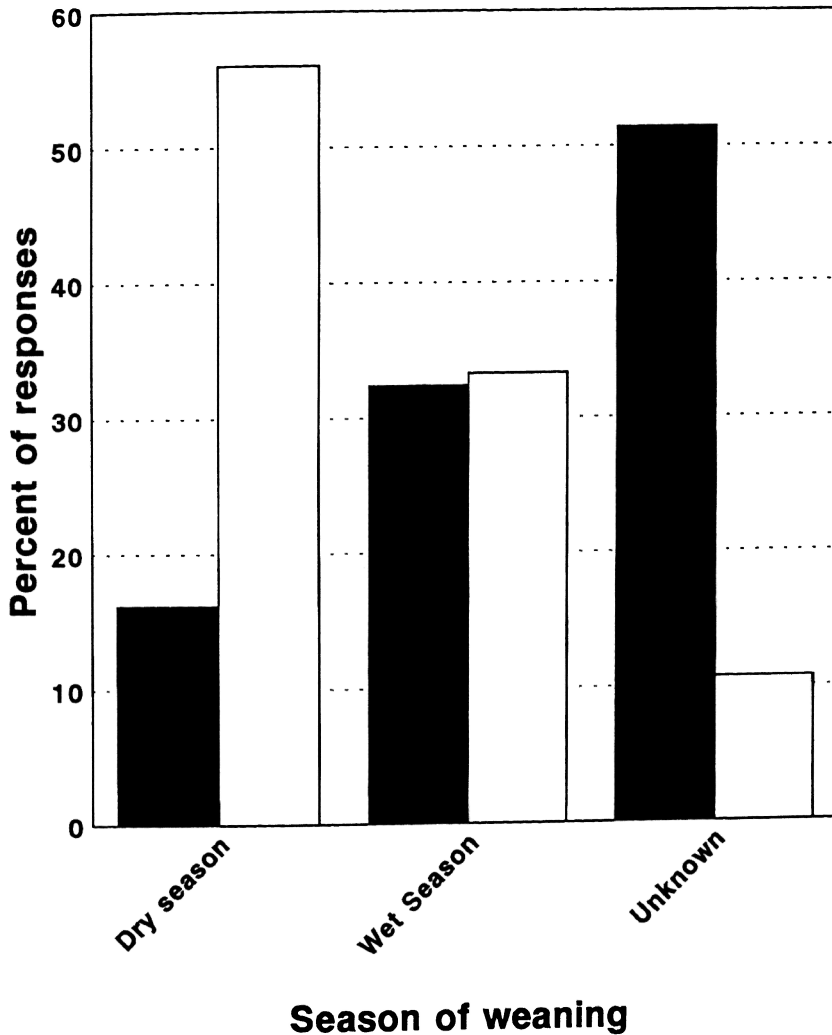
Figure 5. Season in which breast feeding is terminated among nomadic Turkana: Comparison of the prediction for the index child (nursling) and of recall for the previous live birth. Solid bar, predicted (nursling); white bar, recalled (older child). For nurslings, "unknown" indicates failure to predict the season; for the previous child it indicates failure to recall.

results presented here. Only eight mothers failed to recall the season of weaning.

Regarding their nurslings, the same mothers responded to the questions "Why will you wean?" and "In what season will you wean?" somewhat differently from the way they responded for the previous child (see Figure 4). In 43% of all responses for nurslings, developmental cues were expected to be the motivation to wean. The second most frequent response was pregnancy (31%), followed by the availability of appropriate replacement foods (15% of all responses) and insufficient breast milk (11% of responses). None of the multiparas in the study planned on giving their nursling to an adoptive mother. Because this practice usually involves the first live birth of an unmarried mother, this result was expected. Thirteen women declined to speculate about why they would wean their nursling; all of these were mothers of children aged 3 months or younger.

With regard to the season in which women expected to wean their nurslings, 38 of the 75 multiparas responded that they could not predict the season (51%) (see Figure 5). Twelve predicted that they would wean in the dry season (16%), and 24 expected to wean in the wet season (32%). An intriguing response, heard from a few women, was, "In the dry season—when I get pregnant. It's the same."

Although reasons given for weaning both the previous child and the child currently breast feeding fell into the same general categories, frequencies of different responses varied significantly for the two groups of children (likelihood ratio $X^2 = 29.04$, $p < 0.0001$). Differences were apparent in all categories (see Figure 4). There was also a highly significant association between season of weaning and weaning status (likelihood ratio $X^2 = 38.93$, $p < 0.0001$) (see Figure 5). Although few multiparas predicted that they would wean their nursling in the dry season, it was in fact the season in which most of these women (56%) had weaned their previous child. Percentages of multiparas naming the wet season as the season of weaning were comparable for both children.

A possible confounding influence on the timing and reason for weaning was the season in which children were born. Percentages of children born in the wet season and the dry season were comparable for the sample of breast-feeding children (47% vs. 53%), but mothers reported that a slightly higher proportion of their older children had been born in the wet season (64%). The differences in the birth seasons of the two samples of children were significant (likelihood ratio $X^2 = 4.373$, $p < 0.05$). For nurslings only the predicted reason for weaning and the birth season were associated. Only 18% of multiparas whose nurslings were born in the dry season expected to wean because they were pregnant, compared with 53% of the mothers whose nurslings were born in the wet season (likelihood ratio $X^2 = 9.83$, $p = 0.020$). That this is an age effect is also possible, because children born in the dry season in this sample were significantly younger ($t = -2.80$, $p = 0.006$) and smaller than

children born in the dry season ($t = -3.66$, $p = 0.0004$). Season of birth and season of weaning for either child were not associated.

To determine whether past reproductive experience influenced projections about when and why mothers would wean the child currently breast feeding, I compared responses of primiparous and multiparous mothers. There were no significant associations of any weaning variable with parity. In other words, mothers' predictions about weaning showed no effect of reproductive history. It should be noted, however, that sample size of primiparas was only 25, and cell sizes were too small to ascertain true differences in percentages.

Mother-Infant Interactions: Prospective Component.   When their mothers were present in the herding camp, nurslings younger than 12 months rarely were observed outside their mothers' immediate vicinity or in the care of other individuals. When separations did occur, they were seldom longer than a few minutes. Frequency and duration of in-camp separations were increased among children older than age 12 months, but they were still rare events.

Five mothers left camp for a prolonged period during the focal study without taking their nurslings along. Of these women, three were mothers of children aged 12 months or older and one was an unmarried mother whose infant had been adopted by its maternal grandmother. Three of the women spent, on average, approximately 10% of total observation time in absentia. The mother of the oldest child (aged 19 months) was away for 3 hours (nearly 40% of the total time observed). She had also been absent for several hours on the preceding day and reported that she was attempting to terminate breast feeding. The unmarried mother was absent for 6 hours (50% of observation time) on the day of the focal study and had also been away from the camp for several hours on the previous day. In her case there was some suggestion that she was to be married and would soon be leaving her natal herding group for her husband's camp. At the time of the study her child, a 3-month-old female, was being wet-nursed by both its adoptive mother and its maternal aunt. With the exception of these five pairs, Turkana mothers and nurslings were observed to be in almost constant physical contact.

Other types of mother-infant interactions occurred more frequently, and their pattern among the focal pairs showed a normal distribution. Factor analysis was undertaken to control for correlations among these variables and to identify significant underlying behavior (Table 2). Three independent factors, identified here by the variable with the highest loading on each factor, accounted for 71% of the variation in this set of mother-infant interactions. These include (1) the frequency of suckling events, (2) the percentage of time nurslings were held by their mothers, and (3) the frequency of crying episodes. Factor scores were computed for the three axes and were used in all subsequent correlation and regression analyses.

The factors contrast several types of mother-nursling interactions. Frequency of breast feeding and percentage of time spent playing near mother,

Table 2. Factor Analysis of Mother-Nursling Interactions among Nomadic Turkana

	Rotated Factor Loading		
Variable Entered	Factor 1: Suckling Frequency	Factor 2: Time Nursling Was Held by Mother	Factor 3: Crying Episodes
Frequency of crying episodes	0.019	−0.023	0.973
Percentage of cries eliciting immediate maternal response	−0.011	−0.047	0.051
Frequency of suckling events	0.850	0.243	0.168
Percentage of suckling events stopped by mother	−0.812	0.010	0.328
Percentage of time nursling napped	−0.740	0.321	−0.160
Percentage of time nursling was held by mother	−0.009	0.960	−0.018
Percentage of time nursling was in immediate vicinity of mother[a]	0.713	−0.541	0.009
Eigenvalue	2.602	1.243	1.136
Difference	1.359	0.107	0.135
Proportion	0.372	0.178	0.162
Cumulative	0.372	0.549	0.712

a. Distinct from the amount of time nurslings were physically held by mothers.

both of which show high positive loadings on factor 1, are contrasted with the time infants spent napping and with the percentage of all breast-feeding events that were terminated by the mother. Factor 2 is dominated by the high loading for the percentage of time infants were actually held by their mothers, which is contrasted with time they spent in their mothers' immediate vicinity but were not held. Factor 3 shows a positive correlation between the number of crying episodes and the percentage of suckling events stopped by the mothers, as opposed to by the nurslings, suggesting that crying may have been a result of denial of the breast by mothers.

Behavior summarized by the three factors was expected to show some association with growth and development of children. In this sample nursling recumbent length and head circumference proved to be the strongest anthropometric correlates of mother-nursling interactions, with nursling head circumference showing a slightly stronger overall association (Table 3). Because nursling head circumference was previously found to be the strongest developmental correlate of breast-feeding behavior (Gray 1995b), it is used in the remainder of this analysis to summarize growth and development effects on nursling care and feeding. The results of the correlation analysis showed a significant positive association between head circumference and factor 1 (suckling frequency) and slight but suggestive negative associations between head circumference and factors 2 and 3 (time held by mother and crying

Table 3. Coefficients of Correlations between Mother-Nursling Interactions and Nursling Growth among Nomadic Turkana[a]

Factor	Recumbent Length	Head Circumference
Factor 1: suckling frequency	0.518[b]	0.506[b]
Factor 2: time nursling was held by mother	−0.322[c]	−0.337[c]
Factor 3: crying episodes	−0.212	−0.276[c]

a. Factor scores for three principal factors used in correlation analysis.
b. H_0: $r = 0$; $p < 0.01$.
c. H_0: $r = 0$; $0.10 < p < 0.20$.

episodes). What is of particular interest is the strong correlation with factor 1 ($r = 0.506$, $p = 0.010$), which indicates that suckling frequency increased rather than decreased as children grew.

Although mother-nursling interactions summarized by the three principal factors were also correlated with the observed frequency of non-breast-milk feedings (of milk and tea, butterfat, and nondairy foods), these associations were generally not independent of growth and developmental effects (Table 4). The exception was the frequency of nondairy foods (in this sample, primarily maize-meal porridge), which showed a slight negative correlation with factor 1 even after controlling for size of nurslings. There were also persistent, albeit weak ($p < 0.20$) negative correlations between nonmilk foods and factors 2 and 3. In fact, these statistical relationships reflect changes in the pattern of feeding for children who were closest to weaning (children aged 19 months or older), who also were more likely to be denied access to the nipple.

Relationships between measured intake of non-breast-milk foods and mother-nursling interactions differed somewhat from the pattern for fre-

Table 4. Coefficients of Rank Correlations (r_s) between Mother-Nursling Interactions, Nursling Growth and Development, and Frequency of Non-Breast-Milk Feeding among Nomadic Turkana

Variable	Milk and Tea	Butterfat	Nondairy Foods
Factor 1: suckling frequency[a]	0.236	−0.179	−0.408[c]
Factor 2: time held by mother[a]	0.054	0.039	−0.321
Factor 3: crying episodes[a]	0.095	0.011	−0.282
Nursling head circumference	0.569[b]	−0.184	0.588[b]

a. Head circumference is partialled.
b. H_0: $r_s = 0$; $p < 0.01$.
c. H_0: $r_s = 0$; $0.05 < p < 0.10$.

Table 5. Coefficients of Rank Correlations $(r)_s$ between Mother-Nursling Interactions, Nursling Growth and Development, and Measured Intake of Non-Breast-Milk Foods among Nomadic Turkana

Variable	Milk and Tea	Butterfat	Nondairy Foods
Factor 1: suckling frequency[a]	0.409[d]	−0.178	0.207
Factor 2: time held by mother[a]	0.287	0.146	0.078
Factor 3: crying episodes[a]	0.469[c]	−0.085	−0.120
Nursling head circumference	0.831[b]	−0.169	0.436[c]

a. Head circumference is partialled.
b. H_0: $r_s = 0$; $p < 0.01$.
c. H_0: $r_s = 0$; $0.01 < p < 0.05$.
d. H_0: $r_s = 0$; $0.05 < p < 0.10$.

quency of feedings. Independent of growth, as summarized by nursling head circumference, measured intake of milk and tea was significantly and positively correlated with suckling frequency and frequency of crying episodes (Table 5). In this sample, therefore, animal milk and tea clearly were used as supplements to breast milk rather than as its replacement, and increased use of these foods did not result in any observable decrease in nursing activity. Older children received more non-breast-milk foods but were also observed to be more demanding of the breast.

Relationships between observed mother-infant interactions, supplementation patterns, and projected reasons for weaning were examined. Primary reasons given by the 23 mothers in the prospective study included the development stage of the child (48% of mothers), pregnancy (30%), and availability of animal milk (1 mother). Four mothers (17%) could not predict why they would wean. Sample sizes were judged to be too small to permit reliable analysis of variance or multiple comparisons, but mean values for behavioral and anthropometric variables by reason for weaning agreed with the results of the retrospective study: Nurslings of mothers who named developmental characters of their children as the major motivation to wean tended to be younger than 1 year. Mothers of older children were more likely to cite pregnancy as the main reason they would wean. Mothers of young infants were either more reluctant or less able to project when or why they would wean.

Only 9 (39%) of the 23 mothers speculated about the season in which they would wean (6 in the dry season; 3 in the wet season). The rest stated that they did not know or had no preference.

Discussion

Attitudes regarding care and feeding of young children expressed by the mothers in this study and observed contrasts between ideal and actual

behavior underscore the reproductive dilemma of nomadic Turkana women. In keeping with their caretaking role, mothers were most concerned with the welfare of their nurslings. This concern was immediately apparent in the virtually exclusive attention nurslings received from their mothers and the emphasis on the growth and development of children as a major factor in the decision to wean. On the other hand, the structure of the pastoralist system requires high human fertility if the family herds are to be maintained at adequate levels. Their childbearing role thus requires that Turkana women balance the needs of the child currently breast feeding with the demand for large families. The implications of this constraint for caretaking behavior are suggested by the finding that the real reason for weaning is the next pregnancy.

The duality of women's reproductive roles in the Turkana context is played out in an environment where disease and undernutrition are chronic and where both maternal and child mortality are reported to be high (Fry and Leslie 1985; Brainard 1981). In reconciling the needs of the child currently breast feeding with the needs of the unborn child, Turkana mothers all too often must choose from a set of options that are perhaps best characterized as bad and worse. Mothers are fully cognizant of the need to balance their reproductive demands and of the poor quality of the choices afforded them to achieve that balance. This awareness is reflected in contrasts between ideal and actual behavior and in the contradictions observed in caretaking and weaning practices.

During their first 15–18 months, Turkana children are in almost constant physical contact with their mothers, held in their arms or lap during the day, carried on their backs during milking of livestock, and sleeping next to them at night. Furthermore, the results of factor analysis suggest that many behavioral interactions between mothers and nurslings revolve around the immediacy of maternal physical responses to the children's demands. Until the middle of the second year, mothers react swiftly and positively. Marked changes in this pattern were observed among children approaching the end of their second year (after age 18 months). The observed timing of these changes agrees with maternal recall of the timing of weaning of the previous child. Mothers begin to spend more time away from the camp and from their infants, although children still demand and receive constant attention and are still breast-fed on demand when their mothers are in camp. For the oldest and most demanding children, however, some mothers actually refuse access to the breast or apply a bitter substance to their nipples to discourage suckling. Factor 3, which links crying frequency and denial of the breast, summarizes the effects of a lack of maternal responsiveness on nursling behavior. Late in the second year, some mothers also entrust their nurslings to the care of older sibs or to a grandmother during the night. This change in sleeping arrangements appears to be a prelude to complete cessation of breast feeding. In addition to these caretaking shifts, mothers of nurslings older than age 18 months reported that they had resumed sexual relations with their husbands.

Introduction of weaning foods is gradual, but reduction in breast-feeding activity is not. Although it is true that non-breast-milk foods are introduced over a period of two years or more in accordance with a culturally dictated pattern, this prolonged process does not lead to decreased breast-feeding activity, nor does it appear to prepare children for the cessation of breast feeding. The frequency of suckling actually increased among the oldest children in the study [see also Gray (1994a)]. Attempts to prevent children from nursing are markedly ineffectual. As a result, termination of breast feeding of Turkana children occurs abruptly when mothers realize they are again pregnant. As a consequence, the event of weaning is traumatic for both mothers and children. Weanlings were observed to respond with frequent tantrums, loss of appetite, and refusal to eat. Mothers reported that the most effective solution was for them to leave the herding camp for several weeks, entrusting the weanling to the care of an older, postreproductive woman, usually the child's grandmother. Three women whose children were weaned during the period of the study were known to have used this strategy. In fact, weaning for Turkana children apparently involves not only the loss of access to the breast, but indeed complete loss of access to their mothers.

Other details of infant feeding and caretaking are similarly contradictory. Close and constant mother-infant contact contrasts with what appears to be maternal laxity in preventing nurslings from engaging in dangerous behaviors, such as playing with sharp objects or near a fire. Essentially, proximity seems to ensure that mothers can respond quickly when such behavior produces predictable results. Furthermore, careful attention to appropriateness of non-breast-milk foods for nurslings of different ages contrasts with apparent disregard for risks of food contamination. Although lack of education about food hygiene might explain some part of such inattention, most mothers are aware of the benefits of keeping foods covered and protected from flies, but most neglect to do so. Finally, the force-feeding of pure fat to infants younger than 3 months certainly runs counter to medical recommendations.

The seemingly contradictory sets of behavior described here are best explained by (1) an attitude toward nursling care in which Turkana mothers attempt to mediate those conditions over which they believe they have some modicum of control, in the hope that their intervention will ameliorate those conditions over which they feel they have less control, and (2) a conscious shift in maternal focus from the nursling to the next pregnancy, which occurs during the end of a child's second year. I propose that both positions reflect a rational solution to the problem of maximizing reproductive success in Turkanaland as well as in other populations experiencing similar ecological constraints.

Reproductive reality in Turkana has no soft edges and, as stated earlier, choices are made from a limited number of generally poor options. The effect of these harsh realities on human biology and behavior is articulated most eloquently in the practice of introduction of butterfat in the first postpartum

month. An overriding reality, according to Turkana mothers, is that children are sick "from the womb," and, indeed, personal observation of three neonates who developed respiratory infections on the day of their birth leads me to accept that conclusion. As has been suggested by Maher (1992), for such populations exclusive breast feeding in the first 4–6 months confers no health advantage to infants other than immunological effects, which are passed on to the infant regardless of early introduction of non-breast-milk foods. In other words, reduced exposure to infection through food contamination may be less of a factor when balanced against other risks, such as constant proximity to human, animal, and insect vectors, limited access to modern health care facilities, and limited access to water. Where morbidity risks at all ages are high and are exacerbated by chronic undernutrition, as is the case among nomadic Turkana (Shell-Duncan 1993), energetic benefits accrued to nurslings by increased intake of foods such as butterfat may be of far greater significance than any reduction in exposure to infection supposed to accompany exclusive breast feeding.

Nursling energy balance clearly is the issue for the mothers in this study. Their immediate objective in early supplementation appears to be to increase or maintain infant fat stores so long as appropriate non-breast-milk foods are available. As such, the strategy may be partially successful, because fatness of the children in the study was sustained approximately between the National Center for Health Statistics (NCHS) 50th and 75th percentiles through the first 6 months (Gray 1992), dropping off thereafter. The decrease coincides with the dry season. Enhanced fat storage throughout early infancy may improve a child's options later, when passive immunity is no longer adequate and/or when dry season food shortages and undernutrition compromise the development of active immunity (Gray 1996). Although it is impossible in this study to separate growth effects of butterfat intake from the general growth patterns of breast-fed children, some data support an immunological explanation: Shell-Duncan (1993) found that immunocompetence, in general, was depressed among a sample of poorly nourished Turkana during the dry season.

As additional support for the ecological soundness of infant feeding strategies in this population, interspecific and seasonal variation in protein and fat content of the milk of Turkana livestock should be noted (Table 6). Mothers in the sample are clearly aware of these differences insofar as they are translated into appropriate nutritional supplements for nurslings; this is evident in the carefully followed schedule for the introduction of different foods at different stages of development. In this, there appears to be some effort on the part of mothers to accommodate the immature gastro-intestinal tract of nurslings.

In the present analysis methodological issues, such as failure to segregate supplementation and breast-feeding effects on growth or incomplete characterization of the protein and fatty acid composition of animal milk, may

Table 6. Mean Annual Crude Protein, Fat, and Energy Contents of Milk from Different Species of Livestock Herded by Nomadic Turkana[a]

Species	Crude Protein (g/100 g)	Fat (g/100 g)	Energy (kcal/100 g)
Camel	2.7	2.3	58
Cattle	3.2	2.8	83
Sheep and goat	3.8	3.0	87
Donkey	1.9	0.7	49

a. Fat, crude protein, and energy contents vary throughout the year in response to the physical condition of animals. From Galvin (1985).

be moot. The concern here is with maternal attitudes and perceptions, maternal behavior, and human adaptation. It is proposed that early introduction of non-breast-milk foods in association with frequent breast feeding represents a long-standing adaptive solution to the problem of infant survival in Turkanaland. Mothers apparently believe that they can do little about infant exposure to illness and disease, but they might nevertheless have some effect on infant susceptibility or recovery by ensuring positive energy balance in young children for as long as possible. That this is indeed the way of maternal thinking is supported by mothers' descriptions of certain illnesses as "always" or "from the womb" and by earlier research by Karen Shelley. In a 1985 study Shelley argued that Turkana attitudes toward illness emphasize protection and reaction to threat because disease is believed to be either an inevitable part of the natural order or a product of human malice. As such, it is inherently unpreventable. Early introduction of high-energy breast-milk supplements is interpreted here as one such protective strategy, and infant fatness represents, both literally and figuratively, a protective layer. In Turkana thinking infant fatness equates with infant health.

Although this argument may serve to justify one controversial aspect of an adaptive explanation of infant care and feeding among nomadic Turkana, it does not resolve entirely other contradictory elements of this set of behaviors. These include (1) the recorded differences between actual and speculative reasons for weaning in this sample and (2) the abrupt termination of breast feeding, which can be disastrous for the traumatized weanling (Gordon et al. 1963; Dettwyler 1986).

What is especially striking about the differences in motivations to wean is that, whereas 58% of all responses for nurslings related to developmental landmarks or availability of appropriate replacement foods, most mothers had weaned their older child because they became pregnant. In fact, several women said they had weaned their preceding child because they wanted to get pregnant. The differences in responses suggest that, although almost exclusive maternal investment in the child currently breast feeding may be the

cultural ideal, the precariousness of the ecological context requires that the next reproductive event take precedence over the continuation of such investment beyond approximately 2 years. Ultimately, high fertility is the best strategy where survival cannot be assured. That this is the strategy in Turkana is suggested by relationships between the age of nurslings and the responses of women to the question of why they would wean. Nurslings whose mothers cited the development stage of their child as the primary reason to wean were younger (mean age = 6.3 months, SE = 0.77) than nurslings whose mothers emphasized the next pregnancy (mean age = 10.5 months, SE = 1.33; t = 57.2, p = 0.009 for unequal variances). The significant cutoff was age 7 months (Figure 6). Maternal attitudes changed as early as the second half of the first year, with pregnancy gradually assuming greater prominence in maternal thinking.

During the second year, the shift in maternal focus is accompanied by a shift in caretaking responsibility to an older woman who is as attentive to the needs of the nursling as its mother had been previously. This woman gradually assumes the lion's share of responsibility for the child during the last months of the second year. The effect of abrupt weaning on the weanling may be mitigated to some degree by this strategy. It is also clear that this shift in caretaking responsibility facilitates realization of the ultimate maternal objectives: resumption of marital relations and conception.

Mothers who predicted that they would wean because of insufficient milk were of interest. They tended to be older high-parity women (mean age was estimated to be 32 years and mean parity was 5). Furthermore, their infants were very young (younger than 3 months). Because insufficient breast milk was usually explained as a consequence of hunger or food shortages, its inclusion among speculative reasons to wean may have reflected a perception on the part of high-parity women that they had few reserves left with which to support prolonged lactation. Or, alternatively, insufficient breast milk may have reflected uncertainty about the prospects for a newborn; it is no exaggeration that failure to sustain lactation in Turkana must seriously limit an infant's chances for survival. Concern that she would not have adequate breast milk may have been a mother's euphemistic way of expressing her expectations: that her infant would not survive.

Finally, responses to inquiries about the actual and predicted season of weaning also argue persuasively for a change in maternal focus as children grew. Based on the results of earlier studies, it had been hypothesized that mothers would prefer to wean in the wet season, when milk production of the herds was greatest (Galvin 1985; Leslie and Fry 1989). In fact, food availability was rarely cited as a reason to wean, and most mothers failed to predict a season for the weaning of their nursling. Yet most mothers had weaned their elder child in the dry season, because that was the season in which they became pregnant (Leslie and Fry 1989). Failure to name the dry season may have reflected conflicting maternal attitudes toward yet another
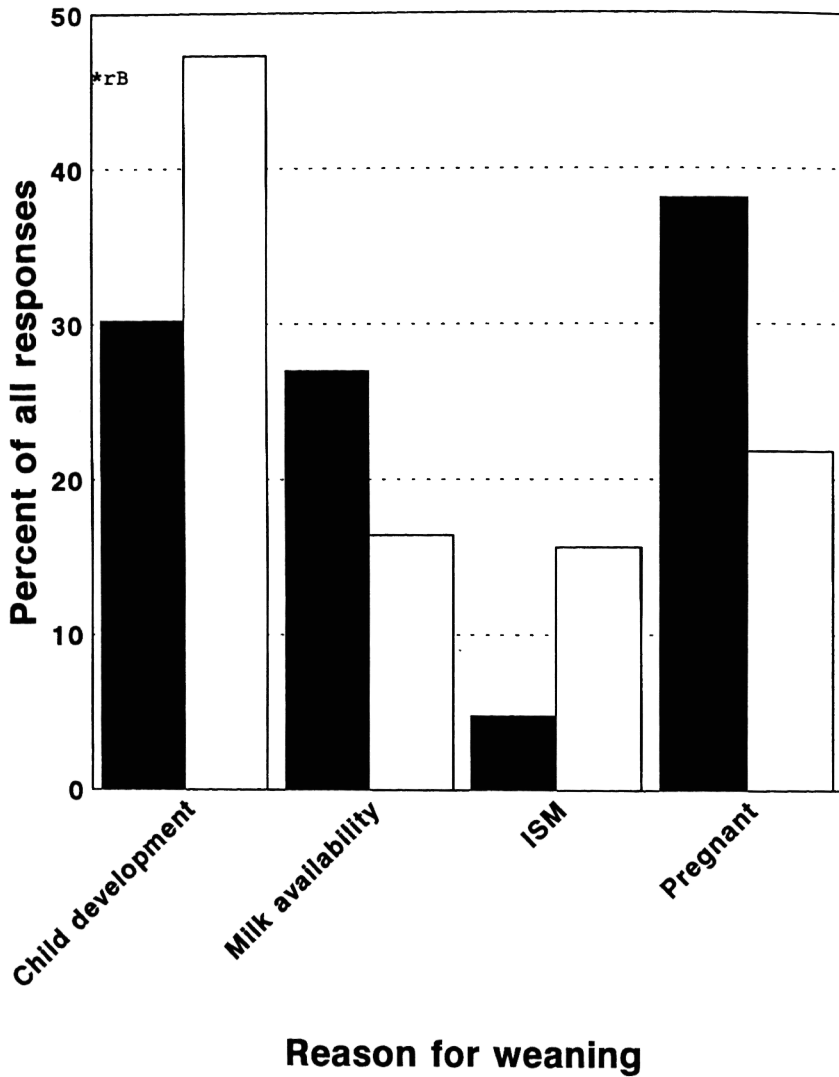
Figure 6. Predicted reasons for weaning among nomadic Turkana by age of nurslings. Data are summarized for both multiparas and primiparas. Solid bar, nursling age greater than or equal to 7 months; white bar, nursling age less than 7 months.

unpredictable outcome. One should wean in the dry season if the child currently breast feeding survives, if the rains come, and if one becomes pregnant according to the culturally ideal schedule. As is the case for all reproductive events in Turkana, however, there are no guarantees.

Conclusions

I have attempted to illuminate relationships between maternal weaning behavior and maternal thinking among nomadic Turkana by comparing observed and recalled behavior within their immediate environmental and social contexts. In so doing, my objective has been to present the weaning process as a component of human adaptation in Turkana. It is hoped that elements of weaning behavior that are controversial from a biomedical perspective, such as early introduction of non-breast-milk foods and abrupt termination of breast feeding, assume a more rational dimension when viewed within an adaptive framework. As adaptations, they should not be dismissed as misguided responses to modernization. Furthermore, that the same behaviors have been observed in other populations operating under similar reproductive constraints, such as high maternal and infant morbidity and mortality and chronic undernutrition, may help to illuminate the adaptive trade-offs that have shaped human reproductive behavior (Alexander 1990). The shift of responsibility for weanlings to alternative caretakers after the intense maternal investment of the first 15–18 months is a case in point.

Although the argument presented here remains largely speculative, this study underscores the need to examine more systematically (1) the ecological contexts of maternal thinking and maternal behavior and (2) the effects of maternal behavior on human fitness. Clearly, maternal strategies operate on one level to mediate environmental effects on offspring survival. Their influence on the survival and fitness of the mother herself is less straightforward. Testing of the adaptation hypothesis ultimately requires quantification of effects of individual maternal strategies on both child survival and completed fertility. Nonetheless, the repertoire of maternal responses in a particular ecological context may tell us a great deal about the selective pressures that have shaped human adaptation in a given ecosystem.

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