

BIRTH INTERVAL AND THE SEX OF CHILDREN IN A TRADITIONAL AFRICAN POPULATION: AN EVOLUTIONARY ANALYSIS

RUTH MACE AND REBECCA SEAR

*Department of Anthropology, University College London, Gower Street,
London WC1E 6BT*

Summary. Birth interval is a major determinant of rates of fertility, and is also a measure of parental investment in a child. In this paper the length of the birth interval in a traditional African population is analysed by sex of children. Birth intervals after the birth of a boy were significantly longer than after the birth of a girl, indicating higher parental investment in boys. However, in women of high parity, this differential disappeared. Birth intervals for women with no son were shorter than for those with at least one son. All these results are compatible with an evolutionary analysis of reproductive decision-making. First born sons have particularly high reproductive success, daughters have average reproductive success and late born sons have low reproductive success. The birth interval follows a similar trend, suggesting that longer birth intervals represent higher maternal investment in children of high reproductive potential.

Introduction

The interval between births is a major determinant of levels of fertility in high fertility populations. From an evolutionary perspective, it is also a measure of parental investment in a child. Parental investment is anything parents give to their children that benefits the future reproductive success of that child at a potential cost to the parent (Trivers, 1972). A long birth interval sacrifices time in which a mother could be producing more children, in order to enhance the development of an existing child. Many studies have shown that children born after short birth intervals are at risk of higher morbidity and mortality (e.g. Blurton-Jones, 1986; Cleland & Sathar, 1984; Hobcraft, McDonald & Rutstein, 1985; Curtis, Diamond & McDonald, 1993; Alam, 1995). Birth interval is frequently correlated with the duration of breast-feeding. Breast-milk is a safe and nutritious source of food for an infant. Weaning frequently introduces a child to a range of new diseases and the threat of malnutrition. The birth of a younger sibling can have an immediate detrimental effect on the morbidity and mortality of its elder sibling (Bohler & Bergstrom, 1995). Thus there is competition between young children for the investment of their parents, particularly mothers, in

terms of both food, and probably other factors such as care and attention. There is also evidence of competition between older siblings for food, as small families are associated with lower rates of mortality (e.g. Ronsmans, 1995; LeGrand & Phillips, 1996). Thus, children born both before and after a long birth interval are likely to benefit throughout childhood, and possibly beyond, in terms of the resources available to them from their family. The length of the birth interval thus indicates how a particular child may be fairing in the competition for parental, and particularly maternal, resources at a crucial time in its development.

Background

This paper examines data on birth spacing from Gabbra pastoralists, a traditional group of nomadic camel herders who live in the north of Kenya. The area they inhabit is arid and prone to drought (Mace, 1993). The nomads live remote from government services. A demographic survey of about 850 families, comprising over 5000 people, was conducted in 1993 (Mace, 1996a). Birth histories were recorded, in conjunction with marriage histories, and information on the number of animals in the household herd. Fertility is high: TFR = 5.63 (Mace & Sear, 1996). Herding is the main source of income in nomadic families, and camels are the key species. Number of adult female camels owned by the household herd provided a simple measure of the wealth of pastoralist households. The society is patrilineal and patrilocal. Polygyny is limited. About 88% of women were the only living wife of their husband.

Mace (1996b) shows that most polygyny is related to the desire for a male child. The probability that a man takes a second wife is strongly, negatively correlated with the number of children, particularly sons, that his first wife had. Remarriage is the decision of the man, and women were frequently unhappy about it. Thus this can be taken as evidence that men wish to continue to reproduce until they have at least one son, but does not necessarily reveal the preferences of women. For evidence of gender preferences in women, this paper examines birth intervals. The decision to have another baby is likely to be a combined decision of husband and wife. As weaning a child is in the domain of the mother, mothers may have considerable control over the spacing of births.

Results

Effect of the sex of a baby on birth interval

Figure 1 shows the mean length of completed birth intervals in ever-married Gabbra women of all ages, who had provided a birth history and had had at least two births. Only birth intervals where the child that opened the birth interval survived are included. Mothers very frequently omitted to report the birth of babies that died in infancy, so all birth intervals over 5 years were excluded from analysis, as they may have included another birth on which there was no information. Birth intervals after boys are longer than birth intervals after girls. The difference is about 2 months, but highly statistically significant.

Whether the sex of the baby that closed the birth interval influenced its length was also investigated. Low (1991) found that birth intervals ending with a boy were

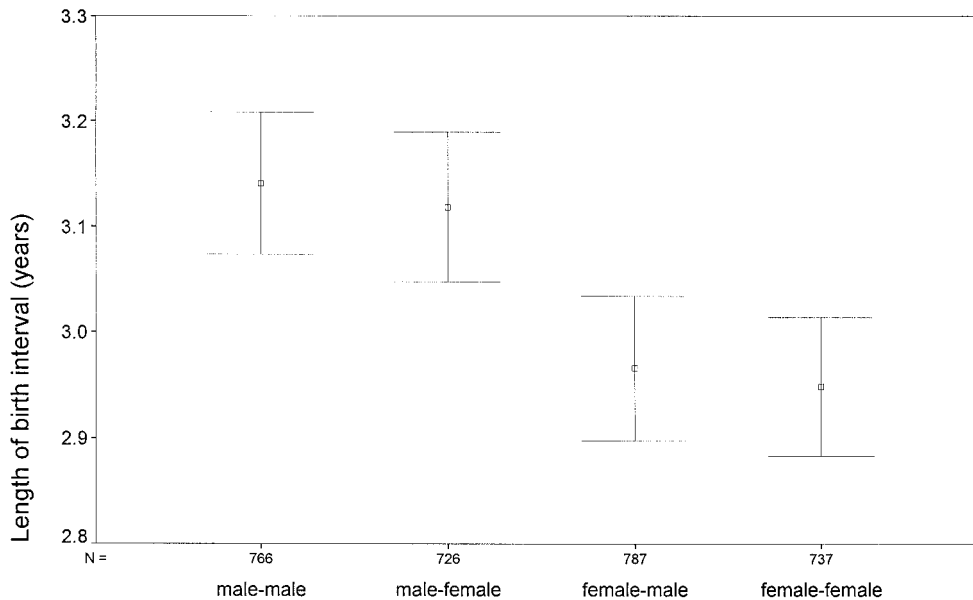


Fig. 1. The length of the birth interval as a function of the sex of children opening and closing the interval (only birth intervals under 5 years are included).

Table 1. Analysis of variance (using a general linear model glm in Minitab) on the length of the birth interval (excluding intervals over 5 years), $N=3170$ birth intervals

	df	F	<i>p</i>
Age of mother	1	4.09	0.043
Sex of child opening interval	1	15.43	0.000
Sex of child closing interval	1	0.13	0.717

significantly longer in 19th century Sweden. She argues that if mothers are in a physiologically depleted state soon after producing a boy, some physiological mechanism may selectively favour female fetuses over male fetuses in the next pregnancy, increasing the chances that male fetuses survive to birth. The present results are in the same direction, with boy–boy intervals being the longest and girl–girl intervals the shortest, but the effect of the sex of the latter child is tiny. Table 1 shows that birth intervals after boys were significantly longer, taking account of age of mother, but the sex of the child closing the birth interval had no significant effect.

The analysis of closed birth intervals can be subject to censoring bias: long birth intervals are less likely to be completed and therefore excluded from the analysis. Hazard model analysis enables all the data, including data from birth intervals that are still open, to be used and thus enables a more accurate analysis of the effect of

Table 2. The effect of the sex of the previous child on the length of the birth interval, using Cox's regression

Model	Variables	B*	Wald	Significance	No. of events	No. censored
(a) Each interval separately						
1	Sex of child	0.008	0.01	ns	614	129
	Mother's age	0.002	0.04	ns		
2	Sex of child	0.244	8.31	0.003	472	123
	Mother's age	0.032	7.02	0.008		
3	Sex of child	0.127	2.81	ns	361	92
	Mother's age	0.022	1.45	ns		
4	Sex of child	0.049	0.77	ns	226	118
	Mother's age	0.049	9.21	0.002		
5	Sex of child	0.106	0.34	ns	123	90
	Mother's age	0.049	4.09	0.042		
6	Sex of child	-0.054	0.19	ns	50	68
	Mother's age	0.105	19.66	0.004		
7	Sex of child	0.114	0.05	ns	21	24
	Mother's age	0.066	0.92	ns		
(b) All intervals combined						
	Sex of child	0.106	5.29	0.011	1867	647
	Birth order	0.039	2.75	0.097		
	Mother's age	0.005	19.00	0.000		

*A positive B indicates birth intervals after males are longer.

preceding children. Table 2 shows the results of a hazard models analysis of the effect of the sex of the child on the length of the birth interval for all birth intervals and for each parity. Only married women of 49 years of age or younger are included in the sample. A male child is followed by a longer birth interval for all of the first five birth intervals, but only significantly so for interval 2.

Swenson & Thang (1993) report a rather similar result in a far more heterogeneous sample of Vietnamese women, with lower average fertility than the Gabbra, when they find birth intervals after boys were longer in the first and second birth interval, but not in higher parity women. They interpret the absence of such an effect in higher parity mothers either as mothers already having the number of sons they require or a breakdown of active reproductive decision-making. The former explanation is thought to be more likely.

The birth interval may be adjusted either biologically, such as a woman becoming fertile only after recovering some level of physiological condition, or by conscious decision, such as to resume sexual activity or wean an infant. These mechanisms are not mutually exclusive. Whether either or both of these mechanisms are operating, a long birth interval after a boy may represent greater maternal investment in her sons. Arnold (1993) reports no general trend in the reported length of post-partum sexual abstinence after the birth of boys or girls, in a sample of demographic surveys from developing countries, but does not explicitly investigate birth intervals. Margulis,

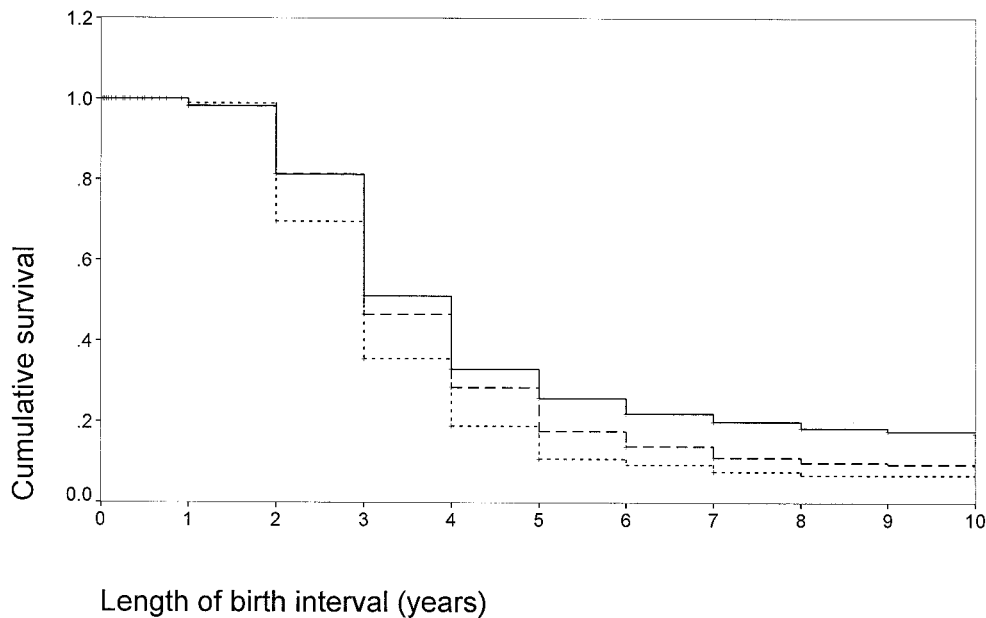


Fig. 2. The survival function of birth intervals for mothers with no sons (solid line), no daughters (dashed line) and at least one son and one daughter (dotted line). All birth intervals except the first are included, for ever-married women up to 49 years of age.

Altmann & Ober (1993) found that the duration of breast-feeding and the interval to the next pregnancy were shorter after the birth of a son in North American Hutterites. The authors interpret this result as indicative of greater parental investment in daughters; however, as safe milk supplements and weaning foods are available in North America, such a result could be a means by which mothers switched hungrier and larger infants (i.e. boys) on to alternative foods at an earlier age, either because they felt the baby would benefit or to relieve tiredness in the mother; so such a result can be interpreted in either way with respect to sex-biases in parental investment.

Influence of family composition on birth interval

The influence of the sex composition of all the previous, surviving children on the length of the birth interval was further investigated. Figure 2 shows a survival function of the length of birth interval, a Kaplan–Meier plot, of all birth intervals after the first one, for women with children of both sexes, with only daughters and with only sons. Women with children of both sexes had the longest birth intervals; women with only daughters had the shortest birth intervals; but women with only sons had shorter birth intervals than women with at least one daughter and a son. All lines differ significantly from each other, according to tests on the Kaplan–Meier plot. A full hazards analysis, using Cox's regression and taking into account the age of the mother, found that those with no son had shorter birth intervals than those with a son, but failed to find a significant difference between those with all sons and those with at least one daughter

Table 3. The significance of differences in the length of the birth interval for mothers with differing sex composition of existing children, using Cox's regression

Variables	B*	<i>p</i>
Model (a)		
No son versus both sexes	-0.155	0.042
Age of mother	0.042	<0.001
Model (b)		
No daughter versus both sexes	0.110	0.169
Age of mother	0.042	<0.001
Model (c)		
Birth order	0.009	ns
Total number of sons	0.063	0.035
Mother's age	0.025	<0.001

*A positive B indicates a longer interval to the next birth.

and a son (Table 3). Table 3 (model c) also shows that the total number of sons has a highly significant influence on the length of the birth interval, taking account of age of mother, whereas simple parity does not.

If birth intervals after boys are longer, then, on average, mothers with many sons will be slightly older than mothers with only daughters, and thus potentially less fertile. However, the effect of not having a son is significant, even accounting for the age of the mother. Thus the determination of the birth interval is not simply an effect of maternal age. Further, the suggestion from Fig. 2 that those with no daughter also have slightly shorter birth intervals could not be explained by any obvious mechanism that is purely physiological. These results strongly suggest that parents are making active decisions with respect to the length of the birth interval, even in a society with no access to artificial methods of contraception.

Gadalla, McCarthy & Campbell (1985) found that the number of sons a woman had in her first two births was a very significant predictor of whether or not that woman would use contraception, in an Egyptian population. The more sons women had, the more likely they were to use contraception. More recent studies from Asia have found that the length of the third birth interval is similarly influenced by the number of sons a woman had in her first two births (Nath & Land, 1994; Pong, 1994). These studies all interpret the length of the birth interval as a measure of the woman's eagerness to have another baby; the result is attributed to son preference. Rahman & DaVanzo (1993) find such son preference and also find 'daughter preference', in that women with no daughters appear to want at least one daughter in Matlab, Bangladesh. Arnold (1993) reports that a stated desire by mothers to continue reproducing if they did not have at least one son and one daughter is now the most commonly stated preference by parents from a large sample of developing countries. The present study provides evidence that such preferences are influencing birth intervals in a traditional, non-contracepting population in sub-Saharan Africa.

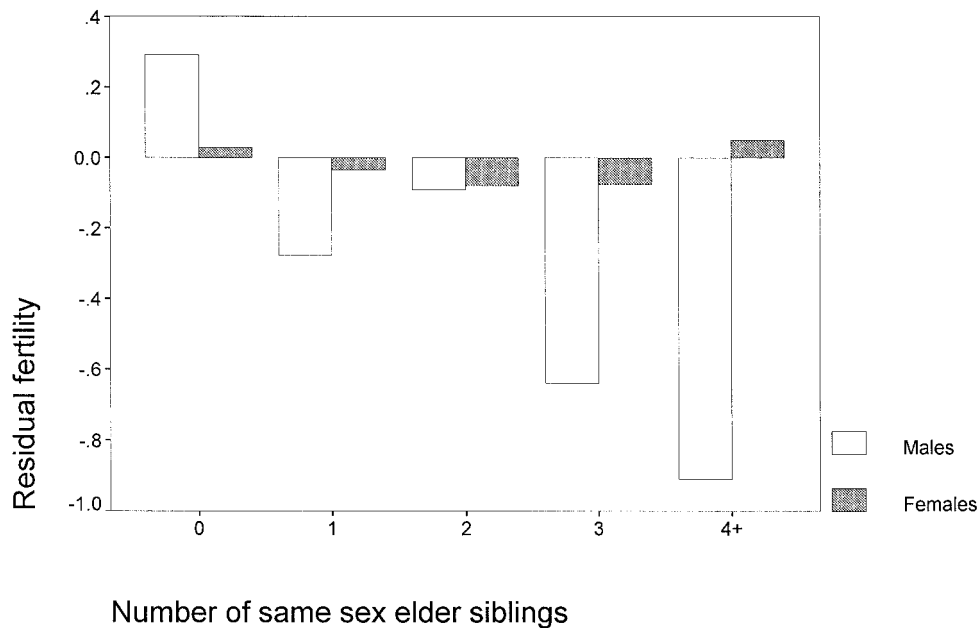


Fig. 3. The relative reproductive success of ever-married male and female Gabbra as a function of the number of same-sex elder siblings in their natal families (adapted from data in Mace, 1996a).

Conclusion and discussion

Variation in the birth interval is interpreted as variation in parental investment. Evidence from the length of the birth interval suggests that maternal investment in male infants is greater than that in female, except at high parity. Evidence from birth intervals also shows strong evidence that couples are likely to continue to reproduce until they have at least one son. There is a strong suggestion that they also would like a daughter, although the effect on birth intervals is not significant.

Figure 3 shows the reproductive success of married, Gabbra adults as a function of their position in the birth order in their natal family. For females, number of elder sisters does not influence their reproductive potential, but for males the number of elder brothers has a highly significant negative effect on reproductive success. First born sons tend to have high reproductive potential, are given larger herds by their family at the foundation of their own household and are married earlier than later born sons (Mace, 1996a). Short birth intervals occur when parents are eager for a first born son. When they already have a number of sons, they are not eager for more (because late born sons have low reproductive potential) and birth intervals increase. Whilst a large number of daughters is not deleterious to parental reproductive success, and would appear to result in a higher mean reproductive success than a large number of sons, a strategy of continuing to reproduce to gain more daughters would not enhance fitness if one already had some sons, because the sex of a child cannot be predetermined. The average fitness of late born children (boys and girls combined) decreases after each son

is born, hence the importance of the effect of number of existing sons on the length of the birth interval. It is suggested here that the patterns observed in birth intervals in this traditional African population, some of which are similar to those described in other, mostly Asian populations, can all be understood as an evolved strategy of highest maternal investment in those children of highest reproductive potential.

Acknowledgments

This research was funded by the Royal Society, and a grant from the EC (DG XII) to IIED (London).

References

- ALAM, M. (1995) Birth spacing and infant and early childhood mortality in a high fertility area of Bangladesh: age-dependent and interactive effects. *J. biosoc. Sci.* **27**, 393–404.
- ARNOLD F. (1993) Sex preference and its demographic and health implications. *Int. Fam. Plann. Perspect.* **18**, 93–101.
- BLURTON-JONES, N. J. (1986) Bushmen birth spacing: a test for optimal interbirth intervals. *Ethol. Sociobiol.* **7**, 91–105.
- BØHLER, E. & BERGSTRÖM, S. (1995) Subsequent pregnancy affects morbidity of previous child. *J. biosoc. Sci.* **27**, 431–442.
- CLELAND, J. G. & SATHAR, Z. A. (1984) The effect of birth spacing on childhood mortality in Pakistan. *Popul. Stud.* **38**, 401–418.
- CURTIS, S. L., DIAMOND, I. & McDONALD, J. W. (1993) Birth interval and family effects on postneonatal mortality in Brazil. *Demography*, **30**, 33–43.
- GADALLA, S., MCCARTHY, L. & CAMPBELL, O. (1985) How the number of sons influences contraceptive use in Menoufia Governorate, Egypt. *Stud. Fam. Plann.* **16**, 164–169.
- HOBcraft, J. N., McDONALD, J. W. & RUTSTEIN, S. O. (1985) Demographic determinants of infant and early child mortality—a comparative analysis. *Popul. Stud.* **39**, 363–385.
- LEGRAND, T. K. & PHILLIPS, J. F. (1996) The effect of fertility reduction on infant and child mortality: evidence from Matlab in rural Bangladesh. *Popul. Stud.* **50**, 51–68.
- LOW, B. S. (1991) Reproductive life in nineteenth century Sweden: an evolutionary perspective on demographic phenomena. *Ethol. Sociobiol.* **12**, 411–448.
- MACE, R. (1993) Nomadic pastoralists adopt subsistence strategies that maximise long-term household survival. *Behav. Ecol. Sociobiol.* **33**, 329–334.
- MACE, R. (1996a) Biased parental investment and reproductive success in Gabbra pastoralists. *Behav. Ecol. Sociobiol.* **38**, 75–81.
- MACE, R. (1996b) When to have another baby: a dynamic model of reproductive decision-making and evidence from Gabbra pastoralists. *Ethol. Sociobiol.* **17**, 263–273.
- MACE, R. & SEAR, R. (1996) Maternal mortality in a Kenyan pastoralist population. *Int. J. Gynec. Obstet.* **54**, 137–141.
- MADISE, N. J. & DIAMOND, I. (1995) Determinants of infant mortality in Malawi: an analysis to control for death clustering within families. *J. biosoc. Sci.* **27**, 95–106.
- MARGULIS, S. W., ALTMANN, J. & OBER, C. (1993) Sex-biased lactational duration in a human population and its reproductive costs. *Behav. Ecol. Sociobiol.* **32**, 41–45.
- NATH, D. C. & LAND, K. C. (1994) Sex preference and third birth intervals in a traditional Indian society. *J. biosoc. Sci.* **26**, 377–388.
- PONG, S. (1994) Sex preference and fertility in Peninsular Malaysia. *Stud. Fam. Plann.* **25**, 137–147.

- RAHMAN, M. & DAVANZO, J. (1993) Gender preference and birth spacing in Matlab, Bangladesh. *Demography*, **30**, 315–332.
- RONSMANS, C. (1995) Patterns of clustering of child mortality in a rural area of Senegal. *Popul. Stud.* **49**, 443–461.
- SWENSON, I. & THANG, N. M. (1993) Determinants of birth interval in Vietnam: a hazard model analysis. *J. trop. Pediat.* **39**, 163–167.
- TRIVERS, R. L. (1972) Parental investment and sexual selection. In: *Sexual Selection and the Descent of Man, 1871–1971*, pp. 136–179. Edited by B. Campbell. Aldine, Chicago.