Contemporary Abortion Patterns: A Life History Approach

Elizabeth M. Hill and Bobbi S. Low

Evolution and Human Behavior Program, (E.M.H., B.S.L.) and School of Natural Resources (B.S.L.), The University of Michigan, Ann Arbor, Michigan

This paper applies an ecological model of reproductive choice, life history theory, to humans. It models a tension among further investment in self, in present offspring, and later investment in future offspring. Some reproductive decisions for men and women in modern societies may fit this type of "now vs later" analysis; we model the decision of a woman to have an elective abortion. This theory assumes a knowledge of the returns from parental investment (in terms of the child's future mating) and somatic investment (in terms of one's own future mating). Predictions about this decision can be made if the relevant parameters can be estimated: the probability of a child's future reproduction when reared by one or by two parents and the probabilities for each of the parents of mating again. We find evidence that abortion decisions are affected by age and previous parity of the mother, and by expectations of available investment by the father or other sources. Still, researchers are left with determining the shape of the trade-off curve between allocations to one's own mating or to a given child's, and with better specifying the effects of variations in resource parameters.

INTRODUCTION

Reproductive patterns in modern society appear at first to be anomalous in terms of evolutionary theory. Women in industrialized nations give birth to far fewer children than is physiologically possible (e.g., Coale and Trussel 1974; Coale and Watkins 1986); in these nations, childbearing has become more independent of marriage, paralleling increases in the rate of divorce and the rate of births to unmarried women; and female fertility seems to decrease linearly with female resources (e.g., Kasarda et al. 1986). One of the most apparently anomalous repro-

ductive behaviors is elective abortion. We examine contemporary data on the decision to continue or terminate parental investment (Trivers 1972) in any particular child. Theoretical models are frequently used for similar analyses in other species. Here, we utilize the life history approach for evaluating the costs and benefits of parental investment in different situations in order to examine this decision. Specific predictions about whether a pregnancy is terminated arise from basic theory.

We suggest that this important reproductive decision rests on a parent's assessment of costs and benefits (perhaps subconscious), which are affected by other factors, including relative current versus future costs and benefits. This assessment includes evaluating other potential mates, one's age and resources, as well as those of one's partner, and also the impact of investing in this new child on the success of existing offspring. The spectrum of parental investment or neglect extends from investment in germ cells to grandparenting; all aspects could be subjected to selection for optimal reproductive behavior.

Cost-benefit analyses have been used to understand the incidence of both behavioral and physiological patterns of parental investment. Infanticide has been seen as "... analogous and continuous [with abortion]—as methods of fertility control under different cultural and historical contexts characterized by different levels of medical technology" (Scheper-Hughes, 1987, p. 15). Daly and Wilson (1984) examined the coded rationale for infanticide in the Ethnographic Record and the statistics on early childhood homicides from contemporary Canadian data. The reported cultural justifications for infanticide supported their predictions in that infanticide was accepted of newborns whose rearing would incur a high cost (resources were currently low). For recent Canadian homicide cases, Daly and Wilson (1984) predicted and found that mothers who committed infanticide were less likely than average mothers to be married; they also were more likely to be very young (less than 18 years old). The same two factors (mother's age and the availability of resources for investment) were reported to be influential in Bugos and McCarthy's (1984) case study of infanticide among the Ayoreo of Bolivia and Paraguay.

A similar approach to adaptive variation in ovarian function has been presented by Ellison (1990). Much of the evidence on energy variables (e.g., changes in energy balance or aerobic activity) and ovarian parameters (such as luteal insufficiency, ovulatory failure, or suppression of follicular development) can be interpreted as "a mechanism to modulate reproductive effort in accord with its expected returns (i.e., the probability of a successful pregnancy)" (p. 945) or in accord with expected costs of current reproductive effort in terms of the risk of maternal mortality. Thus, both internal physiological processes (e.g., ovarian function) and seemingly extraordinary behaviors such as infanticide, vary similarly with maternal age and resource availability.

ECOLOGICAL MODELS OF REPRODUCTIVE DECISIONS

There are two main ecological approaches to mating and parental decisions, life history theory and game theory. Life history approaches model the conflict between expenditure of effort to different ends (somatic, reproductive) throughout the lifetime. Benefits are reproductive, and the currencies are energy, risk, and offspring. This model optimizes fitness benefit (genes transmitted), though quantitative measurement can be difficult. For example, foraging models often examine only the calories spent versus calories gained; the assumption is that more efficient foragers will reap enhanced reproductive gain (e.g., Stephens and Krebs 1986; Winterhalder and Smith 1981; cf. Ritchie 1989 who has tested the assumption). Another cost-benefit method often used is modeling based on game theory, as when the probability of mate desertion is seen as a conflict between two players (Grafen and Sibly 1978; Maynard Smith 1977). It is shown by these models that for a parent to invest profitably, the increment in this offspring's survival or reproduction must be greater than the decrement in production of future offspring caused by expending these resources now. In this model, when a male has deserted the female's decision to rear the offspring depends on her assessment of reproductive benefit for continued investment now versus her expectations of future possibilities. Such future probabilities (e.g., of finding another mate) are obviously affected by factors such as age. The female should continue parental investment when the probability of a future mating with a good investor is small, or the efforts of two parents are not much more effective than investment by a single parent.

Life history models analyze costs and benefits from the allocation of parental versus mating effort and allow comparisons of investment "now" versus "later." This behavioral ecological approach, so useful in analysis of behavior in other species (Endler 1986; Alcock 1979; Wittenberger 1981; Dewsbury 1978; Daly and Wilson 1983; Krebs and Davies 1984), has rarely been used to examine human reproductive decisions. Attempts to use these approaches to predict variation in human reproductive strategies include those of Dickemann (1983, 1986), Draper and Harpending (1987), Lancaster and Lancaster (1987), and Low (1989a,b, 1990). These attempts have been extremely valuable, often providing new insight into previously intractable questions and sometimes raising entirely new questions. We will use the life history approach for the decision we consider here rather than game theory, because it offers richer analysis of age and resource effects.

Life History Theory and Parental Investment

In this model, individuals in a population allocate resources (energy, effort) over their lifetimes, to maximize the intrinsic rate of natural increase. This is accomplished by maximizing survival or fecundity (i.e., maximizing the

l_x m_x column in a life table) or minimizing generation time; these three variables comprise the major components of fitness. This formulation could be expanded into juvenile and adult portions or into several time periods because costs and benefits may differ measurably throughout the lifetime.

One useful approach is from Sibly and Calow (1986), who assume for animals that n (the number of offspring) is a function of m (size) and u (the proportion of available energy that is devoted to one's own growth, somatic effort). Available energy is finite; what is invested in self is unavailable for offspring and vice versa. The shapes of these curves determine the most profitable timing for reproductive versus somatic effort. The "trade-offs" are the effect of allocation to self on (1) one's own growth or survivorship; (2) own fertility; and (3) offspring survival and fertility.

For humans we could change the parameters in the following ways: Rather than own survival, S_t, we will use M_s to reflect the probability of oneself mating again. Instead of n_t we will use M_j, the probability of the juvenile's mating successfully (subsuming survival). Sibly and Calow's (1986) model is appropriate for continuously growing organisms, where *size* reflects available resources. For humans we will simply use *available resources*. There are several possible shapes for these functions (linear, monotonic increasing or decreasing; e.g., see Fig. 1 "Male A, B, and C"). Individuals are predicted to allocate effort according to the reproductive value (Fisher 1958; Williams 1966) of one's self relative to one's offspring.

Figure 1 shows a combination of such curves for three people, a man, a woman, and a child. For each parent, there are three families of trade-off curves (A, B, and C) for the effect of allocating resources to oneself on own future mating success. In addition, there are three curves for the (detrimental) effect of investment in self by a parent on an offspring's mating success (Offspring A, B, C in Fig. 1). We do this to facilitate overlying the curves on a common x axis; an alternate representation would show a positive effect of investment 1-u on M_j. The positive effect of parental investment on the child, although not shown, would parallel the parent curves but probably only increase when past a certain resource level. The shaded area (e.g., examples 1 and 2) represents the difference in gain between investment in offspring and investment in self. That difference becomes zero at the point the curves cross. In this figure, sometimes the return curves from investment in self are identical for the parents (examples 1 and 2), and sometimes the mother's and father's returns differ (example 3); these patterns make quite different predictions.

Both partners should cooperate in rearing a child when the "return from the child" curve is higher than the "return from new mating" curves for *both* parents at that resource level (Fig. 1: shaded area in superimposed curves). Thus, in example 1 (Fig. 1), both male and female parents have concave return curves for investment in self. Cooperative rearing is most likely when parental curves are concave (monotonic increasing) and the child curve is convex (monotonic decreasing). Here both parents gain by investing
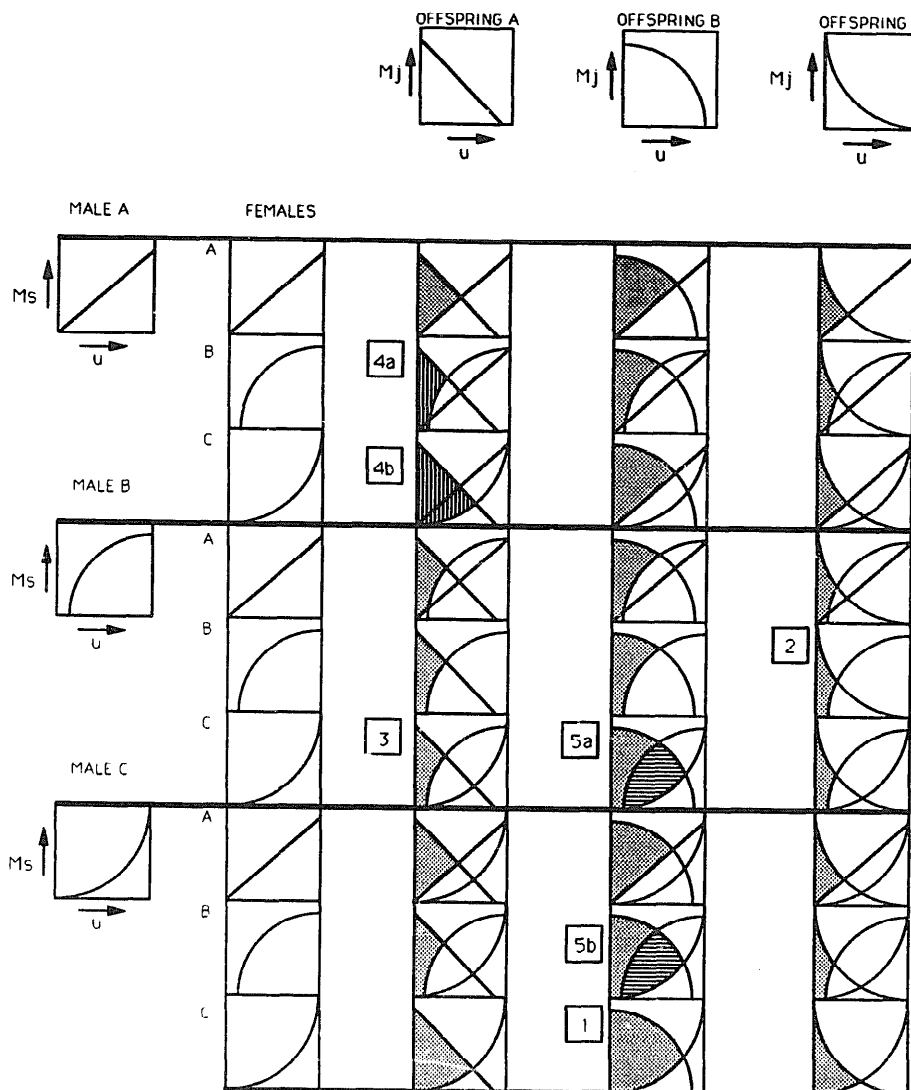
FIGURE 1.   Superimposed trade-off curves for male and female parents and offspring. For each parent, there are three families of trade-off curves (A, B, and C) for the effect of allocating resources (u) to oneself on own future mating success (M_S). In addition, there are three curves for the (detrimental) effect of investment by a parent in self (u) on an offspring's mating success (M_j for offspring A, B, C) (from Sibly and Calow 1986). The shaded area represents the difference in gain between investment in offspring and investment in self (when both parents are identical). That difference becomes zero when the curves cross. Examples 1, 2, and 3 focus on parental confluences of interest (shaded area); examples 4a and 4b show how female interests might change with age (vertical hatching). Examples 5a and 5b show male/female confluence (shaded) and conflict (horizontal hatching) of interest over further investment in a child.

resources in that child, more than the return from deserting it, and investing in their next future mating. The smallest range of resource levels at which the child is likely to be kept occurs when both parental curves are convex and the child's curve is concave (that is, case 2 in Fig. 1). With convex curves, investment in self is very beneficial. In all situations in which pa-

rental curves are identical, no conflict of interest exists between the parents, whether they are likely to keep or to desert the child.

Consider a married couple, both 42 years old, in which the man is rich and powerful, the woman has no independent support, and she becomes pregnant (Fig. 1: 3). The woman will profit by investing in this child compared to a future child. For this husband, using 0.5 of the available resources for his own new mating will have more benefit for him than investing in this child. In this example, age differentially affects decisions by men and women.

Because women's reproductive value peaks at the age of first reproduction and declines thereafter (Fisher 1958), age will almost always have a greater impact on the shape of women's curves than on men's. For example, in Figure 1 we represent the tradeoffs for an older versus younger woman, holding the male and child curves identical: 4a represents the conflicts for a younger woman, 4b for an older woman. The vertical hatching represents the area in which it pays the female to continue to invest; this area is greater for the older woman. Because the trade-off curves are shaped so differently, there will always be a greater benefit for the older woman to stay and invest in this child. This is a graphical representation of the fewer and fewer remaining childbearing opportunities for older women. Another influential factor is resource availability for females: women with considerable resources can enhance their own chances of remating without significantly altering the child's chances; women with fewer resources have a more significant conflict of interests. We do not treat such effects explicitly here, but they could simply be modeled by changes in the shape of the woman's return curve.

In each diagram, there is potential for conflict of interest if the return curves differ. In example 5a, a case of married couples with differing return curves is represented. In the shaded area, resource levels and returns are such that both parents profit from keeping the child, while in the horizontally-hatched area, male interests favor desertion but female interests favor continued investment in this child. The reverse situation could occur in example 5b, possibly typified by a young woman, married to an older husband who had just been diagnosed with a disease that is protracted and debilitating (such as multiple sclerosis). Given knowledge of a pregnancy, the man would favor investment in that child while the woman would be more likely to terminate and invest in future mating.

Resource variation.   Life history strategy theory models a choice between present versus future reproduction; variation in ecological or resource parameters affect this choice. For example, environmental unpredictability is important: If future changes are uncertain, the individual is more likely to continue investing in the current offspring. The economic defensibility or availability of resources also can have important impact (e.g., Low 1989a,b). The mating systems literature can be translated into "Reproductive Effort

Arrays," as suggested by Kurland and Gaulin (1984). That is, if resources are predictable and defensible, males are more likely to invest. If resources are not economically defensible, male allocations to self have little detrimental effect on juveniles; females and juveniles can life in autonomous units (cf. Low 1989a). Uniparental care is favored if young are precocial, food is readily harvestable, and predation rates are either low or so high that parents are unable to deter predators (all situations in which increased parental investment has less effect on the probable success of juveniles; cf. Low 1978). In Figure 1, Offspring B suffers less detrimental effect of allocations to Self than Offsprings A or C. A full picture of trade-offs would include those in Figure 1 plus those showing the positive effects of parental investment on an offspring's future (which are probably negligible if below a threshold level) and the negative results of that amount of investment on the parent's future mating. The shape of curves can model the influences of resource defensibility and predictability.

Predictions

Predictions about the decision to invest resources in one's own future mating versus the present child's require estimation of several relevant parameters: probability of one's own future mating and the probability of child's surviving and mating. Also important is the effect of allocating these resources on already-existing children. For example, we can predict that age and sex of a parent have an effect on the decision to desert because they affect the probability of finding another mate; the difference between the probability of survival with one versus two parents is also affected by age and sex of parent. We also predict that availability of resources will have a strong effect: More pregnancies are likely to be terminated when resources are scarce. That is, whether married or not, women who could reasonably expect help from the father or other kin would be less likely to terminate a pregnancy. Data from several studies of pregnancy terminations will now be examined in the context of life history theory. We sought, but did not find, statistical reports that cross-classified women's age, parity, and marital status or other resource measures. Instead, we review studies from around 1980 and show some combination of these factors.

APPLICATION TO CONTEMPORARY ABORTION PATTERNS

Age Effects

Figure 2 shows that the remarriage probability for women is clearly higher for younger than older women. Data shown are from an analysis of U.S. census results (Glick and Lin 1986). The relative proportions marrying at
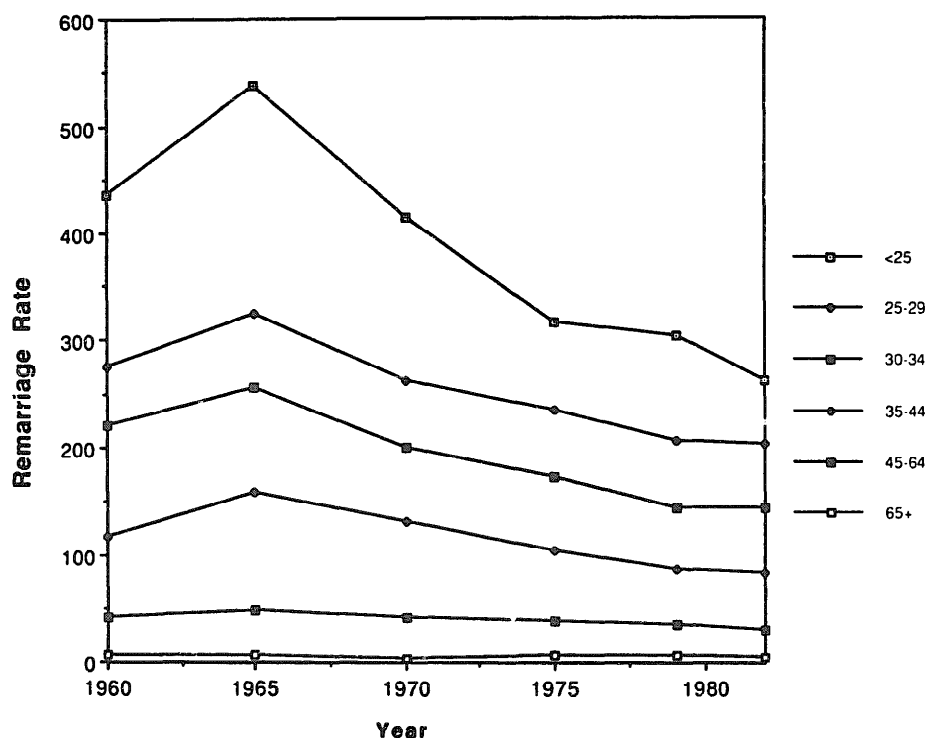
FIGURE 2. Remarriage rates per 1000 divorced women by age: United States, 1960–1982 (from Glick and Lin 1986).

different ages are consistent regardless of fluctuations in cultural norms about marriage. Men do not show such a strong age differential in the probability of remarriage. Thus, younger women clearly have a higher probability for future reproduction than older women, as estimated by remarriage.

The effect of age on probability of terminating pregnancy is shown in Figure 3 (U.S. data from Henshaw et al. 1985), which includes all pregnancies. In general, the percentage of pregnancies aborted is the inverse of the pregnancy rate. Terminations are high at both extremes of age, but for different reasons. It is likely that many young women, particularly unmarried women, abort to delay the onset of childbearing, while older women, more of whom are married and have other children, likely abort to control or regulate family size. Such an effect was depicted in Figure 1, examples 4a and 4b.

Examining first pregnancies better shows the effect of age (Fig. 4). Statistics from Scotland for several years (1976–1979) are summarized (Pritchard and Thompson 1982). In general, the percentage of pregnancies aborted is high until age 20 and then decreases, while marital fertility increases. After age 25 few first pregnancies were terminated. Because the data for Figure 3 included all pregnancies rather than first pregnancies only, this effect was masked.

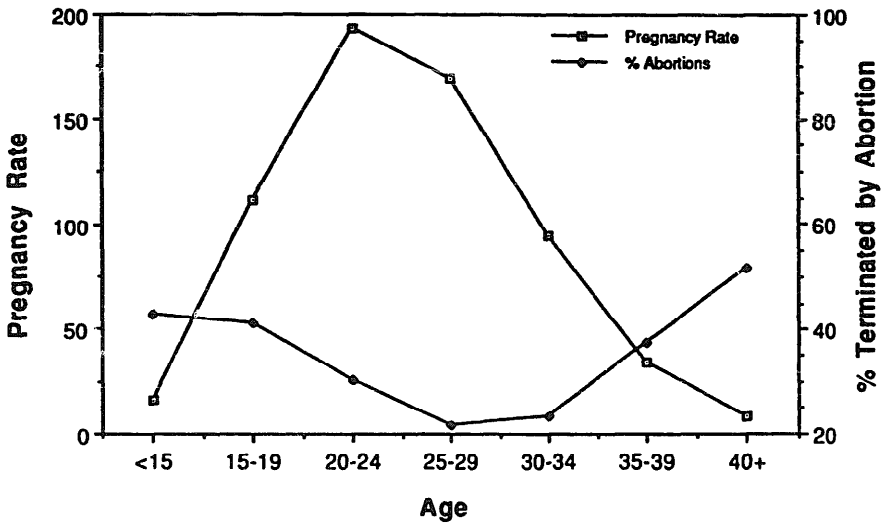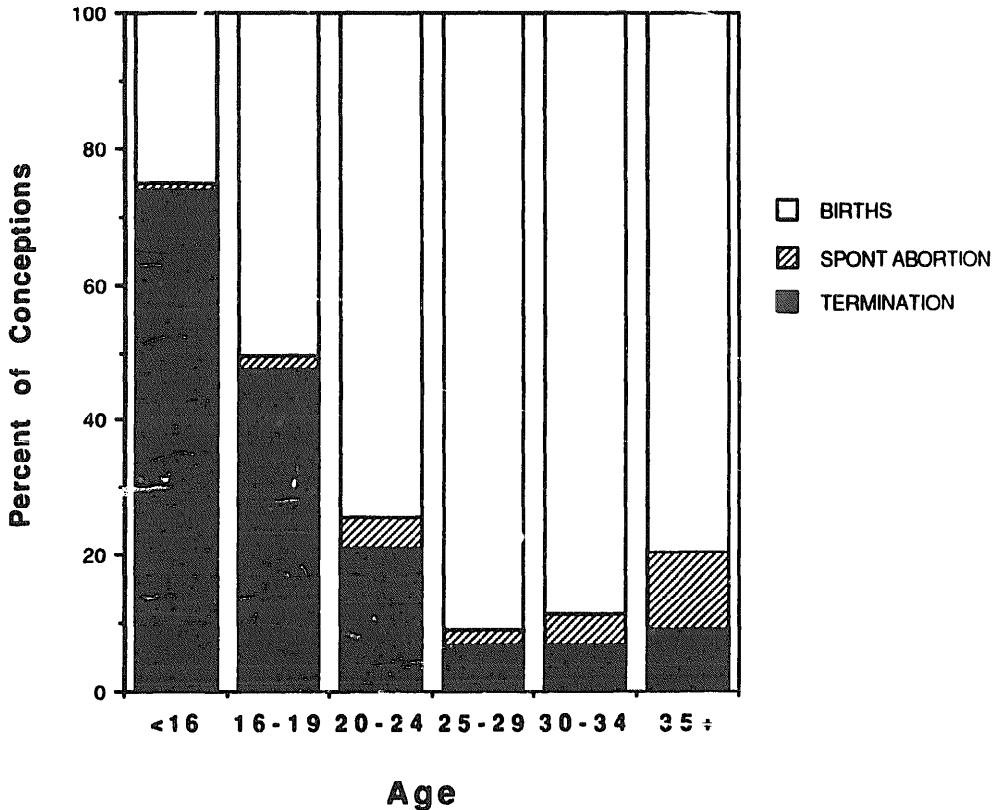More data exist on teenage or young nonmarital pregnancy than any

FIGURE 3. Rates of pregnancy per 1000 women and termination by abortion, by age: United States, 1980 (from Henshaw et al. 1985).

FIGURE 4. Outcomes (termination, spontaneous abortion, or birth) of first pregnancies by age: Aberdeen, Scotland, 1976–1979 (data adapted from Pritchard and Thompson 1982).

other category. Of unmarried women under age 19 who become pregnant, fewer than 20% get married (Leibowitz, Eisen, and Chow 1985). Comparing women of ages 13–19, the younger women are more likely to bear the child. Fewer than one-half of the young unmarried pregnant women under age 17 aborted, compared to three-quarters of those ages 18–19 (Leibowitz, Eisen and Chow 1985). Perhaps very young minors, probably supported by parents, are more likely to keep a baby than nonminor teens ages 18–19, who may be more likely to be independent of their parents (i.e., this age effect may be a correlate of the family-support effect discussed below).

Resource Effects

One major predictor of resources available to rear the child is the willingness of the father to remain and invest. The strongest predictor of bearing the child is having a husband present: U.S. Data for 1975–1981 show each year that 65% of pregnancies among unmarried women were terminated by abortion, compared to about 10% among pregnant married women (Henshaw et al. 1984). Given a nonmarital conception, a child is usually delivered only if resources are available from other sources than self-support.

Availability of financial help definitely increases the probability of bearing the child, as shown by results from a study of teenagers comparing terminators to those who got married or gave birth while remaining single (Leibowitz, Eisen and Chow 1985). In this group, 42% of women who expected financial help bore the child, compared to 11% of women who had no help (Yates-corrected χ^2 (1) = 12.1, p < 0.01; data aggregated from Leibowitz, Eisen, and Chow 1985). Similarly, 57% of women who had state financial aid bore the child versus 29% of those who did not (Yates-corrected χ^2 (1) = 4.86, p < 0.05; data aggregated from Leibowitz, Eisen, and Chow 1985).

Thus, concrete expectations of financial help from a father, from family, or from the state affect probability of pregnancy termination. Other indicators that could suggest the father's willingness to invest can also matter. Pearson (1973) interviewed unmarried volunteers from a clinic in London. While the length of relationship with the putative father did not matter, the characteristics of the relationship with the father were extremely important. The teenager was more likely to bear the child if the relationship with the father was good (if they were planning to marry or if they "got on well"). The teenager was also more likely to bear the child if this was the "most important relationship ever," or was more meaningful compared to previous relationships. In another study (Fischman 1977), over 60% of the adolescent women who delivered their babies "indicated that their boyfriend was going to support the baby either completely or in part (p. 221)." The mothers' boyfriends were more likely to be older and working full time than the terminators' boyfriends (Fischman 1977). In sum, this relationship may be more promising than others that could be expected in the future.

COMMENT

Abortion decisions are affected by age and previous parity of the mother, and by expectations of available investment by the father or other sources. Reflecting on the return and trade-off curves discussed above, young women invest in current reproduction when resources are available and the benefit to the child's future is greater than the benefit to one's own future mating, if thus allocated. Women are less likely to have abortions if they are older and primiparous. Elective abortion is also less likely if resources are available from a father, which may then exceed a threshold of investment level required for child-rearing. As resource level increases, however, they may become abundant enough to push a woman beyond the point when mother and child return curves cross. At that juncture, the higher benefit results from investment in self and one's future mating, hence a woman is more likely to abort a current pregnancy. Such a decision might be favorable if one could expect better future opportunities.

Thus, the important benefits and costs considered in life history theory are the richness, availability, and predictability of resources important to successful rearing of a child, and the opportunity costs of investing in this child versus oneself (i.e., own future reproduction). In the case of abortion, important conditions include the availability of assistance from family or mate, and the availability of assistance from the state. The first of these has very common homologues in nonhuman species, and there are clear "decision rules." That is, paternal care is associated with monogamous mating systems and behavior by the male that reduces the chances that any offspring is fathered by any other male (e.g., Wittenberger 1981; Krebs and Davies 1984, Daly and Wilson 1983). Paternal care is rare in mammals, which are principally polygynous, with low confidence of paternity; exceptions include many mammalian carnivores in which the parents hunt together and in which the male feeds both his mate and the offspring at some periods. Again, this male investment is associated with much reciprocal and mate-guarding behavior. Assistance by family (e.g., "helpers at the nest") is common among monogamous species in which the family members live together (e.g., Woolfenden and Fitzpatrick 1984). Assistance by the state has no direct homologues in other species, but a broadly ecological view simply notes that the state assistance mimics an ecological situation in which sufficient resources are available to the female—and in both cases, ecological and cultural, sufficient resources increase the probability of carrying the fetus to term.

Future research could profitably focus on several problems. First, we must find methods of estimating quantitatively the important parameters (e.g., How likely are children to survive and reproduce if they received investment from two, one, or no parents? What cues are used by individuals to compare current reproductive conditions to expected future ones?). Second, this type of analysis needs to be extended to analysis of direct versus indirect parental investment. The effects of shareable versus nonshareable

parental investment (Wittenberger 1981; also Low 1978) on children's reproduction may differ between environments. Finally, we need more detailed work on different strategies associated with environmental resource variation (cf. Low 1989a).

In summary, we feel that sociological studies of termination of reproduction can be informed by theories developed around the concept of parental investment, based on reproductive costs and benefits. Considering costs and benefits produces qualitatively accurate predictions about choices at one point in time, and by extending these choices sequentially, can be summed over children or over choices to produce predictions about lifetime patterns. Despite their relative cultural complexity, in the final analysis humans must solve the same ecological problems as all other species. All organisms must obtain resources to survive and reproduce; all organisms must allocate effort (energy, risk taking) over their lifetimes, to self, to getting a mate, and to raising offspring. The more we learn about the evolutionary ecology both of humans and of other species, the more it appears that the same selective rules obtain, that similar conditions (extremeness, predictability, range of variation of resources) exert the same selective pressures, though human responses are, of course, considerably more complex and varied (e.g., Alexander 1979, 1986; Chagnon and Irons 1979; Betzig, Borgerhoff Mulder, and Turke 1988; Low 1989a,b).

REFERENCES

Alcock, J. *Animal Behavior: An Evolutionary Approach*. Second Edition. Sunderland, Massachusetts: Duxbury, 1979.

Alexander, Richard D. *Darwinism and Human Affairs*. Seattle: University of Washington Press, 1979.

——. *The Biology of Moral Systems*. Chicago: Aldine, 1986.

Betzig, L., Borgerhoff Mulder, M., and Turke, P. (Eds.). *Human Reproductive Behaviour: A Darwinian Perspective*. Cambridge, Massachusetts: Cambridge University, 1988.

Bugos, P.E., and McCarthy, L.M. Ayoreo infanticide: A case study. In *Infanticide: Comparative and Evolutionary Perspectives*. G. Hausfater and S.B. Hrdy (Eds.). New York: Aldine, 1984, pp. 503–520.

Chagnon, N.A., and Irons, W. (Eds.). *Evolutionary Biology and Human Social Behavior*. North Scituate, Massachusetts: Duxbury, 1979.

Coale, A.J., and Trussel, T.J. Model fertility schedules: Variations in the age structure of childbearing in human populations. *Population Index* 40: 203–213, 1974.

——, and Watkins, S.C. *The Decline of Fertility in Europe*. Princeton: Princeton University Press, 1986.

Daly, M., and Wilson, M. *Sex, Evolution, and Behavior (2nd Ed.)*. Belmont, California: Wadsworth, 1983.

——, and ——. A sociobiological analysis of human infanticide. In *Infanticide: Comparative and Evolutionary Perspectives*, G. Hausfater and S.B. Hrdy (Eds.). New York: Aldine, 1984, pp. 487–502.

Dewsbury, Donald A. *Comparative Animal Behavior*, New York: McGraw Hill, 1978.

Dickemann, M. Family choice, male life histories and male celibacy in U.S. black ghettos. Paper presented at Workshop on the Application of Life History Strategies to the Study of Human Development, University of California, Los Angles, May 21, 1983.

——. Multiple genders and reproductive strategies in humans: Steps toward a radical socio-biology. Paper presented at the Anthropology Colloquim series, University of Michigan, Ann Arbor, October 7, 1986.

Draper, P., and Harpending, H. Parent investment and the child's environment. In *Parenting Across the Lifespan*, J.B. Lancaster, J. Altmann, A.S. Rossi, and L.R. Sherrod (Eds.). Chicago: Aldine, 1987, pp. 207–235.

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

Endler, J.A. *Natural Selection in the Wild*, Princeton: Princeton University Press, 1986.

Fischman, S.H. Delivery or abortion in inner-city adolescents. *American Journal of Orthopsychiatry* 47: 127–133, 1977.

Fisher, R. *The Genetical Theory of Natural Selection. 2nd Ed.*, New York: Dover Press, 1958.

Glick, P.C., and Lin, S.-L. Recent changes in divorce and remarriage. *Journal of Marriage and the Family* 47: 737–747, 1986.

Grafen, A.G., and Sibly, R. A model of mate desertion. *Animal Behavior* 26: 645–652, 1978.

Henshaw, S.K., Binkin, N.J., Blaine, E.B., and Smith, J.C. A portrait of American women who obtain abortions. *Family Planning Perspectives* 17: 90–96, 1985.

Henshaw, S.K., Forrest, J.D., and Blaine, E.B. Abortion Services in the United States. *Family Planning Perspectives* 16: 119–27, 1984.

Kasarda, J.D., Billy, John O.G., and West, K. *Status Enhancement and Fertility: Reproductive Responses to Social Mobility and Educational Opportunity*, New York: Academic Press, 1986.

Krebs, J.R., and Davies, N.B. (Eds.). *Behavioural Ecology*. Oxford: Blackwell, 1984.

Kurland, J.A., and Gaulin, S.J.C. The evolution of male parental investment: Effects of genetic relatedness and feeding ecology on the allocation of reproductive effort. In *Primate Paternalism*, D.M. Taub (Ed.). New York: Van Nostrand Reinhold, 1984, pp. 259–306.

Lancaster, J.B., and Lancaster, C.S. The watershed: Change in parental investment and family-formation strategies in the course of human evolution. In *Parenting Across the Lifespan: Biosocial Dimensions*, J.B. Lancaster, J. Altmann, A.S. Rossi, and L.R. Sherrod, (Eds.). Chicago: Aldine, 1987, pp. 187–205.

Leibowitz, A., Eisen, M., and Chow, W.K. An economic model of teenage pregnancy decision-making. *Demography* 23: 67–77, 1985.

Low, B.S. Environmental uncertainty and the parental strategies of marsupials and placentals. *American Naturalist* 112: 197–213, 1978.

——. Human responses to environmental extremeness and uncertainty: A cross-cultural perspective. In *Risk and Uncertainty in Tribal and Peasant Economies*, E. Cashdan (Ed.). Boulder: Westview Press, 1989a.

——. Occupational status and reproductive behavior in 19th century Sweden: Locknevi Parish. *Social Biology* 36: 82–102, 1989b.

——. Occupational status, land ownership, and reproductive behavior in 19th century Sweden: Tuna Parish. *American Anthopologist* 92: 115–126, 1990.

Maynard Smith, J. Parental investment: A prospective analysis. *Animal Behavior* 25: 1–9, 1977.

Pearson, J. Social and psychological aspects of extra-marital first conceptions. *Journal of Biosocial Science* 5: 453–496, 1973.

Pritchard, C., and Thompson, B. Starting a family in Aberdeen 1961–79: The significance of illegitimacy and abortion. *Journal of Biosocial Science* 14: 127–139, 1982.

Ritchie, M. Optimal foraging and fitness in Columbian ground squirrels. *Oecologia* 82: 56–67, 1989.

Scheper-Hughes, N. The cultural politics of child survival. In *Child Survival: Anthropological Perspectives on the Treatment and Maltreatment of Children*, N. Scheper-Hughes (Ed.). Dordrecht: D. Reidel, 1987, pp. 1–29.

Sibly, R.M., and Calow, P. *Physiological Ecology of Animals: An Evolutionary Approach*. Oxford and Boston: Blackwell Scientific, 1986.

Stevens, D., and Krebs, J. *Foraging Theory*, Princeton: Princeton University Press, 1986.

Trivers, R. Parental investment and sexual selection. In *Sexual Selection and the Descent of Man: 1871–1971*, B. Campbell (Ed.). Chicago: Aldine, 1972, pp. 136–179.

Williams, G.C. *Adaptation and Natural Selection*, Princeton: Princeton University Press, 1966.

Winterhalder, B., and Smith, E.A. (Eds.). *Hunter-Gatherer Foraging Strategies*, Chicago: University of Chicago Press, 1981.
Woolfenden, G., and Fitzpatrick, J.W. *The Florida Scrub Jay: Demography of a Cooperatively-Breeding Bird*, Princeton: Princeton University Press, 1984.
Wittenberger, J.F. *Animal Social Behavior*, Boston: Duxbury, 1981.