Parental investment and age at weaning in a Caribbean village

Robert J. Quinlan*, Marsha B. Quinlan, Mark V. Flinn

Department of Anthropology, University of Missouri, Columbia, MO, USA

Abstract

Predicting the timing of weaning in diverse environments is important because breast-feeding significantly contributes to child survival and overall health, especially in developing countries. This study examines associations between weaning and household demographic variables that test predictions derived from parental investment (PI) theory. Data were collected for 101 children (49 males and 52 females) in a rural community in Dominica. Analyses indicate that father absence is associated with early weaning. This was the only prediction from PI theory that was supported. The following results were contrary to expectations: (1) Availability of female alloparents and household wealth were negatively associated with age at weaning. (2) Number of dependent children in the household was positively associated with age at weaning. (3) Mother's age at birth was not correlated with the timing of weaning. Lastly, (4) interaction terms for child's sex by wealth and sex by maternal social support were not associated with age at weaning, indicating the lack of a Trivers–Willard effect on weaning in this population. We suggest that explanations of weaning from PI theory will benefit from including high opportunity costs of prolonged nursing, demands for reciprocal female labor, and the importance of investment in "embodied capital." © 2002 Elsevier Science Inc. All rights reserved.

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* Corresponding author. Present address: Department of Anthropology, Ball State University, Muncie, IN 47306-0435, USA. Tel.: +1-765-285-1575.

E-mail address: enyepa@yahoo.com (R.J. Quinlan).

1. Introduction

Breast-feeding contributes significantly to child survival and health, especially in developing countries. Factors associated with breast-feeding duration are well documented (e.g., Rogers, Emmett, & Golding, 1997; Scott & Binns, 1999), and the cultural ecology of breast-feeding has been described for many populations (e.g., Cosminsky, Mhloyi, & Ewbank, 1993; Gray, 1996). A predictive model for the timing of weaning, however, is not well developed, impeding further empirical work. Here, we propose a socioecological model for the timing of weaning in Bwa Mawego, a horticultural village in the Commonwealth of Dominica.

Some benefits of breast-feeding for infant health are well known (Oddy, 2001), and it may also afford protection against diseases appearing later in development and even adulthood (Cunningham, 1995). Recent studies have also found that prolonged nursing has positive influence on long-term psychomotor and neural development including mastery of developmental milestones (Vestergaard et al., 1999), vocabulary at 5 years (Pollock, 1994), and verbal and performance IQ at 8 years (Horwood, Darlow, & Mogridge, 2001).

Breast-feeding is a key component of mammalian ''parental investment (PI),'' which is defined as the expenditure of resources for the benefit of one offspring that decreases parents' ability to invest in another (Trivers, 1972). Evolved psychological mechanisms that influence the allocation of resources among offspring should enhance parents' inclusive fitness in environments similar to those of human evolutionary history, and evidence that prolonged nursing is beneficial suggests that such mechanisms will regulate the timing of weaning.

Breast-feeding is also an important building block of the mother–child bond. For many women, breast-feeding evokes intense positive feelings that are linked with maternal hormones (Ellison, 2001, pp. 83–126). Nursing, then, may be an indicator of a mother's willingness and ability to invest in her child.

Several recent theoretical works examine social and environmental factors that may affect fitness through prolonged lactation (Lee, 1996; McDade, 2001; McDade & Worthman, 1998). Breast-feeding transfers substantial caloric resources from mother to child. Nursing may also interfere with economically important activities. Weaning, therefore, should occur when the fitness costs of continued breast-feeding exceed the benefits. In general, a woman's access to resources for PI determines the costs of continued breast-feeding. In Bwa Mawego, coresident kin are the main source of social, emotional and material resources. We focus, therefore, on relations between family environment and timing of weaning.

Some recent studies have examined weaning from an evolutionary perspective. Consistent with an optimal investment hypothesis, Bereczkei (2001) found that mothers weaned ''high-risk'' infants earlier than healthy infants. Several other studies have found sex biases in breast-feeding that were consistent with predictions from PI theory (Bereczkei & Dunbar, 1997; Cronk, 2000; Koziel & Ulijaszek, 2001), although other researchers have not (Keller, Nesse, & Hofferth, 2001). Finally, a study of 133 preindustrial societies suggests that maternal work patterns, subsistence strategies, and the reproductive costs of prolonged lactation affect breast-feeding duration (Sellen & Smay, 2001).

In sum, evolutionary theory generates testable models of human weaning that require further testing and potential modification. In this study, we test eight predictions from

PI theory for the timing of weaning. Our results are then placed in context of rural Dominican ethnography.

2. Hypotheses and predictions

Raising successful offspring involves expending limited resources, and the investment each child receives depends in part on parents' access to resources. Firstly, parents with abundant resources can invest them in their children in the form of education, status symbols, etc. Secondly, easy access to resources may allow parents to spend more time in direct childcare because parents' time is not limited by labor demands. In some cases, breast-feeding may involve a conflict over resource acquisition and direct childcare. When resources are abundant, however, weaning may be delayed because prolonged nursing does not conflict with economic production. In rural Dominica, access to material resources varies among households, and women in wealthier households may be freed from labor demands that conflict with breast-feeding.

•*Prediction 1: Household wealth is positively associated with age at weaning.*

Investment in a child is affected not only by parental access to resources but also by the numbers of other children and investing adults. Investing adults may be any close relatives, and their effect on child well-being may be indirect. For example, coresident adults can make economic contributions to households that allow women to spend less time working outside the home and more in direct childcare. In Dominica, men in conjugal unions take on much of the household work that conflicts with childcare, and women regularly help their coresident kin with childcare and other domestic duties (Quinlan, 1995), potentially freeing mothers to provide more care. Hence, social support that diminishes labor constraints on breast-feeding should increase age at weaning (see McDade, 2001, pp. 17–19).

•*Prediction 2: Number of coresident adult female kin is positively associated with age at weaning.*

•*Prediction 3: Father-present children are weaned later than are father-absent children.*

•*Prediction 4: Number of children in the household is negatively associated with age at weaning.*

There is a tradeoff between current and future reproduction that influences PI decisions: Current offspring are worth more than future offspring in terms of their expected impact on maternal fitness, but continued investment in an existing child can reduce future reproductive success (RS). One example of this tradeoff is that breast-feeding reduces fecundity (Ellison, 2001, pp. 83–126), and weaning decisions depend, in part, on the potential cost to future reproduction of continuing to nurse an existing offspring (Lee, 1996). As women age, this cost diminishes, both because fecundity decreases and families are more likely to have reached a desired size. Thus, children of older women should be weaned relatively late.

•*Prediction 5: Maternal age at birth of the child is positively associated with age at weaning.*

Sex biases in the duration of breast-feeding have been observed in several human populations (Bouvier & Rougemont, 1998; Nath & Goswami, 1997; Scott, Aitkin, Binns,

& Aroni, 1999), and according to the theory advanced by Trivers and Willard (1973), mothers in poor condition should bias investment toward daughters while mothers in good condition prefer sons. This prediction is logical if male fitness is more variable than female fitness and if RS is sensitive to parental care in childhood. In humans, men typically have higher fitness variance than women, and this is evidently true in Caribbean communities, including Bwa Mawego (Flinn, 1986; R.J. Quinlan, 2000, pp. 79–89). Thus, women in difficult situations may wean sons earlier and daughters later than women in better situations. Whether living conditions are difficult or advantageous depends on household wealth, pairbond status, and number of coresident female kin.

   • Prediction 6: In wealthy households, boys are weaned later than girls, and the reverse is true in poor households.
   • Prediction 7: Father-present boys are weaned later than father-present girls, and father-absent girls are weaned later than are father-absent boys.
   • Prediction 8: Boys are weaned later than girls when there are coresiding alloparents, and the reverse is true when there are none.

3. Methods

3.1. Field techniques

   Data were collected in the village of Bwa Mawego in 1988–2001 as part of an ongoing study of family environment and child health in rural Dominica (see Flinn, 1999), using various methods to ensure reliability and validity (see Trotter & Schensul, 1998). Key informant interviews (Bernard, 1995, pp. 208–254) provided household demographic and economic data. Direct observation, informal interviews, and annual census updates afforded cross-checks (Bernard, 1995, pp. 136–164 and 208–215; Dewalt & Dewalt, 1998)—for details, see R.J. Quinlan (2000). Determining ages is relatively easy in Bwa Mawego: Most villagers know their date of birth, and clinic health cards verify self-reported dates of birth.

   Age at weaning (complete cessation of breast-feeding) was determined through retrospective health interviews, conducted by M.B.Q. in 1993, 1994, and 1997 and by a Dominican research assistant in 1999, and by review of individual clinic health cards (M.B. Quinlan, 2000). Interviews were semistructured to allow coverage of diverse health topics and involved a series of open-ended questions asked of each village mother regarding the health history and current condition of all household members. Mothers were asked to recall the nature and treatment of illnesses and injuries suffered by their coresident family members in the past week, past month, and the past year and to identify any health problems that each child had up to the date of the interview. Mothers were also asked each child's age, in months, at the time when food was introduced and when breast-feeding was stopped. Clinic health cards that recorded monthly "well-baby" check-ups were used to cross-check weaning data from retrospective interviews, and the weaning ages from clinic health cards were highly correlated with mothers' recall ($r = .91$). Quandt (1987) reported a similarly high correlation ($r = .89$) between such measures in another population.

3.2. Sample

Demographic data are for 101 children (49 males and 52 females) born between 1980 and 1995. This data set includes children in permanent residence in Bwa Mawego, whose families participated in a longitudinal study of family environment and childhood stress (see Flinn, 1999).

Additional demographic data were used to test the assumptions of the Trivers–Willard hypothesis: Number of children surviving to adulthood (i.e., RS) was assessed from complete genealogies, collected and cross-checked by use of multiple informants (see R.J. Quinlan, 2000) for 252 women and 248 men born between 1924 and 1951.

3.3. Variables and analysis

Linear regression analysis was done in four steps. In the first step, the child's age in months at the time of weaning was regressed on five predictor variables and one control variable. The predictors were PAIRBOND: whether the mother was living with the child's father at the time of weaning, ALLOMOMS: the number of adult female relatives (age > 15 years) that lived in close proximity (i.e., in more or less contiguous dwellings) to the mother, CHILDREN: the total number of dependent children (including nonsiblings, age < 16 years for females and < 19 years for males) residing in the household when the focal child was weaned, MOMSAGE: the mother's age in years at the birth of her child, and WEALTH. This last predictor was based on an inventory of durable goods owned by the household (radios, gas stoves, etc.): Presence or absence of 10 items was recorded for each household, and these 1-0 scores were submitted to principal components analysis (PCA), yielding two components. The eight items with loadings >0.50 on the first component were submitted again to PCA and a single component, which we call WEALTH and which explains about 50% of the variance in household items, was extracted. (Other economic variables such as estimated house value are highly correlated with WEALTH (R.J. Quinlan, 2000). The child's age at the time of the health interview (KIDSAGE) was included as a control variable, because there may be secular trends in duration of breast-feeding or maternal recall may decay over time.

The remaining steps of the regression analysis use product terms to test for interaction effects predicted by the Trivers–Willard hypothesis. Dummy variables (SEX and PAIR-BOND) were coded as 0.5 and − 0.5 rather than 0 and 1 so that interaction effects predicted by the Trivers–Willard hypothesis are accurately indicated by the product terms. First-order variables were centered around their mean and multiplied by sex (0.5 = male, − 0.5 = female) to create the product terms (Jaccard, Turrisi, & Wan, 1990). In the second model, age at weaning was regressed on four predictor variables, with KIDSAGE again included as a control variable. ALLOMOMS was entered into the model with *sex of child* (SEX) and one product term, SEX × ALLOMOMS. In the third model, age at weaning was regressed on another four variables: KIDSAGE, SEX, WEALTH, and SEX × WEALTH. In the fourth model, age at weaning was again regressed on four variables: KIDSAGE, SEX, PAIRBOND, and SEX × PAIRBOND.

4. Research site

4.1. Bwa Mawego

The Commonwealth of Dominica is a small, rural island nation located between Guadeloupe and Martinique (15°N, 61°W). The island is mountainous and relatively undeveloped. Dominica's population (approximately 65,000) is of mixed African, European, and Island-Carib descent. Most Dominicans are bilingual in English and French-Patois.

Bwa Mawego, the study site, is one of the least developed villages on the remote Windward side of the island. There are about 700 full-time and part-time residents, occupying small (150–600 ft^2), mostly one or two room, houses. Many have electricity, but only a few have rudimentary plumbing. Family compounds and single-family dwellings and out-buildings are typically arranged around a yard where most daytime domestic activity takes place. Average annual income in Bwa Mawego is approximately $5000 E.C. (US$1850). Economic activities include subsistence gardening, fishing, bay oil production, banana production, and limited wage labor. Most adults are involved in some subsistence horticulture. In addition, many families cultivate bay leaf, bananas, or fruits and vegetables for market. Opportunities for education are limited, and few villagers have a high school education. Entrance into high school is very competitive, and for many families the costs of school supplies, uniforms, and transportation are prohibitive.

Household composition varies. Conjugal families, male-headed extended families, single-mother families, and various permutations are common (R.J. Quinlan, 2000). Often, several households of closely related kin are grouped together in a family compound.

Bwa Mawego (and the island in general) has a relatively healthy population. Life expectancy for Dominicans is 74 years compared with 66 for the Caribbean region. The infant mortality rate is 17 per 1000 live births compared with 46 per 1000 for the Caribbean. (Data are from the U.S. Census Bureau available at www.census.gov/ipc/www/idbnew.html.) One infant and one young child died in Bwa Mawego during the course of this fieldwork.

4.2. Cultural context of weaning

Breast-feeding for the first 3 months is nearly universal in rural Dominica. The Ministry of Health has successfully encouraged improvements in public health. Physicians and nurses in health centers recommend that women breast-feed for at least 6 months. Most women comply in part because commercial baby formulas are expensive and hard to obtain except in the capital city of Roseau and a few large villages. There is little social stigma attached to breast-feeding, and nursing in public is traditional. Babies sometimes drink a mixture of water and arrowroot starch, occasionally fortified with condensed cow's milk, but this formula is recognized as inferior to breast milk and is used mainly as a supplement when mothers are unable to breast-feed. Most babies are exclusively breast-fed for at least 6 months, when some mothers introduce porridge or bananas. The mean age for introducing food is 6.5 months, with a mode and median of 6 months. Mean age at weaning is 12.5 months, with a mode and median of 12 months. This mean age at weaning is slightly higher than in other Caribbean

Table 1
Reasons women gave for weaning their children

Reason for weaning	%
Interfered with mother's work	34
Insufficient milk	21
Child quit by itself	8
Mother got sick (not including mastitis)	8
To encourage child to eat solid food	8
Mother taking medication	6
Child was biting	4
Mother got pregnant	4
Mother got mastitis	2
Child started school	2
Mother left village to care for sick relative and left child behind.	2
Total responses	48

In the majority of cases, women gave no specific reason for the timing of weaning. Data are for a subsample of women interviewed in 1999.

populations (Perez-Escamilla, 1994), albeit lower than in many societies (Dettwyler, 1995; Sellen, 2001).

Mothers in Bwa Mawego expressed various reasons for weaning their children, but most gave no specific reason for the precise timing. Some simply reported a doctor or nurse instructed them to breast-feed for at least 6–12 months and that they tried to comply. When mothers did give specific reasons for weaning, the most common were that breast-feeding interfered with work and an insufficient milk supply. All reported reasons for weaning are given in Table 1.

5. Results

Multiple linear regression was used to test the predictions. Analysis of residuals showed three potential outliers. Excluding potential outliers from the analysis did not appreciably influence the results. Maximum Cook's distance was 0.099. The outlying cases were retained for the analyses reported below. Multicollinearity was not a problem in these models. The maximum VIF for all four models was 1.19 for Model 1. Other regression diagnostics indicate that the models are adequate. Descriptive statistics are given in Table 2. Table 3 shows the correlation coefficients among the variables in the regression analysis.

In the first analysis, four predictors were significantly associated with age at weaning (Table 4). As predicted, father-present children were breast-fed longer than father-absent children ($\beta = 0.27$, $P = .006$), with an average difference of more than 4 months. However, the other significant associations were in opposite directions to predictions. More available alloparents, for example, predicted briefer breast-feeding ($\beta = -0.35$, $P = .001$): Children who lived with one or more adult female relatives besides mother nursed 10 weeks less, on average, than those who did not. WEALTH was associated with earlier weaning

Table 2
Descriptive statistics

Variable	Mean	S.D.	Minimum	Maximum
Age at weaning	12.5	8.0	0	42
PAIRBOND[a]	0.52	0.50	0	1
ALLOMOMS	0.94	1.06	0	4
CHILDREN	3.7	1.8	1	11
MOMSAGE	24.3	4.0	15	37
SEX[b]	0.49	0.50	0	1
WEALTH	4.1	2.1	0	10
KIDSAGE	8.3	3.9	0	14

PAIRBOND = father present, ALLOMOMS = number of female relatives available for childcare, CHILD-REN = number of children in the household, MOMSAGE = mother's age at birth of the child, SEX = child is male, WEALTH = inventory of material goods in the household (descriptive statistics are for the raw score, not the PCA score), KIDSAGE = age of the child at the time of the interview.

[a] Indicates reference dummy variable: 1 = father present.
[b] Indicates reference dummy variable: 1 = male.

($\beta = -0.29$, $P = .002$): Children in the lowest quartile breast-fed almost 8 months longer, on average, than those in the highest quartile. Also contrary to prediction, the number of children in the household was positively associated with breast-feeding duration, although this association was not significant ($\beta = 0.20$, $P = .088$): Children that lived with four or more other children were weaned about 6 weeks later, on average, than those who lived with only one other child.

Maternal age at the birth of the child ($\beta = 0.01$, $P = .930$) was not significantly associated with age at weaning. Two variables, KIDSAGE and CHILDREN, were correlated with maternal age ($r > .50$, see Table 3), but removing these two variables from the model did not considerably change the association between maternal age and age at weaning ($\beta = 0.06$,

Table 3
Correlation coefficients for variables in multiple regression analyses

	1	2	3	4	5	6	7
Age at weaning	.085	.367***	− .152*	− .384***	.146 *	.084	− .262***
1 KIDSAGE	–	.061	− .092	− .055	−.570***	−.276***	− .077
2 PAIRBOND		–	.238***	− .337***	.237***	.190**	− .108
3 WEALTH			–	− .070	.198**	.261***	− .127
4 ALLOMOMS				–	−.208**	.211**	.149*
5 MOMSAGE					–	.519***	− .062
6 CHILDREN						–	.054
7 SEX							–

Variable definitions are the same as in Table 2.
* $P < .10$.
** $P < .05$.
*** $P < .01$.

Table 4
Multiple regression models with "age at weaning" as the criterion

	B	Lower CL	Upper CL	β	*P*-value
Model 1					
KIDSAGE	0.171	− 0.276	0.619	0.084	.449
PAIRBOND	4.435	1.279	7.591	0.274	.006
WEALTH	− 2.487	− 4.058	− 0.916	− 0.287	.002
ALLOMOMS	− 2.661	− 4.248	− 1.075	− 0.346	.001
MOMSAGE	0.019	− 0.416	0.454	0.012	.930
CHILDREN	0.849	− 0.128	1.826	0.197	.088
Model 2					
KIDSAGE	0.101	− 0.275	0.477	0.006	.947
SEX	− 3.326	− 6.311	− 0.340	− 0.224	.012
ALLOMOMS	− 2.697	− 4.115	− 1.279	− 0.264	.005
SEX × ALLOMOMS	**0.107**	**− 2.731**	**2.945**	**− 0.027**	**.770**
Model 3					
KIDSAGE	0.133	− 0.250	0.516	0.065	.492
SEX	− 3.905	− 6.896	− 0.913	− 0.245	.011
WEALTH	− 1.212	− 2.827	0.403	− 0.140	.140
SEX × WEALTH	**2.389**	**− 0.853**	**5.631**	**0.138**	**.147**
Model 4					
KIDSAGE	0.102	− 0.273	0.476	0.050	.590
SEX	− 3.509	− 6.475	− 0.543	− 0.217	.021
PAIRBBOND	5.481	2.519	8.444	0.339	.000
SEX × PAIRBOND	**− 3.108**	**− 9.027**	**2.811**	**− 0.096**	**.300**

B = unstandardized regression coefficients. CL = 95% confidence limits for *B*. β = standardized regression coefficient. Variable definitions are the same as in Table 2.

P = .489). Using child's birth order as the predictor, rather than maternal age, yielded similar null results. Age of the child at the time of the interview (the control variable) was not associated with duration of breast-feeding (β = 0.08, *P* = .449) nor did it have appreciable influence on the partial regression coefficients for the predictor variables.

A second set of models was used to test the Trivers–Willard effect on age at weaning. Product terms for SEX × ALLOMOMS, SEX × WEALTH, and SEX × PAIRBOND were entered into three separate models along with their first-order terms and KIDSAGE as a control variable. However, before turning to the results for the interaction effects, we assess whether the main assumption of the Trivers–Willard model holds for this population.

The model requires that there be more variance in the RS of one sex than of the other. Average RS in Bwa Mawego is 2.8 offspring ($\male\mu$ = 2.7, $\female\mu$ = 2.9), with a median of 2. Men have slightly higher variance in RS than women ($\male\sigma^2$ = 5.27, $\female\sigma^2$ = 5.04), have higher odds of being childless (OR = 2.24, 95% CI = 1.07–4.70), and are less likely to be above the median of RS (OR = 0.71, 95% CI = 0.50–1.01). Additional data for 48 women and 40 men born between 1899 and 1924 show a larger sex difference in reproductive variance ($\male\sigma^2$ = 7.47,

$\female\sigma^2 = 4.85$) but no difference in the odds of being childless or odds of being above the median in RS (OR = 0.71, 95% CI = 0.29–1.75; OR = 1.32, 95% CI = 0.55–3.20). These results suggest that cues relevant to the Trivers–Willard effect may be present in Bwa Mawego, although differences in male and female reproductive variability do not appear to be dramatic in this population compared with, for example, the Yanomamo (Chagnon, 1997).

The other main assumption of the Trivers–Willard hypothesis — that maternal condition influences offspring fitness — is extremely difficult to assess among humans, but we think it reasonable to assume that offspring fitness is sensitive to parental care during development and that parental condition influences parental care.

Results of the regression analyses show that boys tended to be weaned significantly earlier than girls ($-0.25 < \beta < -0.22$, .01 $< P <$ .02): The average difference was about 14 weeks. None of the three interaction terms was statistically significant, suggesting that there was no Trivers–Willard effect on weaning, although one of the interactions may indicate a weak signal in the data: As predicted, SEX × WEALTH was positively associated with age at weaning ($\beta = 0.14$, $P = .147$). For each unit of SEX × WEALTH, weaning was delayed, on average, by more than 2 months (95% CI = -0.85–5.63).

6. Discussion

These results suggest that breast-feeding duration may not be an adequate gauge of total PI. Only one of eight predictions was supported: Father-present children were weaned later than father-absent children, a finding that is consistent with several other studies (Bar-Yam & Darby, 1997; Kiehl, Anderson, Wilson, & Fosson, 1996; Pande, Unwin, & Haheim, 1997; Vega & Gonzalez, 1993).

In Bwa Mawego, conjugal households tend to be more geographically isolated and self-sufficient than matrifocal households. Even when a couple lives in an extended family compound, their house and yard are usually somewhat peripheral to the compound. In-marrying women receive little direct assistance from their husband's coresident sisters. Men rarely move into a mate's family compound. When a man does move in with his mate's family, it is usually a temporary arrangement until the couple establishes their own household or the man quits the union. (See R.J. Quinlan [2000] for a detailed description of rural Dominican families.)

Conjugal families in Bwa Mawego appear intensely child centered and focused on "cultural success" and have other characteristics, besides prolonged nursing, that enhance reproduction and economic production. The men spend more than twice as much time engaged in productive activity as single men, for example, although there are no differences in time spent in productive activity by single versus "married" women (Quinlan, 1995). Women in stable conjugal unions have higher RS than do single women (Quinlan, 2001), and their children are better supervised, spend more time engaged in productive activity, and spend less time roaming about the village (Quinlan & Flinn, in press). Finally, multiple comparisons indicate that conjugal family households in Bwa Mawego *do not* have significantly more wealth than extended family households (R.J. Quinlan, 2000, p. 113),

suggesting that the increased production of the men is invested in their children's well-being rather than in material goods.

Contrary to predictions, the availability of childcare, as measured by the number of coresident adult female relatives, was negatively associated with age at weaning, which is again consistent with other studies (Bick, MacArthur, & Lancashire, 1998; Lindenberg, Artola, & Estrada, 1990). The inverse relationship may reflect the modes of household production and childcare in Bwa Mawego. In a conjugal family, a woman and her mate have complementary roles that reflect their common reproductive interest in their children, and the father may take on a larger share of horticultural and other external economic duties when he and his mate have an infant (see also Hurtado, Hill, Kaplan, & Hurtado, 1992). Although a single woman in an extended family environment receives substantial assistance in domestic and economic activities, she may feel more pressure to reciprocate in kind, perhaps because of asymmetry in relatedness between the woman, her children, and other kin resident in the compound.

Labor that takes women away from home (gardening, wage labor, etc.) may influence breast-feeding duration in different family environments. Single women in extended families are sometimes expected to return to gardening and other chores soon after giving birth, and unlike women in some agrarian societies (e.g., Panter-Brick, 1991), Bwa Mawego women do not take infants with them to their gardens or work places outside the family compound. Reticence to take infants away from home may be due to physical geography and patterns of land use in Dominica: Gardening and laundry spots along streams are located in the bush away from village neighborhoods, and many women report suffering miscarriages after falling along the often slippery trails (M.B. Quinlan, 2000, p. 115). Relatively long daily separations between mother and infant may thus lead to earlier weaning by single mothers, much like what has been reported of working women in developed countries (Arlotti, Cottrell, Lee, & Curtin, 1998; Bick et al., 1998; Bouvier & Rougemont, 1998; Fein & Roe, 1998; Hill, Humenick, Argubright, & Aldag, 1997; Lindenberg et al., 1990; Visness & Kennedy, 1997). Ethnographic and time allocation data support this interpretation. The most common rationale for weaning in Bwa Mawego was that breast-feeding conflicted with mothers' work, and the second most common reason, insufficient milk, has also been linked to long mother–infant separations (Gussler & Briesemeister, 1980). Furthermore, analysis of reproductive age women's time allocation indicates that single mothers in Bwa Mawego spend more time away from home: 32% of their time compared with 13% for women in conjugal unions ($P = .044$ by Mann–Whitney test).

Also defying prediction was the finding that household wealth was negatively associated with age at weaning, but this, too, matches other data. In the developing world, income and socioeconomic status (SES) tend to be inversely related to duration of breast-feeding (Chabra, Grover, Aggarwal, & Dubey, 1998; Lindenberg et al., 1990; Marandi, Afzali, & Hossaini, 1993; Perez-Escamilla, Cobas, Balcazar, & Holland Benin, 1999; Rea, Venancio, Batista, & Greiner, 1999), whereas SES is positively associated with breast-feeding duration in the developed world (Bourgoin et al., 1997; Hoyer & Pokorn, 1998; Riva et al., 1999). In some developing countries, breast-feeding is apparently perceived as a low status activity, such that upper-class and upwardly mobile women favor infant formula (Farb & Armelagos, 1980, p. 103). In rural Dominica, however, there is no stigma attached to breast-feeding, and

commercial infant formula is not widely available. We suggest that the inverse correlation between wealth and age at weaning in Bwa Mawego has more to do with household economic behavior than with perceived status. Disparities in wealth in the village are not large compared with urban areas of many developing nations, and families become relatively well off through hard work and economic cooperation. Wealthy families are more likely to be involved in wage labor and commercial agriculture. Opportunity costs of breast-feeding interfere with these economic activities. Women cannot nurse and work at the same time.

Breast-feeding and wealth are somewhat mutually exclusive forms of PI in Bwa Mawego. Wealth may be invested in offspring's "embodied capital" (education, status symbols etc.; see Kaplan & Lancaster, 2000) that may have greater influence on offspring's long-term well-being than does prolonged breast-feeding. In contrast, when a family cannot expect to participate extensively in the market economy, then the opportunity costs of prolonged breast-feeding may not outweigh the benefits of additional work. Evolutionary models of weaning should therefore consider the costs of breast-feeding against the benefits of conflicting activities. Such tradeoffs are likely to be specific to particular environments.

Maternal age was not associated with age at weaning. This finding is contrary to PI theory *and* to previous studies, which have found a positive association (Bourgoin et al., 1997; Jackson et al., 1992; Vega & Gonzalez, 1993; Vogel, Hutchison, & Mitchell, 1999). Again, we interpret this negative result in terms of the tradeoff between breast-feeding and work. In Bwa Mawego, older women are largely the economic engines of extended families, running shops, doing laundry for pay, organizing family agricultural enterprise, etc. Delays in weaning merely hinder acquisition of resources for shared investment in children and grandchildren.

Contrary to predictions and findings from other studies (Jackson et al., 1992), the number of children in the household (including the children of other mothers) was *positively* associated with age at weaning in Bwa Mawego (though not quite significantly so). This finding is hard to interpret, in light of the negative association between availability of childcare and breast-feeding duration. It may be that the nature of cooperation within extended families is dynamic with respect to household composition. Older children in Bwa Mawego often take on adult domestic tasks (Quinlan, 1995), and in some households, girls no older than 11 or 12 years spend as much time in domestically "productive" activities as grown women (R.J. Quinlan, 2000, pp. 84–85). In households with many children, the combined efforts of several older children can significantly reduce labor demands on mothers, allowing them to nurse their infants longer.

Three tests of the Trivers–Willard hypothesis failed to support its predictions, which is consistent with several recent studies. Keller et al. (2001) found no status by child's sex interaction effect on the duration of breast-feeding. Koziel and Ulijaszek (2001) found a weak *paternal* status by child's sex interaction effect on breast-feeding duration but no maternal status by sex interaction. Freese and Powell (1999) did not test for a Trivers–Willard effect on breast-feeding duration but found no Trivers–Willard effect on other measures of PI. There are several possible interpretations for our null results. (1) The opportunity costs of breast-feeding in Bwa Mawego may preclude an adequate test of Trivers–Willard, i.e., breast-feeding is not a good overall indicator of investment in this environment. (2) Given the strong matrifocal

flavor of Dominican families, female offspring may be much more valuable to extended families than are male offspring. Hence, "local resource enhancement," in which labor contributions of one sex offsets their costs to parents, may be the appropriate model of sex-biased PI (see Chagnon, Flinn, & Melancon, 1979; Sieff, 1990). (3) Bwa Mawego is one of the poorest and most remote villages on the island. It is possible that the female bias is due to a regional Trivers–Willard effect, much like that among the Mukogodo of Kenya (Cronk, 2000; see also Irons, 2000). (4) In Bwa Mawego, mothers sometimes suggest that compared with boys, "girl-babies are easy." This sentiment is comparable to findings of a study in which women that perceived that their infant had an "easy temperament" tended to breast-feed longer (Vandiver, 1997). (5) The Trivers–Willard hypothesis may not be sufficiently complex to account for PI decisions among humans, with their multiple resource needs for competitive reproduction. (6) Finally, our sample may be too small to detect significant interactions.

In general, we interpret these results in terms of the costs and benefits of pursuing particular PI strategies in a specific context. Prolonged lactation in Bwa Mawego may interfere with acquisition of resources that are more important for developing children's potential. In addition, different household compositions likely have different effects on maternal work patterns and hence ability to prolong nursing.

In sum, although breast-feeding may be an important aspect of PI, it is not a good measure of overall PI in some human groups. Relations between the components of PI and the proximate determinants of fitness in specific environments are complex and context dependent (Geary & Flinn, 2001). Different patterns of women's work have different effects on breast-feeding behavior and duration (Quandt, 1995, pp. 136–137). Household composition, women's work, and weaning decisions appear mutually interdependent and hence involve complex responses to individual and cultural circumstances. Evolutionary models of human behavior may benefit from greater attention to such nuances.

Acknowledgments

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