Local Resource Enhancement and Sex-biased Breastfeeding in a Caribbean Community[1]

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Parents often treat sons and daughters differently. Boys are favored in some societies (Messer 1997), but in others

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TABLE 1
Studies Showing Sex-biased Breastfeeding

Sex Bias	Country/Culture	PI Hypothesis	Reference
Female	Switzerland	–	Bouvier and Rougemont (1998)
Female	Hungary, Gypsy	TW*/LRE*	Bereczkei and Dunbar (1997, 2002)
Female	Kenya, Mukogodo	TW*	Cronk (2000)
Female	U.S., Hutterites	TW/LRE*	Margulis, Altmann, and Ober (1993)
Female	Dominica	TW	Quinlan, Quinlan and Flinn (2003)
Female	Australia	–	Scott et al. (1999)
Female	United Kingdom	–	Whitehead, Paul, and Ahmed (1986)
Female	Norway	–	Pande, Unwin, and Haheim (1997)
Male	Northern Thailand	–	Jackson et al. (1992)
Male	India	–	Nath and Goswami (1997), Rao and Kanade (1992)
Male	Bangladesh	–	Brown et al. (1982)
Male	Egypt	–	Ahmed (1990)
Depends on father's status	Poland	TW*	Koziel and Ulijaszek (2001)

NOTE: PI, parental investment; TW, Trivers-Willard; LRE, Local resource enhancement. Results consistent with the hypothesis are indicated by *.

girls receive preferential treatment including better medical care and more frequent breastfeeding (Cronk 2000). Cross-culturally, breastfeeding is a major component of early parental care that directly affects child health. Here we examine female-biased breastfeeding in Bwa Mawego, a horticultural community in the Commonwealth of Dominica, and test hypotheses from parental investment theory about the reasons for such bias (reviewed in Clutton-Brock and Godfray 1991). Multiple linear regression suggests that sex differences in children's time allocation to productive activity account for female-biased breastfeeding in this community. Ethnographic data from Bwa Mawego suggest that female-biased maternal care results from male socioeconomic marginality and its effects on sex-specific risks of parental investment.

Breastfeeding is a primary mechanism among mammals for provisioning dependent offspring and is a key component of parental investment—care benefiting one offspring at a cost to parents' ability to invest in other components of fitness (Clutton-Brock 1991:9).[2] Components of fitness include well-being of existing offspring, parents' future reproduction, and "indirect fitness" through aid to kin (see Hamilton 1964, Beatty 1992). Nursing can be an important building block of the mother-child bond, associated with positive emotions and intense attachment that are linked to maternal hormones including prolactin and oxytocin (Ellison 2001: 83–126). Because of its reliability as a mechanism for bonding, it may have evolved regulatory functions affecting other aspects of human parental investment (Hrdy 1999). Its infant health advantages are well known (Oddy 2001) and it may also protect against diseases appearing in adulthood (Cunningham 1995). Other benefits to children's long-term cognitive and psychomotor development are apparent (Horwood, Darlow, and Mogridge 2001, Feldman and Eidelman 2003, Mortensen et al. 2002, Pollock 1994, Vestergaard et al. 1999) and may have long-term fitness consequences.

For mothers, lactation entails energetic and opportunity costs and suppresses fertility (Valeggia and Ellison 2001, Tracer 1996, Vitzthum 1994). The energetics of human lactation requires 670 kcal/day during exclusive breastfeeding (Dewey 1997), which may be 50% of a woman's total energy budget in undernourished populations (Valeggia and Ellison 2001:86). Increased energy demand may tax household production and delay future reproduction through reduced fecundity among undernourished mothers (Jasienska 2001). Opportunity costs may also be substantial (Quinlan, Quinlan, and Flinn 2003). Nursing can interfere with work that benefits other children or kin and direct maternal care for older offspring. Finally, length and frequency of breastfeeding sessions are associated with postpartum fecundity, possibly through effects on gonadotrophin-releasing hormone (Vitzthum 1997). Such "structural" costs of breastfeeding (associated with nursing-session length, frequency, and age at weaning) should be expressed in future reproduction or "residual reproductive value."

In general, the costs of lactation for mother's future reproduction easily fit within a life-history framework (see Hill and Kaplan 1999, Roff 2002). Delayed reproduction is "discounted" in growing populations because later-born offspring represent a smaller proportion of the total population and, hence, reduced fitness. Delay also increases the likelihood that a woman will die before the birth of her next child. Costs to existing offspring are more complicated to model in terms of residual reproductive value, but formal life-history models can be extended to include special aspects of parental investment (Hill 1993). In sum, we expect the timing of weaning to reflect a trade-off between benefits to offspring and costs to mother, which among humans may be influenced by family cooperation.

Sex-biased breastfeeding is evident in many human populations (table 1). Evolutionary theory predicts that

2. "Fitness" is defined as an individual's genetic representation in future generations.

sex-biased parental investment will be adaptive in certain circumstances. In general, if parental expenditures in one sex yield higher fitness than expenditures in the other sex, then parents should bias investment toward the former. Socioecological conditions may affect sex-specific fitness returns on parental investment. Mating system, competition, and cooperation among kin are important factors (see Chagnon, Flinn, and Melancon 1979, Clutton-Brock 1991, and Sieff 1990 for reviews).

One evolutionary hypothesis for sex-biased parental investment posits that mothers in poor condition (usually measured in terms of socioeconomic status) may bias investment toward daughters while mothers in good condition bias investment toward sons (Trivers and Willard 1973). This prediction is logical if males have more reproductive variance than females and if offspring reproduction is sensitive to parental resources. Parents in good condition provide more resources, leading to potentially higher fitness through sons, and parents in poor condition provide fewer resources, leading to higher fitness through daughters. Among humans, males often have higher reproductive variance than do females, and correlates of reproductive success (wealth, social competence, etc.) may be sensitive to parental influence (Geary and Flinn 2001).

Recent studies of sex-biased breastfeeding show conflicting results for a test of the Trivers-Willard hypothesis. (Studies of nonhuman primates [Brown 2001] and other mammals [Hewison and Gaillard 1999] also produce conflicting results for such tests.) Among the relatively low-status Mukogodo of Kenya, girls were more likely than boys to be observed nursing (Cronk 2000). Compared with ethnic Hungarians, low-status Gypsies weaned girls later than boys (Bereczkei and Dunbar 1997). In Poland, Koziel and Ulijaszek (2001) found a weak paternal-status × child's-sex interaction effect on breastfeeding duration but no maternal-status × sex interaction. Research in the contemporary United States found no status × child's-sex interaction effect on age at weaning (Keller, Nesse, and Hofferth 2001), and a study of Hutterites concludes that female-biased breastfeeding cannot be attributed to a Trivers-Willard effect (Margulis, Altmann, and Ober 1993).

Absence of the effect in some populations may be due to local factors that alter the sex-specific costs of children (Brown 2001, Sieff 1990). If girls help parents (or relatives) more than boys do, then parents may bias investment toward daughters because expenditures on them are less costly to other components of fitness. Conversely, if sons are more helpful, then we expect male-biased care. Indeed, among foragers, sex differences in subsistence contributions are associated with the juvenile sex ratio, indicating sex-biased parental investment (Hewlett 1991: 23–28). Male-biased parental investment among the Inuit, for example, may be related to hunting and male contributions to family well-being (Smith and Smith 1994). If reproduction is constrained by maternal work, then investment biased toward the more helpful sex can increase parental fitness. Among Hungarian Gypsies, for example, girls take on child-care duties, apparently increasing their mothers' fertility, and are weaned later than boys (Bereczkei and Dunbar 2002). Similarly, in rural Dominica girls spend more time in household work than boys (Quinlan 1995), and this may offset the costs of investing in girls. Sex-specific repayment of parental care has been dubbed "local resource enhancement" (Gowaty and Lenartz 1985). Here we test the hypothesis that female-biased breastfeeding in rural Dominica is attributable to sex differences in children's time allocation to productive activities.

METHODS

Data were collected in the village of Bwa Mawego from 1993 to 1999 as part of an ongoing study of family environment and child health in rural Dominica begun in 1987 (see Flinn and England 2003; Quinlan and Flinn 2003, 2005; Quinlan 2003). Age at weaning was determined through retrospective health interviews conducted in 1993, 1994, 1997, and 1999 and cross-checked by review of individual clinic health cards when available (Quinlan 2004). Although the weaning process usually begins with the introduction of solid food, here we define weaning as the complete cessation of breastfeeding. Cessation of breastfeeding often marks the point at which mothers are no longer willing or able to continue nursing because of other demands on their time and attention. Completed weaning is therefore a good indicator of shifts in parental investment behavior. Another advantage of this measure is that, in contrast to that for other infant feeding transitions, recall of complete cessation of breastfeeding is quite reliable (Quandt 1987). Weaning ages recorded on clinic health cards were highly correlated with mother's recall ($r = .91$). (Quandt [1987] reported a similarly high correlation ($r = .89$) between such measures in another population.) Children's time allocation to productive activity was measured using instantaneous behavioral scans. The method was a modified version of "spot-check" behavioral sampling (Flinn 1988, Hames 1992, Johnson and Sackett 1998, Quinlan 1995). The sample included 1,074 observations of 21 boys and 22 girls between age 5 and 16 years living in two hamlets of Bwa Mawego.

Breastfeeding duration is the child's age in months at weaning (complete cessation of breastfeeding). *Sex* is coded as 1 = male, 0 = female. *Time allocation to productive activity* is the percentage of observations of a child coded as child care, chores, and subsistence activities. *Age* is the mean of a child's age in years in the summers of 1993 and 1994 and is included as a control variable because children's time allocation to productive activity is a linear function of age (Quinlan 1995).

Multiple linear regression with breastfeeding duration as the dependent variable was performed in two steps. In the first model control variables for age and father presence were entered with sex to estimate sex-biased breastfeeding duration. Other studies in the community have shown that father presence is associated with age at weaning (Quinlan, Quinlan, and Flinn 2003) and chil-

dren's time allocation to productive activity (Quinlan and Flinn 2003). Children's time allocation to productive activity and an age × sex interaction term entered the second model to test the hypothesis that sex differences in children's productive activity mediate sex-biased breastfeeding duration: If children repay parental investment through household productive activity, then there should be little association between sex and breastfeeding duration after time allocation to productive activity enters the equation. The age × sex term was necessary to control for sex differences in the association between age and time allocation to productive activity. All other interactions were tested, and nonsignificant terms were excluded from the final analysis. Alpha was set at .10 to compensate for reduced power due to the small sample. Increased alpha is justified by the directional hypotheses for female-biased breastfeeding and the predicted positive association between breastfeeding duration and time allocation to productive activity.

ETHNOGRAPHIC SETTING

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 of 65,000 is of mixed African, European, and Island Carib descent. Most Dominicans are bilingual in English and French-Patois. Bwa Mawego is one of the least-developed villages on the island. It has approximately 700 full- and part-time residents. Economic activities include subsistence agriculture, fishing, and, for a few villagers, wage labor or penny capitalism. Cash crops from smallholdings are an important source of income for many families. Average annual household income in Bwa Mawego is approximately $5,000 E.C. (US$1,850). (For more detailed descriptions see Quinlan, and Flinn 2005, Quinlan 2004.)

Mean surviving offspring for a completed-fertility sample (130 males and 124 females born between 1900 and 1955) is 4.4 for men (95% CI = 3.8–5.1) and 5.0 for women (95% CI = 4.4–5.6), suggesting a low-fertility but growing population. Multigenerational data show no difference in the number of descendents produced through sons or daughters. Adult sex-ratios are balanced for these individuals (Quinlan and Flinn 2005).

Breastfeeding for the first three months is nearly universal in rural Dominica. Physicians and nurses in health centers recommend exclusive breastfeeding for at least 6 months, conforming to World Health Organization (WHO) recommendations. Many women comply, in part because commercial baby formulas are expensive and hard to obtain except in the capital and a few large villages. There is little social stigma attached to breastfeeding, 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. The mean age for introducing food (porridge or bananas) is 6.5 months with a median of 6 months (rated "good" by WHO [2003] standards). Mean age at completed weaning is 12.5 months with a median of 12 months (Quinlan, Quinlan, and Flinn 2003) (rated "poor"). This is slightly higher than in other Caribbean 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 that a doctor or nurse had instructed them to breastfeed for at least 6 months and they had tried to comply. When mothers did give specific reasons for weaning, the most common were breastfeeding's interference with work and an insufficient milk supply (Quinlan, Quinlan, and Flinn 2003). Women living with a long-term mate tended to nurse about 4.5 months longer than single mothers, and women living with multiple adult female kin weaned their children relatively early. Age at weaning was negatively associated with household wealth. These associations are apparently due to differences between families in women's work that interferes with nursing (Quinlan, Quinlan, and Flinn 2003).

Finally, three tests of the Trivers-Willard hypothesis failed to support its predictions (Quinlan, Quinlan, and Flinn 2003). Our predictions of male-biased breastfeeding among (1) women living with their mother or adult sisters, (2) women living with their children's father, and (3) women from wealthier households were not supported in multiple regression analyses. These analyses did show that girls were weaned on average about 3.5 months later than boys.

Women and their daughters in Bwa Mawego do most of the family's domestic chores, and women typically spend more time in productive activity than men (53% versus 30% of daylight hours [Quinlan 1995]). Mothers are primarily responsible for child care, but grandmothers, sisters, and older daughters often help. Girls aged 8–10 years frequently take some responsibility for caring for younger siblings. Girls' time spent in productive activity is a linear function of age ($r = .80$, between 1 and 16 years), and by about 15 years most girls have a fully adult time allocation pattern. Men are responsible for more periodic tasks such as repairing buildings, collecting large amounts of firewood, and hauling bay leaf. In general men spend 20% of their time in productive activity until they enter a long-term conjugal union, when time allocation to production increases to about 40% (Quinlan 1995). Differences between married men's and women's time allocation to production may reflect greater energetic demands for men's work. Boys, however, spend less time in productive activity and more time playing than girls (Quinlan 1995), and their productive activity does not significantly increase with age ($r = .12$, between 1 and 16 years).

Household composition is associated with children's time allocation. Number of adults in the household and time spent with mother are negatively associated with children's time spent roaming the village. Additionally, children living with their father spend significantly more time in productive activity than father-absent children (Quinlan and Flinn 2003).

RESULTS

Descriptive statistics show sex differences and potential confounding variables. Girls were weaned later than boys (fig. 1, *A*; one-tail $p = .042$ by Mann-Whitney test), which is consistent with previous research in a larger sample from this community (Quinlan, Quinlan, and Flinn 2003). Girls also spent more time in productive activity than boys (fig. 1, *B*; one-tailed $p = .003$). There was no sex difference in age, however (fig. 1, *C*; two-tailed $p = .971$), nor was age significantly associated with breastfeeding duration, although a nonsignificant trend was apparent ($r = -.258$, two-tailed $p = .113$; fig. 2, *A*). Age was correlated with time allocation to productive activity for girls ($r = .750$, one-tailed $p < .001$) but not for boys ($r = .002$, one-tailed $p = .497$; see fig. 2, *B*). Finally, productive activity was positively correlated with breastfeeding duration ($r = .362$, one-tailed $p = .001$; fig. 2, *C*).

Regression diagnostics suggested problematic outliers. Descriptive statistics revealed that breastfeeding duration and time allocation to productive activity were significantly skewed (breastfeeding skewness = 2.04, 90% CI = 1.45–2.634; time allocation skewness = 0.70, 90% CI ⩽ 0.11–1.29), which is likely with small samples. Plots of residuals and diagnostic statistics identified four potentially influential outliers, two brothers and two sisters from one family (shown in fig. 1, *A*). The sisters (aged 7 and 11 years) were weaned at 38 and 42 months and were engaged in productive activity in 29% and 25% of observations. Their two brothers (aged 13 and 14 years) were weaned at 24 months and were engaged in productive activity in 0% and 8% of observations; hence, this family with unusually late weaning conformed to the predictions of the repayment hypothesis. When the four outliers were removed from the sample, diagnostic analyses indicated approximately normal errors and nonsignificant skew. Four sibling outliers point to potential hierarchical family effects. Thirty-one children in the reduced sample also had at least one sibling in the sample. An additional multilevel analysis, however, showed little clustering of breastfeeding duration within families. Further inspection of the raw data showed no obvious pattern of residuals.

Two multiple regression models tested the hypothesis that local resource enhancement among females was associated with sex-biased parental investment. Sex was associated with breastfeeding duration in the first regression model, which included age and father presence as control variables. Mean breastfeeding duration was about 3.5 months longer for girls, which is comparable to differences reported in Quinlan, Quinlan, and Flinn (2003:9). The second model tested the repayment hypothesis by entering children's time allocation to productive activity as a predictor. If including time allocation to productive activity appreciably decreases the association between sex and breastfeeding duration, then female-biased breastfeeding duration is associated with girls' greater contribution to household production, which is consistent with the hypothesis. Children's time allocation to productive activity was positively associated with breastfeeding duration (table 2; fig. 3, *A*) and mediated the association between breastfeeding duration and sex. Child's sex was not significantly associated with breastfeeding duration after productive activity entered the model (table 2; fig. 3, *B*), indicating that sex-biased parental investment in the form of breastfeeding was associated with girls' contribution to household labor. Age × sex was included as a control variable because girls' time allocation to productive activity was strongly associated with age and boys' was not (fig. 2, *B*). If age × sex entered model 1 *without* time allocation to productive activity, then sex was still significantly associated with breastfeeding duration and age × sex was not. Conversely, if time allocation to productive activity entered *without* age × sex, then time allocation was significant and sex was not. This pattern shows that the age × sex interaction was significant because of its association with time allocation to productive activity (fig.

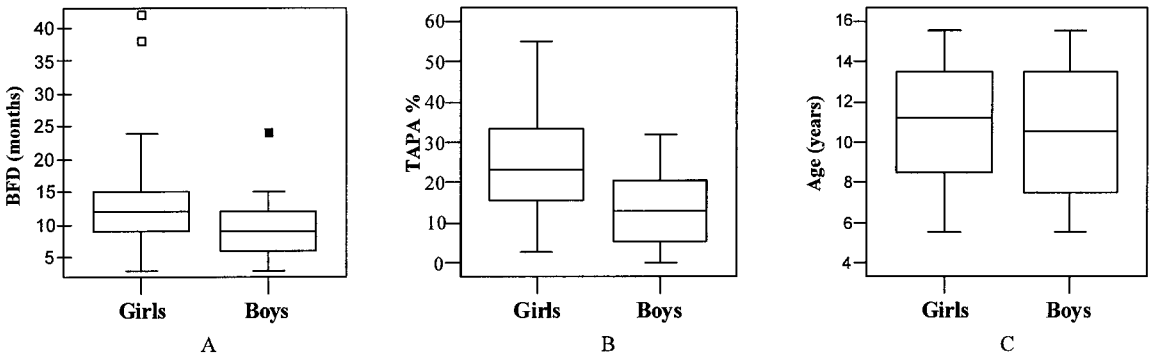

FIG. 1. *Boxplots showing sex difference in* (A) *breastfeeding duration (BFD),* (B) *time allocation to productive activity (TAPA), and* (C) *age for 22 girls and 21 boys. The horizontal line in the center of each box is the median. Upper and lower segments of the box indicate the 25th and 75th percentiles respectively. Small squares indicate outliers.*

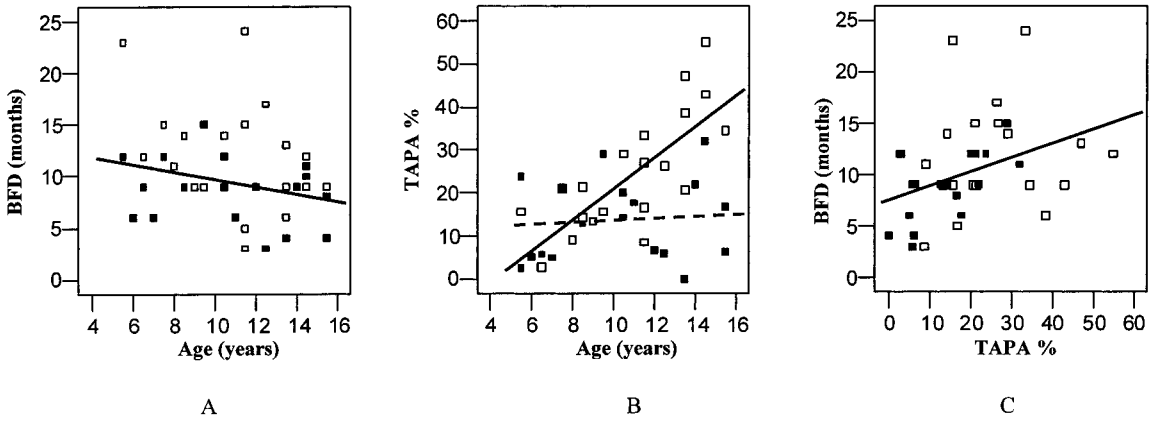

FIG. 2. *Scatter plots showing bivariate correlations between variables in the multiple regression analysis.* White squares, *girls;* black squares, *boys. Lines show linear association.* A, *a non-significant correlation between age and breastfeeding duration (BFD) (*r = −.26*).* B, *age × sex interaction for time allocation to productive activity (TAPA):* solid line, *linear association for girls;* dashed line, *association for boys. Age is significantly associated with girls' (*r = .75*) but not boys' (*r = .002*) TAPA.* C, *a significant association between BFD and TAPA (*r = .36*).*

2, *B*). Other interactions (including sex × time allocation to productive activity) were not significant and were excluded from the final model.[3] In sum, children's residualized time allocation to productive activity accounted for 29% of the variance in residualized breastfeeding duration, and sex accounted for nonsignificant variance.

In a separate analysis including the four outliers, breastfeeding duration and time allocation to productive activity were recoded as 20% Winsorized variables, which may increase accuracy and power (Wilcox 2001). The Winsorized mean for breastfeeding duration of 10.6 months was lower than the non-Winsorized mean of 12.4 but consistent with age at weaning in other Caribbean populations (Perez-Escamilla 1994). Diagnostic analyses indicated normally distributed errors using the complete Winsorized sample ($N = 43$). Winsorized regression yielded more conservative estimates, but the pattern was similar to that of the reduced sample (table 2). Initially sex was significantly associated with breastfeeding duration, but the association was not significant after productive activity entered the model.

Sample size analysis demonstrated that a significant association between sex and breastfeeding duration of $\beta = -.16$ adjusted for covariates (table 2) would require a sample of 450+ children (alpha = .05 and power = .95), which is impossible given the community size and the constraints of formal direct observation. Given these constraints, it is appropriate to consider that the association between sex and breastfeeding was largely mediated by productive activity.

3. Here interaction terms are the product of two first-order variables centered around their means (e.g., age × sex = [age − mean age]*[sex − mean sex]). Interaction terms did not substantially increase variance inflation factors.

DISCUSSION

The results suggest that mothers in Bwa Mawego may make weaning "decisions" anticipating that children will repay parental investment through household work. The completed weaning variable in this well-nourished low-fertility population indicates maternal costs of breastfeeding primarily as lost opportunities to engage in other activities.

Other research in Bwa Mawego showed potential indirect fitness benefits from daughter-biased parental investment. Reproductive success was higher among men from kin groups with a female-biased sex ratio, though the effect may be due to competition among male kin rather than female resource enhancement (Quinlan and Flinn 2005). Number of sisters in the community, however, influenced neither male nor female fitness, suggesting that kinswomen's mutual aid is diffuse among a broad kin group. Previous research did indicate that having sisters *coresident* in a household had effects on components of female fitness (Quinlan 2001). In sum, indirect fitness gains in Bwa Mawego may be rooted in reciprocity among mothers, daughters, and sisters.

Weaning decisions may not be entirely conscious, and the psychological mechanisms for sex-biased parental investment are unknown. Some informants claim to give equal treatment to their boys and girls; however, weaning data for children of those informants show female-biased breastfeeding duration by as much as five months. (Senior [1991:33] reports similar unstated female bias in several Caribbean populations.) Other village mothers say that, compared with boys, "girl-babies are easy." Culturally patterned relations among and between sexes may affect willingness to continue nursing a particular child.

TABLE 2
Multiple Linear Regression Showing Effects of Sex and Time Allocation to Productive Activity on Age at Weaning

	B	SE	*β*	*t*	*P*
Breastfeeding duration ($N = 39$)					
Model 1 (adjusted $R^2 = 16$, $P = .028$)					
Intercept	16.13	2.62	–	6.22	0.000
Age	−0.47	0.23	−0.316	−2.09	0.044
Father present	1.49	1.39	0.162	1.07	0.291
Sex	−3.53	1.38	−0.384	−2.56	0.015
Model 2 (adjusted $R^2 = .38$, $P = .001$)					
Intercept	16.02	2.30	–	6.31	0.000
Age	−0.90	0.23	−0.603	−4.00	0.000
Father present	0.17	1.27	0.019	0.14	0.892
Sex	−1.47	1.36	−0.160	−1.08	0.289
Time allocation to productive activity	0.25	0.07	0.702	3.68	0.001
Age × sex	1.18	0.45	0.400	2.61	0.014
Winsorized breastfeeding duration ($N = 43$)					
Model 1(adjusted $R^2 = .17$, $P = .017$)					
Intercept	12.92	1.73	–	7.45	0.000
Age	−0.24	0.15	−0.230	−1.61	0.115
Father present	2.24	0.94	0.341	2.39	0.022
Sex	−2.05	0.92	−0.317	−2.24	0.031
Model 2 (adjusted $R^2 = .28$, $P = 004$)					
Intercept	11.55	1.80	–	6.41	0.000
Age	−0.37	0.15	−0.345	−2.49	0.018
Father present	1.33	0.96	0.203	1.39	0.174
Sex	−1.10	1.01	−0.169	−1.09	0.283
Winsorized time allocation to productive activity	0.16	0.07	0.438	2.45	0.019
Age × sex	0.69	0.30	0.331	2.27	0.029

NOTE: *B*, unstandardized regression coefficient in months of breastfeeding duration; *SE*, standard error of *B*; *β*, standardized regression coefficient; *t*,*B*/*SE*; *P*, significance; R^2, proportion of variance in breastfeeding duration explained by the model. Log-transformed breastfeeding duration was regressed on variables in model 2 in an additional analysis (not shown) that included the outliers and yielded similar results to the Winsorized regression.

Family life in Bwa Mawego is strongly matrifocal. As elsewhere in the Caribbean, reciprocity between mothers and daughters often forms the core of stable family relations. Households in Bwa Mawego are usually linked through women. Villagers often recognize a man as the owner of a house (e.g., "down past Roger's house"), but they identify *households* with women (e.g., " she stays with Margaret and them"). Female kin organize and carry out economic enterprises and maintain reciprocal child care arrangements that may entail costs to reproduction (Quinlan 2001).

In contrast, relations between Caribbean men and women are sometimes antagonistic (Senior 1991: 166–84). Caribbean mothers also appear to be stricter and more demanding with daughters than with sons, which may reflect indifference as well as indulgence toward sons (cf. Senior 1991:33–36; Moses 1985). These relationship qualities may be due to unbalanced reciprocity between the sexes (e.g., Barrow 1999:72–79). Extreme and unpredictable variability in men's contribution to families suggests local motivation for daughter-biased investment. Some men in Bwa Mawego contribute significantly to household wealth, but access to resources through wage labor and commercial agriculture is limited and unreliable. In impoverished Caribbean areas, skilled men often emigrate, and those who stay behind may have little earning potential or pursue risky illegal trade (Williams 2002). Further, men's income is often channeled into luxury items and alcohol. Rum drinking, a common problem among village men, interferes with productivity and family relations. Lack of opportunity and widespread alcohol abuse can make a man unreliable and a periodic drain on family material and emotional resources. Stable conjugal families exist, but those households often develop into a matrifocal variant as daughters are unwilling (or unable) to enter a neolocal or patrilocal conjugal relationship (Quinlan and Flinn 2003). Sons of respected village families are not guaranteed to escape the risks of Caribbean social ecology. Male economic and social marginality (perhaps associated with antagonistic relations between the sexes) is a part of life that village women cannot ignore, and this may lead them to bias their attention and energy to more reliable relationships among female kin. We propose, then, that local environmental risks that can be reduced through parental care (see Borgerhoff Mulder 1992, Quinlan 2003) may be gender-specific and therefore affect sex-biased parental investment. In general, environmental unpredictability associated with sex differences in reproductive value tends to reduce sex-biased parental investment (West and Sheldon 2002), but gender cultures among humans (see Helman 2001:109–14) allow for dif-

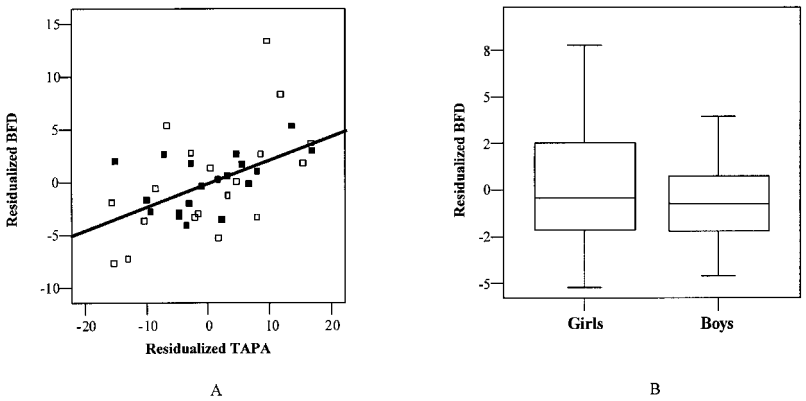

FIG. 3. A, *partial regression plot showing the association between breastfeeding duration (BFD) and time allocation to productive activity (TAPA) after both variables have been adjusted ("residualized") for the other variables in table 2, model 2 ($r^2 = .291$).* B, *sex differences in residualized BFD. Comparison of B with figure 1,* A, *shows that sex-biased breastfeeding is statistically mediated by children's time allocation to productive activity.*

ferent levels of predictability for men and women. This possibility is not a variant of the Trivers-Willard hypothesis (no gradient of parental condition is necessary) but rather illustrates the complexity of parental investment in humans.

An alternative interpretation is that sex-biased breastfeeding and children's time allocation covary in ways that mask a Trivers-Willard effect. For example, women at one end of a resource gradient may be more likely to have daughters, breastfeed them longer, and demand more work from them. Inspection of the raw data, however, shows that female-biased breastfeeding is evident in many families with balanced sex ratios. Rather, female-biased parental investment appears to be related to expected sex differences in contributions to family well-being.

Studies in other populations indicate complex relations among socioeconomic status, household productivity, and sex-specific costs of children that may result in misleading conclusions. For example, one study comparing Gypsies with ethnic Hungarians found that female-biased parental investment among Gypsies was consistent with the Trivers-Willard model, predicting female-biased investment in low-status families (Bereczkei and Dunbar 1997). Subsequent research, however, found that Gypsy girls spent more time engaged in child care than ethnic Hungarians and that low-birth-order daughters decreased mothers' interbirth interval and increased fertility, consistent with local resource enhancement (Bereczkei and Dunbar 2002). An apparent Trivers-Willard effect may, then, be due to different patterns of children's time allocation in the two ethnic groups.

Multiple factors may work to create patterns of parental investment that are difficult to tease apart. For example, among Gabbra pastoralists of Kenya, male reproductive success is more sensitive to household wealth than female reproductive success, males with older brothers tend to have reduced fertility, and females repay a portion of parental investment through bride-price (Mace 1996). Three models of sex allocation (Trivers-Willard, resource enhancement, and resource competition [see Sieff 1990]) apparently account for different facets of parental investment in one population. The cross-cultural trend for girls to contribute more to domestic work than boys (Whiting and Edwards 1988) suggests, again, that parental investment strategies may be difficult to observe in many populations, and domestic work is just one factor that may influence sex-specific costs of children. Despite the possibility of multiple influences on sex-biased parental investment, previous research in Bwa Mawego found female-biased breastfeeding inconsistent with a Trivers-Willard effect (Quinlan, Quinlan, and Flinn 2003) or its variant the "advantaged daughter" hypothesis (see Hiraiwa-Hasegawa 1993), but the findings reported here are consistent with local resource enhancement.

This study has limitations, and the small sample warrants caution. The results, however, address previously unexplained female-biased breastfeeding in Bwa Mawego and justify further research and replication in similar communities. Factors influencing gender relations and parental care in Dominica (poverty, male marginality, and cooperative female kin) may be common to many rural communities in developing nations—precisely where breastfeeding may be most important for child well-being.

In sum, evolutionary ecology offers new avenues for understanding gender relations and child well-being in the Caribbean and elsewhere. This study shows that girls spend more time in productive activity than boys and that this difference statistically mediates sex-biased breastfeeding in Bwa Mawego, a horticultural village in the Commonwealth of Dominica. Empirical advances concerning parental investment and components of fitness await research into locally determined household labor demands, residence patterns, relations among kin

groups, gender differences in environmental risks, and sex-specific costs of children. Such research depends on longitudinal multimethod, multilevel analyses.

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Human Migrations in Continental East Asia and Taiwan: Genetic, Linguistic, and Archaeological Evidence

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A multidisciplinary conference held in Geneva in June 2004[1] brought together geneticists, linguists, and archaeologists to debate a wide range of hypotheses concerning the origins and early dispersal histories of a number of major human populations in East and Southeast Asia. This conference followed a predecessor entitled "The Peopling of East Asia," held in Périgueux in 2001

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