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Fosterage as a System of Dispersed Cooperative Breeding

Evidence from the Himba

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Abstract Humans are obligate cooperative breeders, relying heavily on support from kin to raise children. To date, most studies of cooperative breeding have focused on help that supplements rather than replaces parental care. Here we propose that fosterage can act as a form of dispersed cooperative breeding, one that enhances women's fitness by allowing them to disinvest in some children and reallocate effort to others. We test this hypothesis through a series of predictions about the costs and benefits of fosterage for mothers, foster parents, and foster children using data from the Himba, a group of Namibian agro-pastoralists. We show that fostering out children enhances mothers' fitness, and we provide evidence for a causal link from fosterage to enhanced fitness by showing that fosterage of early-born children is associated with greater maternal reproductive success. Foster parents minimize the costs of fosterage by skewing their care toward their postreproductive years, and by mainly fostering close kin. However, the system is associated with some detrimental effects on foster children, who are more likely to be stunted and underweight than their non-fostered counterparts.

Keywords Fosterage · Cooperative breeding · Himba · Child nutrition

Humans are unusual among primates because our offspring develop exceptionally slowly and mothers are often responsible for the care of more than one dependent child at the same time (Hawkes et al. 1998; Mace 2000). Studies of modern foragers indicate that the nutritional needs of mothers and their offspring are partially subsidized by the foraging efforts of other group members (Hawkes et al. 1997; Hill and Hurtado 1996), and Hrdy (2005, 2009) has persuasively argued that humans have become obligate cooperative breeders. Help from other group members typically supplements

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parental care but does not replace it entirely. However, in some societies parents routinely delegate primary care of their offspring to others (Volk 2011). For example, ethnographers and demographers have documented high rates of adoption in Oceania (Bowie 2004; Carroll 1970) and the North American Arctic (Guemple 1979), and high rates of fosterage throughout sub-Saharan Africa (Alber 2003; Bledsoe and Isiugo-Abanihe 1989; Isiugo-Abanihe 1985). Even in societies in which adoption and fosterage are uncommon, death, divorce, and serious illness of biological parents sometimes necessitate that children will be reared by individuals other than their biological parents. Such variation in childrearing practices provides an opportunity to examine the cultural and biological forces that shape decisions about who raises children and to assess the outcomes of such decisions on children, their biological parents, and their caretakers.

The prevalence of adoption and fosterage around the world has presented an important challenge to evolutionary anthropologists because the temporary or permanent transfer of responsibility for children's care seems to violate the basic logic of evolutionary theory (Sahlins 1976). If parental fitness depends directly on the welfare of one's children, and childrearing is a costly endeavor, then why would parents allow their children to be raised by others? Furthermore, why would people take on the costly responsibility of caring for children who are not their own?

Qualitative analyses of the pattern of adoption in Oceania and the North American Arctic, and fosterage in Africa, suggest that decisions about giving up children and taking in children are largely consistent with predictions derived from evolutionary theory (Silk 1980, 1987a, b, 1990). Biological parents mainly give children up for adoption or fosterage when they cannot care for them and their other children properly. For example, parents in Burkina Faso foster out more often when they have experienced negative income shocks (Akresh 2009); among the Herero, fosterage is common among mothers who bear children out of wedlock (Pennington 1991); and in West Africa, parents foster their children out to wealthier or more urban families to facilitate their education and training (Bledsoe and Isiugo-Abanihe 1989; Goody 1969).

Children are typically adopted or fostered by close relatives, suggesting that kin selection underlies many fosterage transactions (Silk 1987a, b, 1990). In addition to the inclusive fitness benefits, foster parents sometimes gain other advantages from these interactions as well, either directly via child labor (Ainsworth 1996) or other material gains (Bledsoe 1990) or more indirectly through social benefits, as demonstrated in the Micronesian island of Ifaluk where the children of high-ranking men are frequently fostered in, solidifying ties that are beneficial to the foster parents (Betzig 1988). The effects of fosterage on children are more mixed. In some cases, fosterage has negative effects on child health and welfare (Bledsoe et al. 1988; Madhavan and Townsend 2007; Monasch and Boerma 2004; Oleke et al. 2006), while in others, fostered and non-fostered children fare equally well (Anokhi et al. 2007; Castle 1995; Lindblade et al. 2003; Shell-Duncan 1994; Sudre et al. 1990).

Detailed quantitative analyses of the costs and benefits of adoption and fosterage, framed with an evolutionary perspective, are rare (but see Pennington 1991 and RendeTaylor 2005 for exceptions), and most studies focus on outcomes related to only one of the involved parties. Here, we examine decisions about fosterage made by both biological and foster parents and assess the impact of foster care on the growth and nutritional condition of children among the Himba, agro-pastoralists in northern Namibia.

Study Population

The Himba reside mainly in the Kunene region of Namibia, in an area referred to as Kaokoveld. They are culturally, linguistically and genetically very similar to the Herero and were part of the Bantu expansion that moved east and south through Africa over the past thousand years (Malan 1995). While the two groups were historically considered as one, or more commonly the Himba were considered a subgroup of Herero, recently the unique ethnic identity of the Himba has been emphasized both by scholars and politicians and by the Himba themselves (Bollig 2006). Unlike most Bantu, the Himba and Herero are pastoralists rather than subsistence farmers. The Himba/Herero likely arrived in Namibia in the seventeenth and eighteenth centuries, and today there are about 25–50 k Himba in the region. In addition to caring for large and small livestock, some Himba now maintain gardens, growing maize, sorghum, melons, and gourds. In the area where this study was conducted (the Omuhonga Basin), these gardens now constitute an important source of calories, and the Himba here may be more accurately described as agro-pastoralists.

The Himba practice "double descent," which means that rights, obligations, and material goods are passed down through both the maternal and paternal lines (Malan 1973). Specifically, the Himba pass on territorial and ritual rights through the patrilineage and the majority of material wealth matrilaterally, between men in the maternal line (e.g. mother's brother to sister's son). Additionally, every individual maintains membership in both a patriclan and a matriclan, Their residence pattern is patrilocal, but frequent visitations occur, which results in women continuing to have periodic access to their kin, particularly around times of pregnancy and childbirth (Scelza 2011b). Polygyny is practiced, but women maintain a large degree of autonomy in their everyday lives and in their marital and reproductive decisions. Throughout their reproductive careers, Himba women make decisions about where to live, which children to take along when they move from one residence to the next, and whether to foster children in or out of their own households (Scelza 2011a). Divorce is common and can be initiated by either party, and both out-of-wedlock births and extramarital affairs are normatively allowed (Scelza 2014). A substantial proportion of children in this population are the product of married women's extramarital affairs (Scelza 2011b). The combination of low paternity certainty, matrilateral inheritance, and the importance of matriclans means that maternal kin play an especially important role in this society. Additional details about contemporary Himba lifestyles can be found elsewhere (Bollig 2006; Malan 1995; Scelza 2011a).

The Himba are a particularly appropriate population for studying fosterage for several reasons. First, the practice is very common, providing a large sample of fostered children to study. Second, fosterage among the Himba occurs for a variety of reasons, and this allows us to determine how differing circumstances and motivations for fosterage are linked to the outcomes of foster children. One of the most common reasons that fosterage occurs among the Himba is because the child's mother has experienced some type of marital or reproductive shift. For example, if a child is born out-of-wedlock and the mother then marries, or if the mother is divorced and remarries, she may place a child or children into foster care when she moves to the household of her new husband. Himba women rarely use contraception and have fairly short interbirth intervals (IBI between 1 and 3 years). Women who have children in quick

succession often place the elder child into fosterage when the next child is born. In other cases, it is the foster parent who requests a child from the biological parent, often either to aid them in their old age or to help with household labor. A final significant cause of fosterage occurs in cases of parental death. A third reason that the Himba are an ideal population to study fosterage is that children play a critical role in household production from a young age. This makes them valuable to their caretakers, but it also means they may be at risk of being overworked or underfed in some circumstances. There is a gendered division of labor among the Himba, starting from middle childhood. Girls are expected to help with work in the household, such as grinding maize, cooking, and milking goats, as well as assisting with heavier labor such as the transport of water or firewood. Young boys also help with carrying water, but their main work is in herding small livestock.

Theory and Predictions

Our analyses address a series of predictions about fosterage derived from evolutionary theory (Table 1). More specifically, the cooperative breeding framework provides a particular lens through which we study the interrelated perspectives of the affected parties: biological parents (BP), foster parents (FP), and foster children (FC). These analyses are not designed to determine whether fosterage is an "adaptive" or "maladaptive" cultural practice, but rather to determine whether BP and FP make use of the fosterage system in ways that seem to increase the benefits that they accrue and reduce the costs that they incur. Although children are not active participants in decisions about their own fosterage, we examine their outcomes in order to assess more fully the costs and benefits of fosterage to biological and foster parents.

Fosterage from the Perspective of Biological Parents

Biological parents are more likely to foster children out if they are unable to provide adequate care for all of their children. Women's ability to provide adequate care for their children may be affected by the number of children they have and the spacing of their births (interbirth intervals). We predict that BP with many children will be more likely to foster children than BP with fewer children. When children are born in quick succession, it may be difficult for mothers to provide adequate care for both newborns and older offspring. Therefore, short interbirth intervals are also expected to be linked to the decision to foster children out.

Women's decisions to foster may also reflect the amount of support that they can obtain within their households. Himba women move to their husbands' households when they marry. Early in their reproductive careers, women have few older children to help them with childcare and other household tasks and may not have developed close relationships within their marital households. Thus, young women may benefit more from fosterage than older women, particularly in societies such as the Himba with patrilocal postmarital residence norms. If this is the case, then we would expect early-born children to be fostered at higher rates than later-born children.

Biological parents who give up a child for fosterage are relieved of the need to feed, house, clothe, and care for that child. To the extent that these activities represent a form

Table 1 Model Predictions and Summary of Results

Focal Individual(s)	Prediction	Supported?
Biological Parent (BP)	*1. Fosterage will occur when it eases mothers' reproductive burden*	
	a) Mothers of higher parity will foster children out more often	+
	b) Short interbirth intervals will be a common reason for fosterage	+
	c) Early-borns will be more likely to be fostered out than later-borns because mothers have less help and fewer resources early in their reproductive careers	+
	2. Fosterage will have a positive impact on mothers' reproductive success	
	a) Fostering a child out will be positively correlated with maternal RS	+
	b) Women who foster an early-born will have greater subsequent fertility (indicating a causal arrow from fosterage to fertility)	+
Foster Parent (FP)	*1. Others will bear the burdens of foster care when the costs are low and/or the benefits are high*	
	a) Women with more children (especially more dependent children) will be less likely to take in a foster child	+
	b) As they age, women will be more likely to take in a foster child, particularly after reaching menopause	+
	c) Women who request a foster child for help in their household will have fewer children of their own than women who foster children in for other reasons	−
	d) Women with fewer children of one sex should be more likely to foster in children of that sex	+
Biological and Foster Parents (BP & FP)	*1. Kinship will play and important role in fosterage decisions*	
	a) Closely related individuals are more likely to act as FP than less related or unrelated parties	+
	b) Maternal kin will foster in more often than paternal kin owing to high rates of paternity uncertainty	+
Foster Children (FC)	*1. Foster children will have worse health outcomes than biological children*	
	a) Foster children will have lower HAZ, WAZ, and WHZ than non-fostered children of the same sex and age	+/−
	b) Foster children's nutritional deficits will be inversely related to the degree of relatedness they have to their FP	−
	c) Children fostered by maternal kin will have better health outcomes than those fostered by paternal kin	−
	2. The context of fosterage will affect the health outcomes of foster children	
	a) Children who were requested by FP will have better health outcomes than those who were fostered in under other circumstances	−

of parental investment *sensu* Trivers (1972), fosterage should have a positive impact on maternal fertility and infant survival. A positive correlation between fosterage and fertility might arise because women with many children are more likely to give children up for fosterage, or because fosterage enhances future female fertility. One way to

disentangle the causal connection is to examine the impact of early fosterage on women's later fertility. If fosterage is used to promote future fertility, we expect: (a) early-born children will be more likely to be fostered than later-borns; (b) women who foster an early-born will have greater reproductive success than those who do not foster early-born offspring.

Fosterage from the Perspective of Foster Parents

Foster parents who take on primary responsibility for rearing children are more likely to be able to bear these costs if they have fewer dependent children of their own to care for. Thus, we would expect to observe a negative relationship between the number of dependent BC and FC women have. In addition, we expect that the relationship between the number of dependent BC and FC will be stronger for women who are still in the active part of their reproductive careers than for postmenopausal women who may be shifting investment toward grandchildren. As women reach the end of their reproductive careers, they will have fewer dependent children of their own to care for, and we would therefore expect a positive relationship between women's age and the number of foster children in their households. Similarly, postmenopausal women are expected to have more foster children in their households than premenopausal women.

In some cases, FP may be motivated to request a foster child because they need help in household tasks. We expect that women who request a foster child for help in the household will have fewer children than those who foster in for other reasons or than women who do not foster in children at all. We also expect sex differences in which children are fostered in according to household demography. Pastoralist societies such as the Himba exhibit a sexual division of labor among children (Malan 1995). Thus, we would expect that women with fewer children of one sex should be more likely to take in foster children of that sex.

Fosterage from the Overlapping Perspectives of BP and FP

Kinship is expected to play an important role in fosterage decisions of both BP and FP. Because foster parents may gain inclusive fitness benefits from rearing related children, they are expected to be more willing to take in related than unrelated FC and more motivated to provide good care for related than unrelated FC. If this is the case, then BP are expected to prefer that their children be fostered by relatives rather than nonrelatives. Among the Himba, we would also expect to find matrilineal biases in fosterage decisions. High rates of extrapair paternity, even where husbands are aware of such trends, generate lower confidence of relatedness for paternal kin. Thus, we would expect maternal kin to play a more active role in fosterage than paternal kin.

Fosterage from the Perspective of Foster Children

We expect BP to choose FP who are able and willing to provide good care for their children, but FP will inevitably be more closely related to their BC than to their FC. Moreover, because parents' ability to provide resources for children is limited, there may be direct or indirect competition for resources among FC and BC, and we might expect to find that FC are disadvantaged in some ways. They may be expected to work

harder or be fed less, both of which could produce differences in the nutritional status of BC and FC.

We predict that FC should fare worse for their sex and age than children living with their biological parents. We also predict that the nutritional deficits of FC will be inversely related to the degree of relatedness between FC and FP. Low paternity confidence may also generate disparities in care for children fostered by maternal and paternal kin.

The circumstances that lead to fosterage are also expected to affect outcomes for FC. Children who are fostered in to provide help with household tasks are expected to fare better than children who are fostered in for other reasons. This is predicted because BP may be more likely to respond to fosterage requests by giving up children who are in good health and because foster parents that initiate fosterage transactions may be better equipped to deal with the costs of additional children and value their labor more highly.

Methods

Life history interviews, which included a series of questions about fosterage, were conducted with 117 Himba women (Table 2). All adult women residing in each of 23 compounds were eligible to be interviewed. Four women declined. Questions were asked about who raised the women, who raised each of their children, and whether they had fostered in any children they did not give birth to. Details on the circumstances of each fosterage event were also recorded, including the genetic relationship between the foster parent and the child and the reason for fosterage. Age at the time of fosterage was unfortunately not collected for the majority of individuals, so this could not be included as a covariate in analyses. However, the most common age for fosterage to occur among the Himba is at the time of weaning (about 2–3 years old). Complete reproductive and marital histories for each woman were also compiled. These data were then used to construct a demographic database with information on the women and each of their children (n=669).

Information on height and weight was collected on a subset of individuals who were present in the focal compounds at the time life history interviews were conducted. Anthropometric data on 192 children aged 2–16 were available (n_{FC}=77; n_{BC}=115). Height and weight were assessed using a digital medical SECA scale with fixed stadiometer. Children were measured in light clothing and without shoes. Information on children's fosterage status, reason for fosterage, and relationship to foster parent was collected at the time of measurement or during life history interviews with their mother or caretaker.

Data on height, weight, and age were used to create standard anthropometric measurements—weight-for-height, height-for-age, and weight-for-age—and these values were then converted to Z scores using the 2000 CDC growth standards as a reference population with the program Epi-Info 7. Weight-for-height is a measure of acute malnutrition or wasting, height-for-age is a measure of chronic malnutrition or stunting, and weight-for-age is a measure of protein energy malnutrition or underweight. Although anthropometric Z scores are standardized for age and sex, the wide age range among our participants (2–16), as well as differences in the growth

Table 2 Demographic Characteristics of Study Population

	Adult Sample (N=120)		Child Sample (N=669)[b]		Child Sample (N=192)[c]	
	Biological Parents (BP)	Foster Parents (FP)	Biological Children (BC)	Foster Children (FC)	Biological Children (BC)	Foster Children (FC)
N	117	51	469	200	116	77
Mean age (min, max)	46.15 (19, 88)	55.86 (20, 87)	24.61 (0, 88)	17.21 (0, 91)	6.11 (2, 16)	7.23 (2, 16)
% postreproductive (age>45 years)	49.6	76.5	1.73	0.8	–	–
Mean reproductive success (SD)[a]	3.95 (2.48)	4.12 (2.82)	–	–	–	–
Mean sibship (SD)	–	–	5.21 (2.37)	5.13 (2.65)	–	–

[a] Includes women who have yet to complete their reproductive careers. The average reproductive success of the postreproductive BP in the sample is 4.43 (n=58, SD=2.80) and of the FP is 4.38 (n=39, SD=3.04). Reproductive success is defined as the number of children surviving to age 5

[b] This sample consists of all individuals (women and children) for whom we have data on their own fosterage histories (i.e., whether an adult woman was fostered when she was a child)

[c] This sample includes only children aged 2–16 for whom we have anthropometric data

trajectories and pubertal timing of boys and girls, mean that it is important to look for fosterage effects after controlling for age and sex, which we have done. Because birth order and number of siblings are hypothesized to affect the chances of being fostered, we also added these variables to our initial analyses, but neither had a significant effect on any of the anthropometric outcomes so they were dropped from the final models.

Results

Fosterage is common among the Himba. Of the 117 adult women interviewed, 38% had fostered out at least one child and 44% had fostered in at least one child. Similarly, of the 194 children in the anthropometric database, 39% were being fostered at the time of data collection.

We ascertained the reason for the fosterage of 200 children (Table 3). Twenty percent of all fosterage events occurred because one or both parents had died or become gravely ill. About half of the remaining cases of fosterage were initiated by mothers who fostered out children from previous relationships when they married (21%) or had short intervals between successive births (24%). Foster parents initiated 19% of all fosterage transactions because they wanted help with household tasks (13%) or they wanted to strengthen relations with family members (6%). In the remaining cases (18%), the reasons for fosterage were unclear.

Fosterage occurs almost exclusively among kin (Table 3), with a modal degree of relatedness between FP and FC of 0.25, which in the demographic sample included grandmothers (38.5%), aunts (20%), and uncles (9%). However, the degree of relatedness between FP and FC varies depending on the reason for fosterage, with the highest degree of relatedness when fosterage is attributed to marriage of the mother and the lowest degree of relatedness when fosterage is linked to labor assistance or maintenance of family relationships (Table 3).

There is also a strong bias in favor of fosterage by maternal kin. Among foster children in the demographic sample, significantly more than half were fostered by maternal kin (n=177, 62.71%; binomial probability <0.001). The primary exception to this pattern occurs when children are fostered after the death of one biological parent: nearly three-quarters of children that were fostered after the father's death went to

Table 3 Reasons for Fosterage

	N=200[a]	Party Initiating the Fosterage Transaction	Mean Degree of Relatedness between FP and FC
Parent sick or died	39 (19.5%)	Neither	0.24
Mother marries/remarries	42 (21%)	BP	0.40
Short IBI/too many children	47 (23.5%)	BP	0.25
Labor assistance in FP household	26 (13%)	FP	0.20
Keep up family relations	11 (5.5%)	FP	0.19
Reason unknown/other	35 (17.5%)	–	0.24

[a] This sample consists of all fostered individuals (adults and children) for whom the reason for their fosterage was known

paternal kin (5 of 7), whereas all children who were fostered after the mother's death went to maternal kin (n=6; Fisher's exact test, p=0.021). Children who were fostered by a paternal relative were more closely related to their FP than those fostered in by a maternal relative (maternal: 0.24 [SE=0.016], paternal: 0.36 [SE=0.004], t=9.20, df=175, p<0.0001).

Women who have produced more children have also fostered more children out (n=117, r^2=0.42, p<0.001). This result holds for a smaller sample of women (n=88) in which we could control for a number of other factors that influence women's reproduction, including the number of times they have been married, whether they have produced a child out of wedlock, and the sex ratio of their children (Table 4). In addition to parity, birth order also affected fosterage. Holding children's age and sex constant, birth order is negatively associated with the likelihood of being fostered (Logistic regression, n=402, birth order: coef.=−0.210, SE=0.078, p=0.007; current age: −0.019, SE=0.008, p=0.015; child gender: −0.315, SE=0.272, p=0.248).

If fosterage enhances the fitness of BP, then we would expect women who foster out many children to have higher reproductive success than women who foster few or no children. This is suggested by the correlation between the number of children born and the number of children fostered, reported above. Among postreproductive women, there is also a strong positive correlation between the number of children fostered out and the number of children that survive to age 5 (r=0.48, p<0.001, n=58). When mothers decide to foster out an early-born child (here considered to be either their first- or second-born), they reap particular reproductive advantages. Early-born children who were fostered out by their mother's choosing had on average 5.57 (SE=0.49) biological siblings, whereas early-borns who were not fostered had on average 4.15 (SE=0.18) biological siblings (t=−3.02, df=179, p=0.003). Results from the women's life history sample are similar. Women who fostered more early-born children had greater subsequent fertility (Full sample, controlling for age, Poisson regression, coefficient=0.21, SE=0.08, p=0.008, n=117; Post-menopausal sample, Poisson regression, coefficient=0.23, SE=0.10, p=0.027, n=58).

Women are expected to foster in more children when they have fewer dependent children of their own to care for. There is a strong, negative relationship between the number of children a woman had ever produced and the number of children she had ever fostered in (Poisson regression: coefficient=−0.36, SE=0.14, p=0.01, n=117, controlling for women's age). This pattern is more pronounced when the analysis is limited to the number of dependent children under the age of 5 a woman has (Poisson regression, coefficient=−0.96, SE=0.27, p<0.001, n=117, controlling for women's

Table 4 Factors affecting the number of children fostered out

	Coef.	SE	p
Number of children	0.19	0.05	0.000
Age at first birth	0.02	0.03	0.597
Out-of-wedlock birth (binary)	0.55	0.24	0.021
Ratio of sons:daughters	0.17	0.09	0.052
Number of marriages	0.16	0.19	0.410

age). Similarly, as women reach the end of their reproductive careers, and consequently have fewer dependent children of their own to care for, they tend to foster in more children (r=0.41, p<0.0001, n=117). Postmenopausal women have on average 1.34 children fostered in, compared with an average of 0.24 children currently fostered by reproductively active women (t=−5.36. df=115, p<0.0001).

In the subset of children who are fostered in to provide extra household labor, there is no relationship between the number of dependent children (under age 12) that a woman has in her household and whether she has fostered in a child to provide help. However, women who have a dearth of help from children of one sex do foster in more children of that sex. Women who have more dependent daughters in the household (12 and under) are less likely to foster in a girl (Poisson regression, coefficient=−1.39, SE=0.41, p=0.001, n=117) than other women. There is a similar effect for boys; the number of dependent sons in the household is negatively, but not significantly, associated with the number of boys fostered in (Poisson regression, coefficient=−0.050, SE=0.26, p=0.059, n=117).

Impacts of Fosterage on Children

In general, Himba children fall below CDC standards for weight-for-height, height-for-age, and weight-for-age (Fig. 1 a-d) though they are fairly robust compared with children in other small-scale African pastoralist communities (Little et al. 1983; Sellen 2000). However, FC have more pronounced deficits than BC. After controlling for age and sex, we found that children living in foster households had lower nutritional scores for weight-for-height (WHZ), weight-for-age (WAZ), and height-for-age (HAZ), though only WAZ was significantly lower for the fostered group (Table 5). However,

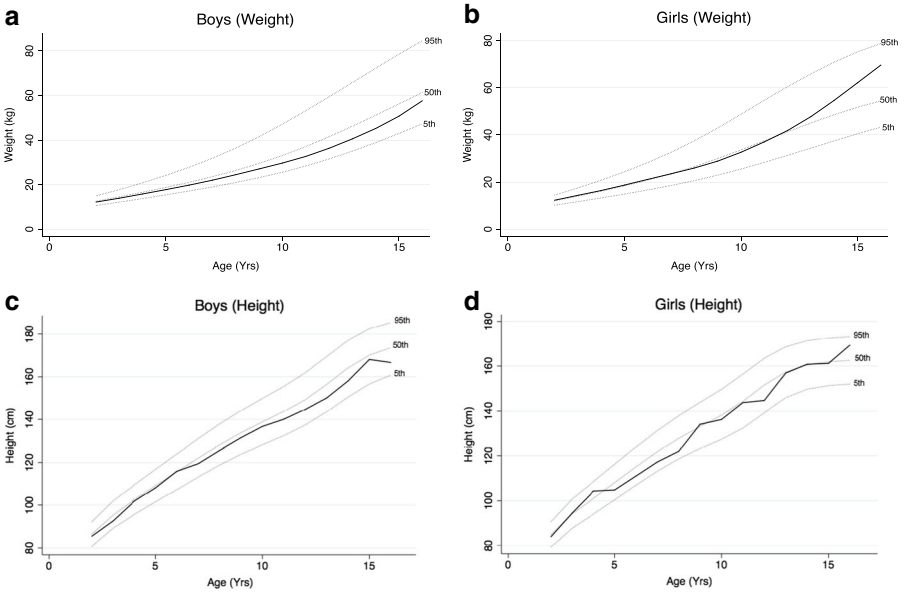

Fig 1 (**a-d**): Himba Child Nutrition Scores. Solid lines: Lowess smoothed Himba data. Dotted lines: Lowess smoothed CDC 2000 data for 5th, 50th, and 95th percentiles

Table 5 Linear Regressions: effects of fosterage status on nutritional outcomes of children (aged 2–16, N= 192)

	WHZ			WAZ			HAZ		
	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*
Mean *Z* scores[a]									
Fosterage status	−0.29	0.16	0.076	−0.38	0.17	**0.023**	−0.32	0.21	0.122
Age	−0.03	0.02	0.106	−0.02	0.02	0.351	0.01	0.03	0.743
Sex	−0.22	0.16	0.158	−0.50	0.17	**0.003**	−0.66	0.21	**0.002**
Z scores >2 SD below the mean[b]									
Fosterage status	0.02	0.03	0.518	0.08	0.04	**0.046**	0.15	0.05	**0.005**
Age	0.00	0.00	0.686	0.01	0.01	0.745	−0.00	0.01	0.510
Sex	0.03	0.03	0.434	0.07	0.04	0.070	0.08	0.05	0.104

[a] Negative coefficients for fosterage indicate that fostered children had lower scores than non-fostered children. *Z* scores are based on comparisons with the CDC 2000 reference population

[b] Positive coefficients for fostered children indicate that these children are more likely to be malnourished than non-fostered children

Bold indicates significant results

fostered children were significantly more likely to fall more than two standard deviations below the mean (the standard metric for malnutrition) for both HAZ and WAZ than children living with their BP (Table 5). Although the age range of children in this sample is quite wide (2–16 years), there were few age effects. Sex effects were more pronounced, with boys tending to have more pronounced deficits than girls.

Other studies have shown that the reason for fosterage can influence health outcomes for fostered children. We find some support for those differences here (Table 6). Children who were fostered out due to mother's high fertility had significantly lower HWZ and WAZ than non-fostered children, and they were more likely to have *Z* scores more than two standard deviations below the mean in both these categories as well. Stunting, represented by low HAZ, was more likely among children fostered either for help in the FP household or because of parental death. The finding that those children fostered in to help the FP had lower HAZ than other children is contrary to our prediction that this might be a context where FC would fare better. Other factors that we predicted might affect the nutritional status of foster children, such as the degree of relatedness between FP and FC and whether children were fostered by maternal or paternal kin, were not associated with any of the nutritional scores we assessed.

Discussion

Our data suggest that fosterage functions as a form of dispersed cooperative breeding in which mothers gain critical help in rearing offspring from others outside their households. For mothers, fosterage provides an important safety net that they can rely on to buffer the costs of demanding reproductive trajectories. Foster parents appear to be most willing to take on these costs when they are closely related to the BP, and when

Table 6 Nutritional Status According to Reason for Fosterage

	WHZ			WAZ			HAZ		
	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*
Mean *Z* scores[a]									
Parental death	−0.10	0.30	0.745	−0.37	0.32	0.251	−0.39	0.39	0.323
Short IBI	−0.74	0.25	**0.003**	−0.65	0.26	**0.013**	−0.34	0.32	0.287
Remarriage	−0.21	0.31	0.509	−0.28	0.32	0.385	−0.19	0.41	0.642
Help	0.22	0.32	0.494	−0.33	0.34	0.338	−0.80	0.43	0.061
Family relations	−0.00	0.56	0.998	−0.35	0.58	0.555	−0.60	0.73	0.411
Z scores >2 SD below the mean[b]									
Parental death	−0.06	0.06	0.373	0.13	0.08	0.098	0.23	0.10	**0.020**
Short IBI	0.13	0.05	**0.013**	0.17	0.06	**0.008**	0.13	0.08	0.115
Remarriage	0.19	0.06	0.767	0.01	0.08	0.925	0.05	0.11	0.641
Help	−0.05	0.07	0.475	0.03	0.08	0.743	0.32	0.22	**0.003**
Family relations	−0.04	0.12	0.748	−0.04	0.14	0.803	0.18	0.18	0.326

[a] Negative coefficients for indicate that foster children in that category had lower scores than those in the reference category (non-fostered children). *Z* scores are based on comparisons with the CDC 2000 reference population

[b] Positive coefficients indicate that foster children in that category are more likely to be malnourished than children in the reference category (non-fostered children)

Bold indicates significant results

they gain needed household labor in exchange for their support. These arrangements have negative impacts on the nutritional conditions of children being fostered, though it is difficult to ascertain whether FC would be better off if they remained in their natal homes.

Fosterage may play an especially important role in ameliorating the quantity/quality trade-offs that women confront early in their reproductive careers. This is the time when young mothers have the least amount of support available to them. Upon marriage, they leave their natal compounds and lose the everyday support of their maternal kin. At this stage, they also lack older children who can act as "helpers-at-the-nest." Finally, in the early years of marriage it may be difficult to garner help from women in their affinal household, such as mothers-in-law and co-wives, because these new relationships are not well-developed. Together, these factors may explain the high rate of fosterage for firstborn children that we report, as well as the measurable benefits that women accrue as a result of fostering out an early-born child. As women's relationships with others in their affinal households develop and their own children mature, women appear to be able to shift the demands of allocare away from their natal kin and become less reliant on the fosterage system.

Across their reproductive careers, Himba mothers utilize the fosterage system in response to particular demographic events. The most common reason for fosterage in this sample is a short interbirth interval. Previous studies have emphasized the role of grandmothers in easing the demands of closely spaced offspring (Hawkes et al. 1997; Sear and Mace 2008). Here we suggest that fosterage may be another way that

grandmothers and others can support their kin by easing the burden of having multiple dependent children, allowing for higher fertility at reduced cost to the mother. This is supported by the fact that most fosterage transactions occur at the time of weaning, the exact time that other studies have shown grandmothers to be particularly helpful (Hawkes et al. 1997; Sear et al. 2000). In fact, some Himba women even report that they use the fosterage system to encourage weaning, as it provides the physical distance necessary to facilitate this break. Similarly, reaching the latter half of pregnancy is another commonly cited reason for both weaning a child and transferring them into fosterage. These patterns indicate that Himba women are acutely aware of the energetic demands of pregnancy and lactation and are consciously using the fosterage system to relieve some of their burden.

Another way that fosterage can aid women in optimizing their reproduction is by easing the transition to new marital relationships. More than 20% of fosterage transactions occurred when the mother married a new partner. The presence of children from previous relationships may present an obstacle in marriage negotiations (Borgerhoff-Mulder 1985), and children may be more likely to be mistreated by stepfathers (Daly and Wilson 1985). Thus, fosterage may provide an important option for women who have produced children before marriage, or for those who are divorced or widowed and have dependent children when they remarry.

The decision to take on the responsibility for rearing a foster child also reflects the changing trade-offs that women face over the course of their reproductive careers. Foster parents must weigh investment in their own children against investment in foster children. Women who are premenopausal face greater trade-offs to fostering in, and as expected, women who have more dependent children in the household foster significantly less. Conversely, postmenopausal women are much more likely to foster. This signals some conditional acceptance of fostering responsibilities based on the potential cost to direct fitness and again points to adaptive use of the fosterage system by FP. One special case in which the net cost of fosterage is particularly low is when children can be brought in to assist with household labor. Fostering in children for help often occurs among women who have fewer reproductive trade-offs—in other words, those who have few children of their own or whose children are grown and out of the household. As would be expected using the logic of inclusive fitness, the degree of relatedness between FC and FP is lowest in cases where FP accrue some benefit, either where FC provide household labor or where the reason for fosterage is to keep up family relations (Table 2).

The case of parental death was an exception to some of the patterns of fosterage that are otherwise common among the Himba. In contrast to the majority pattern, where maternal relatives were more likely to take in foster children than paternal relatives, in the case of parental death, family members of the parent who died were the ones most likely to take on fostering responsibilities. This translates to a paternal bias in the case of father's death and a maternal bias in the case of mother's death. In these cases, the family of the deceased may feel more responsibility to maintain a relationship with the child, in order to protect that child's identity with their lineage. Because the Himba practice double descent, maintaining contact with and allegiance to both the maternal and paternal lineages is important.

The cooperative breeding hypothesis predicts that alloparental care will either enhance the welfare of mothers or lighten their parenting burden, and this in turn will

benefit their children. However, our anthropometric data indicate that foster children have poorer nutritional outcomes than children living in natal households. In particular, foster children are more likely to be stunted (HAZ >2 SD below the mean) and underweight (WAZ >2 SD below the mean). One explanation is that fosterage is detrimental to children and reflects a form of parent-offspring conflict over investment (Trivers 1974). However, it is possible that foster children would be even more disadvantaged if they remained in their natal households. To test this, it would be useful to compare the nutritional condition of pairs of fostered and non-fostered children closely matched for birth order, sex, age, and family composition. In addition, there were significant sex differences in nutritional outcomes in our dataset, over and above the effects of fosterage. These may be linked to differences in labor requirements for boys and girls, or possibly to biases in investment (though the Himba claim that they do not have preferences for sons or daughters). In order to test between these predictions, larger samples of boys and girls in each age group would be needed, as well as ideally some information about time allocation and energy expenditure.

It seems likely that the conditions that children face in foster households produce the adverse outcomes that we observed. However, it is important to consider the possibility that children with poor growth patterns may be particularly likely to be fostered out. Women did not cite this as a reason for fostering children, but we did not explicitly inquire about this possibility. To address this question, it would be necessary to monitor the nutritional condition of children as they left their natal households and entered foster households.

Conclusions

Our analyses suggest that fosterage may be an important part of the cooperative breeding system in humans. We show fosterage to be especially advantageous for mothers, who are able to terminate investment in certain offspring and reallocate investment to others, positively impacting their overall fitness. Foster parents, in turn, gain inclusive fitness benefits when they provide care for related children, and they sometimes gain useful assistance with household tasks. We do not have any evidence that foster mothers' care reduces their ability to invest in their own offspring or reduces their fertility. In fact, because so much fostering is done by grandmothers, women who have more children actually foster more as they age. Thus, fosterage seems to be generally advantageous for biological parents and foster parents. Fosterage does appear to impose some costs on children; they are more likely to be stunted and underweight than children living in their biological households. However, we cannot be certain that these nutritional deficits are the product of fosterage, and we cannot draw neat conclusions about whether fosterage is in the best interests of children. Additional information about the lives of Himba children is needed to resolve these questions. This ambiguity about the impact of fosterage on children highlights a larger point about the adaptive nature of fosterage. Fosterage involves multiple players, with goals that sometimes overlap and sometimes conflict. To fully understand fosterage practices, we need to consider the perspectives of all parties and move beyond simplistic questions about whether fosterage is adaptive. Viewing fosterage within the system of cooperative breeding is one way this can be done.

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