

Hadza Children's Foraging: Juvenile Dependency, Social Arrangements, and Mobility among Hunter-Gatherers¹

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The assumption that children of mobile foragers provide little of their own food is a common and important (if often implicit) element of many arguments about major developments in human prehistory, from the origin of bipedalism through the development of agriculture. Its principal support comes from the Dobe !Kung. Other, less well-known but equally mobile, groups display different patterns, with children foraging actively and contributing significantly to their own support. These "exceptions" challenge the common assumption and any arguments that depend on it. More important, they provide an opportunity to identify the determinants of variation in children's foraging practices. The more successfully that variation can be explained, the better the foundation for hypotheses about its effects in the past.

Among the best-known exceptions to the proposition that children of mobile hunters do not forage are the Hadza, whose children have been described as active foragers throughout this century (e.g., Obst 1912; Bleek 1931; Kohl-Larson 1958; Jelliffe et al. 1962; Woodburn and Hudson 1966; Blurton Jones, Hawkes, and O'Connell 1989, n.d.). We confirm the productivity of Hadza children's foraging, show that their success can have an important effect on their mothers' foraging patterns, and demonstrate that the combined activities of women and

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children can be understood in fairly simple cost/benefit terms. The Hadza case indicates that it is not mobility or travel distance that determines children's participation but the age-specific return rates to be earned from available food resources and the processing required to extract their nutrients. These variables account for both the foraging patterns of Hadza children and the general absence of children's foraging among the !Kung. Not only is the conventional assumption that foragers' children do not work shown to be inaccurate but a basis for explaining differences in work effort is established. Better predictions about children's work effort and its consequences in the past should follow.

THE PROBLEM

The proposition that foragers' children are unproductive plays an important role in many evolutionary scenarios. Hominid divergence, for example, is said to entail an unprecedented degree of juvenile dependence, requiring that adult males contribute to their support. Consequences include an adult sexual division of labor, regular food sharing, and the family as a universal economic unit, each with further profound implications for the evolution of human social behavior (e.g., Washburn and Lancaster 1968, Lovejoy 1981, Lancaster and Lancaster 1983). The same proposition is central to explanations for terminal-Pleistocene diet change, in which climate-related shifts in resource choice prompt reductions in overall mobility with consequent increases in productive contributions from children. Sharp population growth, resource "stress," and experiments in domestication leading to the development and spread of agriculture are among the results, with further rises in rates of population growth as children contribute to farming and herding (see Binford 1968 and Cohen 1977 for classic statements and Layton, Foley, and Williams 1991; Moore and Hillman 1992; Henry 1991, and Wenke 1990: 225–76 for more recent discussions).

The widespread consensus that children work little among mobile foragers is not matched by agreement about the reasons for it. Sometimes children's leisure is seen to result from the relative ease with which adults meet family subsistence needs (e.g., Lee 1968, 1969); sometimes it is said to reflect the requirements of adult skill and strength levels for productive work (e.g., Draper and Harpending 1987). With settlement, children are expected to contribute more to their own subsistence because settlement is associated with resource depletions that force everyone to work more (e.g., Draper and Harpending 1987). Or the argument may be that children are more productive because the tasks of settled life more readily absorb children's labor (e.g., Lancaster and Lancaster 1987; Wenke 1990:237). In short, some assume that children work only if they must, others that they work whenever they can. Inquiry into the underlying variables may help resolve some of the contradictions and thus direct revisions in common assumptions about both hominid social arrangements and patterns of hunter-gatherer mobility. If "mobility"

is an umbrella for variables that can be separated and those most strongly affecting children's work are distinguishable, then hypotheses about evolutionary transitions can be framed more precisely (cf. Kelly 1992).

THE 1988 RESEARCH

The Eastern Hadza, numbering about 750, occupy a 2,500-km² area in the Eastern Rift, southeast of Lake Eyasi (Blurton Jones et al. 1992). The climate of this region is warm and dry. Annual average rainfall is in the 300–600-mm range, most of it falling in the six-to-seven-month wet season (November–May). Vegetation is primarily savannah woodland (Schultz 1971). Large herbivores (e.g., zebra, impala) are abundant, major predators (lion, leopard, hyena) not uncommon.

The Hadza have made their living as hunter-gatherers in this region for at least a century (Obst 1912; see Blurton Jones, Hawkes, and O'Connell n.d. for more on history). They first attracted serious ethnographic interest in the 1930s (Bleek 1931, Kohl-Larson 1958) and have been the subjects of more or less sustained observation since the late 1950s (e.g., Barnicot et al. 1972; Bunn, Bartram, and Kroll 1988, Hierneaux and Hartono 1980, Tomita 1966, Vincent 1985, Woodburn 1964). Our research, initiated in the early 1980s, has focused primarily on demography, time allocation, foraging, and related ethnoarchaeological issues (e.g., Blurton Jones et al. 1992; Hawkes, O'Connell, and Blurton Jones 1991, O'Connell, Hawkes, and Blurton Jones 1992). Basic data-collecting routines have included census, anthropometry, systematic scan sampling, and focal-person follows.

During September–November 1988 (late-dry-season conditions throughout), data on children's foraging were gathered at two sequentially occupied camps, Mbea and Ilomo, both located near the crest of a ridgeline about 10–15 km south of the southern shore of Lake Eyasi. Camp populations varied from 45 to 60. The core group at each site included 48 persons: 14 women, 9 men, 10 girls, and 15 boys. Three of the women were well beyond their childbearing years; the others ranged from their late teens or early twenties to late middle age. Men present spanned the same overall range. The oldest children were 2 boys, each about 17; the youngest (1 girl, 2 boys) were infants. As is often the case among the Hadza (Woodburn 1972), household composition varied widely. Six of the women and 1 of the men were not living with spouses. Of the 20 children weaned through age 17, 11 had resident mothers and 5 had resident fathers; only 2 were living with currently married parents, and 6 had no coresident parents.

Subsistence at both sites was based almost entirely on hunting and gathering, but the mix of resources differed from that in earlier study periods. Hunting was poor (only eight large animals taken over 43 days of direct observation [cf. O'Connell, Hawkes, and Blurton Jones 1988]) and baobab fruit (*Adansonia digitata*) less available than before (cf. Blurton Jones, Hawkes, and O'Connell 1989; Hawkes, O'Connell, and Blurton Jones 1989). Principal

foods were tamarind fruit (*Tamarindus indica*, Hadza *muhibe*) and especially berries (*Cordia* sp., Hadza *ondishibe*; *Salvadora persica*, Hadza *tafabe*), but tubers (*Eminia atenullifera*, Hadza *makalita*; *Vigna frutescens*, Hadza //ekwa) were also taken. Tubers of both types were encountered throughout the upland area surrounding the camps; tamarind were found in small stands to the west; berries were located in large patches 5–7 km north of Ilomo and about 160 m lower in elevation.

Activities were monitored through a combination of systematic scan samples in camp and follows on foraging trips. Our recognition of the importance of children's work (Blurton Jones, Hawkes, and O'Connell 1989) came after we had compiled a large time-allocation data set in 1985–86 in which adult activities were the central focus. Children had been recorded but with more concern for their location—as it might affect adult patterns—than for precise descriptions of their activities. To correct this omission and measure youngsters' time allocation in and around camp, we employed a protocol of one-hour focal-child follows. All children in the core group except the two oldest boys and the nursing infants ($n = 20$) were included in the near-camp focal-child follow sample. Subjects' ages were estimated from their positions in a 1985 age ranking and whether they appeared in a 1977 census (Blurton Jones et al. 1992). Estimates were cross-checked with age rankings done in 1988, 1990, 1991, and 1992. Because there were some reversals in ranking, children near in age were grouped and their age calculated from the mean of their 1985 age rank (Blurton Jones et al. 1992). The difference in mean age by sex in this sample (girls 8.4 ± 3.8 years, boys 11.5 ± 4.1) is not statistically significant, but the fact that the three youngest were girls and the five oldest boys causes sex differences to affect some of the apparent age differences (and conversely). Analyses of variance are used to measure these interactions.

Two hundred seven in-camp one-hour follows were completed between 0700 and 1900 hours from September 8 through November 6. The initial goal was to complete a follow on each child during each of the 12 daylight hours. After the first few, subjects were selected from those not yet followed in a given hour with a bias toward those with the fewest accumulated follows. Total observations completed for each of the 12 daylight hours range from 14 to 22 (rarely, a child was followed more than once in a given hour). Because boys were often away from camp, more data were compiled on girls (110 hours on 9 girls, 97 hours on 11 boys). Follows on each child are also distributed across the day; totals per child range from 5 to 17. During a follow, the focal child's location and companions (if any) were noted. Activities were recorded in running notes, with special attention to the starting and stopping times of food acquisition and processing. To tabulate time allocation, events were assigned a minimum of one minute,² with longer durations as recorded.

2. This procedure overestimates time allocated to activities of brief duration, an error in the conservative direction here (see results).

TABLE I
Time Allocation to Food Acquisition and Processing in or near Camp by Children by Hour of the Day

Hour of the Day	n of One-Hour Follows	Time Spent Acquiring Food in or near Camp (min./hr.)	Time Spent Processing Food in or near Camp (min./hr.)
700	17	0.00	2.94
800	22	6.73	1.27
900	19	0.00	2.68
1000	16	1.56	0.25
1100	14	4.36	0.21
1200	14	0.14	1.93
1300	18	0.28	0.72
1400	18	0.00	0.06
1500	15	0.53	0.27
1600	22	0.00	0.05
1700	16	0.81	1.25
1800	16	0.00	0.38
Total	207	14.41	12.01

Near-camp foraging return rates were measured during the one-hour follows and, more often, outside the hour sampling scheme by opportunistic follows initiated when children foraged spontaneously within a few hundred meters of camp. Time spent was recorded and any food collected weighed with hanging spring scales. Return rates were also measured on trips to more distant resource patches. Foraging parties for these long trips usually consisted of several women, at least one man (often more), and children of many ages. Most participants remained together throughout the trip. Party composition was recorded on departure from camp and from the resource patch, and walking and resting times during travel were noted. Resources accumulated by each forager to carry home were weighed either on departure from the patch or on arrival at camp. Food was seldom consumed en route.

Measuring return rates for berries presents special problems because people eat as they collect. The amount set aside to bring home is only a fraction of the total taken. To estimate acquisition rates more accurately, members of a sample of men, women, and children were timed as each filled a small tin with berries. They agreed not to eat during the exercise, and any breaches were noted and subtracted. The contents of the tin were weighed, and the collection rate was calculated.

The following presentation of results reports sample means with standard errors. All comparisons of means are unpaired *t*-tests with two-tail probabilities. When children are divided into categories "older" vs. "younger," we draw the boundary at 11 years of age, putting ten subjects in each category. All age-related analyses of variance use this division.

RESULTS

Time allocation near camp. On average, children spent less than 15 minutes a day foraging near camp, mainly

TABLE 2
Time Allocation to Food Acquisition and Processing in or near Camp by Focal Child

Child	Estimated Years of Age	Sex	Mother Resident	Father Resident	n of One-Hour Follows	Time Spent Acquiring Food in or near Camp (min./day)	Time Spent Processing Food in or near Camp (min./day)
208	3.5	f	no	no	11	54.55	5.45
209	4.0	f	yes	yes	13	0.00	0.92
007	4.0	f	yes	no	14	11.14	0.00
306	5.0	m	yes	no	9	33.33	2.67
109	6.5	m	yes	no	13	3.69	3.69
307	6.5	m	yes	no	13	44.31	3.69
308	8.2	m	yes	no	10	0.00	3.60
214	8.2	f	no	no	16	89.25	37.50
221	8.2	f	yes	no	11	0.00	13.09
219	11.0	f	yes	no	10	0.00	8.40
216	11.5	f	yes	no	10	1.20	2.40
018	11.5	f	no	no	14	1.71	34.29
311	12.0	m	no	yes	10	0.00	0.00
019	13.6	f	no	yes	10	0.00	0.00
122	14.0	m	no	yes	5	0.00	24.00
317	14.0	m	no	no	8	0.00	10.67
119	14.0	m	yes	yes	8	0.00	36.00
316	14.0	m	no	no	6	0.00	6.00
125	15.0	m	yes	no	9	0.00	0.00
318	17.0	m	no	no	7	0.00	42.86
Mean					10.35	11.96	11.76

in the morning hours (table 1). Only 12 minutes a day were devoted to food processing. There were no differences by sex in time given to either activity (table 2).³ Time spent processing varied directly but not quite significantly with age ($r = 0.409$, $p = 0.0734$); time spent acquiring varied *inversely* with age ($r = 0.48$, $p = 0.0322$). Younger children averaged about half an hour (25.9 ± 12 minutes) collecting food near camp, older children less than a minute ($p = 0.0033$). Among younger children, those without coresident mothers spent more time in food acquisition ($p = 0.0045$) and processing ($p = 0.0434$) near camp than did those living with mothers.

Time spent away from camp was patterned by age and sex (table 3). At Mbea boys foraged far afield twice as often as girls. The fraction of days away from that site varied closely with age.⁴ Ilomo was the primary base for berry-collecting trips, particularly for *tafabe*. Age had a strong effect on frequency of participation in these trips by children ($r = 0.924$, $p = 0.0001$). The 4 youngest

never went; the other 16 traveled, on average, every other day. Mean trip times were long, just under ten hours, including about 90 minutes' travel each way. Although boys were away from Ilomo more often than girls, there was no significant difference by sex in frequency of trips to berry patches.⁵

Acquisition rates near camp. Children collected only tubers near camp (table 4). One 15-year-old boy (individual 125) earned a rate on *//ekwa* that set him apart from the others; excluding him from the sample, mean in-patch returns for tubers were strongly correlated with age: $r = 0.781$ ($p = 0.0045$) for *makalita*, $r = 0.655$ ($p = 0.0288$) for *//ekwa*. Children over 7 or 8 averaged 598 ± 146 g/hr. in-patch for *makalita*, 314 ± 54 g/hr. for *//ekwa*. *Makalita* yield about 73 Cal/100 g, *//ekwa* about 85 Cal/100 g (Galvin et al. n.d.).⁶ The 29 minutes

5. Boys were away 0.65 ± 0.09 of all days, girls 0.36 ± 0.10 ($p = 0.074$), but this was strongly biased by age: a two-factor analysis of variance shows older children away more ($p = 0.0001$), and the sex differences do not reach significance ($p = 0.1281$; interaction $p = 0.8655$). Analysis of variance of the fraction of days away at locations other than the berries shows differences by both age, older children being away more ($p = 0.0008$), and sex, boys being away more ($p = 0.0134$) (interaction $p = 0.356$). The correlation with age for boys alone is $r = 0.785$ ($p = 0.0042$). For trips to the berries only the age ($p = 0.0001$) but not the sex ($p = 0.452$) differences are significant (interaction $p = 0.7989$). Mean fraction of days at the berries for the 16 children who went at all is 0.53 ± 0.04 of all days, for boys 0.56 ± 0.06 and for girls 0.47 ± 0.05 , $p = 0.3249$.

6. Vincent (1985) reports 53 Cal/100 g for *makalita*. The lower rate would change numerical values but not the qualitative form of any of the following analyses.

3. Girls were followed more often than boys (12.11 ± 0.73 vs. 8.91 ± 0.77 hours, $p = 0.0083$) and younger children more often than older ($r = 0.659$ for age with hours of observation, $p = 0.0016$), biases arising from the availability of children in or near camp. Summary totals in table 2 differ slightly from those in table 1, the latter weighs all observation hours equally, the former all subjects equally.

4. Boys were away 0.40 ± 0.06 of all days, girls 0.19 ± 0.03 ($p = 0.0138$); the correlation of the fraction of days away with age is $r = 0.767$ ($p = 0.0001$). For boys only $r = 0.73$ ($p = 0.0108$). A two-factor analysis of variance shows significant differences by both age ($p = 0.0414$) and sex ($p = 0.0473$) (interaction $p = 0.27$).

TABLE 3
Time Spent Away from Mbea and Ilomo Camps by Child Subjects of In- and Near-Camp Follows

Child	Days Observed as Resident of Mbea	Fraction of Days Away from Mbea	Days Observed as Resident of Ilomo	Fraction of Days Away from Ilomo	Fraction of Ilomo Days at Berries	Average Duration of Berry Trips (min./trip)
208	9	0.11	22	0.00	0.00	n.a.
209	9	0.11	25	0.00	0.00	n.a.
007	10	0.00	24	0.00	0.00	n.a.
306	9	0.11	20	0.00	0.00	n.a.
109	9	0.11	24	0.25	0.17	477
307	9	0.11	24	0.38	0.33	580
308	11	0.64	23	0.70	0.57	595
214	10	0.30	23	0.44	0.35	621
221	9	0.22	24	0.38	0.38	605
219	8	0.25	25	0.40	0.36	540
216	11	0.27	25	0.64	0.56	570
018	0		24	0.67	0.54	585
311	9	0.44	25	0.64	0.48	585
019	9	0.22	25	0.72	0.64	571
122	9	0.33	22	1.00	0.77	590
317	5	0.60	22	0.91	0.77	578
119	9	0.44	25	0.76	0.52	586
316	9	0.56	21	0.86	0.67	591
125	11	0.55	25	0.84	0.76	563
318	9	0.56	25	0.84	0.60	594
Mean	8.7	0.31	23.65	0.52	0.42	576.94

TABLE 4
Children's Acquisition and Stashing Rates

Child	Makalita Rates (g/hr.)			//ekwa Rates (g/hr.)			Tin-measured Tafabe Rates (g/hr.)			Tin-measured Ondishibe Rates (g/hr.)			Tafabe Stashing Rates (g/hr.)			Ondishibe Stashing Rates (g/hr.)		
	Mean	S.E.	n	Mean	S.E.	n	Mean	S.E.	n	Mean	S.E.	n	Mean	S.E.	n	Mean	S.E.	n
208	39	6	2	42	—	1	—	—	—	—	—	—	—	—	—	—	—	—
209	67	42	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
007	353	74	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
306	259	7	7	117	34	4	—	—	—	—	—	—	—	—	—	—	—	—
109	220	—	1	—	—	—	—	—	—	—	—	0	—	1	—	—	—	—
307	254	46	2	—	—	—	—	—	—	—	—	0	—	1	—	—	—	—
308	480	—	1	211	64	3	958	214	2	—	—	52	24	4	—	—	—	—
214	1,158	269	5	270	117	3	600	—	1	1,088	569	2	188	55	2	400	—	1
221	370	116	4	94	34	5	780	—	1	—	—	236	22	2	800	—	1	
219	601	225	3	197	34	6	—	—	—	—	—	157	—	1	62	62	3	
216	—	—	—	550	130	4	610	—	1	1,714	—	1	288	37	3	487	—	1
018	—	—	—	529	30	2	978	88	3	1,510	454	3	384	117	4	533	—	1
311	—	—	—	—	—	—	—	—	—	—	—	17	17	3	—	—	—	—
019	1,100	—	1	484	112	6	844	88	2	2,040	—	1	308	8	2	588	—	1
122	—	—	—	—	—	—	1,025	16	2	—	—	—	32	32	3	0	—	1
317	—	—	—	229	86	3	923	22	2	—	—	—	33	24	5	0	—	1
119	—	—	—	—	—	—	—	—	—	—	—	29	29	2	0	—	—	1
316	—	—	—	271	—	1	965	—	1	977	—	1	0	0	2	—	—	—
125	—	—	—	2,145	—	1	1,248	24	4	2,033	—	1	217	28	4	—	—	—
318	—	—	—	—	—	—	—	—	—	—	—	39	39	2	—	—	—	—

TABLE 5
Acquisition Rates for Tafabe and Ondishibe Berries by Sex and Age

	Girls			Women			Boys			Men			Children			Adults		
	Mean	S.E.	n	Mean	S.E.	n	Mean	S.E.	n	Mean	S.E.	n	Mean	S.E.	n	Mean	S.E.	n
Ondishibe	1,547	±208	4	2,771	±231	10	1,505	±528	2	—	—	—	1,533	±19	6	2,771	±231	10
Tafabe	762	±72	5	1,281	±93	14	1,024	±58	5	1,156	±93	6	893	±62	10	1,244	±69	20

TABLE 6
Tin-Measured Acquisition, Stashing, and Estimated Consumption Rates and Time Spent Picking by Sex and Age

	Tin-Measured Rate (Cal/hr.)			Stashing Rate (Cal/hr.)			Consumption Rate (Cal/hr.)			Estimated Picking Rate/ Tin-Measured Rate (%)
	Mean	S.E.	n	Mean	S.E.	n	Mean	S.E.	n	
Women	1,383	±100	14	866	±66	16	379	±13	17	90
Men	1,248	±100	6	147	±94	6	508	±16	8	52
Girls	823	±78	5	281	±37	6	354	±11	6	77
Boys	1,106	±63	5	59	±23	12	384	±16	10	40
Children	964	±67	10	123	±29	18	373	±2	16	51

a day spent by younger children on *makalita* gave them just over 200 Cal.

Acquisition and stash rates in distant patches. Acquisition rates for berries, measured by tin as described above, differed substantially by type, *ondishibe* yielding about twice as much as *tafabe* (probably because they are larger). Children's rates were surprisingly high, 50–70% of those of adults (table 5).⁷ *Ondishibe* contain about 145 Cal/100 g, *tafabe* about 108 Cal/100 g (Galvin et al. n.d.), giving children mean in-patch acquisition rates of 2,223 and 964 Cal/hr. for these resources. Thus they could earn their own daily consumption requirements in less than three hours once they reached the patch.

In addition to eating berries while at the patch, people also "stashed" them in containers to carry home. Stashing rates are defined as the total weight of fruit accumulated for transport per hour in the resource patch. They represent the minimum rate that would have been taken had foragers eaten none of the berries they picked. Children's stashing rates for *ondishibe* tended to be higher than those for *tafabe* (table 4), and this was true for

adults as well.⁸ Foragers earned more from *ondishibe* than from *tafabe*, but *ondishibe* were not fully ripe until the very end of the observation period.

Acquisition and stashing rates by age and sex for *tafabe* are shown in table 6. Stashing rates varied more widely than tin-measured acquisition rates,⁹ suggesting

8. In this sample, women stashed *ondishibe* at a surprisingly low rate (945 ± 114 g/hr., n = 15). Since their tin-measured acquisition rates are about twice those for *tafabe* (table 5), one might have expected them to stash *ondishibe* at something closer to twice the *tafabe* rate (i.e., ca. 1,600 g/hr.). One reason to have more confidence in the *tafabe* than the *ondishibe* rate is the coincidence of the former with estimates made for another species of berry using a different method to calculate rates. In Hawkes, O'Connell, and Blurton Jones (1989) we reported acquisition rates for *Grewia bicolor* (Hadza *kongorobe*) based on scan samples in *kongorobe* patches where foragers were coded as "picking to eat," "picking to stash for transport," or engaged in some other activity. In that sample, foragers spent 47% as much time eating as stashing. We assumed that they picked at the same rate whether eating or stashing and estimated total acquisition (eating plus stashing) accordingly. The coincidence between the results of this approach and the results of the tin-measured technique applied to *tafabe* is striking. Women's mean stash rate for *tafabe* is 802 ± 61 g/hr. (n = 16). If they ate 47% as much in addition, their overall mean acquisition rate would have been 1,179 g/hr., very close to the tin-measured rate of 1,281 g/hr.

9. Two-factor analysis of variance for children shows significant differences by both age and sex, older children and girls stashing at higher rates (p = 0.0184 and 0.0001, respectively; interaction p = 0.2491). When adults are added as a third age category, the significance of both age and sex effects is p = 0.00001, and there is a significant interaction (p = 0.007).

7. Samples for *ondishibe* are too small to evaluate for age and sex effects. For *tafabe*, analysis of variance for children shows no significant difference by age (p = 0.4062), and the higher rates for girls are not quite significant (p = 0.0711; interaction p = 0.8721). Adding adults as a third age category indicates rates increasing with age (p = 0.0302) but no significant sex differences (p = 0.3958; interaction p = 0.2964).

differences in how foragers actually spent their time in the patch. If we can estimate eating rates, those rates added to stashing rates should indicate actual picking rates. To model the amount foragers ate, we used the National Research Council's (1989:26) equations for resting energy expenditure by sex, age, and weight and their multiplier for exceptionally active individuals to predict daily caloric intake for each subject.¹⁰ We assumed that each forager ate a day's ration of calories during the ~6.5 hours they spent in the patch and calculated an hourly consumption rate accordingly. The sum of this modeled consumption rate and the stashing rate gives an individual's estimated picking rate. The more steadily foragers pick while in patch, the more closely their estimated picking rate must approach their tin-measured rate. Comparison of these rates serves as an index of the time in-patch foragers spent actually picking berries. The last column in table 6 shows how close the estimated picking rate for each age and sex category came to its mean tin-measured rate. Not surprisingly, adults were more attentive to picking than children of the same sex. Nor is it unanticipated that women picked more to carry home than men. What is surprising is that girls picked and carried back more than did boys and at about the same ratio as women versus men.

DISCUSSION

We use these data to address four questions: (1) How important is distance as a limiting factor on children's foraging effort? (2) What determines children's foraging choices? (3) What impact do their returns have on foraging choices made by adults? (4) What accounts for the differences between !Kung and Hadza children's foraging behavior? The data also provoke a comment on the surprising pattern of gender differences in children's foraging effort.

The question of distance. The Hadza are an exception to the conventional anthropological wisdom that the children of mobile hunter-gatherers do little to support themselves but instead rely completely on their parents for subsistence. Observers of the Hadza have long reported children's active participation in food acquisition from surprisingly early ages. In our own initial report on the topic we described youngsters aged 5 and older foraging near camp in the late dry season of 1986 at a locality called /ilo, a setting similar to those near Mbea and Ilomo (Blurton Jones, Hawkes, and O'Connell 1989). There children took four resources: *makalita*, //ekwa, baobab fruit, and a kind of honey called *kanoa*. Acquisition rates for *makalita* and //ekwa were similar to those reported above for the areas around Mbea and Ilomo. Although the time children spent foraging near /ilo was not monitored systematically, they were actively en-

gaged in it, providing themselves with substantial returns as a result. Two hours devoted to collecting and processing baobab would have given 5–10-year-olds about 1,300 Cal and 11–15-year-olds about 2,100 Cal. The same time spent collecting *makalita* and //ekwa would have yielded lower but still appreciable totals (see Blurton Jones, Hawkes, and O'Connell 1989 and Blurton Jones, Hawkes, and Draper 1994b for additional details).

Our 1988 near-camp follows were planned primarily to measure children's time allocation to foraging. To our initial surprise, we found that they did very little near camp, much less than we had estimated in 1986. Instead they spent long hours accompanying adults on trips to distant berry patches, earning significant nutrient returns in the process. Children's participation in such trips is not unique to the 1988 study period: we observed it regularly in the course of earlier fieldwork (Hawkes, O'Connell, and Blurton Jones 1989), as had various other observers throughout this century (Blurton Jones, Hawkes, and O'Connell n.d.). These data not only underline the importance of Hadza children's contribution to their own subsistence but also refute the notion that distance alone limits that contribution.

Determinants of resource choice. A satisfactory explanation of the Hadza patterns must account both for the variation they displayed among seasons and localities and for differences between the Hadza and other mobile foragers. Such an explanation will generate predictions about the foraging behavior of children in different circumstances, not only the ones observed ethnographically but also others not represented currently or in the recent past.

We begin with the simple hypothesis that children seek to maximize their mean rate of nutrient acquisition while foraging. In the 1988 study period Hadza youngsters had a limited set of options: staying near camp and gathering *makalita* and/or //ekwa or traveling with adults to the distant berry patches and gathering *tafabe* and/or *ondishibe*. The resource that figured so prominently in the 1986 sample, baobab, was essentially unavailable to children foraging near Mbea and Ilomo during the 1988 observation period. There were many baobab trees near both camps but little fruit in that season.

Given only the tuber options near camp, the choice is straightforward: *makalita* yield 436 Cal/hr., //ekwa 267 Cal/hr. Not surprisingly, children generally chose the *makalita* patch. They collected //ekwa often enough to allow return rates to be measured but never within the one-hour focal-follow sampling scheme designed to measure time allocation.

In the far patches, children earned an average of 2,223 Cal/hr. from *ondishibe*, 964 Cal/hr. from *tafabe*, making the former the optimal choice. The fact that all spent most days collecting *tafabe* reflects the fact that *ondishibe* were not quite ripe during most of the study period. In early October people stopped frequently at *ondishibe* on arrival at the berries, but, after picking some and finding it still unripe, they moved on to *tafabe*. When *ondishibe* became ready just at the end of

10. Modeled this way, the daily allowance for women in this sample is 2,464 ± 87 Cal/day ($n = 17$), for men 3,301 ± 105 ($n = 8$) ($p = 0.0001$). For girls it is 2,303 ± 70 ($n = 6$), for boys 2,498 ± 107 ($n = 10$) ($p = 0.2147$), and for children combined 2,424 ± 12.

the study period, all began collecting it exclusively, even though *tafabe* were still available.

The trade-off between near and far patches is a bit more complex. At 964 Cal/hr., *tafabe* is a better choice than *makalita* at 436 Cal/hr., but it requires a three-hour round trip before any returns are realized.¹¹ On brief forays, more could be earned from *makalita*, but on ventures long enough to offset the cost of travel *tafabe* would yield higher overall returns.

Figure 1, *a*, illustrates this trade-off more precisely. In drafting it, we assumed that children's overall collecting efficiency in a patch was lower than in short-term trials. *Tafabe* collection rates are estimated at half the tin-measured acquisition rates (as suggested by table 6), *makalita* rates at half those measured for short digging bouts. The *makalita* rate (indicated by the slope of the dotted line) is lower than that for *tafabe* (solid line), but the collector begins to earn calories within minutes of leaving camp. Tubers are the higher-return choice for trips of less than 329 minutes (5.5 hours).¹² All children's tuber-collecting trips were well under that length (maximum duration 144 minutes [2.4 hours]), all *tafabe* trips well in excess of it (mean duration 577 minutes [9.6 hours]). In 1988, long trips to *tafabe* gave Hadza children higher rates than did other options. The rarity with which they dug tubers near camp (less than 1 minute a day for the older children) shows their clear preference for the higher returns from long trips to the berry patch.

Implications of children's foraging success for adults. These results explain why Hadza children sometimes forego foraging opportunities near home to accompany their mothers on long walks to the berry patch, but the

chance to do so depends on whether women choose to exploit that distant patch. We initially expected that women would make the foraging choices that maximized their mean rates of nutrient acquisition. Surprisingly, they did not.

At Ilomo, women earned an average of 1,043 Cal/hr. (1,227 g/hr.) in-patch digging //ekwa.¹³ These tubers were available in the immediate vicinity of camp. In-patch returns from *tafabe* were higher, about 1,383 Cal/hr. (1,281 g at 108 Cal/100 g), but the difference in travel time to patches was so great that a woman's own overall return rate was higher for tubers unless she planned to spend more than 732 minutes (12.2 hours) foraging (fig. 1, *b*).¹⁴ Given daylight as a constraint, she could not take trips long enough to earn personal returns as high as those she could from taking //ekwa close to home. If her goal had been to maximize her own mean rate of nutrient acquisition, she should not have gone to the distant berry patches. Nevertheless, most women did so routinely during the study period.

The general reason for expecting foragers to maximize their mean rates of nutrient acquisition is that higher rates yield either more food or more time to devote to other activities. If higher rates of food acquisition are advantageous to women because with higher rates they can feed children more, or feed more children, then when children are active foragers themselves a woman's children will consume food at a higher rate if she chooses the strategy that maximizes the *team rate* she and her children earn collectively, *even if the rate she earns herself is less than the maximum possible.*

In the 1988 study period, a woman's choice between taking a child to the berries or staying closer to camp and digging //ekwa while the child took *makalita* depended on the time spent foraging. Over short periods, the nearby option gave higher team rates. Berries offered higher overall rates for forays longer than 556 minutes (9.3 hours) (fig. 1, *c*). If two children accompanied her, berries gave higher collective return rates after 486 minutes (8.1 hours). The greater the number of children she was responsible for, the lower the threshold at which berries became the optimal choice.¹⁵ The mean length

11. The distance from Ilomo to the berry patches raises the obvious question why the group did not camp closer to the berries, especially since it did so on other occasions. When the question was put to residents (several times in 1988 and again in 1990), they claimed that they had picked the site because of its proximity to water and ready access to the berries. This is inconsistent with our own observations. The water source at Ilomo was small and unreliably intermittent. Moreover, there were other waters within 30 minutes' walk of the berry patch. It may be that the distribution of other resources taken occasionally by Ilomo residents, notably baobab and tamarind, influenced the choice of site, but the low frequency with which these were exploited relative to the berries makes us skeptical of this explanation. Alternatively, it may be that the daily presence of potentially troublesome pastoralists at the water point closest to the berries made Ilomo seem a more prudent alternative.

12. Children's rates for *tafabe* and *makalita* could be estimated separately by sex. Table 6 shows that while the estimated picking rate for children overall was 50%, it was 77% for girls and 40% for boys. If those rates were used, the slopes of both lines for girls would be steeper and both lines for boys less steep than in figure 1, *a*. The differences in slopes would not, however, alter the trip length at which the lines crossed. As long as the same maximum (tin-measured and short-digging-bout) rates are assumed for both sexes (964 Cal/hr. for berries, 436 Cal/hr. for tubers), both girls and boys would earn higher overall rates for tubers on forays shorter than 5.5 hours (328 minutes), for berries on longer ventures. If the sex-specific tin-measured rates are used in calculating overall berry rates (i.e., 77% of 823 Cal/hr. for girls, 40% of 1,106 for boys [table 6]), berries become the higher-return choice for trips longer than 6.4 hours (383 minutes) for girls, 4.9 hours (297 minutes) for boys.

13. This figure is based on a sample of 28 digging bouts. It is much lower than rates measured for women in previous years at other localities (e.g., October 1985, Tsipitibe camp, 2,015 ± 52 g/hr. [*n* = 294 bouts]; November–December 1985, Mugendeda camp, 2,202 ± 251 g/hr. [*n* = 13 bouts]). Both means are significantly higher than the October 1988 Ilomo rate (*p* < 0.001).

14. This calculation ignores the energetic cost of the trip itself, including a 160-m descent to reach the *tafabe* patch. The uphill return and the loads women carried (mean 5.53 ± 0.32 kg/person, *n* = 51) increased their cost. At the same time, digging is much more energetically expensive than berry picking, and the cost accrues continuously with the length of the digging bout. The cost of the walk to the berry patch is fixed, except as a function of the size of the load brought back. This suggests that ignoring the costs of both travel and digging underestimates the relative advantage of longer foraging bouts at the berry patch.

15. If children's rates are estimated separately for girls and boys, the threshold for the duration of trips for which berries give higher team returns differs with the child's sex. If girls' rates are estimated

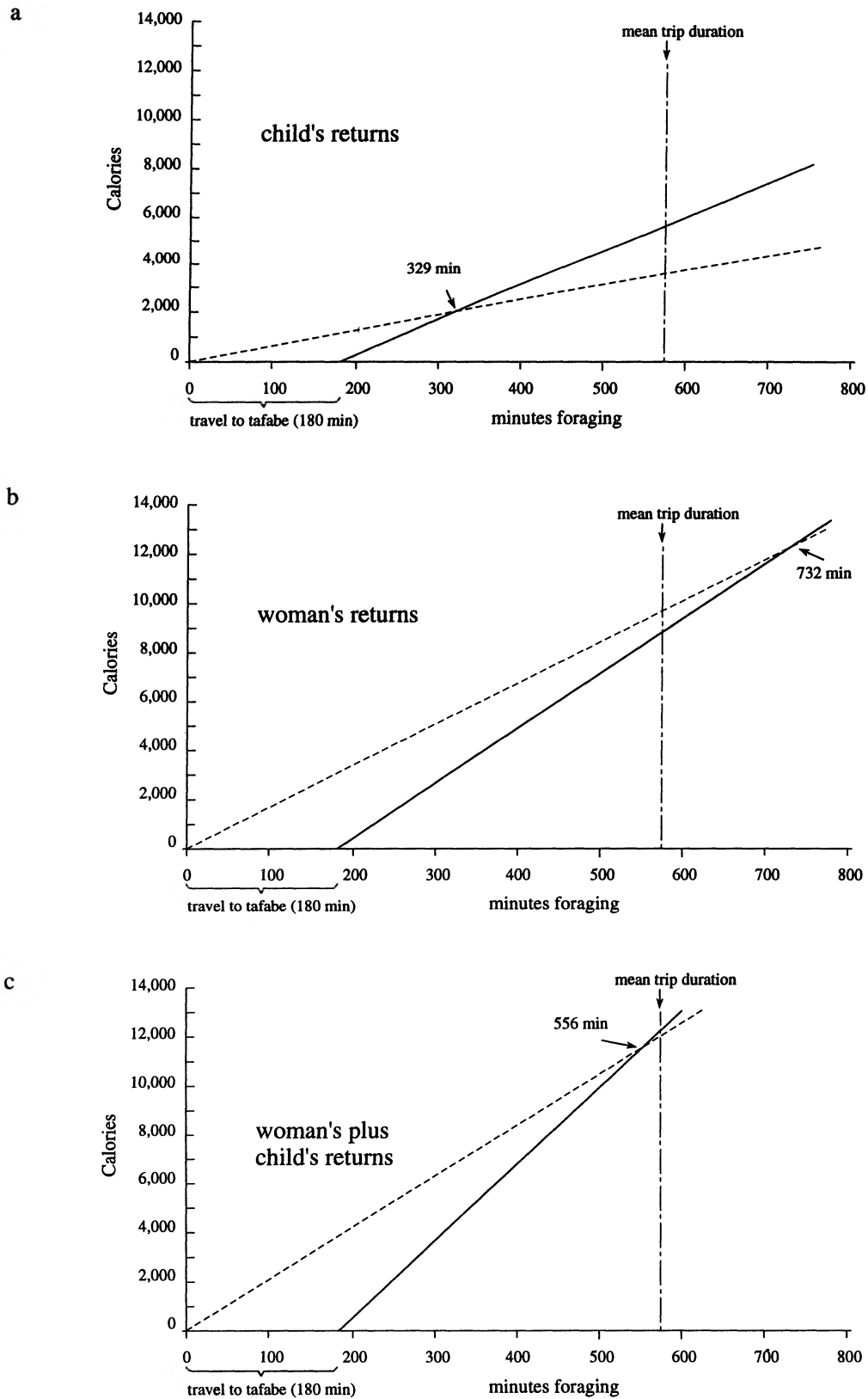


FIG. 1. Overall returns for alternative foraging choices, tubers vs. tafabe. Children's rates are estimated to be half that measured in short bouts (see text). a, child's caloric returns for digging makalita near camp (dotted line) vs. picking tafabe in the distant patch (solid line). b, women's caloric returns for digging //ekwa near camp (dotted line) vs. picking tafabe in the distant patch (solid line); c, woman and child's combined caloric returns for digging tubers near camp (dotted line) vs. picking tafabe in the distant patch (solid line). The y values show the total calories expected for each alternative given the total foraging time specified by an x value. For any x value, the alternative giving a higher y value gives a higher return. The overall rate Cal/min is y/x . Where the lines intersect, the overall foraging rates are equal.

of berry-collecting trips actually observed—577 minutes—is 2.5 hours too short to be the optimal choice for a woman maximizing her own personal rate but just long enough to provide the best collective return for her and a child.¹⁶ The choice of both women and children to travel to the berries and the long duration of the trips are all necessary to give higher team rates of nutrient acquisition.

Comparisons with the !Kung. Hadza children's heavy involvement in food acquisition differs sharply from the pattern reported for the Dobe !Kung, where children forage little or not at all until well into their teens (e.g., Lee 1968, 1969; Draper 1976; Draper and Cashdan 1988). The contrast in near-camp effort is due to the limited foraging opportunities in the northern Kalahari. Experimental surveys around Dobe (Blurton Jones, Hawkes, and Draper 1994 *a, b*) indicate that the returns available near dry-season water sources are very low, even for adults, less than 50 Cal/hr., *an order of magnitude less* than those gained by 5–10-year-old Hadza children taking ripe baobab in the immediate vicinity of their camps in 1986 and less than one-fifth those available from tubers in 1988. !Kung children's pattern of infrequent foraging near camp can be explained as a direct response to the lack of nearby resource opportunities.

But what of distant patches? Since Hadza children routinely accompany adults on daily forays of 10–15 km, distance alone cannot explain why !Kung children

at 77% and boys' at 40% of measured maxima (table 6), then a mother-daughter team will do better by going to the berries as long as the trip lasts 510 minutes, a mother-son team as long as the trip lasts 577 minutes. If picking rates are calculated as fractions of sex-specific mean maxima for berries, 823 Cal/hr. for girls and 1,106 Cal/hr. for boys (table 6), instead of fractions of the overall children's average (964 Cal/hr.), then mother-daughter teams must take berry trips lasting at least 568 minutes and mother-son teams trips lasting 540 minutes to do better targeting berries. These alternatives show that while the precise predictions are sensitive to the particular measurements and assumptions, the general form of the trade-offs is quite robust.

16. This analysis leaves important questions unanswered. Why don't mothers collect tubers near home and send their children to the berries? Alternatively, if children can't make the trip on their own, why don't some women take children to the berries while others dig tubers closer to camp? We cannot yet answer these questions. The common Hadza pattern is that women and children form a single foraging party unless operating very close to camp. Women talk about the propriety of foraging together and sometimes speak disparagingly of a woman who spends the day with her husband instead. They also depend on the company of a male armed with bow and arrows—sometimes an adult, more often one or two older boys—to act as guards against strangers, particularly local pastoralists (see also Matthiessen 1972:212–34; Woodburn 1988), suggesting that large parties may form because traveling alone is dangerous for them, their daughters, and their younger sons. The clear gender bias is notable. While women and girls rarely travel far without an armed male, boys (generally armed) often leave camp in the company of one or two age-mates. The cost and benefits of alternative foraging locations as well as the timing and length of collecting bouts are thus less independent among female foragers. Girls' and very young boys' berry collecting may depend on their mothers' participation. Moreover, the options for one woman apparently depend on what other women do. We have yet to determine how these collective decisions are negotiated.

do not join their elders on trips of comparable length, particularly to the mongongo groves, the key dry-season resource in this habitat. Team rates for exploiting this resource account for the difference. Unlike berries and tubers, mongongo nuts require substantial processing before they can be eaten (Hawkes and O'Connell 1981, 1985). Lee (1979:277–78) reports that “children over eight and *all adults of both sexes* do most of their own cracking. Children 4 to 7 eat smaller quantities of nuts and these are cracked for them by their parents and older siblings.” Experimental data (Blurton Jones, Hawkes, and Draper 1994*b*) show that, except for the youngest children, the returns gained by a mother-and-child pair are greater if the child stays at home cracking nuts than if its mother has already brought back than if it accompanies her to the groves, collects nuts, carries them home, and cracks them. The extra weight in nuts that the child brings back does not offset the gains it makes by devoting its entire work time to processing. For the younger children unable to crack nuts with much success, inclusion in the foraging party exacts a cost in adult efficiencies. Conversations with !Kung informants (Blurton Jones, Hawkes, and Draper 1994*a*) indicate that relatively high dry-season temperatures and the lack of water and shade are recognized as substantial impediments to children. Youngsters are said not to suffer the walk well and to slow the progress of adults, a result that would lower team rates (Blurton Jones, Hawkes, and Draper 1994*b*). Just as Hadza mothers earned higher team rates by taking their children to the distant berry patches than by foraging closer to camp, so !Kung mothers earn higher team rates by *not* taking their children to the mongongo groves, leaving them at home to crack nuts instead. The difference lies in the processing requirements of the resources that provide the highest available team rates.

The surprising gender differences. Hadza boys spent about twice as much time away from camp as did Hadza girls. Except for visits to the berries, boys were usually off with other boys, more often as they got older. Both sexes spent about equal amounts of time at the berry patches, but boys spent less time picking and brought less home than did girls. We are currently unable to explain these differences.

Among the requirements for an explanation is a better understanding of Hadza adult sexual strategies than we have yet developed. We generally expect to find sex differences in foraging among adults because people acquire and process food not only for their own consumption but for its effects on other consumers. Effects important to women can be different from those important to men. We also expect the character and magnitude of the difference to vary with features of local ecology. However large the differences among adults, we expect gender differences among children to be smaller because they are not yet mating and parenting. To the extent that juvenile patterns are practice for adult behavior, they will reflect some of the local adult differences and do so increasingly with age. The data reported here show gender differences emerging surprisingly early, al-

though some show marked increase with age. The differences in the time boys and girls spend away from home are similar to those reported for a wide array of settings (e.g., Gaulin and Hoffman 1988).

Although the Hadza patterns remain to be explained, they show that the minimal gender differences among !Kung children cannot be attributed to mobile foraging. Draper (1975; Draper and Cashdan 1988) described differences between the amount of work and of gender differences among bush-living and recently sedentary !Kung children. In the settled villages children did more work, and their activities were more strongly differentiated by gender, boys engaging in tasks that took them regularly away from home while girls were usually closer to their mothers. Looking only at these !Kung comparisons, it is tempting to see the differences as the result of transitions from mobile foraging to “incipient food production” (Draper and Cashdan 1988). But the work patterns, gender differentiation, and greater spatial ranging of boys among the mobile foraging Hadza indicate that distinctive features of the local Dobe ecology are better candidates for an explanation. The more carefully we can specify the particular variables underlying the patterns, the better our position to predict arrangements beyond the ethnographic cases at hand.

CONCLUDING REMARKS

Hadza children are active foragers, not only exploiting foraging opportunities near home but accompanying adults to distant resource patches. Children’s efficiencies are closer to those of adults for some resources than for others. As a consequence, even though a woman’s personal nutrient acquisition rate would be higher if she exploited nearby tubers, she and her children together would earn lower team rates from that choice. When women take their children on long trips to distant patches where all pick berries, they maximize the rate earned by the team, making nutrients available to youngsters at a higher rate than if all exploited tubers nearer home.

The foraging patterns of Hadza children are determined by the age-specific return rates for local resources. Comparisons with the !Kung show that the processing requirements of these resources are also determinants. Berries require little processing, while the mongongo nuts collected by the !Kung require much. Hadza children raise team rates by picking berries, !Kung children by not gathering mongongo nuts but staying at home and cracking them instead. The comparison contributes to separating variables and detecting systematic interactions that can generate hypotheses to be applied beyond these particular ethnographic cases.

The widely appreciated fact that !Kung children depend on their mother’s food acquisition until well into their teens suggests a degree of juvenile dependence that is misleading in light of these results. Hadza children are active foragers, and a !Kung child’s own nut cracking—not counted as a part of subsistence in widely cited tabulations—is the most productive activity available

to them. The patterns suggest that among mobile hunter-gatherers children may often be more productive (e.g., Hill and Kaplan 1988) than is widely assumed. Scenarios of prehistoric transitions can profitably be revisited in this light.

For example, the sexual division of labor, food sharing, and the nuclear family as the basic economic unit are regularly nominated as features that distinguish human social organization from that of other primates. Influential evolutionary scenarios relate these features to the evolution of increasingly dependent offspring, which both requires and favors a transition in adult male strategies whereby men, unlike adult male nonhuman primates, support their mates and expensive offspring. Elsewhere we have reported aspects of men’s foraging strategies among the Hadza (Hawkes, O’Connell, and Blurton Jones 1991) and other ethnographically known hunter-gatherers (Hawkes 1990, 1991, 1993) that are inconsistent with this view. The patterns described here suggest that attention to the foraging strategies of women and children may provide alternative hypotheses about both the ecological context and the character of hominid radiations.

The extreme contrasts often drawn between human and nonhuman primate juveniles with regard to dependency can be usefully reappraised. Recent research shows marked age differences in the foraging capabilities of nonhuman primate juveniles. For example, Janson reports data for a sample of brown capuchin monkeys in which successful resource searches increased in each six-month age-class from 25% in 6–12-month-olds to the adult rate of 50% by 3 years of age (Janson and van Schaik 1993:58). Janson and van Schaik compare the foraging time of juveniles with that of adult females across several species and, adjusting for body-size differences, find that juveniles spend more time than expected. “This increased foraging effort is consistent with lower juvenile foraging competence” (Janson and van Schaik 1993:59). They also survey food choice and conclude that juveniles usually acquire only some of the resources taken by adults. The patterns show that juvenile abilities could limit the foraging choices of nonhuman primate mothers, which, like human mothers in the Hadza case, may forego higher personal rates to accommodate their juvenile offspring (van Schaik and van Noordwijk 1986).

The nonhuman-primate trade-offs are different because mothers and offspring do not form a food-sharing team—the pattern usually cited to illustrate the qualitative difference in the extent of juvenile dependency among humans. Nonhuman primate youngsters acquire almost all their own food after weaning; human children do not. The food transfers may be associated with reduced foraging competence in human juveniles, but they need not be. Human adults as well as youngsters get large fractions of their subsistence from the foraging efforts of others. In both human and nonhuman cases the choices open to juveniles depend on their mothers’ choices. Instead of *increasing* the limits on mothers’ foraging, regular food transfers may give women more

latitude than nonhuman primate mothers to target resources that juveniles cannot exploit profitably enough to feed themselves. In addition, older children and grandmothers (Hawkes, O'Connell, and Blurton Jones 1989) may make contributions to team productivity that compensate for the inefficiency of younger juveniles. This interaction of age-specific foraging capacities and maternal resource choices may offer guidance for a richer menu of hypotheses about hominid evolution (cf. Zihlman and Tanner 1978).

Turning to changes in the terminal Pleistocene, the assumed heavy dependence of children on adults among mobile foragers has been contrasted with the picture of sedentary populations in which children are regularly engaged in productive labor. Inferences about social and demographic consequences of settlement are then used to explain transitions in the archaeological record after the last glacial maximum. Reliance on the !Kung to exemplify mobile foragers has been especially influential in spite of demonstrations that specific features of Dobe ecology constrain the reproductive strategies of foraging women there (Blurton Jones and Sibly 1976; Blurton Jones 1986, 1987). The Hadza are at least as mobile as the !Kung, perhaps more so in that they can move camp more often to more water sources in the dry season. Consequently the regular foraging of Hadza children is a powerful challenge to widespread notions about the effects of mobility on children's activities. Mobile foraging does not necessarily result in excluding juveniles from food acquisition, nor is it just distance to resources that limits their participation. The inclusion of resources that require substantial processing does not necessarily make children more—or less—productive.

Two variables emerge as important in explaining the character of children's productive activity among mobile foragers. The first is the age-specific return rates for locally available resources that determine which alternatives give the highest team rates for women and children. The second is the character of the resources offering the highest team rates. If those resources require extensive processing, rates may be maximized if some members specialize in processing tasks. This is a partial list of the variables likely to be important. In some circumstances other maternal trade-offs may shape women's strategies, with consequences for the opportunities available to children (e.g., Hurtado et al. 1992, Kaplan 1994). By continuing to investigate the effects of these local ecological variables on the activities of both children and adults where people live by hunting and gathering, we improve both the descriptive record of behavioral variability and the foundation for hypotheses about economic, social, and demographic transitions in the past.

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