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# 6

# Mardu Children's Hunting Strategies in the Western Desert, Australia

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> Mothers and fathers gone out hunting and leave us kids in camp. When we got hungry we go hunting for little lizard, get him and cook it and eat him up. Me little bit big now, I go hunting myself, tracking goanna and kill him. . . . Soon as mother leave him, little ones go hunting, kill animals, blue tongue, mountain devil, take them home before mother and father come back, cook and eat it. Mothers, they bring him goannas and blue tongue and father one still long way. Mother come back and feed all them kids. . . . After lunch mother and father go hunting for supper, all the little kids walk and kill little lizard, take him home, cook and eat him. . . . Morning again, father one he go hunting. All little kids go hunting self. . . . Mother go out separate from father and come back with big mob of animals. Me big enough to hunt around self. . . . Morningtime, father one bin for hunting long way way. He bin get and kill an emu, bring and cook him. Everyone happy, they bin say he good hunter. Mother and father sometime bin come back late from hunting. They bin go long way. (Yuka Napanankga, Mardu woman from Kukatja Community, Western Australia; Napanankga 1995:143)

The contributions to this book make it abundantly clear that human juvenility is unusual in the extreme. Human juvenile periods not only last a long time, they are time *consuming*. Once weaned, children in all societies rely on their elders for well over a decade (Kaplan et al. 2001, 2003). In this volume John Bock, Nicholas Blurton Jones, Sarah Hrdy, and Bram Tucker focus our attention on the important implications of understanding this prolonged juvenility: aspects of our unique fertility profiles, our long life spans, our low mortality, our patterns of social and local organization, and our highly complex systems of cooperation are probably all linked to our peculiar juvenility.

What is responsible for this strange life history pattern? Is childhood designed as a period to gain experience, skills, and knowledge? Or do we learn a lot because we have a long childhood? Maybe both, but hunter-gather studies are especially important in addressing such issues: many researchers have argued that the evolution of a unique human foraging niche involving intergenerational resource flows corresponds with the evolution of our long juvenile period (Isaac 1978; Kaplan and Robson 2002; Kaplan et al. 2003; O'Connell et al. 2002). Until recently there has been little research on the lives of hunter-gatherer children, especially relative to their role in a subsistence economy. Many scholars have assumed that children are primarily the recipients of adult labor, and that, especially among foragers, they contribute little to their own maintenance (e.g., Bogin 1988; Tooby and Cosmides 1992; Quiatt and Kelso 1985). This may reflect a general notion about childhood as a period primarily of practice for the complexities of adulthood. Implicit in the concept of "growing up" is the idea that children's lives are all about gaining the skills to become successful adults.

This view of juvenility has been challenged by some recent studies of contemporary hunter-gatherers. For example, Blurton Jones and colleagues (Blurton Jones and Marlow 2002; Blurton Jones et al. 1994a, 1997, 1999) have shown that Hadza children in Tanzania are effective foragers and children's subsistence efforts are constrained primarily by size and strength rather than the difficulty of learning adult skills. Some developments in life history theory also suggest that delayed human maturity is principally a product of decreased extrinsic mortality, where selection favors longer juvenile periods with decreasing extrinsic *adult* mortality because of the advantages of growing longer (and thus larger) (Charnov 1993; Charnov and Berrigan 1993). For primates, the age of maturity and extrinsic adult mortality vary widely, but their product is approximately invariant: humans fall well within the confidence interval for all primates in which these variables have been measured (Alvarez 2000).

Nevertheless, even in societies where children are very productive from a young age, they remain critically dependent on others for over a decade after they are weaned, and it often takes many years to reach peak efficiency (Bock 2002a; Kaplan and Bock 2001; Kaplan et al. 2003). In a recent comparison across a broad range of foraging societies, youngster's consumption of resources exceeds what they produce for themselves so that offspring continue to depend on nutritional subsidies from others up to age 18 or older (Kaplan and Robson 2002). This is not the case with other hominoids: mother-child food sharing occurs in most ape societies, but only human mothers provide a substantial fraction of their weaned children's diets.

Some researchers have suggested that a such a foraging niche (focused on widely shared resources that are difficult for juveniles to acquire) is the

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key to understanding unique aspects of the evolution of our genus, in particular specialized foraging by men and women, which increased the benefits of widespread food sharing and central place foraging (e.g., Isaac 1978; Washburn and Lancaster 1968). Kaplan and colleagues (2000a, 2001, 2003) have argued that the costs and benefits of caring for a highly dependent young primate, along with changes in the opportunities for access to game animals, made certain foraging activities unattractive to women. In response, men began to focus on skill-intensive foraging that (once learned) is highly efficient for provisioning high-cost offspring through intergenerational resource flows. This in turn favored more direct maternal care and fed back to decrease extrinsic mortality and increase the benefits of growing longer to maturity (i.e., getting larger gives more to invest in production for maintenance and reproduction).

> It is this partnership of men and women that allows long-term juvenile dependence and learning and high rates of survival. . . . Human pair bonding and male parental investment is the result of complementarity between males and females. The commitment to caring for and carrying vulnerable young . . . together with the long period required to learn human hunting strategies, renders hunting unprofitable for women. (Kaplan et al. 2000a:173)

Others, including ourselves, have argued that human social organization may have less to do with male-female pair bonding to provision costly children than the above model would predict (e.g., Bliege Bird 1999; Hawkes 1991, 1996, in press; Hawkes and Bliege Bird 2002; Hrdy 1999). We have suggested that among the Meriam of Australia's Torres Strait Islands, highly skilled male hunting is designed more as a public display than as a means to efficiently provision offspring (Bliege Bird and Bird 1997; Bliege Bird et al. 2001, 2002; Smith and Bliege Bird 2000; Smith et al. 2003). Moreover, like the Hadza, foraging efforts among Meriam children are primarily constrained by size, not the complexity of learning how to forage like an adult (Bird and Bliege Bird 2000, 2002; Bliege Bird and Bird 2002; Bliege Bird et al. 1995). If size allows, Meriam children learn even the most complex fishing activities very quickly.

But what about hunting? Researchers have rarely recorded independent hunting by children. Most of children's foraging seems focused on activities like fishing and gathering fruits and vegetables. While in many cases boys begin to practice hunting skills at very young ages, peak efficiency in acquiring large game is not usually reached until well into adulthood (Hill and Hurtado 1996). And in some cases peak energy production from many skill-based activities (like hunting) is not reached for more than a decade after puberty (e.g., Kaplan et al. 2000b; Ohtsuka 1989). Whether or not this results from changes in the intensity of effort or the cognitive complexity of hunting, it is hard to imagine that children could possibly

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hunt large game that are often the specialty of men. However, this says nothing about whether from a child's perspective large game hunting would be an efficient option no matter how practiced or large they were. And as Mrs. Napanangka states in the introductory quote, children of Australia's Western Desert *do* hunt. Among the Mardu at Parnngurr Outstation, children above the age of five often search for and pursue game animals. But they focus their efforts in different resource patches than adults. Are these differences the result of the time it takes to learn adult hunting strategies, or are they the result of differences in the payoffs to be gained for small-sized foragers? By choosing different types of prey are children practicing hunting skills that they will use later in life, or are they simply making the best of a small situation?

## BACKGROUND AND METHODS

The term Mardu (or *Martu* in many current orthographies) conventionally refers to foraging groups whose traditional estates surround Lake Disappointment, the Rudall River, and the Percival Lakes in the northwest section of Australia's Western Desert (Figure 6.1). For the people that commonly call themselves *Martu,* the term is not necessarily exclusive: in some situations they use it to refer to traditional speakers of the core dialect groups of the area, especially Manyjilyjarra, Kartujarra, Warnman, Putijarra, and Nyangajarra. In other circumstances *Martu* may designate humans in general. Today, people sometimes use *Martu* to distinguish indigenous people around the world, as opposed to people who "don't belong." While there are many speakers of Manyjilyjarra and Kartujarra, there are very few people who still speak Warnman, Putijarra, and Nyangajarra. All Mardu (numbering about eight hundred to one thousand people) now use a lingua franca referred to as *Martu Wangka,* with components of numerous Western Desert dialects.

The linguistic situation reflects the enormous changes that have occurred among the Mardu over the last century. Limited contact with white explorers and settlers began in the early twentiethth century with pastoral efforts on the western and southern fringe of Mardu territory. In the 1930s some Mardu began a process of migration westward from their desert estates, visiting and eventually settling in Jigalong (a maintenance depot, and later protestant mission) and surrounding cattle stations (for detailed history, see Tonkinson 1974). However, many families, especially those from the easternmost part of Mardu territory, remained in the heart of the desert until the mid-1960s, when prolonged drought and depopulation drove them into Jigalong and pastoral stations such as Balfour Downs. While

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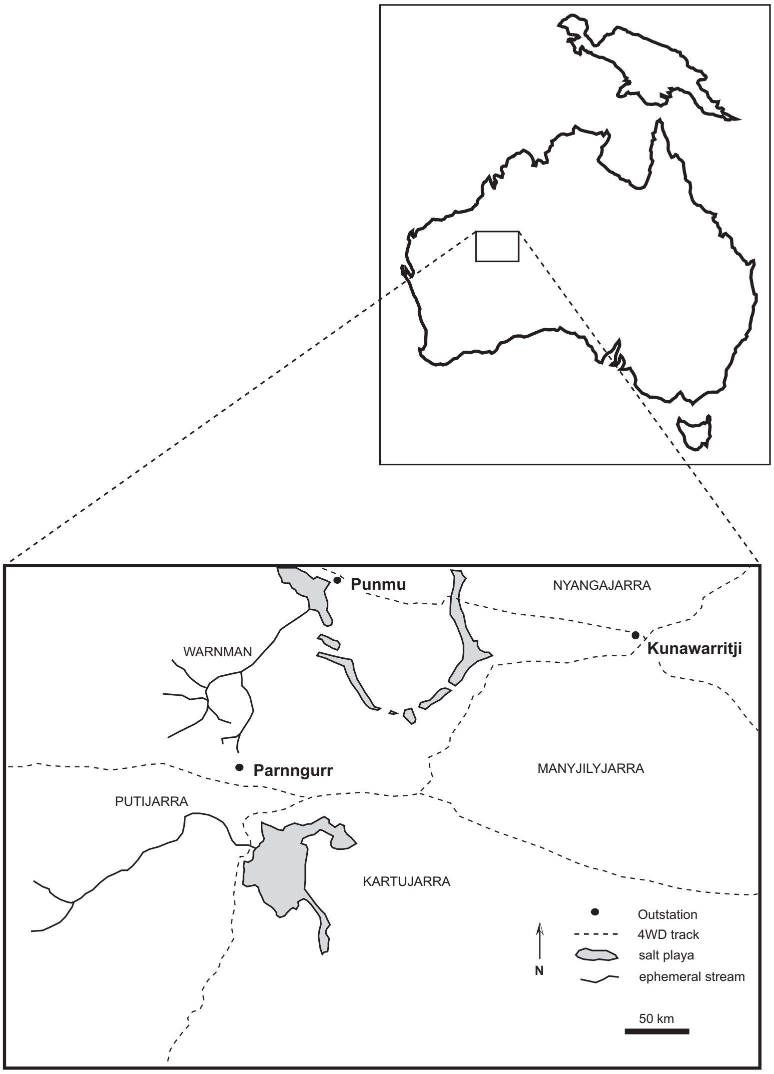


*Figure 6.1.* Mardu territory and dialect groups.

many Mardu stayed in Jigalong, many also left soon after their arrival, either for employment in towns and stations, or back to the desert proper. In the mid-1980s numerous families (mostly those that were the last to leave the desert) returned permanently to Mardu homelands. By 1986 they had established two "outstation" camps (Punmu and Parnngurr) in the newly designated Rudall River National Park (another outstation at Kunawarritji, Well 33 on the Canning Stock Route, soon followed). The reoccupation of Mardu estates was initiated primarily to resist mining expansion near sacred sites, but it was also a response to the increasing influence of alcohol and "Western" culture, especially among Mardu youth. Many Mardu felt that their ability to keep sacred Law and practice their religion depended on moving back to their homelands (Tonkinson 1991: 174–178).

Especially for the families at Parnngurr (comprising a core population of about one hundred people), their return to the desert meant a return to a foraging economy. Government rations were trucked out when possible, but often vehicle access to the camp was cut off for months at a time. Throughout the mid- to late 1980s and early 1990s, much of the daily subsistence at Parnngurr came from hunting and gathering. Walsh (1990; Veth and Walsh 1988) conducted critical research on foraging activities in and around Parnngurr during this period, focusing on Mardu ethnobotany, seasonal variability, and gathering ecology.

Today, the importance of foraging has declined relative to what it was at Parnngurr's establishment. The supply route to the community is more reliable (although still precarious, especially with occasional summer storms), and regular government funds (e.g., social security and Community Development Employment Program, CDEP) along with a small store (usually stocked with basic food and household items) have increased reliance on a cash/welfare economy. Hunting is usually poor near the permanent settlement; foragers often require vehicles to visit more distant hunting and gathering grounds on day trips, and there are few working four-wheel-drive trucks in the community. Introduced fauna, especially camels, may also be depressing certain game populations. Mardu also face changing demands on their time: with sedentism, clothing, and vehicles came the need to allocate more time to cleaning, washing, and maintenance; men and women are often involved in ritual activity, with some men spending months at a time away from the community; time is also taken up with various government meetings and functions; and obtaining CDEP wages means at least some time working during the week on various community projects.

Nevertheless, Mardu at Parnngurr continue to hunt and gather on a regular basis, their foraging frequency limited primarily by vehicles and fuel to access more distant hunting and gathering locales. Although most people at Parnngurr would prefer to hunt every day, the majority forage about two to four days out of the week. Vehicle trips to foraging locations within fifty kilometers of the community occur nearly every day, and extended camps to more distant locales are common, especially during the cool/dry season (*Wantajarra*, May–August).

## CHILDREN

An ethos of self-sufficiency surrounds Mardu children. Desert-born adults recall a childhood spent foraging with other children to keep themselves fed while the women hunted burrowed game (especially *parnaparnti*-sand goanna, *Veranus gouldii*) and men hunted mobile game (kangaroo, bustard, and emu). Children would remain behind, usually with teenagers or a young adult. If camped in sandhill areas near rocky outcrops they would spend their day hunting medium-sized lizards (*winyjikiti*-ridge-tail goanna *Veranus acanthurus,* and *lungkuta*-blue tongue skink *Tiliqua scincoides*), picking fruit (especially *kumpulpaja-Solanum diversiflorum* and *jinyjawirri-Solanum ellipticum*), hunting small birds, digging grubs (*lunki-Cossid* spp. larvae), or collecting bird eggs. If near the margins of ephemeral watercourses, they would dig wild onion (*minyarra-Cyperus bulbosus*) or pencil yams (*kanjamarra-Vigna lanceolata*) during *Wantajarra*. Early in *Wantajarra* children would also collect and process woollybutt grass (*kunaruntu-Eragrostis eriopoda*.[1] Much of what children acquired was for their own immediate consumption and they often cooked their own meals on small fires. Children were actively discouraged from accompanying men or women on their separate hunting trips, but encouraged (and relied upon) to assist adults in collecting fruit, roots and corms, or grubs. By the age of first marriage (for girls, just after the time of first menstruation) and at the beginning of initial stages of initiation (for boys), between 13 and 16 years, youths were expected to begin to take on adult responsibilities and adult foraging strategies. Boys began to hunt with men, and girls to hunt with women.

Parnngurr children today always accompany adults on foraging and camping trips away from the community, but are left in temporary residential or day camps unless women are gathering (fruit, roots, or grubs) or men are hunting using the vehicle. Women spend much of their time hunting for *parnaparnti* goanna in the sandhills and flats, and rarely take children with them (although nursing mothers occasionally carry infants). Women hunt on foot with a digging stick, and they often remark that children are too slow to keep pace while they are searching and tracking. While in the past men would never take children on foot hunts, now children often accompany them when hunting in a vehicle, particularly for bustard (*kipara-Ardeotis australis*), so that their wives can walk long distances in search of *parnaparnti*. During men's vehicle hunts, children are expected to help spot animals and to assist in burning patches of grass if needed. While children can sometimes be a disturbance, they are usually silent while men are tracking and pursing an animal. (For further details on men's and women's hunting, see Bird et al. 2003, submitted; Bliege Bird and Bird, in press).

When children are left behind, depending upon camp location and season, they often decide to pick *kumpulpaja* and *jinyjawirri* or hunt lizards. Generally all children in camp, boys and girls, will forage together in the same group. Their efforts are highly praised by young and old alike, but their decisions about whether or not to forage and what to look for are not directly influenced by adults. When hunting, children occasionally search for *lungkuta* and *parnaparnti* around camp in the sandhills and flats, but when rocky outcrops are nearby, they almost always prefer to hunt for *winyjikiti* goanna. Capturing *winyjikiti* is difficult. Children fan out and search the sands between the rocks for recent tracks, and carefully follow signs of the lizards to a likely den. They then use a *wana* (a long metal crowbar or specialized wooden digging stick) to turn over rocks and pry apart friable crevices. When one child locates a promising den, others may come to assist, just as adult women do when cooperating on *parnaparnti* goanna hunts. And as women do, when children capture the *winyjikiti,* they pull it from the nest by the tail, swiftly crack its head on the *wana*, and break the legs. After hunting, children sometimes cook and eat their lizards before adults return to camp.

## DATA COLLECTION

All Mardu participants, including the children, spent most of their lives in the desert, and the formative years of those aged 35 and older were spent as full-time foragers. In the following analysis, unless we indicate specific age categories, individuals referred to as "children" are age 4–14, and "adults" are 15 years or older. Ages of youngsters are known from birth records, but for adults born in the desert there are no birth records. For these individuals we estimated ages within five-year age categories relative to each other (older or younger) and the timing of known events (World War II and the date of first contact with government welfare patrols and anthropologist Robert Tonkinson in 1963).

Foraging is defined as time spent searching, pursuing (including tracking and extracting an individual prey), collecting, and processing wild foods. Travel is defined as time spent on foot or in the vehicle en route to foraging locations. Each of these activities is mutually exclusive. We define hunting (as opposed to gathering) as foraging activities that primarily involve searching for *mobile* animals, whether they burrow, run, or fly to escape capture. Most of the data we analyze here were collected during *Wantajarra* (cool/dry season) by four researchers (ourselves and two postgraduate students, Christopher Parker and Bonnie Bass) on twelve extended camping trips (some lasting for a month) away from Parnngurr. Data from these extended camps are available from three field seasons

2000–2002. For the children's analysis, we also included five focal follows from five separate day trips out of Parnngurr in 2002.

Mardu participants traveled by car to field camps of their choosing, and from those camps walked or drove to foraging locations. During foraging trips we conducted detailed focal individual foraging follows: each researcher accompanied a single individual and noted all time allocated to travel, search, pursuit, collecting, and processing, along with the weight of each item (if game) or parcel (if fruit, vegetable, or insects) captured at the end of foraging. A total of 157 focal individual foraging follows (131 adults: 95 female and 36 male; 26 children: 14 female and 12 male) are used in the analysis of hunting presented below. In addition to the focal follows, during the extended camping trips we recorded the duration of all foraging episodes and the weight (by item or type) of all food captured by all camp or trip participants. For this analysis a total of 156,084 foraging hours were recorded over 307 individual foraging trips by 32 *different* Mardu (20 adults and 12 children). Energy values were taken from published sources analyzing the composition of aboriginal foods (Brand-Miller et al. 1993). Edible weights for animals were calculated in the field by weighing uncooked individuals and asking foragers to discard the waste material from those same individual animals into a receptacle (n=88, including samples from all game animals reported here). On extended camps, individuals averaged 1702 ± 210 (SE) kilocalories per forager per day, not including those in camp who did no foraging (only the smallest children and the researchers). We supplied an average of five hundred kilocalories per day per participant, primarily in the form of flour and sugar.

We also recorded walking speeds while some foragers *searched* for game on foot during hunting activities. This was accomplished using hand-held differentially corrected GPS while the primary author walked along with a hunter. Speeds were recorded in spot observations at two-minute intervals during search, but only when recording accuracy was ±6 meters or less. This provided a dataset of 150 spot observations during thirteen focal follows of *different* foragers (6 adults: 3 women and 3 men; 7 children: 4 girls and 3 boys; the number of spot observations ranged between 9 and 13 per follow). To control for the effects of variable landform and activity type, we only recorded walking speeds while foragers were walking in the sandhill flats (for children, this was usually en route to rocky outcrops). To measure the effects of body size on walking speed, we also recorded the height of the child foragers.

## RESULTS

If we concern ourselves with hunting activities that both adults and children choose *independently*, only two hunting "patches" (*sensu*, Smith

1991) are available on foot from most *Wantajarra* camps: the sandhill patch where hunters search primarily for *parnaparnti* (sand goanna), and rocky outcrops where hunters search for *winyjikiti* (ridge-tail goanna). Where rocky outcrops are within walking distance from camp, accessing them requires at least some travel through sandhills. The focal follow data from hunting demonstrate clear differences in the decisions of adults and children. In 131 hunting follows where search took place on foot, adult foragers never chose to search in rocky outcrops. Children on the other hand, hunted for *winyjikiti* in rocky outcrops on all (26) focal hunting follows, and on only two of these follows did children spend time searching in the sandhills while traveling to the outcrops. On average, children earned 402.4 ± 67.9 (SE) kilocalories/hour foraging in the rocky outcrops. Adults earned 1102.1 ± 276.5 kilocalories/hour foraging in the sandhills. Here we investigate two hypotheses concerning these differences:

H1: The difference is caused by the difficulty of learning how to hunt *parnaparnti* (sandhill patch) relative to *winyjikiti* (rocky outcrops). If so, we would expect a clear increase in overall return rates (kilocalories/hour foraging) with age (assuming age correlates with experience). As experience increases with age, children should switch from *winyjikiti* to *parnaparnti* hunting when the overall return rate in rocky outcrops is exceeded by the expected payoff from the sandhill patch.

H2: If children focus on *winyjikiti* primarily due to the constraints of being small foragers, we would expect stronger effects on return rates with size (i.e., height) than experience (i.e., age). Height may affect return rates in the form of influencing average walking speeds in the sandhill patch: children are shorter, thus may walk slower and encounter prey less frequently. If prey in the rocky outcrops is found at higher density than prey in the sandhills, shorter and slower foragers may encounter less prey in the sandhills than they would encounter walking for the same length of time in the rocky outcrops.

## H1

Figure 6.2 demonstrates that age alone is a very poor predictor of hunting efficiency among children in the *winyjikiti* rocky outcrop patch (linear regression, $r^2 = .025$, $f = .62$, $p = .44$, $n = 26$ follows for which we have corresponding return rates and forager age). Nor is there a general tendency toward increasing efficiency with age subgroups: foragers age five to seven on average earn 467.1 ± 114.3 kilocalories/hour foraging ($n = 8$), those age 8–11 earn 237.7 ± 89.3 kilocalories/hour foraging (n = 12), and those age 12–14 earn 652.9 ± 112.9 kilocalories/hour foraging (n = 6).

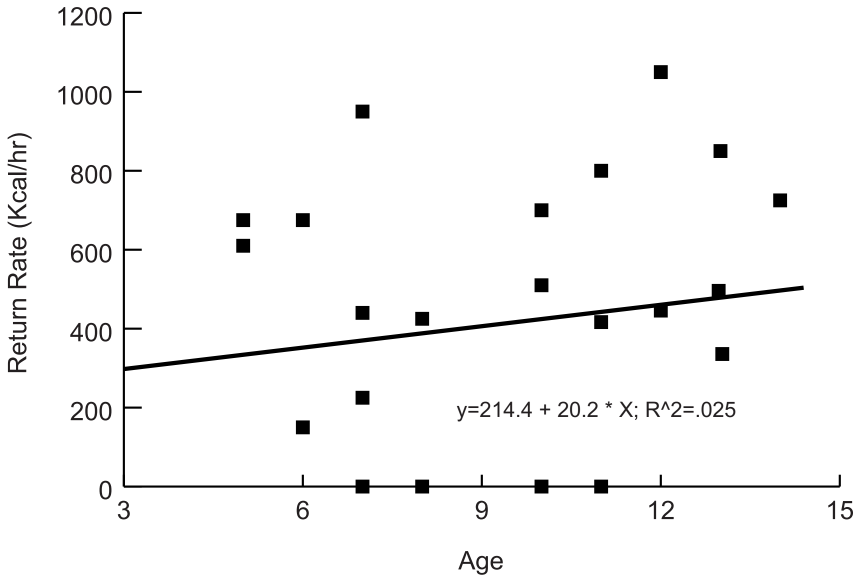


*Figure 6.2.* Please provide caption.

While sample sizes for subgroups are small, the return rates for children age 5–7 are not significantly different from those age 12–14 (df = 12, $t$ = –1.13, $p$ = .28).

## H2

Figure 6.3 shows that unlike age, standing height has a significant effect on children's foraging efficiency in the *winyjikiti* rocky outcrop patch ($r^2$ = .25, $f$ = 4.94, $p$ = .04, $n$ = 17 follows for which we have corresponding return rates and forager height). Regardless of age, taller children gain higher foraging returns than shorter children. Part of this increase is due to the smaller sample size (i.e., there are two foragers with low return rates for which we are lacking height measures). If we assume an average height by age category (ages 5–7; 8–11; 12–14) of children for which we lack height ($n$ = 9), the effect of height on efficiency is less ($r^2$ = .17), but still significant ($p$ = .04).

Can this height effect account for the fact that given the choice, children choose to hunt *winyjikiti* in the rocky outcrops rather than *parnaparnti* in the sandhills? Accessing rocky outcrops inevitably involves some travel *through* the sandhill patch: adults choose the sandhills, children choose the

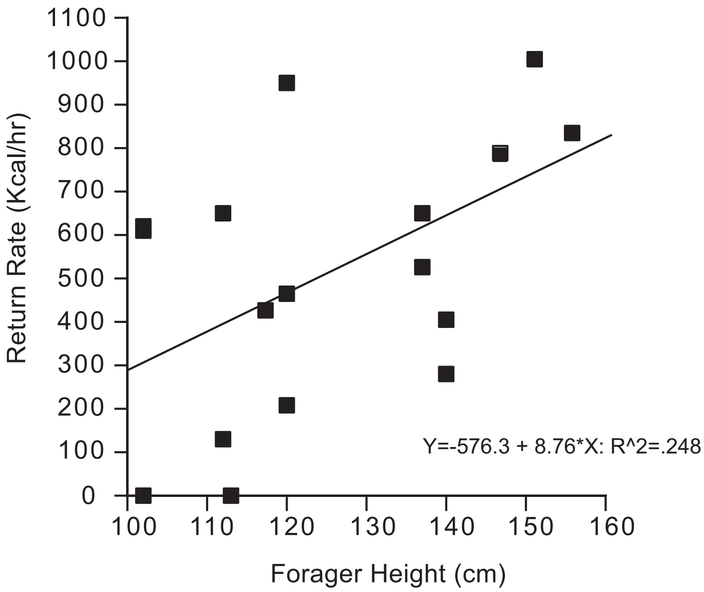


*Figure 6.3.* Please provide caption.

outcrops. It might be that because height and walking speed are closely correlated (partial correlation, $R = .70$, $p = .01$), these, not age per se, determine the rate at which foragers encounter prey, especially if children were to hunt in the sandhills where encounters with prey are less frequent (see below).

To account for the independent effects of height, walking speed, and age on efficiency, we perform a number of tests. First, we model children's *winyjikiti* hunting efficiency with both age and height in a multiple regression. As Table 6.1 shows, the combined effect of age and height is a stronger predictor of efficiency than either is alone ($r^2 = .52$ vs. .025 and .25, respectively). However, since age, height, and walking speed are closely correlated, their differential effects on efficiency are difficult to interpret in a multiple regression. As such, we first examine a regression of age on height to obtain the residual variation in height after accounting for differences due to age. We then do the same with a regression of height on age to obtain the residual variation in age after accounting for differences in walking speed due to height. Finally, we use the residual from each of these regression models as independent variables in two simple linear regression models predicting walking speed. By itself, age is significantly correlated with walking speed (partial correlation $R = .57$, $p = .04$), but

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*Table 6.1* *Winyjikiti* Hunting in Rocky Outcrops: Multiple Regression Coefficients for Children's kcal/hr Foraging vs. Age and Height

| *Summary* | | | *Coefficient* | *Std. Error* | t-*Value* | p-*Value* |
|---|---|---|---|---|---|---|
| $n$ | 17 | Intercept | –2162.02 | 692.33 | –3.12 | .001 |
| $r^2$ | .52 | Age | –167.07 | 58.73 | –2.85 | .013 |
| Adj. $r^2$ | .46 | Height | 32.95 | 9.10 | 3.62 | .003 |

height alone is a better predictor ($R = .96$, $p < .001$). If we control for the interaction between age and height using residual analysis, we find that residual height is a far better predictor of walking speed than residual age (linear regression of residual height versus walking speed, $R = .78$, $p < .002$; regression of residual age, controlling for height, on walking speed, $R = .14$, $p = .65$). In other words, the effects of age on walking speed are due to the correlation between age and height, and once we remove that effect, height remains the most significant predictor of walking speed *and* efficiency.

## EFFECTS OF WALKING SPEED ON ENCOUNTER RATES AND PATCH CHOICE

While in the sandhill patch, children (all below 160 centimeters in height) walk at an average speed of 2.86 ± .01 kilometers/hour, and adults (all above 150 centimeters) walk at 3.77 ± .08 kilometers/hour (df = 148, $t$ = (7.20, $p < .001$). Because the density of prey in rocky outcrops and sandhills differs, walking speed has differential effects in the two patches: children in rocky outcrops encounter prey (averaging 350 grams/item) at 1.56 ± .27 items/hour *searching* ($n = 24$), while adults encounter prey (averaging 450 grams/item) at a rate of .90 ± .12 items/hour searching in the sandhill patch ($n = 131$) (means are significantly different, df = 153, $t = –2.14$, $p$ = .03). At children's average walking speed, *if they chose to search for prey only in the sandhill patch,* their encounter rate would be .68 items/hour search, yielding 307 grams/hour search, or an overall foraging return rate of 442 kilocalories/hour. This compares favorably to the 402 kilocalories/hour children acquire in rocky outcrops. If we examine only the benefits of foraging in terms of energetic return, children should be equally likely to choose sandhills as rocky outcrops for their hunting trips. However, because they walk slower, smaller children would be even less successful in the sandhills than in the rocky outcrops. If smaller hunters (101–130 centimeters in height, mean walking speed = 2.25 ± .12 kilometers/hour, $n$ = 36 spot observations) chose to forage in the sandhill patch, they would

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gain 268 grams/hour search, yielding roughly 385 kilocalories/hour foraging. In rocky outcrops children this height earn 448.7 ± 86.7 kilocalories/hour foraging for *winyjikiti* ($n = 7$).

While on average the return rates for all children might be similar in the two patches, additional *costs* of acquiring prey in the sandhills may preclude smaller hunters from hunting there. The average length of time children spend hunting in the rocky outcrops is only 48 ± 7 minutes, while adults average 193 ± 9 minutes hunting in the sandhills. In order to acquire one prey item (450 grams) in the sandhills, children must forage for 88 minutes on average and walk at least four kilometers. In order to acquire one prey item of 350 grams in the rocky outcrops, children need only forage for 38 minutes and walk 1.8 kilometers. Although the gross foraging return rates are the same, foraging in sandhills as compared to rocky outcrops requires 2.3 times greater time investment and 2.2 times more walking as does rocky outcrop foraging for only 1.3 times as many calories per hour.

## DISCUSSION

Our data suggest that height and walking speed are more important constraints on hunting success than age. Once Mardu children systematically begin to hunt for goanna lizards, they are already well practiced: in our sample the youngest hunters can be nearly as efficient as the older children. Beyond about five years, age alone has little effect on children's hunting success in rocky outcrops. However, standing height and walking speed do predict increases in children's success. Moreover, the data indicate that walking speed (which is more closely correlated with height than age) has an important effect on children's decisions to avoid the sandhills and focus on hunting in rocky outcrops. Children who are smaller walk more slowly and take longer to cover enough ground to acquire at least one sandhill goanna. Such slow walkers find the costs of sandhill foraging higher relative to the increase in benefits received compared to hunting in rocky outcrops. On average, children who choose to hunt in rocky outcrops find more prey more quickly and with less walking. Foragers might begin to increase their return rates by switching from hunting in rocky outcrops to the sandhills when their height (roughly 150 centimeters) permits higher-speed walking over long distances, or perhaps when body size allows them to tolerate higher-cost foraging strategies.

One of the problems with our analysis here is that we lack height measurements for adult foragers: some of the larger children and some of the smaller adults would walk and search at similar rates, and yet *they still choose different hunting patches*. Why this is so will require specific investi-

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gation of the effects of height, walking speed, body weight, and age in the sandhill patch. It may be the case that exogenous factors not measured here may play an important role in influencing children's time allocation to different activities (Bock 2002a, Chapter 5 in this volume). For example, camping within reasonable walking distance of both sandhill and rocky outcrop patches may provide opportunities for adults to leave older children to care for youngsters in locales where smaller children can be especially productive. Thus, it may be that larger children, when accompanied by smaller children, would have to walk more slowly in the sandhills: they choose rocky outcrops to increase their efficiency when caring for and foraging with small children. Hawkes et al. (1995a) have shown similar effects of children on a mother's patch choice among the Hadza. Testing this among Mardu would require experimental foraging in the sandhills by children of different ages and in different group compositions.

Another possibility is that the costs of walking longer distances in the hot sun may be lower for individuals of higher body mass than for those with lower body mass. Children are notorious for their intolerance of heat stress and thirst. This might explain why short but high-mass adults will still choose sandhills over rocky outcrops even though they are the same height as some of the thin but light children.

It should also be noted that our analysis does not *directly* control for learning experience: we have no quantitative measure of learning curves with age, which are likely to be different for different foraging activities. We only show that among children, size is a better predictor than age for both walking speed and foraging efficiency; we *assume* that age indicates the amount of experience and learning (and that increases in these would be roughly equivalent in the two hunting patches analyzed, see below). One way of addressing this issue would be to investigate differences in the percentage of time that foragers have spent in the desert as opposed to time in European settlements for individuals of all ages. But for experience to account for the increase in hunting success with forager height, this would mean that taller children (at any age) have spent more time foraging in the desert. We doubt that this is the case.

Another possible critique is that there are many other factors (than those investigated here) inherent in adult hunting activities that make them too difficult for children (see Bock 2002a). This may indeed be the case for large game hunting and the use of lethal weapons, but whether children avoid these as a result of size or learning constraints would require experimental data. Ohtsuka (1989) demonstrates that among Gidra hunters on the Papuan Oriomo Plateau, regardless of size or strength, men age 35–45 have four times the hunting efficiency as teenagers and young men. But we do not know from this how long it takes to learn such activities or how changes in motivation to learn how to hunt vary with age.

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Does it take an entire childhood? Blurton Jones et al. (1999) and Blurton Jones and Marlowe (2002) provide data showing that among the Hadza, growth-based constraints are more important than experience in success at using hunting weapons. When size allows, foragers *can* gain experience related to hunting fairly quickly if so motivated.

If learning and experience account for Mardu children's hunting decisions, this would suggest that it takes over ten years to learn to hunt like adults in the sandhill patch. But in comparing current options for Mardu to hunt on foot, we would argue that the *learning* constraints are similar in both available patches (*winyjikiti* in rocky outcrops or *parnaparnti* in the sandhills). Hunting in the sandhills is cognitively difficult, but no more so than hunting in rocky outcrops. Foraging in both patches focuses on similar types of prey (goanna). Both require complex knowledge about where and when to hunt, and intricate strategies to search for, track, and extract the prey. Tracking prey in both patches requires hunters to synthesize complex information about goanna feeding and denning behaviors and their signatures across substrates that vary with location, season, and weather conditions. Foragers in both patches use identical tools (digging sticks), and both require roughly equal amounts of exertion to pursue and extract the prey once encountered. The primary difference is how far a forager must walk to encounter prey: while prey are smaller in rocky outcrops, they are more often encountered than in the sandhills. For children this means that choosing to focus their hunting in rocky outcrops is often a better option.

It may be that some of these cognitive costs are reduced for younger hunters by following the older children. More data on youngsters foraging independent of more experienced children will help to address this issue. Nevertheless, during the hunts reported here, children searched and tracked by themselves, and only while extracting goanna from the den did older children sometimes help youngsters.

There might be broader implications of these results for how we view the evolution of human childhood. If the extended juvenile period for humans evolved for more learning to occur, we would expect experience rather than size to be the primary constraint on foraging success. As Bock (2002a, Chapter 5 in this volume) has pointed out, growth-based constraints *alone* cannot account for the long time it takes for many foragers to reach peak efficiency. But some researchers investigating such constraints among young foragers have found that size differences have stronger effects than age and experience (Bird and Bliege Bird 2000, 2002; Bliege Bird and Bird 2002b; Blurton Jones, Chapter 10 in this volume; Blurton Jones et al. 1997, 1999; Blurton Jones and Marlowe 2002; Tucker, Chapter 7 in this volume). This is so even for Mardu children who often hunt game. These results suggest to us that the constellation of modern human life history variables and physical characteristics (e.g., prolonged juvenility, large adult body size, large brains, and long and productive postreproductive lives) may result from benefits other than those strictly linked to learning complex foraging activities. It could be that our extensive learning is a product, rather than the cause, of extended juvenile periods (Blurton Jones and Marlowe 2002). Theorists have suggested that this constellation of human life history characteristics emerged as a result of decreased extrinsic *adult* mortality that came with the coevolution of productive postreproductive lives and "delayed" maturation, tapping into the benefits of growing longer with resources that require both strength and skill to extract (e.g., Alvarez 2000; Charnov 1993; Hawkes et al. 1998; Kaplan et al. 2003). If so, distinctive characteristics of anatomically modern humans (including our extensive learning) would be expected from any long-lived primate of our body size with low adult extrinsic mortality. If all of these characteristics coevolved, the social behavior linked to them (e.g., central place foraging, intergenerational food sharing, large game hunting) would have emerged relatively recently in human evolution, possibly only with the spread of anatomically modern human traits over the last glacial maximum of the Pleistocene (O'Connell et al. 1999, 2002).

## CONCLUSION

Mardu children are active and independent hunters. Their efforts are unsupervised without direct instruction by adults. Their skills and decisions, while praised by their elders, are more directly influenced by other children. So far our data show that for children's hunting in the Western Desert's rocky outcrops, forager size is a more important effect on hunting success than age. Moreover, children's decisions to hunt in rocky outcrops as opposed to the sandhills (that adults target) are not likely to be the result of learning constraints. By focusing their efforts in rocky outcrops, children (who walk slower than adults) can encounter prey at a higher rate. On average, this provides return rates for children that are equivalent to those they might expect if they hunted in the sandhills, while avoiding the long search distances involved in sandhill hunting. Only when walking speeds approach the adult average does hunting in sandhills consistently offer higher efficiency. These data may be consistent with the argument that prolonged human juvenility evolved for reasons other than to learn complex hunting strategies, but a great deal of further work will be required to evaluate how learning and size influence age-linked variability in extractive foraging activities.

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## NOTE

1. This is especially remarkable: numerous authors (e.g., Latz 1996:51–55, O'Connell and Hawkes 1981, Tonkinson 1991:45–46) and our own observations of woollybutt winnowing attest to the intricacy and skill needed to process these seeds—no doubt it takes years of practice to master the technique