CHILDREN ON THE REEF
Slow Learning or Strategic Foraging?

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Meriam children are active reef-flat collectors. We demonstrate that while foraging on the reef, children are significantly less selective than adults. This difference and the precise nature of children's selectivity while reef-flat collecting are consistent with a hypothesis that both children and adults attempt to maximize their rate of return while foraging, but in so doing they face different constraints relative to differences in walking speeds while searching. Implications of these results for general arguments about factors that shape differences between child and adult behavior and human life-histories are explored.

KEY WORDS: Children's foraging; Life history theory; Meriam; Shell-fishing

The notion that children in foraging societies are entirely dependant on the efforts of others is a critical (if often implicit) component of many influential models of human ecology and evolution. Anthropologists and psychologists have often characterized essential features of human social organization as originating with the "universal human condition" of an unprecedented degree of juvenile dependence owing to a protracted period of learning (e.g., Bogin 1996; Isaac 1978; Lovejoy 1981; Tooby and Cosmides 1992; Washburn and Lancaster 1968; see Bjorklund 1997). According to this scenario, the costly learning of human children increased the payoffs of extended juvenile provisioning for nuclear families. These payoffs

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were tapped by foraging from a central place, dividing labor between parents, and widespread sharing, resulting in the essence of the human family (Kaplan et al. 2000).

Such scenarios were further entrenched with studies suggesting the young in contemporary foraging societies are not expected to contribute to their own or others' subsistence until they are fully mature (e.g., Lee 1979). When ethnographers have noted children's subsistence activities, the difference between their behavior and that of adults has often been portrayed as further evidence of the uniquely long learning period that characterizes humans. These assumptions have been challenged empirically with observations among the Hadza, a population of mobile hunter-gatherers in Tanzania whose children are active and productive foragers from a very young age (Blurton Jones 1993; Blurton Jones and Marlowe 2002; Blurton Jones et al. 1994a, 1994b, 1997; Hawkes et al. 1995). While it is true that Hadza children and children everywhere must be provisioned well beyond weaning, their own production can often be a substantial and an important factor in determining adult subsistence, mobility, and reproductive decisions.

**THE CASE OF COASTAL FORAGING**

Problems with assumptions about the helplessness of human children are especially evident in even the most cursory review of coastal economies. While the intensity of children's subsistence labor varies from place to place, the extent to which young children worldwide consistently participate in marine subsistence activities is often substantial and striking [see Hockey et al. 1988 (Transkei Coast, South Africa), Bird and Bliege Bird 2000 and Bliege Bird et al. 1995 (Eastern Torres Strait), De Boer et al. 2000 (Inhaca Island, Mozambique), Hill 1978 (suburban Samoa), Meehan 1977, 1982, 1983 (Arnhem Land, Australia), and Waselkov 1987:96–99 for review]. Although detailed reports on children's subsistence are rare, their activities are especially important throughout much of Island Oceania, where they are often mentioned as active intertidal shellfishers [e.g., Mead 1942 (New Guinea), Swadling and Chowning 1981 (New Guinea), Bell 1947 (New Ireland), Fuary 1991 (Torres Strait), Thomas 1994 (Kiribati), Firth 1957 (Tikopia), Hill 1978 (Samoa)].

Until recently, detailed evaluations of children's intertidal foraging decisions, efficiency, and the extent to which their activities vary from those of adults have never been presented (see, e.g., Bird and Bliege Bird 2000; De Boer et al. 2000; Waselkov 1987). Nevertheless, where researchers have noted distinctions between adults and children, the adults are usually highly discriminating of the prey they exploit whereas children's harvest-
ing decisions are more varied. Most of these studies have assumed that
the differences in prey choice were due to a lack of experience on the part
of child foragers.

If we base our models of human evolution on the notion that much of
what we consider to be “human nature” involves an unprecedented and
prolonged period of juvenility, we need to know whether the subsistence
efforts of children (and juvenile primates in general) are directed toward
learning foraging skills (e.g., Kaplan et al. 2000; King 1993), or whether
their foraging decisions are a product of their immediate juvenile trade-
offs (e.g., Blurton Jones and Marlowe 2002; Janson and van Schaik 1992). If
the latter, this might suggest that although subsistence skills are gained
as a result of our extended childhood, the distinct pattern of human ju-
venility evolved for reasons other than to permit additional foraging pro-
ficiency (e.g., social learning [Whiten and Byrne 1997], or life history
trade-offs discussed below).

EVOLUTION OF HUMAN LIFE HISTORIES

Recent advances in life history theory may provide important clues about
the evolution of human juvenility and the role of learning. All organisms
face problems of energy allocation for lifetime reproductive success: en-
ergy invested in somatic growth and maintenance cannot be spent in re-
production. In an important model of mammalian life history evolution,
Charnov (1993) begins with the assumption that an organism with a
longer period of growth will have more to invest in production (for itself
and its offspring) and a longer lifespan. This means that an organism’s
productive value at maturity increases with time spent growing. However,
the potential increase in adult productive capacity comes at a cost of not
reproducing sooner. The optimal solution to this trade-off is reached when
the proportional change in survivorship with age is equal to the propor-
tional change in reproductive value. Selection thus favors a shorter juve-
nile period (α) with increasing extrinsic mortality (M) (because of the costs
of waiting to reproduce), and longer α when M decreases (because of the
advantage of a longer growth period). While α and M vary widely across
primates, their product is approximately invariant: human αM falls well
within the confidence interval for all primates for which these values are
known, suggesting that our long juvenility is a function of low mortality
rates, not learning per se (Blurton Jones and Marlowe 2002).

Kaplan and colleagues (2000) have proposed an important formal model
for human life-history evolution that predicts optimal juvenile somatic in-
vestment with simultaneous investments in mortality reduction. Rather
than assuming that mortality is simply extrinsic to the organism, Kaplan
and colleagues assume that during juvenility, energy can be invested in either embodied capital (growth and learning) for future energy production or reducing mortality rates. Although the benefits of gaining skill and knowledge may depreciate over time, those skills related to difficult-to-learn but highly efficient foraging (such as hunting large game) continue to influence time-energy allocation over a life course. This is critical because specializing in learning skill-intensive foraging means increasing production with age, and thus selection for lower mortality and longer juvenile periods designed for more learning. The model thus predicts the coevolution of longer juvenile periods, exceptionally long lifespans, large brains, and intergenerational resource flows (to support juveniles), all in response to a dietary shift to large-package, nutrient-dense, difficult-to-acquire resources.

Here we investigate whether differences in the prey choice of Meriam children and adults while reef-flat collecting are a result of attempts by children to learn adult strategies, or whether their efforts reflect differences in the constraints the children face while foraging on the reef. If we can anticipate consistent differences in prey choice and processing strategies, tests of these predictions may help us to identify sources of age-linked behavioral variability in many circumstances. Moreover, if children differ from adults in their foraging decisions in patterned and predictable ways, this may have important consequences for models of human evolution and their archaeological tests (see Bird and Bliege Bird 2000; Hawkes et al. 1995). After a brief introduction to the study site and intertidal subsistence on Mer, we demonstrate how Meriam children’s shellfishing activities (in terms of prey choice and processing) differ from adults. We then present predictive tests of the hypothesis that these differences are consistent with variability in foraging trade-offs where the goal of foraging is to maximize energetic efficiency.

THE STUDY SITE

The Meriam are the indigenous Melanesian inhabitants of the three easternmost islands (Mer, Dauar, and Waier) in the Torres Strait, which lies between the northern tip of Australia’s Cape York Peninsula and the southern coast of Papua New Guinea (Figure 1). They speak Meriam Mir, a Papuan language unrelated to neighboring Aboriginal and Austronesian languages. The Meriam Islands are small volcanic crests with broad, coral fringing reefs located on the northern extent of the Great Barrier Reef. The Torres Strait, which includes about 5,000 km² of traditional Meriam sea estate, has been under the administration of Australia since 1879. The Meriam have had a varied and often tumultuous relationship with European colonialism, and our project is the most recent in a long history of
Figure 1. The Meriam Islands (from Bird and Bliege Bird 1997).
ethnography on Mer (Beckett 1987; Haddon 1908, 1935; Johannes and MacFarlane 1984; Kitaoji 1977; Sharp 1993, 1996). Data reported here were collected in the course of four periods of fieldwork, which consisted of 27 months in residence on Mer between January 1993 and July 1999 and covering all seasons. The goals of our work were to collect quantitative data on age- and sex-linked variability in marine prey and patch choice, marine subsistence return rates, time allocation to various foraging activities, food-sharing patterns, and their archaeological implications. In 1998 we also collected information on demography, genealogy, and social status (Bliege Bird et al. 2001; Smith and Bliege Bird 2000).

Although the Meriam are known throughout their region as intensive horticulturalists and sea traders, subsistence fishing and hunting have always been central to their economy. Of the 430 people currently living on Mer, most acquire the majority of protein they consume from fishing and marine turtle hunting (Bliege Bird et al. 2001). Subsistence fishing activities are varied and include fishing from the foreshore and reef edge with hand lines; offshore and reef-top hand-line fishing; spearfishing with bamboo spears within or near the large stone fish traps on the fringing reef; and gathering shellfish in the intertidal zone (for details see Bird 1997; Bird and Bliege Bird 1997, 2000; Bliege Bird 1996; Bliege Bird and Bird 1997; Bliege Bird et al. 2001; Smith and Bliege Bird 2000). Meriam children are active in many types of subsistence (Bird and Bliege Bird 2000; Bliege Bird et al. 1995), especially hand-line fishing from the foreshore and intertidal gathering (Bliege Bird and Bird, this issue). Here we focus exclusively on their foraging efforts in the intertidal zone.

MERIAM INTERTIDAL GATHERING

Two types of intertidal gathering commonly occur on the Meriam islands: reef-flat collecting (RFC, Meriam Mir—meskep) and rocky shore harvesting (RSH, kaip). Both activities focus on procuring molluscs during low tide: RFC involves mobile search for shellfish in the mid- to sublittoral zone, whereas RSH is a sedentary activity in which foragers dig for small bivalves (Asaphis violanscens, kaip) and pluck small gastropods (Nerita undata, kuk) from rocky areas in the upper littoral. Children are rarely involved in RSH; therefore here we will limit our description and analysis to RFC (see Bird 1996, 1997, and Bird and Bliege Bird 1997, 2000 for more detailed treatment of the foraging context and analysis of prey choice, processing, and transport strategies involved in intertidal gathering).

The fringing reefs that surround Mer, Dauar, and Waier are remarkably productive and offer an extensive assortment of prey options. Nevertheless, during our study most (94%) of the shellfish flesh harvested by RFC
came from only three prey types: the spider conch, *Lambis lambis* (Meriam Mir, *asor*) and two types of tridacnid clams, *Hippopus hippopus* (*beizam mi*) and *Tridacna maxima/squamosa* (*terpar mi*). Tiger cowries (*Cypraea tigris, mokepu*), trochus shell (*Trochus niloticus, nazir*), and red-lipped conch (*Strombus luhuanus, kurit*) are also occasionally exploited when encountered. Other potential prey are either very rarely encountered (e.g., *Tridacna gigas, kim kim*) or very common but rarely harvested (e.g., *Tridacna crocea, kebi mi*).

Procuring RFC prey is a straightforward endeavor. Foragers enter the fringing reef from their residences on the foreshore when an ebbing spring tide exposes the mid-littoral. After making their way through the upper sections of the intertidal zone, they generally walk parallel to the shoreline in the outer mid-littoral, harvesting and often processing prey as they go. Shellfish in the RFC patch are thinly distributed and generally encountered singly (except *T. crocea*, which are deeply embedded in clusters on shallow, sublittoral coral heads, and occasionally *S. luhuanus*). Foragers often process tridacnids and conch in the field, culling the meat from the valves and discarding the shells at the procurement location. For conch this entails cracking the shell with a hammer or stone, and for clams this involves cutting the flesh from the valve with a long-bladed knife. During RFC, foragers generally carry a 10 liter plastic bucket, a knife, and a hammer, although sometimes locating a hammer is difficult.

RFC on the Meriam Islands occurs mainly from April through September, corresponding roughly with the season of dry southeasterly winds. This is the time of the lowest diurnal spring tides, when RFC prey are most easily spotted. The months of June and July are especially well suited for RFC, and on some days during the weeks of spring tides at the new and full moon it is not uncommon for 20 to 30 people to be visible on the reef at once. But while shellfishing is seasonally important for some, not all people on the islands participate in RFC, nor does it make up a significant part of anyone’s overall diet. Of special importance is the difference between adult men and women: while men occasionally collect on the reef flat, women were responsible for 74% of adult RFC hours during time allocation observational sample periods over 10 consecutive months in 1994–1995 (Bliege Bird 1996). Even among women, however, not everyone regularly spends time in RFC: we observed 42% of the 129 women (16 years of age and older) in the community reef-flat collecting regularly enough for them to be represented in our systematic observational samples. Part of this variance is due to differences in access to reef flat areas owned by one’s patriline: women and children in the northeastern part of the village (see Figure 1) live immediately adjacent to their (or their husbands’) reef flat areas and are far more active shellfishers (see Bird 1996: 125–129).
While adults most often forage on the reef flat alone (mean group size = 1.7 ± .2 individuals, $n = 43$ episodes), children (henceforth defined as individuals 15 years old or younger) often enter the reef flat in groups (mean group size = 3.2 ± .6, $n = 17$ episodes). Foraging alone was a deliberate aim for adults: RFC prey are almost always encountered as single specimens and are dispersed across the reef. Thus foraging in close proximity with anyone will likely reduce efficiency. Women regularly try to leave young children with babysitters before they go collecting. If adults happen to take children out on the reef, foraging with them while carrying a load of shellfish is difficult. Children are often encouraged to do their best to keep up on their own and to forage at some distance from an adult. As a result, they go out on the reef without adults, and their activities occur independently of immediate adult direction or influence. Their foraging usually occurs after school or on weekends when children leave for the reef in "play" groups. Children’s individual yields are then returned for their own household’s consumption.

RFC is generally viewed as a fun activity by both children and adults who participate; we were struck, however, by differences in the "intensity" of children’s foraging relative especially to that of women. Women generally walked quickly while searching and spent very little time in any one field-processing event. Children often left the village for the reef flat in groups which dispersed while searching and coalesced during processing; their efforts were often marked by short bursts of intense individual gathering interspersed with periods of occasional cooperative field processing and less-directed search. In comparison with adults, children walked more slowly, spent more time socializing, and encountered fewer prey while foraging. Despite our impressions of reduced intensity on the part of children, we were always surprised by the wealth of knowledge Meriam children had about reef ecology, prey characteristics, search techniques, and handling strategies. Children were good at RFC: many were skilled shellfishers and took great pride in their efforts.

METHODS

We monitored variability in RFC prey choice, processing, efficiency, and encounter rates with different resource types through three procedures: focal individual follows, home processing sequences, and a reef flat resource survey.

Focal Individual Follows

Details on methods are given in Bird 1997, Bird and Bliege Bird 1997 and 2000. In summary, focal individual follows were conducted during random time-allocation observation periods of nearshore and intertidal sub-
sistence activities and during episodes when either one of us participated in RFC. During time allocation observations, the first person to enter the reef flat was chosen as a focal individual. If, however, we were participating in a foraging episode that included RFC, each of us chose a single forager as a focal individual. During focal follows, the total time a forager devoted to traveling to the reef flat, searching while in the patch, and each processing event was recorded with a stopwatch. The distance and route taken by the forager were later mapped. During two adult follows and two children's follows we also monitored walking velocities. This was done using a Magellan ColorTrak GPS unit set to record average speed on ground every 5 seconds. Walking speed was checked and recorded at 30-second intervals during the follow. This provided a total of 28 spot observations of adult search speed and 45 spot observations of children's search speed. At the end of every focal follow, we counted and weighed the processed and unprocessed prey with handheld tubular scales.

These focal follows allowed us to monitor variability in overall RFC efficiency, on-encounter profitability (energy per unit time spent handling) of different prey types, field processing costs, and the amount of shell waste transported. Records are available for 82 RFC follows (35 children's follows: 16 male and 19 female; and 47 adult follows: 15 male and 32 female) of 52 different individuals (19 children and 33 adults) consisting of 143 observation hours. Fifty of the follows were recorded during systematic observation periods of intertidal activities, and 32 took place during participant observation. We found no significant differences in efficiency between the two types of follows \((p = .76)\). Children in the sample ranged from ages 5 to 15 (8 follows of children ages 5 through 8, 19 of children ages 9 through 12, and 8 of children ages 13 through 15); adults ranged from ages 19 to 64. The Meriam record birthdays and thus know specific ages. There are no follows of children ages 16 through 18 because they are usually away from the island at high school.

Home Processing Sequences

In order to obtain ratios of shellfish meat to gross weight and measures of the profitability of resources that were either rarely field processed or rarely exploited, we recorded a series of home processing sequences. During the sequences we timed 13 different foragers (8 adults and 5 children) while they were processing 65 loads of 10 different shellfish prey types that had been previously collected. The shellfish from each load were counted and weighed prior to and after each processing sequence.

Reef Flat Surveys

Finally, in order to estimate encounter rates for different prey types, data on the distribution and density of reef flat resources were obtained
through a series of reef flat surveys. The methods used have been describe elsewhere (Bird 1997; Bird and Bliege Bird 2000); briefly, the surveys were conducted by researchers and Meriam field assistants with extensive experience in RFC. Seventeen corridor transects, most extending from the shore to the reef edge, were established around Mer’s fringing reef (see Figure 1). Each consisted of four passes (two researchers walking the length of the corridor and back) at intervals of 10 meters. The number, size, and location of every edible mollusc encountered were recorded as each transect was walked. About 270,400 square meters of fringing reef was surveyed (about 3% of the total fringing reef on Mer). Assuming that the observer could spot all potential prey that a forager would, we can then estimate encounter rates for different prey at different search velocities.

MEASURING ASSOCIATIONS WITH AGE

During follows on children it seemed obvious that, in comparison with adults, they focused on a broad range of prey types. We expected that when we compared the number of prey types collected per follow, children would average far more than do adults. But this is not the case. Both children and adults average 2.7 prey types collected per follow with no significant differences in the variation around these means (children’s standard error = .33, adults’ standard error = .28; ANOVA df = 80, f = 0, p = .89). However, the data do show strong systematic differences between adults and children in terms of the probability of handling items different prey types on encounter.

In the following section we focus on quantifying age-linked differences in prey selectivity by comparing differences in the collecting rates and encounter rates of children and adults. In situations where an encounter with an item of a given prey type does not predictably change the probability of encountering more items of that prey type, prey that are always handled on encounter are characterized by equivalent rates of collection \((\lambda_c)\) and encounter \((\lambda_e)\). Differences between collecting and encounter rates will indicate either \((a)\) the extent to which foragers search for a particular prey type at the expense of other options in the patch (where, for a given prey type, \(\lambda_c / \lambda_e > 1\); in other words, foragers do not search the patch in a fine-grained manner) or \((b)\) the extent to which foragers pass over a particular prey type to continue searching for other options (where, for a given prey type, \(\lambda_c / \lambda_e < 1\)). We call this measure of “choosiness” the selectivity quotient (SQ).

Estimating expected encounter rates for items of different prey types requires data independent of foraging observations since during our data collection we did not necessarily know whether a forager intentionally or
accidentally passed over an item. Asking foragers about this would change the encounter rate, which was what we wanted to measure in the first place. In order to obtain a predictive value for encounter rates, we model a hypothetical forager on the reef flat who walks at an average collecting velocity and encounters resources in proportion to the densities calculated from the survey transects. We assume that foragers encounter resources in the same proportion as the mean densities from the survey (see Table 1) and search at speeds as measured for children \( (V_{\text{child}} = 1.43 \pm .26 \text{ km/hr, } n = 45) \) and adults \( (V_{\text{adult}} = 2.86 \pm .31 \text{ km/hr, } n = 28) \) while collecting. Measures of search velocity exclude any time spent handling resources on the reef.

Table 2 presents a comparison of the predicted encounter rates \( (\lambda_e) \), the mean collecting rates \( (\lambda_c) \), and the selectivity quotient \( (SQ) \) values for adults and children. Here the SQ gives an estimate of bias in selectivity while reef-flat collecting:

\[
SQ = \frac{\lambda_c}{\lambda_e}
\]

where \( \lambda_c \) is the mean number of specimens of different prey types collected in one hour of searching and \( \lambda_e \) is the number of specimens predicted to be encountered in one hour of searching, based on the density survey and the walking speeds recorded during collection. In this case,

\[
\lambda_e = d \times V_{\text{child or adult}}
\]

where \( d \) is the shellfish density, or number of specimens of different prey types per 10,000 square meters; \( V_{\text{child}} \) is the mean search velocity of children; and \( V_{\text{adult}} \) is mean adult search velocity. Multiplying the resource densities calculated from the reef flat survey by \( V \) provides an independent measure of rates of encounter of different prey by adults and children (assuming that children and adults can spot prey with equal success). This important measure allows us to determine the probability that a potential prey type will be passed over—this level of precision is usually unattainable, but reef environments with visible, sessile prey are uniquely suited for this type of analysis.

Again, a prey type with an SQ value of 1 would be collected by a child or an adult in proportion to its density as estimated from the reef flat survey. Three sets of prey types are noteworthy:

1. Those that are associated with collecting rates significantly higher than the predicted encounter rate (where SQ is significantly greater than 1, suggesting that such prey types may be searched for at the expense of others).
2. Those associated with collecting rates that are similar to the expected encounter rate (where SQ is not significantly different from
Table 1. Shellfish Densities on Mer’s Reef Flat at Spring Low Tide

<table>
<thead>
<tr>
<th>Prey Type</th>
<th>Area A (5 transects)</th>
<th>Area B (2 transects)</th>
<th>Area C (7 transects)</th>
<th>Area D (3 transects)</th>
<th>All transects (n = 17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hippopus</td>
<td>0.64 ± 0.26</td>
<td>1.43 ± 0.36</td>
<td>1.88 ± 0.41</td>
<td>1.57 ± 0.82</td>
<td>1.41 ± 0.25</td>
</tr>
<tr>
<td>Tridacna spp.</td>
<td>0.44 ± 0.43</td>
<td>0.53 ± 0.50</td>
<td>1.24 ± 0.38</td>
<td>1.83 ± 1.03</td>
<td>1.03 ± 0.28</td>
</tr>
<tr>
<td>Trochus (lg)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.05 ± 0.05</td>
<td>0.40 ± 0.34</td>
<td>0.09 ± 0.07</td>
</tr>
<tr>
<td>Lambis</td>
<td>7.82 ± 4.50</td>
<td>1.96 ± 1.17</td>
<td>11.61 ± 2.76</td>
<td>6.14 ± 3.71</td>
<td>8.4 ± 1.90</td>
</tr>
<tr>
<td>Cypraea</td>
<td>0.00</td>
<td>0.79 ± 0.79</td>
<td>3.76 ± 1.15</td>
<td>0.00</td>
<td>1.64 ± 0.64</td>
</tr>
<tr>
<td>Trochus (sm)</td>
<td>0.22 ± 0.20</td>
<td>0.00</td>
<td>0.21 ± 0.07</td>
<td>3.24 ± 2.60</td>
<td>0.72 ± 0.49</td>
</tr>
<tr>
<td>Tridacna crocea</td>
<td>58.03 ± 55.1</td>
<td>17.02 ± 16.5</td>
<td>2.43 ± 2.29</td>
<td>111.73 ± 35.19</td>
<td>39.79 ± 18.89</td>
</tr>
<tr>
<td>Strombus</td>
<td>15.25 ± 7.65</td>
<td>2.22 ± 0.44</td>
<td>3.18 ± 2.01</td>
<td>1.11 ± 0.69</td>
<td>6.25 ± 2.67</td>
</tr>
</tbody>
</table>

See Figure 1 for area and transect locations
Error is Standard Error
Tridacna spp. includes T. maxima and T. squamosa
Table 2. Collecting Rates, Encounter Rates, and the Selectivity Quotient

<table>
<thead>
<tr>
<th>Prey Type</th>
<th>$\lambda_c$</th>
<th>$\lambda_e$</th>
<th>SQ</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ADULTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(follows)</td>
<td>$n = 47$</td>
<td>$n = 17,$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hippopus</td>
<td>$6.73 \pm 1.61$</td>
<td>$4.03 \pm 0.72$</td>
<td>1.67</td>
<td>0.99</td>
<td>0.326</td>
</tr>
<tr>
<td>Tridacna spp.</td>
<td>$2.15 \pm 0.52$</td>
<td>$2.94 \pm 0.80$</td>
<td>0.73</td>
<td>-0.79</td>
<td>0.431</td>
</tr>
<tr>
<td>Trochus (lg)</td>
<td>$0.20 \pm 0.10$</td>
<td>$0.26 \pm 0.21$</td>
<td>0.76</td>
<td>-0.29</td>
<td>0.775</td>
</tr>
<tr>
<td>Lambis</td>
<td>$19.60 \pm 2.77$</td>
<td>$24.04 \pm 5.43$</td>
<td>0.81</td>
<td>-0.79</td>
<td>0.434</td>
</tr>
<tr>
<td>Cypraea</td>
<td>$2.65 \pm 1.36$</td>
<td>$4.71 \pm 1.84$</td>
<td>0.56</td>
<td>-0.82</td>
<td>0.418</td>
</tr>
<tr>
<td>Trochus (sm)</td>
<td>$0.00$</td>
<td>$2.07 \pm 1.39$</td>
<td>0.00</td>
<td>-2.07</td>
<td>0.015</td>
</tr>
<tr>
<td>Strombus</td>
<td>$1.56 \pm 0.62$</td>
<td>$17.90 \pm 7.65$</td>
<td>0.09</td>
<td>-3.51</td>
<td>0.001</td>
</tr>
<tr>
<td>Trid. crocea</td>
<td>$0.02 \pm 0.02$</td>
<td>$113.95 \pm 54.07$</td>
<td>&lt;0.01</td>
<td>-3.56</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Trid. gigas</td>
<td>$0.34 \pm 0.19$</td>
<td>$0.00$</td>
<td>~1</td>
<td>na</td>
<td></td>
</tr>
<tr>
<td><strong>CHILDREN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(follows)</td>
<td>$n = 35$</td>
<td>$n = 17,$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hippopus</td>
<td>$1.02 \pm 0.23$</td>
<td>$2.01 \pm 0.36$</td>
<td>0.51</td>
<td>-2.39</td>
<td>0.021</td>
</tr>
<tr>
<td>Tridacna spp.</td>
<td>$0.80 \pm 0.28$</td>
<td>$1.47 \pm 0.40$</td>
<td>0.54</td>
<td>-1.38</td>
<td>0.174</td>
</tr>
<tr>
<td>Trochus (lg)</td>
<td>$0.20 \pm 0.12$</td>
<td>$0.13 \pm 0.10$</td>
<td>1.54</td>
<td>0.32</td>
<td>0.749</td>
</tr>
<tr>
<td>Lambis</td>
<td>$7.24 \pm 1.35$</td>
<td>$12.03 \pm 2.72$</td>
<td>0.60</td>
<td>-1.77</td>
<td>0.082</td>
</tr>
<tr>
<td>Cypraea</td>
<td>$0.71 \pm 0.58$</td>
<td>$2.36 \pm 0.92$</td>
<td>0.30</td>
<td>-1.58</td>
<td>0.121</td>
</tr>
<tr>
<td>Trochus (sm)</td>
<td>$0.61 \pm 0.24$</td>
<td>$1.04 \pm 0.70$</td>
<td>0.59</td>
<td>-0.72</td>
<td>0.471</td>
</tr>
<tr>
<td>Strombus</td>
<td>$4.00 \pm 1.02$</td>
<td>$8.96 \pm 3.83$</td>
<td>0.45</td>
<td>-1.64</td>
<td>0.110</td>
</tr>
<tr>
<td>Trid. crocea</td>
<td>$0.08 \pm 0.05$</td>
<td>$57.01 \pm 27.05$</td>
<td>&lt;0.01</td>
<td>-3.05</td>
<td>0.004</td>
</tr>
<tr>
<td>Trid. gigas</td>
<td>$0.00$</td>
<td>$0.00$</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
</tbody>
</table>

$\lambda_c$ = observed number of specimens collected per hour of search (all RFC follows)
$\lambda_e$ = predicted number of specimens encountered (based on all survey transects) per hour of search at 2.86 km/hr for adults and 1.43 km/hr for children
SQ = selectivity quotient ($\lambda_c/\lambda_e$)
Tridacna spp. includes T. maxima and T. squamosa.

1. suggesting that these prey types are collected in similar proportions to the rate at which they are encountered on the reef flat).

Those prey types with collecting rates that are obviously lower than the expected encounter rate (where SQ is significantly less than 1, suggesting that these are consistently avoided on encounter).

For adults, Hippopus is the only prey type that is collected at a rate higher than the predicted encounter rate (SQ = 1.67). However, this figure is not significantly greater than 1, nor did we ever observe an occasion in which a forager obviously targeted Hippopus at the expense of other RFC prey. Tridacna, Lambis, and large Trochus (>400 g gross wt) are collected at rates similar to their predicted encounter rates (.7 < SQ < 1) while Cypraea, small
*Trochus*, *Strombus*, and *Tridacna crocea* are collected at rates lower than the predicted encounter rate ($SQ < .6$). *T. crocea* is the most obvious of these latter types with $SQ < .001$. This is the most abundant prey type on the reef flat, yet it is almost never collected. *Strombus* is also striking in this respect: it is abundant but almost always passed over by adults in RFC ($SQ = .09$).

Children collect *Lambis*, *Hippopus*, *Tridacna maxima/squamosa*, and large and small *Trochus* at rates similar to their predicted encounter rate ($SQ > .5$), and *Strombus* nearly so ($SQ = .45$). Only *Tridacna crocea* had a very low $SQ$. The obvious differences between children and adults are in children’s higher $SQ$ values for smaller prey (small *Trochus* and *Strombus*). This matched our overall qualitative assessment: we very rarely observed children (obviously or purposefully) passing over small *Trochus* and *Strombus*, whereas adults almost always did.

**PREY CHOICE ANALYSIS**

The key difference in prey choice is in the higher probability that only children, on encounter, select *Strombus* and small *Trochus*. They do so consistently and in large numbers. Why are children less choosy than adults? It is tempting to think that such differences arise because children don’t yet have the proper search image and haven’t learned to process their prey correctly. But why would it take up to 15 years to learn what to exploit and how to process it, when naive researchers can do so after a few months?

Below we test the alternative hypothesis that children are less discriminating because they encounter high-ranked resources at a far lower rate than adults (for age linked changes in efficiency and inter individual variability, see Bliege Bird and Bird 2002).

Table 3 shows the overall foraging return rates and profitability of different RFC prey types for adults and children. The primary prediction from the fine-grained prey choice model (sensu Stephens and Krebs 1986) is that, on encounter, foragers will pursue only those prey types that exhibit levels of productivity ($e/h$, or energy per unit time handling where handling is post-encounter time spent pursuing, harvesting, and processing) greater than the returns expected from continuing to search for other items (the overall foraging return rate, $E/T_f$, or total energy per unit of time foraging where foraging includes both searching and handling). The model predicts that prey types with $e/h < E/T_f$ will be passed over. Bird (1996, 1997) provides further details on calculating energetic return rates for various reef flat prey types.5

Based on the above components and the calculations of expected encounter rates ($\lambda_e$) vs. actual collecting rates ($\lambda_c$), below we test the following predictions concerning intertidal prey choice:
Table 3. Reef-Flat Collecting Efficiency

<table>
<thead>
<tr>
<th>Prey Type</th>
<th>n</th>
<th>Mean e/h (kcal/hr)</th>
<th>SE</th>
<th>SQ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(loads processed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADULTS (mean E/T_f = 1491.5 ± 173.2 kcal/hr, n = 47 follows)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tridacna gigas</td>
<td>4</td>
<td>13064.8</td>
<td>2375.3</td>
<td>~1.0</td>
</tr>
<tr>
<td>Hippopus</td>
<td>34</td>
<td>6858.9</td>
<td>464</td>
<td>1.67</td>
</tr>
<tr>
<td>Tridacna spp.</td>
<td>16</td>
<td>4534.2</td>
<td>676.1</td>
<td>0.73</td>
</tr>
<tr>
<td>Trochus (lg)</td>
<td>4</td>
<td>3904.0*</td>
<td>466.8</td>
<td>0.76</td>
</tr>
<tr>
<td>Lambis</td>
<td>23</td>
<td>3411.9</td>
<td>205.6</td>
<td>0.81</td>
</tr>
<tr>
<td>Cypraea</td>
<td>3</td>
<td>2214.4*</td>
<td>239.2</td>
<td>0.56</td>
</tr>
<tr>
<td>Trochus (sm)</td>
<td>2</td>
<td>977.4*</td>
<td>61.9</td>
<td>0.00</td>
</tr>
<tr>
<td>Tridacna crocea</td>
<td>2</td>
<td>763.7*</td>
<td>75.0</td>
<td>&gt;0.01</td>
</tr>
<tr>
<td>Strombus</td>
<td>3</td>
<td>534.6*</td>
<td>118.7</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHILDREN (mean E/T_f = 522.0 ± 90.4 kcal/hr, n = 35 follows)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hippopus</td>
<td>12</td>
<td>3106.2</td>
<td>711.9</td>
<td>0.51</td>
</tr>
<tr>
<td>Tridacna spp.</td>
<td>9</td>
<td>1652.0</td>
<td>142.5</td>
<td>0.54</td>
</tr>
<tr>
<td>Trochus (lg)</td>
<td>2</td>
<td>1638.9*</td>
<td>380.7</td>
<td>1.54</td>
</tr>
<tr>
<td>Trochus (sm)</td>
<td>2</td>
<td>1064.3*</td>
<td>84.4</td>
<td>0.59</td>
</tr>
<tr>
<td>Lambis</td>
<td>11</td>
<td>895.5</td>
<td>91.6</td>
<td>0.60</td>
</tr>
<tr>
<td>Cypraea</td>
<td>2</td>
<td>852.3*</td>
<td>183.4</td>
<td>0.30</td>
</tr>
<tr>
<td>Strombus</td>
<td>3</td>
<td>747.8*</td>
<td>186.1</td>
<td>0.45</td>
</tr>
<tr>
<td>Tridacna crocea</td>
<td>3</td>
<td>257.3</td>
<td>127.7</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

E/T_f = kcal per hour foraging (searching and handling)

e/h = kcal per hour handling (post-encounter processing)

SE = standard error

SQ = selectivity quotient (λ_c/λ_e)

Tridacna spp. includes T. maxima and T. squamosa.

*Indicates post-encounter return rates determined from home processing sequences as opposed to handling while foraging on the reef. These include prey types rarely field processed or rarely harvested.

Details on weights harvested, handling (meat extraction and cleaning) times, and processing strategies by children and adults are provided in Bird and Bliege Bird 2000. Details on determining caloric values are provided in Bird 1997:303-304.

1. For each type of forager (child or adult), those prey types with e/h > E/T_f (where on-encounter return rate exceeds overall return rate) should always be associated with an SQ value not significantly different from 1. These are prey that are harvested in similar proportion to their expected encounter rate. The strict prediction of the encounter-contingent prey choice model anticipates that prey types with (e/h)/(E/T_f) > 1 will always be associated with SQ = 1. In our prediction above we make some allowance for discrepancies in the calculated λ_c based on our transect survey sample, measured V, and variability in λ_c with reef locale, tide conditions, and foraging ability.
2. For each type of forager (child or adult), prey types with $e/h < E/T_f$ will always be associated with an SQ value significantly < 1. The strict prediction of the encounter contingent prey choice model anticipates that prey types with $(e/h)/(E/T_f) < 1$ will always be associated with SQ = 0. In other words, prey types that will reduce the average foraging returns will not be pursued on encounter.

**Adults**

Figure 2 demonstrates that for adult reef-flat collectors none of the resources for which we have estimates of $e/h$ measurably violates predictions 1 or 2. Those RF prey types that will on average significantly increase overall in-patch foraging returns if exploited on encounter have an SQ value near 1. *Hippopus, Tridacna maxima/squamosa*, large *Trochus*, and *Lambis* all have mean $e/h$ values significantly greater than their mean $E/T$ values (Mann-Whitney $U, p < .05$) and are collected at a rate anticipated by the encounter rate (SQ not significantly different from 1; see Table 2). On the other hand, all of the prey types (small *Trochus, Tridacna crocea*, and *Strombus*)...
bus) that will decrease energetic returns if exploited \( (e/h < E/T_f) \) are associated with SQ values significantly less than 1 (see Table 2).

The highest-ranked resource in RFC is *Tridacna gigas*, but these are only available during a few days of the year when extreme low spring tides expose the reef below the fringe edge. On most follows the highest-ranked resource is *Hippopus*, which is associated with the highest SQ value (although greater than 1, it is not significantly so). Foragers increase their harvesting rate for *Hippopus* by concentrating their efforts when possible on the mid- to sublittoral boundary. By avoiding the upper littoral and the outer sublittoral fringe, foragers increase their chances of encountering *Hippopus* without significantly decreasing encounters with other prey. The same is true for *T. maxima/squamosa*, which is ranked second when *T. gigas* is unavailable.

*Lambis* were passed over only very rarely (SQ = .81) and, as anticipated by the model, are associated with \( e/h \) values significantly greater than the overall mean foraging return rate. *Lambis* prey were passed over on two follows in which foragers ran out of space in their containers and during five follows when only tridacnids were harvested. This happened at extreme low spring tides in June and July when *Tridacna gigas* were available below the reef edge, thus increasing the opportunity costs of *Lambis*.

The data for *Cypraea* are somewhat problematic. Although overall return rates should increase if this prey type is exploited, the SQ value (.56) is below (but not significantly below) what we might expect if they were consistently taken on encounter. Foragers stated that on occasion they purposefully passed over *Cypraea*. Three possibilities might explain this result:

1. Given that *Cypraea* are often found on similar substrates as *Hippopus*, *T. maxima/squamosa*, and *Lambis*, perhaps as a result of sampling error, the actual abundance of *Cypraea* is lower than our reef survey suggests. If this is the case, then the expected encounter rate would be artificially high, resulting in an SQ value substantially lower than it should be. We suspect that this is not the case given the consistent variability in \( \lambda_c \) and \( \lambda_e \) across other prey types.

2. The \( e/h \) might actually be lower than that reported. This possibility cannot be ruled out especially given the small sample size for *Cypraea* processing \( (n = 3 \) loads; see Table 3). We suspect, however, that, if anything, the reported \( e/h \) is lower than the actual profitability for this prey type. The edible flesh weight for *Cypraea* is very similar to that of *Lambis*, and it is our impression that the Meriam do not consider it to be any more costly to process (as the \( e/h \) for *Cypraea* in Table 3 suggests).
The result may actually indicate systematic avoidance of a prey type that would maximize foraging efficiency if it were exploited. This possibility is supported by the fact that on a few occasions I observed foragers intentionally pass over *Cypraea* on encounter. Later, when asked why they did so, some foragers explained that this prey type can cause digestive discomfort to some people. Thomas (1994:22) has found that *Cypraea* from Micronesia have varying levels of a toxic lipid of unknown origin. While similar tests have not been conducted on Meriam *Cypraea*, perhaps prey choice on Mer is being influenced by similar factors.

These findings are similar to other quantitative tests of the encounter-contingent prey choice model which have shown that human foragers in fine-grained environments exploited prey types whose on-encounter returns were greater than the average foraging return rate (see Winterhalder and Smith 2000 for a review). But Figure 2 also demonstrates a more stringent test of the model. The resources (except possibly *Cypraea*) that are systematically passed over by adults (where SQ values are significantly less than 1) have on-encounter return rates that are lower than the mean return rate for adults while reef-flat collecting.

For small *Trochus* (specimens <200 g gross weight), the selectivity index is 0 (i.e., small *Trochus* were never handled by adults), and as expected, these small, abundant specimens fall outside the optimal set, exhibiting on-encounter \( e/h \) values substantially below the average overall RFC return rate. Similarly, *Tridacna crocea*, which is the most abundant option on the reef, is associated with an adult selectivity index value of nearly zero. This is anticipated by the model given that the \( e/h \) is half that of the mean adult \( E/T_F \). While they may look similar, on average extracting a *T. crocea* specimen from its coral matrix took three times as long as it took to harvest a *T. maxima/squamosa* specimen and yielded significantly less flesh. During follow we only observed adult foragers collecting one *T. crocea* specimen, which was not deeply embedded in the coral. In this isolated case, harvesting this specimen was no more expensive than harvesting small examples of *T. squamosa/maxima*.

*Strombus* is an interesting case. During reef-flat collection, adults almost always passed over this reasonably abundant option. This outcome is predicted by the prey-choice model given that handling this resource on encounter will significantly reduce overall foraging returns (Figure 2). However, in the midlittoral in reef Section A (Figure 1), as opposed to most other areas on the fringing reef, *Strombus* can be found in relatively dense patches. Adults sometimes target these patches to the exclusion of other RFC prey. The analysis of these patch exploitation decisions is beyond the
scope of our current problem, but we might predict that under some circumstances switching from the RFC patch to the *Strombus* "patch" would pay off (for example, if tidal conditions and particulars of the substrate in Section A decrease RFC returns to the point that switching patches will maximize foraging efficiency, see Bird 1996).

Children

For young foragers the model predicts that *Hippopus, Tridacna maxima/squamosa, large Trochus, Lambis, Cypraea, small Trochus, and Strombus* should all be handled on encounter. Only *Tridacna crocea* should be passed over. Relative to predictions 1 and 2, only *T. crocea* should be associated with SQ significantly < 1.

Figure 3 illustrates a test of these predictions with children's RFC efficiency. Only one prey type (*Hippopus*) fails to match predictions 1 and 2 (that all prey types with e/h > E/Tf will be associated with SQ not significantly different from 1, while the converse should hold for prey types with SQ significantly < 1). Although the predictions are generally met, some comments will be useful.

**Figure 3.** Children's foraging efficiency: on-encounter return rate (e/h) vs. mean RFC return rate (E/T) where e/h is kcal/hour handling and E/T is kcal/hour searching and handling. SQ is the Selectivity Quotient; error bars are SE.
Children’s SQ for Hippopus is significantly lower (.51, p = .02; see Table 2) than predicted by the model. This may be the result of a number of factors, but given that we never observed a child pass over Hippopus, we suspect that our SQ measures for children are too low.

1. Our measures of V for children may be higher than the actual walking speed while collecting. This would increase the predicted λc and decrease the SQ. This strong possibility (there are 45 observations during 2 children’s follows) is currently untestable. Velocity data from a larger sample of follows would be needed to investigate this further.

2. The collecting rate for children may be biased relative to the location of follows, decreasing the observed λc relative to the predicted λc. Although the reef survey took place around the whole fringing reef, most of the children’s follows took place in area A, where the encounter rate for Hippopus is low (see Figure 1 and Table 1).

We suspect that both of these reasons may contribute to the results, but the first may be more important. This is primarily because of the consistent reduction in SQ values (relative to adults) for almost all children’s resources predicted to be handled on encounter (Figure 3), even for Lambis, which is no less likely to be encountered in area A than elsewhere (see Table 1). While the low encounter rate of Hippopus in area A may contribute to the increase in the probability that children will handle a low-ranked prey type on encounter, it does not seem to differentially affect children’s SQ.

Although both Cypraea and Strombus are commonly exploited by children (SQ not significantly different from 1, Table 2), occasionally children stated that they purposefully passed over some of these prey items. We suspect that sometimes children avoid Cypraea for the same reasons that adults do (see above). For Strombus this may result from the fact that handling this resource will increase children’s foraging efficiency on average, but sometimes it won’t (22% of children’s follows were associated with E/Tf > mean e/h for Strombus). Conversely, since Strombus are never field processed, whether or not the forager expects to pay the costs of processing at home may also influence the attractiveness of this option for children.

The increase in predicted diet breadth for children (relative to adults) results mostly from a reduction in the overall foraging return rate without correlated reductions in the handling costs for some resources. This is especially so for Strombus and small Trochus, for which adults and children can expect very similar on-encounter return rates (see Table 3). Children
are very efficient at handling these small prey, probably because extracting the meat requires no upper body strength (unlike tridacnids and Lambis), and with their small fingers children can more easily pull the meat from the small valve opening (see Bird and Bliege Bird 2000 for the effects of transport costs on children’s strategies).

**IMPLICATIONS**

These data suggest that age-linked differences in overall reef-flat collecting efficiency among the Meriam are mostly a function of a reduction in the rate at which children encounter the highest-ranked resources. This makes harvesting small prey such as *Strombus* and small *Trochus* an efficient option for children. Regardless of where they forage on the reef, children are likely to encounter half the number of *Hippopus, Tridacna maxima/squamosa*, and *Lambis* than adults. This reduces the opportunity costs of handling lower-ranked prey, and decreases “choosiness.”

Meriam children are no better than anyone else as analog for understanding age-linked differences in foraging in other times or places. However, the predictions of the simple foraging model we tested with the Meriam data may be instructive for understanding factors that shape prey selection in many contexts. The model leads us to suspect that under circumstances where it pays for children to forage on their own, and where their foraging efficiency is in large part a function of their encounter rate while searching, children’s prey choice should differ from that of adults. If children walk slowly simply as a result of being smaller than adults, when they search for resources by walking, they will always encounter high-ranked resources at a lower rate than adults. All other things being equal, this should always broaden a child’s diet to include lower-ranked prey. For Meriam children, this may be an important influence on why usually only they choose *Strombus* and small *Trochus*, and it provides an interesting hypothesis to explain the common observation that children in intertidal environments are less choosy than their parents (cf. Meehan 1982).

The Meriam data also suggest that, relative to adults, children may be very efficient at handling some resources and comparatively inefficient with others. Significant differences exist between child and adult return rates for processing *Hippopus, Tridacna maxima/squamosa*, and *Lambis* (Mann-Whitney U, p < .02), whereas the same differences are not seen from handling small *Trochus* and *Strombus* (see Table 3). Those prey exhibiting greater discrepancies between return rates of adults and children require more upper body strength to process. Holding overall return rates constant, where children forage, those prey types that require less upper body
strength to handle should be especially attractive (e.g., fruit, shellfish, berries, small animals), and differences in how they handle these prey might best be attributed to the smaller size of the forager rather than a long process of social learning. Likewise, the observation that young children often avoid the roots and seeds that adults focus on (e.g., Cane 1987; Hawkes et al. 1995) may be best understood relative to the age-specific costs and benefits of exploiting resources that require upper body strength to process.

One criticism of this analysis is that shellfish foraging is not a skill-based activity. The constraints on learning for children are more likely to involve skill-based foraging (where success is especially a function of skills that require a great deal of practice and learning). There are other foraging activities in which children don’t engage until much older: in many societies, children of both sexes learn non-skill-based activities quickly, but skill-based activities don’t begin to become part of a child’s repertoire until around age 10 or 11. And children don’t use those skills to forage until they have reached adult size. For example, Hadza boys of age 10 get half of their diet by foraging for tubers and baobab, and while they hunt small game with bows and arrows, they don’t hunt large game as their fathers do until they are much older (Blurton Jones et al. 1997). Some Meriam girls and most Meriam boys begin spearing fish by age 5 or 6 (see Bliege Bird and Bird, this issue) but don’t start hunting as men do until after puberty. Women often avoid highly skill-based activities altogether, yet they are as self-sufficient as any human adult. This makes it difficult to claim that children remain dependent longer when high-ranked foraging activities are entirely skill-based because it takes too long to learn how to forage efficiently. Our argument draws attention to the observation that the process of learning can be very fast—and under some circumstances a child’s subsistence may be more constrained by the slow pace of growth. Just because it takes longer to reach adult foraging efficiency doesn’t mean children stay small because they need to learn how to become efficient.

A possible response to the argument that differences in prey choice can be understood relative to the physiological constraints of being small (walking speed, strength) is that maybe children walk slower than adults not because they are physiologically constrained as such but because they are looking for different kinds of prey than adults, or because they just don’t see as well. But regardless of the reason (limb length or energy cost), children’s pace when walking comfortably is slower than that of adults. Meriam children also walk slower than adults when they are not collecting. When we measured travel speeds to the reef flat, we found the same magnitude of difference between adults and children ($V_{\text{adult}}$ in travel = 5.01 ± 0.17 km/hr, $V_{\text{child}}$ in travel = 3.64 ± 0.39 km/hr, $V_{\text{adult}}$ collecting = 2.86 ± 0.31 km/hr, $V_{\text{child}}$ collecting = 1.43 ± 0.26 km/hr). This suggests that even if children could walk as fast as adults, they don’t, and as a result
they will encounter higher-ranked prey at a lower rate than adults in any fine-grained patch of resources. This would result in children choosing more lower-ranked prey on encounter to increase foraging returns.

CONCLUSIONS

How much experience do Meriam children need before they become efficient reef foragers? Evidently very little. Adults are reluctant to take children out on the reef or to allow them to play in groups on the reef before age 5 or 6. Four-year old children we have observed on the reef don't really forage: they have knowledge of appropriate reef prey, but they are easily distracted and spend time pursuing items that are inedible or associated with extremely low foraging returns. They are also extremely slow and tire easily when the substrate is difficult to negotiate. By age six, children have become fairly efficient foragers. The learning process involves little or no direct adult instruction: when four year old children first accompany adults, they may play the role of retriever in picking up individual *Hippopus/Tridacna* or *Lambis* spotted by adults, and they may be told to steer clear of certain dangers. The knowledge gained from adults about the reef and how to forage remains limited mainly to what is edible and what is dangerous until they begin, about age 6, to forage in groups with older children, observing intently their prey choice and processing strategies through play and experimenting with various reef activities. It makes sense for children to gain general knowledge about dangers and edibility of particular prey from adults, but to learn specific details of the efficiency of edible prey types from other similarly constrained children, and to further refine their foraging strategies based on their own experience and their own unique individual trade-offs.

Judging from this case study and recent work among the Hadza (Blurton Jones and Marlowe 2002; Blurton Jones et al. 1997), ignorance and learning constraints are not necessarily good explanations for differences in foraging practices of adults and children. We show that age linked differences are consistent with a hypothesized goal of maximizing overall efficiency for time spent searching and handling resources while reef-flat collecting. Learning seems to have little effect on children’s decisions beyond about age 5 or 6: children don’t focus on learning intensive activities that are important for adults, but on resources that maximize their immediate foraging returns. The differences in selectivity, wherein juveniles are more eclectic than adults, are predictable given the reduction in the opportunity costs of handling low-ranked prey on encounter with decreased encounter rates for higher-ranked resources.

Our work with the Meriam illustrates two lessons when it comes to thinking about the evolution of human life histories: (1) when it comes to
survival, children face different trade-offs than adults, and (2) in certain activities after about age 5 or 6, children are less likely to be constrained by their intellect than by their size, which is one third to one fourth that of adults. Because a number of phenotypic traits are correlated with age, including size, experience, digestive morphology, and nutritional requirements, one cannot use simple age differences in behavior to support the hypothesis that a long period of juvenility is a response to the complexity of adult behavior. The Meriam data in part support recent life history theory that suggests a long period of human juvenility is related to trade-offs between current and future reproduction, and mortality rates (Charnov 1993; Janson and van Schaik 1992). In some circumstances we might expect children to forage differently than adults simply because they have long juvenile periods, not because they are learning adult foraging. Paying attention to the differences from a child's perspective may help adults remember what being a child was all about.

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NOTES

1. Numerous authors have commented on the differences between adults and children while foraging in the intertidal:

   • Meehan (1982:71): [The] gathering strategy in which gatherers focus on one species is a conscious part of Anbarra behaviour. People, especially mature
women, are quite explicit and vocal about it. I was told repeatedly during the early days of my shellfish-gathering apprenticeship to discard the odd *Mac-utra meretriciformis* I had proudly displayed because we were getting 'only diyama'. Young children are inclined to gather more species than adults. This is partly because they are less skilled but also because they forage in the intertidal zone close to the beach, which contains a wide variety of sparsely scattered shellfish. The children also appear to be interested in different species for their own sake as well as for their taste.

- Meehan (1983:10): Why was such a broad spectrum of species associated with the marked targeting onto a single species? . . . Children often collected several species of shellfish. This seems to be because they had not yet absorbed the search image so well understood and practiced by adult women. Also, children tended to play and forage in the upper part of the intertidal zone where many, but sparsely distributed, species could be procured. To accumulate even a snack these small foragers were forced to be eclectic.

- Swadling and Chowning (1981:161): The children of Nakakau [New Guinea] gather shellfish for their own consumption. These are *Atactodea striata* (peperu), *Gafarium tumidum* (pauliki) and *Anadara antiquata* (uleule). The first two are small in size and are found along the beach area used for defecation. Nakakau adults do not gather or eat these shellfish and laugh at children for eating them . . . Pigs, too, are often seen rooting in this sand zone in search of these shellfish which they happily crunch and eat . . . Children were frequently observed gathering and cooking these shellfish in the morning. They would gather them in an old mackerel tin or some similar container and then boil them open in the same container over a small fire.

- Thomas (1994:23): *Gafarium pectinatum* was at the time of my investigations the prominent mollusc gathered by the people of Tebanga Village on Maiana Atoll [Kiribati]. These were especially important for children whom I often saw collecting these small bivalves, simply scraping the sand and gathering large numbers of shells in a short time.

- De Boer et al. (2000:83–84): Women were better foragers than children [on Inhaca Island, Mozambique], their catches were heavier and contained fewer but more profitable species . . . The species diversity of the catches changed with significant differences between children-women, neap-spring tide, substrates and tidal phase. Women were more effective foragers and only picked up larger animals, ignoring smaller species which were collected by children.


3. All errors given are Standard Error.

4. The GPS data are not differentially corrected. This reduces confidence in the specific values, but since the speeds are averages over some distance, the degree of random error between adults and children should not differ significantly (Schutz and Herren 2000). We thus expect the differences in search velocity between adults and children to be meaningful.

5. Energetic values for each prey type were obtained by averaging values of similar or identical species. See Bird 1997:303–304 for details.

6. Weights for specimens not exploited were calculated in the home processing
sequences (see Table 3). For those that neither children nor adults harvest, we requested that foragers harvest a sample to determine post-encounter return rates (this was not done during foraging follows).

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