The Ethnoarchaeology of Juvenile Foragers: Shellfishing Strategies among Meriam Children

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Recognizing children's contribution to the archaeological record may be crucial for our ideas about the role of children in human evolution. Despite this, analyses of children's activities and how they might shape archaeological patterns are almost entirely absent from discussions about site formation processes. This may in turn result from the assumption that children are either inconsequential in their foraging activities or that identifying children's activities archaeologically will be difficult if not impossible. This challenge drew our attention toward children's intertidal gathering among the Meriam of the Eastern Torres Strait as a possible agent of patterned and predictable variability in shell middens. We present an analysis of differences between the prey choice and field processing strategies of children and adults and explore an hypothesis for predicting their archaeological effects on faunal assemblage variability. © 2000 Academic Press

Key Words: ethnoarchaeology; children; shellfish gathering; central place foraging theory.

INTRODUCTION

While archaeologists have recognized that the behavior of children is likely to be an important determinant of archaeological variability (e.g. Baker 1997; Denison 1994; Derevensky 1997; Finlay 1997; Karlin and Julien 1994; Lillenhammer 1989; Pigeot 1990; Schiffer 1987), there are very few attempts to test hypotheses of juvenile behavior and their site formation consequences (Hammond and Hammond 1981). When our analytical focus turns to reconstructing and explaining past subsistence, we generally think about *adult* subsistence, assuming implicitly that patterning in the remains of food acquisition are ultimately linked to adult provisioning of themselves and others. This assumption,

that children's subsistence efforts will not generally be an important archaeological agent, may in part stem from the commonly held notion that human children are unproductive and that the "universal human condition" is one of an unprecedented degree of juvenile dependence.

In comparison to other primates and mammals, human life histories are odd, especially in their extended period of postweaning juvenility. As such, our long childhoods have been a key feature in the most influential models of the evolution of "human" behavior; patterns like extensive food sharing, central place foraging, hunting, tool use, and a sexual division of labor, have all been linked to the enduring reproductive costs that a lengthening juvenile period would entail (e.g., Isaac

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1978). Recently Hill and Kaplan (1999) and Kaplan et al. (2000) have taken these notions further in a model of human life history evolution that formally couples juvenile dependence (along with long life spans and menopause) with a dietary shift toward nutrient-dense large-package resources that are difficult to acquire. The key to the model lies in the assumption that delays in reproduction and extended adult provisioning are determined by the time it takes to learn the complexity of adult behavior and attain the skills for acquiring the high-quality, large-package resources humans consume. The model suggests that investment in the acquisition of knowledge and skill will favor selection for a long juvenile phase.

Similar notions have led many investigators to assume that age linked foraging variability is evidence for the high costs of acquiring adult foraging knowledge and skills. But recent work on children's foraging decisions among the Hadza (Blurton Jones et al. 1994a, 1994b, 1997 and Hawkes et al. 1995) and Meriam Islanders (Bird and Bliege Bird submitted; Bliege Bird and Bird submitted) has questioned these assumptions by illustrating two possible concerns with conventional wisdom regarding children's production. First, it is not necessarily the case that *differences* between adult and child behavior will always indicate attempts by children to acquire the knowledge and skills of adults: age-linked differences in foraging may sometimes better reflect differences in foragers' physiological constraints than differences in goals (e.g., learning goals vs efficiency goals). Second, it is difficult to imagine, let alone demonstrate empirically, that the value of foraging as learning experience can *fully* account for our distinct life history patterns: while socialization and learning are critical features and determinants of child behavior, it is probably *not* the case that our long juvenile period evolved simply for more learning

to occur (Blurton Jones et al. 1997; Bliege Bird and Bird submitted; see Charnov and Berrigan 1993; and Janson and van Schaik 1993 for development of this argument for nonhuman primates). These studies suggest that relative to the constraints of being a *juvenile* forager, children are not always just practicing to be good adults as such, but are predictably behaving in ways that efficiently solve immediate fitness-related trade-offs.

This hypothesis, that children's foraging strategies may differ from adults in ways consistent with a goal to maximize efficiency now rather than in their adult futures, has potentially interesting archaeological applications. In this article we illustrate some archaeological problems created by children and present a potential explanatory framework for understanding the ways that children can shape a faunal assemblage. This framework is supported by the idea that since juveniles live in a world free of immediate reproductive trade-offs, their success is determined entirely by factors that influence the chance of reaching the point at which they are no longer juveniles. For youngsters, somatic investment (how much and how fast) is what matters (Janson and van Schaik 1993). Therefore, natural selection should design the flexible nature of children's foraging strategies to be especially sensitive to the immediate opportunity costs of attempts to maximize efficiency while foraging.

Such opportunity costs of foraging are particularly relevant to archaeological problems when the goal of foraging is to maximize delivery rate of a resource rather than the rate of acquisition per se (e.g., Bird and Bliege Bird 1997; O'Connell et al. 1988, 1990; Barlow and Metcalfe 1996; Zeanah and Simms 1999). Inherent in decisions about delivering resources to a central place is an important dilemma: If a forager can obtain more than s/he can carry, s/he can increase the utility of his or

her load by culling resource parts of low quality, which costs foraging and transport time, or s/he can avoid the opportunity cost of field processing by continuing to forage and transport, which costs load utility (Metcalfe and Barlow 1992). This trade-off has important archaeological consequences, especially when it comes to children's foraging decisions.

In this article we propose some ways that we might go about assessing the material correlates of children's foraging with analyses of data on shellfishing among the Meriam. After a brief introduction to the study site and intertidal subsistence on Mer, we present predictive tests of the hypothesis that differences between adult and child foraging strategies are consistent with variability in foraging trade-offs where the goal of foraging is to maximize the rate at which flesh is gained and delivered to a central place. Subsequently, we provide some evidence that differences between adults and children can have important archaeological implications. And finally we suggest some possible alternative hypotheses that are potentially testable with archaeological remains to distinguish age-linked foraging patterns.

CHILDREN AND SHELLFISH

Problems with the assumption that children's foraging is archaeologically inconsequential are especially evident in even the most cursory review of coastal economies. While the intensity of children's subsistence varies from place to place, the extent to which children worldwide consistently participate in marine subsistence activities is striking [see Bigalke 1973 and de Boer n.d. (Transkei Coast and Mozambique, Africa), Bliege Bird et al. 1995 (Eastern Torres Strait, Australia), Hill 1978 (suburban Samoa), Meehan 1977, 1982, 1983 (Arnhem Land, Australia), and Waselkov 1987:96–99 for review]. This is es-

pecially the case in Island Oceania, where children are often most active in shellfishing, an activity usually thought to have high archaeological visibility [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)].

But one striking thing about shellfishing is that children consistently do it differently than adults: in the eyes of a child gathering shellfish, adult perspectives about where to forage, what to handle, and where to handle it may seem bizarre. Anywhere that we have details on children's shellfishing, the general theme is one of differences in selectivity and processing. For example Swadling and Chowning (1981:161) report that off the northern coast of New Britain

> The children of Nukakau gather shellfish for their own consumption. These are *Atactodea striata* (*peperu*), *Gafrarium tumidum* (*pauliki*) and *Anadara antiquata* (*uleule*). The first two are small in size and are found along the beach area used for defecation. Nukakau adults do not gather and 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.

This pattern is common throughout coastal and island societies: children forage differently than adults (see especially Waselkov 1987 and Meehan 1982). Our data show a similar pattern among Meriam children of the Torres Strait.

The Meriam

The Meriam are the indigenous Melanesian inhabitants of Mer, Dauar, and Waier—the easternmost islands in the Torres Strait, located on the northern

Great Barrier Reef 140 km south of Papua, New Guinea. The population on Mer and Dauar today consists of 430 individuals. Details on contemporary Meriam social structure, subsistence strategies, and children's activities in general are provided elsewhere (Beckett 1987; Bird 1997; Bird and Bliege Bird submitted; Bliege Bird 2001; Bliege Bird and Bird submitted; Bliege Bird and Bird 1997; Bliege Bird et al. 1995; Bliege Bird et al. 2001; Sharp 1993; and Smith and Bliege Bird 2000). In brief, over 600 calories per person, per day, come from marine foraging activities (Bliege Bird 2001). Contemporary Meriam foraging includes marine turtle hunting (Bliege Bird and Bird 1997; Smith and Bird 2000; Bliege Bird et al. 2001), beach fishing with handlines (Bliege Bird 2001), offshore fishing handlines (Bliege Bird 2001), shellfish collecting (Bird 1997; Bird and Bliege Bird 1997), and spearfishing (Bliege Bird et al. 2001). Meriam children participate in a wide range of these subsistence activities, including others only they target, such as seasonal fruit and nut collection and reef edge fishing (Bliege Bird et al. 1995), but especially beach fishing, shellfish collecting, and spearfishing (Bird and Bliege Bird submitted; Bliege Bird and Bird submitted). In this article we limit our analysis to age-linked differences in shellfish gathering.

On the Meriam Islands two types of gathering take place in the intertidal zone: reef flat collecting and rocky shore harvesting. Both activities target marine shellfish. Here we focus on the more common of the two activities, reef flat collecting (see Bird 1996, 1997; Bird and Bliege Bird 1997 for details on rocky shore harvesting and detailed analysis of shellfishing techniques and strategies). Children are especially active in reef flat collecting; they forage independent of adults, often in "play" groups after school or on weekends. This is the case for many of the fishing and collecting activities that Meriam children are involved in: when it comes to subsistence, children learn mostly from other children, not adults. Adult instruction is limited to generalities about edibility and variability in prey and patch availability, location, and quality; for detailed knowledge, children primarily rely upon other children or self-experimentation (for more complete descriptions of children's foraging and its developmental aspects see Bliege Bird et al. 1995; Bird and Bliege Bird submitted; and Bliege Bird and Bird submitted).

Reef flat collection occurs mostly in the mid- to sublittoral zones on fringing reefs during a 2- to 4-h low spring tide that exposes reef substrates for 1 to 2 weeks per lunar cycle. It is uncommon from October to February because of poor diurnal reef exposure. Shellfish are collected mostly as foragers search within the midlittoral band around the fringing reef, parallel to the reef margin. Foragers generally encounter each item singly and often cull the shells immediately.

A wide range of reef flat shellfish (21 different species) were taken during our study, but only three prey types made up over 90% of all flesh procured while reef flat collecting: two types of tridacnid clams (*Hippopus hippopus* and *Tridacna* spp.[1,*]) and one conch (*Lambis lambis*). While adults focus primarily on these three prey types (sometimes collecting other types only as an afterthought on the way back from foraging), children often collect *Strombus luhuanus* (black lipped conch), small *Trochus niloticus* (top-shell), and other shellfish throughout the course of a foraging bout.

Below we analyze differences in the prey choice and processing decisions of adults and children while reef flat collecting. If children forage differently than adults because of differences in physio-

* See Notes section at end of article for all footnotes.

logical constraints rather than lack of practice or knowledge, some simple predictions can be made about the material consequences of children's subsistence.

METHODS

The analysis presented here is drawn from three shellfishing data sets that we collected during 26 months of field work (1993–1995 and 1997–1998) which focused on fishing, hunting, sharing, and demographic parameters among the Meriam (e.g., Bliege Bird et al. 2001; Smith and Bliege Bird 2000). The first data set is a series of focal individual follows during reef flat collecting where we (a) monitored time spent in travel, search, and field processing; (b) counted and weighed all items of each prey type; and (c) monitored walking paths and speed with a Magellan Color Tracker GPS unit on four follows (two children and two adults). A total of 35 children's focal follows (5–15 years old, $\bar{x}$ = 10 ± 2)[2] and 47 adult follows (16–65, $\bar{x}$ = 41 ± 11) were conducted.

The second data set is a series of home processing sequences totaling 65 loads of various types of shellfish where we measured time foragers spent in processing, counted items of each prey type; and weighed edible flesh, shell, and waste. Records are currently available for five different children (7–13 years old) and nine different adults (35–61 years old).

And finally, we conducted a reef flat shellfish survey consisting of 17 corridors on the reef flat, most of which extended from the shore to the reef edge ($\bar{x}$ = 325 ± 177 m in length). Each corridor was made up of four transects (except one of two transects) at 10 m apart running the length of the corridor. Researchers walked the transects and recorded the number, size, and substrate zone location of every edible mollusc sighted within 5 m to each side. This provided coverage of about 270,440 m^2 (about 3% of Mer's fringing reef).

RESULTS

Differences in Prey Choice

Here we review some quantitative differences between adults and children in prey choice while reef flat collecting. Previously, to demonstrate quantitative differences in the prey choice of adults and children we have compared observed collecting rates (λ_c) and encounter rates predicted by observed mollusc density on the reef flat and collecting velocity of adults and children (λ_e, see Bird and Bliege Bird in press for details on calculation). This gives us a measure called the selectivity quotient (SQ, or λ_c/λ_e; items collected per number encountered), an estimate of selective bias while reef flat collecting. Below we will look at two measures of prey choice: SQ and relative collecting rate of children and adults.

Table 1 presents summary data on collecting rates, relative collecting rates, and the SQ of different prey types. Investigating absolute differences in the rate at which adults and children collect different types of prey is not entirely useful if we want to know about differences in prey choice or selectivity. This is because children walk more slowly than adults and as a result they encounter all items at a lower rate. Differences in collecting rates are better expressed relative to differences in the speed at which a forager is likely encounter different kinds of prey. Here, *relative* collecting rate (V') is the mean child and adult collecting rate for different prey types relative to observed age differences in walking velocities while collecting:

$$V'_i = \frac{\lambda_c}{V_c \text{ or } V_a} \tag{1}$$

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TABLE 1

Meriam Shellfish Collecting Rate, Relative Collecting Rate, and Selectivity Quotient[a]

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Prey type	λ_c		V'		SQ		V' (children vs adults significance test*)	
	Adults (n = 47)	Children (n = 35)	Adults (n = 47)	Children (n = 35)	Adults	Children	U	p
Hippopus	6.73 ± 1.61	1.02 ± 0.23	2.35 ± 0.56	0.81 ± 0.19	1.67	0.51	357	.039
Tridacna spp.**	2.15 ± 0.52	0.80 ± 0.28	0.75 ± 0.18	0.56 ± 0.195	0.73	0.54	698	.243
Trochus (lg)	0.20 ± 0.10	0.20 ± 0.12	0.07 ± 0.04	0.13 ± 0.10	0.76	1.54	811	.914
Lambis	19.60 ± 2.77	7.24 ± 1.35	6.85 ± 1.00	5.05 ± 1.13	0.81	0.60	523	.147
Cypraea	2.65 ± 1.36	0.71 ± 0.58	0.93 ± 0.47	0.51 ± 0.40	0.56	0.30	607	.051
Trochus (sm)	0.00	0.61 ± 0.24	0.00	0.43 ± 0.17	0.00	0.59	611	.047
Strombus	1.56 ± 0.62	4.00 ± 1.02	0.54 ± 0.22	2.80 ± 0.71	0.09	0.45	431	<.001
Tridacna crocea	0.02 ± 0.02	0.08 ± 0.05	0.01 ± 0.01	0.05 ± 0.03	<0.01	<0.01	768	.609
Trid. gigas	0.34 ± 0.19	0.00	0.12 ± 0.07	0.00	~1	na	770	.623

[a] Abbreviations: λ_c = mean number of specimens collected per hour of search across all follows, adult or child; V' = relative collecting rate, λ_c/V; V = mean search velocity during collection (kilometers per hour) adult or child; SQ = λ_c/mean number of specimens predicted to be encountered at observed reef survey densities when walking at $V_{child\ or\ adult}$.

* Mann–Whitney U test.

** Includes *Tridacna maxima* and *Tridacna squamosa*.

where for each prey type *i*, λ_c is the mean number of specimens collected in a 1-h search on each follow, V_c is the mean search velocity of children while collecting (1.43 ± 1.71 km/h, $n = 45$), and V_a is mean adult search velocity (2.86 ± 1.63 km/h, $n = 28$). The key differences between adults and children in V' are with *Hippopus,* small *Trochus,* and *Strombus* (see Table 1). While adults collect *Hippopus* at a significantly higher relative rate than children ($p = .039$), children collect small *Trochus* and *Strombus* at a significantly higher rate than adults ($p = .047$ and .001 respectively). These were the only significant differences in the relative collecting rates of children and adults across prey types and correspond to similar differences in the probability of collecting items of these on encounter (children's SQ for *Strombus* is .45, while for adults it is .09; children's SQ for small *Trochus* is .59, while for adults it is 0; see Table 1). The question is, why do children and adults differ so measurably in prey choice?

Differences in Efficiency

The predictions from the encounter-contingent prey choice model assume that the pay-offs from searching and handling trade off with each other such that on encounter, an item of a given prey type will be handled *if and only if* doing so will provide a return rate greater than the returns expected by passing over the item to continue searching for other prey types to handle (Stephens and Krebs 1986:13–24). Here, we test the prediction that prey types collected at a significantly lower rate than they are encountered will be prey that have a profitability significantly lower than the overall reef flat collecting return rate for adults and children respectively. In more formal terms, when prey are ranked in order of their profitability (energy gain per unit time handling) then: if $SQ_i < 1$, then for prey type *i*,

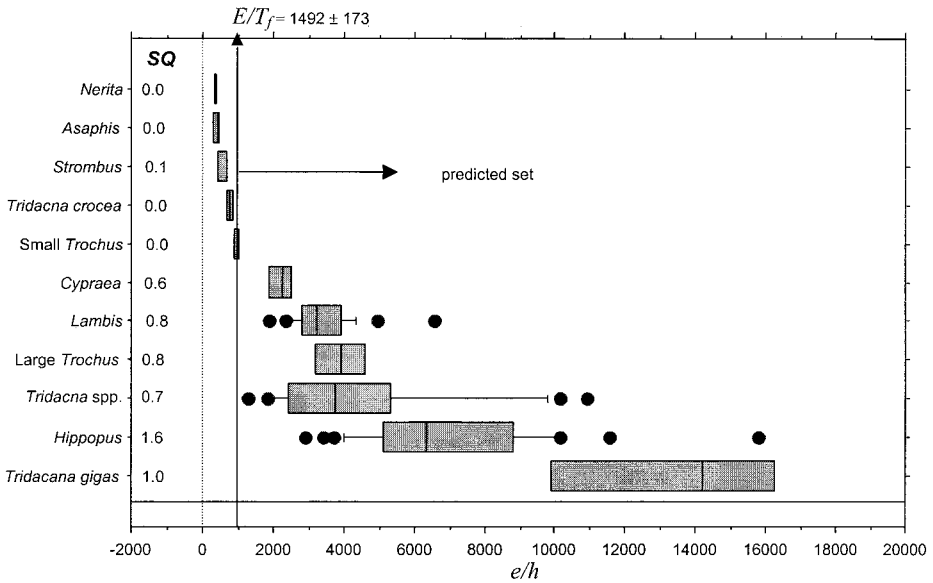$$\frac{e_i}{h_i} < \frac{\Sigma E}{\Sigma T_s + T_h}, \tag{2}$$

FIG. 1. Adult reef flat collecting efficiency. The model [Eq. (2)] predicts that those prey types with postencounter profitability (e/h) less than the overall foraging return rate (E/T_f) will have a selectivity quotient significantly (SQ) less than 1.

where e is the expected net energy gained from an item of prey type i, h is time spent handling an item of type i (where handling consists of post encounter time spent harvesting and processing), E is the energy gained from all prey types during a foraging bout, T_s is the time spent searching for all prey, and T_h is the time spent handling all prey such that $T_s + T_h = T_f$, the total time spent foraging in patch. If the inequality holds relative to age-linked differences in prey choice on the reef flat, then differences in the selectivity of adults and children would be predictable as a function of differences in postencounter profitability and the encounter rate with more profitable resources.

Figure 1 presents a test of this prediction for adults. Those prey types with adult profitabilities that are on average below the mean overall RFC return rate (E/T_f) have SQs significantly less than 1.

These prey types include one tridacnid clam species, *T. crocea,* small *Trochus,* and *Strombus.* While the Meriam do sometimes target rocky shore *patches* to harvest *Asaphis* and *Nerita,* the fact that adults never collected these during reef flat collection is also predicted by the model.

Figure 2 shows that for children, small *Trochus* and *Strombus* are especially interesting. As predicted, children are more likely to handle items of these prey types on encounter; moreover, these are the only prey that children also collect at significantly higher relative rates than adults (see Table 1). Only *Hippopus* failed to match the predictions for children ($e/h > E/T$ and SQ is significantly <1). The overall trend is one repeated in many descriptions of children's shellfishing: Meriam children have a quantitatively broader diet on the reef than adults—a result predicted by the fact that they encounter higher ranked resources at a lower rate.
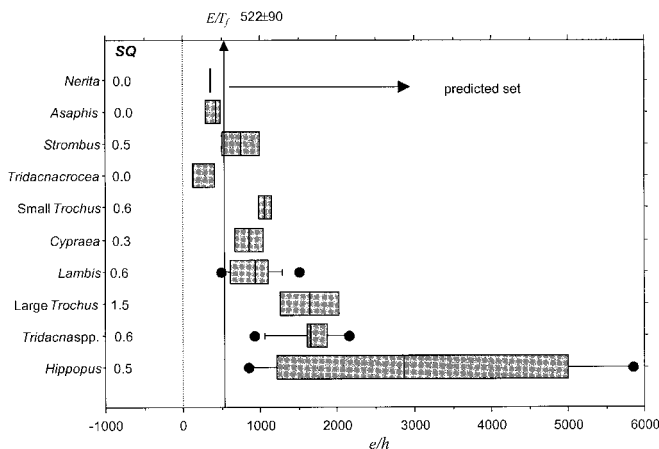
FIG. 2. Children's reef flat collecting efficiency. The model [Eq. (2)] predicts that those prey types with postencounter profitability (e/h) less than the overall foraging return rate (E/T_f) will have a selectivity quotient significantly (SQ) less than 1.

Field Processing and Transport

While children are more likely to handle lower ranked prey than adults, what matters archaeologically, especially relative to children, is what happens with the prey during handling. Figure 3 presents a summary of age-linked differences in the time to field process 1 kg of edible flesh of the three most important shellfish prey types, *Hippopus, Tridacna* spp., and *Lambis.* While for each of these resources, children take significantly longer than adults to field process (*Lambis* $t = 10.15$, $p < .001$; *Hippopus* $t = 5.23$, $p < .001$, Tri-dacna $t = 4.37$, $p < .001$), the mean difference between adults and children is three times greater for *Lambis* (47 min/kg) than for *Hippopus* and *Tridacna* spp. (13 and 14 min/kg, respectively). Meriam children, relative to adults, are more efficient at processing some things than others. Consequentially, this has counterintuitive implications for our expectations about differences in transport decisions.

If a shellfisher attempts to maximize the rate at which s/he can deliver edible flesh to a central place and can harvest more bulk shellfish than s/he can carry while collecting, s/he can either stop to cull the shells or carry more loads back and forth from the reef flat. If field processing as opposed to bulk transport pays off, we would expect important archaeological biases in the types of shellfish remains that end up in a midden (as is the case for game animals, see Binford 1978; Bartram and Marean 1999; and O'Connell et al. 1988). This is especially important for shellfishing because if processing occurs at the procurement site, no archaeological signatures remain (Bird and Bliege Bird 1997). Predicting circumstances under which we would expect field processing
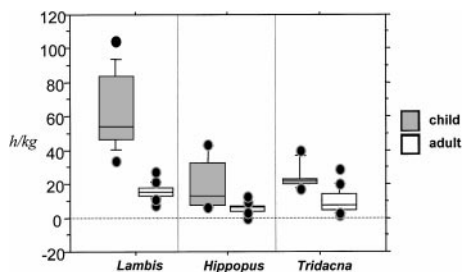

FIG. 3. Differences between children and adults in time required to field process 1 kg of edible flesh (h/kg; handling time per kg) for the three most important prey types.
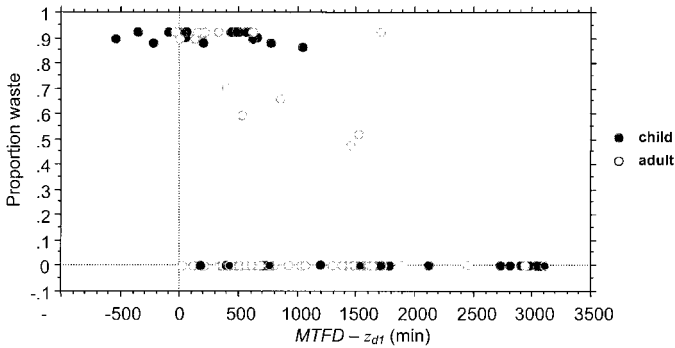
FIG. 4. Relationship between proportional waste transported to a central locale and the distance walked beyond the point at which field processing will increase delivery rate of *Hippopus, Tridacna,* and *Lambis* edible flesh. MTFD is the maximum terminal foraging distance on a follow (meters), z_{d1} is the one way distance (traveling at 3 km/h) field processing threshold (meters) for each follow. Follows during which the MTFD exceeded the z value (positive points on the x axis and with no waste transported or follows that did not exceed the z value (negative points on the x axis) and with waste transported fit the model's predictions [Eq. (3)].

are thus critical for reconstructing and understanding variability in ancient subsistence. The threshold (in time) at which a central place forager should field process to increase load utility at a cost in foraging and transport time is given in Metcalfe and Barlow's (1992) model, expressed linearly as follows:

$$z_i = \frac{y_0 x_1 - y_1 x_0}{y_1 - y_0}, \qquad (3)$$

where for each prey type i, z is the point in round-trip travel at which field processing rather than bulk transport will increase delivery rate, x_0 is the time to collect a load of unprocessed resource, x_1 is the time to collect and field process a load of resources, y_0 is the proportion of an unprocessed load consisting of high-quality material, and y_1 is the proportion of a processed load consisting of high-quality material.

The model predicts that if a forager does not cross the field processing threshold during a foraging bout, the load transported to a central place will be made up of both high-quality (edible flesh) and low-quality (mostly shell) material (that is, the load will have some proportion of waste above 0). Conversely, for resources collected beyond the field processing threshold, loads should have no waste. Figure 4 demonstrates that overall, foragers field processed in a manner consistent with these predictions: Children and adults respectively processed 71% ($n = 38$; 27 loads matched, 11 failed) and 82% ($n = 86$; 71 loads matched, 15 failed) of all loads of the three most important resources, *Hippopus, Tridacna* spp., and *Lambis,* as predicted. Loads that matched the predictions are loads when foragers did not exceed the predicted threshold (in distance) and did no field processing or when they walked beyond the threshold and fully processed at the site of procurement (see Bird and Bliege Bird 1997 for further details on calculation of z values and analysis of shellfish less commonly taken).

Figure 5 shows the mean z values for these resources across all follows, child and adult. The predicted adult and child field processing thresholds for the two tridacnid clams, *Hippopus* and *Tridacna* spp., are not significantly different (all-around
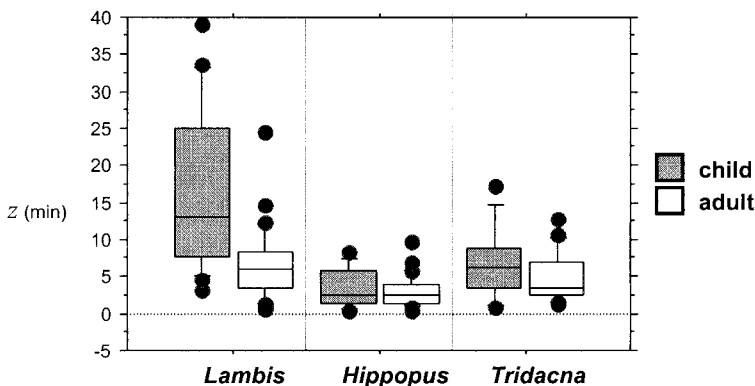
FIG. 5. Differences between children and adults round-trip travel time at which field processing will increase delivery rate of edible flesh for three most important prey types.

5-min round-trip travel time, two-tailed t test for children vs adults, ts = .77 and 1.3, ps = .44 and .20 for *Hippopus* and *Tridacna* spp. respectively). But the increased difference between adults and children in field processing times for *Lambis* (see Fig. 3) translates into significant differences in predicted z values for this prey type: On average children have to travel twice as far as adults before field processing *Lambis* will max delivery rate (child $\bar{x}$ = 16.14 ± 11.00 min; adult $\bar{x}$ = 6.74 ± 4.92 min; t = 4.17, p = < .001).

Because of this difference, qualitatively we would predict that on follows near their residence (within 1 km),[3] children

should be more likely to transport whole *Lambis,* but field process and transport *Hippopus* and *Tridacna* in a manner similar to adults. Figure 6 presents a test of this hypothesis, demonstrating that while children never field processed a load of *Lambis* on follows near home, adults did over 20% of the time. Conversely, for tridacnids children are just as likely to field process as adults (66% of childrens loads of *Hippopus* were field processed and 72% of adults'; 57% of children's loads of *Tridancna* spp. were field processed and 63% of adults').

SOME ARCHAEOLOGICAL IMPLICATIONS

Numerous studies have applied the logic of foraging theory to account for archaeological variability in coastal economies (e.g., Beaton 1973; Perlman 1980; Erlandson 1991; Glassow and Wilcoxon 1988). For coastal midden studies, Broughton (1994, 1995) and Raab (1992) provide especially clear archaeological tests of the encounter-contingent prey choice model presented above. Broughton's analysis of faunal remains from middens in the San Francisco Bay Area demonstrates that high-ranked resources (large artiodactyls)
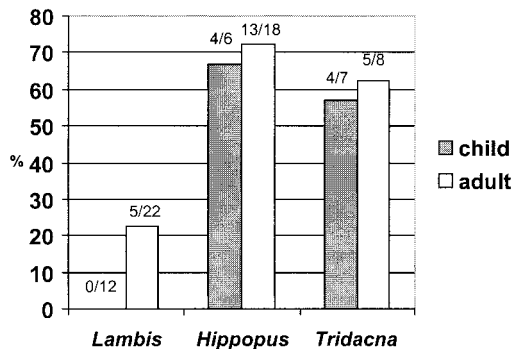

FIG. 6. Percentage of loads field processed prior to transport on follows within 1 km of the central locale.

were progressively depleted over time. The results suggest that in response, subsistence efforts intensified during the late Holocene to include lower ranked prey types (sea otters, other small mammals, fish, and shellfish) when overall foraging efficiency declined below the profitability of these lower ranked resources. Similarly, Raab argues that the prehistoric inhabitants of San Clemente Island, California, began to exploit small snails (which densely populate the intertidal) only when the abundance of the larger, more meaty abalone decreased. These results are consistent with the prey choice model predictions that, independent of the abundance of lower ranked prey types, diet breadth will expand to incorporate them as the encounter rate for higher ranked resources decreases.

Our results show that if particular types of foragers with particular constraints are more or less likely to take certain resources, their involvement in the subsistence economy will have significant effects on midden composition. As such, there may be important archaeological circumstances where variability in the types and amounts of subsistence remains at an archaeological site will not be predicted by the prey choice model. This is clearly the case when it comes to children's foraging, where at least partly because of their activities, patterning in the material consequences of intertidal subsistence can consistently vary in ways unpredicted by the simple prey choice model. The problem here is not the validity of the model, but the difficulty in translating its logic into predictions that can be tested archaeologically, especially when children are contributing to the archaeology.

Children may be important agents of archaeological bias in two ways relevant to studies of variability in plant and faunal assemblages. First, where children are active in a subsistence economy, within any particular resource patch we would expect that often their prey choice would include a wider array of resource types compared to adults and that those resources should be resources of low relative profitability. The broader "diet" of children would be predicted in any resource patch where (1) slower search speeds for children result in decreased encounter rates with higher ranked resources and (2) differences between adults and children in postencounter profitability for prey within the patch are *less* than the differences in encounter rates. These conditions are likely to characterize many resources that both adults and children exploit: fruit, berries, nuts, some types of tubers, and especially shellfish (e.g., Blurton Jones 1993; Blurton Jones et al. 1994a, 1994b, 1997; Hawkes et al. 1995; Meehan 1982).

Second, where the costs of processing differ significantly for children and adults, resources that children exploit should be more likely to end up in middens. We have shown elsewhere that because high-ranked prey (in terms of postencounter profitability) are more often field processed, relative to their importance in the diet, low-ranked shellfish are proportionally overrepresented in contemporary residential middens on Mer (Bird 1997; Bird and Bliege Bird 1997). This study suggests that children's activities especially exaggerate this bias.

An important archaeological implication lies in the fact that lower ranked prey are often less likely to be field processed: Given the costs of handling different prey types relative to the benefits of increasing the load utility by handling prey near the procurement site, it is precisely those prey types that *children* are more likely to exploit that should be transported without field processing while foraging close to home. This is shown in Figure 7, where prey profitability rank is regressed against the predicted point at which field processing will maximize the delivery rate of ed-
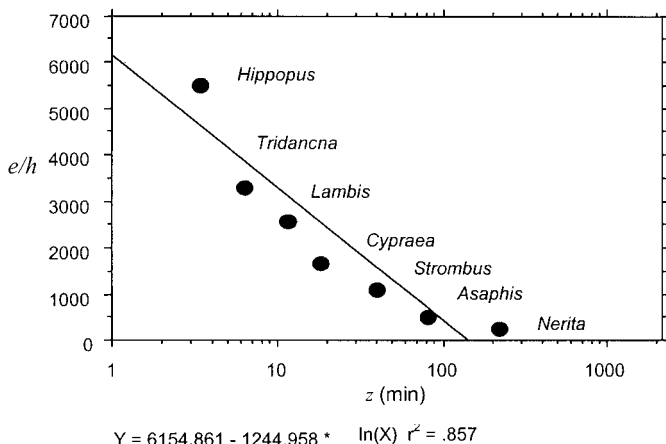
FIG. 7. Relationship between postencounter profitability (e/h; mean of all follows, children and adults) and round-trip travel time at which field processing will increase delivery rate of edible flesh (z; mean of all follows, children and adults).

ible flesh to a central place. Increases in profitability are strongly correlated with decreasing field processing thresholds: other things being equal (load size and proportional utility), the more profitable a prey type is, the shorter the travel distance that field processing it will boost its delivery rate.

An archaeological test of this hypothesis relative to children can be illustrated in studies that have compared ethnographically known prey choice and archaeological remains. For example, Swadling and Chowning (1981) contrasted their ethnographic observations of shellfishing on Nukakau and shellfish remains from a midden excavated in the same community: The shellmidden consisted of a wide array of prey types no longer actively collected by adults today. The authors suggest that these discrepancies indicate intensification with certain resources being overexploited due to an increasing human population. The interesting thing is that those prey types most frequently occurring in the shellmiddens are those that children take and adults avoid (*Atactodea striata, Gafrarium tumidum,* and *Anadara antiquata,* p. 161).

An alternative to the intensification hypothesis to account for such differences could be formulated given that we might expect children to be more likely to exploit low-ranked resources and that they are less likely to field process their prey than adults. Testing these two hypotheses (children vs intensification) should be possible with data on prey profitability rank. We would predict that if intensification accounts for the differences, over time the introduction of lower ranked prey in the assemblage should correlate with a depression in high-ranked resources. In contrast, if the diverse remains are a product of children, we would expect a more constant frequency of lower ranked prey types relative to more profitable prey.

CONCLUSION

Our study of Meriam children suggests that it is not the case that differences between adult and child behavior will, in and of themselves, necessarily indicate attempts by children to acquire the knowledge and skills of adults. Age-linked differences in foraging may often be more

strongly linked to differences in foragers' physiological constraints than differences in goals (leaning vs efficiency). Meriam children are efficient shellfishers relative to their size and strength constraints. They encounter high-ranked resources at a lower rate than do adults and consequently choose to exploit a wider array of prey types. Moreover, because they are more efficient at handling some resources than others, relative to adults they are less likely to field process the less profitable resources they exploit. This, in turn creates patterning in the archaeological record that mimics what we would expect from an "intensifying" coastal economy.

But this observation is not an argument to suggest that Meriam children are necessarily an analog for understanding age-linked foraging differences in the past. Rather, it suggests that a hypothesis that predicts differences between the behavior of adults and children may be heuristically valuable for understanding variability in past subsistence. The degree to which children provision themselves and others is the result of the interaction of local ecology and parental investment/socialization strategies (Blurton Jones 1993; Blurton Jones et al. 1994a, 1994b). But if children *are* active in a subsistence economy, we would expect their prey choice to often include a wider array of resources within a given patch, with resources that may often be more visible archaeologically. This could vary independent of parental investment strategies and the socialization of children. As a result, children may often exaggerate proportions of low-ranked prey delivered whole to a residence. While the archaeological results of this may not be predicted by the encounter-contingent prey choice model, it is consistent with a hypothesis that considers differences in the constraints on foraging when the goal is to maximize *delivery rate* rather than acquisition rate.

Would predictable differences between adults and children be discernable in depositional features? No doubt, teasing apart the effects of children and the archaeological noise of numerous other site formation processes will be very difficult. But doing so is not inherently more difficult than recognizing and explaining any aspect of material-producing behavior. To further this line of investigation, we are currently analyzing the remains of several shell middens from the Meriam Islands excavated in 1998 (Carter et al. 2001; Bird and Richardson 2000). If the goal of archaeology is to understand variability in human behavior relative to the material patterns it creates, and if children are likely to differentially affect these patterns, then paying close attention to factors that shape age-linked differences in foraging will be important for more testable explanations of human variability through time.

ACKNOWLEDGMENTS

NOTES

[1] *Tridacna* spp. includes specimens from two species, *Tridacna maxima* and *Tridacna squamosa.*

[2] All means in text are given with standard deviations.

[3] This is well beyond the predicted field processing threshold of the tridacnids regardless of walking speed, but not beyond the children's threshold for *Lambis.*

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