Child and Adolescent Foraging: New Directions in Evolutionary Research

Version submitted as an Issue Essay to *Evolutionary Anthropology*

by:

Ilaria Pretelli[1,2], Alyssa N. Crittenden[3], Edmond Dounias[4], Sagan Friant[5], Jeremy Koster[2], Karen L. Kramer[6], Shani M. Mangola[7, 8], Almudena Mari Saez[9], Sheina Lew-Levy[10]

[1] Institute for Advanced Study in Toulouse

[2] Department of Human Behavior, Ecology, and Culture; Max Planck Institute for Evolutionary Anthropology

[3]University of Nevada, Las Vegas

[4]CEFE, Univ Montpellier, CNRS, EPHE, IRD, Montpellier, France

[5] Department of Anthropology; The Pennsylvania State University

[6] Department of Anthropology, University of Utah

[7] The Law School of Tanzania, Dar es Salaam, Tanzania

[8] Olanakwe Community Fund, Mang'ola, Tanzania

[9] TransVHIMI unit, French National Institute for Sustainable Development, IRD, Montpellier, France

[10]Department of Psychology, Durham University

Abstract:

Young children and adolescents in subsistence societies forage for a wide range of resources. They often target child-specific foods, they can be very successful foragers, and they share their produce widely within and outside of their nuclear family. At the same time, while foraging they face risky situations and are exposed to diseases that can influence their immune development. However, children's foraging has largely been explained in the light of their future (adult) behavior. Here, we reinterpret findings from human behavioral ecology, evolutionary medicine and cultural evolution to center foraging children's contributions to life history evolution, community resilience and immune development. We highlight the need to foreground immediate alongside delayed benefits and costs of foraging, including inclusive fitness benefits, when discussing children's food production from an evolutionary perspective. We conclude by recommending that researchers carefully consider children's social and ecological context, develop cross-cultural perspectives, and incorporate children's foraging into Indigenous sovereignty discourse.

Author biographies:

Ilaria Pretelli is a Research Fellow at IAST in Toulouse, France. She is an evolutionary anthropologist, interested in the evolution of human life history, with a focus on the emergence of childhood, learning, and cooperative breeding. She conducted field studies in an agricultural village on the Island of Pemba, Tanzania. ilaria.pretelli@iast.fr

Alyssa Crittenden is Professor of Anthropology, the Vice Provost for Graduate Education and the Dean of the Graduate College at University of Nevada in Las Vegas, USA. She is an interdisciplinary scholar with expertise in anthropology and human biology. Her research explores the relationship between behavior, reproduction, and the environment (ecological, political, and social) with an emphasis on nutrition and maternal and infant health & wellbeing. She has worked with Hadza communities since 2004. alyssa.crittenden@unlv.edu

Edmond Dounias is Research Director at the Institute of Research for Development (IRD) in Montpellier, France. He is an ethnobiologist working with tropical rainforest dependent peoples, with particular interest in the biocultural interactions between forest dwellers and tropical forests in a context of drastic change, with a focus on formerly nomadic hunter-gatherers in Africa and South-East Asia. edmond.dounias@ird.fr

Sagan Friant is an Assistant Professor in the Department of Anthropology and member of the Ecology Institute & Center for Infectious Disease Dynamics at The Pennsylvania State University, USA. She is an integrative anthropologist studying the health consequences of human-animal-environment interactions, with 15 years of work in Nigeria. She is the founder and Director of the Cross River Ecology and Health Project and also led several additional projects focused on zoonotic spillover. Through research and related programs she aims to identify and implement solutions that provide win-win for food, environmental, and global health security. sagan.friant@psu.edu

Jeremy Koster is Program Director at National Science Foundation (NSF) and an external faculty member at the Max Planck Institute for Evolutionary Anthropology. His interdisciplinary interests include conservation biology, behavioral ecology, social network analysis, canine science, and multiple membership models. He is the co-director of the ENDOW project, a global collaboration that examines the social determinants of wealth inequality in human communities. An advocate for open science, Koster's work combines multilevel modeling, longitudinal fieldwork in Nicaragua, and cross-cultural comparisons. jeremy_koster@eva.mpg.de

Karen Kramer is Professor of Anthropology at the University of Utah, Salt Lake City, USA. Her research interests span behavioral ecology, demography, comparative life history and reproductive ecology, the evolution of juvenility, cooperative breeding, intergenerational transfers and the interaction between economic and demographic transitions. Drawing from research carried out in three field sites with small-scale horticultural and hunter-gatherer societies, she addresses questions of life history, cooperative breeding, human juvenility and intergenerational transfers. karen.kramer@anthro.utah.edu

Shani Msafiri Mangola is Hadzabe and Co-founder and Co-director of Olanakwe Community Fund. He obtained a Law degree-TUMa and IPLP Masters from the University of Arizona, Tucson. He combines the practice of Law in Dar es Salaam, Tanzania, with aid and developmental work for the Olanakwe Community Fund. shani.mangola@olanakwe.org
Almudena Mari Saez is a Researcher and Junior Chair Professor at the Institute of Research for Development (IRD) in Montpellier, France. Her interests focus on the sociocultural and ecological factors leading to the emergence of zoonotic diseases, and on the dynamics and responses to epidemics. She carried out research combining theoretical and methodological tools of anthropology with those of other disciplines concerning the conditions for the emergence of diseases in and Democratic Republic of Congo. almudena.marisaez@ird.fr
Sheina Lew-Levy is Assistant Professor in the Department of Psychology at Durham University, U.K.. She uses methods from anthropology and psychology to conduct research in hunter-gatherer societies, with the goal of understanding the cultural diversity in, and evolution of, social learning in childhood. She co-founded and co-directs Forager Child Studies, an interdisciplinary research team that conducts cross-cultural reviews and secondary data analysis on the pasts, presents, and futures of forager children's learning. Since 2016, she has worked with egalitarian BaYaka foragers and their farmer neighbors in the Congo Basin. sheina.lew-levy@durham.ac.uk

Acknowledgement: This paper is based on a roundtable “Children’s foraging in a changing world” at the American Anthropological Association annual meeting in 2021, held online and in Baltimore. We thank the communities with whom we work for inspiring many of these ideas, including BaYaka, Hadza, Maya, Mayangna, Mkpot, Mvae, Pumé and the children of Pemba Island.

Author contributions: IP and SLL conceived of the manuscript. All authors wrote the manuscript. IP edited the manuscript with help from SLL.

Conflict of Interest: The authors declare no conflict of interest.

Data sharing statement: Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Introduction

In this paper, we draw on our collective expertise in human life history theory, cultural evolution, evolutionary medicine, and applied participatory research to outline new and underexplored avenues for future inquiry regarding the ontogeny and evolutionary implications of child and adolescent foraging. Research aimed at understanding the evolution of human subsistence has overwhelmingly conceived of childhood as an extended period for learning, and by extension, a life history phase shaped by selective pressures encountered in adulthood (e.g. Kaplan et al., 2000). Yet, evolutionary theory predicts that child and adolescent foraging should not only confer delayed adaptive benefits, but immediate ones as well. First, because of their pre-reproductive status, the force of natural selection is expected to be stronger for traits that help children and adolescents reach maturity than for traits that increase fertility (Frankenhuis & Amir, 2022; Hamilton, 1966). Second, the benefits of achieving high adult levels of foraging proficiency is unlikely to come at the cost of adverse behaviors in childhood (i.e., temporal discounting, Villmoare et al., 2023). Together, these perspectives compel us to consider child and adolescent foraging–not only *how much* they collect, but also *what* they target, and with *whom* they share–as ontogenetic adaptations which confer immediate adaptive benefit (Bjorklund & Pellegrini, 2000). To do so, we first summarize main findings from previous research regarding juvenile foraging participation and production. Then, we reinterpret these findings to raise three distinct issues for future evolutionary work: children's contributions to human life history evolution, community resilience, and finally pathogen transmission and immune development. We conclude by recommending that researchers carefully consider children's social and ecological context when characterizing individual immediate and inclusive fitness benefits and costs. We also suggest that children's foraging has implications for Indigenous sovereignty, and for predictive modeling of community resilience and human adaptation to climate change.

Juvenile foraging participation

Cross-cultural studies suggest that in subsistence communities, juveniles are subsidized until their mid- to late-teens (e.g. Kaplan, 1996; Kramer, 2005). Further, foraging returns overall increase with age, with proficiency at the most complex tasks (tuber digging, large game hunting) peaking in adulthood (Gurven et al., 2006; Koster et al., 2020; Pretelli et al., 2022; Walker et al., 2002). These findings have been interpreted as suggesting that childhood is devoted to acquiring adult subsistence skills. Much less research has focused on how child and adolescent foraging is adapted to immediate environmental, physical, cognitive, and social opportunities and constraints (see Blurton Jones et al., 1989; Bock, 2002; Lew-Levy et al., 2022 for exceptions). For example, children among the Australian Martu and Mikea in Madagascar target lizards and tuber species that are appropriate for their smaller size, lesser strength, and slower walking speed (Bird & Bliege Bird, 2005; Tucker & Young, 2005). In some societies, such as the Tanzanian Hadza, children aged three to twelve years spend between five (girls) and six and a half (boys) hours a day foraging (Hawkes et al., 1997), and they often produce a surplus of some resources, such as baobab and fig fruit (Crittenden, 2016; Froehle et al., 2019). Even in societies where children's subsistence contribution is notably low, such as among the Kalahari !Kung Sanand the Venezuelan Savannah Pumé, children spend between one to two hours per day foraging (Draper & Cashdan, 1988; Kramer & Greaves, 2011). Even limited foraging may supplement children's own diets, and that of their families.

Beyond self-provisioning, children and adolescents derive a variety of other immediate benefits from foraging. They learn through play, participation, teaching, and experimentation with adults and peers during foraging excursions (Bock & Johnson, 2004; Boyette, 2016; Fouts et al., 2016; Hewlett et al., 2011; Kline et al., 2013; Kramer, 2021; Lew-Levy et al., 2017). They can also acquire social status as successful, albeit young, foragers (Gurven & von Rueden, 2006). Yet, foraging may also carry immediate costs: children risk injury, are exposed to diseases, and expend time and energy which could be invested in somatic growth or social capital. For example, Savannah Pumé girls invest the energy they save from reduced activity levels into somatic growth (Kramer & Greaves, 2011). In order to correctly assess the evolutionary drivers of child and adolescent foraging, in this paper we broaden the spectrum with regards to defining the immediate costs and benefits associated with this activity, in order to help correctly estimate the (inclusive) fitness benefits that children derive from foraging.

Caption Figure 1: A - Mikea child in Madagascar digging for tubers. Courtesy of Bram Tucker. B - Striped grass mouse or zebra mouse (*Lemniscomys striatus*) hunted by Bateke children in the forest-savannah edge using small nets set up on the ground, in Bolobo territory, Mai Ndombe province, Western DRC. Courtesy of Romain Duda. C - Building traps for blue duikers (*Philantomba monticola pembae*) in Pemba, Zanzibar. Ilaria Pretelli.D - Malaysian Batek children line-fishing. Courtesy of Kirk Endicott and Vivek Venkataraman.

Human life history evolution

Most evolutionary explanations for the emergence of modern human life history focus on downward transfers of resources from reproductive or post-reproductive adults to children

(Hawkes et al., 1998; Kaplan et al., 2000). For example, the Embodied Capital Model (Kaplan et al., 2000) outlines how our species' reliance on technologically-assisted hunting and gathering favored long childhoods as a protracted and dedicated period for learning these complex foraging skills. Support for this model emphasizes that adults, particularly men, overproduce food that is transferred to children. In this section, we argue that these models overlook the significant contributions that children make to childcare and resource production, and we chart a path forward for incorporating these observations into human life history research.

While provisioning weaned children is a defining feature of human evolution, an equally derived trait in the hominin lineage is the sharing of resources and labor by children with their mothers, siblings, and others. In subsistence societies, children participate in economic tasks long before they achieve adult return rates (Blurton Jones et al., 1989, 1997; Draper & Cashdan, 1988; Hawkes et al., 1995; Kramer, 2021; Kramer & Greaves, 2011; Lee, 1979). In hunter-gatherer societies, children commonly forage for fruit, berries, shellfish, insects, small game, birds, and reptiles (Figure 1), which may contribute substantially to their own calorie intake, and to that of others (Bird & Bliege Bird, 2005; Crittenden, 2016). A wealth of ethnographic data also report that children in subsistence societies provide much of the alloparental care to infants and younger children (e.g. Crittenden & Marlowe, 2008; Jang et al., 2022; Kramer & Veile, 2018; Page et al., 2021; Weisner & Gallimore, 1977).

An additional explanation for the evolution of childhood is the Pooled Energy Model (Kramer & Ellison, 2010), which can help to explain the constellation of human adult life history traits (short birth intervals, rapid reproduction, high fertility) while accounting for children's productive activities. Within this model, both children and adults draw from and contribute to pooled energy, such that activity budgets are linked across individuals within reproductive units (e.g., families). As a result, the calories that an individual needs to survive and grow as a child, and reproduce as an adult, are not bound by her/his capacity to produce that energy. If a juvenile contributes to the energy pool now, and cooperates to help support her/himself, then s/he receives an immediate fitness benefit rather than having to delay until fully grown. In other words, children can make the best of growing slowly by leveraging their nonreproductive status into a higher reproductive potential for their mothers and, via their siblings, indirectly for themselves (Kramer, 2009; Kramer & Russell, 2014; Reiches et al., 2009). This time-discounting advantage of contributing to the energy pool may be important in ancestral and contemporary environments where mortality is high, where as many as 35% of children may not live long enough to reproduce, but benefit through indirect reproductive effort (Kramer & Ellison, 2010).

Community resilience

While previous research has focused on what children *do not* specialize in (i.e., difficult-to-collect resources such as large game or deep tubers), in this section we focus on what children *do* specialize in: fruit, rodents, shallow tubers, and especially, perching and other small birds. We argue that children's foraging helps to maintain knowledge practices which fall outside of everyday use. We suggest that such knowledge may be called upon to help buffer communities against food insecurity during periods of resource scarcity (Dounias & Aumeeruddy-Thomas, 2017).

Much of children's foraging occurs in the context of play (Crittenden, 2016), and as a result, collected food is not always consumed. Among Mikea, children specialize in the collection of *ovy* tubers, which are smaller and shallower than those usually collected by adults (Tucker & Young, 2005, see figure 1, panel A). In one instance, children participated in a food fight which destroyed several kilograms of *ovy*. Tucker and Young (2005, p. 168) conclude that rather than doing so purely to produce food, "children forage for the physical and mental challenge, and because it is an enjoyable social activity". Play, in this context, can be interpreted as an adaptive feature of childhood evolution, as it allows for explorative cognitive patterns that increase novel solutions for behavioral problems, in a period of life when the costs of failure are mitigated by adult provisioning (Gopnik, 2020). Exploration and specialization are highlighted by Gallois and colleagues (2017), who, during a free-listing task which asked participants to name all the species they knew, observed that Cameroonian Baka children listed birds, mice, fish, mushrooms, caterpillars, and fruit species that adults never did. This distinct knowledge was intimately related to child-only hunting and collecting strategies, which resulted in distinct ecological knowledge (see also Bird & Bliege Bird, 2005; Porcher et al., 2023). As one adult respondent noted: "Children have their own knowledge about mice. They are always inventing new names!" (Gallois et al., 2017, p. 73).

Of note is children's special foraging relationship to perching and other small birds. For example, Crittenden (2016) describes the production of 'sticky traps' which are used by Tanzanian Hadza children to collect weaver birds. While these are sometimes eaten, they are also threaded into necklaces, an ultimate example of children 'playing with their food'. Small birds are also often the target of boys' bow-and-arrow hunting around camp (Crittenden, 2016). Baka and Congolese BaYaka children regularly collect wild rubber and clay to produce slingshots and pellets, which they use to hunt songbirds (Gallois et al., 2017; Lew-Levy & Boyette, forthcoming). While adults do hunt larger game birds (e.g. Alvard, 1993), small bird hunting is not usually practiced by adults. This is because capturing small birds is time consuming and rarely yields a significant amount of food.

Further, in the Congo Basin, small birds are often considered intermediaries between humans and the supernatural world because of their capacity of flight and song, and thus, are usually prohibited food items for adults (Terashima, 2007). Yet, children in this region are not usually subject to these same food taboos. As a result, children tend to be custodians of bird-related knowledge. Considering that birds act as ecological indicators for other species, including elephants, pangolins, snakes, duikers, bees, and culturally-significant plants (e.g. Ichikawa, 1998; van der Wal et al., 2022), children's knowledge of perching and other small birds may not only facilitate their own attempts to collect them, but likely has direct implications for ecosystem tracking more generally.

Children's foraging niche specialization gains particular relevance during periods of food shortages, when children's unconstrained food collection easily transitions to exploitation. In the Logone region of Northern Cameroon, for example, a third of the resources consumed by children during periods of resource scarcity are self-provisioned snacks (De Garine, 1993). Crittenden and colleagues (2013) similarly highlight the case of two Hadza children, six and ten, who collected 7,000 and 10,000 kcals, respectively, of figs, reflecting a unique case in which their parents were unable to routinely provision their household. Children's foraging success during episodes of resource scarcity likely reflects two factors. First, children tend to target fallback foods, i.e., "abundant foods of relatively low quality that are used during periods of low overall food availability" (Marshall et al., 2009, p. 604). Second, children tend to collect resources in zones that adults don't exploit, including rats and squirrels which live in settlements or in gardens (Dounias, 2016). Children not only collect food for themselves, but also share these resources within the peer group (Boyette, 2019; Crittenden, 2016; Crittenden & Zes, 2015). Further, in some forager communities from the Congo Basin, such as among the Kola of Southern Cameroon, children and elders are not subject to food taboos due to their pre- and post-reproductive status. As a result, elders receive prey from active hunters that reproductive adults are not allowed to eat, and children frequently join their elders for the consumption of this bushmeat (Dounias, 1993). But, children *also* share their own foraging returns with elders. This highlights the possibility that intergenerational relationships are not solely unidirectional (cf. Hawkes et al., 1998), with grandparents provisioning grandchildren, but bidirectional, with knowledge and resources being mutually exchanged.

In summary, while children's food collection is playful in times of resource plenty, in this section we have argued that it can significantly contribute to food security for themselves, peers, and in some cases, elders. Together, this research suggests that we must move beyond snapshots of food collecting, and towards longitudinal research which tracks children's foraging in the context of fluctuating seasonal variation in resources and during rarer periods of major resource shortfall.

Pathogen transmission & immune development

Direct immediate costs can result from foraging, as trapping and hunting exposes hunters (women, men, children) to animal body fluids, a source of zoonotic diseases, through bites, manipulation, transport, and processing (Bonwitt et al., 2017; Douno et al., 2021). As outlined in the previous section, children may specialize in hunting small and ecologically resilient animals. More so than big game, such small prey may be reservoirs of zoonotic disease, thus possibly triggering pathogen transmission (Baize et al., 2014; Marí Saéz et al., 2015; Nolen et al., 2015). In this section, we argue that children's foraging has important implications for zoonotic disease transmission, and in turn, immune development.

The species children tend to hunt are often reservoirs for infectious disease. Descriptions of children's prey are rampant throughout the literature; setting traps for rats in the bush is described as "boy" activities (Bonwitt et al., 2016), small animals are repeatedly referred to as "children's meat" (Douno et al., 2021; Friant et al., 2015; Gallois et al., 2017, figure 1, panel B), and increased consumption of smaller animals (e.g., rodents and small primates) is reported for children in rural settings (van Vliet et al., 2015). Children also tend to rely on a diversity of methods for catching small animals, such as smaller traps, digging burrows, catapults, poison, dogs, fire ant hill/bush, nets, and sticks (Bird & Bliege Bird, 2002; Gurven et al., 2006; Kawabe, 1983, Pretelli, 2023, see figure 1, panel C). While in southern Sierra Leone the smell of insectivorous bats precludes them from consumption, children will still hunt them and use them as playthings (Bonwitt et al., 2017). In areas where Lassa fever, a viral illness commonly transmitted by rats, is endemic, children bring home hunted prey and, prior to butchering, play with the dead animal, often joined by younger siblings (Douno et al., 2021). When baby animals are caught, it is sometimes the responsibility of children to rear them to adulthood (Bonwitt et al., 2017; Lew-Levy & Boyette, forthcoming), increasing exposure to highly stressed animals that may have increased viral shedding. As recognized companions, protectors, and hunting partners (Duda et al., 2017; Goodman et al., 1985; Koster & Noss, 2014), dogs accompanying children may increase multi-species contact, thus potentially representing a complex pathway for virus transmission (Haun et al., 2019; Milstein et al., 2020; Seang et al., 2022). Zootherapy treatments for children's specific illnesses, such as use of extracts or mixtures made from animal parts and by-products as enemas to treat weakness or stomach pain in Cross River State, Nigeria, provide additional exposure pathways (Friant et al., 2022). While in some settings adults may report not wanting their children to hunt, considering it a low-merit livelihood (Friant et al., 2015), for children, hunting is a moment of freedom without supervision from adults and high risk behaviors may thus be done in secret (Bonwitt et al., 2016, 2017; Douno et al., 2021). For example, in Lassa fever endemic regions, children were more ready to admit eating town and bush rats when interviewed in the absence of an adult (Bonwitt et al., 2016).

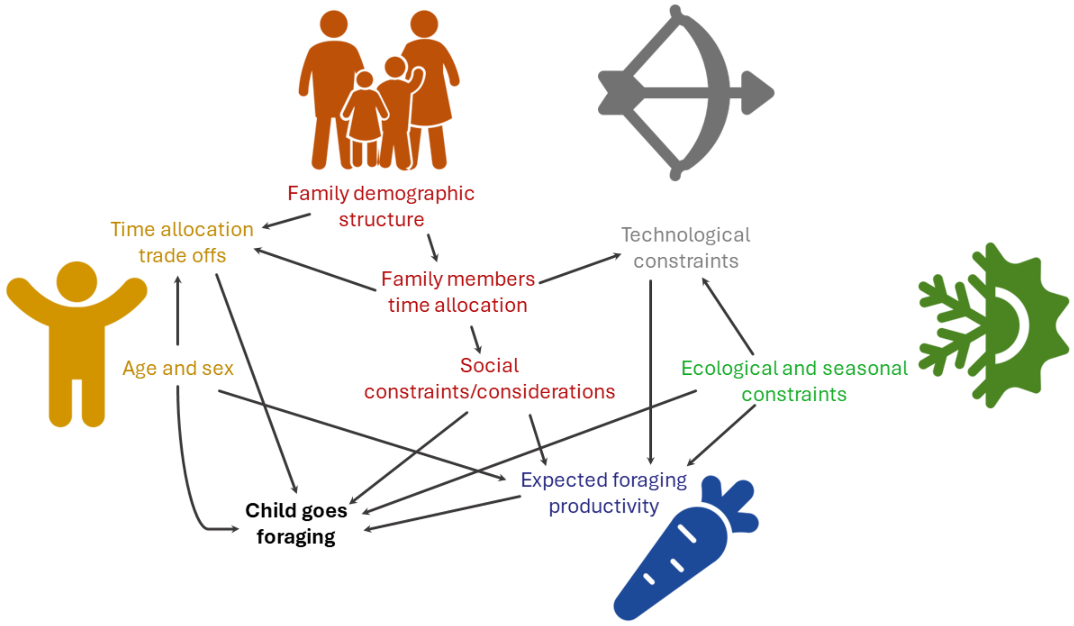
Despite their participation in hunting, children are usually left out of outbreak investigations of emergent virus spillovers (Marí Saéz et al., 2015). Yet, data from case investigations in hospitals reported children with Ebola in Democratic Republic of the Congo (Heymann et al., 1980) and Uganda (Shoemaker et al., 2012). Studies of Mpox, a zoonotic disease caused by a virus of the same family as smallpox, suggest that younger individuals, and specifically children, play an important role in introducing the animal host to communities (Duda et al., 2023; Nolen et al., 2015), for example, through exposure to the virus while interacting with squirrels and mice through playing, dismembering, eating. In the case of Lassa fever, it has not been possible to correlate infection with activity and age, but antibodies against the virus have been detected in children of rodent hunting age (Douno et al., 2021). In light of the fact that contact rates may likely increase as human-dominated ecosystems increase small mammalian host diversity (Gibb et al., 2020), future research should more explicitly explore the role of children's foraging in zoonotic disease emergence.

Infectious disease exposures through hunting practices may also play a key role in immune development for children and communities, underwriting a set of hypotheses for the role of hunting in human health. For example, Lassa virus infection can range from asymptomatic to acute hemorrhagic fever. Variation in the severity of illness may be due selection of genes associated with immunity (Andersen et al., 2012). The disease's antiquity and continual exposure to the rodent reservoir suggest Lassa infection was an important selective pressure. Repeated exposure to sublethal variants of the virus during childhood or high case numbers and fatality rates in children may help to explain variation in disease outcomes in adults. Behavioral research shows that children are in consistent contact with the rodent reservoir of Lassa fever through hunting (Bonwitt et al., 2016; Douno et al., 2021) and seroprevalence studies of Lassa virus show that five-year-old children already have antibodies to this disease (Jankhöfer et al., 2019). However, it is unclear whether these were acquired via hunting or in domestic settings, or how long these antibodies last. Future research should explore the role of zoonotic diseases as selection pressures in hunting populations, and the role of children's hunting, and foraging more generally, in immune priming and development, especially in the context of zoonotic disease.

Conclusion

In this paper, we foregrounded lesser explored immediate benefits and costs of child and adolescent foraging (Table 1). Specifically, we have highlighted that juvenile foraging can support the acquisition of specialized knowledge and skill, contribute to self-provisioning, and may affect immune development. Juvenile foraging may also be a key asset to communities through their cooperative activities, knowledge stewardship, and resource sharing during periods of scarcity. Finally, we have argued that children's foraging may bring them into contact with zoonotic diseases, thus reflecting the potential severe risk that such food production entails. These considerations lead us to make three recommendations regarding evolutionary research on child and adolescent foraging.

First, while child and adolescent foraging is usually studied at the individual-level, foraging typically occurs in a social context. Children have heterogeneous opportunities to accompany adults and peers on foraging trips, and these opportunities are contingent not only on the benefits and costs to the children but also to potential foraging partners (Koster et al., 2013). Incentives for forming foraging groups are often asymmetric among individuals (Smith, 1985), and interests of children do not always align with those of other potential members of foraging parties. Moreover, opportunity costs associated with foraging impact children, their families, and their foraging partners, depending on what else a child could do instead of foraging, who benefits from foraging or from alternative activities, who else might be going foraging and so on, as well as on social benefits associated with foraging, such as status. While we have a reasonably clear understanding of the processes determining foraging success *during* foraging (optimal foraging theory, individual-level traits; e.g. Bird & Bliege Bird 2005), the mechanisms influencing the decision *to go* foraging are much less clear and depend on a plethora of interconnected factors (see Figure 2 for a conceptual summary). In line with the pooled energy budget model, a holistic approach that places children's behaviors in the framework of their families and communities is needed. This is especially relevant in riskier ecologies, where the presence of adults may mitigate against environmental hazards, thus maximizing children's immediate individual (e.g., self-provisioning) and inclusive (e.g., sharing with sibling) benefits while minimizing potential costs (e.g., injury). While it is often difficult to reflect the complexity of foraging in data collection and analytical models, it is important to consider opportunity costs for *both* caregivers *and* children when making inferences concerning the immediate and deferred adaptive value of children foraging activities.



Caption Figure 2: The decision making processes that lead to children engaging in foraging involve many different factors. In addition to risks or norms associated with foraging, which limit the participation of children of a certain age or sex to specific forms of foraging, and ecological and seasonal variability that influence expected foraging returns, a large component is represented by the social and familial situation. When considering whether to forage or not, a child will not only take into account whether the activity is age and sex appropriate, or whether the specific resource is available at a specific point in time, but will also weigh foraging against alternative activities that might yield other kinds of benefits to themselves and their families. These activities in turn depend on the demographic structure of their family (e.g. is there someone else who can fetch water? Is there a baby to care for?) and the tradeoffs of not performing them is a limit to the free time a child can dedicate to foraging. Moreover, according to their own cost-benefit considerations, all the other members of the family will decide how to allocate their time, and this has implications for children's likelihood to forage. For example, a boy might decide to go fishing if a boat is available (i.e. no-one else in the family took it), or he may accompany his father, who can paddle him to a good fishing spot, while it will not be in his immediate interest to expend energy finishing for low yields in a spot nearby. To complicate things, other individuals, external to a child's family, are relevant too; for example a mixed-age playgroup might decide to go foraging only if a skilled individual joins the party, as the trip will likely yield higher returns for everyone (Kandza, 2020). These factors potentially generate a strong selection bias in sampling, as children who decide not to forage are not going to appear in records of foraging returns, which is something researchers need to consider when analyzing foraging returns data. Overall, to characterize the immediate costs and benefits associated with children and adolescent foraging, researchers must expand their frame of inquiry to account for the social and ecological environment in which children grow up, and short- and long-term changes within these environments. Directed Acyclic Graphs such as this one are useful for illustrating the variables that must be measured to obtain unbiased estimates in subsequent statistical modeling (Cinelli et al., 2022).

Second, social context shapes the immediate costs and benefits of children's foraging, and by extension, opportunity costs. Yet, the potential heterogeneity of these social dynamics across study sites complicates research into foraging skill and efficiency among children (e.g. Pretelli et al., 2022). Diversity in foraging behaviors emerges as a consequence of community ecology and culture, while underlying similarities in cognitive and developmental processes generate generalizable patterns. Researchers aiming at studying children's foraging should, on the one hand, identify shared aspects of this behavior, while, on the other hand, define how this responds to environmental and cultural variation. In order to do so, it is key to prioritize careful longitudinal data collection and statistical modeling to discount the possibility that observed effects could be the by-product of unaddressed confounds. These longitudinal studies should ideally be carried out in a representative sample of societies, varying in subsistence strategy and ecological setting, and paired with ethnographic observations in order to contextualize behaviors within their cultural framework.

Table 1: summary of the current state of the art concerning children foraging and future avenues for research.

Topic	Issue raised	Immediate benefit	Future research
Human life history evolution	Children's foraged products are important contributions to family budgets.	Inclusive fitness benefits, brought by increased parental reproductive success and siblings' survival, could have contributed to the evolution of childhood and interbirth intervals in our species.	Better estimate children's contribution to the family budget across cultural and ecological contexts. Summarize evidence on effect on sibling survival and parental reproduction. Model potential effect of childhood food production on human life history evolution.
Community resilience	Children are holders of specialized knowledge, and often are not subject to the same taboos as adults; they thus have access to a range of resources, many of which are fallback foods.	Children's foraging and resource selection could buffer against food shortages.	Explore the mechanisms by which knowledge of children-specific resources is transmitted. Estimate the relevance of children-specific foods on food security.
Pathogen transmission & immune development	Children's foraging activities create entry points for zoonotic diseases.	Selective pressures on survival may be dependent on the development of immunocompetence via foraging.	Understand the development of the immune system in response to high zoonotic pathogen exposure in relation to food production. Investigate the role of children's hunting in multi-species virus transmission.

Finally, it is increasingly noted that evolutionary models must be applied to current and future adaptive problems (Gibson & Lawson, 2015). For many Indigenous communities, foraging is not only a means of subsistence, but of resistance, through which access and relationship with traditional territories are maintained (Coté, 2016), and food collection and preparation techniques are transmitted (Budowle et al., 2019; Hoover, 2017). Our paper shows that children play a central role in community nutrition, at least at key moments of food scarcity. Further, children's playful foraging may generate new knowledge which may help communities adapt to increasingly radical ecological change.

Diets of almost all contemporary foraging communities are undergoing rapid transition due to myriad factors such as globalization, government policies, land grabbing, and climate change, threatening the relationships between Indigenous communities and their local environment (Fernández-Llamazares et al., 2021; Reyes-García et al., 2019; Scheidel et al., 2023). There has been a recent call to study communities in transition, particularly current and formerly foraging communities (Pollom et al., 2020) to better understand the impact of changes on dietary breadth, choice, health, and identity. A changing dietary landscape is necessarily tethered to food sovereignty, defined here as "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems" (Patel, 2009). As children are the future stewards of the planet, their activities must be recognized in discourse surrounding climate change, land rights, and Indigenous sovereignty, and incorporated into models aimed at predicting and bolstering food security (Cidro et al., 2015), and mitigating against zoonotic spillover (Carlson et al., 2022) in the face of climate change.

References

Alvard, M. S. (1993). Testing the "ecologically noble savage" hypothesis: Interspecific prey choice by Piro hunters of Amazonian Peru. *Human Ecology*, *21*, 355–387.

Andersen, K. G., Shylakhter, I., Tabrizi, S., Grossman, S. R., Happi, C. T., & Sabeti, P. C. (2012). Genome-wide scans provide evidence for positive selection of genes implicated in Lassa fever. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1590), 868–877.

Baize, S., Pannetier, D., Oestereich, L., Rieger, T., Koivogui, L., Magassouba, N., Soropogui, B., Sow, M. S., Keïta, S., & De Clerck, H. (2014). Emergence of Zaire Ebola virus disease in Guinea. *New England Journal of Medicine*, *371*(15), 1418–1425.

Bird, D. W., & Bliege Bird, R. (2002). Children on the Reef: Slow Learning or Strategic Foraging? *Human Nature*, *13*(2), 269–297.

Bird, D. W., & Bliege Bird, R. (2005). Mardu children's hunting strategies in the Western Desert, Australia: Foraging and the evolution of human life histories. In *Hunter Gatherer Childhoods* (pp. 129–146). AldineTransaction.

Bjorklund, D. F., & Pellegrini, A. D. (2000). Child development and evolutionary psychology. *Child Development*, *71*(6), 1687–1708.

Blurton Jones, N. G., Hawkes, K., & O'Connell, J. F. (1989). Modelling and measuring the costs of children in two foraging societies. In *Comparative Socioecology, the behavioural ecology of humans and other mammals* (pp. 367–390). Blackwell Scientific Publications.

Blurton Jones, N. G., Hawkes, K., & OConnell, J. F. (1997). Why do Hazda children forage? In *Uniting psychology and biology: Integrative perspectives on human development* (pp. 279–313). American Psychological Association. /buy/1997-09106-029

Bock, J. (2002). Learning, life history, and productivity: Children's lives in the Okavango Delta, Botswana. *Human Nature*, *13*(2), 161–197. https://doi.org/10.1007/s12110-002-1007-4

Bock, J., & Johnson, S. E. (2004). Subsistence ecology and play among the okavango delta peoples of botswana. *Human Nature*, *15*(1), 63–81. https://doi.org/10.1007/s12110-004-1004-x

Bonwitt, J., Kandeh, M., Dawson, M., Ansumana, R., Sahr, F., Kelly, A. H., & Brown, H. (2017). Participation of women and children in hunting activities in Sierra Leone and implications for control of zoonotic infections. *PLoS Neglected Tropical Diseases*, *11*(7), e0005699.

Bonwitt, J., Kelly, A. H., Ansumana, R., Agbla, S., Sahr, F., Saez, A. M., Borchert, M., Kock, R., & Fichet-Calvet, E. (2016). Rat-atouille: A mixed method study to characterize rodent hunting and consumption in the context of Lassa fever. *Ecohealth*, *13*, 234–247.

Boyette, A. H. (2016). Children's Play and Culture Learning in an Egalitarian Foraging Society. *Child Development*, *87*(3), 759–769. https://doi.org/10.1111/cdev.12496

Boyette, A. H. (2019). Autonomy, cognitive development, and the socialisation of cooperation in foragers. *Hunter Gatherer Research*, *3*(3), 475–500. https://doi.org/10.3828/hgr.2017.23

Budowle, R., Arthur, M. L., & Porter, C. M. (2019). Growing intergenerational resilience for Indigenous food sovereignty through home gardening. *Journal of Agriculture, Food Systems, and Community Development*, *9*(B), 145.

Carlson, C. J., Albery, G. F., Merow, C., Trisos, C. H., Zipfel, C. M., Eskew, E. A., Olival, K. J., Ross, N., & Bansal, S. (2022). Climate change increases cross-species viral transmission risk. *Nature*, *607*(7919), Article 7919. https://doi.org/10.1038/s41586-022-04788-w

Cidro, J., Adekunle, B., Peters, E., & Martens, T. (2015). Beyond food security: Understanding access to cultural food for urban Indigenous people in Winnipeg as Indigenous food sovereignty. *Canadian Journal of Urban Research*, *24*(1), 24–43.

Cinelli, C., Forney, A., & Pearl, J. (2022). A Crash Course in Good and Bad Controls. *Sociological Methods & Research*, 004912412210995. https://doi.org/10.1177/00491241221099552

Coté, C. (2016). “Indigenizing” food sovereignty. Revitalizing indigenous food practices and ecological knowledges in Canada and the United States. *Humanities*, *5*(3), 57.

Crittenden, A. N. (2016). Children’s foraging and play among the Hadza. In C. L. Meehan & A. N. Crittenden (Eds.), *Origins and implications of the evolution of childhood* (pp. 155–172). University of New Mexico Press,. https://books.google.it/books?hl=en&lr=&id=pC2yCwAAQBAJ&oi=fnd&pg=PA155&dq=%5B18%5D%09Alyssa+N.+Crittenden.++Children’s+foraging+and+play+among+the+Hadza.++Origins++and++implications+of+the+evolution+of+childhood,&ots=hO56qosGTD&sig=sknTo_OI9P-1yv82FjnX-x

Crittenden, A. N., Conklin-Brittain, N. L., Zes, D. A., Schoeninger, M. J., & Marlowe, F. W. (2013). Juvenile foraging among the Hadza: Implications for human life history. *Evolution and Human Behavior*, *34*(4), 299–304. https://doi.org/10.1016/j.evolhumbehav.2013.04.004

Crittenden, A. N., & Marlowe, F. W. (2008). Allomaternal Care among the Hadza of Tanzania. *Human Nature*, *19*(3), 249–262. https://doi.org/10.1007/s12110-008-9043-3

Crittenden, A. N., & Zes, D. A. (2015). Food Sharing among Hadza Hunter-Gatherer Children. *PLOS ONE*, *10*(7), e0131996. https://doi.org/10.1371/journal.pone.0131996

De Garine, I. (1993). Contribution of wild food resources to the solution of food crises. *Coping with Vulnerability and Criticality. Case Studies on Food-Insecure Groups and Regions*, 339–359.

Dounias, E. (1993). Dynamique et gestion différentielles du système de production à dominante agricole des Mvae du Sud-Cameroun forestier. *Montpellier, Thèse de Doctorat, Université Des Sciences et Techniques Du Languedoc, Miméograph*, *2*.

Dounias, E. (2016). From subsistence to commercial hunting: Technical shift in cynegetic practices among southern Cameroon forest dwellers during the 20th century. *Ecology and Society*, *21*(1).

Dounias, E., & Aumeeruddy-Thomas, Y. (2017). Children's ethnobiological knowledge: An introduction. *AnthropoChildren*. https://doi.org/10.25518/2034-8517.2799

Douno, M., Asampong, E., Magassouba, N., Fichet-Calvet, E., & Almudena, M. S. (2021). Hunting and consumption of rodents by children in the Lassa fever endemic area of Faranah, Guinea. *PLoS Neglected Tropical Diseases*, *15*(3), e0009212.

Draper, P., & Cashdan, E. (1988). Technological Change and Child Behavior among the !Kung. *Ethnology*, *27*(4), 339. https://doi.org/10.2307/3773398

Duda, R., Betoulet, M. J., Besombes, C., Mbrenga, F., Borzykh, Y., Nakoune, E., & Giles-Vernick, T. (2023). *A time of decline: An eco-anthropological and ethnohistorical investigation of mpox in the Central African Republic*. SocArXiv. https://doi.org/10.31235/osf.io/sv89a

Duda, R., Gallois, S., & Reyes-Garcia, V. (2017). Hunting techniques, wildlife offtake and market integration. A perspective from individual variations among the Baka (Cameroon). *African Study Monographs*, *38*(2), 97–118.

Fernández-Llamazares, Á., Lepofsky, D., Lertzman, K., Armstrong, C. G., Brondizio, E. S., Gavin, M. C., Lyver, P. O., Nicholas, G. P., Pascua, P., Reo, N. J., Reyes-García, V., Turner, N. J., Yletyinen, J., Anderson, E. N., Balée, W., Cariño, J., David-Chavez, D. M., Dunn, C. P., Garnett, S. C., … Vaughan, M. B. (2021). Scientists' Warning to Humanity on Threats to Indigenous and Local Knowledge Systems. *Journal of Ethnobiology*, *41*(2), 144–169. https://doi.org/10.2993/0278-0771-41.2.144

Fouts, H. N., Neitzel, C. L., & Bader, L. R. (2016). Work-themed play among young children in foraging and farming communities in Central Africa. *Behaviour*, *153*(6–7), 663–691.

Frankenhuis, W. E., & Amir, D. (2022). What is the expected human childhood? Insights from evolutionary anthropology. *Development and Psychopathology*, *34*(2), 473–497. https://doi.org/10.1017/S0954579421001401

Friant, S., Bonwitt, J., Ayambem, W. A., Ifebueme, N. M., Alobi, A. O., Otukpa, O. M., Bennett, A. J., Shea, C., Rothman, J. M., & Goldberg, T. L. (2022). Zootherapy as a potential pathway for zoonotic spillover: A mixed-methods study of the use of animal products in medicinal and cultural practices in Nigeria. *One Health Outlook*, *4*(1), 1–21.

Friant, S., Paige, S. B., & Goldberg, T. L. (2015). Drivers of bushmeat hunting and perceptions of zoonoses in Nigerian hunting communities. *PLoS Neglected Tropical Diseases*, *9*(5), e0003792.

Froehle, A. W., Kilian Wells, G., Pollom, T. R., Mabulla, A. Z. P., Lew-Levy, S., & Crittenden, A. N. (2019). Physical activity and time budgets of Hadza forager children: Implications for self-provisioning and the ontogeny of the sexual division of labor. *American Journal of Human Biology*, *31*(1). https://doi.org/10.1002/ajhb.23209

Gallois, S., Duda, R., & Reyes-Garcia, V. (2017). Local ecological knowledge among Baka children: A case of "children's culture"? *Journal of Ethnobiology*, *37*(1), 60.

Gibb, R., Redding, D. W., Chin, K. Q., Donnelly, C. A., Blackburn, T. M., Newbold, T., & Jones, K. E. (2020). Zoonotic host diversity increases in human-dominated ecosystems. *Nature*, *584*(7821), 398–402.

Gibson, M. A., & Lawson, D. W. (2015). Applying Evolutionary Anthropology. *Evolutionary Anthropology*, *24*(1), 3–14. https://doi.org/10.1002/evan.21432

Goodman, M. J., Estioko-Griffin, A., Griffin, P. B., & Grove, J. S. (1985). Menarche, pregnancy, birth spacing and menopause among the Agta women foragers of Cagayan Province, Luzon, the Philippines. *Annals of Human Biology*, *12*(2), 169–177. https://doi.org/10.1080/03014468500007661

Gopnik, A. (2020). Childhood as a solution to explore–exploit tensions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *375*(1803), 20190502.

https://doi.org/10.1098/rstb.2019.0502

Gurven, M., Kaplan, H., & Gutierrez, M. (2006). How long does it take to become a proficient hunter? Implications for the evolution of extended development and long life span. *Journal of Human Evolution*, *51*(5), 454–470. https://doi.org/10.1016/j.jhevol.2006.05.003

Gurven, M., & von Rueden, C. (2006). Hunting, social status and biological fitness. *Social Biology*, *53*(1–2), 81–99. https://doi.org/10.1080/19485565.2006.9989118

Hamilton, W. D. (1966). The moulding of senescence by natural selection. *Journal of Theoretical Biology*, *12*(1), 12–45. https://doi.org/10.1016/0022-5193(66)90184-6

Haun, B. K., Kamara, V., Dweh, A. S., Garalde-Machida, K., Forkay, S. S., Takaaze, M., Namekar, M., Wong, T. A. S., Bell-Gam Woto, A. E., & Humphreys, P. (2019). Serological evidence of Ebola virus exposure in dogs from affected communities in Liberia: A preliminary report. *PLoS Neglected Tropical Diseases*, *13*(7), e0007614.

Hawkes, K., O'Connell, J. F., & Blurton Jones, N. (1995). Hadza Children's Foraging: Juvenile Dependency, Social Arrangements, and Mobility among Hunter-Gatherers. *Current Anthropology*, *36*(4), 688–700. https://doi.org/10.1086/204420

Hawkes, K., O'Connell, J. F., Blurton Jones, N., Alvarez, H., & Charnov, E. L. (1998). Grandmothering, menopause, and the evolution of human life histories. *Proceedings of the National Academy of Sciences*, *95*(3), 1336–1339. https://doi.org/10.1073/pnas.95.3.1336

Hawkes, K., O'Connell, J. F., & Blurton Jones, N. G. (1997). Hadza Women's Time Allocation, Offspring Provisioning, and the Evolution of Long Postmenopausal Life Spans. *Current Anthropology*, *38*(4), 551–577. https://doi.org/10.1086/204646

Hewlett, B. S., Fouts, H. N., Boyette, A. H., & Hewlett, B. L. (2011). Social learning among Congo Basin hunter–gatherers. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *366*(1567), 1168–1178. https://doi.org/10.1098/rstb.2010.0373

Heymann, D. L., Weisfeld, J. S., Webb, P. A., Johnson, K. M., Cairns, T., & Berquist, H. (1980). Ebola hemorrhagic fever: Tandala, Zaire, 1977–1978. *Journal of Infectious Diseases*, *142*(3), 372–376.

Hoover, E. (2017). “You can’t say you’re sovereign if you can’t feed yourself”: Defining and enacting food sovereignty in American Indian community gardening. *American Indian Culture and Research Journal*, *41*(3), 31–70.

Ichikawa, M. (1998). The Birds as Indicators of the Invisible World: Ethno-Ornithology of the Mbuti Hunter-Gatherers. *African Study Monographs*, *25*, 105–121. https://doi.org/10.14989/68390

Jang, H., Janmaat, K. R. L., Kandza, V., & Boyette, A. H. (2022). Girls in early childhood increase food returns of nursing women during subsistence activities of the BaYaka in the Republic of Congo. *Proceedings of the Royal Society B: Biological Sciences*, *289*(1987), 20221407. https://doi.org/10.1098/rspb.2022.1407

Jankhöfer, C. H., Saez, M. A., Magassouba, N., Soropogui, B., Camara, A., Günther, S., Gabriel, M., Fichet-Calvet, E., & Borchert, M. (2019). Lassa-seroprevalence and its predictors in Faranah prefecture, Guinea: A cross-sectional survey. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *113*, S111–S111.

Kandza, V. (2020). *Selection of food species by indigenous BaYaka children in the tropical dense forest*. Marien Ngouabi University.

Kaplan, H. (1996). A theory of fertility and parental investment in traditional and modern human societies. *American Journal of Physical Anthropology*, *101*(S23), 91–135. https://doi.org/10.1002/(sici)1096-8644(1996)23+<91::aid-ajpa4>3.0.co;2-c

Kaplan, H., Hill, K., Lancaster, J., & Hurtado, A. M. (2000). A theory of human life history evolution: Diet, intelligence, and longevity. *Evolutionary Anthropology: Issues, News, and*

Reviews, *9*(4), 30.

Kawabe, T. (1983). Development of hunting and fishing skills among boys of the Gidra in lowland Papua New Guinea. *J. Human Ergol.*, *12*, 65–74.

Kline, M. A., Boyd, R., & Henrich, J. (2013). Teaching and the Life History of Cultural Transmission in Fijian Villages. *Human Nature*, *24*(4), 351–374. https://doi.org/10.1007/s12110-013-9180-1

Koster, J., Grote, M. N., & Winterhalder, B. (2013). Effects on household labor of temporary out-migration by male household heads in Nicaragua and Peru: An analysis of spot-check time allocation data using mixed-effects models. *Human Ecology*, *41*, 221–237.

Koster, J., McElreath, R., Hill, K., Yu, D., Shepard, G., Van Vliet, N., Gurven, M., Trumble, B., Bird, R. B., Bird, D., Codding, B., Coad, L., Pacheco-Cobos, L., Winterhalder, B., Lupo, K., Schmitt, D., Sillitoe, P., Franzen, M., Alvard, M., … Ross, C. (2020). The life history of human foraging: Cross-cultural and individual variation. *Science Advances*, *6*(26), 1–8. https://doi.org/10.1126/sciadv.aax9070

Koster, J., & Noss, A. (2014). Hunting dogs and the extraction of wildlife as a resource. *Free-Ranging Dogs and Wildlife Conservation*, 265–285.

Kramer, K. L. (2005). Production and Consumption across the Life Course. In *Maya Children* (pp. 123–136). Harvard University Press.

Kramer, K. L. (2009). Does It Take a Family to Raise a Child? Cooperative Breeding and the Contributions of Maya Siblings, Parents and Older Adults in Raising Children. In G. Bentley & R. Mace (Eds.), *Substitute Parents* (pp. 77–99). Berghahn Books. https://books.google.it/books?hl=en&lr=&id=QppIIXDCnTcC&oi=fnd&pg=PA77&dq=%5B72%5D%09Karen+L.+Kramer.+Does+It+Take+a+Family+to+Raise+a+Child%3F+Cooperative+Breeding+and+the+Contributions+of+Maya+Siblings,+Parents+and+Older+

Adults+in+Raising+Children.+&ots

Kramer, K. L. (2021). Childhood Teaching and Learning among Savanna Pumé Hunter-Gatherers Mismatch between Foraging and Postindustrial Societies. *Human Nature*, *32*(1), 87–114. https://doi.org/10.1007/s12110-021-09392-x

Kramer, K. L., & Ellison, P. T. (2010). Pooled energy budgets: Resituating human energy -allocation trade-offs. *Evolutionary Anthropology*, *19*(4), 136–147. https://doi.org/10.1002/evan.20265

Kramer, K. L., & Greaves, R. D. (2011). Juvenile Subsistence Effort, Activity Levels, and Growth Patterns. *Human Nature*, *22*(3), 303. https://doi.org/10.1007/s12110-011-9122-8

Kramer, K. L., & Russell, A. F. (2014). Kin-selected cooperation without lifetime monogamy: Human insights and animal implications. *Trends in Ecology & Evolution*, *29*(11), 600–606. https://doi.org/10.1016/j.tree.2014.09.001

Kramer, K. L., & Veile, A. (2018). Infant allocare in traditional societies. *Physiology & Behavior*, *193*, 117–126. https://doi.org/10.1016/j.physbeh.2018.02.054

Lee, R. B. (1979). *The! Kung San: Men, women and work in a foraging society*. Cambridge University Press.

Lew-Levy, S., & Boyette, A. H. (n.d.). *Learning to walk in the forest*. Ethos, Revisions requested.

Lew-Levy, S., Reckin, R., Kissler, S. M., Pretelli, I., Boyette, A. H., Crittenden, A. N., Hagen, R., Haas, R., Kramer, K., Koster, J., O'Brien, M. J., Sonoda, K., Surovell, T. A., Stieglitz, J., Tucker, B., Lavi, N., Ellis-Davies, K., & Davis, H. E. (2022). Socioecology shapes child and adolescent time allocation in twelve hunter-gatherer and mixed-subsistence forager societies. *Scientific Reports*, 1–16. https://doi.org/10.1038/s41598-022-12217-1

Lew-Levy, S., Reckin, R., Lavi, N., Cristóbal-Azkarate, J., & Ellis-Davies, K. (2017). How Do Hunter-Gatherer Children Learn Subsistence Skills? *Human Nature*, *28*(4), 367–394.

https://doi.org/10.1007/s12110-017-9302-2

Marí Saéz, A., Weiss, S., Nowak, K., Lapeyre, V., Zimmermann, F., Düx, A., Kühl, H. S., Kaba, M., Regnaut, S., Merkel, K., Sachse, A., Thiesen, U., Villányi, L., Boesch, C., Dabrowski, P. W., Radonić, A., Nitsche, A., Leendertz, S. A. J., Petterson, S., … Leendertz, F. H. (2015). Investigating the zoonotic origin of the West African Ebola epidemic. *EMBO Molecular Medicine*, *7*(1), 17–23. https://doi.org/10.15252/emmm.201404792

Marshall, A. J., Boyko, C. M., Feilen, K. L., Boyko, R. H., & Leighton, M. (2009). Defining fallback foods and assessing their importance in primate ecology and evolution. *American Journal of Physical Anthropology*, *140*(4), 603–614. https://doi.org/10.1002/ajpa.21082

Milstein, M. S., Shaffer, C. A., Suse, P., Marawanaru, E., Gillespie, T. R., Terio, K. A., Wolf, T. M., & Travis, D. A. (2020). An Ethnographic Approach to Characterizing Potential Pathways of Zoonotic Disease Transmission from Wild Meat in Guyana. *EcoHealth*, *17*(4), 424–436. https://doi.org/10.1007/s10393-021-01513-3

Nolen, L. D., Osadebe, L., Katomba, J., Likofata, J., Mukadi, D., Monroe, B., Doty, J., Kalemba, L., Malekani, J., Kabamba, J., Bomponda, P. L., Lokota, J. I., Balilo, M. P., Likafi, T., Lushima, R. S., Tamfum, J.-J. M., Okitolonda, E. W., McCollum, A. M., & Reynolds, M. G. (2015). Introduction of Monkeypox into a Community and Household: Risk Factors and Zoonotic Reservoirs in the Democratic Republic of the Congo. *The American Journal of Tropical Medicine and Hygiene*, *93*(2), 410–415. https://doi.org/10.4269/ajtmh.15-0168

Page, A. E., Emmott, E. H., Dyble, M., Smith, D., Chaudhary, N., Viguier, S., & Migliano, A. B. (2021). Children are important too: Juvenile playgroups and maternal childcare in a foraging population, the Agta. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *376*(1827). https://doi.org/10.1098/rstb.2020.0026

Patel, R. (2009). Food sovereignty. *The Journal of Peasant Studies*, *36*(3), 663–706.

https://doi.org/10.1080/03066150903143079

Pollom, T. R., Herlosky, K. N., Mabulla, I. A., & Crittenden, A. N. (2020). Changes in Juvenile Foraging Behavior among the Hadza of Tanzania during Early Transition to a Mixed-Subsistence Economy. *Human Nature*, *31*(2), 123–140. https://doi.org/10.1007/s12110-020-09364-7

Porcher, V., Li, X., Carrière, S. M., Alvarez-Fernandez, S., Cresson, D., Reyes-García, V., & Gallois, S. (2023). *As proficient as adults: Distribution of children's knowledge of wild edible plants in the arid Mahafaly region, Madagascar*.

Pretelli, I., Ringen, E., & Lew-Levy, S. (2022). Foraging complexity and the evolution of childhood. *Science Advances*, *In press*. https://pure.mpg.de/rest/items/item_3386016/component/file_3386017/content

Reiches, M. W., Ellison, P. T., Lipson, S. F., Sharrock, K. C., Gardiner, E., & Duncan, L. G. (2009). Pooled energy budget and human life history. *American Journal of Human Biology*, *21*(4), 421–429. https://doi.org/10.1002/ajhb.20906

Reyes-García, V., Powell, B., Díaz-Reviriego, I., Fernández-Llamazares, Á., Gallois, S., & Gueze, M. (2019). Dietary transitions among three contemporary hunter-gatherers across the tropics. *Food Security*, *11*(1), 109–122. https://doi.org/10.1007/s12571-018-0882-4

Scheidel, A., Fernández-Llamazares, Á., Bara, A. H., Del Bene, D., David-Chavez, D. M., Fanari, E., Garba, I., Hanaček, K., Liu, J., Martínez-Alier, J., Navas, G., Reyes-García, V., Roy, B., Temper, L., Thiri, M. A., Tran, D., Walter, M., & Whyte, K. P. (2023). Global impacts of extractive and industrial development projects on Indigenous Peoples' lifeways, lands, and rights. *Science Advances*, *9*(23), eade9557. https://doi.org/10.1126/sciadv.ade9557

Seang, S., Burrel, S., Todesco, E., Leducq, V., Monsel, G., Le Pluart, D., Cordevant, C., Pourcher, V., & Palich, R. (2022). Evidence of human-to-dog transmission of monkeypox virus. *The*

Lancet, *400*(10353), 658–659.

Shoemaker, T., MacNeil, A., Balinandi, S., Campbell, S., Wamala, J. F., McMullan, L. K., Downing, R., Lutwama, J., Mbidde, E., & Ströher, U. (2012). Reemerging Sudan ebola virus disease in Uganda, 2011. *Emerging Infectious Diseases*, *18*(9), 1480.

Smith, E. A. (1985). Inuit foraging groups: Some simple models incorporating conflicts of interest, relatedness, and central-place sharing. *Ethology and Sociobiology*, *6*(1), 27–47.

Terashima, H. (2007). The status of birds in the natural world of the Ituri forest hunter-gatherers. *Animal Symbolism: The "Keystone" Animal in Oral Tradition and Interactions between Humans and Nature. IRD, Paris*, 147–162.

Tucker, B., & Young, A. G. (2005). Growing Up Mikea Children's Time Allocation and Tuber Foraging in Southwestern Madagascar. In B. S. Hewlett & M. E. Lamb (Eds.), *Hunter-gatherer childhoods* (pp. 147–171). AldineTransactions.

van der Wal, J. E., Gedi, I. I., & Spottiswoode, C. N. (2022). Awer honey-hunting culture with greater honeyguides in coastal Kenya. *Frontiers in Conservation Science*, *2*, 727479.

van Vliet, N., Nebesse, C., & Nasi, R. (2015). Bushmeat consumption among rural and urban children from Province Orientale, Democratic Republic of Congo. *Oryx*, *49*(1), 165–174. https://doi.org/10.1017/S0030605313000549

Villmoare, B., Klein, D., Lienard, P., & McHale, T. (2023). *The evolutionary origins of temporal discounting: An adaptive peak model shows how time and uncertainty impose constraints on selection for optimal decision-making in a temporal framework.* https://doi.org/10.21203/rs.3.rs-2515272/v1

Walker, R., Hill, K., Kaplan, H., & McMillan, G. (2002). Age-dependency in hunting ability among the Ache of eastern Paraguay. *Journal of Human Evolution*, *42*(6), 639–657. https://doi.org/10.1006/jhev.2001.0541

Weisner, T. S., & Gallimore, R. (1977). My Brother's Keeper: Child and Sibling Caretaking. *Current Anthropology*, *18*(2), 169–190. https://doi.org/10.1086/201883