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Nutrition Transition of Hadza Foragers: Implications for Juvenile Behavior

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NUTRITION TRANSITION OF HADZA FORAGERS: IMPLICATIONS FOR JUVENILE BEHAVIOR

By

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Abstract

The Hadza foragers of Tanzania are undergoing early stages of nutrition transition and an increased level of market integration. Accompanying these shifts is a significant change in diet composition with greater access to maize, wheat, and other domesticated cultigens, even in the most remote bush camps. Despite the rapid rate of nutrition transition, few studies have attempted to quantify the possible effects this transition is having on Hadza diet or foraging behaviors. Here, we attempt to fill this gap in the literature by reporting results of a mixed methods cross-sectional study on juvenile foragers taken from two time points, 2005 and 2017. During the summer of 2017 we conducted detailed interviews and recorded in camp food returns for a sample of young Hadza foragers aged 5-14 years. Comparing our 2017 data to age matched data collected in 2005, our results indicate that juveniles are targeting a smaller variety of wild foods, with noticeable absences of food species that have historically been considered staples in Hadza diet (e.g. honey, tubers, figs). Accompanying these dietary shifts are important behavioral changes, such as a smaller percentage of juveniles residing in camps going out to forage in 2017 compared to 2005. Additionally, semi-structured interview data suggests that maize has become a reliable staple food. However, despite changes in foraging return composition, increased reliance on maize, and a reduction in the overall percentage of children producing foraging returns, we found that some juveniles still remain highly productive foragers in the midst of nutrition transition. These data have important implications for understanding the decisions that foragers make in shifting ecological landscapes, monitoring the health outcomes of Hadza juveniles, and the use and interpretation of data generated from contemporary Hadza research in the 21st century.

Acknowledgments

I would like to begin by thanking the Hadza, who graciously accepted me onto their land and into their homes. Despite being a population continuously swarmed with researchers and tourists, they remained patient with my foolish interests and poor Swahili. The Hadza trusted me with their children, and my only hope is that this (and future) research will help build those children a better future.

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Dedication

This document is dedicated to the brave parents of wayward anthropologists

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Chapter 1

Introduction

The Hadza foragers of Tanzania are a group of semi-nomadic foragers that have historically collected the majority of their diet by hunting animals and gathering wild plants (Marlowe 2010). They occupy a 4000 km^2 region in Northern Tanzania, in a savannah woodland habitat south of the Serengeti. Approximately 150 of the 1000 Hadza still practice hunting and gathering, however, there is increasing access to domesticated cultigens in even the most remote bush camps (Crittenden, 2017). Due to their geographic location and foraging subsistence practices, the Hadza are commonly cited as a close representation of the human environment of evolutionary adaptedness (EEA). The Hadza are of particular interest to evolutionary theorists because they are a small-scale, natural fertility population of hunter-gatherers that forage foods thought to be targeted by our hominin ancestors. While they are certainly not living replicas of Pleistocene foragers, they have historically lived a lifestyle that in some ways aligns with the ecology and social environment in which our ancestors evolved (Marlowe 2010). In the past century the Hadza have been well-researched by ethnographers, and in the past decade they have been popularized in various news and media outlets as the "last hunter-gatherers" on Earth. While Hadza children have not been studied to the same extent as adults, Hadza childhood is well-documented within the ethnographic literature.

Hadza children are raised in a communal setting and often play in large mixed age and mixed sex groups (Crittenden, 2016). Hadza childhood is often characterized as carefree (Konner, 2010) and children report that they have freedom to decide how to spend their day (Wells et al. 2014). Hadza children spend copious amounts of time playing together including singing, dancing, and wrestling (Crittenden, 2016). While Hadza children do spend considerable

amounts of time engaged in play, they also run many errands for adults, provide significant amounts of childcare (Crittenden and Marlowe, 2008), and significantly contribute to the household foraging economy (Crittenden et al., 2013). In areas that have low predator pressure and terrain that is easily navigated, Hadza children spend a considerable amount of time each day collecting food (Blurton Jones et al. 1989; Crittenden et al. 2013). Highly productive foraging juveniles are able to provide food for themselves, as well as other occupants of the camp.

Anecdotal observations by early ethnographers suggested that Hadza juveniles were highly productive (Bleek, 1931; Woodburn, 1968), a finding that has been continually corroborated by recent recordings of naturalistic food returns (Blurton Jones et al., 1994; Crittenden et al., 2013). Most juveniles begin making important contributions to household foraging economy shortly after they are weaned, at age two or three, and long before they are independent around age 18 (Blurton Jones et al. 1989, 2002; Crittenden et al., 2013; Crittenden 2016; Konner, 2016). Children spend a considerable amount of time foraging, and tend to focus on food sources that are easier to target and acquire. Some Hadza juveniles are capable foragers, collecting the majority of their daily caloric needs, and are at times capable of foraging a surplus of calories to help feed others (Crittenden et al., 2013).

Traditionally, young children accompany foraging parties comprised of adult women, or forage independently in mixed-sex groups of children (Blurton Jones et al., 1997). Young foragers tend to focus their collection efforts on fruits, and historically both sexes have spent a considerable amount of time digging tubers until the age of 10 or 12 (Crittenden, 2013; Blurton Jones et al., 1997; Blurton Jones and Marlowe, 2002). During middle and late childhood sex differences become apparent in foraging behaviors, and males begin to spend an increasing amount of time hunting small animals or birds with their bows. As males age, their hunting

activities take them farther from camp and they begin to target medium sized and eventually large mammals or birds. While males (working alone or in small groups) improve their hunting skills, females continue to focus on foraging plant foods and become adept at extracting plant species that are more difficult to acquire. Historically, females are more productive foragers than their male counterparts and yield a greater net caloric return that is brought back to camp (Crittenden et al., 2013), a trend that continues throughout adulthood (Marlowe, 2010).

The Hadza have been gradually shifting away from their hunter-gatherer lifestyle for many years, and towards a mixed-subsistence practice that is less reliant on wild foods. Here, we broadly define these changes in terms of the "nutrition transition" defined by Popkin (2002). This dietary shift is multi-factorial and linked to both resource depletion as well as increased interactions with missionaries, local pastoralists, non-profit organizations, government subsidies, and eco-tour operators. Cultural and environmental impacts that interfere with the Hadza foraging lifestyle have been acknowledged in the ethnographic literature for many years (Marlowe, 2002; Yatsuka, 2015; Blurton Jones 2016). Some anthropologists have long hypothesized that a number of environmental and cultural impacts, especially ethno-tourism, will eventually cause the Hadza to fully abandon their hunter-gatherer lifestyle (Marlowe, 2002).

The number of Hadza actively engaging in a predominately foraging lifestyle has been declining for decades, and some predictions estimate that 15% of Hadza foragers will transition away from their hunter-gatherer lifestyle per year (Marlowe, 2010). When detailed ethnographic data collection among the Hadza began in the 1960s (by James Woodburn), he reported that the majority of the total population of Hadza were still foraging (1968). By 1985 this number had declined significantly, and Nick Blurton-Jones (1992) recorded in his census that around 300 of the Hadza were living a predominately or exclusively hunter-gatherer lifestyle. A comprehensive

census of the Hadza has not been published for many years; however, recent studies estimate that only 150 of the 1000 Hadza are still actively participating in a forager subsistence lifestyle (Crittenden et al., 2017). This evident decline in Hadza foragers is just one sign (of many) that Hadza nutrition transition is no longer a distant eventuality.

The "global nutrition transition" is broadly defined in the scientific literature, but generally refers to a society shifting its dependence away from high-fiber wild foods, and towards a greater reliance on low-fiber starchy agricultural products (Popkin, 2002). This transition towards agriculture is generally associated with an initial increase in malnutrition and famine, but eventually generates a society with food surpluses (Popkin, 2002). This dietary transition coincides with a comparable "epidemiological transition," in which infectious disease and malnutrition eventually recede and are replaced by chronic diseases associated with an urban/industrial lifestyle (Omran, 1971; 2005).

The Hadza, due to a variety of economic and ecological factors, are rapidly undergoing an increasing level of market integration. Accompanying these shifts is a significant change in diet composition with greater access to domesticated cultigens, even in the most remote bush camps. While some studies have alluded to an eventual nutrition transition for many years, few studies have attempted to record the depth or effect transition has had on Hadza health and foraging behavior. Much of the current ethnographic literature, including the literature regarding juvenile behavior, has documented foraging behaviors during a time period when the Hadza had less access to agricultural foods. This study attempts to begin to fill this gap in the literature by revisiting the productivity of Hadza juveniles in a naturalistic setting. While the productivity of Hadza foragers is considered canon in the ethnographic literature, no research has quantified the effects of transition on juvenile foraging behavior.

Here, we report naturalistic foraging returns of Hadza juveniles during the dry season of 2017 and compare to similar data collected in the same region and season in 2005. Additionally, we report interview data regarding juvenile foraging behavior and foraging motivations collected during 2017. Using a mixed methods approach incorporating data from foraging returns, participant observation, and semi-structured interviews, we aim to (1) compare diversity profiles of foods collected in 2005 and 2017; (2) compare foraging returns collected in 2005 and 2017 to determine patterns of collection in terms of kilocalories foraged, and (3) use interview data to determine what is currently motivating children to forage, and whether or not the introduction of maize into camps is influencing foraging productivity.

Chapter 2

Methods

Foraging Returns

The 2017 project was approved by the Office of Research Integrity – Human Subjects at the University of Nevada, Las Vegas. The 2005 project was approved by the Human Research Subjects Institutional Review Board at the University of California, San Diego and the Committee on the Use of Human Subjects at Harvard University. In both studies, informed consent was obtained orally from all the parents of study participants and the participants themselves, as the Hadza are a predominantly non-literate population. All data were collected with the permission of the Tanzanian Commission for Science and Technology (COSTECH).

Methods used to collect and record food return data were the same in 2005 and 2017. During the consent process, research participants were told that the research team was interested in the foods they were bringing back to camp and that the team wanted to weigh the foods that they collected. Participants were reminded every morning that researchers were interested in weighing their foraging returns and were asked to bring any food (animal or plant) that they might collect so that it may be weighed throughout the day. Participants were not incentivized or encouraged to forage in any way and would not receive a gift or payment of any kind upon return to camp. All compensation was given at the end of the study period, regardless of whether or not an individual foraged or returned with food to be weighed. All food was weighed with an electronic hanging spring scale and was always immediately returned to the participant. The current study does not report on any consumption patterns in camp or out of camp.

In 2017, foraging returns were collected by Trevor Pollom in three camps over a five week period. An additional camp was visited during the study period, but has been excluded from analysis because juveniles were often restricted by adults from leaving the camp to travel/forage. All data was collected during the dry season from July-August 2017, for a total of 20 days. Foraging returns were recorded every day that food was brought back to camp; in total juveniles returned to camp with food 11 of the 20 total days. All food brought to camp was measured using a hanging spring scale, and energy estimates were calculated utilizing previously tested and standardized analytical methods for assessing caloric content of wild foods (Crittenden, 2016). In total, 39 participants aged 5-14 years (n_1 = 21 males; n_2 = 18 females) resided in camp during the study period. Of this total, 32 individuals (n_1 = 20 males; n_2 = 12 females) participated in the short semi-structured interviews.

In 2005, foraging returns were collected by Alyssa Crittenden in two camps (*Gangidape* and *Siponga*). Data were collected during late rainy season/early dry season in Gangidape from May 7 to June 11, 2005 (total of 36 days) and in the dry season in Siponga from October 3 to October 25, 2005 (total of 22 days). In total, 31 participants aged 5-14 years (n_1 = 14 males; n_2 = 17 females) resided in camp during the 2005 study period.

Statistical analysis

The software SPSS was used for all statistical analysis. Comparisons were made between the foraging returns of males and females in the 2017 sample to determine if sex significantly affected foraging behavior. Also, comparisons between foraging returns in 2005 and 2017 were performed to determine if there have been statistically significant changes in foraging returns since 2005; for this comparison, same age and sex participants were selected from the 2005 data. We used a Mann-Whitney U test for several comparisons due to our small sample size, and

because these data were not normally distributed. Significance was set at an alpha of .05. We also used a Chi-Square and Exact Fisher's test for comparison of dichotomous variables. Additionally, we investigated the types of foods being returned to camp in order to document the species (of both plants and animals) in order to make descriptive comparisons between types of returns in 2005 and 2017, and also portray basic changes that have occurred in the diet composition and foraging returns of Hadza juveniles.

Interviews

In 2017, research participants completed a short semi-structured interview designed to inform our understanding of possible motivations and cultural pressures that might affect foraging returns (see appendix for complete interview schedule). The research team asked questions pertaining to a variety of topics; here, we only report on data regarding foraging motivations. Participants were interviewed in private away from adults or other children, often outside of camp or within the research team's vehicle. All interviews were conducted in Swahili, the second language of the Hadza, with the assistance of a Swahili speaking Tanzanian research assistant acting as a translator. For their participation, children received small gifts of candy immediately following their interview and later, upon completion of the entirety of research, received gifts of shoes and clothing. All compensation was approved by the Office of Research Integrity – Human Subjects at the University of Nevada, Las Vegas.

We report on the results of the following:

1. While in the bush, does anyone tell you to hunt?

    (If yes) Who tells you to hunt?

    (If no) Why do you decide to forage?

2. If you don’t go (hunting/gathering), will anyone go hungry?

(If yes) Who will go hungry?

Chapter 3

Results

Foraging Returns

A variety of plant and animal species were collected during the 2017 field season, including baobab, berries, birds, and several species of small game. However, there were notable absences in the 2017 food returns that were present in 2005; including honey, figs, legumes, and tubers. Comparing the types of foods being returned to camp in 2005 and 2017 reveals an overall reduction in the variety of plants and animal species currently being targeted by young foragers (Figure 1 and Figure 2).

Figure 1. Kilocalories Collected in 2017

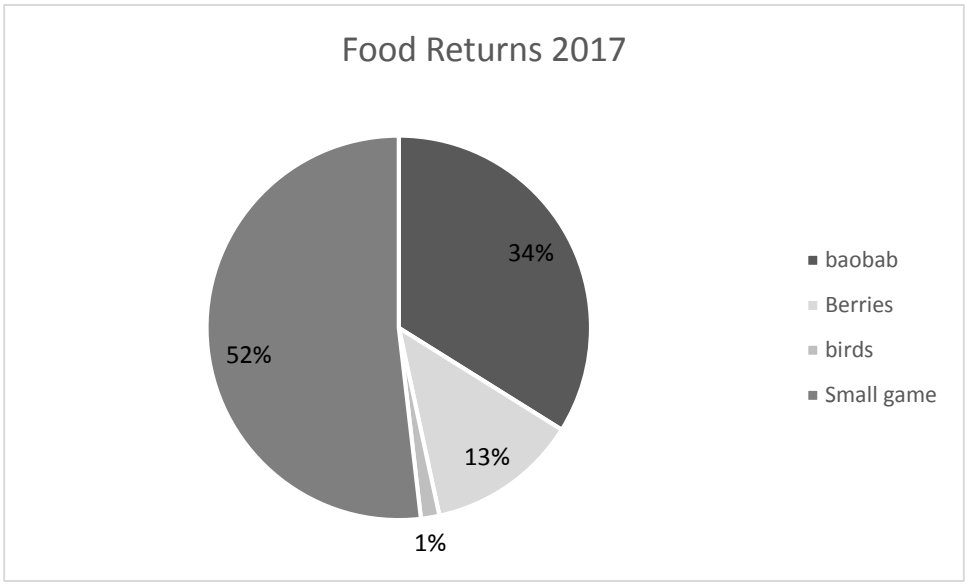
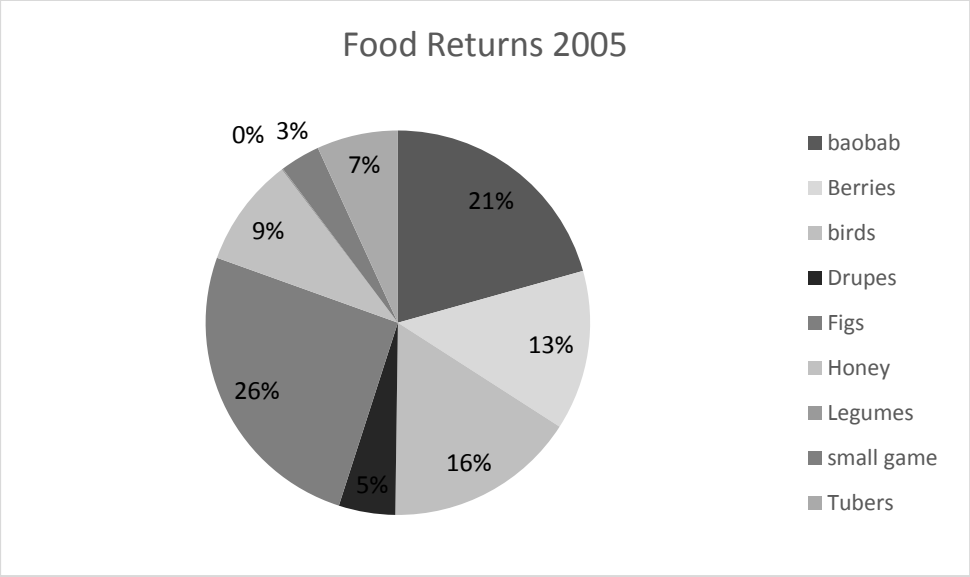


Figure 2. Kilocalories Collected in 2005



Fewer juveniles residing in camp foraged in 2017 as compared to 2005. In 2005, 27 of the 31 study participants ($N_1 = 12$, $N_2 = 15$) returned to camp with foraged food. In 2017, only 21 out of our 39 participants ($N_1 = 15$, $N_2 = 6$) ever returned to camp with foraged food. This change is exemplified among females; in 2017 only 6 out of 18 females participating in the study were documented with any foraging returns, which was significantly less than the 16 female individuals in 2005 (p=.04). While the reduction in female participation is significant, the exact cause is difficult to identify.

Despite fewer female foragers returning to camp with food in 2017, those who did leave camp to forage were slightly more productive, on average, than females in 2005. On days that they foraged, females returned to camp with an average of 690.98 kcals in 2017, compared to an average of 550 kcals in 2005. However, the discrepancies in average foraging returns was not significant (p=.261). Similarly, 15 out of 21 Hadza males that participated in the 2017 study were recorded with foraging returns. In 2017, males returned to camp with an average of 1075.15

kcals on days they foraged, which was higher than the 374.82 kcals recorded in 2005. Despite recording a higher average return rate in 2017, differences in return rates only approached significance ($p = .079$).

Having discovered there were no significant differences when comparing females in 2005 to females in 2017, and similarly males in 2005 to males in 2017, we further utilized a Mann-Whitney U to investigate sex differences within study years. Females in 2005 were compared to males in 2005, and females in 2017 were compared to males in 2017. There were no significant sex differences between females and males in 2005 ($p = .3$), or 2017 ($p = .677$), suggesting that there are not significant sex differences in the kilocalories returned to camp during dry season foraging activities. Although the sex differences in average foraging returns were not considered significant when using a ranked Mann-Whitney U, it is noteworthy that in 2017 males returned to camp with a total combined sum of 37,381 kcals during the study period, while females returned to camp with a total combined sum of only 7,967 kcals. Conversely, in 2005, females were recorded collecting a sum of 170,611 kcals, while males were recorded collecting 86,827. Therefore, only viewing changes in average return rates might be misleading, considering the obvious sex differences when viewing sum returns.

Figure 3. Percentage of Kilocalories Foraged by Males and Females – 2005

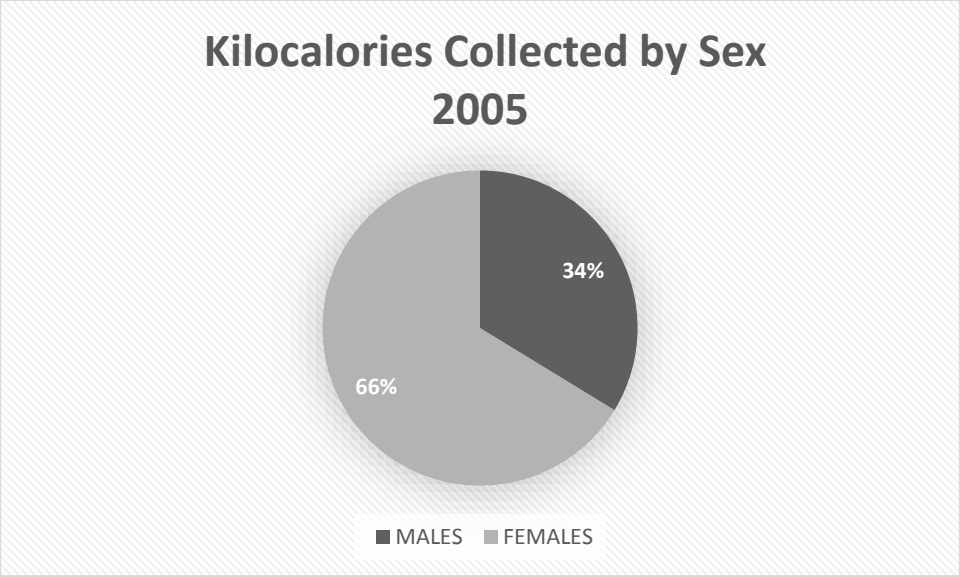
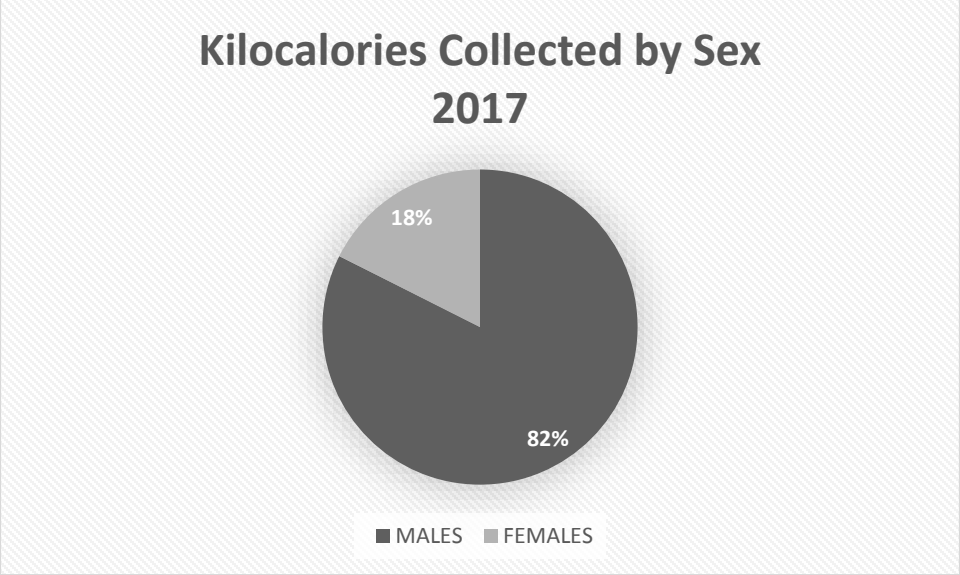


Figure 4. Percentage of Kilocalories Foraged by Males and Females - 2017



Finally, having found no statistically significant differences in the average return rates between females or males in either year, we did a final overall group comparison of foraging

returns between 2005 and 2017. On days that they foraged, juveniles in 2017 foraged an average of 902.6 kcals, compared to an average of 475 kcals in 2005. These findings were statistically significant (p=0.05), implying that on days they foraged, participants in 2017 were more productive than juveniles in 2005.

Table 1. Average Foraging Returns by Year/Sex – reported in Calories

YEAR	SEX	N	AVG FORAGING RETURNS	MEDIAN	STANDARD DEVIATION
2005	MALE	12	374.82	346.32	327.27
2005	FEMALE	16	550.1	419.95	499.56
2017	MALE	16	1075.15	613.5	1226.56
2017	FEMALE	6	690.98	634.48	372.74

Interviews

Interviews were only conducted during the 2017 field season. In total, 32 children participated, 12 females and 20 males aged 6-14 years. Of these participants, 50% stated that someone told them to forage while they were living in the bush - we will refer to these individuals as "encouraged participants". Of the individuals that were encouraged to forage, 100% stated that a family member (sibling, parent, or grandparent) told them to do so. Instructions to forage came predominately from parents, with 87.5% of encouraged participants stating that either their mother or father told them to forage. However, it appears that there is a preference towards mothers pressuring for participation in foraging behavior, as 50% of encouraged participants stated that only their mothers encouraged them to forage – making mothers the most common response to "who tells you to forage?" These data suggest that it is not uncommon for family members to encourage children to forage, as half of juveniles we sampled stated that a family member would tell them to hunt/gather. Evidently this

encouragement to forage always came from a family member, particularly parents and especially mothers. However, there was no correlation between individuals being encouraged to forage, and individuals actually producing any foraging returns according to a Chi-Square Test ($p = .719$).

When asked, "If you don't hunt/gather, will anyone go hungry?" 14 out of 32 participants (44%) responded "yes". In total, 32% of males (7/22) responded yes, while 50% of females (6/12) responded yes. Of the participants that indicated others might go hungry ("concerned participants"), 38% expressed concern for their parents, and 38% indicated concern for children or younger siblings. These results suggest that a large portion (44%) of Hadza juveniles we sampled experience some level of concern regarding food availability. That being said, individuals that expressed hunger concerns were not significantly more likely to produce foraging returns according to a Chi-Square test ($p = .242$). Additionally, a majority of children (18/32) stated that no one would go hungry if they did not forage. Interestingly, one 10 year old participant told the research team that no one would go hungry if there were no foraging returns, because "the women would grind maize."

The question "why do you forage?" was met with mostly confusion from a majority of the participants, many juveniles provided straightforward and general answers such as "to find food" or "just because." However, one older participant (aged 14) clarified by stating, "[we hunt] to find food to eat with our maize flour". Later, this same participant reported to the research team that he had sold his hunting returns in a nearby village so that he could buy maize flour. While the broader significance of the responses from a single Hadza forager should be interpreted with caution, his responses may warrant further consideration.

Ultimately, these interview responses suggest complex social interactions that likely encourage foraging returns among many Hadza juveniles. A significance proportion of the

juveniles sampled appeared to be encouraged to forage, at least in part, by either family or concern for food scarcity. Further, some interview responses contribute to the ongoing discussion regarding Hadza nutrition transition. However, the large percentage of children that verbalized at least moderate concern for food scarcity suggests that foraging activities still play an important part in Hadza culture, even in the midst of nutrition transition that ostensibly buffers food insecurity.

Summary of Results

Our quantitative data suggests that Hadza juveniles are foraging for a smaller variety of plant and animal species in 2017 compared to 2005, with tubers being a noticeable and important absence from the foraging returns. A much lower percentage of children were participating in foraging activities in the year 2017 compared to 2005, and this was especially true for female participants. However, juveniles who were still foraging had greater average return rates when compared to juveniles from 2005. We caution that analyzing average returns could be misleading as they do not account for children not participating in foraging activities. Therefore, it is difficult to determine from these data if there is an overall change in productivity as measured by kcals. Another notable finding is the lack of significant sex differences in foraging behavior in either 2017 or 2005; suggesting that sex has a limited influence on productivity during the dry season, as measured by kcals.

Our interview data suggest that Hadza juveniles receive encouragement to forage from a variety of sources. About half of all juveniles we sampled were encouraged to forage by their immediate family, and of these encouraged participants 50% stated their mothers told them to forage. Additionally, a large percentage of juveniles reported that someone would go hungry if they did not forage and showed particular concern for immediate family members. These

responses suggest motivation to forage comes from a variety of ecological and social pressures. Further, multiple interviews suggested that maize is becoming a consistent and important part of Hadza culture and diet. Despite the inclusion of maize into Hadza diet and behavioral practices, these data suggest that foraging returns continue to provide an important source of food for Hadza camps in the midst of nutrition transition.

Chapter 4

Discussion

Perhaps the most important element of this study, as it pertains to Hadza behavior and eventual health outcomes, is the reduction in variety of plant and animal species being foraged. There were notable absences in the juvenile foraging returns, including several plant species that are considered staples of Hadza diet in the canon of literature on Hadza foraging and diet composition. We interpret the absence of these formerly staple foods as important markers for nutrition transition. Tubers are largely cited as an important Hadza staple food (Blurton Jones and Marlowe, 2002; Marlowe and Berbeque, 2009), and their collection is the cornerstone of some evolutionary arguments (Hawkes et al., 1998), yet not a single juvenile returned to camp with a tuber during the 2017 field season. Notably, the research team neither witnessed the digging of any tubers by adult women, nor did we observe any women carrying digging sticks around camp or out of camp forage during the study period.

Historically, tubers have been available to Hadza foragers throughout all seasons of the year and are targeted as a staple food (Marlowe and Berbesque, 2009). Similarly, figs and honey were entirely absent from the 2017 foraging returns despite playing a pivotal role in the 2005 data. For example, the most productive forager from our 2005 data was a 10 year old girl that targeted mostly figs. It's unclear why Hadza juveniles have stopped targeting some of these notable species in 2017, however, we postulate that it is likely linked to the multi-factorial effects of ethno-tour companies, donations of large quantities of maize from missionary groups, encroachment of local pastoralists, government modernization efforts, researcher saturation, and NGO interventions that have collectively affected both the ability and need for Hadza juveniles

to target some of these species. During the study period, we witnessed ongoing interactions between Hadza foragers and all of these different entities.

Throughout the duration of our study period, adult foragers informed us that they were in communication with ethno-tour companies via cell phone. It was not uncommon for adult foragers to temporarily leave their camp of residence in order to meet with safari companies and perform foraging demonstrations for tourists. In exchange for their engagement with tourists, the Hadza would receive payment in the form of Tanzanian shillings, maize, tobacco, and/or marijuana. It's likely that these payments of maize and money have, in part, reduced the dependency the Hadza have formerly had on foraging wild foods. Such a finding is unsurprising, as anthropologists have long acknowledged that tourism is a catalyst for nutrition transition, especially among the Hadza (Marlowe, 2002). Cultivated foods, such as maize or wheat flour, come to Hadza camps from other sources as well. Charitable missionary groups, who are funded through private donations and crowd sourcing, report gifting considerable amounts of maize to Hadza foragers each year. Our research team narrowly missed a missionary group, as we departed one of our campsites the day before missionaries were supposed to arrive.

In addition to food drops from missionaries and tour companies, the Hadza also utilize their limited funds to purchase agricultural products. The Hadza have access to motorbike couriers that, for payment, transport food and other products into the bush. Our research team witnessed the drop off of a 25kg bag of wheat flour at one Hadza camp, as well as multiple 25kg bags of maize the summer before. The purchase of maize and other cultigens happens on a smaller scale as well. Take, for example, the 14 year old boy in our study that reported walking to a village to sell his foraging returns and buy maize. We find it likely that these combined contributions of maize from various sources (tourism, missionaries, and subsequent self-

purchase) have reduced the need for Hadza juveniles (and potentially adults) to target some of the wild foods they used to rely on, such as tubers.

Additionally, there has been a considerable amount of government and NGO intervention in Hadza land. Notably, the Hadza have been trained in building fixed comb beehives. Many Hadza camps have a number of fixed hives located in bushes and trees nearby or even within camp. Wild bees occupy the hives, and the Hadza periodically harvest honey. While we didn't quantify the number of hives or the amount of honey they were producing, the use of these hives appeared very common in Hadza land. Additionally, the Tanzanian government has demonstrated commitment to providing Hadza communities with 100 fixed bee hives per year (Babati, 2017). The surplus honey these hives generate provides the Hadza with a valuable commodity, and allows them to sell honey in villages or to local pastoralists. The presence of these hives and associated honey surpluses might explain, in part, the absence of honey returns amongst our juvenile foragers. But also, and perhaps more importantly, it further elaborates how a variety of competing cultural and ecological factors are lessening the dependence Hadza foragers have on wild foods.

It is important to note that a variety of ecological factors may also be precipitating this dietary shift away from wild foods. To date, there have been few studies investigating climate change in Hadza territory. However, one study has noted that access to water is becoming increasingly scarce in Hadza territory, that the Hadza themselves have noticed climate change, and that the Hadza are concerned with the diminishing presence of large game (Mabulla, 2012). Additionally, recent studies have noted high variability in rainfall in other areas of Tanzania, this variable or diminished rainfall has created food insecurities and migration pressures among horticulturalist and pastoralists around Tanzania (Noah et al., 2017; Afifi et al., 2014). Further,

recent rainfall projections for Tanzania predict an overall reduction in annual total rainfall throughout the 21st century (Cioffi, 2016), and droughts have already pressured communities throughout the country (Mwakaje, 2013). The impacts of these climate changes might already be affecting certain food availabilities in Hadza land. Considering the paucity of data on this subject, we can do little more than speculate at this time. However, Tanzania was undergoing a severe drought during our 2017 field season (Mtaki, 2017), and it is unclear how the drought impacted the foraging returns we recorded. It's possible that drought conditions reduced the availability of certain wild foods during our study period, requiring the Hadza to rely more heavily on agricultural products. To what extent drought and climate change effect Hadza foraging behavior and nutrition transition remains to be seen. However, considering current climate change predictions for the region (Cioffi, 2016), it's likely that drought conditions will become more common in Hadza land. Therefore, future studies must consider the environmental pressures that are contributing to behavioral change, and to what extent ecological changes have effected/caused nutrition transition.

Another important finding of our study was a reduction in the overall proportion of Hadza juveniles participating in foraging behavior, yet a higher average return rate among foragers that did participate. While it's possible that reduced participation is due to differences in the 2005 and 2017 study parameters, it could also signify a general reduction of foraging behavior in light of nutrition transition. It's unclear why fewer juveniles are foraging, yet they average a higher return rate when they do forage. It's possible that with fewer juveniles foraging in any given area, there is less competition for the resources that are targeted by children, therefore, the juveniles that choose to forage are able to return to camp with a higher average of foraging returns. If more juveniles began to forage in any given area, competition for resources

would increase, and average returns measured in kcals might decrease. Such a hypothesis is in line with the economic principle of diminished returns. Future research will be necessary to explore this increase in average returns on foraging days, however, we find the more important behavioral trend to be reduced participation in foraging activities. This reduction in participation is another important indicator of nutrition transition.

Our interview data suggests that Hadza foragers are regularly consuming maize, and that agricultural foods are becoming an important part of their everyday culture. However, the interview data implies that many juveniles are potentially motivated to forage by a variety of social and ecological factors, including familial encouragement as well as concern for food scarcity. This suggests that even though the Hadza are clearly in the midst of nutrition transition, and likely experiencing changes to both their behavior and health as an outcome, foraging still plays an important part in the day-to-day activities of Hadza juveniles. Therefore, it is likely that evolutionary studies amongst this population will still maintain an element of their validity, similar in nature to other mixed-economy foragers, such as the Ache and Tsimane. However, despite the continuation of certain foraging behaviors, it's likely that nutrition transition will eventually be accompanied by changing health outcomes.

It's largely accepted that nutrition transition is accompanied by an epidemiological transition, where cause of mortality shifts away from infection and towards chronic and metabolic diseases (Omran, 1971; 2005). To date, however, few studies have addressed the possibility of this epidemiological transition occurring among the Hadza. This could be of some concern to contemporary research, considering 70-85% of the Hadza have already fully transitioned away from their foraging lifestyle, and the remaining 150 active foragers are likely to transition in the near future. While evolutionary studies will maintain an important element of

study as some of the Hadza continue to hunt or gather, it will be important for anthropologists to address this looming potential for epidemiological transition. Contemporary research that is willing to acknowledge that the Hadza have transitioned towards a mixed-foraging society will be in a unique position to investigate the cultural and biological effects of this transition. Such research will not only be imperative for our understanding of human health, but also will be necessary for the accurate and ethical portrayal of the Hadza in both scientific literature and media representations.

Study Limitations & Future Research

The present study has several important limitations. Firstly, there are research design asymmetries between the two study years 2017 and 2005. The 2005 research team was in the bush longer than our 2017 team, therefore some of our results might be an outcome of our reduced time in the field, rather than actual behavioral changes. For example, had we been allowed more time in each camp, it is possible that we would have recorded participation from foragers that otherwise brought us zero foraging returns. Similarly, had the team spent more time in the field it's possible juveniles would have eventually returned to the anthropologists with plant/animal species we did not otherwise record. Also, this study did not account for foods Hadza juveniles might have been eating in the bush, prior to showing their returns to the research team. It's possible that juveniles were consuming plant and animal species in the bush for which we recorded "zero" returns. Further, while we did our best to season match data, the 2005 team was in the field at the beginning and end of the dry season, and our 2017 research team was in the field in the middle of the dry season. It is unclear how early and late dry season conditions affect plant species availability compared to the middle dry season – especially since the 2017 research team was in the field during a drought year.

It's also impossible for us to know all of the factors that may be impacting hunting/gathering returns, including the presence of our research team. We noticed a very high average return rate among a few of the older males in this study and it's possible that, although we did not incentivize foraging, these foragers were motivated by a self-imposed desire to impress us (or their peers) with their hunting prowess. It is also worth noting that Tanzanian schools were in session during our study period, and some Hadza juveniles had left the bush to attend boarding schools in town. Juveniles that chose to attend school might have been inept hunters and less inclined towards life in the bush, which could potentially bias our study participants towards better hunters. Further, a few of our participants had attended 1-2 years of school, which was more than participants in 2005. While some studies have argued that this time in school does not negatively impact foraging skills among Hadza juveniles (Blurton Jones and Marlowe, 2002), it is possible that time in school has detracted from learning bush skills and limited the ability to produce foraging returns among some individuals.

Additionally, many of our field procedures were not specifically designed for recording many of the signs of transition that we have discussed. Our interview data alluded to nutrition transition and juvenile interaction with agricultural products such as maize, however, our interviews were not specifically geared towards investigating nutrition transition or documenting the quantity of maize located in these camps. Also, while we observed signs of transition in the camps we visited, and openly discussed these observations, we did not specifically have methods in place to document these indicators of transition (e.g. weighing maize that was being dropped in camps). Similarly, we did not extensively question the Hadza regarding their interpersonal interactions with outside organizations, such as ethno-tour companies, missionary groups, and

NGOs. Instead, much of our knowledge was derived from personal interactions and participant observation.

Future studies should begin documenting the nutrition transition occurring among Hadza foragers. The implementation of simple dietary recalls and food frequency questionnaires could provide answers regarding the extent of transition and consumption of domesticated cultigens in Hadza camps. Similarly, future studies should consider employing more sophisticated observational measures for recording maize drops, fixed comb beehives, and similar signs of transition away from a diet composed primarily of foraged foods. It is our opinion that studies focused on Hadza health outcomes as a result of transition should be considered with the utmost importance. Additionally, ecological studies in Hadza territory could allude to how possible climate change effects both Hadza health and behavior.

Chapter 5

Conclusion

In conclusion, we have presented evidence for change in foraging behavior and foraging returns among Hadza juveniles. We consider these changes to be a possible outcome of early nutrition transition among this population. While the many causes and effects of transition are not fully understood or quantifiable at this time, transition is likely linked to a variety of interrelated factors. These data have important implications for the directionality of Hadza health and behavior outcomes, and should be taken into consideration during the interpretation of contemporary Hadza research. Here, we have postulated that climate change has likely reduced the availability of wild food sources, while interactions with outside entities (including missionaries, NGOs, and tour companies) have simultaneously provided access to cultigens and the market economy. To date, however, few studies have addressed or quantified the effects of nutrition transition within this population.

In this study, we suggest that, currently, the Hadza should be referred to as a mixed-foraging population, and have drawn attention to elements of their socio-ecological subsistence that largely go underreported. The presence of nutrition transition among this population has been acknowledged by anthropologists for many years (Marlowe, 2002), and most contemporary research recognizes that a majority of the Hadza no longer practice a hunter-gatherer lifestyle (Crittenden, 2017; Pontzer et al., 2015). Here, we argue that the remaining Hadza foragers have entirely transitioned to a mixed-subsistence foraging economy. Acknowledging this transition is important for empowering the Hadza with the ability to accurately represent their own livelihood, especially as they become increasingly integrated within the market economy.

Despite changes in foraging return composition, increased reliance on maize, and a reduction in the overall percentage of children producing foraging returns, we found that some juveniles still remain highly productive in the midst of nutrition transition. This suggests to us that the Hadza are still comparable to our hunter-gatherer ancestors in some ways, however, contemporary research must investigate the Hadza with many of the same limitations that apply to other modern day mixed-foraging populations – such as the Ache (Hill and Hurtado, 2017), Tsimane (Gurven et al., 2017), Pumé (Kramer and Greaves, 2017), and Aka (Hewlett, 2017). Foragers have shown remarkable flexibility and resilience in maintaining aspects of their subsistence practices in the 21st century (Codding and Kramer, 2016). To what extent the Hadza maintain their hunter-gatherer subsistence practices remains to be seen. However, regardless of the speed or directionality of transition among this population, these data have important implications for understanding the decisions that foragers make in shifting ecological landscapes, the directionality of Hadza health and behavior, and the use and interpretation of data generated from contemporary Hadza research in the 21st century.

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FIELD RESEARCH

2017 Lake Eyasi, Tanzania

- Anthropometry and Diet of Transitioning Hadza Juveniles: an investigation into health outcomes as a result of changing diet
- Changing Growth and Development Patterns Among Hadza Juveniles
- Spatial Cognition and Navigation: towards an understanding of sex differences in mobility, navigation, and spatial cognition among Juvenile Hadza Foragers
- Violent and Non-violent Injuries: investigating mechanism for injury among adult Hadzabe men and women

CONFERENCE AND PLENARY PRESENTATIONS

2018 **Trevor Pollom,** Kristen Herlosky, Ibrahim Mabullah, and Alyssa Crittenden. *The Effects of Early Nutrition Transition on Growth Trajectories and Child Productivity Among the Hadza of Tanzania.* American Association of Physical Anthropology Annual Meeting, Austin, TX, April 12th-15th

2018 **Trevor Pollom** and Alyssa Crittenden. *Foraging Motivations among Hadza Juvenile Hunter-Gatherers.* Society for Cross-Cultural Research Annual Meeting, Las Vegas, NV, February 21-23rd

2018 **Trevor Pollom**. *Hadza Foragers: Transition of the Last Hunter-Gatherers.* Graduate and Professional Student Association Annual Research Forum, Las Vegas, NV, February 3rd

- Honor and Award: "2nd Place" Best Speaker/Presenter

2017 **Trevor Pollom**, Kristen Herlosky, and Alyssa Crittenden. *The effects of nutrition transition on child productivity among the Hadza Hunter-Gatherers of Tanzania.* Southwestern Association of Biological Anthropologists Annual Meeting, San Diego, CA, November 3rd

PEER REVIEWED JOURNAL ARTICLES

2018 Jennifer Pharr, **Trevor Pollom**, Alyssa Crittenden. (2018). Pedometer Measurement of Physical Activity in Hadza Hunter-Gatherer Children. *Journal of Adolescent Health.* Under Review

PROFESSIONAL EXPERIENCE

Research Assistant: School of Nursing January 2018 – Present

Provides support to supervising faculty members by performing a variety of tasks, including but not limited to the following ways:

- Formatting, editing, and writing manuscripts as they are prepared for publication
- Performing literature searches on topics related to relevant research projects
- Entering and "cleaning" data relevant to ongoing research
- Helping design and implement descriptive/intervention health studies

Graduate Assistant: Department of Anthropology

August 2016 – December 2017 Provided support to the Anthropology Department in a variety of ways, including but not limited to:

- Teaching introductory evolutionary biology courses
- Formatting and editing manuscripts as they were prepared for peer-reviewed publication
- Preparing online courses and learning modules, as well as graded upper and lower division course-work

SCHOLARSHIPS AND AWARDS

Spring 2018	Graduate and Professional Student "2nd Place" Speaker Award
Spring 2018	Graduate and Professional Student Research Funding, UNLV
Spring 2018	Rocchio Scholarship, Department of Anthropology, UNLV
Spring 2017	Angela Peterson Scholarship, Department of Anthropology, UNLV
Fall 2016	Edward and Olswang Scholarship, Department of Anthropology, UNLV

VOLUNTEER AND SERVICE

UNLV Volunteers

Member — Fall 2016 – Present

- Participate in volunteer events designed to improve the community, particularly targeting projects that improve UNLV and the greater Las Vegas Valley Area

Aspiro Wilderness Therapy

Volunteer — Summer 2015

- Helped provide therapeutic modalities to at-risk juveniles in a wilderness environment

Las Vegas Swim Club

Coach — June 2011 – March 2014

- Directed multiple teams of 20-40 juveniles
- Supervised Assistant coaches
- Provided mentorship and physical training to children aged 5 – 17