

*Original Research Article***BaAka Women's Health and Subsistence Practices in Transitional Conservation Economies: Variation With Age, Household Size, and Food Security**CAROLYN A. JOST ROBINSON,^{1,2*} AND MELISSA J. REMIS²¹Department of Anthropology, University of North Carolina, Wilmington, North Carolina 28403-5618²Department of Anthropology, Purdue University, West Lafayette, Indiana 47907-2059

Objectives: Using ethnographic interviews and biological measures, this article investigates changing health and nutrition of a hunter-gatherer population transitioning from a forest-based subsistence system to a horticultural and market-driven lifestyle.

Methods: This study represents biological and dietary recall data for adult female foragers (18+; $n = 60$) across two villages, Mossapoula (MS) and Yandoumbé (YDBE), in the Dzanga Sangha Protected Areas (APDS), Central African Republic (CAR). Standard anthropometric measurements (height, weight, skinfolds) and hemoglobin values were collected to assess short-term nutritional status.

Results: BMI was similar across all three age classes in YDBE, but differed amongst women of MS (ANOVA; $F = 6.34$, $df = 30$, $P = 0.005$). Values were lowest among the older women in older age class 3 who also had the greatest number of dependents. Overall SS values were significantly negatively correlated with the number of biological children ($r = -0.33$, $P = 0.01$) in both villages.

Conclusions: Here, we identify older BaAka women, caring for their own children and grandchildren, as particularly vulnerable to economic changes and food insecurity. We found older women, especially those in a community with greater restrictions on access to forest resources to have more dependents, reduced market integration, and low BMI relative to younger women in the population. *Am. J. Hum. Biol.* 28:453–460, 2016. © 2015 Wiley Periodicals, Inc.

Traditionally, studies of Congo Basin foragers (sometimes referred to as pygmies) have focused on relevance of their research for human origins and adaptation (Cavalli-Sforza, 1986; Verdu et al., 2009). These groups are also broadly represented in literature on subsistence practices, farmer-forager relations, and issues of resource governance (Hewlett, 2014). Yet, despite the relevance to anthropological research, few studies have addressed the gendered nutritional, health, or social consequences of changing ways of life in the forest among contemporary foragers (Dounias and Froment, 2011; Jackson, 2006; Ohenjo et al., 2006; See also Scelza et al., 2014). Here we demonstrate that gender dynamics among forager subsistence patterns in Central Africa (Grinker, 1994; Hewlett and Noss, 2001) are crucial to considerations of adult health, with applications for associated studies concerning fertility, infant morbidity, and mortality (Bentley, 1985; Kaplan et al., 2015; Kramer & Greaves, 2007). Research among central African foragers, and other naturally fertility populations, demonstrates that women's work and reproductive efforts are flexible with multiple dimensions related to subsistence and childrearing practices (Ellison, 2008; Panter-Brick et al., 1993; Peacock, 1991). A lifespan approach considering changing energetics and ecology within evolutionary, economic, and cultural frameworks increases our understanding of variations in health outcomes over the life course (Jasienska, 2009; Zihlman, 1997).

In this article, we examine nutritional status and dietary recall to address how transitioning economies, protected areas management, and declining access to wild foods have consequences for health and gendered subsistence strategies among contemporary BaAka foragers in the Dzanga Sangha Protected Areas (APDS), Central African Republic. During the 1990s, few BaAka in the region planted their own fields and women's contribution to hunting was high. BaAka women even net hunted in

all female groups when men were occupied with wage labor (Hewlett and Noss, 2001). Yet now, net hunting returns have declined and without access to guns, fewer men hunt (Jost Robinson, 2012). Women spend more time as hired hands in the agricultural fields of their neighbors than foraging in the forest with their husbands and older children. As such, BaAka diets have come to be increasingly dominated by agricultural products from women's labor in the fields and the wild plants they gather there and in adjacent forests. The BaAka in APDS may be following trends identified earlier by Bahuchet (1988) and Hewlett (1991) for other Aka forager groups who reported agricultural products making an increasingly large contribution to diets.

Contextualizing synchronic data for multiple age-classes of women within a period of economic transition allows us to examine the relationships between demographic factors, including household size and number of children in the household, and access to purchased and/or foraged foods. In this article, we demonstrate the importance of considering the nutritional and health needs of women across the lifespan in economies in transition and areas zoned for conservation management.

Forager women's work: lifespan health and fitness

In hunter-gatherer societies, almost everyone participates in childcare (Crittenden and Marlowe, 2008; Ivey, 2000). Fathers, grandmothers, siblings, and others may

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provision mothers and children (Hewlett, 1991; Hewlett et al., 2011; Meehan, 2005a, b, 2009), offsetting the energetic costs to mothers of reproduction and infant care (Hawkes et al., 1989; Hurtado and Hill, 1990). Kin support, especially in the form of a maternal grandmother can enhance infant nutrition and survival (Gibson and Mace, 2005; Leonetti et al., 2005; Meehan et al., 2014; Sear et al., 2000, 2003). Forager lifeways and egalitarian practices have long buffered the energetic costs of women through cooperative childcare and shared subsistence efforts (Crittenden and Marlowe, 2008; Howell, 2010). Allomothering (non-maternal care of infants) patterns and the work of older women in hunter-gatherer societies may protect younger, reproductive women in situations of food insecurity (Fouts and Brookshire, 2009; Hawkes et al., 1998; Meehan et al., 2013; Piperata, 2009; Sear et al., 2003), but not without consequences for their own nutritional status and health.

Research has examined the linkages between energetic constraints, women's work, and reproduction (Meehan et al., 2013; Panter-Brick, 2003; Pennington, 1992; Piperata and Dufour, 2007) to illustrate the consequences of subsistence work and childcare on biological health, reproductive success, and survival of mothers and children (Lartey, 2008; Panter-Brick, 1997, 2003). Prentice and Prentice (1988) report significant negative consequences of women's subsistence work for maternal and child health and mortality in Gambian populations. Kaplan et al. (2015) linked physiological energy stores (BMI) to fertility and infant mortality outcomes among the transitioning Tsimane forager farmers of Bolivia. Further, research among Efe foragers of the Ituri forest indicates that women's work allocations are predicated upon the constraints of reproduction and lactation rather than physical strength or capability (Peacock, 1991). These studies on the energetic constraints on women's health have primarily centered on the impacts of amenorrhea, lactation, and chronic energy depletion for reproductive women (Ellison et al., 1989, 1993; Panter-Brick et al., 1993; Vallengia and Ellison, 2004). Yet, little is known about health outcomes for senior and postreproductive women who continue, and possibly increase, their productivity and contributions to childcare and subsistence for the extended family long after their children are grown (Blurton Jones et al., 2005; Hawkes et al., 1997; Meehan, 2005a,b; Peacock, 1991; Sear et al. 2000, 2003).

Recent detailed energetics research by Hooper (2011) among the Tsimane showed that net-energy productivity increased over time in both adult males and females, well into their 1960s, 1970s, and 1980s, with a net benefit for close dependents. Moreover, older individuals provided a significant proportion of the food calories consumed by their grandchildren, and produced more food calories when grandchildren were present. Among Aka from other areas of the Central African Republic, postreproductive women and fathers assist mothers in childcare, especially in camps and villages (Hewlett, 2013). More than 90% of young Aka infants are nursed by allomothers, usually maternal or paternal grandmothers (Fouts and Brookshire, 2009; Hewlett and Winn, 2014).

Allomothering by fathers, grandmothers, and others is typically more prevalent in foragers than their farmer neighbors. Work in fields or collecting firewood and water is often a solitary activity for farmer women, and may not lend itself to receiving assistance with care for dependent

infants (Meehan, 2005b). As foragers continue to shift toward more agricultural and market-driven life-styles, we anticipate changes across age classes in amount of time allocated for childcare versus subsistence efforts. Data from Aka communities north of APDS indicated that approximately 50% of the time that infants were nursed by allomothers, their mothers were working away from camp. The remaining time was evenly distributed between times when the mothers were working nearby (25%) and times when the mothers were resting within arms reach (25%). Additional data from this region demonstrate that the presence of a grandmother in Aka camps in the Lobaye decreased a mother's holding time by almost 20% (Meehan, 2005b). Further, maternal grandmothers did more to reduce mother's energy expenditures than fathers or other caregivers (Meehan et al., 2013).

In a recent article, we identified differences in nutritional status across forager settlements in APDS. Further, BaAka women at APDS appeared more heavily affected by food insecurity and changes in subsistence practices than their male counterparts (Remis and Jost Robinson, 2014). The identified differences between settlements appear to reflect differential access to forest resources and variations in the transition to a more agricultural, wage labor-based economy (Remis and Jost Robinson, 2014). Here, our objective is to directly address the extent to which women's experiences in shifting subsistence practices impact their nutritional status. Further, these transitions will likely impact characteristic allomothering and life history patterns with negative consequences for the health of reproductive and post reproductive women.

We investigated the importance of age, demographic factors, subsistence practices, and market integration on BaAka women's nutritional status at APDS. We expected that women's nutritional status and health would vary in relationship to their age, the numbers of children they are feeding, and access to forest and purchased foods. Based on the cooperative childcare patterns observed among the BaAka, we predicted that an increased reliance upon agricultural goods with low access to wild game and poor market integration would differentially impact older and post reproductive women across villages. Further, we expected that those living with the most restricted access to wild game meat and other forest resources would be particularly vulnerable.

METHODS

Study population

This study was conducted among BaAka hunter-gatherers in the Dzanga-Sangha protected Area (APDS, sometimes referred to as Dzanga Sangha Reserve, RDS), in the southwestern corner of the Central African Republic (CAR) (4200 km², 2°13'26N, 16°11'26E)(Fig. 1). Fieldwork was conducted from June to August 2012, before the violent coup in March 2013 and civil unrest and violence that have followed. BaAka comprise approximately 24% of the total APDS population (approximately 6,468 people). The two largest villages are Mossapoula (MS = 598), and Yandoumbé (YDBE = 261) (Ngbo-Ngbangbo et al., 2010). Since the 1970s, the area has been marked by several periods of immigration and economic change associated with selective logging economies and conservation management (est. 1990). The area has seen an increase in extractive hunting with firearms coupled with declining

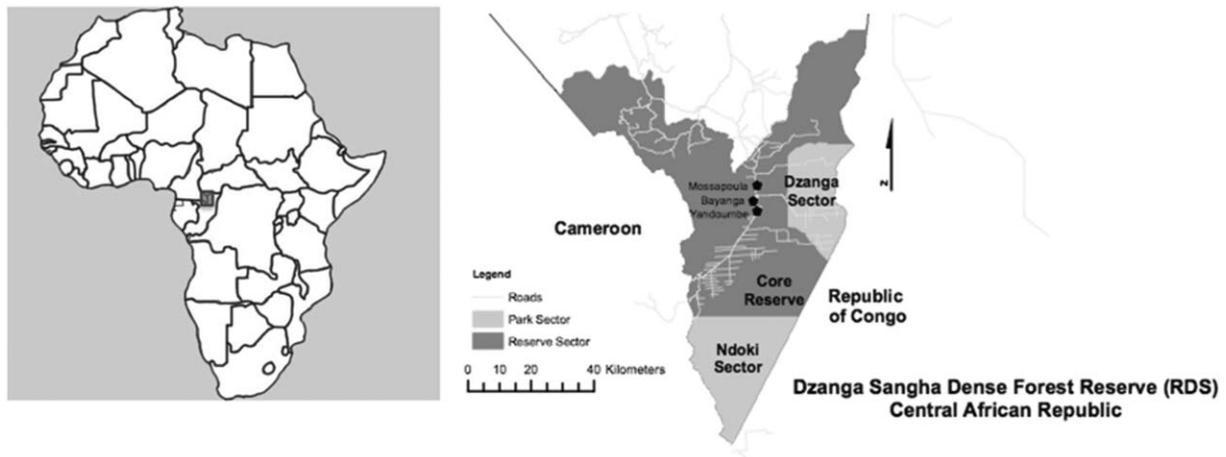


Fig. 1. Map of the Dzanga-Sangha Protected Areas, Southwestern Central African Republic in Context. NOTE: Data provided by APDS.

biodiversity and the further marginalization of BaAka communities, who lack the capital to participate in this form of hunting (Ngbo-Ngbangbo et al., 2010; Noss, 1995; Remis and Jost Robinson, 2012).

The foragers in APDS refer to themselves as BaAka. We follow local custom and precedent in the literature (Hardin and Remis, 2006; Kretsinger and Hardin, 2003; Woodbourne, 2011) to differentiate them from the Aka further to the north in the Lobaye, Central African Republic, and Northern Congo whose histories of integration into market economies have been different, though there are similarities in language, and many cultural, child rearing, and subsistence patterns between these two groups (Bahuchet, 1988; Hewlett, 1991; Kitanishi, 1995; Meehan, 2005a,b; Meehan et al., 2013). In this study, we focus on two communities of BaAka: Mossapoula and Yandoumbé. The BaAka community of Mossapoula is closest to the park headquarters, while the BaAka of Yandoumbé live further south of town. Most of Mossapoula's traditional hunting territory has been zoned as integrally protected Park because of its close proximity to the famous Dzanga saline. Yandoumbé abuts a larger community-hunting zone and many families maintain some access to traditional hunting territories. Thus, the populations in these communities have been differently impacted by conservation zoning, and vary in time spent in the forest, diet, and health.

In both of these communities at APDS, BaAka have been living in settlements by the roadside for more than 30 years, predating the inception of conservation zoning (Kretsinger and Hardin, 2003), with trips to small temporary or larger seasonal hunting and honey camps within traditional hunting territories (Hardin and Remis, 2006). By 2012, they were increasingly purchasing rather than foraging for food, primarily bitter manioc (*gozo*) but also wild game meat from neighboring non-BaAka (locally known as *Bilo*) hunters and traders. Nevertheless, only some BaAka have access to paid labor. Some men work for the conservation project or researchers; these jobs are generally temporary rather than full-time permanent work. In the past, others have been employed by the logging company or safari hunting businesses that were both closed during our study. Women have more limited access to cash, though some are occasionally paid as daily

agricultural workers or for their work with tourists. BaAka men and women also trade labor, forest products, or artisanal goods for cash or food.

Data collection and analysis

In June of 2012, adult BaAka individuals were recruited across two villages (Yandoumbé (YDBE) and Mossapoula (MS)) (described in Remis and Jost Robinson, 2014). The Instructional Review Board for Human Subject at Purdue University (IRB 1203012023) approved all data collection methods. We conducted interviews and data collection in the national language Sango, although on a few occasions, our BaAka research assistants assisted by translating into BaAka for some of the older women.

We collected anthropometric measurements (height and weight for BMI, mean upper arm circumference, sum of skinfold thicknesses) (Frisancho, 1990) hemoglobin levels and dietary information using 24 h diet recalls (Remis and Jost Robinson, 2014). Individuals were provided with an identification number to be used through the duration of the study. All potential participants were screened, and per IRB regulations, those who reported that they were pregnant or ill were not included in the sample. Women were asked to report the number of biological and nursing children during biomedical data collection. In dietary recall interviews, women were asked to further clarify how many adults and children were both residing and eating in the household on the days surveyed.

Body mass index (kg/m^2) is a standard measure for adult and child nutritional status (Lohman et al., 1988). Stature was measured to the nearest millimeter using a portable SECA stadiometer and body weight to the nearest 0.1 kg using a standing scale. Mean upper arm circumferences (MUAC), as indicators of protein and energy status, were measured to the nearest millimeter using a plastic tape measure (Frisancho, 1990). Sum of skinfolds (SS), a measure of short-term change in subcutaneous fat stores, was determined from the average of bicep, tricep, subscapular, and suprailliac skinfolds measured to the nearest 0.5 mm using Lange skinfold calipers (Frisancho, 1990; Godoy et al., 2005).

Capillary blood was collected from a single finger prick and analyzed using a portable Hemocue for on-site notification of hemoglobin levels (Garrett et al., 2011). We

found this method to be most feasible for preliminary assessments of anemia and protein nutrition during this pilot study, but acknowledge that there may be within subject variability in hemoglobin concentrations in capillary blood (Morris et al., 1999). We also acknowledge the possibility that *Helicobacter pylori* may be a factor influencing iron-deficiency anemia in developing world populations (Barabino, 2002), though our finding of a low incidence of protein-rich foods in dietary intake recalls support the likelihood that dietary iron deficiency is a factor for this population. Further, measures of body weight, BMI, and skinfolds to indicate fat reserves should be used cautiously for food-limited foragers as ways of detecting variation in energetic status. BMI is difficult to use as a biological referent in lean populations, as it becomes less accurate at low body weights (Frisancho, 1990; Sherry and Marlowe, 2007). Skinfolds may be more likely to vary seasonally than indices of body weight (Panter-Brick, 1997), both are used in the current study.

Demographic and dietary interviews were conducted by MR and research assistant Robert Sambo. We used 24 h dietary recalls to assess the relative frequency of consumption of particular foraged (including meat, gathered *payo* nuts, or other forest products) and purchased market foods. Given the preliminary nature of our data collection a single 24 h period was assessed to determine the feasibility of long-term dietary and health-related research. During the 30 min interviews, we also conducted food frequency questionnaires on the weekly consumption of meat and manioc (*Manihot esculenta*), and whether purchased (with price), foraged, from fields, or a gift. Given the nature of this pilot study, we limited our surveys to frequency (number of times food was consumed). We did not quantify intake in terms of energy consumed as respondents generally prepared and ate foods from a communal pot. The accuracy of dietary recall data is improved when researchers engage multiple methods (Bernard, 2011; Smith et al., 1996), and quantification of energy and food consumed will be a part of future research.

The data analyzed in this study represent adult female foragers (18+) for whom we have the full complement of anthropometric, dietary, and interview data ($n = 60$). Age estimates for older women were developed during interviews, as cohorts of BaAka know their relative ages, these were confirmed by one of our research assistants (Robert Sambo) and community nurse (the late Viktor Baboin) who had maintained long-term contact with these communities. Given the small sample size, we have grouped women into three age classes based on participant observation and ethnographic data regarding BaAka women. Age-Class 1 includes women ages 18–30. These women are just starting out their households and have fewer children. Age-Class 2 includes women age 31–40, who are in their reproductive prime, with more children. Age-Class 3 includes women 41+ who are still actively working to provision their extended households, we expect most are close to or have reached the end of their reproductive years.

Data were analyzed using student's *t*-tests and ANOVA to assess age and inter and intravillage variation in short-term measures of nutrition (BMI, MUAC, SS, Hemoglobin). Bonferroni post hoc pairwise tests were used for comparisons within villages by age class. Pearson's bivariate correlations were used to address potential relationships between dietary recall data and short-term measures of nutrition. The 24 h dietary recall data were converted

into three indices that reflect overall dietary diversity as well as access and integration into the emergent market economy (see Remis and Jost Robinson, 2014). These variables include: total foods consumed (TFC), subsistence index (SI), and market index (MI). TFC represents the diversity and number of food items reported in the diet during a 24 h period. Those foods consumed more than once during the previous recall period were scored once. The subsistence index is the average number of the TFC that were foraged, versus the market index, which represents the average number of TFC that were purchased in a market. We were not able to address seasonal variation in diet or health measures during this pilot study.

RESULTS

The dataset analyzed here includes 60 adult female foragers from Yandoumbé (YDBE; $n = 29$) and Mossapoula (MS; $n = 31$). Each individual represented consented to the collection of anthropometric and hemoglobin data, and also participated in dietary surveys and semistructured interviews. Those individuals who declined participation in certain parts of the study were excluded from this analysis. We first provide data on short-term measures of health across villages and age classes (BMI, Mean Upper Arm Circumference, Sum of Skinfolds, Hemoglobin). We then examine the relationships between indicators of health, household size, number of children in the household, number of biological children and dietary indices.

Short-term health measures for adult female foragers in APDS

Average BMI for women in this study was 20.52 (SE = 0.26, range = 16–25) and does not vary significantly between the two sample villages. (YDBE = 20.22, SE = 0.40; MS = 20.81, SE = 0.31). Average BMI was similar across age all three age classes in YDBE, but differed significantly among women of MS (see Table 1) (ANOVA; $F = 6.34$, $df = 30$, $P = 0.005$). A Bonferroni post hoc test indicated that women from Age-Class 3 have statistically significantly lower BMIs than women from Age Class 2 ($P = 0.004$), who had the highest average BMI.

Overall, there were no significant differences in Mean Upper Arm Circumference (MUAC) between YDBE (22.58; SE = 0.47) and MS (23.53, SE = 0.30). Further, when age classes were examined at each village, there were no significant differences in MUAC (See Table 1). Similar to MUAC, there were no significant differences between Sum of Skinfold (SS) values at each sample village; however, within each village there were significant differences across age classes. At YDBE, women from Age Class 2 had significantly greater SS values (ANOVA; $F = 3.60$, $df = 28$, $P = 0.042$) than women from Age Class 3 (bonferroni $P = 0.038$). A similar pattern was observed at MS with women from Age Class 2 having greater SS values than women from Age Class 3 (ANOVA; $F = 3.74$, $df = 30$, $P = 0.036$; bonferroni $P = 0.047$). Examination of average hemoglobin values indicates uniformly low numbers across women from both villages and all age classes (YDBE = 11.51 g/dL, SE = 0.32; MS = 11.19, SE = 0.25) with 70% of women having a value less than 12 g/dL.

Short-term measures of health and the household

The average reported household size for women in APDS is 5.07 individuals (SE = 0.31). There were no

TABLE 1. Age and inter-village variation in short-term measures of nutritional status and hemoglobin, APDS 2012

		BMI (SE)		Mean upper arm circumference (cm) (SE)		Sum of Skinfolts (mm) (SE)		Hemoglobin (g/dL) (SE)	
		YDBE (n = 29)	MS (n = 31)	YDBE (n = 29)	MS (n = 31)	YDBE (n = 29)	MS (n = 31)	YDBE (n = 27)	MS (n = 28)
Adult females	18-30 (n = 29)	20.14 (0.83)	20.79 (0.30)	22.78 (0.83)	23.61 (0.33)	29.76 (2.66)	31.73 (1.52)	11.60 (0.42)	10.97 (0.32)
	31-40 (n = 14)	20.97 (0.65)	22.45 (0.99)	22.68 (1.20)	24.30 (0.62)	36.50 (3.32)	34.45 (3.85)	11.31 (0.51)	11.43 (0.49)
	41+ (n = 17)	19.77 (0.60)	18.93 (0.77)	22.37 (0.59)	22.27 (0.91)	26.6 (2.09)	22.80 (3.50)	11.55 (0.65)	11.60 (0.68)

significant differences in average household size between villages (YDBE = 5.31 individuals, SE = 0.45; MS = 4.84 individuals, SE = 0.43). Women sampled reported giving birth to an average of 3.56 children (SE = 0.34), with an average of 2.82 children (SE = 0.26) currently residing and eating within the household. There were no significant differences in the average number of biological children reported and the average number of children currently reported as residing and eating in each household between the two study villages. We do observe intra-village variation by Age-Class and household variables for women belonging to age class 3. Although not statistically significant, older women (age class 3) in MS report have bigger households, and report greater average numbers of biological children (6.4 biological children) and have more dependent offspring (5.4 dependents) compared to similarly aged women in YDBE (biological children 5.22; dependents = 3.44).

Pearson's bivariate correlations were used to address relationships between health measures and household variables. There were no statistically significant relationships between BMI, MUAC, or hemoglobin and any of the household variables examined in this relatively small sample. However, overall SS values were significantly negatively correlated with the number of biological children ($r = -0.33, P = 0.01$) in both villages.

Diet, health, and the household

In the 24 h recalls, only 35% of women reported eating meat (wild game meat), 11% ate fish, while 100% consumed gozo (bitter manioc) and 95% consumed payo nuts (*Irvingia wombolu*) (n = 60 interviews). Approximately 71% of women consumed other nonmeat forest products, ranging from 1 to 5 different food items during a 24 h day. Other nonmeat forest products consisted primarily of koko (*Gnetum africanum*), but also included mushrooms, yams, and wild fruits. Respondents did not report consuming any domestic meat, peanuts, or other legumes during their recall of the previous 24 h period. No statistically significant differences were observed in the reported frequency of consumption of wild meat, fish, gozo, payo nuts, or other forest products between study villages.

Although not statistically significant, there were notable variations in the reported frequency of consumption of food items across age classes. The number of times wild meat was reported was more variable amongst age-classes in MS than YDBE. Older women (Age-Class 3) in MS reported no meat consumption at all during 24 h recalls (see Fig. 2). Fish was reported more commonly in MS, while rarely reported by women in YDBE. On aver-

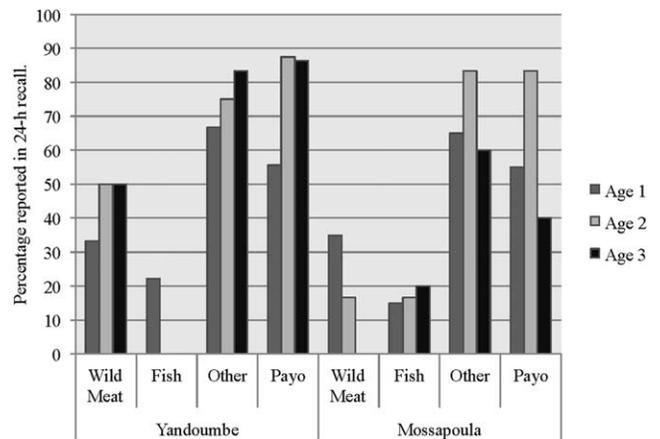


Fig. 2. Comparison of geographic and age variation in reported frequency of foods consumed during 24 h recalls. NOTE: OTHER = other non-meat forest products

age across villages, women reported eating 1.48 different kinds of other nonmeat forest products (hereafter, other forest products) per recall (SE 0.17; range 0–5). As with meat, there were varied patterns in the reporting, where the older women from Yandoumbe in Age-Class 3 reported higher rates of consumption of other forest products than other groups. In Mossapoula, women from Age-Class 2 reported the greatest rates of consumption of other forest products.

Consumption of bitter manioc (gozo) was recorded for all women during 24 h recalls. All 60 women reported that they purchased gozo from formal or informal markets. Although all women purchased gozo, there were variations between villages and Age-Classes in the amounts purchased to feed families of varying sizes. Table 2 provides data on the average amount of gozo purchased/person/day and the number of individuals in the household. There were no differences in the overall average amount of money spent on gozo by women in YBDE (108.24 CFA/person, SE = 12.88) and MS (108.14 CFA/person, SE = 18.09). However, within each village, there were varied patterns of spending. While no significant difference were observed across age-classes in Yandoumbe, older women in Mossapoula appeared to be poorer; spending significantly less money on gozo per person per day than women from Age-Class 1 (ANOVA: $F = 3.39, df = 30, P = 0.048$).

The representations of food types in dietary recall are also impacted by women's participation in the emergent

TABLE 2. Village variation in household size and amount of money spent on manioc per person, APDS 2012

	Mossapoula		Yandoumbe	
	Avg. household size (SE)	CFA on Gozo/person (SE)	Avg. household size (SE)	CFA on Gozo/person (SE)
Age 1	3.70 (0.36)	140.30 (25.05)	3.22 (0.36)	147.69 (26.42)
Age 2	7.17 (1.08)	58.36 (13.90)	5.75 (0.45)	83.30 (12.58)
Age 3	6.60 (0.81)	39.24 (14.18)	6.58 (0.78)	91.96 (20.48)

market economy. We examined the total numbers of foods consumed in relation to both subsistence and market index during the early wet season period of data collection (see Methods). Data from YDBE indicate no differences in total foods consumed (TFC), subsistence index (SI), or market index (MI) across age-classes. Although not significant, MS women of Age-Class 3 had a lower MI (0.6) than women from other Age-Classes (1 = 1.37; 2 = 1.14). The reported MI for women from Age-Class 3 in MS differs from similarly aged women in YDBE (1.67), though differences do not reach statistical significance.

DISCUSSION

In this study of BaAka forager women in transition to market economies at APDS, we found low consumption of meat and variation that related to restricted access to resources in an area zoned for conservation management. Overall, hemoglobin levels were low in this population. BMI was similar across all three age classes in the YDBE who had better access to hunting areas and forest foods, but differed among women of MS, who had less access to forest resources, spent less on *gozo*, and consumed fewest market and foraged foods. We found further relationships between measured indicators of health, age class, dietary indices, number of children in the household, and number of biological children. Overall SS values were significantly negatively correlated with the number of biological children in both villages. Nutritional status (BMI) at MS and the market index were lowest among the older women in older Age Class 3, who also had the largest number of dependents.

Foragers in transition at APDS, while shifting to include more calorie-rich market foods, still use foraging to obtain the wide diversity of foods in their diet (about 70% of the food items identified during dietary recalls). Future studies will aim to identify the relative importance of consumption of market foods relative to total calorie intake. In a previous study, we found that overall BaAka health and short-term nutritional status of men and women varied between Yandoumbe (YDBE) and Mossapoula (MS). Adult female foragers appear to suffer more negative consequences of the transition to agricultural foods and sedentism than their male counterparts. Women in MS spent less time in the forest, making fewer overnight trips than those at Yandoumbe (Remis and Jost Robinson, 2014). Here, although our sample is small, our results further demonstrate that those in MS are impacted most heavily, particularly women in different age-classes with varied degrees of integration into the market economy.

Despite the small sample size, our results show that women in Age Class 2 were better integrated into the market economy, purchased more *gozo*, and apparently spent less time foraging in the forest as they consumed a narrower variety of other forest products. In contrast, older women (Age Class 3) seem to be the least integrated into the market economy, spending little on *gozo*, while also not consuming as large a variety of other forest products in their diet compared to women in Age Class 2.

Moreover, during our interviews, we found that women over 30 years of age were feeding and caring for more children in their households than they had reported in response to inquiries about numbers of biological children. By contrast, there were better matches between numbers of biological children and children in the household reported by younger women aged 18–30 years old.

The shifting work of older and post reproductive women in forager societies in combination with continued communal childcare patterns can have cascading consequences for the nutritional status and health of allomothers if they face an increasing labor burden during the transition to an agricultural, wage-labor economy. In the present study, we found that markedly low values in BMI, hemoglobin, dietary variables, and market indices were seen in older women, who were by their own accounts exhausted. By contrast, younger reproductive women appeared likely to have been buffered by BaAka social practices of communal food sharing and childcare (Meehan et al., 2013), as their BMI and hemoglobin levels were higher. We found significant variation for women across the lifespan at APDS, especially for those at Mossapoula. At the village level, there were fewer differences across age classes in Yandoumbe, suggesting higher stress for older women of Mossapoula, where access to forest is most restricted, and women are reporting feeding more children, while spending less on market goods.

Relating nutritional status to childcare and work patterns: implications for life history

Women across sub-Saharan Africa who engage in productive agricultural labor, domestic work, reproduction, and childcare across their lifespans, face a challenging set of energetic commitments that may result in malnutrition (Little et al., 1992; Townsend and McElroy, 1992). As suggested here, we expect the BaAka in transition to agricultural and market economies at APDS to also be at risk. Panter-Brick (2003) examined differences in energy demands of subsistence-based work efforts (e.g. those characterized by long-term endurance) and agricultural, wage-labor (e.g. characterized by short-term, high bursts of productivity). She concluded that long-term endurance work strategies, like foraging, are more compatible with the compromised energetic status of pregnant and lactating women, or those in poor health or nutritional status. Thus, a transition to wage-labor for reproductive women in natural fertility populations may result in decreased productivity across activities and cascading outcomes for dependent offspring (Marotell and Arroyave, 1988; Panter-Brick, 2003; Tanner et al., 2013).

Our data on variation in short-term nutritional status can perhaps best be understood in context of other studies that examine the relationship between childrearing practices and women's work and reproduction over the lifespan. Forager women with infants and young children in

many societies show a decrease in subsistence effort and products (Hawkes et al., 1997; Hurtado et al., 1992; Marlowe, 2003) and depend, especially seasonally, upon older women, usually grandmothers to supplement their caloric intake (Hurtado et al., 1992). Meehan (2005b) and Meehan et al., (2013) showed that grandmother's childcare efforts, but not those of fathers, reduced maternal energy expenditure and enhance the nutritional status of grandchildren (Meehan et al., 2014). Consistent with other studies, we found older and post reproductive women to be very productive, even those without large households were frequently observed returning from fields or forests carrying large loads to provision extended families (Hawkes et al., 1989; Meehan, 2005a). Our work suggests that this activity across the lifespan has consequences for the health of older women, especially during periods of food insecurity and transition.

Among the BaAka, most women have a young child to carry and nurse throughout their reproductive careers, so they are more likely to get assistance from a post reproductive woman than one in her reproductive prime. Ninety percent of Aka grandmothers in Meehan's study (2005a) stated that women should stop having children when their children began reproducing in order to help take care of grandchildren. Indeed, many BaAka may follow a practice of terminal abstinence reported in some other African societies whereby grandmothers avoid competing with their own children's reproduction and redirect resources to grandchildren (Caldwell and Caldwell, 1977; Leidy, 1993; Lesthaeghe et al., 1981). Contributions of elder family members and allomothers are likely especially important among hunter-gatherers in transition to a more agricultural diet. Grandmothers have invaluable childcare and foraging skills, including knowledge that likely increases infant survival (Scelza, 2009).

In Central Africa as wildlife populations, hunting and the subsistence work of BaAka men decline, increased nutritional insecurity appears to fall hard on the elder women working to support increasingly large extended families (Kretsinger, 2002) with agricultural work and gathering wild plant foods to exchange for bitter manioc. Dietary recalls in 2012 signal exacerbated food insecurity as a result of the high 2012 market price of manioc at APDS. Surveys and participant observation indicate that households had insufficient food resources. For example, older women in the Mossapoula community were sharing what would more typically be considered one adult serving of manioc across a relatively large household of more than six people.

Our data on declining nutritional status and lack of market integration among older women, especially those from the Mossapoula community find parallels among the Hadza. Hawkes et al. (1989) report that during a drought period, older women lost more weight than reproductive women or girls. The poor health of grandmothers in foraging societies likely also negatively impacts their adult daughters and grandchildren who are dependent upon their labor. Our preliminary work suggests the importance of safeguarding the health and nutritional status of all women across the lifespan. Researchers and humanitarian organizations alike often focus on implications of food security for children and reproductive women. However, we find that nearly all older BaAka forager women examined in the APDS protected area, have restricted use of game meat and other forest resources, suffer low hemo-

globin levels and poor nutritional status. Though often overlooked, it seems that older women provide critical support to extended families in conservation zones with their combined foraging and agricultural labor. These efforts may undergird the health of younger individuals, as well as buffer long-term population demographics.

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