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A Biocultural Investigation of Gender Differences in Tobacco Use in an Egalitarian Hunter-Gatherer Population

Casey J. Roulette[1] · **Edward Hagen**[2] · **Barry S. Hewlett**[2]

Abstract In the developing world, the dramatic male bias in tobacco use is usually ascribed to pronounced gender disparities in social, political, or economic power. This bias might also reflect under-reporting by woman and/or over-reporting by men. To test the role of gender inequality on gender differences in tobacco use we investigated tobacco use among the Aka, a Congo Basin foraging population noted for its exceptionally high degree of gender equality. We also tested a sexual selection hypothesis—that Aka men's tobacco use is related to risk taking. Tobacco use, income, tobacco purchases, tobacco sharing, reasons for using tobacco, risk taking, and other variables were measured using structured surveys and peer reports. Tobacco use was verified by testing for salivary cotinine, a nicotine metabolite. Contrary to expectations, we found a very large male bias in tobacco use. Low levels of use among females appeared to be explained by aversions to tobacco, concerns over its negative effects on fetal health, and a desire to attract husbands, who prefer nonsmoking wives. High male use appeared to be related to a desire to enhance hunting abilities and attract and/or retain wives, who prefer husbands that smoke. We conclude that low levels of smoking by Aka women are better explained by the hypothesis that women evolved to avoid plant toxins to protect their fetuses and nursing infants. High male use might be better explained by sexual selection. We also highlight the important role that recreational drugs appear to play in hunter-gatherer sharing relationships.

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✉ Casey J. Roulette
caseyroulette@gmail.com

[1] Department of Anthropology, San Diego State University, 5500 Campanile Dr, San Diego, CA 92182, USA

[2] Department of Anthropology, Washington State University, Vancouver, WA, USA

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Tobacco use is responsible for 1 in 5 deaths in high-income countries and 1 in 10 deaths in low-income countries (Ezzati and Lopez 2004). Globally, it is responsible for 16% of all male deaths and 7% of all female deaths (Eriksen et al. 2012), most of which occur in the developing world (Mathers and Loncar 2006). Unfortunately, little is known about the biocultural factors involved in tobacco use in the traditional rural populations of many developing nations.

One dramatic difference in smoking patterns in developed vs. developing countries is the gender difference. Male smoking prevalence is very similar in developed vs. developing countries (30.1% vs. 32.0%, respectively). Female smoking, on the other hand, differs dramatically: in the developed world, 17.2% of women smoke, but in the developing world, only 3.7% smoke (Ng et al. 2014). Further, within each population, female prevalence is almost always lower than male prevalence, and it is especially low in Africa (Fig. 1; Ng et al. 2014).

Gender Disparities vs. Gender Differences in Tobacco Use

Gender disparities, such as women's reduced social power and economic status relative to men and/or religious proscriptions on their use of tobacco, are commonplace in much of the developing world and thus might explain the large gender difference in tobacco use in these countries (e.g. Eriksen et al. 2012; Hitchman and Fong 2011; Kaplan et al. 1990; Waldron et al. 1988; World Health Organization 2007). Among traditional African populations, such as the Maasai, Samburu, Kisii, and Gikuyu, Kaplan et al. (1990) found that gender differences in tobacco use were related to a general pattern of social restrictions on women's behavior. Similar explanations have been widely used to explain gender differences in the use of other drugs, such as alcohol (Heath 1991; McDonald 1994; Room 1996) and khat (Almedom and Sembatu 1994). In a cross-national study, Hitchman and Fong (2011) found a strong correlation between low

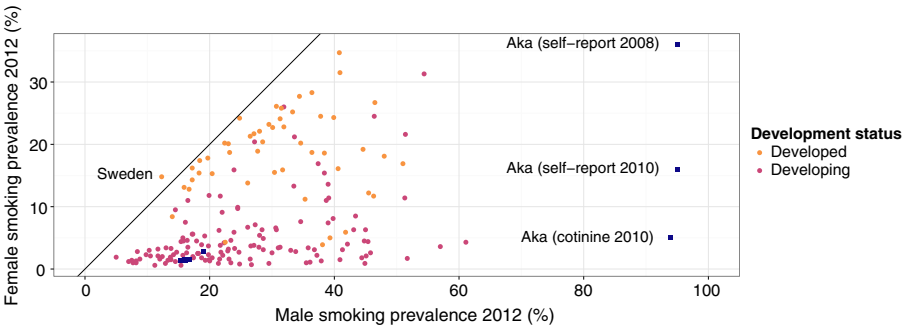

Fig. 1 Female smoking prevalence vs. male smoking prevalence in 187 countries in 2012. Solid line represents equal prevalence. Central African countries, including Aka data, are dark squares. Although there are more female smokers in Sweden than male smokers, more Swedish men use tobacco due to their use of snus, a smokeless tobacco product (Foulds et al. 2003). Country data and development status from Ng et al. (2014). Aka data as reported here, and in Roulette et al. (2014)

incidence of smoking among women relative to men and women's reduced levels of political and economic power.

High prevalence of smoking among men, on the other hand, is often attributed to the rewarding neurobiological effects of nicotine (Hyman et al. 2006), the low cost of tobacco (Chaloupka and Warner 2000; Eriksen et al. 2015; US Department of Health and Human Services 2014), and to extensive marketing by transnational tobacco companies (Lee et al. 2012). The neurobiological effects of nicotine are presumably similar in all humans (Hagen et al. 2013) and therefore cannot explain cross-cultural differences in smoking. Population differences in men's smoking are thought to rest on differences in the price of tobacco and the extent of pro-smoking advertisements vs. anti-smoking campaigns.

Under-reporting?

The exceptionally low female tobacco use suggested for the developing world can be called into question because both men and women tend to under-report smoking. Gorber et al. (2009) reviewed 67 studies that tested for the presence of cotinine to validate self-reported smoking. Cotinine, a nicotine metabolite, is a widely used and well-validated biomarker of recent tobacco use that can be assayed in saliva, urine, or blood (Benowitz 1996). Most studies reviewed by Gorber et al. found that participants under-reported smoking, with the mean difference between the reported and measured rate ranging from −4.8% for studies that measured cotinine in saliva to −9.4% for studies that measured cotinine in urine. Unfortunately, Gorber et al. did not examine gender differences. Kang et al. (2013), however, found that although Korean men and women both under-reported smoking, women did so much more than men (leading to an apparent female smoking prevalence of less than half the true rate), perhaps owing to social proscriptions against female smoking. Gan et al. (2008), on the other hand, found over-reporting of smoking by US women.

Lack of Studies of Tobacco Use among Egalitarian Hunter-Gatherers

If gender differences in smoking are due to gender inequality, then in egalitarian societies male and female smoking prevalence rates should be similar. In many developed countries, such as the US and Europe, where gender inequality is relatively low, female smoking prevalences indeed approach male prevalences (Fig. 1; Hitchman and Fong 2011). Developed countries differ from developed countries in many ways beyond levels of gender inequality, though, such as lower per capita income, higher burden of infectious disease, and higher fertility (Hitchman and Fong 2011; Mathers and Loncar 2006; United Nations 2013). One way to tease apart the influence of gender inequality vs. other aspects of developing populations is to study patterns of tobacco use in highly egalitarian populations in the developing world.

Congo Basin foragers, which include the Efe and Mbuti in the eastern Congo and the Aka and Baka of the western Congo, as well as numerous other groups, are embedded within developing nations; they have low per capita income, a high burden of infectious disease, and generally high fertility (Hewlett 2014). Nevertheless, these groups

(commonly referred to as "pygmies," a term that some consider derogatory, and that we will avoid) share several cultural and ecological features that distinguish them from typical subjects of tobacco use research in the developing world. First, many are active hunter-gatherers. Outside of the extensive ethnohistorical and archaeological literature on tobacco use in the Americas (e.g., Wilbert 1987; Winter 2000) and pituri use in Australia (e.g., Ratsch et al. 2010; Watson 1983), very few studies of tobacco use have been completed among extant hunting-gathering populations. Second, they typically live in remote regions of the Congo forest; hence many of the groups have relatively little exposure to transnational tobacco company advertising, and to anti-tobacco campaigns. Third, and most important, they value autonomy and are egalitarian, with marked gender and age equality.

The frequent use of tobacco, cannabis, and other psychoactive substances by Congo Basin foragers has been noted by several ethnographers (e.g., Bailey 1991; Grinker 1994; Hewlett 1977, 1991; Turnbull 1961), yet there are few systematic studies. Tobacco, which is indigenous to the Americas, was brought to West Africa by Europeans sometime in the 1600s (Philips 1983) and reached the Congo Basin by the late 1800s if not earlier (Laufer et al. 1930). Congo foragers' use of tobacco and cannabis seems to coincide with the peak in the ivory trade, suggesting that the first smokers might have been traditional elephant hunters (John Hart [1], personal communication, cited in Hewlett 1977). This could explain why these foragers perceive a link between smoking and hunting success.

Oishi and Hayashi (2014) mention that tobacco use pervades the daily life of the Baka foragers in Cameroon. The Baka say that they cannot hunt without it and will often move their forest camps closer to villages in order to maintain access to it. They also extensively share tobacco. Recently Roulette et al. (2014) reported a very high prevalence of tobacco use among Aka men (94%) as determined using salivary cotinine biomarkers. Efe foragers of the Ituri forest depend on Lese villagers to satisfy their intense craving for tobacco. Efe foragers trade labor and meat to villagers for tobacco and cannabis (cf. Terashima 1998), often at the expense of acquiring other important resources. In fact, Efe smokers (of tobacco or cannabis) were significantly more likely to be poor than nonsmokers (Bailey 1991). Similarly, Roulette et al. (2015) found that two thirds of adult male Aka smoke cannabis and that, among the smokers, the heaviest users (as determined using urinary THCA concentrations) had the least material wealth. These ethnographic observations of frequent tobacco use stand in contrast to the relatively low prevalence of male tobacco use in other parts of Africa (Ng et al. 2014; Fig. 1).

Study Aims

This study had three aims. The first was to conduct one of the few quantitative investigations of tobacco use in an egalitarian population of Congo Basin foragers, and perhaps the only to focus on possible gender differences. The second was to validate women's and men's self-reported smoking using salivary cotinine. The third was to evaluate the gender inequality theory of differences in tobacco use in a population noted for its exceptional levels of gender equality and relative isolation from tobacco marketing and anti-tobacco campaigns.

[1] Now at the Wildlife Conservation Society's Global Conservation Program & Lukiru Wildlife Research Foundation, Gombe, Kinshasa, Democratic Republic of Congo.

We report the results of three studies that investigated the personal, sociocultural, and political-economic factors involved in gender differences in tobacco use among Aka foragers of the Central African Republic. The primary study was conducted in 2008, and two follow-up studies were conducted in 2010 and 2011. The goals of study 1 were to (*a*) determine if there were gender differences in tobacco use among a hunter-gatherer population with high levels of gender equality, (*b*) determine if there were gender differences in income and money spent on tobacco, and (*c*) investigate emic cultural models of gender differences in tobacco use.

Based on the results of study 1, the goal of study 2 was to validate self-reported tobacco use in a much larger sample using a cotinine biomarker. The goals of study 3 were to (*a*) determine the population prevalence of smoking in all age categories and both genders for all Aka living in this region using self- and peer-reports and (*b*) to investigate a sexual selection hypothesis regarding the relationship between risk taking and tobacco use in men.

We deliberately use the term *gender* rather than *sex* to acknowledge the probable role of cultural transmission in shaping patterns of drug use by sex (for discussion of gender vs. sex, see Walker and Cook 1998).

Study Population

Aka (also called BaAka, Biaka and Bayaka) are a group of hunter-gatherers residing in the western Congo Basin, a tropical forest region encompassing southwestern Central African Republic (CAR) and the northern part of the Republic of the Congo (ROC) (Bahuchet 1984; Hewlett 1991). Most of the estimated 30,000 Aka live in small camps scattered throughout the western Congo Basin (Bahuchet 1992; Hewlett 1996). They are transitional foragers who maintain important social and economic relations with their farming neighbors, consuming agricultural products on an almost daily basis. Although they spend a majority of the year in the tropical forest hunting and gathering, Aka live near farming villages for 4 to 6 months each year to trade forest products, such as meat and honey, and labor, for agricultural goods, clothes, salt, cigarettes, alcohol, axes and knives, and occasionally money. Aka also work on villager coffee plantations in exchange for food, money, and tobacco.

Currently, Aka smoke a variety of substances, including a leaf that grows on trees in the rain forest (*Polyalthia suaveolens*, Annonaceae, also known as *Greenwayodendron suaveolens* Verdc., Annonaceae; Engl. & Diels) that the Aka call *motunga* (see figure A1 in the ESM); cannabis; and two kinds of tobacco—cigarettes (called *blancs*, which refers to the color of the cigarette packaging) and locally grown tobacco (called *gbangaya*; see figure A2 in the ESM). Collectively, both kinds of tobacco are referred to as *ndako*. This study focuses on *ndako* use (for a more detailed ethnographic description of *ndako* use, as well as a brief description of the use of snuff, chewing tobacco, and cannabis, and of their smoking materials, see section 2 in the ESM).

Participants were recruited from three regional subpopulations along the Lobaye River, CAR, with a combined Aka population of about 300 adult men and 300 adult women. Since the Aka do not keep track of their ages, ages were estimated by one of the authors (BSH) based on 30 years of fieldwork at this site, as well as by the research assistants, who have lifelong associations with this population. Adults were defined as married Aka with at least one child.

Overview

Each study was approved by the Institutional Review Board of Washington State University. Informed consent was obtained from all participants prior to data collection. All interviews and surveys were administered with the aid of a local research assistant who translated English into DiAka, the Aka language. Participants were paid 500 Central African Francs (CFA), the equivalent of $1 US, for participating in each survey, and an additional 500 CFA for providing biological specimens. Statistical analyses were conducted using Stata/IC 11.0 for Mac and R version 3.2.0. Sample sizes, gender distributions, and ages of the samples of each of the three studies are listed in Table 1.

Study 1: Cultural Factors and Gender Differences in Tobacco Use

Interviews with Aka informants and focus groups in 2008 indicated there might be a dramatic male bias in smoking. Aka attributed the low female use of tobacco to cultural norms (smoking is for men) and to concerns about harm to the fetus. The Aka are a natural fertility population in which adult women are either pregnant or nursing much of their adult lives. Many Aka said smoking was bad for the baby. The goals of study 1 were to estimate the prevalence of smoking among adult men and women, to determine if concern about harm to the fetus might explain low female use, as participants in our focus groups suggested, and also to investigate additional factors that might influence

Table 1 Sample sizes and demographic variables for the three studies

		Age			
	N	mean	median	range	Measures
Study 1					First three questions in Table 2
M	40	34.4	32.5	18–70	
F	66	33.5	32.0	18–70	
Subsample					Last five questions in Table 2; all questions in Tables 4 and 5
M	20	32.3	30.0	25–45	
F	20	32.9	29.5	25–43	
Study 2					Age; salivary cotinine
M	206	36.3	35	18–70	
F	44	32.2	30	20–55	
Study 3					Age category; self- and peer-rated smoker status
M	545	see text	see text	0–70	
F	547	see text	see text	0–70	
Subsample					Age; peer-rated risk taking; self-reported risk taking; salivary cotinine
M	62	36.7	35	18–60	

use, such as vertical and horizontal cultural transmission, the price of tobacco, and concerns about the impact of tobacco use on one's own health.

Methods

We conducted a structured survey (Bernard 2006; Schensul et al. 1999) with all available adults ($n=106$) from one trail in the largest regional subpopulation.[2] All participants were asked if they smoked tobacco, if their mothers smoked tobacco, and if their fathers smoked tobacco. A subsample of 40 Aka were asked additional questions about their tobacco use. Composite salience scores ($\sum$) (Quinlan 2005) were calculated for responses to some of the questions (not all composite salience scores are reported. For a complete list see section 3 in the ESM). Sample sizes for some questions vary slightly because not all participants responded to every question.

We asked if smoking is *ekila*, a term used by Aka and Baka to refer to practices or rules that regulate hunting, eating, sex, and menstruation (Bahuchet 1984; Lewis 2008). Violation of these regulations (except by accident) could have terrible consequences for oneself or one's child (Motte-Florac et al. 1993). For instance, in an Aka causes-of-death study, Hewlett et al. (1986) found that *ekila* (eating a taboo food) was the second leading cause of infant death.

Results

Sample demographics are summarized in Table 1.

Patterns of Tobacco Use Based on the total sample, 95% of Aka men self-reported as smokers compared with 36% of Aka women (Table 2). The gender difference in smoking was large and significant, with an odds ratio of 33.25 ($SE=25.58$, $z=4.55$, $p<0.001$). Some women (10%) reported trying tobacco but not developing a regular smoking habit. In contrast, all men were habitual smokers at some point in their lives.

Female smokers were marginally significantly older than male smokers ($SE=3.78$, $t=1.91$, $p=0.06$). The proportion of female smokers increased markedly in the postreproductive years. Whereas only 27.8% (15/54) of women between 18 and 44 smoked tobacco, 75% (9/12) of women 45 and older smoked tobacco, a statistically significant difference ($SE=0.14$; $z=-3.27$, $p=0.002$). A logistic regression model of female smoker status vs. age found that each 1-year increase in age increased the odds of being a smoker by 1.06 (Table 3, model 1). A logistic regression model of female smoker status vs. both age and maternal smoker status found that women whose mothers smoked were 12 times more likely to be smokers than women whose mothers did not smoke, after controlling for age (Fig. 2; Table 3, model 2).

Based on the subsample, women and men smokers reported having smoked 0.8 and 1.8 cigarettes, respectively, on the day of the study; 2.4 cigarettes each on the day prior to the study; and 6.2 and 9.3 cigarettes, respectively, on a typical day (Table 2).

[2] In order to provide labor to the farmers, Aka make temporary camps near the village. These camps are located on trails that radiate out from the village into the forest. There are numerous trails in the village, but this study included all of the available adults (i.e., those who were present in the camp on the day of the survey) from only one of these trails.

Table 2 Epidemiology of tobacco based on self-report data

	Female	Male	Total
Total sample			
Do you smoke tobacco?	24 (36%)**	38 (95%)**	62 (58%)
Mean age of smokers	40.6*	33.4*	36.2
Were you ever a regular smoker?	1 (2%)	2 (5%)	3 (3%)
Mean age of former smokers	40.0	54.0	49.3
Does (or did) your:[a]			
Mother smoke tobacco?	32 (48%)	11 (28%)	43 (41%)
Father smoke tobacco?	59 (89%)	38 (97%)	97 (92%)
Mother used to smoke but quit?	3 (5%)	2 (5%)	5 (5%)
Father used to smoke but quit?	6 (9%)	1 (3%)	7 (7%)
Subsample			
Do you smoke motunga?[b]	5 (25%)	13 (65%)	18 (45%)
Do you plant gbangaya?[b]	3 (15%)	4 (20%)	7 (18%)
How many cigarettes do you smoke per day?[c]			
Mean blancs today	0.6	1.3	1.2
Mean gbangaya today	0.2	0.5	0.4
Mean blancs/gbangaya yesterday	2.4	2.4	2.4
Mean blancs/gbangaya typical day	6.2	9.3	8.6
When did you first start smoking?[d]			
As a mona	0 (0%)	4 (21%)	4 (16%)
As a bokala/ngondo	6 (100%)	15 (79%)	21 (84%)
With whom did you first smoke?[e]			
Father	3 (75%)	11 (64%)	14 (66%)
Older Sibling/Friend	0	4 (23%)	4 (19%)
Spouse	1 (25%)	0 (0%)	1 (4%)
Other	0	2 (11%)	2 (9%)

[a] $N = 105$ for all variables

[b] $N = 40$, 20 male and 20 female

[c] Smokers only, $N = 24$

[d] Smokers only, $N = 25$

[e] Smokers only, $N = 21$

*Marginally significant gender difference at $p < 0.1$

**Significant gender difference at $p < 0.001$

Nearly all of the participants reported first smoking tobacco as an adolescent (*bokala*/*ngondo*), although four men reported starting to smoke in middle childhood (or *mona*) (Table 2). Most participants started smoking with their fathers: the child lit the cigarette for their father or their father passed them a lit cigarette (Table 2).

Cultural Models of Tobacco and Smoking We asked Aka to estimate how much they are paid by the neighboring farmers for a day's worth of labor. The assessment of Aka

Table 3 Logistic regression models of female smoking vs. age and mother's smoking

	ß	*SE*	*z*	*p*
Model 1				
Age	0.06	0.02	2.90	0.004
Intercept	−2.59	0.76	−3.42	0.001
Model 2				
Age	0.07	0.03	2.90	0.004
Mother's smoking	2.51	0.72	3.47	0.001
Intercept	−4.53	1.18	3.83	0.000

income is rudimentary not only because it was based on self-report, but because when Aka provide labor to the villagers they are infrequently paid with money and typically compensated with goods (e.g., manioc, salt, soap, cigarettes). However, the estimates illustrate how much money an average Aka can expect to earn on a given day if he/she were paid in cash while working for villagers (termed "daily income").

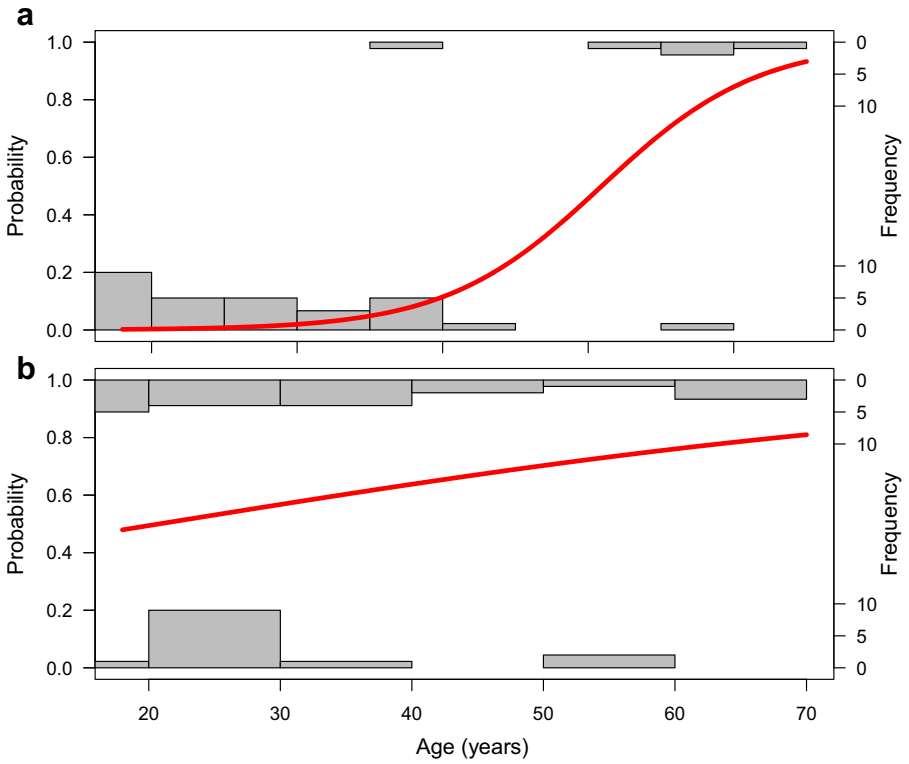

Fig. 2 Smoking status of Aka women vs. age and vs. the smoking status of her mother. **a** Mother does not smoke ($n = 34$). **b** Mother smokes ($n = 32$). Histograms represent the age distribution of non-smokers (bottom of each plot) and smokers (top of each plot). Curved lines are the probabilities of smoking computed from a logistic regression (Table 4, model 2)

Table 4 Economics of tobacco smoking

	Female	Male	Total
What is your estimated daily income?			
Mean	115.8**	242.2**	173.6
How much tobacco do you purchase when you have money?			
Mean spent on tobacco	30.3	125.1	73.6
Mean spent on *blancs*	14.5	81.3	45.0
Mean spent on *gbangaya*	15.8	43.8	28.6
Mean percent spent on tobacco	36%*	64%*	49%
When you purchase tobacco, how much of it do you share with others?			
Mean tobacco shared	19.1***	51.4***	33.9
Mean percent purchased tobacco shared	62%*	44%*	49%
Mean percent income shared as tobacco	24%	29%	26%

All estimates are in Central African Francs, CFA

$N = 35$; three highest wage earners, all male *ngangas*, were excluded

*Marginally significant gender difference at $p < 0.1$

**Significant gender difference at $p < 0.05$

***Significant gender difference at $p < 0.01$

The estimated average daily income across both genders was 173.57 CFA (approximately $0.35 US) (Table 4). (Traditional healers, *ngangas*, earn significantly more money and were therefore excluded from this analysis.) There was a significant gender difference in daily income, with males earning more ($M = 242.19$, $SD = 167.26$) than females ($M = 115.79$, $SD = 62.48$; $t = -2.86$, $p = 0.01$). There was no significant difference in the daily income of female nonsmokers ($M = 121.4$, $SD = 72.6$) vs. smokers ($M = 100.0$, $SD = 0.0$; $t_{13} = 1.1$, $p = 0.29$).

Based on the mean daily income (173.57 CFA) and the price of one pack of the cheapest locally available manufactured cigarettes (500 CFA), more than 280% of daily income is needed to purchase one pack of cigarettes.

Aka estimated spending almost half of their daily income on tobacco (73.57 CFA, or $0.15 US; Table 4). Men ($M = 0.64$, $SD = 0.34$) spend a marginally significant greater proportion of their daily income on tobacco than do women ($M = 0.36$, $SD = 0.59$; $t = -1.72$, $p = 0.095$).

Of the purchased tobacco, Aka estimated that they share almost half of it with others (Table 4). In terms of daily income, Aka give away more than a quarter of their earnings to other Aka in the form of tobacco. In terms of CFA, men share significantly more tobacco ($M = 51.41$, $SD = 25.87$) than women ($M = 19.08$, $SD = 33.43$; $t = -3.15$, $p = 0.0034$). However, women give away a marginally significant greater proportion of their tobacco ($M = 0.62$, $SD = 0.30$) than men ($M = 0.44$, $SD = 0.13$; $t = 1.98$, $p = 0.0628$). Women distribute most of the tobacco they purchase to husbands and male relatives.

Aka associated tobacco smoking with negative health effects (Table 5). For example, more than 80% of participants mentioned that they had coughing and/or chest pain caused by smoking *blancs*, *gbangaya*, and/or *motunga* (for a list of traditional

Table 5 Cultural attitudes toward tobacco

	Female	Male	Total
Do you prefer a spouse who smokes?[a]	15 (79%)**	0 (0%)**	15 (39%)
Have you ever had any of the following:[b]			
Coughing or chest pain due to:			
Blancs?	6 (100%)	16 (84%)	22 (88%)
Gbangaya?	6 (100%)	16 (84%)	22 (88%)
Motunga?	6 (100%)	15 (79%)	21 (84%)
Vomiting from:			
Blancs?	2 (33%)	8 (42%)	10 (40%)
Gbangaya?	2 (33%)	7 (37%)	9 (36%)
Motunga?	1 (17%)	7 (37%)	8 (32%)
Diarrhea from:			
Blancs?	1 (17%)	3 (16%)	4 (16%)
Gbangaya?	0 (0%)	4 (21%)	4 (16%)
Motunga?	1 (17%)	2 (11%)	3 (12%)
Is maternal smoking while pregnant:[c]			
Bad for baby?	16 (89%)	18 (95%)	34 (92%)
Ekila?	6 (33%)*	2 (11%)*	8 (22%)
Have you ever learned from a doctor or missionary that smoking:[a]			
Is bad for your own health?	7 (37%)	11 (58%)	18 (47%)
Is bad for health of fetus?	4 (21%)	7 (37%)	11 (29%)

[a] $N = 38$

[b] Smokers only, $N = 25$

[c] $N = 37$

*Marginally significant gender difference at $p < 0.1$

**Significant gender difference at $p < 0.001$

treatments related to smoking illnesses and of the medicinal uses of tobacco, *motunga*, and cannabis, see section 4 in the ESM).

More than 90% of Aka participants mentioned that maternal smoking while pregnant (MSP) was bad for the fetus. The most salient health risks mentioned were that it causes a baby to cough either inside the womb or once it is born ($\sum = 0.36$, $n = 12$). Other risks included unspecified sickness, baby cannot breathe, baby dizzy/eyes dizzy, baby gets diarrhea, baby turns very black, baby will not listen when older, smoke into eyes of the baby, women get tired/slow, stomach turns, and baby dies (for composite salience scores, see section 3 in the ESM).

When asked if smoking while pregnant or breastfeeding is *ekila* (taboo), 22% of participants mentioned it was (Table 5). A marginally significant greater proportion of women (33%) mentioned that smoking is *ekila* than did men (11%); $z = 1.77$, $p = 0.09$.

About a third of Aka reported hearing from a doctor or missionary that smoking is bad for the fetus, and about half had heard it was bad for their own health (Table 5).

All males (100%, $n = 19$) preferred a woman who does not use tobacco whereas most females (79%, $n = 15$) preferred a mate who does (Table 5). The proportion of

women who preferred a smoking spouse (79%) was significantly greater than the proportion of men who preferred a smoking spouse (0%), $z = 4.98$, $p < 0.0001$.

Aka men did not like women who smoke for several reasons, but the most salient response was that the "spouse might become lazy, or may not listen or obey" ($\sum = 0.53$, $n = 10$). In contrast, most females preferred a mate who smokes tobacco because it gives them "strength" for subsistence hunting and foraging or for working for the villagers ($\sum = 0.80$, $n = 12$) (for a list of additional reasons see section 3 in the ESM).

The most salient response for why smokers continue to smoke was their tobacco use satisfies a "hunger" or "desire" (*ndjala*) ($\sum = 0.70$, $n = 11$), although some mentioned that they use it because it is their usual thing ($\sum = 0.20$, $n = 3$) or that it gives them strength or helps them keep warm ($\sum = 0.17$, $n = 3$).

When the female nonsmokers were asked why they do not smoke, the most salient reasons had to do with personal preference (e.g., do not like tobacco/it made them sick) ($\sum = 0.55$, $n = 6$). However, proscriptive reasons (e.g., it is not for women, it is for men) were still very salient ($\sum = 0.50$, $n = 5$) and accounted for the remainder of the responses.

Study 2: Cotinine Validated Smoking Prevalence

Studies in other populations have found that self-reported smoker status is often contradicted by biomarker data (Gorber et al. 2009). The objectives of study 2 were to determine the optimal salivary cotinine concentration threshold to discriminate smokers from nonsmokers, and then to validate self-reported smoking with the cotinine biomarker. True nonsmokers have small but non-zero salivary cotinine levels owing to exposure to environmental tobacco smoke (ETS). True smokers have a wide range of cotinine levels owing to variation in smoking intensity, nicotine and cotinine elimination rates, and time since their last cigarette. Thus, the distribution of cotinine levels in smokers vs. nonsmokers overlap. In Western populations, estimates of the optimal cotinine threshold to distinguish smokers from nonsmokers have ranged from 3 to 20 ng/ml, with 15 ng/ml having been widely used in the past; however, more recent estimates have been revised downwards (e.g., Benowitz et al. 2009; Jarvis et al. 2008).

The Aka live outdoors, which might lower the optimal cotinine threshold relative to Western populations, but they sleep in small enclosed huts, which, since we collected saliva upon wakening, might increase the threshold.

Methods

Self-reports of tobacco smoking (yes/no) and saliva samples were collected from 206 men from the three subregions and 44 women from two trails in the largest of the three subregions. The salivary cotinine data were first reported in Roulette et al. (2014), to test the relationship between male smoking and worm burden. Here, we report new analyses of these data to investigate gender differences in smoking.

All participants provided ~2–5 ml of saliva every other day for about 6 days, for a total of three samples per participant per year. We instructed participants to provide saliva immediately upon wakening and before smoking their first cigarette (after first rinsing their mouth with water). Saliva were stored at −20 °C in a solar-powered freezer

and then shipped to the Bioanthropology Laboratory at Washington State University (WSU) Vancouver for analysis.

To estimate the optimal cotinine threshold to distinguish Aka smokers from non-smokers, we used a receiver operating characteristic curve (ROC) analysis, which requires identification of true smokers and true nonsmokers. Female Aka (most of whom do not smoke) (1) who self-reported that they did not smoke tobacco and (2) whose cotinine values did not clearly indicate recent smoking (were less than 50 ng/ml) were classified as true nonsmokers. Men (most of whom smoke) who self-reported that they smoked tobacco were classified as true smokers.

Results

Cotinine Threshold for Smoker vs. Nonsmoker Status The maximum cotinine value in the true nonsmoker group ($n = 34$) was 4.2 ng/ml ($M = 1.2$, $SD = 0.98$). The minimum cotinine value in the true smoker group ($n = 189$) was 0.79 ng/ml ($M = 149.3$, $SD = 134.5$). An ROC analysis of the cotinine distributions of true smokers vs. that of true nonsmokers found that the area under the ROC curve was 0.995, and that a threshold of 5 ng/ml had a specificity of 100% and a sensitivity of 95%.

Male and Female Smoking Prevalence Using the 5 ng/ml threshold, 94% ($n = 194$) of men were tobacco users compared with only 5% ($n = 2$) of women (Fig. 3). In comparison, 95% ($n = 196$) of men and 16% ($n = 7$) of women self-reported as smokers. Of the 7 women who self-reported as smokers, only 1 had a cotinine value consistent

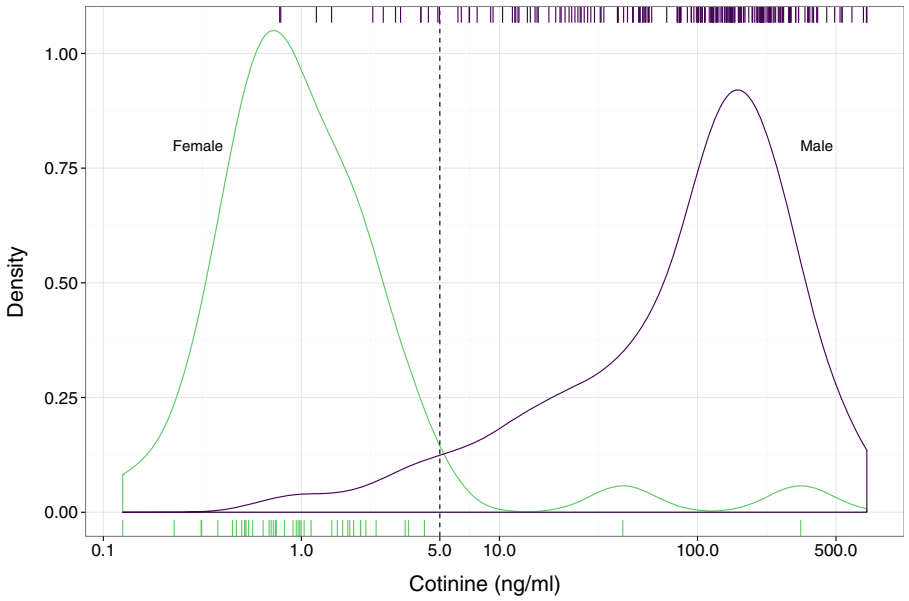

Fig 3 Density of salivary cotinine concentrations (log scale) of all participants by sex. Concentrations to the left of the dotted line (<5 ng/ml) indicate no recent tobacco use. Concentrations to the right of the line (>5 ng/ml) indicate recent tobacco use. Rugs represent male (*top*) and female (*bottom*) individual cotinine concentrations

with recent smoking. One women who self-reported as a nonsmoker had a cotinine value indicating recent smoking. Both women whose cotinine values indicated recent smoking were 40 years old.

Study 3: Total Population Prevalence of Tobacco Use and Male Risk-Taking vs. Smoking

The objectives of study 3 were to use self- and peer-reports (1) to investigate smoking prevalence in the entire Aka population (all ages and both genders) living in the three study communities and (2) to explore a sexual selection hypothesis for the relationship between smoking (cotinine validated) and risky subsistence activities in adult men. The latter was motivated by results from study 1 in which most Aka women reported that they preferred a spouse who smoked because smoking increased strength and hard work (Table 5), and from previous ethnographic research indicating that Aka men smoke to improve hunting abilities. Thus, men might use performance-enhancing drugs, such as tobacco, to increase their hunting and foraging returns, thereby attracting mates. Aka are net-hunters, and men and women often hunt together. However, two important male-dominated subsistence activities, climbing trees for honey and hunting with a spear, are also very risky activities. In one study (Hewlett et al. 1986), for example, falling from trees and hunting accidents accounted for 3.2% ($n = 13$) of all male deaths; these, along with other violent causes, were the third leading causes of death among Aka men (6.4%, $n = 26$), behind only infectious and parasitic diseases and diarrhea. We hypothesized that among Aka men the frequency of engaging in these risky subsistence activities would be positively correlated with salivary cotinine concentrations.

Methods

Structured Surveys In 2011 we visited all 36 camps in the three subregions and interviewed those present in order to collect demographic and smoking status data for all individuals of all ages. Those present provided a self-report of smoking status and a peer- (or in some cases parental-) report of smoking for those who were absent. Age was coded using Aka age categories: (1) infant/child (*mona*), which roughly corresponds to 0–11 years; (2) adolescent (*bokala*, male; *ngondoa*, female), which roughly corresponds to 12–17 years; and (3) adult, which roughly corresponds to 18–70 years. The total sample was 1092 Aka (Table 1). We refer to these data as *total reported tobacco use*.

Surveys were conducted with a subsample of 62 male Aka from the three subregions. Participants were asked to self-report the number of times within the last year they (*a*) climbed trees for honey and (*b*) hunted with a spear. These were summed to create a *self-reported risk* variable. Participants were then rated by three raters from their respective trail. The raters were shown pictures of the participants and asked to rate them in terms of climbing trees for honey and hunting with a spear "more" (1) or "less" (0) than other Aka. A *peer-reported risk* variable was created by summing the scores for climbing trees and hunting with a spear, which ranged between 0 and 6.

Salivary Cotinine Assays Cotinine was assayed in saliva from 62 male participants from the three subregions. Saliva specimens were collected, stored, and assayed similarly to the 2010 protocols (see study 2). These cotinine data were first reported in Roulette et al. (2014) to test the relationship between smoking and reinfection with worms. Here, we report new analyses of these data to investigate smoking vs. self- and peer-reported risky subsistence activities in men.

Results

Total reported tobacco use was 93% ($n=153$) for adult men and 15% ($n=33$) for adult women. The gender difference in adult total reported tobacco use was large and significant (two-tailed $z=15.05$, $p<0.001$). Among adolescents, significantly more males (69%, $n=171$) than females (4%, $n=5$) smoked tobacco (two-tailed $z=13.82$, $p<0.001$). Significantly more adult males smoked tobacco than adolescent males (two-tailed, $z=-5.81$, $p<0.001$), and significantly more adult females smoked tobacco than adolescent females (two-tailed, $z=-3.74$, $p<0.001$). No children or infants were reported as smokers.

Self-reported risk ranged between 0 and 100 and had a significant positive rank correlation with salivary cotinine (Spearman's $\rho=0.27$, $p=0.034$, $n=60$). We next investigated whether this correlation persisted after controlling for age. A multiple regression with square root cotinine as a function of age and self-reported risk found marginally significant positive effects of both predictors. However, one participant had a risk score of 100, or 6.7 standard deviations above the mean. When we removed this outlier, both predictors had significant positive effects on smoking (Fig. 4, Table 6).

We next compared smoking with peer-reported risk. Spearman rank correlation analysis found no significant correlation between cotinine and peer-reported risk scores. However, a generalized additive model of cotinine versus peer-reported risk, controlling for age, found an unexpected significant curvilinear relationship between cotinine and risk (edf = 1.89, $F=4.18$, $p=0.022$; Fig. 5).

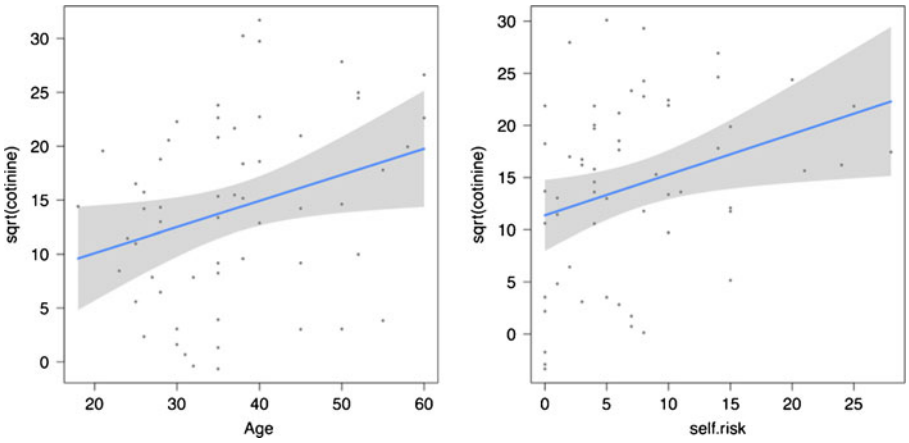

Fig 4 Effect plots of square-root-transformed cotinine versus age (left) and self-reported risk (right). Shading represents 95% confidence intervals. For model coefficients see Table 6

Table 6 Linear regression model of square-root-transformed cotinine versus self-reported risk, controlling for age

	Dependent Variable: Sqrt (Cotinine)
Self-reported risk	0.39* (0.17)
Age	0.24* (0.11)
Constant	2.91 (4.61)
Observations = 58	
Adj. $R^2 = 0.10$	
$F_{2,\ 55} = 4.17$*	
$p < 0.05$	

Discussion

Low Smoking Prevalence among Aka Women

In sub-Saharan Africa, women's smoking rates range from 0.6% in Cameroon to 9.9% in Namibia, with a median of 4.5%, which is similar to the overall 3.7% rate for women in the developing world. In CAR, age-adjusted female smoking rates are 1.5% (Ng et al. 2014).

We obtained four values for Aka female smoking prevalence. The first, from the 2008 study, was a 36% self-reported prevalence; the second, from a much larger sample, was a 16% self-reported prevalence; the third, from the same larger sample, was a 5% cotinine-validated prevalence; and fourth, from the largest and most representative sample, a 15% self-reported prevalence.

The discrepancy between Aka women's 2010 self-reported smoking (16%) and that indicated by cotinine biomarker data (5%) has at least two possible explanations. First, the half-life of cotinine is about 17 h. Aka women who self-report as smokers might be smoking infrequently and thus usually have low cotinine values. Second, some women

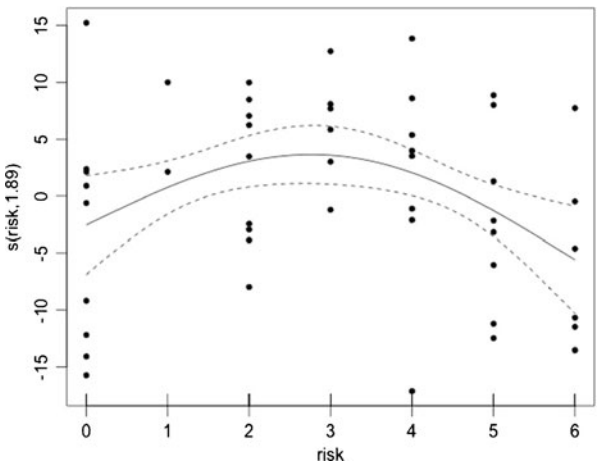

Fig. 5 Effect plot of square-root-transformed cotinine (mean centered) versus peer-reported risk. Plot determined using a GAM of square-root-transformed cotinine versus a smooth function of peer-reported risk, controlling for age. Dotted lines represent 95% confidence intervals

might have mistakenly believed that if they claimed to be smokers we would give them cigarettes, which they could have then shared with others.

The first two self-reported values fall between the mid and high range of prevalences seen in developed countries, which would support the positive relationship between gender equality and female smoking, but the low cotinine-validated prevalence of 5% is similar to that seen for women in other developing populations (Fig. 1). In addition, even the higher self-reported prevalence rates are much lower than the prevalence of smoking among Aka men (see below).

Conventional Theories Do Not Easily Explain Low Aka Female Use Relative to Men Low smoking among women relative to men is usually ascribed to women's reduced political and economic power, relative to men (Hitchman and Fong 2011), and throughout Africa, long-established cultural traditions, including Islamic and Christian religious beliefs, forbid women from smoking (Kaplan et al. 1990; Laufer et al. 1930; Waldron et al. 1988).

Gender disparities in social norms and political power cannot easily explain the large sex difference in use among the Aka, however, because the Aka, like other Congo Basin foragers, are known for having pronounced gender equality and also value autonomy. Although statements such as "tobacco is for men, not for women" indicate that tobacco smoking is gendered, this does not mean that Aka women are proscribed from smoking. Aka of both sexes are free to participate in activities typically designated for the opposite sex (Hewlett 1991). Indeed, many women mentioned that they tried tobacco and that they currently do not smoke because they do not like it or it made them sick. A few Aka said that in the past both male and female Aka smoked. Therefore the gender difference in tobacco smoking might be a recent trend.

There were also gender disparities in daily income, with Aka men earning twice as much as Aka women earn per day of work (Table 4). However, this also cannot easily explain low female smoking because female nonsmokers earned as much daily income as female smokers. Furthermore, Aka men reported spending a greater fraction of their income on tobacco than women, and women gave away more purchased tobacco than men, which suggests that men value tobacco more than women do.

Alternative Biocultural Explanations for Low Aka Female Use Relative to Men Both sexes viewed smoking as harmful to the fetus, and, importantly, significantly more women than men mentioned that smoking while pregnant is taboo (*ekila*) (Table 5). The Aka are a natural fertility population. Their total fertility rate is between 5 and 6 (Fouts and Brookshire 2009; Hewlett 1992), which means that from their late teens to their late thirties, most Aka women are pregnant or lactating. As a consequence, women in this age range who smoked would be exposing their fetuses or nursing infants to tobacco constituents. Although the fetal consequences of tobacco use mentioned in the scientific literature differ from those mentioned by the Aka, there is abundant evidence from the former that maternal smoking is harmful to fetuses, nursing infants, and children exposed to environmental tobacco smoke (Eriksen et al. 2012). It is possible that toxin avoidance mechanisms (e.g., bitter taste perception, nausea) deter pregnant and lactating women from using tobacco and other drugs (Hagen et al. 2013; Hook 1978; Profet 1995), which we refer to as the *fetal protection hypothesis*. In addition, 29% of Aka in our sample had heard from doctors or missionaries that

smoking was bad for the fetus (horizontal cultural transmission). Cultural transmission might reinforce an innate propensity to avoid toxic substances during pregnancy and lactation (cf. Henrich and Henrich 2010; Placek and Hagen 2015).

Under the fetal protection hypotheses, postmenopausal women would be free to smoke if they chose. In support of this prediction, female self-reported smokers were significantly older than male smokers, and only two women in our sample had cotinine levels consistent with recent smoking, both of whom were 40 years old. Further, the likelihood of being a self-reported female smoker increased as age increased. Interestingly, the Aka say that women become more like a man after menopause, which might also influence smoking among older women.

The few reproductive-aged women who self-reported as smokers also reported having mothers who smoked (Fig. 2). We can only speculate about why, especially since most self-reported female smokers stated they first started smoking with their father or husband (Table 2). Perhaps smoking is culturally transmitted from parent to offspring (vertical transmission). Alternatively, tobacco might have been more available to such women, they were more comfortable smoking, or they were more willing to admit smoking.

Virtually all Aka men preferred a spouse who does not smoke (Table 5). Therefore, younger Aka women might also be avoiding tobacco because men find female smoking to be unattractive, and these women are trying to attract or retain a spouse.

Alternatively, gendered smoking norms might be culturally diffused from Ngandu farmers, who provide the tobacco to the Aka. Based on ethnographic observations of the Ngandu over several years of research we have seen very few Ngandu women smoke, but there are no systematic data. In comparison, the age-adjusted smoking prevalence for women in the country of CAR as a whole is 1.5% (Ng et al. 2014), and most of these women come from traditional farming populations that have marked gender inequality, similar to the Ngandu. However, when one group adopts a technology from another group it does not necessarily imply that they adopt the gender roles associated with it. For example, most researchers agree that Congo Basin forager groups that use nets, such as the Aka, received the nets from Bantu-speaking farmers (Hewlett 1996). When Bantu farmers use nets on their own, such as among the Ngandu of the CAR, only men participate in net hunting. Among the Aka or Mbuti, however, both men and women use nets to hunt. In fact, in some areas, when men are engaged in wage labor, women-only net hunts occur (Noss and Hewlett 2001). Differences in gender equality may account in part for the differences in smoking prevalence between Aka women and other women in CAR. However, in the absence of data on Ngandu tobacco use it is difficult to assess this, or the possible influence that Ngandu smoking might have on Aka tobacco use.

High Smoking Prevalence among Aka Men

The highest national male smoking prevalences range from 60 to 70% in Russia, Indonesia, and some Pacific Islands. The prevalence of male smoking in the Congo

Basin is 13–16%, and 15.9% in CAR (Ng et al. 2014). By these standards the 94% prevalence of Aka male smoking is extraordinarily high. However, daily cigarette consumption is low. Aka men report smoking 9.3 cigarettes per day, and women smokers, 6.2 per day. In contrast, globally, smokers smoke an average of 18.8 cigarettes a day, and 16.6 per day in the developing world (Ng et al. 2014). Low cigarette consumption are probably because of their high cost. Aka men's mean cotinine levels were only slightly lower than those seen in Western populations, though, suggesting that Aka tobacco consumption might be higher than reported.

Conventional Theories Do Not Easily Explain High Aka Male Use Theories from political economy that link tobacco use to tobacco marketing (e.g., Lee et al. 2012) do not easily explain the high male rate in the Aka, a population with limited daily exposure to tobacco advertising. Only 10% of Aka men in this region had a radio (Roulette et al. 2014), and radio shows are typically broadcast in either French or Sango (the national languages); Aka men do not speak French and only a few speak Sango. Aka men also have limited exposure to health warnings about tobacco, however, which could help explain the high rate. Yet the Aka indigenous cultural models recognize many health hazards from smoking (Table 5).

Other political-economic explanations for variation in tobacco use focus on the relative price of tobacco (Adams et al. 2012; Chaloupka and Warner 2000; Eriksen et al. 2015; Maclean et al. 2015; US Department of Health and Human Services 2014).

The estimated daily income for Aka was about 175 CFA (approximately $0.35 US) (Table 4). This is much lower than in most of the developing world, where the average income is about $34 US per day, and even low compared with sub-Saharan Africa, where it is about $2 US per day (World Bank 2012). Our assessment of Aka income is rudimentary, however, because it is based on self-report, and because when Aka provide labor to the villagers they are often compensated with goods, such as manioc, salt, soap, and cigarettes. Among the Efe, a foraging group in the eastern Congo, 29% of exchanges with Lese villagers involved receipt of tobacco and cannabis, second only to exchanges for food (Terashima 1998).

At our field site, one pack of commercial cigarettes costs 500 CFA (about $1 US). Locally grown tobacco (*gbangaya*) is somewhat cheaper (although Aka often steal it from the villagers' gardens). Assuming the Aka worked 250 days a year, they would require about 114% of their annual income to buy 100 packs of cigarettes, compared with the global median and mean of 3.4 and 7.6%, respectively, and 14.5% in the Central African Republic (Eriksen et al. 2012).

On a daily basis, Aka estimated spending 73.6 CFA ($0.15 US) on tobacco, or almost half of their daily income (Table 4). Notwithstanding some limitations, our data indicate that, relative to its cost in other populations in the developing world, tobacco is very expensive for the Aka. Similar results are reported for the Efe, who expend considerable time and effort to obtain tobacco and cannabis at the expense of obtaining food and material items (Bailey 1991). Aka male smoking prevalence is one of the highest known, despite the extraordinarily high cost of tobacco in this population.

Alternative Biocultural Explanations for High Aka Male Use Among the Aka, as well as most other populations, substance use onsets very rapidly in middle-to-late adolescence. This, of course, is the same period in which males start to seek mates. Substance use might therefore be an honest signal of some dimension of mate quality (for discussion, see Hagen et al. 2009, 2013). In support of this model, 79% of the Aka women in our study reported that they preferred husbands who smoked, perhaps because the Aka believe that smoking makes men better hunters and workers. In particular, climbing trees for honey, a very risky activity, was described by one Aka camp as the "first reason for a marriage"—the more an Aka man climbs trees and provides honey, the more attractive he becomes to a woman and her family. We found that those who engage in such risky subsistence activities, as measured using self-reports, had higher salivary cotinine concentrations. The unexpected curvilinear relationship between cotinine concentrations and peer-ratings of risk taking might indicate a perceived need for performance-enhancing drugs by those with moderate levels of hunting and honey-collecting skill, but no such perceived need by those with the highest skills.

A complementary explanation for high male tobacco use, which we develop and test elsewhere, is that substance use is linked to parasite infections (Hagen et al. 2009, 2013; Roulette et al. 2014, 2015; Sullivan et al. 2008). In brief, nicotine and other plant drugs are harmful to human parasites, such as intestinal worms. Populations with high parasite prevalence, and little access to Western medicine, might consume toxic plants as an unconscious form of self-medication. In our population, almost all Aka men and women were infected with intestinal worms, though a marginally significantly greater proportion of women were uninfected (7.1% of females vs 1% of males, $\chi^2 = 3.8$, $p = 0.052$). Thus, the benefits of parasite defense would be the same for both sexes, but among reproductive aged women the costs of exposing fetuses to teratogens would possibly outweigh these benefits, leading to a male bias in use (see Hagen, Roulette, and Sullivan 2013 for a discussion of this perspective).

Personal gratification (*ndjala*, or a "desire" or "hunger") was the most salient response given for why smokers use tobacco.

Tobacco Sharing

Despite its high cost, Aka reported that they give away nearly half of all the tobacco they purchase, which is one quarter of their daily income (Table 4). Tobacco sharing occurs in all economic and social settings. Virtually all ethnographers of foraging societies have emphasized the importance of sharing and generalized reciprocity (e.g., Bird-David 1990; Sahlins 1972; Woodburn 1982), with theoretical models emphasizing the sharing of meat (e.g., Gurven 2004). Aka, too, almost always share meat (e.g., Kitanishi 2000). Given the number of hours Aka must work to obtain tobacco, and the large fraction they then share with others, tobacco might play an unexpectedly large role in the development and maintenance of Aka social relationships and cooperation.

In one of the only other studies to systematically investigate drug use in an African hunting-gathering community, Damon (1973) found that although personal gratification had a strong effect on why the !Kung smoked, tobacco also played a prominent social role in that the !Kung prefer to smoke with other people and often pass around a

pipe during discussions. The social importance of tobacco sharing among small-scale societies more generally is noted by several observers (e.g., Black 1984; Brady and Long 2003; Haddon 1946; Hays 1991; Kaplan et al. 1990; Marshall 1981; Vallance et al. 1987; Waldron et al. 1988).

Tobacco is an ideal "good" upon which to ground a sharing-based society. It is valuable, lightweight and easy to transport, does not spoil, and can therefore be enjoyed by Aka in the village and in the forest. We conjecture that valuable "recreational" drugs have played an important but largely unrecognized role in the sharing-based social organization seen in many foraging societies, such as central African foragers, San, Hadza, and the many Australian foraging groups.

Whereas meat sharing often depended on male hunting, valuable recreational plant drugs would have been obtained by both women and men. Aka women, for example, obtain tobacco by working in villager gardens or by growing it (Table 2). Further, Aka women and men both share tobacco widely. Men typically pass around a lit cigarette, which could help explain their exceptionally high smoking prevalence, whereas women give the tobacco to their husbands, male relatives, older female relatives, and friends. In fact, Aka women gave away a greater proportion of their purchased tobacco (62%) than men (44%).

Conclusions

These studies highlight six features of Aka tobacco use: (1) The male-biased gender difference in smoking prevalence is one of the largest recorded; (2) gender differences in smoking appear in adolescence and continue into adulthood but attenuate slightly as older women increase smoking; (3) among adults, self-reports of tobacco use were verified with salivary cotinine assays, which found that women over-reported their tobacco use; (4) women's low use might be linked to aversions to smoking and concerns over the health of a fetus and attracting and retaining mates; (5) men's high use is surprising given the high cost of tobacco in this population and relatively low exposure to tobacco advertising, but it appears to be linked to strengthening sharing relationships, concerns over attracting and retaining mates, and perhaps high worm burden; and (6) among men and women, tobacco appears to play an important, yet often overlooked, role in sharing relationships.

Notwithstanding some exceptional features, Aka tobacco use has a number of similarities to the recreational use of tobacco seen in other societies: Aka smoke on a daily basis but especially during social events, such as dances; they do so because they enjoy it; men smoke more than women; and children generally do not smoke. Even the role of tobacco in attracting mates is seen in other societies (e.g., Chiou et al. 2014; Jones and Figueredo 2007; Kurzban et al. 2010; Quintelier et al. 2013), as is its role in enhancing physical and mental performance (Groark 2010; Wilbert 1987; Winter 2000).

Exceptional population growth in the developing world ensures that tobacco-caused deaths will impose an enormous burden on these countries for decades to come. One bright spot in tobacco statistics in the developing world is the very low female prevalence (Ng et al. 2014). Aka gender differences, and their cultural model of women's avoidance of tobacco, raise the concern that as women in the developing world adopt birth control and reduce their fertility, they will increase their use of tobacco and other drugs.

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Casey J. Roulette is an assistant professor in the Department of Anthropology at San Diego State University. He specializes in evolutionary and cultural approaches to human behavior, including the non-dietary use of plant secondary metabolites and its effects on health.

Edward Hagen is an associate professor of the Department of Anthropology at Washington State University, Vancouver. He specializes in evolutionary approaches to health and social behavior.

Barry S. Hewlett is a professor in the Department of Anthropology at Washington State University, Vancouver. He specializes in Congo Basin hunter-gatherers and cultural and evolutionary approaches to childhood, cultural transmission, and infectious and parasitic diseases.