

Human–Bat Interactions in Rural West Africa

Priscilla Anti, Michael Owusu, Olivia Agbenyega, Augustina Annan, Ebenezer Kofi Badu, Evans Ewald Nkrumah, Marco Tschapka, Samuel Oppong, Yaw Adu-Sarkodie, Christian Drosten

Because some bats host viruses with zoonotic potential, we investigated human–bat interactions in rural Ghana during 2011–2012. Nearly half (46.6%) of respondents regularly visited bat caves; 37.4% had been bitten, scratched, or exposed to bat urine; and 45.6% ate bat meat. Human–bat interactions in rural Ghana are frequent and diverse.

Bats are increasingly being recognized as hosts for pathogens that affect humans and livestock (1). The 2014–2015 outbreak of Ebola virus disease in West Africa demonstrates how human–bat interactions in even remote locations can trigger infection chains that affect global public health and strain the national health care systems in Africa (2). One of the major challenges to preventing bat-related diseases is lack of knowledge about the frequency of, circumstances surrounding, and motivations for human–bat interactions in rural African communities. Only a few quantitative records are available in the scientific literature, and most are not specific for Africa (3).

In Ghana, bats carry potentially zoonotic viruses including lyssa-, corona-, henipa-, and filoviruses (4–6). Although anecdotal knowledge exists with regard to human contact with bats and bat roosts within rural communities and information about the ubiquitous bush meat trade (7), little information is available about the intensity and circumstances of exposure (8). We therefore studied the cultural practices, sociodemographic factors, and religious activities that determine human–bat contact in remote rural communities from which new disease outbreaks have repeatedly emerged (9). Specifically, we studied the sociocultural association of humans with bats in rural communities in Ghana, focusing on potential routes of virus transmission.

The Study

The study was conducted in 3 communities in Ghana: Kwamang (population 8,000), Forikrom (population 3,800),

Author affiliations: Kwame Nkrumah University of Science and Technology, Kumasi, Ghana (P. Anti, M. Owusu, O. Agbenyega, A. Annan, E.K. Badu, E.E. Nkrumah, S. Oppong, Y. Adu-Sarkodie); University of Ulm, Ulm, Germany (M. Tschapka); University of Bonn Medical Centre, Bonn, Germany (C. Drosten); German Centre for Infection Research, Bonn (C. Drosten)

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and Buoyem (population 3,900). Kwamang is part of the Ashanti Province; Buoyem and Forikrom are in Brong Ahafo Province (Figure 1). Ethics approval was obtained from the Committee for Human Research, Publications and Ethics of Komfo Anokye Teaching Hospital and School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi.

In each of the 3 communities, in-depth interviews of local leaders were conducted. Buoyem leaders described an activity called the Yam Festival, a hunting festival during which men took ladders to caves on Wednesday evenings and caught bats as they returned from feeding. These bats were described as fruit bats and thus were possibly *Rousettus aegyptiacus* bats, the species most commonly identified in Buoyem caves. The night's catch was collected by the women; menstruating women were excluded from participation

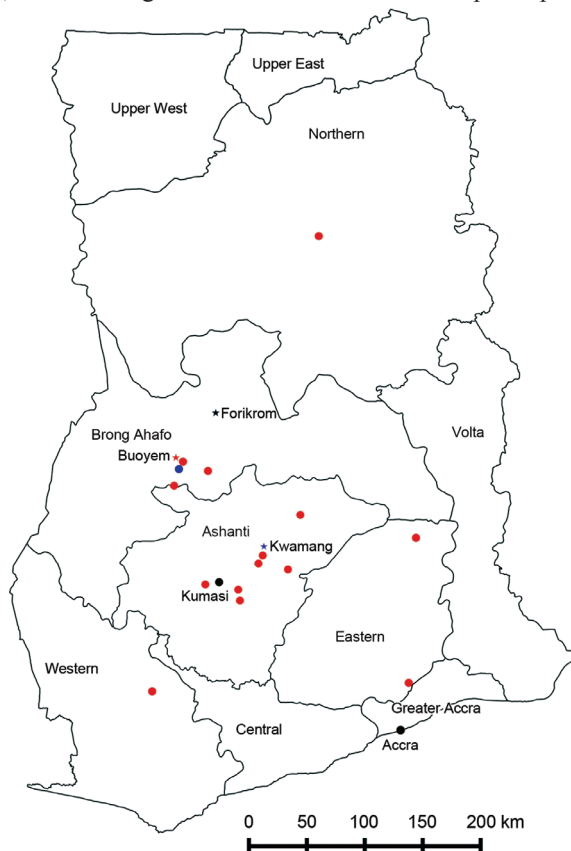


Figure 1. Human–bat interaction study locations and provinces within Ghana, 2011–2012. Asterisks indicate the study sites, Kwamang, Forikrom, and Buoyem. Red circles indicate sources of bush meat. The main Techiman market is situated in the Techiman municipality (blue circle); this market is ≈ 15 km from Buoyem and is the largest and most economically active market in the Brong Ahafo region. Accra and Kumasi, the largest cities in Ghana, also receive supplies of bat meat from the Techiman market.

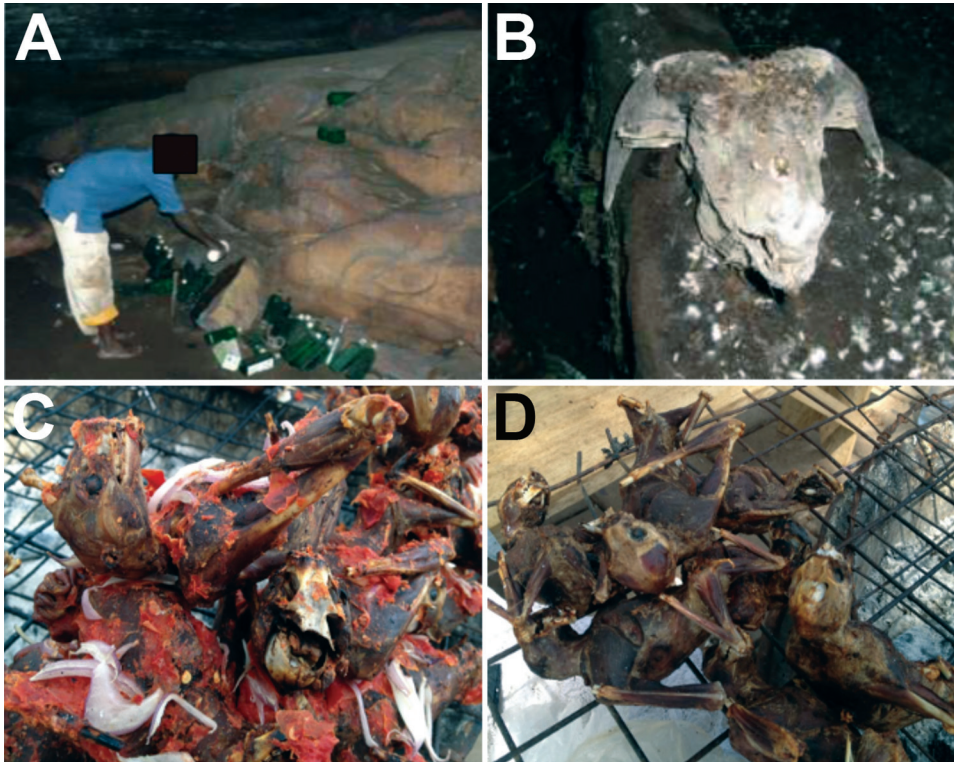


Figure 2. Typical situations in which direct and indirect bat–human contact occurred in Ghana, 2011–2012. A) Religious activity at the Mprisi cave in Buoyem. The man is pouring libation to the natural gods. The liquid poured before entering the cave is liquor. Note the number of deposited empty bottles, indicating the frequency of cave entries. B) Goat sacrificed for natural gods at the Mframabuom cave in Kwamang. C, D) Typical examples of roasted bats widely offered and consumed in markets and public places in Ghana. Photographs provided by and published with permission from H. Baldwin.

in Yam activities for reasons explained as cleanliness. In recent years, Yam activities had been discontinued because of chieftaincy disputes and conflict over ownership of cave lands. Traditional authorities in Kwamang and Forikrom did not report similar cultural activities in connection with bats.

Regular human activities were directly observed at all cave sites, including the Mprisi (Figure 2, panel A) and Dwamerewa caves in Bouyem, Boten cave in Forikrom, and Mframabuom and Ohene Abutia caves in Kwamang (Figure 2, panel B). The Ohene Abutia cave served as one of the major water sources in the Kwamang community. Several caves served as spiritual sanctuaries. Focus group discussions were conducted in all communities (online Technical Appendix, <http://wwwnc.cdc.gov/EID/article/21/8/14-2015-Techapp1.pdf>).

Structured household survey questionnaires were received back from 1,274 respondents: 32.3% from Buoyem, 28.4% from Forikrom, and 39.2% from Kwamang. Contact with bats was reported by 841 (66%) respondents; bat bites, scratches, or urine exposure was reported by 476 (37.4%) respondents. Almost half (594 [46.6%]) of respondents visited bat caves frequently; 217 (17%) reported coming into contact with bats only in their normal living or work environment (Table). The proportion of respondents who deliberately visited caves was significantly higher than the proportion exposed only in their living and work environments ($p < 0.001$).

Bat species identification was based on observations and standard illustrated field guides (10). Focus group participants identified bats species by using standard images of species recorded from each study site. Observed insectivorous bats included *Nycteris* spp. (Nycteridae), *Hipposideros jonesi*, *H. aff. Ruber*, *H. gigas*, and *H. abae* (Hipposideridae); observed fruit bats included *Hypsignathus monstrosus*, *Rousettus aegyptiacus*, and *Eidolon helvum* (Pteropodidae). These bat species are known to carry coronaviruses (particularly Hipposideridae bats) (11); hantaviruses (particularly Nycteridae bats) (12); paramyxoviruses, including henipavirus (13); and filoviruses (14).

Trading of roasted and fried bats was widely observed in market places (Figure 2, panel C, and Figure 1, panel D). Initial information about the supply routes of bat meat obtained from hunters and members of the indigenous community led to investigation of the bat meat trade at the main market in Techiman. Hunters from the surrounding communities supplied most traded bats. Information gathered from traders showed that the supply route of bat meat extends far beyond the Brong Ahafo region to other regions in Ghana and neighboring countries (Figure 1). Some places mentioned by the traders as sources of bat meat include towns and villages in the Ashanti region. Some of these were Duamo (3 km from Kwamang), Adobomam, Kyekyebon, Kumawu, Deduako, Agogo, and the zoological gardens in Kumasi, where migratory *E. helvum* bats roost

Table. Modes of human–bat contact and purposes of cave visitation, Ghana, 2011–2012

Contact	Community, no. (%)		
	Buoyem, n = 412	Forikrom, n = 362	Kwamang, n = 500
Respondents reporting bat contact	263 (63.8)	244 (67.4)	334 (66.8)
In houses through broken ceilings	69 (16.7)	51 (14.1)	65 (13)
In bat roosts on farms	41 (10)	28 (7.7)	63 (12.6)
In caves	129 (31.3)	161 (44.5)	187 (37.5)
At work places	0	1 (0.3)	0
In school buildings	24 (5.8)	3 (0.8)	5 (1)
In other areas	0	0	14 (2.8)
Respondents visiting bat caves	181 (43.9)	178 (49.3)	222 (44.4)
For religious activities	19 (4.6)	79 (21.8)	5 (1)
For recreation	58 (14.1)	73 (20.2)	46 (9.2)
To collect bat guano	0	14 (3.9)	2 (0.4)
To fetch water	1 (0.2)	0	123 (24.6)
To hunt for bats	102 (24.8)	6 (1.7)	10 (2)
To farm	9 (2.2)	17 (4.7)	33 (6.6)
For other reasons	2(0.5)	5 (1.4)	14 (2.8)

*Data based on focus group discussions and stratified household surveys (online Technical Appendix, <http://wwwnc.cdc.gov/EID/article/21/8/14-2015-Techapp1.pdf>).

seasonally (13). Other areas were in Techiman, Nkoranza, Tanoso, and Tuobodom in the Brong Ahafo region; Afram Plains and Akuapem in the Eastern region, and Accra in the Greater Accra region. Some supplies came from the Northern region and beyond the borders of Ghana from Côte d'Ivoire.

Of the 1,274 respondents, 581 (45.6%) reported having consumed bats. Among these, 257 (44.2%) respondents were from Buoyem, 141 (24.2%) from Forikrom, and 183 (31.5%) from Kwamang (online Technical Appendix Table 1). Of the 581 respondents who ate bat meat, 237 (40.8%) obtained bats from caves, 123 (21.1%) caught bats on farms with bat roosts, 114 (19.6) bought bats from community markets, and 60 (10.3%) bought bats from restaurants as part of meals served. Most respondents described the consumed animals as “big bats,” suggesting that most were fruit bats (Pteropodidae).

To identify the factors associated with bat consumption, we compared determinant variables for the 581 respondents who consumed bats and the 690 who did not (online Technical Appendix Table 2). Bat meat was eaten by a significantly higher percentage of men than women ($p < 0.001$) and a significantly higher proportion of farmers than those with other occupations ($p < 0.001$). To determine the variables that significantly influenced the consumption of bat meat, we entered all significant variables into a logistic regression model. The odds of consuming bat meat were higher for men (odds ratio 2.47; 95% CI 1.93–3.17) than for women and for respondents >25 years of age (odds ratio 4.14; 95% CI 2.91–5.89) than for those ≤25 years of age (online Technical Appendix Table 3).

A second multivariate analysis, conducted to determine factors that predict visitation of bat caves, indicated that older age and male sex were significantly associated with visitation of bat caves (online Technical Appendix). The association between cave visitation and bat consumption

was significant ($\chi^2 = 75.6$; $p < 0.001$); odds of eating bat meat were twice as high among respondents who visited bat caves (odds ratio 2.74) than among those who did not.

Conclusions

The deliberate entry into bat caves represents a prevalent behavior that could be influenced by community-level education in the aftermath of the ongoing outbreak of Ebola virus disease in West Africa. Another obvious target is the widespread bat meat trade and consumption. Further research will be necessary for understanding belief systems and developing acceptable guidance for rural communities exposed to bats because of traditional and spiritual reasons.

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Ms. Anti is an MSc student at Kwame Nkrumah University of Sciences and Technology, Kumasi, Ghana. Her research focuses on the influence of human behavior on zoonotic disease transmission.

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Address for correspondence: Christian Drosten, Institute of Virology, University of Bonn, Sigmund Freud St, 25, 53105 Bonn, Germany; email: drosten@virology-bonn.de


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Technical Appendix

Supplemental Materials and Methods

Focus group discussions

Focus group discussions were organized in each of the study areas to assess the knowledge and cultural beliefs of subjects on bats (1). To ensure unbiased representation from the community, subjects with diverse occupations and economic status were selected. Discussion guides were used to generate open discussions in three key areas: importance of bats, cultural beliefs about bats and negative impacts of bats in the communities. Subjects were organized in 8–12 per group and interviews were conducted by trained field research assistants. General discussions especially on sensitive subjects was led by a group leader selected by participants. The focus group leader concept was used to encourage participants to disclose information freely. Responses obtained from the groups were documented and similar results were aggregated using tallies. All discussions were conducted in the local dialect of respondents.

Stratified random sampling for household surveys

The study site was divided into four areas based on the major roads. Social centers in each quadrant were identified, and every other adjacent house starting from the social center was marked and respondents were interviewed using structured questionnaires. Respondents were from 13 years and above.

Data management and statistical analysis methods

Data was collected on demographics, bat cave-associated activities, contact with bats, bites and scratches from bats and the use of bats for food, medicinal or ritual purposes. An exposure to bats was defined as a bite or scratch from a bat or circumstances such as direct skin contact with a bat, bat urine or guano.

Quantitative data from questionnaires were recorded using EPI INFO version 5 (2), and imported into Microsoft® Excel. Subsequent analysis was performed using R statistical software version 3.0.2 (3). Categorical variables were analyzed using Chi-square or Fischer's

exact test depending on the cell sample sizes being compared. Continuous variables were expressed as medians with their inter-quartile ranges (IQR).

The associated factors influencing the consumption of bat meat and visitation of caves were assessed by entering all variables that were significant at $p < 0.1$ from the bivariate analysis into an unconditional multiple logistic regression model. A backward stepwise approach was used for selection of significant variables from the model. All results were expressed as adjusted odd ratios and 95% confidence interval (CI). For all analysis, a two-sided p-value of less than 0.05 was considered significant.

Technical Appendix Table 1. Sources and processing of bat meat

Community	Buoyem	Forikrom	Kwamang	Tests	TEST*
Respondents	n = 257	n = 141	n = 183		P-value
Sources of bat meat	n (%)	n (%)	n (%)		
Bat Caves	179 (69.6)	10 (7.1)	48 (26.2)	X^2 (2df) = 171	<0.001
Markets	22 (8.6)	23 (16.3)	69 (37.7)	X^2 (2df) = 58.9	<0.001
Bat roost in farms	18 (7)	61 (43.3)	44 (24)	X^2 (2df) = 73.1	<0.001
Homes	8 (3.1)	15 (10.6)	3 (1.6)	X^2 (2df) = 17.1	<0.001
Hunters	28 (10.9)	14 (9.9)	3 (1.6)	X^2 (2df) = 14.1	0.001
Restaurants/Food vendors	25 (9.7)	17 (12.1)	18 (9.8)	X^2 (2df) = 0.6	0.74
Other sources of bat	2 (0.8)	1 (0.7)	7 (3.8)	Fisher's exact	0.046
Respondents mode of catching bats	n (%)	n (%)	n (%)		
Hands	134 (52.1)	1 (0.7)	2 (1.1)	X^2 (2df) = 208.6	<0.001
Guns	15 (5.8)	25 (17.7)	56 (30.6)	X^2 (2df) = 47.7	<0.001
Net	2 (0.8)	20 (14.2)	0	X^2 (2df) = 55.4	<0.001
Sticks	54 (21)	4 (2.8)	12 (6.6)	X^2 (2df) = 36.0	<0.001
Catapult	18 (7)	31 (22)	18 (9.8)	X^2 (2df) = 20.8	<0.001
Other Mode of capture	1 (0.4)	5 (3.5)	8 (4.4)	Fisher's exact	0.004
Type of bat consumed	n (%)	n (%)	n (%)	Fisher's exact	0.991
Big bats	250 (97.3)	137 (97.2)	177 (96.7)		
Small bats	1 (0.4)	1 (0.7)	1 (0.5)		
Not known	6 (2.3)	3 (2.1)	5 (2.7)		
Mode of cooking bats	n (%)	n (%)	n (%)		
Boiling	201 (78.1)	128 (90.8)	120 (65.6)	X^2 (2df) = 29.1	<0.001
Roasting	217 (84.4)	64 (45.4)	144 (78.7)	X^2 (2df) = 74.9	<0.001
Frying	2 (0.8)	0	0	Fisher's exact	0.518
Other modes of bat processing	2 (0.8)	1 (0.7)	0	Fisher's exact	0.603

The proportions of respondents who reported either Yes or No for each categorical variable were compared across the three communities using Fisher's exact test or Chi-square test (X^2) where appropriate. A p-value of less than 0.05 was considered statistically significant. All p-values less than 0.001 were abbreviated to "< 0.001". "df" denotes degrees of freedom.

Technical Appendix Table 2. Factors associated with consumption of bat meat

	Not Consumed bats	Consumed bats	Test	P-value
	n = 690	n = 581		
Variables	n (%)	n (%)		
Gender Male	245 (35.5)	309 (53.2)	X ² (1 df) = 39.4	<0.001
Gender Female	245 (35.5)	309 (53.2)	X ² (1 df) = 39.4	<0.001
Highest level of education - Primary Education	100 (14.5)	69 (11.9)	X ² (1 df) = 1.7	0.199
Highest level of education -JHS Education	192 (27.8)	134 (23.1)	X ² (1 df) = 3.5	0.061
Highest level of education - SHS Education	210 (30.4)	179 (30.8)	X ² (1 df) = 0.01	0.934
Highest level of education - Tertiary Education	25 (3.6)	20 (3.4)	X ² (1 df) <0.001	0.983
Christians	640 (92.8)	531 (91.4)	X ² (1 df) = 0.6	0.428
Muslims	30 (4.3)	6 (1)	X ² (1 df) = 11.4	<0.001
Traditionalists	4 (0.6)	5 (0.9)	X ² (1 df) = 0.07	0.796
Belonging to other religions	14 (2)	34 (5.9)	X ² (1 df) = 11.7	<0.001
Age groups of respondents			X ² (2 df) = 137.5	<0.001
10 - 25	305 (44.6)	90 (15.6)		
26 - 45	195 (28.5)	187 (32.4)		
46 - 115	184 (26.9)	301 (52.1)		
Students	191 (27.7)	52 (9)	X ² (1 df) = 70.4	<0.001
Farmers	226 (32.8)	359 (61.8)	X ² (1 df) = 105.9	<0.001
Teachers	11 (1.6)	21 (3.6)	X ² (1 df) = 4.5	0.035

The proportions of respondents who reported either Yes or No for each categorical variable were compared between those who consumed bats and those who did not using Fischer's exact test or chi-square test where appropriate. A p-value of less than 0.05 was considered statistically significant. All p-values less than 0.001 were abbreviated as "<0.001." JHS: Junior High School; SHS: Senior High School and df = degrees of freedom.

Technical Appendix Table 3. Final multivariate model

Predictors of bat consumption				
Variables	Crude OR (95% CI)	Adj OR (95% CI)	P (Wald's test)	P (LR-test)
Age Group ref (10 - 25)				<0.001
26 - 45	3.25 (2.39, 4.43)	2.79 (1.98, 3.91)	<0.001	
46 - 115	5.54 (4.11, 7.47)	4.14 (2.91, 5.89)	<0.001	
Gender ref (Female)	2.04 (1.63, 2.56)	2.47 (1.93, 3.17)	<0.001	<0.001
Farming ref (Not Farming)	3.27 (2.6, 4.13)	1.93 (1.46, 2.55)	<0.001	<0.001
Predictors of cave visitation				
	Crude OR (95% CI)	Adj OR (95% CI)	P (Wald's test)	P (LR-test)
Age Group ref (10 - 25)				<0.001
26 - 45	1.5 (1.13, 2)	1.57 (1.17, 2.1)	0.003	
46 - 115	2.01 (1.53, 2.64)	2.08 (1.58, 2.74)	<0.001	
Gender ref (Female)	1.69 (1.35, 2.12)	1.74 (1.38, 2.19)	<0.001	<0.001

P-values less than 0.001 were abbreviated as "<0.001." Crude OR represents crude odds ratio, Adj OR represents adjusted odds ratio and LR represents likelihood ratio test.

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