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), 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.
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 Mmframabuom 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 Bouyem, 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), Hippo- siders 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, Kyekye- bon, Kumawu, Deduako, Agogo, and the zoological gardens in Kumasi, where migratory E. helvum bats roost.
seasonally (13). Other areas were in Techiman, Nkoranza, Tanoso, and Tuobodom in the Brong Ahafo region; Afiram 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 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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The first issue of the Emerging Infectious Diseases journal was released in February 1995 — 20 years ago next month. Click here to see the CDC/NDLICD announcement of this now historic event.

**Emerging Infectious Microbial Threats to Health in the United States**

In the early 1990s, Joshua Lederberg was a champion and advocate for emerging infectious diseases. He strongly believed that a need existed for a vigorous CDC response. With this goal in mind, he met with leadership at CDC and co-chaired one of the first meetings in the early 1990s to strategize on how to meet these needs.

**Color Has Arrived**

Cover and pages image were added to EID journal covers after two years of publication. Previous covers were merely grey and white tables of contents. Founding CDC managing editor, Whitney Ritter, said “I think that we felt it was better with the color cover of the journal—it made it more attractive and interesting so that readers would recognize it and pick it up.”

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Etymology is concerned with the origins of words, how they’re pronounced over time, and changed in form and meaning as they were translated from one language to another.

**EMERGING INFECTIOUS DISEASES**

http://go.usa.gov/3w9X6
Human–Bat Interactions in Rural West Africa

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 n = 257 | Forkrom n = 141 | Kwamang n = 183 | Tests | \( \chi^2 \) (2df) | P-value |
|-------------|-----------------|-----------------|-----------------|-------|-------------------|---------|
| **Sources of bat meat** | | | | | | |
| 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** | | | | | | |
| 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** | | | | | | |
| Big bats    | 250 (97.3)      | 137 (97.2)      | 177 (96.7)      | Fisher's exact | 0.991  |
| Small bats  | 1 (0.4)         | 1 (0.7)         | 1 (0.5)         | Fisher's exact | 0.874  |
| Not known   | 6 (2.3)         | 3 (2.1)         | 5 (2.7)         | Fisher's exact | 0.518  |
| **Mode of cooking bats** | | | | | | |
| 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 Fischer'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

| Variables                                      | Not Consumed bats | Consumed bats | Test | P-value |
|------------------------------------------------|-------------------|---------------|------|---------|
|                                                 | n = 690           | n = 581       |      |         |
| Gender Male                                     | 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) = 3.5  | 0.199  |
| Highest level of education - JHS Education      | 192 (27.8)        | 134 (23.1)    | $X^2$ (1 df) = 0.01 | 0.934  |
| Highest level of education - SHS Education      | 210 (30.4)        | 179 (30.8)    | $X^2$ (1 df) = 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) = 0.07 | 0.796  |
| Traditionalists                                 | 4 (0.6)           | 5 (0.9)       | $X^2$ (1 df) = 11.7 | <0.001 |
| Belonging to other religions                    | 14 (2)            | 34 (5.9)      | $X^2$ (1 df) = 137.5| <0.001 |
| Age groups of respondents                       | 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)                        |                   |                 |                 |             |
| 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

| Variables                                      | Crude OR (95% CI) | Adj OR (95% CI) | P (Wald's test) | P (LR-test) |
|------------------------------------------------|-------------------|-----------------|-----------------|-------------|
| Age Group ref (10 - 25)                        |                   |                 |                 |             |
| 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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