PUBLICATION INFORMATION

2

3   **Understanding the influence of non-wealth factors in determining**

4   **bushmeat consumption: results from four West African countries**

5

6   Luca Luiselli[a,b], Emmanuel M. Hema[c], Gabriel Hoinsoudé Segniagbeto[d], Valy Ouattara[e],

7   Edem A. Eniang[f], Massimiliano Di Vittorio[g], Nioking Amadi[b], Gnoumou Parfait[c], Nic

8   Pacini[h,i], Godfrey C. Akani[b], Djidama Sirima[c], Wendengoudi Guenda[c], Barineme B.

9   Fakae[a,b], Daniele Dendi[a,b], John E. Fa[j,k]

10

11   [a] IDECC - Institute for Development, Ecology, Conservation and Cooperation, via G. Tomasi di Lampedusa

12   33, I-00144 Rome, Italy.

13   [b] Department of Applied and Environmental Biology, Rivers State University of Science and Technology,

14   P.M.B. 5080, Port Harcourt, Nigeria.

15   [c] Université Ouaga 1 Professeur Joseph KI-ZERBO/CUPD, Laboratoire de Biologie et Ecologie Animales, 09

16   B.P. 848 Ouagadougou 09 - Burkina Faso.

17   [d] Department de Zoologie, Université de Lomé, Lomé, Togo.

18   [e] Groupe des Expert en Gestion des Eléphants et de la Biodiversité de l'Afrique, de l'Ouest, Ouagadougou,

19   Burkina Faso.

20   [f] Department of Forestry and Wildlife, University of Uyo, Akwa-Ibom State, Nigeria

21   [g] Ecologia Applicata Italia s.r.l., via E. Jenner 50, Rome, Italy.

22   [h] Department of Environmental and Chemical Engineering, University of Calabria, Arcavacata di Rende (CS),

23   Italy.

24   [i] Centre for Landscape and Climate Research, University of Leicester, UK.

25   [j] Division of Biology and Conservation Ecology, School of Science and the Environment, Manchester

26   Metropolitan University, Manchester M1 5GD, UK.

27   [k] Center for International Forestry Research (CIFOR), Jalan Cifor Rawajaha, Situ Gede, Bogor Barat, Kota

28   Bogor, Jawa Barat 16115, Indonesia.

29   **Abstract**

30   The meat of wild animals (bushmeat) is consumed extensively in many tropical regions.

31   Over the past few decades bushmeat consumption has greatly increased, threatening the

32   survival of some hunted species and the supply of animal protein to countless numbers of

33   people. Understanding patterns of bushmeat consumption is thus vital to ensure the

34   sustainable use of this resource. Although the economic drivers of bushmeat consumption

35   has been well studied, non-wealth correlates have been poorly considered. Here, we analyse

36   how factors such as age and gender influence bushmeat consumption in four West African

37   countries, within the Guinean forests (Togo and Nigeria) and Sahel (Burkina Faso and

38   Niger). We interviewed a total of 2,453 persons (1,253 urban, 1,200 in rural areas) to

39   determine frequency of consumption of bushmeat as well as main species eaten. We found

40   significant differences in bushmeat consumption between rural and urban areas in all four

41   countries. In particular, the proportion of persons not consuming any bushmeat was highest

42   in urban areas. Gender differences in bushmeat consumption was not generally important

43   but young people consistently avoided eating bushmeat, especially in Togo and Nigeria, and

44   in urban areas. The complicated interplay between tradition and evolution of social systems

45   (especially the trends towards westernization) may explain the different perceptions that

46   people may have towards consuming bushmeat in the four studied countries. In addition, we

47   found considerable variation in types of bushmeat eaten, with antelopes and large rodents

48   eaten by the great majority of interviewees, but bats, monkeys, and snakes being avoided,

49   especially in urban settlements.

52

1.   Introduction

Terrestrial wild vertebrates are central to the nutritional wellbeing of many rural people, particularly those inhabiting the world's tropical regions (Fa et al., 2002; Golden et al., 2011). This reliance on wild meat is as much a consequence of the lack of alternative domestic meat resources (Mainka & Trivedi 2002; Nasi et al. 2008), as much as it is an attribute of centuries-old cultural traditions (Milner-Gulland et al., 2003). However, although wild animals have been hunted for millennia, their consumption has greatly increased over the past few decades (Nasi et al., 2011). In West and Central Africa, commercial hunting, especially to supply large urban centres, has risen dramatically, largely driven by a human population growth of 2–3% per year (Nasi et al., 2011). Such intensification of demand for bushmeat will have fatal consequences for many species but particularly large-bodied and slow-growing species if extraction exceeds their replacement rate (Wilkie et al., 2001). Indeed, the decline of some species as a consequence of bushmeat extraction has already been documented for tortoises (Luiselli, 2003) and antelopes (Fischer and Linsenmair, 2001; Grande-Vega et al., 2016; Hema et al., 2017). As a consequence, loss of wildlife may threaten the food security of many marginalized forest foragers, and farmer-forager communities that are isolated from markets and depend on bushmeat as their primary protein source (Eves and Ruggiero, 2001).

Few studies have centred on understanding why people eat bushmeat. Knowning what motivates people to eat bushmeat can help in developing politically acceptable ways to manage wildlife hunting and trading with the aim of halting unsustainable exploitation. Bushmeat may be eaten because it is cheaper or there are no alternatives available in the market place (Apaza et al., 2002; Wilkie and Godoy, 2001), because consumers prefer the taste of wildlife (Chardonnet et al., 1995; Trefon and de Maret, 1999) or to add variety to the diet and for special social events and occasions (Njiforti, 1996). Despite this variety of

78   possible reasons that may motivate buyers to eat bushmeat, most studies have focused on the

79   socioeconomic background of consumers as the main reason underpinning their choice (e.g.

80   Wilkie and Godoy, 2001; Brashares et al., 2011). In general, wealthier households consume

81   more bushmeat in settlements nearer urban areas, but the opposite pattern is observed in

82   more isolated settlements (Brashares et al., 2011). Nonetheless, Brashares et al. (2011) also

83   indicate that household wealth is only weakly linked to wildlife consumption, and thus such

84   a lack of a strong correlation could be explained by the undisclosed importance of other

85   factors e.g. spatial differences in wealth. Thus, understanding what may influence

86   consumption patterns, other than wealth, are urgently needed to disentangle the part played

87   by ecological, socioeconomic and cultural factors. Recent studies have shown that price and

88   income have significant roles in determining the level of consumption of bushmeat, fish,

89   chicken, and beef (Apaza et al., 2002; Wilkie and Godoy, 2001; Wilkie et al., 2005).

90   However, few investigations have focused on how bushmeat consumption is affected by

91   geographic location, gender or age of consumers; all attributes of a population that reflect

92   cultural influences (Hema et al., 2017; Luiselli et al., 2017).

93   Household surveys have been extensively used to understand potential linkages

94   between conservation and local livelihoods. Studies reporting on the amounts and

95   preferences of bushmeat consumed have focussed on the collection of quantitative

96   household-level data and have been useful in determining possible socioeconomic

97   characteristics of a community that may be linked to bushmeat consumption. However,

98   household surveys have both theoretical and logistical weaknesses. Logistically, these

99   surveys can be costly in terms of time and resources especially if adequate sample sizes are

100   collected. Theoretically, a given household often includes resident of different ages (from

101   over 80 to less than 5 years old) and scholarization levels (from complete illiteracy to

102   university-level students), and these may be linked to contrasting lifestyles and points of

103   view, including their perception towards bushmeat consumption (Luiselli et al., 2017). Thus,

104   focusing on just households can introduce biases to the overall conclusions. To avoid these

105   biases face-to-face interviews allow the collection of large amounts of qualitative

106   information that can be used to ascertain bushmeat consumption levels and factors that may

107   affect these. Here we use interview responses from inhabitants of rural communities and

108   urban centres in a number of localities in four West African countries to: 1) quantify the

109   frequency of consumption of bushmeat, 2) determine the influence of gender and age, and 3)

110   assess whether location (rural/urban; in forest versus in savannah habitats), and country

111   influenced bushmeat consumption.

112

113   **2.   Methods**

114   *2.1.   Study sites*

115   We interviewed a total of 2,453 individuals (1,253 urban, 1,200 in rural areas) from

116   27 separate human settlements in Nigeria, Togo, Burkina Faso and Niger (Fig. 1). Study

117   localities in Nigeria and Togo were located within the Guinean Forests of West Africa

118   region; swamp forest and moist rainforest vegetation zones in southern Nigeria (Niger Delta

119   Environmental Survey, 1998; Oates et al., 2004) and in the deciduous moist forest zone of

120   southwestern Togo (Ern, 1979). Sites in Burkina Faso and Niger were found within the

121   Sahel, in Sudanian and Sahel Acacia savannahs (Thiombiano and Kampmann, 2010).

122

123   *2.2.   Interviews*

124   To obtain information on bushmeat use, we conducted face-to-face interviews using

125   a standardized questionnaire. All data were gathered during 2012-2016. We selected

126   interviewees at marketplaces, roadsides, canteens, restaurants, hairdressing salons, food

127   shops, and other gathering places. We stopped the first person we encountered after a given

128   time period (in minutes); the time interval was randomly generated by a Random Number

129   Generator. Local scientists (VO, NA, GP, DS, WG, EAE and other students) performed all

130   interviews. All interviewees were informed of the aims of the project and their consent was

131   obtained before proceeding. All interviews were conducted in the local language.

132   We interviewed persons in Ouagadougou, Niamey, Lomé, Benin City, Port Harcourt,

133   Calabar (all cities with more than 500,000 residents) as well as in rural villages (500 to

134   25,000 inhabitants, apart from Pama that has about 40,000 inhabitants). We recorded the

135   interviewees' gender (male or female) and age (≤ 25 years, 26-50 years, ≥ 51 years) but not

136   their names (St. John, 2010; Nuno et al., 2014; Luiselli et al., 2017). To avoid non-

137   independence of the data, we never interviewed two persons of the same family or those

138   living in the same house, even if they were not relatives (see also Hema et al., 2017, for

139   similar procedure).

140   Interviewees were asked the following two questions: (1) Do you like eating

141   bushmeat? (2) If yes, how often do you eat bushmeat? Interviewees would then be asked if

142   they ate bushmeat frequently (at least once a week), rarely (about once per month or less) or

143   never. Persons who answered that they consumed bushmeat only occasionally were then

144   asked whether they selected the type of animal orwhether they would just buy/eat whatever

145   kind of bushmeat was available.

146   *2.3.   Statistical analyses*

147   We employed Generalized Linear Models (GLZs) to determine the relationship

148   between bushmeat consumption frequency and site (rural versus urban), gender

149   (male/female) and age classes (three categories) (Hosmer and Lemeshow, 2000). The codes

150   for the variables used in the GLZs are given in Appendix 1. In the model, the response

151   "never eat bushmeat" was the dependent variable (i.e. consumption data were converted into

152   a binary variable, 1 = eat (often or rarely) and 0= never eat bushmeat) and the identity of the

153   link function and a normal distribution of error were used (McCullagh and Nelder, 1989).

154   Three age categories were used for all analyses: persons aged less than 25, aged less than 50,

155 and aged 51 years or more. In the GLZ models, a stepwise forward regression procedure was

156 used to test the statistical significance of each variable in turn, and variables were excluded

157 when they did not correlate significantly with the dependent variable (Wald test P > 0.05).

158   To explore deviance and hierarchical partitioning, the selected variables were

159 analyzed in order to determine the comparative influence of each variable (Borcard et al.,

160 1992). The decomposition of the variation into subsets of explanatory variables was carried

161 out by means of a partial regression analysis (Legendre and Legendre, 1998).

162   Frequency differences between groups of interviewed people were analyzed using

163 the χ^2 test, for comparing both differences among frequently-eating, rarely-eating and non-

164 eating bushmeat respondents, and for determining differences in terms of type of bushmeat

165 eaten. The statistical software PASW 11.0 was used for all analyses, and alpha was set at

166 5%.

167

168 **3.**   **Results**

169 *3.1.*   *General patterns*

170   A summary of the data gathered for this study is shown in Table 1, the raw dataset is

171 given in Appendix 2. In general terms, bushmeat was consumed more often by rural than

172 urban interviewees in all countries (Fig. 2). An average total of 70.3 ± 15.7% of rural

173 respondents answered that they ate bushmeat (either eaten rarely or often) in contrast to only

174 42.8 ± 19.0% of urban interviewees. In all countries more rural than urban respondents ate

175 bushmeat; 1.59 times more in Niger, 1.26 times more in Nigeria, 0.46 times in Togo and

176 0.14 times in Burkina Faso.

177   A general GLZ model using data from all countries pooled and type of bushmeat

178   eaten as the dependent variable showed that, the probability of eating ungulates or birds was

179   significantly affected by gender or age of the respondents respectively, while the eating of

180   monkeys, bats, carnivores, crocodiles, snakes and turtles was influenced by the age of the

181   respondents and their urban/rural location (Table 2).

182   We found significant differences in responses between interviewees in Guinean

183   forests and the Sahel region. Age classes, followed by urban/rural location, accounted for

184   the strongest pure effect in the Sahelian localities with gender explaining only a very small

185   proportion of the variance (Fig. 3). Within the Guinean forest localities, urban/rural location

186   was the predominant effect, age had a lesser relevance in terms of explained variance, but

187   gender had almost no effect (Fig. 3).

188   We found a significant effect of distance (in km) of the interviewee to the nearest

189   urban area where the probability of never-eating bushmeat increased in Sahelian countries,

190   but not in the two countries within the Guinean forest region (for Sahel: GLZ estimate =

191   6.56, standard error = 1.34, Wald = 24.0, $P < 0.0001$; for age classes: estimate = -7.62,

192   standard error = 2.32, Wald = 10.79, $P < 0.001$; for Guinean forests: in all cases $P > 0.165$).

193   *3.2.   Country effects*

194   Our GLZ model revealed that effect of country on bushmeat consumed were

195   relatively minor (Table 2). Nonetheless, country had a statistical effect on the consumption

196   of primates, with people from the Guinean Forests countries being more likely to eat

197   monkeys than people in the Sahel (Table 2). Thus, apart from primates, there were no other

198   statistical differences between areas of Guinean forest countries and Sahelian countries in

199   terms of the probability of consuming the various types of bushmeat.

200   Overall, there were no significant differences between countries (in all cases, at least

201      $P > 0.225$ at χ^2 test) in the proportion of those respondents who declared that they never ate

202   bushmeat (Table 3) as well as in those that declared to frequently eat bushmeat (Table 4).

203   However, there were clear confounding effects of age, gender and urban/rural location on

204   the pure effect of the country (see below). Overall, patterns for the frequency of 'often-

205   eaten-bushmeat' responses were more consistent among countries than in the 'never-eating-

206   bushmeat' answers (Table 4).

207   In Togo, there was a significant effect of age in urban and rural areas; the frequency

208   of respondents never-eating bushmeat declined significantly with age in both locations

209   (Table 3). No effect of gender was found, but the differences between rural and urban areas

210   depended on the strength of the frequency decreases of never-eating-bushmeat respondents

211   in these two locations, i.e. rural and urban people in Togo tended to respond similarly. In

212   Nigeria (Table 3), there was no effect of age in urban areas (people do not eat bushmeat in

213   general) but in rural areas (only young people did not eat bushmeat). In addition, there was a

214   significant effect of gender in urban areas, with women avoiding eating bushmeat more than

215   men. The overall differences between rural and urban areas were significant for both gender

216   and age (Tables 3 and 4). In Burkina Faso, there was a significant effect of age in urban

217   areas (more young people did not eat bushmeat) but not for rural areas, where people do

218   generally eat bushmeat independent of their age (Tables 3 and 4). In Niger, there was only a

219   significant effect of age, with more young people responding that they would never eat

220   bushmeat compared to older people, in both urban and rural locations (Table 3).

221   *3.3.*   *Age effects*

222   Our GLZ model revealed that the age of the interviewees affected the probability of

223   consuming primates, bats, carnivores, crocodiles, snakes and chelonians, in all cases older

224   people were more likely to consume these animals than younger people (Table 2).

225   Overall, age had a significantly stronger effect on the likelihood of consuming

226   bushmeat in the Sahelian region compared to the Guinean forest region (Fig. 3).

227   Nonetheless, the tendency was the same in both regions: young people tended to never or

228   very rarely consume bushmeat significantly more than people of >25 years age ($P < 0.001$ at

229   χ^2 test).

230

231   *3.4.   Gender effects*

232   Overall, gender effects were negligible in both Sahelian and Guinean forests regions,

233   and contributed little to the hierarchical variance partitioning in the interview dataset (Figure

234   3). Nonetheless, some effects of gender were detected in the attitude of consuming a few

235   types of bushmeat as well as in a few local contexts. Indeed, although most people ate

236   ungulates and rodents, there were significant effects of gender on the consumption of these

237   animals, with men being more likely to eat them than women (Table 2). In addition, females

238   tended to avoid eating bushmeat more frequently than males in some countries such as

239   Nigeria. However, this was not a pure gender effect, as it was mediated by age and

240   rural/urban condition in a rather complicated way (Tables 3 and 4). Overall, the 'often-

241   eating-bushmeat' response was especially linked to men in either Guinean forests (e.g.Togo)

242   or Sahel (e.g. Burkina Faso) regions.

243

244   *3.5.   Rural versus urban*

245   Whether living in rural or urban locations determined the outcome of the

246   interviewees' answers in the Guinean forest region but not in the Sahelian region (Fig. 3). In

247   other words, attitude towards bushmeat of people from Sahelian regions was similar in both

248   rural and urban locations, whereas in the Guinean forest region there were differences

249   between locations. In addition, in terms of frequency of never-eating bushmeat people,

250   statistical differences between rural versus urban conditions were much higher ($P < 0.001$ at

251   χ^2 test) than those occurring between countries (see above). Whether a person lived in an

252   urban or rural location affected the probability of consuming bushmeat much more than their

253   country of residence.

254   A total of 41.9% of urban and 67.3% of rural respondents stated they consumed

255   bushmeat (Fig. 4); this difference being significant ($\chi^2 = 231.9$, df = 2, $P < 0.0001$).

256   According to the different response categories, most interviewees in rural areas mentioned

257   they frequently ate bushmeat ($\chi^2 = 7.3$, df = 2, $P < 0.05$), but in urban areas most said they

258   never ate bushmeat ($\chi^2 = 193.4$, df = 2, $P < 0.0001$).

259   Overall, ungulates and rodents were eaten by almost all respondents in either rural or

260   urban areas, but carnivores, monkeys and snakes were eaten rarely (differences significant at

261    $P < 0.00001$ compared to ungulates and rodents, χ^2 test), and mainly in rural areas (Fig. 5).

262   Contingency table analysis showed that there were no significant differences between urban

263   and rural areas in terms of frequency of respondents eating the various bushmeat types ($\chi^2 = $

264   14.48, df = 8, P = 0.0699). However, our GLZ model revealed that primates, bats,

265   carnivores, crocodiles, snakes and chelonians were significantly more likely to be eaten by

266   rural than by urban people, with the highest estimates being for monkeys and bats (Table 2);

267   it was unlikely that people from urban areas, in any of the surveyed countries, ate monkeys

268   and bats.

269   Differences between urban and rural areas were also strongly mediated by the effects

270   of age and gender (Tables 3 and 4). Overall, there were significant differences in both

271   gender and age between rural and urban areas.

272   **4.   Discussion**

273   Previous studies have suggested that bushmeat was universally preferred "due to its superior

274   taste" (King, 1994) and thus African communities therefore preferred and thus primarily ate

275   bushmeat. These statements were not based on empirical evidence until a study reporting on

276   two-choice taste tests showed that consumers in Gabon had only a weak preference for

277   bushmeat and only rural consumers consistently preferred bushmeat over alternatives

278   (Schenck et al., 2006). This result is particularly important given that it manifests that even

279   though basic desires such as hunger and the need for nourishment can influence food choice,

280   availability and cultural norms also affect these. Thus, it is not simply taste that is driving

281   demand for bushmeat, but that price or other culturally mediated factors such as familiarity,

282   tradition, and prestige play a role.

283   Our analyses indicate a very clear and significant difference in bushmeat

284   consumption among rural and urban peoples in all countries. This effect appeared in 7 out

285   of 7 models, in all four of the investigated countries. This difference has been demonstrated

286   in a number of other studies in the African continent (e.g. in the Democratic Republic of

287   Congo, see Van Vliet et al., 2014) and in Madagascar (Jenkins et al., 2011). This contrast

288   between rural and urban dwellers is largely explained by the availability of bushmeat versus

289   alternative protein sources. Rural dwellers are usually restricted in terms of the availability

290   and accessibility of domestic meats but in a much better position to option these resources

291   from the wild. By contrast, urban dwellers have greater access to alternative proteins (Apaza

292   et al., 2002). Nonetheless, cultural complications also explain the preference of non-

293   bushmeat proteins by urban people (see Luiselli et al., 2017 and below).

294   Our analyses clearly showed that age was important in most countries; the pure effect

295   of age was significant in 5 out of 7 models, in Nigeria, Togo and Niger. Younger

296   interviewees generally ate less bushmeat than older persons. That young people ate less

297   bushmeat can in part be due to a growing 'westernization' of the lifestyles, especially among

298   the middle classes. These sector of the community often do not see it as 'socially acceptable'

299   to consume bushmeat, since this is perceived by them as a sign of 'being very local' (i.e. not

300   culturally advanced). In contrast the eating of 'fast foods' (hamburgers, pizza, kebab, etc.) is

301   now the favourite 'social diet' of young people. This pattern is especially evident in urban

302   Nigeria and Togo (our unpublished observations), where young interviewees not only

303   declared that they would not eat bushmeat, but even commented that eating bushmeat was

304   not acceptable because it produces a loss of personal prestige within their circle of friends.

305   In this regard, it was particularly interesting that, among the rarely-eating bushmeat urban

306   people, a sample of 7 young (<25 years) persons from Togo and 15 from Nigeria declared

307   that they would never eat bushmeat in public, but that very occasionally they do during

308   private family events, and only when they visit their rural relatives. Thus, among the

309   respondents who declared that they rarely ate bushmeat, many would only consume

310   bushmeat in special circumstances. We suggest that in urban areas the lower consumption of

311   bushmeat is not because of lack of access, but that it responds to a more culturally-driven

312   avoidance in response to the changing socio-economic context.

313   By contrast to the effects of age we observed in our study, the pure effect of gender

314   was only apparent in 1 out of 7 models. In terms of mixed factors, 'Gender X Rural/Urban'

315   were significant in 4/7 models and 'Age X Rural/Urban' were significant in 5/7 models,

316   whereas 'Gender X Age' in 2/7 models. From these results, we conclude that rural/urban

317   and age are much more important than gender in determining the probability for a person to

318   consume bushmeat. The non-effect of gender is probably related to the enhanced equal

319   rights of women and men in West African societies (especially in Nigeria), with young

320   generations being much more equal in terms of gender and lifestyle (see Gender Equality

321   Index database by the African Development Bank, available at www.afdb.org). Thus, since

322   young men and women typically share a similar life-style (especially in urban areas), even

323   their food preferences tend to be very similar.

324   Since, in all countries, and in urban areas in particular, most of the young

325 respondents stated they never ate bushmeat, this would suggest that bushmeat consumption

326 has been substantially decreasing among the new generations of West Africans,

327 independently on their local culture, religion, ethnicity and level of human development. In

328 Nigeria, where the level of human development (average wealth and scholarization

329 standards) are clearly higher than in the other countries (the country being the 22th economy

330 of the world; World Bank, 2016), only older people in rural areas (age > 51 years) answered

331 that they consumed bushmeat more regularly (Table 2).

332   Although our study is the first to cover a broad spectrum of situations, it is important

333 to note that bushmeat trade analysis are much easier to undertake in the Guinean forests

334 region (such as Ivory Coast, Ghana, Nigeria; e.g. see Fa et al., 2002a, 2002b, 2006) than in

335 Sahel. This difference is related to the fact that in the Sahel region there are no open

336 bushmeat markets and people here may be more reluctant to answer interviewers openly

337 because of social norms (Hema et al., 2017, but see Lindsey et al. 2013). This is also

338 possibly linked to the fact that forest can occur close to urban areas in the Guinean Forest

339 region (e.g., Niger Delta forests surrounding Port Harcourt), whereas the same is not true in

340 the Sahel where all the forested or mature savannah sites (from which most of the bushmeat

341 trade does originate) are situated far from larger urban centres (our unpublished

342 observations). Therefore, 'hub' markets (Akani et al., 2015) are more likely to be found

343 nearby large cities in the forest zone than in the savannah zone. In conclusion, we argue that

344 the cultural drivers of wildlife use are crucial to take into account when seeking long-term

345 sustainability solutions of wildlife resource extraction (e.g., Luiselli et al., 2017).

346

349   Development, Ecology, Conservation and Cooperation (Rome), Mohamed Bin Zayed

350   Species Conservation Fund, Conservation International, Turtle Conservation Fund, Andrew

351   Sabin & Family Foundation, T.S.K.J. Nigeria Ltd., IUCN/SSC TFTSG, Aquater s.p.a. and

352   Snamprogetti s.p.a. for having funded our field projects in the studied countries.

353   **References**

354   Akani, G.C., Amadi, N., Eniang, E.A., Luiselli, L. & Petrozzi, F., 2015. Are mammal

355   communities occurring at a regional scale reliably represented in "hub" bushmeat

356   markets? A case study with Bayelsa State (Niger Delta, Nigeria). Folia Zoologica, 64,

357   79–86.

358   Borcard, D., Legendre, P., Drapeau, P., 1992. Partialling out the spatial component of

359   ecological variation. Ecology, 73, 1045-1055.

360   Brashares, J.S., Golden, C.D., Weinbaum, K.Z., Barrettc, C.B., Okello, G.V., 2011.

361   Economic and geographic drivers of wildlife consumption in rural Africa. Proc. Natl.

362   Acad. Sci. U.S.A. 108, 13931–13936.

363   Ern, H., 1979. Vegetation Togos. Gliederung, Gefährdung, Erhaltung. Willdenowia 9, 295-

364   312.

365   Fa, J.E., Peres, C., Meeuwig, J., 2002a. Bushmeat exploitation in tropical forests: an

366   intercontinental comparison. Conserv. Biol. 16, 232-237.

367   Fa, J.E., Seymour, S., Dupain, J., Amin, R., Albrechtsen, L., Macdonald, D., 2006. Getting

368   to grips with the magnitude of exploitation: Bushmeat in the Cross-Sanaga rivers

369   region, Nigeria and Cameroon. Biol. Conserv. 129, 497–510.

370   Fa, J.E., Juste, J., Burn, R.W., Broad, G., 2002b. Bushmeat consumption and preferences of

371   two ethnic groups in Bioko Island, West Africa. Human Ecol. 30, 397–416.

372   Fischer, F., Linsenmair, K.E., 2001. Decreases in ungulate population densities. Examples

373   from the Comoé National Park, Ivory Coast. Biol. Conserv. 101, 131–135.

374   Golden, C.D., Fernald, L.C.H., Brashares, J.S., Rasolofoniaina, B. J. R., Kremen, C., 2011.

375   Benefits of wildlife consumption to child nutrition in a biodiversity hotspot. Proc. Natl.

376   Acad. Sci. USA 108, 19653–19656.

377   Grande-Vega, M., Farfan, M.A., Ondo, A., Fa, J.E., 2016. Decline in hunter offtake of blue

378   duikers in Bioko Island, Equatorial Guinea. Afr. J. Ecol. 54, 49–58.

379   Hema, E.M., Ouattara, V., Parfait, G., Di Vittorio, M., Sirima, D., Dendi, D., Guenda, W.,

380   Petrozzi, F., Luiselli, L., 2017. Bushmeat consumption in the West African Sahel of

381   Burkina Faso based on interview campaigns, and the decline of some consumed

382   species. Oryx, https://doi.org/10.1017/S0030605316001721.

383   Hosmer, D.W., Lemeshow, S., 2000. Applied logistic regression analysis. 2nd ed. John

384   Wiley and Sons, New York.

385   Jenkins, R.K., Keane, A., Rakotoarivelo, A.R., Rakotomboavonjy, V., Randrianandrianina,

386   F.H., Razafimanahaka, H. et al., 2011. Analysis of patterns of bushmeat consumption

387   reveals extensive exploitation of protected species in Eastern Madagascar. PLoS

388   ONE 6(12), e27570.

389   Legendre, P., Legendre, L., 1998. Numerical ecology. Elsevier Science. Amsterdam,

390   Netherlands.

391   Lindsey, P., Balme, G., Becker, M., Begg, C., Bento, C., Bocchino, C., Dickman, A.,

392   Diggle, R., Eves, H., Henschel, P., Lewis, D., Marnewick, K., Mattheus, J., McNutt,

393   J.W., McRobb, R., Midlane, N., Milanzi, J., Morley, R., Murphree, M., Nyoni, P.,

394   Opyene, V., Phadima, J., Purchase, N., Rentsch, D., Roche, C., Shaw, J., van der

395   Westhuizen, H., Van Vliet, N., Zisadza, P., 2012. Illegal hunting and the bush-meat

396   trade in savanna Africa: drivers, impacts and solutions to address the problem.

397   Panthera/Zoological Society of London/Wildlife Conservation Society report, New

398   York.

399   Luiselli, L., Petrozzi, F., Akani, G.C., Di Vittorio, M., Amadi, N., Ebere, N., Dendi, D.,

400   Amori, G., Eniang, E.A., 2017. Rehashing bushmeat –interview campaigns reveal

401   some controversial issues about the bushmeat trade dynamics in Nigeria. Rev. Ecol.

402   (Terre et Vie) 72, 3-18.

403   Mainka, S. A., Trivedi, M., 2002. Links between biodiversity conservation, livelihoods and

404   food security: the sustainable use of wild species for meat. IUCN, Gland,

405   Switzerland.

406   McCullagh, P., Nelder, J.A., 1989. Generalized linear models. Chapman and Hall/CRC,

407   London, United Kingdom.

408   Milner-Gulland, E.J., Bennett, E.L., the SCB 2002 Annual Meeting Wild Meat Group, 2003.

409   Wild meat: the bigger picture. Tr. Ecol. Evol. 18, 351-357.

410   Nasi, R., Brown, D., Wilkie, D., Bennett, E., Tutin, C., van Tol, G., Christophersen, T.,

411   2008. Conservation and use of wildlife-based resources: the bushmeat crisis.

412   Technical Series no. 33, Secretariat of the Convention on Biological Diversity,

413   Montreal, and Center for International Forestry Research (CIFOR), Bogor.

414   Nasi, R., Taber, A., Van Vliet, N., 2011. Empty forests, empty stomachs? Bushmeat and

415   livelihoods in the Congo and Amazon Basins. Internat. For. Rev. 13, 355-368.

416   Niger Delta Environmental Survey (NDES), 1998. Environmental and Socio-Economic

417   characteristics, volume 1. NDES, Port Harcourt, Nigeria.

418   Nuno, A., Bunnefeld, N., Naiman, L.C., Milner-Gulland, E.J., 2014. Novel Approach to

419   Assessing the Prevalence and Drivers of Illegal Bushmeat Hunting in the Serengeti.

420   Conserv. Biol. 27, 1355–1365.

421   Oates, J.F., Bergl, R.A., Linder, J.M., 2004. Africa's Gulf of Guinea forests: biodiversity

422   patterns and conservation priorities. Adv. Appl. Biodiv. Sci. 6, 1–91.

423   St John, F.A.V., Gibbons, J.M., Edwards-Jones, G., 2010. Testing novel methods for

424   assessing rule breaking in conservation. Biol. Conserv. 143, 1025–1030.

425   Thiombiano, A., Kampmann, D., 2010. Atlas de la biodiversité de l'Afrique de l'Ouest.

426   Tome II. Burkina Faso. Ouagadougou and Frankfurt/Main.

427   Wilkie, D. S., Godoy, R.A., 2001. Income and price elasticities of bushmeat demand in

428   lowland Amerindian societies. Conserv. Biol. 15, 1–9.

429   World Bank, 2016. Statistics: countries and economies. World Bank, New York.

430   Table 1. Synopsis of the interview raw data collected during the present surveys in the four studied countries.

	Urban			Total urban	Rural			Total rural
	Often eaten	Rarely eaten	Never eaten		Often eaten	Rarely eaten	Never eaten	
Burkina Faso								
Males (< 25 yr)	0	0	7	7	4	2	2	8
Males (< 50 yr)	7	69	43	119	66	24	7	97
Males (> 51)	7	12	1	20	17	9	3	29
Females (< 25 yr)	2	1	10	13	1	1	21	23
Females (< 50 yr)	6	52	30	88	17	21	33	71
Females (> 51)	1	8	6	15	9	5	3	17
TOTAL SAMPLE	23	142	97	262	114	62	69	245
Niger								
Males (< 25 yr)	2	2	56	60	20	11	45	76
Males (< 50 yr)	4	6	32	42	30	20	39	89
Males (> 51)	5	6	22	33	33	9	37	79
Females (< 25 yr)	1	0	46	47	14	9	44	67
Females (< 50 yr)	4	7	39	50	24	11	30	65
Females (> 51)	7	7	26	40	22	10	31	63
TOTAL SAMPLE	23	28	221	272	143	70	226	439
Togo								
Males (< 25 yr)	11	9	33	53	14	8	21	43
Males (< 50 yr)	12	16	15	43	33	24	2	59
Males (> 51)	14	12	5	31	24	7	1	32
Females (< 25 yr)	0	11	41	52	4	16	26	46
Females (< 50 yr)	7	17	23	47	14	7	4	25
Females (> 51)	16	11	11	38	16	2	2	20
TOTAL SAMPLE	60	76	128	264	105	64	56	225
Nigeria								
Males (< 25 yr)	7	14	56	77	17	31	11	59
Males (< 50 yr)	12	23	44	79	21	23	8	52
Males (> 51)	16	31	39	86	22	41	5	68

Females (< 25 yr)	3	6	62	71	13	43	14	70
Females (< 50 yr)	7	12	46	65	9	11	2	22
Females (> 51)	19	23	35	77	14	5	1	20
TOTAL SAMPLE	64	109	282	455	96	154	41	291
GRAND TOTAL	170	355	728	1253	458	350	392	1200

Table 2. Results of the Generalized Linear Model on the probability of eating bushmeat by type of animals by country, urban/rural locality, age, sex and gender (female/male). Intercepts are included in all models, and the explained deviance (in %) is also shown. Negative estimates for gender means a preponderance of male respondents. Positive estimates for age indicates a preponderance of older age classes respondents.

Variable	Estimate	St. error	Wald	P
Ungulates				
Intercept	211.71	72.41	8.55	0.003
Gender	-1.68	0.82	4.18	0.041
Explained deviance (%)	90.20			
Rodents				
Intercept	295.85	202.43	2.14	0.144
Gender	-5.14	2.29	5.02	0.025
Explained deviance (%)	88.08			
Monkeys				
Intercept	-2079.08	431.87	23.17	0.000001
Country	5.93	2.99	3.92	0.048
Urban/Rural	-31.26	4.89	40.89	0.000001
Age	14.92	2.99	24.85	0.000001
Explained deviance (%)	34.07			
Bats				
Intercept	-1596.00	376.76	17.94	0.000023
Urban/Rural	-29.26	6.03	23.54	0.000001
Age	16.13	3.69	19.08	0.000013
Explained deviance (%)	45.79			
Carnivores				
Intercept	-1408.96	335.10	17.68	0.000026
Urban/Rural	-17.45	5.36	10.58	0.0011
Age	14.22	3.28	18.74	0.000015
Explained deviance (%)	55.90			
Birds				
Intercept	-837.82	493.40	2.88	0.089

Age	7.33	3.42	4.60	0.032
Explained deviance (%)	88.74			
Crocodiles				
Intercept	-1439.25	453.05	10.09	0.0015
Urban/Rural	-22.29	5.13	18.89	0.000014
Age	15.28	3.14	23.68	0.000001
Explained deviance (%)	46.41			
Snakes				
Intercept	-1330.51	345.56	14.82	0.000118
Urban/Rural	-20.61	5.53	13.87	0.000195
Age	13.41	3.39	15.66	0.000076
Explained deviance (%)	55.05			
Turtles				
Intercept	-853.91	296.62	8.29	0.0039
Urban/Rural	-15.25	4.75	10.31	0.0013
Age	9.156	2.9079	9.91504	0.001639
Explained deviance (%)	64.03			

435

436

Table 3. Summary of the results of contingency tables on the frequencies of the never-eating bushmeat respondents by country. In this table, 'towards' would

indicate the direction of the significant effect. For instance, if in a given area, there was a significantly higher number od 'never-eating-bushmeat' respondents for

young people (< 25 years age), this is highlighted in the table with 'towards young'.

	Differences between gender in rural	Differences between gender in urban	Differences by age in rural	Differences by age in urban	Differences between urban and rural by gender	Differences between urban and rural by age
Togo	P = n.s.	P = n.s.	P < 0.01 (towards young)	P < 0.01 (towards young)	P = n.s.	P = n.s.
Nigeria	P = n.s.	P < 0.05 (towards men)	P < 0.01 (towards old people)	P = n.s.	P < 0.01 (due to men in urban areas)	P < 0.05 (due to age in rural areas)
Burkina Faso	P < 0.01 (towards men)	P < 0.05 (towards women)	P = n.s.	P < 0.05 (towards young)	P < 0.0001 (due to opposite signs of differences)	P < 0.05 (due to consistent trends of age: young do not eat bushmeat)
Niger	P = n.s.	P = n.s.	P < 0.05 (towards young)	P < 0.05 (towards young)	P = n.s.	P = n.s.

440

441

442 Table 4. Summary of the results of contingency tables on the frequencies of the often-eating bushmeat respondents by country. In this table, 'towards' would

443 indicate the direction of the significant effect. For instance, if in a given area, there was a significantly higher number od 'never-eating-bushmeat' respondents for

444 young people (< 25 years age), this is highlighted in the table with 'towards young'.

	Differences between gender in rural	Differences between gender in urban	Differences by age in rural	Differences by age in urban	Differences between urban and rural by gender	Differences between urban and rural by age
Togo	$P < 0.05$ (towards men)	$P < 0.05$ (towards men)	$P < 0.05$ (towards young)	$P < 0.01$ (towards young)	$P =$ n.s.	$P =$ n.s.
Nigeria	$P =$ n.s.	$P =$ n.s.	$P =$ n.s.	$P < 0.01$ (towards young)	$P =$ n.s.	$P < 0.05$ (due to young people responses negative effect)
Burkina Faso	$P < 0.001$ (towards men)	$P < 0.001$ (towards men)	$P =$ n.s.	$P < 0.0001$ (towards young)	$P < 0.05$ (due to men)	$P < 0.05$ (due to young people responses negative effect)
Niger	$P =$ n.s.	$P =$ n.s.	$P =$ n.s.	$P < 0.05$ (towards young)	$P =$ n.s.	$P =$ n.s.

445

446

447 Table 5. Significant effects (P < 0.05; indicated with a X) of the various parameters on the frequency of

448 respondents claiming to eat bushmeat, by a GLM mixed model analysis.

	Nigeria	Togo	Burkina Faso	Niger	Guinean Forests	Sahel	All pooled
Gender			X				
Age	X	X		X	X		X
Rural/urban	X	X	X	X	X	X	X
Gender X Age		X			X		
Gender X Rural/Urban	X		X			X	X
Age X Rural/urban	X	X		X	X		X

449

450   Figure 1. Map of West Africa showing the study sites where interviews were carried out
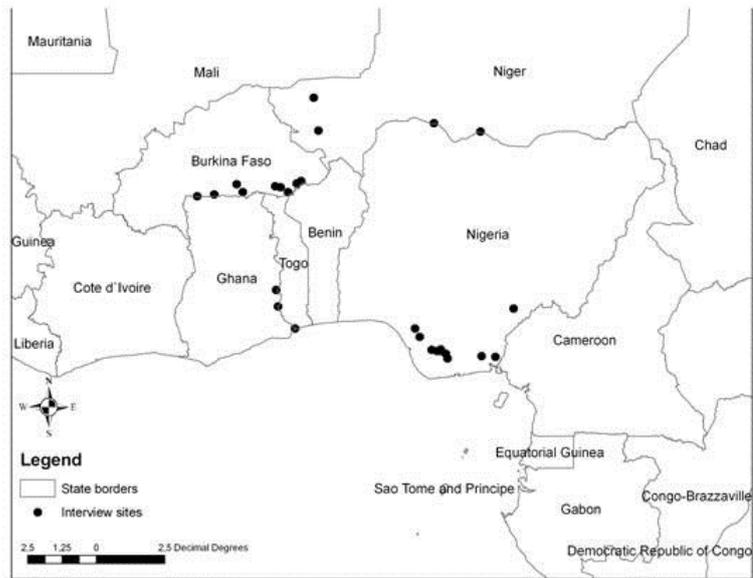
451

452

453

454   Figure 2. Percent interviewees responding whether bushmeat was eaten often, rarely or never in urban and
455   rural settlements in the four countries studied in West Africa.

456
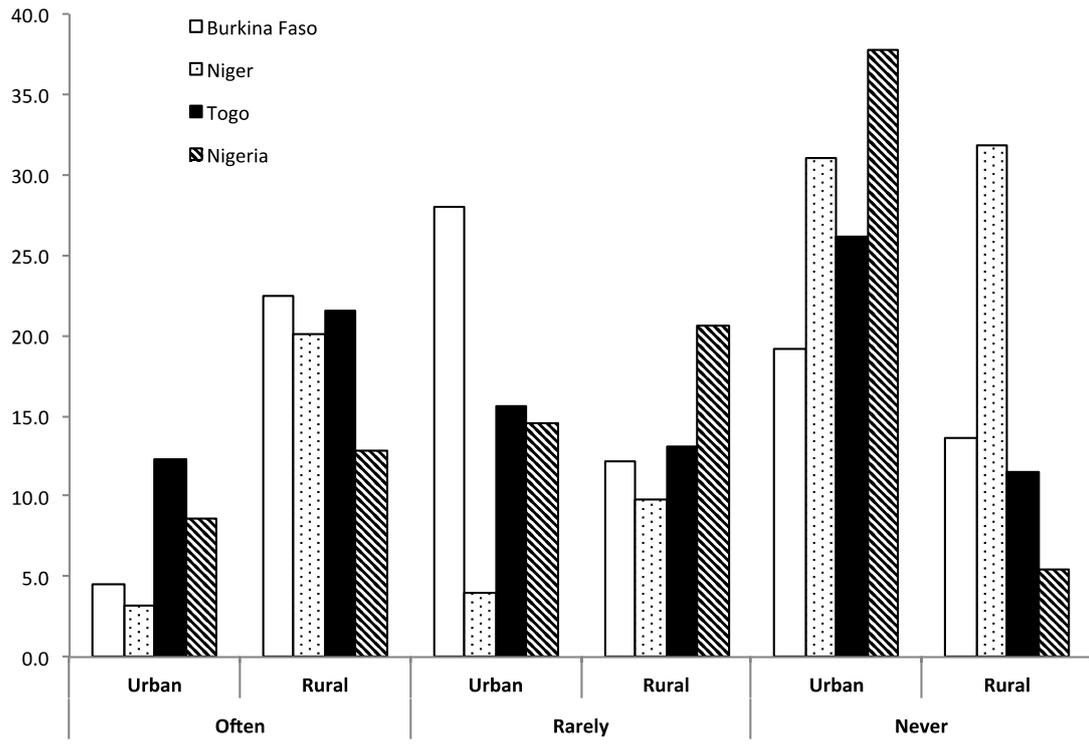
457   Figure 3. Relative importance of predictors (pure effect), as determined by hierarchical variation partitioning,

458   for the model considering all the interviewees' responses as dependent variable, for the Sahel countries

459   (upper graphic) and for the Guinean forests countries (lower graphic). Spatial = urban/rural.
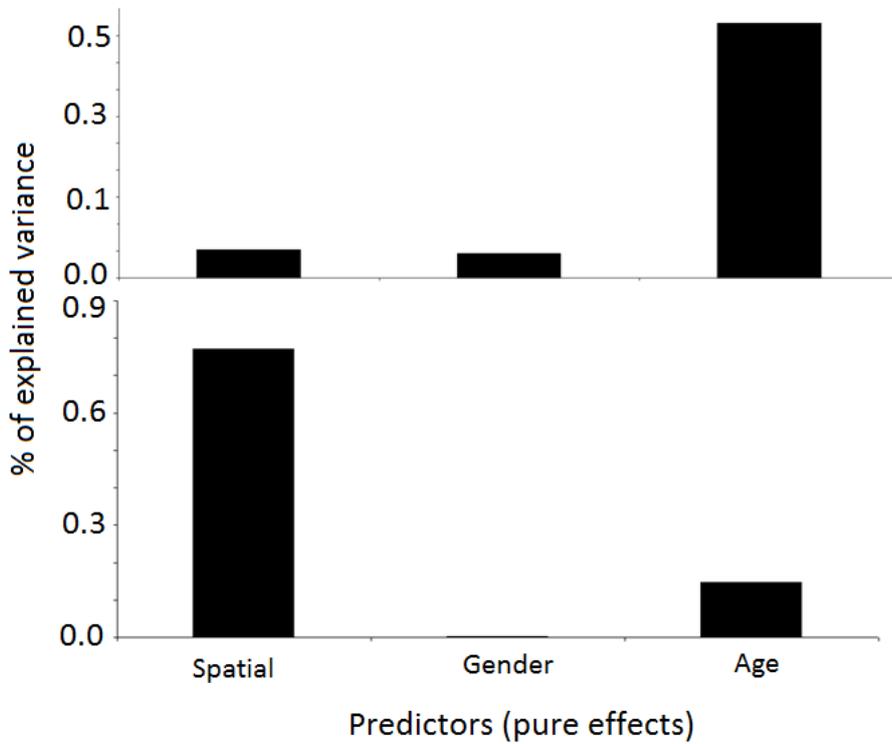
460

461

462

463   Figure 4. Distribution of the various types of answer by respondents in urban versus rural areas in the four

464   studied countries of West Africa as for whether they would eat bushmeat often, rarely or never. All data from

465   the different countries were pooled for this graphic

466

467

468   Figure 5. Distribution of the various types of answer by respondents in urban versus rural areas in the four

469   studied countries of West Africa as for the type of consumed bushmeat is concerned. All data from the

470   different countries were pooled for this graphic

471

472

473

474   Appendix 1. Codes for the variables used in the Generalized Linear Models (GLZs).

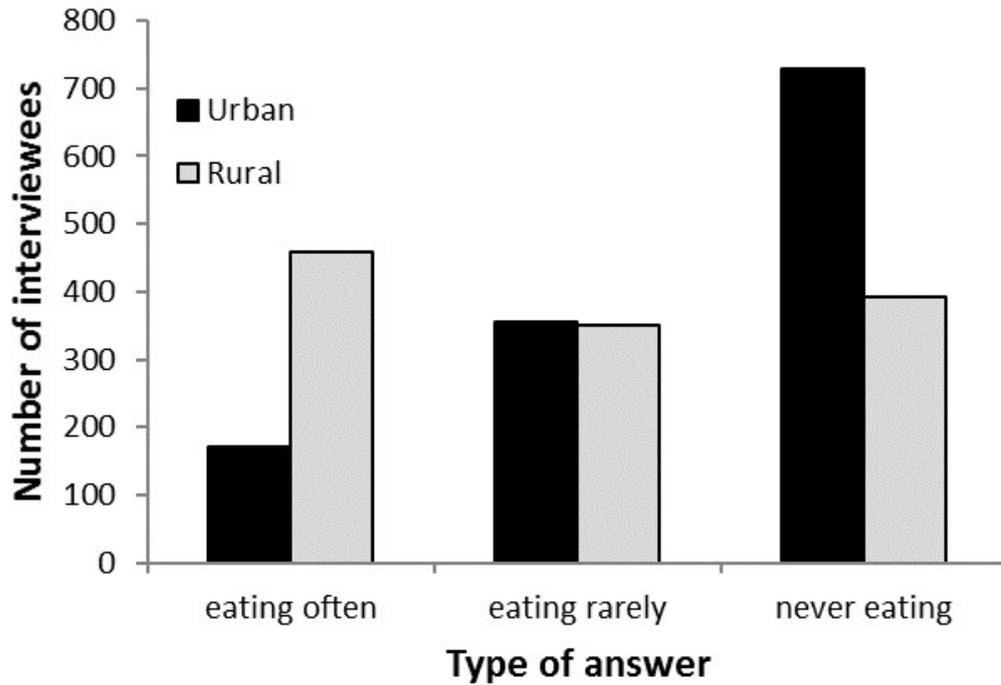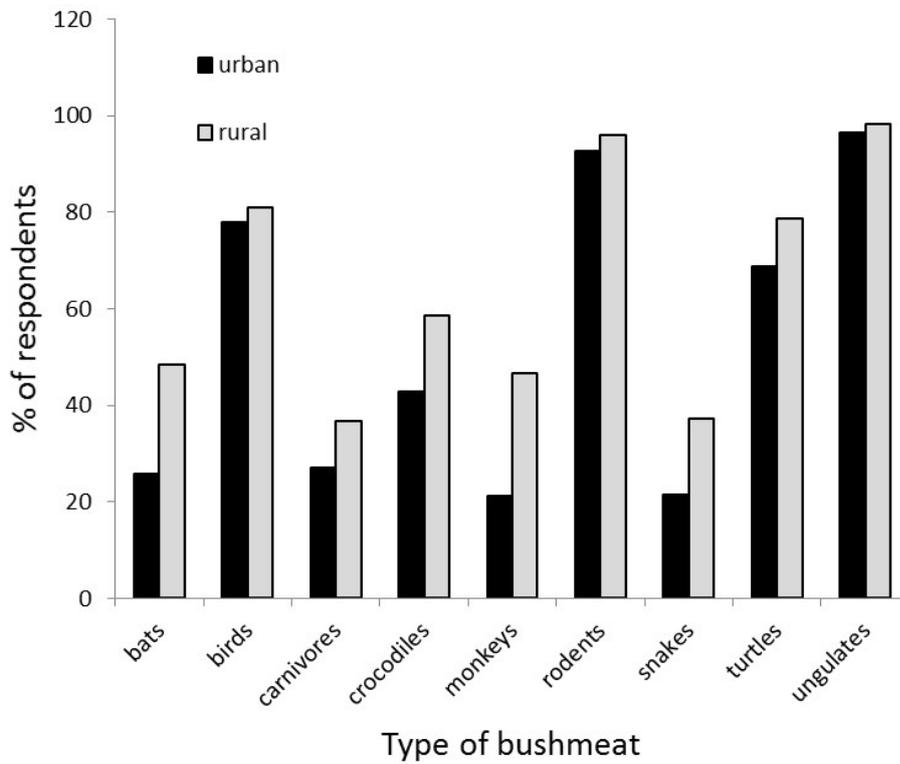| Country	Class	Locality	Cod Loc	Cod age	Cod sex	Never eat bushmeat
Burkina Faso	Males (< 25 yr)	URBAN	1	g	1	7
Burkina Faso	Males (< 50 yr)	URBAN	1	m	1	43
Burkina Faso	Males (> 51)	URBAN	1	a	1	1
Burkina Faso	Females (< 25 yr)	URBAN	1	g	0	10
Burkina Faso	Females (< 50 yr)	URBAN	1	m	0	30
Burkina Faso	Females (> 51)	URBAN	1	a	0	6
Burkina Faso	Males (< 25 yr)	Rural	0	g	1	2
Burkina Faso	Males (< 50 yr)	Rural	0	m	1	7
Burkina Faso	Males (> 51)	Rural	0	a	1	3
Burkina Faso	Females (< 25 yr)	Rural	0	g	0	21
Burkina Faso	Females (< 50 yr)	Rural	0	m	0	33
Burkina Faso	Females (> 51)	Rural	0	a	0	3
Nigeria	Males (< 25 yr)	URBAN	1	g	1	77
Nigeria	Males (< 50 yr)	URBAN	1	m	1	79
Nigeria	Males (> 51)	URBAN	1	a	1	86
Nigeria	Females (< 25 yr)	URBAN	1	g	0	71
Nigeria	Females (< 50 yr)	URBAN	1	m	0	65
Nigeria	Females (> 51)	URBAN	1	a	0	77
Nigeria	Males (< 25 yr)	Rural	0	g	1	59
Nigeria	Males (< 50 yr)	Rural	0	m	1	52
Nigeria	Males (> 51)	Rural	0	a	1	68
Nigeria	Females (< 25 yr)	Rural	0	g	0	70
Nigeria	Females (< 50 yr)	Rural	0	m	0	22
Nigeria	Females (> 51)	Rural	0	a	0	20
Niger	Males (< 25 yr)	URBAN	1	g	1	4
Niger	Males (< 50 yr)	URBAN	1	m	1	4
Niger	Males (> 51)	URBAN	1	a	1	7
Niger	Females (< 25 yr)	URBAN	1	g	0	1
Niger	Females (< 50 yr)	URBAN	1	m	0	9
Niger	Females (> 51)	URBAN	1	a	0	6
Niger	Males (< 25 yr)	Rural	0	g	1	6
Niger	Males (< 50 yr)	Rural	0	m	1	5
Niger	Males (> 51)	Rural	0	a	1	9
Niger	Females (< 25 yr)	Rural	0	g	0	3
Niger	Females (< 50 yr)	Rural	0	m	0	7
Niger	Females (> 51)	Rural	0	a	0	9
Togo	Males (< 25 yr)	URBAN	1	g	1	33
Togo	Males (< 50 yr)	URBAN	1	m	1	15
Togo	Males (> 51)	URBAN	1	a	1	5
Togo	Females (< 25 yr)	URBAN	1	g	0	41
Togo	Females (< 50 yr)	URBAN	1	m	0	23
Togo	Females (> 51)	URBAN	1	a	0	11
Togo	Males (< 25 yr)	Rural	0	g	1	21
Togo	Males (< 50 yr)	Rural	0	m	1	2
Togo	Males (> 51)	Rural	0	a	1	1
Togo	Females (< 25 yr)	Rural	0	g	0	26
Togo	Females (< 50 yr)	Rural	0	m	0	4
Togo	Females (> 51)	Rural	0	a	0	2

475

476

477   Appendix 2. Summary of the raw data on the types of eaten bushmeat by people in the investigated countries.

		Males (< 25 yr)	Males (< 50 yr)	Males (> 51)	Females (< 25 yr)	Females (< 50 yr)	Females (> 51)	Total interviewees
Nigeria		21	35	47	9	19	42	173
	ungulates	21	34	45	9	19	40	
	rodents	21	31	41	9	19	39	
Urban	monkeys	2	7	11	0	3	6	
	bats	3	7	8	1	3	11	
	carnivores	2	10	15	0	2	5	
	birds	15	26	33	5	15	28	
	crocodiles	8	15	27	1	5	9	
	snakes	1	3	5	0	0	3	
	turtles	16	22	26	6	14	32	
Nigeria		48	44	63	56	20	19	250
	ungulates	48	43	61	56	20	19	
	rodents	48	41	55	56	18	19	
Rural	monkeys	6	23	31	3	3	11	
	bats	7	17	22	7	5	13	
	carnivores	9	14	20	21	6	11	
	birds	39	40	55	45	17	17	
	crocodiles	23	21	38	32	9	17	
	snakes	2	8	19	4	6	9	
	turtles	44	33	51	36	16	19	
Togo		20	28	26	11	23	27	136
	ungulates	19	26	25	11	22	25	
	rodents	13	23	24	11	22	23	
Urban	monkeys	4	6	6	0	1	4	
	bats	4	9	6	0	1	3	
	carnivores	8	6	6	0	2	8	
	birds	15	21	21	10	17	23	
	crocodiles	3	18	8	3	6	11	
	snakes	2	4	4	0	1	6	

	turtles	9	16	16	5	15	24	
Togo		22	57	31	20	21	18	169
	ungulates	22	54	31	20	21	18	
	rodents	22	49	31	20	21	18	
Rural	monkeys	14	25	25	2	11	15	
	bats	13	27	27	0	8	17	
	carnivores	3	11	21	1	6	16	
	birds	16	24	31	17	19	18	
	crocodiles	13	26	28	3	8	14	
	snakes	11	22	20	1	6	11	
	turtles	14	41	27	16	17	16	
Niger		4	10	11	1	11	14	51
	ungulates	4	9	11	1	11	14	
	rodents	4	10	11	1	11	14	
Urban	monkeys	0	1	4	0	4	7	
	bats	0	2	3	0	5	11	
	carnivores	0	1	4	0	8	7	
	birds	4	8	9	0	10	12	
	crocodiles	1	6	6	0	7	8	
	snakes	1	4	6	0	7	5	
	turtles	3	8	9	0	10	9	
Niger		31	50	41	23	35	32	213
	ungulates	30	48	41	22	35	32	
	rodents	29	48	41	23	35	32	
Rural	monkeys	8	21	26	16	20	25	
	bats	12	33	27	14	20	27	
	carnivores	8	19	17	11	16	22	
	birds	21	41	37	18	31	31	
	crocodiles	9	28	33	13	28	28	
	snakes	8	21	27	9	18	25	
	turtles	23	33	38	16	28	30	

478