Please cite the Published Version

Additional Information: This is an Author Accepted Manuscript of a paper accepted for publication in Acta Oecologica, published by and copyright Elsevier.

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

7   Ouattara[e], Edem A. Eniang[f], Massimiliano Di Vittorio[g], Nioking Amadi[b], Gnoumou

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

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

10

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

12   Tomasi di Lampedusa 33, I-00144 Rome, Italy.

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

14   Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria.

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

16   et Ecologie Animales, 09 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

19   l'Ouest, Ouagadougou, 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,

23   Arcavacata di Rende (CS), 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

26   Environment, Manchester Metropolitan University, Manchester M1 5GD, UK.

Abstract

The meat of wild animals (bushmeat) is consumed extensively in many tropical regions. Over the past few decades bushmeat consumption has greatly increased, threatening the survival of some hunted species and the supply of animal protein to countless numbers of people. Understanding patterns of bushmeat consumption is thus vital to ensure the sustainable use of this resource. Although the economic drivers of bushmeat consumption have been well studied, non-wealth correlates have been poorly considered. Here, we analyse how variables such as age and gender may influence bushmeat consumption in four West African countries, within the Guinean forests (Togo and Nigeria) and Sahel (Burkina Faso and Niger). We interviewed a total of 2,453 persons (1,253 urban, 1,200 in rural areas) to determine frequency of consumption of bushmeat as well as the main species eaten. We found significant differences in bushmeat consumption between rural and urban areas in all four countries. In particular, the proportion of persons not consuming any bushmeat was highest in urban areas. Gender differences in bushmeat consumption were not generally important but young people consistently avoided eating bushmeat, especially in Togo and Nigeria, and in urban areas. The complicated interplay between tradition and evolution of social systems (especially the trends towards westernization) may explain the different perceptions that people may have towards consuming bushmeat in the four studied countries. In addition, we found considerable variation in types of bushmeat eaten, with antelopes and large rodents eaten by the great majority of interviewees, but bats, monkeys, and snakes being avoided, especially in urban settlements.

Key words: Age; gender; Togo; Burkina Faso; Nigeria; Niger; wildlife; species eaten; frequency.

51 **1.   Introduction**

52   Terrestrial wild vertebrates are central to the nutritional wellbeing of many rural

53 people, particularly those inhabiting the world's tropical regions (Fa et al., 2002; Golden et

54 al., 2011). This reliance on wild meat is as much a consequence of the lack of alternative

55 domestic meat resources (Mainka & Trivedi 2002; Nasi et al. 2008), as much as it is an

56 attribute of centuries-old cultural traditions (Milner-Gulland et al., 2003). However,

57 although wild animals have been hunted for millennia, their consumption has greatly

58 increased over the past few decades (Maxwell et al. 2016). In West and Central Africa,

59 commercial hunting, especially to supply large urban centres, has risen dramatically, largely

60 driven by a human population growth of 2–3% per year (Nasi et al., 2011). Such

61 intensification of demand for bushmeat will have fatal consequences for many species but

62 particularly large-bodied and slow-growing species if extraction exceeds their replacement

63 rate (Wilkie et al., 2001). Indeed, the decline of some species as a consequence of

64 bushmeat extraction has already been documented for tortoises (Luiselli, 2003) and

65 antelopes (Fischer and Linsenmair, 2001; Grande-Vega et al., 2016; Hema et al., 2017). As a

66 consequence, loss of wildlife may threaten the food security of many marginalized forest

67 foragers, and farmer-forager communities that are isolated from markets and depend on

68 bushmeat as their primary protein source (Eves and Ruggiero, 2001).

69   Few studies have centred on understanding why people eat bushmeat. Knowing

70 what motivates people to eat bushmeat can help in developing politically acceptable ways

71 to manage wildlife hunting and trading with the aim of halting unsustainable exploitation.

72 Bushmeat may be eaten because it is cheaper or there are no alternatives available in the

73 market place (Apaza et al., 2002; Wilkie and Godoy, 2001), because consumers prefer the

74 taste of wildlife (Chardonnet et al., 1995; Trefon and de Maret, 1999) or to add variety to

75   the diet and for special social events and occasions (Njiforti, 1996). Despite this variety of

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

77   the socioeconomic background of consumers as the main reason underpinning their choice

78   (e.g. Wilkie and Godoy, 2001; Brashares et al., 2011). Findings show that wealthier

79   households consume more bushmeat in settlements nearer urban areas, but the opposite

80   pattern is typical of more isolated settlements (Brashares et al., 2011). Price and income

81   have significant roles in determining the level of consumption of bushmeat, fish, chicken,

82   and beef (Apaza et al., 2002; Wilkie and Godoy, 2001; Wilkie et al., 2005). Nonetheless, as

83   Brashares et al. (2011) has indicated, household wealth is only weakly linked to wildlife

84   consumption, and thus such a lack of a strong correlation could be explained by the

85   undisclosed importance of other factors. Few investigations have focused on how

86   bushmeat consumption may be affected by non-wealth factors such as age, gender and

87   geographical setting (Hema et al., 2017; Luiselli et al., 2017).

88   Most published studies reporting amounts of bushmeat consumed and preferences

89   have been based on data gathered within households (see Brashares et al. 2011). These

90   have been useful in determining possible socioeconomic characteristics of a community

91   that may be linked to bushmeat consumption patterns, but are generally costly in terms of

92   time and resources. Moreover, because households can include residents of different ages

93   and literacy - attributes generally linked to contrasting lifestyles and points of view

94   including the perception towards bushmeat consumption (Luiselli et al., 2017) - household

95   surveys are less suitable for exploring the influence of non-wealth factors. In this paper,

96   we use face-to-face interviews to examine the possible links between bushmeat

97   consumption frequency and types eaten relative to the age and gender of consumers as

98   well as the influence of the settlement type, ecological and country setting where they live.

99   We focus on a large sample of inhabitants of four West African countries found in Sahelian

100   and Guinean forests environments.

101

102   **2.   Methods**

103   *2.1.   Study sites*

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

105   27 separate human settlements in Nigeria, Togo, Burkina Faso and Niger (Fig. 1). Study

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

107   (GFWA) region; swamp forest and moist rainforest vegetation zones in southern Nigeria

108   (Niger Delta Environmental Survey, 1998; Oates et al., 2004) and in the deciduous moist

109   forest zone of southwestern Togo (Ern, 1979). Sites in Burkina Faso and Niger were found

110   within the Sahel, in Sudanian and Sahel Acacia savannahs (Thiombiano and Kampmann,

111   2010).

112

113   *2.2.   Interviews*

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

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

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

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

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

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

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

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

122   We interviewed persons in urban areas (Ouagadougou, Niamey, Lomé, Benin City,

123 Port Harcourt and Calabar, all cities with more than 500,000 residents) as well as in smaller

124 rural settlements (500 to 40,000 inhabitants). We recorded the interviewees' gender (male

125 or female) and age (≤ 25 years, 26-50 years, ≥ 51 years) but not their names (St. John, 2010;

126 Nuno et al., 2014; Luiselli et al., 2017). To avoid non-independence of the data, we never

127 interviewed two persons of the same family or those living in the same house, even if they

128 were not relatives (see also Hema et al., 2017, for similar procedure).

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

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

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

132 or never. Persons who answered that they consumed bushmeat only occasionally were

133 then asked whether they selected the type of animal orwhether they would just buy/eat

134 whatever kind of bushmeat was available.

135 *2.3. Statistical analyses*

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

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

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

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

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

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

142 of the link function and a normal distribution of error were used (McCullagh and Nelder,

143 1989). Three age categories were used for all analyses: persons aged less than 25, aged less

144 than 50, and aged 51 years or more. In the GLZ models, a stepwise forward regression

145   procedure was used to test the statistical significance of each variable in turn, and variables

146   were excluded when they did not correlate significantly with the dependent variable (Wald

147   test P > 0.05).

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

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

150   1992). The decomposition of the variation into subsets of explanatory variables was carried

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

152   Frequency differences between groups of interviewed people were analyzed using

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

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

155   bushmeat eaten. The statistical software PASW 11.0 was used for all analyses, and alpha

156   was set at 5%.

157

158   **3.**   **Results**

159   *3.1.*   *General patterns*

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

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

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

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

164   only 42.8 ± 19.0% of urban interviewees. In all countries more rural than urban

165   respondents ate bushmeat; 1.59 times more in Niger, 1.26 times more in Nigeria, 0.46

166   times in Togo and 0.14 times in Burkina Faso.

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

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

169   was significantly affected by gender or age of the respondents respectively, while the

170   eating of monkeys, bats, carnivores, crocodiles, snakes and turtles was influenced by the

171   age of the respondents and their urban/rural location (Table 2).

172   Significant differences in responses between interviewees in Guinean forests and

173   the Sahel region appeared. Age classes, followed by urban/rural location, accounted for the

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

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

176   location was the predominant effect, age had a lesser relevance in terms of the explained

177   variance, but gender had almost no effect (Fig. 3).

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

179   urban area; the probability of never-eating bushmeat increased in Sahelian countries, but

180   not in Guinean forest region countries (for Sahel: GLZ estimate = 6.56, standard error =

181   1.34, Wald = 24.0, P < 0.0001; for age classes: estimate = -7.62, standard error = 2.32, Wald

182   = 10.79, P < 0.001; for Guinean forests: in all cases P > 0.165).

183

184   *3.2.   Country effects*

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

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

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

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

189   statistical differences found between Guinean forest and Sahelian country sites in terms of

190   the probability of consuming other types of bushmeat.

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

192   least P > 0.225 at χ^2 test) in the proportion of respondents who declared that they never

193   ate bushmeat (Table 3) as well as in those that declared frequently eating bushmeat (Table

194   4). However, there were clear confounding effects of age, gender and urban/rural location

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

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

197   eating-bushmeat' answers (Table 4).

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

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

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

201   areas depended on the strength of the frequency decreases of never-eating-bushmeat

202   respondents in these two locations, i.e. rural and urban people in Togo tended to respond

203   similarly. In Nigeria (Table 3), there was no effect of age in urban areas (people do not eat

204   bushmeat in general) but in rural areas (only young people did not eat bushmeat). In

205   addition, there was a significant effect of gender in urban areas, with women avoiding

206   eating bushmeat more than men. The overall differences between rural and urban areas

207   were significant for both gender and age (Tables 3 and 4). In Burkina Faso, there was a

208   significant effect of age in urban areas (more young people did not eat bushmeat) but not

209   for rural areas, where people do generally eat bushmeat independent of their age (Tables 3

210   and 4). In Niger, there was only a significant effect of age, with more young people

211   responding that they would never eat bushmeat compared to older people, in both urban

212   and rural locations (Table 3).

213

214

215

216

217 *3.3.   Age effects*

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

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

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

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

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

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

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

225 at χ^2 test).

226

227 *3.4.   Gender effects*

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

229 regions, and contributed little to the hierarchical variance partitioning in the interview

230 dataset (Figure 3). Nonetheless, some effects of gender were detected in the attitude of

231 consuming a few types of bushmeat as well as in a few local contexts. Indeed, although

232 most people ate ungulates and rodents, there were significant effects of gender on the

233 consumption of these animals, with men being more likely to eat them than women (Table

234 2). In addition, females tended to avoid eating bushmeat more frequently than males in

235 some countries such as Nigeria. However, this was not a pure gender effect, as it was

236 mediated by age and rural/urban condition in a rather complicated way (Tables 3 and 4).

237 Overall, the 'often-eating-bushmeat' response was especially linked to men in either

238 Guinean forests (e.g.Togo) or Sahel (e.g. Burkina Faso) regions.

239

240

241   *3.5.   Rural versus urban*

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

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

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

245   both rural and urban locations, whereas in the Guinean forest region there were

246   differences between locations. In addition, in terms of frequency of never-eating bushmeat

247   people, statistical differences between rural versus urban conditions were much higher (P <

248   0.001 at χ^2 test) than those occurring between countries (see above). Whether a person

249   lived in an urban or rural location affected the probability of consuming bushmeat much

250   more than their country of residence.

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

252   bushmeat (Fig. 4); this difference being significant (χ^2 = 231.9, df = 2, *P* < 0.0001).

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

254   they frequently ate bushmeat (χ^2 = 7.3, df = 2, *P* < 0.05), but in urban areas most said they

255   never ate bushmeat (χ^2 = 193.4, df = 2, *P* < 0.0001).

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

257   or urban areas, but carnivores, monkeys and snakes were eaten rarely (differences

258   significant at P < 0.00001 compared to ungulates and rodents, χ^2 test), and mainly in rural

259   areas (Fig. 5). Contingency table analysis showed that there were no significant differences

260   between urban and rural areas in terms of frequency of respondents eating the various

261   bushmeat types (χ^2 = 14.48, df = 8, P = 0.0699). However, our GLZ model revealed that

262   primates, bats, carnivores, crocodiles, snakes and chelonians were significantly more likely

263   to be eaten by rural than by urban people, with the highest estimates being for monkeys

264 and bats (Table 2); it was unlikely that people from urban areas, in any of the surveyed

265 countries, ate monkeys and bats.

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

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

268 both gender and age between rural and urban areas.

269 **4.   Discussion**

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

271 superior taste" (King, 1994) and thus African communities therefore preferred and thus

272 primarily ate bushmeat. These statements were not based on empirical evidence until a

273 study reporting on two-choice taste tests showed that consumers in Gabon had only a

274 weak preference for bushmeat and only rural consumers consistently preferred bushmeat

275 over alternatives (Schenck et al., 2006). This result is particularly important given that it

276 manifests that even though basic desires such as hunger and the need for nourishment can

277 influence food choice, availability and cultural norms also affect these. Thus, it is not simply

278 taste that is driving demand for bushmeat, but that price or other culturally mediated

279 factors such as familiarity, tradition, and prestige play a role.

280

281   The use of face-to-face interviews for assessing bushmeat consumption has been

282 used in some studies e.g. in a recent one in Liberia by Ordaz-Németh et al. (2017). Like in

283 our study, Ordaz-Németh et al. (2017) did not test for any potential bias in responses by

284 interviewees not responding truthfully. In both studies, hunting is not illegal per se and we

285 did not mention explicitly any particular species in the interview form, but instead used

286 open questions so that the interviewee could respond without any prompting e.g. by

287 naming protected species.

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

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

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

291   demonstrated in a number of other studies in the African continent (e.g. in the Democratic

292   Republic of Congo, see Van Vliet et al., 2014) and in Madagascar (Jenkins et al., 2011). This

293   contrast between rural and urban dwellers is largely explained by the availability of

294   bushmeat versus alternative protein sources. Rural dwellers are usually restricted in terms

295   of the availability and accessibility of domestic meats but in a much better position to

296   option these resources from the wild. By contrast, urban dwellers have greater access to

297   alternative proteins (Apaza et al., 2002). Nonetheless, cultural complications also explain

298   the preference of non-bushmeat proteins by urban people (see Luiselli et al., 2017 and

299   below).

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

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

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

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

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

305   acceptable' to consume bushmeat, since this is perceived by them as a sign of 'being very

306   local' (i.e. not culturally advanced). In contrast the eating of 'fast foods' (hamburgers, pizza,

307   kebab, etc.) is now the favourite 'social diet' of young people. This pattern is especially

308   evident in urban Nigeria and Togo (our unpublished observations), where young

309   interviewees not only declared that they would not eat bushmeat, but even commented

310   that eating bushmeat was not acceptable because it produces a loss of personal prestige

311   within their circle of friends. In this regard, it was particularly interesting that, among the

312   rarely-eating bushmeat urban people, a sample of 7 young (<25 years) persons from Togo

313   and 15 from Nigeria declared that they would never eat bushmeat in public, but that very

314   occasionally they do during private family events, and only when they visit their rural

315   relatives. Thus, among the respondents who declared that they rarely ate bushmeat, many

316   would only consume bushmeat for special occasions. We suggest that in urban areas the

317   lower consumption of bushmeat is not because of lack of access, but that it responds to a

318   more culturally-driven avoidance in response to the changing socio-economic context.

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

320   gender was only apparent in 1 out of 7 models. In terms of mixed factors, 'Gender X

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

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

323   rural/urban and age are much more important than gender in determining the probability

324   for a person to consume bushmeat. The non-effect of gender is probably related to the

325   enhanced equal rights of women and men in West African societies (especially in Nigeria),

326   with young generations being much more equal in terms of gender and lifestyle (see

327   Gender Equality Index database by the African Development Bank, available at

328   www.afdb.org). Thus, since young men and women typically share a similar life-style

329   (especially in urban areas), even their food preferences tend to be very similar.

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

331   respondents stated they never ate bushmeat, this would suggest that bushmeat

332   consumption has been substantially decreasing among the new generations of West

333   Africans, independently on their local culture, religion, ethnicity and level of human

334   development. In Nigeria, where the level of human development (average wealth and

335   scholarization standards) are clearly higher than in the other countries (the country being

336   the 22th economy of the world; World Bank, 2016), only older people in rural areas (age >

337   51 years) answered that they consumed bushmeat more regularly (Table 2).

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

339   important to note that bushmeat trade analysis are much easier to undertake in the

340   Guinean forests region (such as Ivory Coast, Ghana, Nigeria; e.g. see Fa et al., 2002a,

341   2002b, 2006) than in Sahel. This difference is related to the fact that in the Sahel region

342   there are no open bushmeat markets and people here may be more reluctant to answer

343   interviewers openly because of social norms (Hema et al., 2017, but see Lindsey et al.

344   2013). This is also possibly linked to the fact that forest can occur close to urban areas in

345   the Guinean Forest region (e.g., Niger Delta forests surrounding Port Harcourt), whereas

346   the same is not true in the Sahel where all the forested or mature savannah sites (from

347   which most of the bushmeat trade does originate) are situated far from larger urban

348   centres (our unpublished observations). Therefore, 'hub' markets (Akani et al., 2015) are

349   more likely to be found nearby large cities in the forest zone than in the savannah zone. In

350   conclusion, we argue that the cultural drivers of wildlife use are crucial to take into account

351   when seeking long-term sustainability solutions of wildlife resource extraction (e.g., Luiselli

352   et al., 2017).

359

360 **References**

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

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

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

364 79–86.

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

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

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

368 and geographic drivers of wildlife consumption in rural Africa. Proc. Natl. Acad. Sci.

369 U.S.A. 108, 13931–13936.

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

371 312.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

391   and Sons, New York.

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

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

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

395   ONE 6(12), e27570.

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

397   Netherlands.

398   Lindsey, P., Balme, G., Becker, M., Begg, C., Bento, C., Bocchino, C., Dickman, A., Diggle, R.,

399   Eves, H., Henschel, P., Lewis, D., Marnewick, K., Mattheus, J., McNutt, J.W.,

400   McRobb, R., Midlane, N., Milanzi, J., Morley, R., Murphree, M., Nyoni, P., Opyene,

401   V., Phadima, J., Purchase, N., Rentsch, D., Roche, C., Shaw, J., van der Westhuizen,

402   H., Van Vliet, N., Zisadza, P., 2012. Illegal hunting and the bush-meat trade in

403   savanna Africa: drivers, impacts and solutions to address the problem.

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

405   York.

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

407   G., Eniang, E.A., 2017. Rehashing bushmeat –interview campaigns reveal some

408   controversial issues about the bushmeat trade dynamics in Nigeria. Rev. Ecol. (Terre

409   et Vie) 72, 3-18.

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

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

412   Switzerland.

413   Maxwell, S.L., Fuller, R.A., Brooks T.M., Watson J.E.M., 2016. Biodiversity: The ravages of

414   guns, nets and bulldozers. Nature 536:143-145.

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

416   London, United Kingdom.

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

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

419   Nasi, R., Brown, D., Wilkie, D., Bennett, E., Tutin, C., van Tol, G., Christophersen, T., 2008.

420   Conservation and use of wildlife-based resources: the bushmeat crisis. Technical

421   Series no. 33, Secretariat of the Convention on Biological Diversity, Montreal, and

422   Center for International Forestry Research (CIFOR), Bogor.

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

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

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

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

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

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

429   Conserv. Biol. 27, 1355–1365.

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

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

432 Ordaz-Németh, I., Arandjelovic, M., Boesch, L., Gatiso, T., Grimes, T., Kuehl, H.S., Lormie,

433   M., Stephens, C., Tweh, C., Junker, J., 2017. The socio-economic drivers of bushmeat

434   consumption during the West African Ebola crisis. PLoS Negl Trop Dis 11(3):

435   e0005450. https://doi.org/10.1371/journal.pntd.0005450

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

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

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

439   II. Burkina Faso. Ouagadougou and Frankfurt/Main.

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

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

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

443   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

444 Table 2. Results of the Generalized Linear Model on the probability of eating bushmeat by type of

445 animals by country, urban/rural locality, age, sex and gender (female/male). Intercepts are included

446 in all models, and the explained deviance (in %) is also shown. Negative estimates for gender

447 means a preponderance of male respondents. Positive estimates for age indicate a preponderance

448 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			

449

450

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.

454

455

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

457 'towards' would indicate the direction of the significant effect. For instance, if in a given area, there was a significantly higher number od 'never-

458 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	$P < 0.05$ (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.

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

460
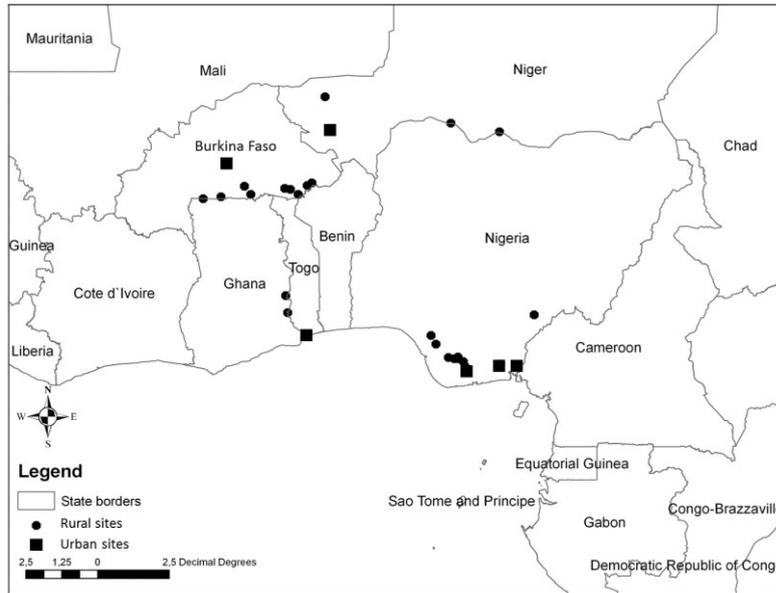
461

462

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

465
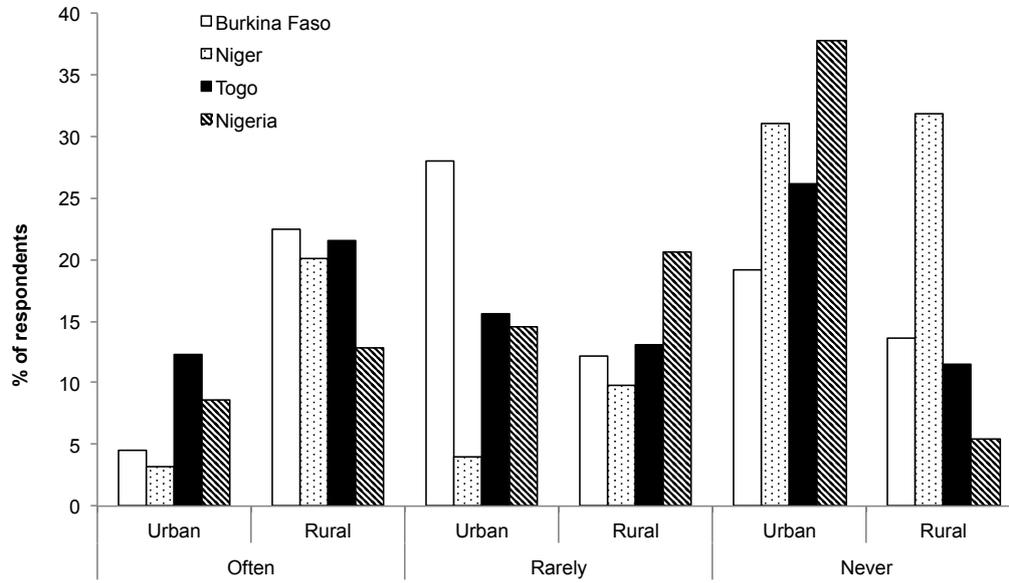
466   Figure 3. Relative importance of predictors (pure effect), as determined by hierarchical variation

467   partitioning, for the model considering all the interviewees' responses as dependent variable, for

468   the Sahel countries (upper graphic) and for the Guinean forests countries (lower graphic). Spatial =

469   urban/rural.

470

471

472
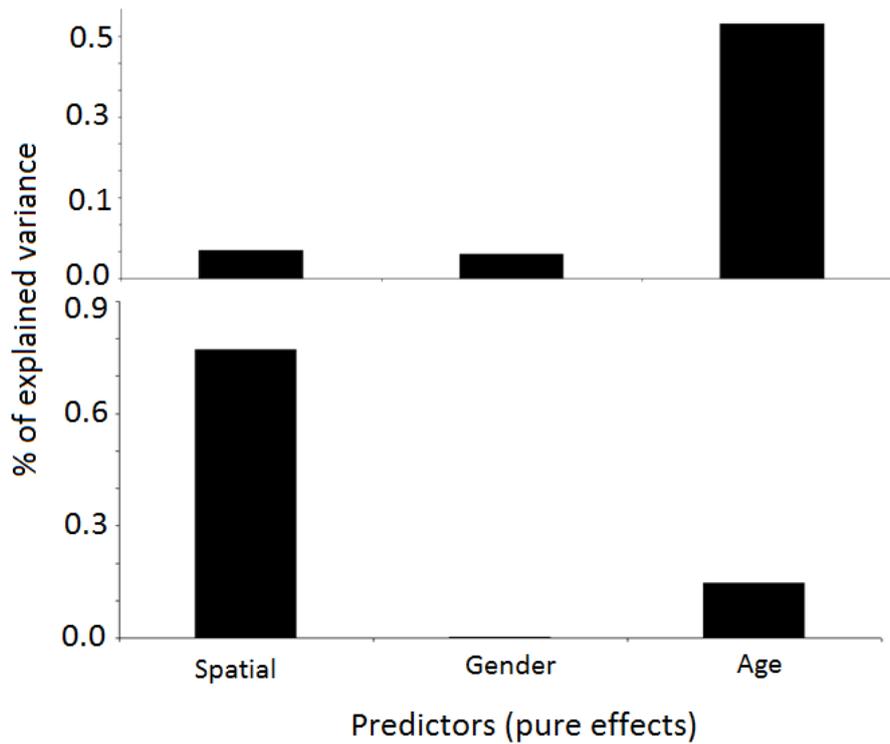
473   Figure 4. Distribution of the various types of answer by respondents in urban versus rural areas in

474   the four studied countries of West Africa as for whether they would eat bushmeat often, rarely or

475   never. All data from the different countries were pooled for this graphic

476

477
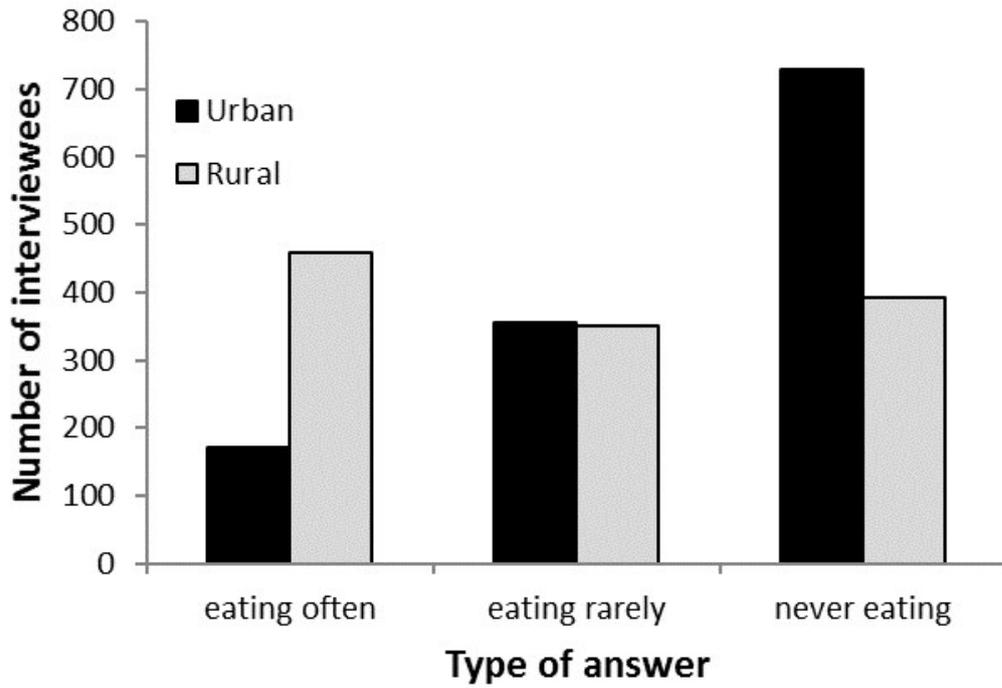
478   Figure 5. Distribution of the various types of answer by respondents in urban versus rural areas in

479   the four studied countries of West Africa as for the type of consumed bushmeat is concerned. All

480   data from the different countries were pooled for this graphic

481
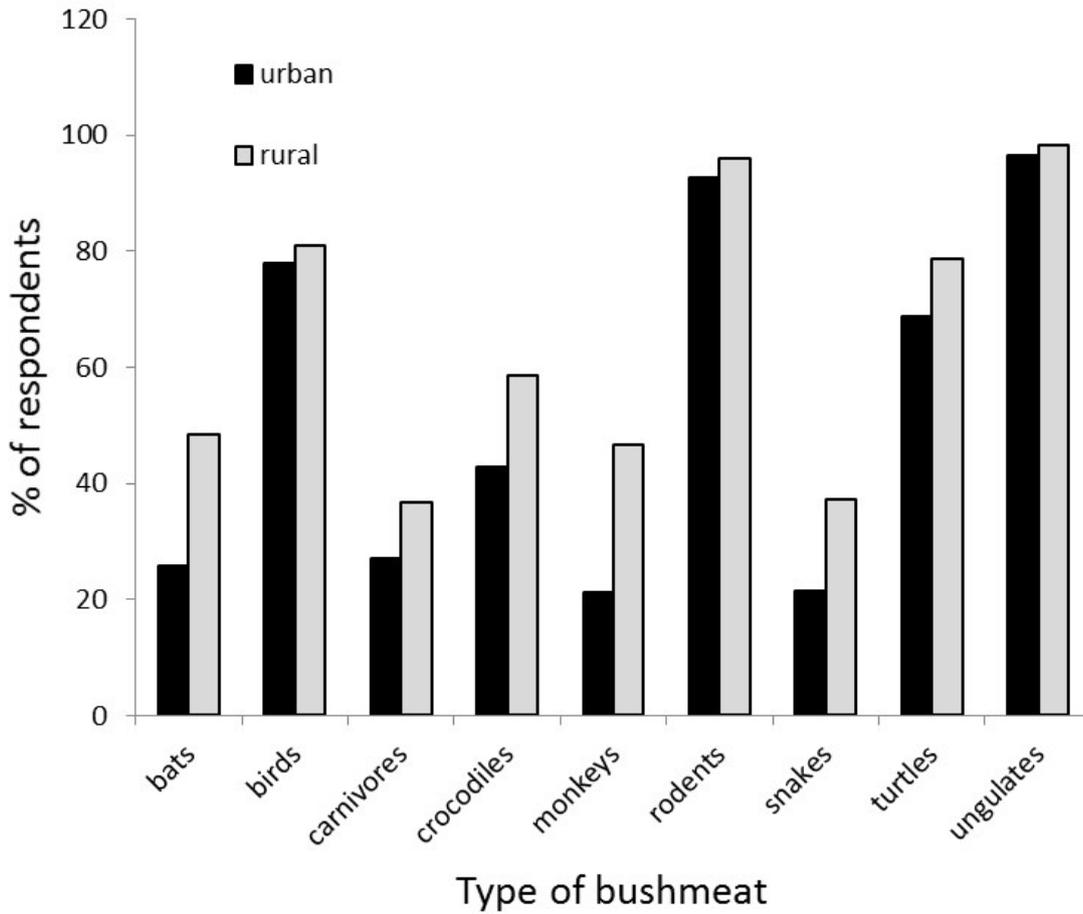
482

483   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

484

485

486   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	

487