Conservation strategies for understanding and combating the primate bushmeat trade on Bioko Island, Equatorial Guinea

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Short Title: Combating bushmeat hunting on Bioko

28

29 **Research Highlights:** We summarize results from multifaceted primate conservation efforts on

30 Bioko Island, detail the negative impact bushmeat hunting has had on primate populations, and

31 discuss what strategies have worked and how we should move forward.

32

Abstract

34 Bioko Island, Equatorial Guinea is among the important places in Africa for the conservation of

35 primates, but a cultural preference for bushmeat and a lack of effective law enforcement has

36 encouraged commercial bushmeat hunting, threatening the survival of the remaining primate

37 population. For over 13 years we collected bushmeat market data in the Malabo market,

38 recording over 35,000 primate carcasses, documenting "mardi gras" consumption patterns,

39 seasonal carcass availability, and negative effects resulting from government intervention. We

40 also conducted forest surveys throughout Bioko's two protected areas in order to localize and

41 quantify primate populations and hunting pressure. Using these data, we were able to document

42 the significant negative impact bushmeat hunting had on monkey populations, estimate which

43 species are most vulnerable to hunting, and develop ecological niche models to approximate the

44 distribution of each of Bioko's diurnal primate species. These results also have allowed for the

45 identification of primate hotspots, such as the critically important southwest region of the Gran

46 Caldera Scientific Reserve, and thus, priority areas for conservation on Bioko, leading to more

47 comprehensive conservation recommendations. Current and future efforts now focus on bridging

48 the gap between investigators and legislators in order to develop and effectively implement a

49 management plan for Bioko's Gran Caldera Scientific Reserve and to develop a targeted

50 educational campaign to reduce demand by changing consumer attitudes towards bushmeat.

51 Using this multidisciplinary approach, informed by biological, socioeconomic, and cultural

52 research, there may yet be a positive future for the primates of Bioko.

53

54 **KEYWORDS:** bushmeat, hunting, red colobus, ecological niche models, conservation, Bioko

55

56 # Introduction

57   The hunting of wildlife for human consumption is common in tropical forests throughout

58 the world, as bushmeat plays a prominent economic and dietary role for many rural populations

59 [Fa et al., 2002b; Milner-Gulland and Bennett, 2003; Robinson and Bennett, 2000], and has been

60 positively linked to improved childhood nutrition and overall human health [Fa et al., 2015b;

61 Golden et al., 2011], despite high risk and repeated incidents of zoonotic disease transmission

62 between humans and wildlife [Leroy et al., 2004; Peeters et al., 2002; Rouquet et al., 2005].

63 Hunting, however, poses a significant threat to wildlife throughout the tropics, as it has become

64 predominantly commercially-driven and unsustainable [Bennett et al., 2002; Fa and Brown,

65 2009; Milner-Gulland and Bennett, 2003; Robinson and Bennett, 2000], and wildlife declines

66 and, in some cases extirpations, have been well documented [Butynski et al., 1997; McGraw,

67 1998; Oates et al., 2000; Robinson and Bennett, 2000; Wilkie and Carpenter, 1999]. In the Gulf

68 of Guinea forests of central Africa in particular, bushmeat hunting is especially extensive. This

69 region contains some of the highest human population densities in all of Africa (e.g., > 500

70 people/km^2) [Oates et al., 2004], and the volume of bushmeat for sale in its markets is estimated

71 at approximately 12,000 tons per year [Fa et al., 2006]. Based on estimates of maximum

72 sustainable production, most taxa hunted for bushmeat are overexploited; potentially more than

73 six times sustainable levels [Bennett, 2002; Bennett et al., 2002; Fa and Brown, 2009]. However,

74   not all wildlife species are equally threatened by hunting. Factors such as ecological flexibility

75   (e.g., broad dietary breadth, ability to exploit numerous habitats), anti-predator behavior, and life

76   history traits can influence species' vulnerability to hunting [Linder and Oates, 2011; McGraw,

77   2007; Struhsaker, 1999]. Diurnal primates, for example, are particularly threatened, with over

78   70% of species in the region thought to be hunted unsustainably [Fa and Brown, 2009], despite

79   most species receiving at least some level of legal protection under both national and

80   international legislation (e.g., CITES, African Convention on the Conservation of Nature and

81   Natural Resources). Primates play a vital role in ecosystem functioning in terms of seed

82   dispersal, and the preservation of primate populations is critically important for the maintenance

83   of forest structure and forest regeneration [Chapman and Onderdonk, 1998; Poulsen et al., 2001;

84   Wrangham et al., 1994]. Declines and/or losses of these species can lead to cascading negative

85   ecological consequences, including reductions in the number of large hardwood trees, a

86   transition towards fast-growing, low-density pioneer species, and declines in the overall tree

87   community diversity, threatening the persistence of the ecosystems they inhabit and the people

88   who depend on them [Abernethy et al., 2013; Chapman and Onderdonk, 1998; Effiom et al.,

89   2013; Laurance et al., 2012; Terborgh et al., 2008; Vanthomme et al., 2010].

90   Hundreds of millions of dollars have been spent on conservation in central Africa,

91   leading to the development and implementation of numerous strategies to better understand and

92   combat the bushmeat trade, which have been met with varied levels of success [Pailler, 2005;

93   Pyhälä et al., 2016]. Development objectives, such as poverty alleviation, are widely utilized and

94   have improved livelihoods of some of those dependent on forest resources, but real conservation

95   effectiveness is rare and often not evaluated [Roe et al., 2015], and as stand-alone measures,

96   development objectives have had minimal success in reducing bushmeat consumption [Astaras,

97 2009; Oates, 1999; Robinson and Bennett, 2002]. In the Oban Division of the Cross River

98 National Park, for example, despite a proposed budget of 18.43 million European Currency Units

99 over a seven-year period (most of which went to development projects and international

100 consultants), high-intensity unregulated hunting in the park led to low mammal densities [Oates,

101 1999]. Heavy hunting in the park has continued since Oates' account, resulting in extremely low

102 mammal densities, and local communities in the vicinity of the park are now 'somewhat

103 antagonistic' due to unfulfilled development promises stemming from the creation of the park

104 [Morgan et al., 2013; Morgan et al., 2011]. Furthermore, many development projects struggle to

105 meet their own objectives due to limited funds, capacity, and available time [Wicander and

106 Coad, 2015]. Forest guard patrols in protected areas have shown to be successful at reducing

107 hunting [Bruner et al., 2001; Campbell et al., 2011; Corlett, 2007; de Merode and Cowlishaw,

108 2006; Hilborn et al., 2006; Rowcliffe et al., 2004; Tranquilli et al., 2012], but they do not fully

109 address the problem of bushmeat demand. These patrols often lack adequate financial resources

110 [Njuh Fuo and Memuna Semi, 2011; Oates et al., 2004], can be ineffective if improperly

111 implemented, and, in some cases, have contributed to conflicts with local communities [Pyhälä et

112 al., 2016]. Blanket criminalization of hunting and consumption could deter hunting if properly

113 enforced, but enforcement regimes are often ineffective or absent, and, as such, have been

114 relatively unsuccessful in reducing the overall trade [Barnes, 1996; Biggs et al., 2013; Burton,

115 1999; Miron, 1998; Rivalan et al., 2007]. Domestication of bushmeat species has been proposed

116 as a way to alleviate demand [Cooper, 1995; Grande Vega et al., 2013; Jori et al., 1995], but it

117 has been shown to be economically inviable in the absence of enforcement, while wild meat

118 remains essentially a free good [Brooks et al., 2010; Mockrin et al., 2005; Nasi et al., 2008].

119 Despite readily available protein alternatives at cheaper prices, taste and cultural preferences for

120   bushmeat contribute to the persistence of its high demand [Bowen-Jones and Pendry, 1999; East

121   et al., 2005; Kümpel et al., 2007; Morra et al., 2009; Reid et al., 2005; Schenck et al., 2006].

122   Education in order to change perceptions towards wildlife and conservation may have long

123   lasting impacts, but societal change is often a slow process, and too many species require

124   solutions in the short-term in order to ensure their persistence. Thus, education and outreach

125   should be critical components of any comprehensive strategy, but they do not address the

126   inherent immediacy of the bushmeat crisis. What is clear is that there is no panacea for the

127   bushmeat crisis and that our understanding of how to most effectively solve the problem remains

128   unclear, largely due to the extremely complex nature of the bushmeat trade, spanning from

129   individual actors to national and international-level policy considerations. No single solution can

130   stand alone in the face of such an intricate problem; rather, we need to address the bushmeat

131   trade from as many angles as possible.

132   It has long been said, however, that conservation is a crisis discipline [Soulé, 1985], and

133   some of the best laid theories often fall victim to limitations of funding, logistics, and the

134   realities on the ground [Cronin et al., 2014b; James et al., 1999b]. Due to these limitations,

135   researchers in central Africa have often focused their efforts on a particular niche, e.g.

136   socioeconomics or ecology [Brashares et al., 2011; Foerster et al., 2012], with the aim of

137   contributing data to an overarching conservation effort. Recent studies (e.g., Fa et al. [2015a];

138   Nasi and Van Vliet [2011]; and Ziegler et al. [2016]) have begun to broaden the focus to provide

139   regional understanding and scope, while still providing great specificity in the details of their

140   findings. However, there have been few instances where it has been possible to develop and

141   implement a long-term multidisciplinary approach tailored to a particular site; where both

142   research and conservation activities could be implemented in an area small enough to feasibly

143   manage multiple projects as well as monitor progress.

144   Bioko Island, Equatorial Guinea provides a unique opportunity to study the bushmeat

145   trade and its effects on primate populations in central Africa. The Bioko Biodiversity Protection

146   Program (BBPP), an academic partnership between Drexel University and the Universidad

147   Nacional de Guinea Ecuatorial (UNGE), has carried out research and conservation activities and

148   has been spearheading conservation efforts on Bioko since its inception in 1998. In recent years

149   however, the BBPP has developed and implemented a more comprehensive approach to

150   biodiversity conservation on Bioko, leveraging the strength of its long-term conservation and

151   monitoring programs to shift to a more results-based approach that encompasses current

152   education, research, and planning techniques. In this paper, we aim to 1) detail the multifaceted

153   conservation framework (Fig. 1) currently being employed by the BBPP, 2) synthesize recent

154   BBPP research to summarize current knowledge on the status of wildlife and conservation on

155   Bioko, 3) demonstrate how we are aggregating results to prioritize conservation efforts, and 4)

156   provide conservation recommendations to improve protection of Bioko's primate populations.

157

158   *Bioko Island: A bushmeat case study*

159   Bioko Island, Equatorial Guinea (2,017 km^2) is a small volcanic island in the Gulf of

160   Guinea, just 37 km off the coast of Cameroon (Fig. 2). The island has been recognized as a

161   hotspot for biodiversity [Myers et al., 2000; Oates et al., 2004], owing in part to its small size,

162   location, and biogeographic history, as well as its seven diurnal primate taxa (Table 1), which

163   make it one of the highest priority sites in Africa for the conservation of primates [Oates, 1996].

164   Human population density varies widely on Bioko, from >100 people/km^2 in Malabo in the north

165   to <10 people/km^2 in the south [Albrechtsen et al., 2006]. Much of the island's biodiversity

166   occurs within two protected areas that comprise approximately 40% of the island, Pico Basilé

167   National Park (PBNP) (330 km^2) and the Gran Caldera Scientific Reserve (GCSR) (510 km^2).

168   Since the late 1990s, urban development surrounding Malabo has expanded greatly, but due to a

169   combination of rugged terrain, isolation, heavy rainfall, and an island-wide ban on logging

170   activities [Republic of Equatorial Guinea, 1991], large swaths of intact forests remain, especially

171   within PBNP and GCSR [Zafra-Calvo et al., 2010]. Despite the readily available intact habitats

172   and biological wealth of Bioko, there are neither management plans for its protected areas, nor

173   detailed enforcement strategies in place with which to effectively conserve its biodiversity.

174   Bioko Island provides a unique opportunity for the study of the bushmeat trade.

175   Bushmeat hunting is the primary threat to the persistence of primates on Bioko. Government

176   attempts to regulate the bushmeat trade in Equatorial Guinea have so far focused on reducing

177   supply by regulating hunting [Republic of Equatorial Guinea, 1988], banning hunting inside

178   protected areas [Republic of Equatorial Guinea, 2000; Republic of Equatorial Guinea, 2003], and

179   prohibiting the hunting, sale, and consumption of primates [Republic of Equatorial Guinea,

180   2007]. Each of these legislative efforts have ultimately been toothless, however, as objectives

181   have been too broad, unfeasible (e.g., no staff/infrastructure to enforce laws in protected area),

182   and/or lacking detailed strategies for funding and implementation. As a result, forests and

183   protected areas are entirely unmanaged and hunting is extensive throughout the island, both

184   outside (legally) and inside (illegally) of protected areas [Cronin et al., 2013; Cronin et al., 2016;

185   Grande-Vega et al., 2016; Grande Vega et al., 2013]. This hunting is conducted nearly

186   exclusively for profit, predominantly by commercial hunters from the mainland sector of

187   Equatorial Guinea [Albrechtsen et al., 2007; Grande Vega et al., 2013; Hearn et al., 2006; Reid et

188   al., 2005]. The market structure and taxonomic profile are relatively similar to other regional

189   markets [Albrechtsen et al., 2007; Cronin et al., 2015b; Fa et al., 2000]. The bushmeat trade on

190   Bioko is confined to a relatively small, contained (insular) system (barring easily identifiable

191   imports from the mainland), with simple transport routes [Fa, 2000], and consumption primarily

192   restricted to Malabo [Albrechtsen et al., 2007]. Malabo's population is not dependent on

193   bushmeat, as alternative protein sources are readily available, and bushmeat contributes an

194   insignificant proportion of the population's minimum protein requirement [Albrechtsen et al.,

195   2006; Grande Vega et al., 2013; Morra et al., 2009; Reid et al., 2005] and fulfills only a fraction

196   of the economic needs for relatively few individuals [Albrechtsen et al., 2006; Reid et al., 2005].

197   Rather, it seems that consumption of bushmeat, and especially of primates, is associated with

198   wealth and status [Albrechtsen et al., 2006; Cronin et al., 2015b; Reid et al., 2005]. As a result,

199   larger vertebrates, specifically monkeys, are in decline on Bioko [Cronin et al., 2010; Cronin et

200   al., 2015a; Cronin et al., 2013; Grande-Vega et al., 2016; Hearn et al., 2006]. This situation is

201   exacerbated by the recent completion of a new highway bisecting the GCSR (Fig. 2), providing

202   easy access to previously inaccessible areas, creating new opportunities for illegal exploitation of

203   wildlife and forest resources, stimulating new interest in development activities at Ureca, and

204   facilitating establishment of (unregulated) tourism in the GCSR.

205

206   *Bushmeat Market Surveys*

207   At the time of the first contemporary conservation assessment of primates on Bioko,

208   primate populations were relatively abundant, but researchers also documented the existence of a

209   bushmeat market on Bioko and warned of the potential negative impacts hunting could have on

210   the island's primates [Butynski and Koster, 1994]. Subsequent studies documented the extent of

211   the market, and demonstrated that throughout the 1990s and early 2000s, wildlife on Bioko was

212   heavily exploited, with some species, including primates, hunted unsustainably [Albrechtsen et

213   al., 2007; Fa et al., 1995; Hearn et al., 2006; Juste et al., 1995; Morra et al., 2009]. These studies

214   formed a critical baseline for conservation planning, but lacking a true temporal component,

215   were only able to provide general 'snapshot' details of market characteristics and trends. Cronin

216   et al. [2015b], however, conducted a comprehensive bushmeat market study using long-term data

217   collected between October 1997 and September 2010, which allowed for the detection of short-

218   and long-term effects of market interventions, species-specific hunting patterns within taxonomic

219   groupings, and seasonality in hunting patterns across several years. Market data were classified

220   into groups (e.g., primates) and analyzed relative to three distinct periods based on conservation

221   activities, government interventions, and notable market changes using an intervention model

222   [Box and Tiao, 1975] and suite of time series analyses (See Cronin et al. [2015b] for an in-depth

223   description of methodology).

224   Over 197,000 carcasses from 45 different taxa were recorded during the course of the

225   study. More than 35,000 of these carcasses were primates, making up about 18% of the entire

226   volume of the market [Cronin et al., 2015b]. The overall market grew significantly over time

227   concurrent to a transition towards increased shotgun hunting. The volume of primate carcasses in

228   the market also increased gradually until October 2007 (Fig. 3a), when the hunting, sale, and

229   consumption of primates were banned by Presidential Decree [Republic of Equatorial Guinea,

230   2007]. As a result, the primate carcass rate temporarily dropped to nearly zero carcasses/market

231   day, but then swiftly increased to rates 3-4 higher than pre-ban, reaching a maximum of 37.42

232   carcasses/market day in April 2010. Cronin et al. [2015b] termed this pattern a 'mardi gras'

233   mentality in relation to attempted conservation interventions, in which bushmeat volume actually

234   increased following implementation of the intervention largely due to a lack of enforcement as

235   market players sought to maximize their gains before the potential effects of the legislation could

236   take hold. Not all primate taxa were hunted equally, however, as interspecific differences

237   revealed via trend analyses shed light on the drivers of the rapid increase in the overall primate

238   carcass rate following the decree. Five of the seven primates occurred in the market at a

239   significantly greater rate in the period following the primate hunting ban, but two species (*P.*

240   *pennantii* and *C. nictitans*) did not follow the same pattern (Fig. 3b). As a result of both

241   environmental factors and a history of unrestricted hunting, populations of these two species are

242   restricted to the remote southern extent of Bioko within the GCSR (Fig. 3c) [Butynski and

243   Koster, 1994; Cronin et al., 2015a; Cronin et al., 2013; Cronin et al., 2016], suggesting that a

244   combination of isolation and long-term BBPP conservation activities focused on the area, have

245   provided at least passive protection from hunting. Furthermore, due to their limited geographic

246   range, these species can serve as indicator species, alerting us to hunting activity in particular

247   areas of the GCSR.

248

249   *Forest Surveys*

250   While many bushmeat studies have been conducted on Bioko, there have been fewer

251   comprehensive field surveys for primates. Rather, the emphasis has been on maintaining a

252   localized, yet regular, long-term monitoring and research effort [Cronin et al., 2010; Hearn et al.,

253   2006; Hearn et al., 2004] in order to provide passive protection in key areas. Although there have

254   been myriad conservation benefits to this program, more broadly-focused, systematically

255   designed surveys were necessary to better estimate the status of primate populations and hunting

256   intensity. In order to investigate the impact of hunting on wild primate populations, targeted

257 forest surveys were conducted throughout the GCSR at three sites representative of differing

258 levels of human access and activity: Moraka Playa, Ureca, and Belebu (Fig. 2) [Cronin et al.,

259 2016]. Moraka Playa, in the remote southwest, had very little hunting and was over 30 km on

260 foot from the nearest road. Ureca, the only village within the GCSR, was located about 22 km

261 over land from the nearest road and at the time had a population of approximately 80 people.

262 Ureca was considered to have moderate levels of human activity due to military personnel

263 hunting in the area and extensive trapping by the villagers. Belebu, on the northern boundary of

264 the GCSR, was a village of several hundred people and served as the primary access point for the

265 GCSR via paved roads from Luba. The area around Belebu was extensively hunted and regularly

266 organized bushmeat transports brought offtake to Malabo [JMEE, pers. obs.]. There also has

267 been a long history of plantation agriculture around Belebu, so in addition to the loss of primary

268 forest in the area, shotguns were widely used to both hunt bushmeat and control agricultural

269 pests [Butynski and Koster, 1994]. It should be noted that these surveys took place between

270 January 2011 and February 2012 and, as aforementioned, direct access to Ureca and the southern

271 beaches via the new road has changed patterns of hunting pressures in the reserve (Fig. 2).

272   Unsurprisingly, primate abundance was negatively associated with shotgun hunting

273 [Cronin et al., 2016]. Primate encounter rates were significantly lower at Belebu than at either of

274 the other two sites, while concurrently shotgun hunting was highest at Belebu (Table 2).

275 Although these data indicated that hunting was adversely impacting the overall primate

276 population, they did not explain how individual species were affected by differing levels of

277 hunting pressure. A "hunting response index" (HRI) was developed in order to infer species-

278 specific vulnerability (Fig. 4). An HRI has been used before (e.g., Linder and Oates [2011]) to

279 provide an estimate of vulnerability to hunting by comparing relative differences in species'

280   encounter rates between highly and lowly hunted forests while controlling for habitat type. HRI

281   values of less than one suggest that a species is vulnerable to hunting, values greater than one

282   suggest the species may be resilient, and a value equal to one suggests no effect from hunting.

283   Both *C. erythrotis* and *C. nictitans* exhibited some resiliency to hunting, which in the case of *C.*

284   *nictitans* supports results from Linder and Oates' [2011] study in Korup National Park in

285   Cameroon, as well as reports of relatively high densities of *C. nictitans* in other heavily hunted

286   forests throughout the region [Garcia and Mba, 1997; Matthews and Matthews, 2002; Muchaal

287   and Ngandjui, 1999]. In contrast, the other four primate species were all vulnerable to hunting, as

288   each was encountered less in heavily hunted forests (Fig. 4). *P. pennantii* was most vulnerable to

289   hunting, a trait it shares with many other highly threatened forms of red colobus across Africa

290   [Struhsaker, 2005]. This vulnerability has been attributed to its high degree of ecological

291   specialization (e.g., limited dietary and habitat flexibility), as well as its large body and group

292   size, and slow and ineffective anti-predator responses [González-Kirchner, 1997; McGraw,

293   2007; Struhsaker, 1999].

294

295   *Biomonitoring and Research Presence*

296   Forest guards can be beneficial in combating the illegal harvesting of wildlife [Bruner et

297   al., 2001; Campbell et al., 2011; Corlett, 2007; de Merode and Cowlishaw, 2006; Hilborn et al.,

298   2006; Rowcliffe et al., 2004; Tranquilli et al., 2012], and are believed to be the most cost-

299   effective and expeditious solution to poaching, as well as an integral part of effective long-term

300   protected area planning [Bennett, 2011]. On Bioko, however, there are no management strategies

301   for the island's protected areas, nor have any governmental enforcement activities, such as forest

302   patrols, been implemented. Since 1998, the BBPP has sought to fill that role by employing a

303 community-based research and monitoring program within the GCSR. Teams of trained

304 monitors, all of whom are hired locally, collect data on the status of hunting, primate

305 populations, and nesting marine turtles throughout the GCSR. In addition to collecting vital data

306 on the status of wildlife and hunting in the reserve, their presence in the forests has proven

307 successful as a deterrent to hunting, despite lacking any official enforcement capacity (CR, pers.

308 obs.). Employment of the monitoring and research teams has also provided an alternative

309 livelihood for the local communities of Ureca and Moka (Fig. 2), and, in doing so, converted a

310 number of former hunters to enthusiastic conservationists. Furthermore, data collected by the

311 monitoring teams have been vital to BBPP's efforts, contributing to a number of reports and

312 publications advancing the cause of biodiversity conservation on Bioko [Cronin et al., 2010;

313 Cronin et al., 2015a; Cronin et al., 2013; Cronin et al., 2016; Fitzgerald et al., 2011; Hearn et al.,

314 2006; Rader et al., 2006], as distilling data into formats understandable to policy makers as well

315 as the general population is key to the development of successful wildlife management plans.

316

317 *Ecological Niche Models*

318   One of the most significant inhibitions to our greater understanding of primate ecology

319 and abundance on Bioko is access. Bioko's climate is one of the wettest in the world with over

320 10,000 mm of rain annually [Font Tullot, 1951; Nosti, 1947], and its rugged terrain has left steep

321 and deep ravines unexplored, and restricted potential areas for primate surveys, especially during

322 the wet season, when access and mobility are extremely limited. As a result, our inferences about

323 primate distributions could not adequately account for inaccessible areas and/or range shifts. We

324 have been able to overcome these hurdles by generating ecological niche models (ENMs) using

325 the program Maxent [Phillips et al., 2006]. ENMs were developed specifically to maximize the

326   utility of presence-only data collected in similar situations [Elith et al., 2011], and have been

327   used successfully elsewhere to model primate distributions [Blair et al., 2013; Etiendem et al.,

328   2013; Sesink Clee et al., 2015]. Using forest survey data collected between 2008 and 2014, we

329   developed species distribution models for each of Bioko's 7 diurnal primate species [Cronin et

330   al., 2015a]. In order to best inform overall primate conservation, we combined individual species

331   distributions to create a heat map depicting hotspots of primate species richness on Bioko (Fig.

332   5a) [Cronin et al., 2015a]. The modeling of primate abundances and distributions in a

333   scientifically accurate manner clearly illustrates the importance of the GCSR to the conservation

334   of primate diversity on Bioko and has proven to be an effective tool for the communication of

335   the importance of priority conservation zones on the island (Fig 5b). The southern slope of

336   Bioko, from the peaks of the Gran Caldera and Pico Biao down to the southern beaches, is likely

337   to be the only remaining place where over 5 species of diurnal primates remain on the island.

338   Even more critical is the Gran Caldera itself, the last vestige of truly remote forest on Bioko,

339   which maintains populations of all 7 species in an area of under 15 km^2.

340

341   *Understanding Human Use*

342   In order to fully understand the bushmeat trade on Bioko, or indeed anywhere the trade occurs, it

343   is important to understand the socioeconomic and cultural drivers that motivate people to hunt

344   illegally and consume wildlife. Despite the wealth of data gained from studies of the market and

345   wild primate populations, a lack of contemporary data on these drivers following the dramatic

346   expansion of the Equatoguinean economy since the late 1990s [Central Intelligence Agency,

347   2016; The World Bank, 2016] has limited our ability to effectively target education, outreach,

348   and conservation strategies. In an attempt to fill these gaps in our understanding of the bushmeat

349 trade on Bioko, we conducted a series of questionnaires, a methodology which has proven useful

350 in elucidating patterns of bushmeat consumption and preferences [East et al., 2005; Jenkins et al.,

351 2011; Kümpel et al., 2010; Schulte-Herbrüggen et al., 2013]. Over 700 public surveys were

352 conducted between June 2013 and September 2014 at various sites in Malabo and in villages

353 throughout Bioko [Bocuma Meñe, 2016]. Results suggested that bushmeat consumption on

354 Bioko is indeed driven by cultural preferences, predominantly in the two major ethic groups,

355 Fang and Bubi, which make up the majority of the island's population. Fang and Bubi

356 respondents consumed bushmeat at a similar frequency (DF = 3; p > 0.05), and reported that

357 bushmeat was their preferred protein source (DF = 1; p > 0.05). However, differences existed

358 among ethnic groups in regards to preferred bushmeat type; Fang respondents had a higher

359 preference for primates (Fisher's Exact Test; p < 0.05). These findings were similar to Fa et al.

360 [2002a] in which they reported that in 1990-1991 the Fang also had a significant preference for

361 primates. This suggests that certain cultural preferences may transcend significant economic

362 growth and changes in the bushmeat market [Cronin et al., 2015b], and the erosion of other

363 seemingly entrenched societal norms related to consumption (e.g., a taboo on eating *Colobus*

364 *satanas*) [Colell et al., 1994; Kümpel et al., 2008]. In a comparison of two hunting villages, one

365 Bubi and one Fang, Grande Vega et al. [2013] also found that only Fang hunters targeted

366 monkeys. However, this may be confounded by the fact that Fang hunters had guns, while Bubis

367 have had limited gun ownership since 1998 [Grande Vega et al., 2013]. These findings highlight

368 the importance of understanding the heterogeneity of local cultures as they relate to variability in

369 bushmeat market drivers, and, as a result, how best to tailor conservation approaches to account

370 for these differences[Walters et al., 2015]. For example, our results suggest that education and

371   outreach efforts aimed at reducing primate hunting and consumption through behavioral change

372   should be tailored to address Fang cultural preferences.

373

374   **Discussion**

375   A broad-based holistic understanding of the status of primates and conservation on Bioko

376   is required in order to engage with policy makers to design and implement effective conservation

377   priorities. To that end, our goal is to leverage the strengths of the BBPP: (*i*) numerous

378   longitudinal datasets, (*ii*) a successful academic partnership with UNGE, long-term history in the

379   villages of both Ureca and Moka, (*iii*) and a continuous research and biomonitoring presence in

380   the GCSR, to 'kick start' the movement towards government-led conservation.

381

382   *Focusing Conservation Efforts: Primates as Umbrella Species*

383   A good example of our strategy in practice is the case of Pennant's red colobus (*P.*

384   *pennantii*), which illustrates the biological importance of the GCSR and the utility of using

385   primates as umbrella species for conservation on Bioko. *P. pennantii* is perennially considered

386   among the world's most endangered primates [Cronin et al., 2014a; Mittermeier et al., 2007;

387   Mittermeier et al., 2010]. Previous work has suggested that *P. pennantii* is the only primate

388   species endemic to Bioko [Groves and Ting, 2013; Groves, 2007; Oates, 2011], despite high

389   subspecific endemism among the other 6 species [Oates, 2011], and that it is also the most

390   vulnerable primate to the impacts of hunting on the island [Cronin et al., 2016]. Forest surveys

391   have suggested that the population size of *P. pennantii* has declined significantly since 2006

392   [Cronin, unpublished data], and that its geographic distribution [Cronin et al., 2015a; Cronin et

393   al., 2013; Cronin et al., 2016] is restricted entirely within the boundaries of the GCSR to an area

394   almost half the size of previous estimates [IUCN, 2016; Oates, 2011]. Furthermore, the

395   distribution of *P. pennantii* encompasses not only the areas with the highest species richness of

396   monkeys on Bioko, but also much of the critical sea turtle nesting habitat along the southern

397   beaches of the GCSR (Fig. 6). Thus, if *P. pennantii* can be effectively conserved, it will serve as

398   an umbrella for the conservation of many other threatened taxa (e.g., white-bellied pangolins,

399   [*Phataginus tricuspis*]; Ogilby's duiker [*Cephalophus ogilbyi ogilbyi*]; and leatherback turtles

400   [*Dermochelys coriacea*]) and habitats, including the Gran Caldera itself and a large swath of

401   contiguous forest along an elevational gradient from sea level to over 2,200 m.

402

403   *Conservation Recommendations*

404   Securing the long-term future of the GCSR will require a multifaceted approach

405   including (*i*) the development and implementation of an adaptive, evidence-based management

406   plan; (*ii*) strengthening of the legal basis for protection of the GCSR; (*iii*) the empowerment of

407   the National Institute of Forestry Development and Protected Area Management (INDEFOR-AP)

408   and the Ministry of Forests and the Environment, the federal entities tasked with management of

409   protected areas; (*iv*) increased law enforcement effectiveness; and (*v*) committed involvement

410   from the Government of Equatorial Guinea in order to not only stop illegal hunting, but also to

411   mitigate impacts from its own development plans.

412   A critical problem that must be addressed is the commitment of the Equatoguinean

413   government to biodiversity conservation, namely through support for protected areas and their

414   management. Equatorial Guinea is far from unique in this situation, as many African rain forest

415   protected areas are underfunded by 50-80% of their necessary annual operating costs [Bruner et

416   al., 2004; Wilkie et al., 2001], and at least 75% lack a secure, long-term funding program

417   [Struhsaker et al., 2005]. In a comprehensive analysis, Struhsaker et al. [2005] estimated that the

418   annual cost of operating a protected area in African rain forests was between 23 and 208 USD

419   per km^2, noting however, that these levels were believed to be insufficient, and that even

420   doubling estimates to about 400 USD per km^2 would still have left the costs significantly lower

421   than protected areas in developed nations [James et al., 1999b]. Blom [2004] had similar results,

422   estimating that the average yearly expenditure to achieve effective management at numerous

423   protected areas across Cameroon, Equatorial Guinea, Gabon and Central African Republic was

424   approximately 212 USD per km^2. Given the high abundance and diversity of species in these

425   forests [e.g., Oates et al., 2004], this suggests that investment in African rain forest protected

426   areas is highly cost-effective [Bruner et al., 2004]. Using the doubled approximations from

427   Struhsaker et al. [2005], 400 USD per km^2 would be approximately 495 USD per km^2 after

428   adjusting for inflation, resulting in an annual operating cost of just 415,800 USD for Bioko's two

429   protected areas [Cronin et al., 2014b]. Assuming a gross domestic product (GDP) for Equatorial

430   Guinea of 15.53 Billion USD [The World Bank, 2014], of which the forestry sector comprises

431   approximately 1.3% (~201.9 million USD) [Bizimana et al., 2014], the effective operation of

432   Bioko's protected areas represent only 0.003% of the annual GPD and 0.22% of the forestry

433   sector. It should be noted, however, that both above estimates assume that there is at least some

434   existing infrastructure with which Bioko's protected areas could be operated effectively (e.g.,

435   equipment and personnel). Despite the minimal costs relative to overall government

436   expenditures, and the strong motivation of INDEFOR-AP to expand their management and

437   conservation efforts, protected areas currently have insufficient infrastructure, personnel, and

438   capital with which to operate in any impactful manner on Bioko. As a result, it is perhaps more

439   realistic to estimate that in the near-term, initial investments must be higher to develop sufficient

440   infrastructure and capacity with which to begin to actively manage protected areas. This serves

441   to illustrate the scale of underinvestment in protected areas and their management in Equatorial

442   Guinea despite its globally recognized biological wealth and the government's declaration of

443   environmental conservation as one of the country's 'Five Pillars' of reform [Quorvis

444   Communications, 2010].

445   Far from simply detrimental to Bioko's primates and other flora and fauna, this also

446   represents a significant economic loss at both local and national scales, which if acknowledged

447   could help tip the scales in favor of improved conservation. Bioko's ecosystems provide services

448   that are of vital importance to the well-being, health, and prosperity of the country and its

449   citizens, yet they are often overlooked due to the enigmatic nature of valuating ecosystem

450   services. In a global assessment, Costanza et al. [2014] posited that tropical forests should be

451   valued at 5282 USD/hectare/year for their services. Based on this estimate, the services provided

452   by Bioko's two PAs should be valued at approximately 452 million USD/year. Furthermore,

453   James et al. [1999a] estimated that roughly 10 billion USD per year are spent safeguarding the

454   world's protected areas, from which approximately 600 billion USD/year is generated in direct

455   in-country expenditure from visitors to these areas [Balmford et al., 2015]. Unfortunately,

456   visitors to Equatorial Guinea are scarce, as it is considered among the least visited countries in

457   the world [Mark, 2015], meaning generating large-scale profits from ecotourism will be difficult

458   in the near-term. However, if some policies were amended to make it easier to visit and transit

459   throughout the country, there is significant potential for ecotourism on Bioko due to its intact

460   forests, expansive beaches, and abundant wildlife, including high densities of both diurnal

461   primates and marine turtles. We recognize that these values are rough estimates and that there are

462   inherent limitations in detailed valuations of ecosystem services or potential future tourism

463   expenditures, but, in general, evidence suggests that increased investments in protected areas and

464   their management could yield substantial returns.

465   Given the current conditions and the task ahead, government-led conservation efforts

466   should be prioritized on Bioko in order to concentrate efforts how and where they are likely to

467   have the maximum possible conservation benefit. Initial efforts should focus on the protection of

468   primates and marine turtles, the taxa most threatened by current offtake patterns. The optimal

469   scenario for the preservation of primates would be a complete ban on shotgun hunting, which

470   accounts for over 90% of all primate carcasses [Cronin et al., 2015b; Grande Vega et al., 2013].

471   Albrechtsen et al. [2004] tested this policy in a model based on Bioko, which also included

472   manipulating market prices for larger animals and increased incomes from alternative

473   livelihoods. The gun hunting ban performed best, not just for the protection of large animals, but

474   also for the conservation of small animals and for reducing the size of the hunting population.

475   Guns have been confiscated previously on Bioko in 1974 [Butynski and Koster, 1994], to the

476   benefit of wildlife, and more recently Grande Vega et al. [2013] reported that during her study,

477   no primates were killed in the village of Basilé Bubi, where there are no guns. It seems, then, that

478   if enacted and effectively enforced, that a ban on gun hunting would considerably improve the

479   long-term viability of Bioko's primate populations.

480   Other measures, such as enforcement of existing legislation, could also be rapidly

481   implemented by the Government of Equatorial Guinea, and may significantly reduce the amount

482   of primate hunting by effecting barriers to the bushmeat trade. The primate hunting ban, for

483   instance, includes prohibitive fines (approximately 200-1000 USD/monkey) [Republic of

484   Equatorial Guinea, 2007], which could disincentivize hunting by threatening a significant portion

485   of hunters' annual hunting income (~480 to 1868 USD/year) [Fa et al., 2000; Grande Vega et al.,

486   2013]. Enforcement could begin in the immediate future at preexisting roadblocks on the two

487   direct routes between catchment areas and Malabo where travelers are already required to stop

488   and periodically show documentation (Fig. 5b). These checkpoints should be supplemented with

489   personnel from INDEFOR-AP tasked with randomized vehicle searches, and supported by

490   military personnel trained in environmental legislation and enforcement. Additional motivation

491   for search and seizure of the citizens may have pitfalls (i.e. the potential for extortion by military

492   staff), but if individuals were supported sufficiently enough to promote compliance with the law,

493   these checkpoints would be well suited to stemming the transport of the majority of bushmeat to

494   Malabo.

495   Perhaps the most practical solution would be the implementation of forest guards

496   [Bennett, 2011], which has been successful elsewhere in reducing hunting and improving the

497   effectiveness of protected areas [Bruner et al., 2001; Campbell et al., 2011; Corlett, 2007; de

498   Merode and Cowlishaw, 2006; Hilborn et al., 2006; Rowcliffe et al., 2004; Tranquilli et al.,

499   2012]. Intensive monitoring for bushmeat hunting could be conducted by these forest guards (or

500   in the immediate future, the trained military personnel) stationed at 'ranger bases' situated at key

501   protected area access points, and by randomized searches of those transiting into and out of

502   protected areas by INDEFOR-AP staff. By focusing on these natural 'choke points,' guards may

503   be more effective than with a more generalized enforcement scheme. The development and

504   implementation of a 'ranger base' or restricted access point at Belebu is especially important to

505   the long-term future of the GCSR (Fig. 5b). It provides the only vehicular access into the GCSR

506   and to the southern extent of Bioko. The highest richness and densities of wildlife are found in

507   this area, providing a biological incentive for protection, but the southern beaches area also a

508   major tourist attraction, and the inability to control access and to generate profits that could then

509   be put back into the management of the GCSR represents a significant missed economic

510   opportunity.

511   A more broadly-focused, systematic program of regular forest patrols covering the

512   entirety of Bioko's protected areas should also be implemented in the long-term, but in the

513   beginning, we recommend that patrol efforts be prioritized following the conservation

514   prioritization framework we developed using our ecological niche model results (Fig. 5b). This

515   framework was created to maximize conservation effectiveness based on amounts of total

516   coverage, as well as the estimated relative investment necessary to effectively patrol the area. We

517   also recommend that forest guard positions eventually be staffed by people living in or alongside

518   protected areas (e.g., Ureca, Moka, Belebu, Moeri, Basilé Fang), as they are best suited for the

519   positions given their local knowledge of the area they will be patrolling. This will aid in the

520   success of the guard program by attaching an economic value to the stewardship of wildlife, and

521   by helping to empower and engage local communities in the process of conservation.

522   The highest priority zone is the southwestern sector of the GCSR, which should be

523   considered a 'critical zone' in each of the following management strategies (Fig. 5b). Using

524   patrols to make this area a 'no-take zone' could be enforced more easily than any offtake

525   restrictions [Milner-Gulland and Bennett, 2003], as it is already protected passively via isolation,

526   difficult terrain, and limited access from the ocean. This area contains all seven diurnal primate

527   taxa at densities higher than elsewhere on Bioko, and has significantly less hunting than other

528   sites [Cronin et al., 2015a; Cronin et al., 2016]. It also holds the highest densities of *M.*

529   *leucophaeus* and *C. satanas* on the island, as well as the entire population of *P. pennantii*

530   [Cronin et al., 2015a; Cronin et al., 2016; Cronin, unpublished data]. In addition to primates,

531   conservation of this zone would protect most of the critical nesting habitat of the four species of

532   marine turtle that nest on the island, as the two 'ranger camps' (Moraka and Moaba) are also the

533   only safe sites for landing small boats, a tactic employed by both terrestrial and marine poachers

534   (Fig. 5B). Thus, by concentrating anti-poaching efforts in the region, guards would be able to

535   maximize conservation benefits at minimal cost.

536   The second priority zone is, in effect, an extension of the first zone to include the entire

537   southern extent of Bioko (Fig. 5b). This would be potentially more of an investment to monitor

538   as it is a larger area, but delineation would be slightly less arbitrary than the first priority zone,

539   and thus, may be easier to enforce. This zone is delineated with a relatively straight line from

540   east to west across the spine of the southern highlands, encompassing the northern rim of the

541   Gran Caldera, but passing below the pastures on the slopes of Pico Biao. This conservation zone

542   would contain an identical faunal species assemblage, but would likely also encompass the entire

543   range of *C. nictitans*. Protecting this zone would also conserve the entirety of the unique

544   monsoon forest habitat type as well as afromontane formations on the two peaks.

545   The third priority would be to simply protect the currently delineated protected areas

546   (Fig. 5b). This is, perhaps, the best place to start, as the protected areas already legally exist, and

547   would require no new designation. This strategy is aided, like the previous two, by the fact that

548   they were originally created since much of the terrain they encompass was deemed inferior for

549   agriculture and overly difficult to access and exploit. In spite of their legal status and difficult

550   terrain, development continues to gradually progress inside Bioko's protected areas with little

551   consideration of their status. Future projects occurring within the protected areas should be

552   subjected to an environmental impact assessment and/or oversight by INDEFOR-AP in order to

553   promote INDEFOR-AP's legal mandate to manage Equatorial Guinea's protected areas and to

554   ensure it meets the conservation and development goals of the protected areas' management

555   plans.

556   Finally, given the extensive territorial waters of Equatorial Guinea, the commercial

557   fishing sector represents a much underutilized resource, but also an opportunity to reduce

558   pressure on Bioko's terrestrial wildlife. Fish availability and bushmeat demand have been shown

559   to be directly linked [Brashares et al., 2004], thus increased availability of fresh fish may help to

560   alleviate demand for terrestrial wildlife. Malabo consumers have a preference for fresh meat

561   [Reid et al., 2005], but the only sources of meat currently 'produced locally' are bushmeat and

562   fish [Albrechtsen et al., 2006], as well as the occasionally available 'cebu' beef (humped cattle).

563   The organization and improvement of the Equatoguinean national fishing fleet may reduce

564   pressure on Bioko's terrestrial wildlife. Furthermore, increasing numbers of non-African fleets

565   are fishing in the Gulf of Guinea, heavily exploiting stocks to the point of decline [Pauly et al.,

566   2014; Pauly and Zeller, 2016], and forcing small scale fisheries to compete with industrial fleets

567   [Belhabib et al., 2015; Pauly and Zeller, 2016]. If fish stocks do not begin to be managed more

568   effectively for the Equatoguinean population, the supply of fish will decline, likely leading to

569   increased demand for bushmeat [Brashares et al., 2004].

570

571   *Cultivating a Culture of Conservation*

572   Despite the significant issues discussed above and Equatorial Guinea's rapid and ongoing

573   development, there are still many reasons to remain optimistic about the future of conservation

574   on Bioko. Human population densities remain low throughout much of the island, and large areas

575   of forest remain intact and relatively inaccessible. Over the last 15 years, UNGE's School of

576   Environmental Sciences has grown from an annual enrollment of fewer than 15 students to over

577   400, and the school is UNGE's most successful and productive academic unit. There are

578   increasing indicators that the Equatoguinean government, via INDEFOR-AP and the Ministry of

579   Forests and the Environment, is interested in taking a more active role in preserving its natural

580   heritage. INDEFOR-AP has recently become more proactive on Bioko, designating

581   Conservators for the two protected areas, partnering with BBPP to deploy INDEFOR-AP

582   ecoguards in Ureca and along the southern beaches, and collaborating with both BBPP and

583   Ecoguinea to train a cadre of future ecoguards from villages around the borders of Bioko's

584   protected areas. There have been periodic confiscations of captured wildlife and bushmeat

585   [Ayecaba and Ortega, 2014], as well as an outreach campaign which distributed pamphlets

586   explaining the primate hunting ban [Republic of Equatorial Guinea, 2007] and the dangers of

587   hunting monkeys. The Equatoguinean government has also made commitments to work with

588   partners, including the BBPP, Ecoguinea, the United Nations Development Program–Global

589   Environmental Facility (UNDP-GEF) and the Wildlife Conservation Society (WCS), to improve

590   management of protected areas, to develop a comprehensive national strategy for management of

591   its protected areas, and to work towards gaining recognition for Bioko Island as UNESCO

592   Biosphere Reserve [Engonga Osono et al., 2015].

593   # Acknowledgements

611

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Figure Captions

Figure 1: In order to effectively understand and combat the bushmeat trade, it is critical that a multidisciplinary approach, such as this example employed by the BBPP, is implemented.

Figure 2: Distribution of major cities (including Ureca), main roads, and protected areas on Bioko Island.

Figure 3: (A) Time series plot of the overall primate carcass rates (carcasses/market day). Vertical lines delineate breaks between periods of distinct market activity identified via intervention analysis [Box and Tiao, 1975]. The second break (between "Pre-ban" and "Post-ban") coincides with the October 2007 Presidential Decree banning primate hunting [Republic of Equatorial Guinea, 2007]. Adapted from Cronin et al. [2015b]. **(B)** Average change in carcass rate per month (slopes) and 95% confidence intervals for each of the diurnal primate species. Adapted from Cronin et al. [2015b]. **(C)** Species range estimation for *P. pennantii* and *C. nictitans* derived from the ecological niche models developed using Maxent, both of which are restricted to the southern extent of Bioko within the GCSR. Adapted from Cronin et al. [2015a].

Figure 4: Hunting response index values (HRI) for six of the seven diurnal primate species on Bioko. *Allochrocebus preussi* was not encountered along transects used for in the HRI analysis, and was excluded from the analysis. HRI values above 1 suggest a relative tolerance to hunting pressure, while values below 1 indicate susceptibility of the species to hunting. Adapted from Cronin et al. [2016].

Figure 5: Using forest survey data, the BBPP developed ecological niche models for each of Bioko's monkey species [Cronin et al., 2015a], which allowed for the identification of **(A)** hotspots of primate species richness. Using these primate hotspots and existing infrastructure as a guide, we designated **(B)** priority areas for primate conservation on Bioko, as well as a series of 'Ranger Bases' at principal protected area access points and 'Bushmeat Checkpoints' that would utilize existing infrastructure at key transit 'choke points' to serve as bushmeat inspection points. Also designated were two remote camps, Moraka and Moaba, both long used by the BBPP, but also key sites for landing small boats, from which forests guards could monitor and protect two of most important beaches on the southern coast.

Figure 6: Bioko Island showing the past [IUCN, 2016] and present [Cronin et al., 2015a] estimated geographic distribution of *P. pennantii*, as well as the overlap between the estimated range of *P. pennantii* and the five (A-E) marine turtle nesting beaches along the southern coast.

Tables

Table 1: The diurnal primates of Bioko Island, Equatorial Guinea and their degree of threat status at the species and subspecies levels [IUCN, 2016]. Taxonomic classification follows Grubb et al. [2003], except for Preuss's monkey, which is allocated to the genus *Allochrocebus* following Grubb [2006]. Table adapted from Cronin et al. [2016].

Common Name	Binomial Name	Red List Category	
		Species	Subspecies
Bioko black colobus*	*Colobus satanas satanas*	Vulnerable	Endangered
Bioko red colobus*†	*Procolobus pennantii pennantii*	Critically Endangered	Endangered
Bioko drill*	*Mandrillus leucophaeus poensis*	Endangered	Endangered
Bioko Preuss's monkey*	*Allochrocebus preussi insularis*	Endangered	Endangered
Bioko red-eared monkey*	*Cercopithecus erythrotis erythrotis*	Vulnerable	Vulnerable
Crowned monkey	*Cercopithecus pogonias pogonias*	Least Concern	Vulnerable
Bioko putty-nosed monkey	*Cercopithecus nictitans martini*	Least Concern	Vulnerable

* Recognized by Grubb et al. [2003] as subspecies endemic to Bioko.
†Recognized by Groves (2007; *Piliocolobus pennantii*) and Oates (2011; *Procolobus pennantii*) as a species endemic to Bioko.

1036 **Table 2:** Measurements of gun hunting intensity and primate abundance across three survey sites within the Gran Caldera Scientific
1037 Reserve. The number of primate group sightings is in parentheses. Table adapted from Cronin et al. [2016].
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Survey Transect	Hunting Intensity (signs/km)	Survey Effort (km)	Species sighting frequency (groups/km)*								Sighting Frequency (groups/km)
			Mle	Csa	Ppe	Cer	Cpo	Cni	Apr	Unk	
Moraka	0.05	210.48	0.11 (19)	0.22 (36)	0.49 (111)	0.64 (133)	0.62 (131)	0.05 (13)	0 (0)	0.12 (26)	2.24 (469)
Ureca	0.29	99.25	0.10 (9)	0.04 (5)	0.19 (16)	0.93 (95)	0.44 (43)	0.05 (6)	0 (0)	0.06 (6)	1.82 (180)
Belebu	2.89	106.67	0 (0)	0.02 (1)	0 (0)	0.11 (9)	0.05 (6)	0 (0)	0.01 (1)	0 (0)	0.18 (17)

*Mle -*Mandrillus leucophaeus*; Csa - *Colobus satanas*; Ppe - *Procolobus pennantii*; Cer - *Cercopithecus erythrotis*; Cpo - *Cercopithecus pogonias*; Cni - *Cercopithecus nictitans*; Apr - *Allochrocebus preussi*; Unk – Unidentified

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