Species Density of *Galago moholi* at Loskop Dam Nature Reserve, South Africa

Ian S. Ray\(^1,2,3\), Brandi T. Wren\(^2,4\), and Evelyn J. Bowers\(^1\)

\(^1\)Department of Anthropology, Ball State University, Muncie, IN USA; \(^2\)Applied Behavioural Ecology and Ecosystem Research Unit, University of South Africa; \(^3\)Department of Social Sciences, Community College of Aurora, Aurora, Colorado USA; \(^4\)Department of Anthropology, Purdue University, West Lafayette, IN USA

Abstract: Galagos are a poorly studied group of nocturnal primates endemic to sub-Saharan Africa, particularly in regard to distribution in southern Africa. We conducted a population survey of *Galago moholi* along the road system of Loskop Dam Nature Reserve in Mpumalanga, South Africa, during the winter months of June and July, 2011. Results from 151 km of transects that were driven over 23 survey hours indicate that the population density of *G. moholi* is several times lower than previously reported in similar areas. We estimate the population density at Loskop Dam to be between 1.4 and 5.1 animals/km\(^2\), suggesting a population estimate for the entire reserve of 296-1029 animals. This number is substantially lower than the expected density of 95 animals/km\(^2\) and total population of 20,000 animals based on previously published density estimates. Low population density may be due to an unknown environmental condition that, in addition, excludes other *Galago* species from the reserve.

Key words: *Galago*, population density, strepsirrhine, bushbaby

INTRODUCTION

Bushbabies, or galagos, are small nocturnal primates endemic to sub-Saharan Africa. Many species of galago inhabit overlapping geographical ranges, though most have differing habitat preferences when found sympatrically (Nash et al. 1989; Pozzi 2016). The only member of the genus *Galago* endemic to this study’s research site in Mpumalanga, South Africa, is the southern lesser bushbaby (*Galago moholi* A. Smith 1836). Based on current published distribution data (Bearder et al. 2008), the thick-tailed bushbaby (*Otolemur crassicaudatus* É. Geoffroy Saint-Hilaire 1812) is not found within this study’s locality, although greater galagos have been observed nearby. There is a significant lack of published field studies on galago behavior and ecology, particularly recent studies. This makes it difficult to establish a baseline understanding of galago ecology and distribution in southern Africa.

*Galago moholi* averages 158 g and 438 mm in total length, with a 288 mm tail and a 150 mm head and body (Nash et al. 1989). Previous reports have listed primary food sources of *G. moholi* to consist exclusively of tree gums and small arthropods (Bearder & Martin 1980; Harcourt 1986), though recent findings have noted the inclusion of plant parts in the diet (Scheun et al. 2014; Ray et al. 2016). No observations of heterothermy during the winter months of June and July, when insects are scarce, have been recorded in natural settings (Mzilikazi et al. 2006; Nowack et al. 2010, 2013).

Bearder & Doyle (1974) reported population densities of *G. moholi* that ranged from a low of 95 animals/km\(^2\) in escarpment riparian bush and scrub habitat to a high of 500 animals/km\(^2\) in *Vachellia karoo* (previously *Acacia karoo*) thickets. That research, however, commenced in 1968 and is now approaching 50 years old. It is likely that those

Correspondence to: Ian S. Ray, Department of Social Sciences, Community College of Aurora, 16000 East CentreTech Parkway, Aurora, Colorado 80011 USA; Email: iray@regis.edu.
numbers are no longer representative due to human encroachment, habitat changes, anthropogenic climate change, and changes in land-use patterns across southern Africa (Hoffman & Ashwell 2001; Thomas et al. 2004; McCusker & Carr 2006). Further, those estimates vary greatly from 95-500 animals/km² and later studies using radio tracking found significantly lower densities of 31 animals/km² (Bearder 1987).

The goal of this study was to survey the population of G. moholi at Loskop Dam Nature Reserve in South Africa to assess its abundance and distribution. Specifically, our objectives were to: 1) record sightings of G. moholi; and 2) calculate an estimated population density of G. moholi at the study site.

MATERIALS AND METHODS

Research Site

This project was conducted between June and July, 2011 at Loskop Dam Nature Reserve (LDNR). LDNR is located in northern Mpumalanga province, South Africa, with a portion of the reserve extending into Limpopo province (25°259’ S, 29°189’ E). The reserve measures 22,000 ha in size including the reservoir created by Loskop Dam (Ferrar & Lotter 2007). Daily temperatures within the reserve ranged from 7°C to 21°C during the study period, and from 7°C to 29°C during 2011 (National Center for Environmental Information 2016). Monthly precipitation in 2011 ranged from 0 cm (July) to 19 cm (January), with no rainfall occurring during the study period. The reserve is managed by the Mpumalanga Tourism and Parks Agency, and the University of South Africa’s Applied Behavioural Ecology and Ecosystem Research Unit maintains a research camp within its boundaries. To our knowledge, no other research has been conducted on galagos in LDNR.

Survey Methods

Transects were driven throughout LDNR’s tourist road system between the hours of 1800 and 2200 on 12 nights between June 29 and July 12, 2011 (winter at the study site). We surveyed a total of 151 km over 23 hours. Transects were driven, not walked, due to safety concerns expressed by reserve management owing to the presence of predators (e.g., leopard) and large dangerous game (e.g., rhinoceros and buffalo). Transects were selected based on major road landmarks and driven for approximately three hours per night (Figure 1). Fifteen minute breaks

Figure 1. Map of driven transects and sightings in Loskop Dam Nature Reserve, Mpumalanga, South Africa
were taken after each transect to avoid observer fatigue. Transects were between 2.4 km and 7.5 km. All roads were driven at the beginning, middle, and end of a night and in each direction, resulting in a total of six separate surveys of each transect. Surveys were scheduled to ensure each segment had not been driven for at least two hours before collecting data.

The following habitat types are present within the survey area of this study: Senegalia caffra–Setaria sphacelata var. sphacelata woodland, Vachellia karoo–Dichrostachys cinerea shrubland, Vachellia nilotica–Senegalia caffra woodland, Heteropogon contortus–Sclerocarya birrea woodland, Hyperthelia dissoluta grassland, Lippia javanica–Loudetia simplex shrubland, and Olea europea subsp. africana–Rhus leptodictya woodland (Barrett et al. 2010). Although a comprehensive vegetation survey of LDNR has not been conducted, these habitat types appear to be representative of the areas of the reserve that were surveyed in this study (Barrett et al. 2010; Filmalter 2010; Nkosi et al. 2016).

A Nissan pick-up truck with an open bed (i.e., bakkie) was used for surveys. One member of the research team was chosen as the driver and two team members knelt in the bed of the truck behind the cab. This provided 360° visibility for the observers above the cab of the truck. Speed varied from 4-13 km per hour with a target speed of 10 km per hour, consistent with the methodologies of other vehicle surveys (Nekaris & Jayewardene 2004; Off et al. 2008; Leca et al. 2013; Acharya et al. 2015). *Galago moholi* were spotted by the distinctive red tapetal reflections using 600 lumen LED torches with an illumination distance of 412 m. We recorded measurements for each of the following variables for every sighting: distance to the individual using a laser rangefinder, a compass bearing to the individual from the transect, and GPS coordinates of the vehicle.

**Analysis**

Transect data were analyzed using six methods presented by the (National Research Council Subcommittee on Conservation of Natural Populations 1981). These were maximum perpendicular distance, maximum reliable perpendicular distance at 15 m and 30 m, maximum observer-to-animal distance, maximum reliable observer-to-animal distance at 30 m and 50 m, mean perpendicular distance, and mean observer-to-animal distance. Maximum perpendicular distance analysis used the greatest perpendicular distance at which a subject was spotted to determine the area analyzed from the area sampled. Maximum reliable perpendicular distance truncates these data by selecting cutoff distances, as it was unlikely that all individuals were sighted beyond this distance. Maximum reliable perpendicular distance was determined by: 1) constructing a histogram of all perpendicular distances at which a subject was sighted (Figure 2) and, 2) selecting any low points in sighting frequency as cutoffs. In this study, these low points occurred at 15 m and 30 m. Maximum observer-to-animal distance assumes that all individuals within the distance to the farthest sighting were observed. Maximum reliable observer-to-animal distance was determined by constructing a histogram of all observer-to-animal distances and selecting any low points in sighting frequency as cutoffs. In this study, these low points occurred at 30 m and 50 m.

For all analytical methods, perpendicular distance was calculated using the degrees off transect of the farthest sighting with the formula (sighting distance) sinθ. Observer-to-animal distance was determined using a laser rangefinder, and thus needed no mathematical adjustment. We used Excel for all statistical analyses.

**RESULTS**

We recorded a total of 29 individual encounters of *G. moholi* (Appendix 1). Observer to animal distance ranged from 5 m to 95 m. Calculated perpendicular distances ranged from 0 m to 65 m. The various methods used yielded a range of estimates from 0.96 ± 0.02 animals/km² to 5.02 ± 0.11 animals/km² (Table 1). Due to the low number of sightings, it was possible to determine only a maximum reliable sighting distance for the entire survey area and not for each individual transect. The mean perpendicular distance method resulted in the highest density estimate of 5.02 animals/km², while the mean observer to animal distance method resulted in a more conservative estimate of 2.97 animals/km². The maximum perpendicular distance method yielded a density estimate of 1.58 animals/km², while the maximum observer to animal distance method yielded a density estimate of 0.96 animals/km². Standard deviations were calculated based purely on statistical error and not systematic error.

With a cut-off of 15 m, the maximum reliable perpendicular distance method yielded an estimate of 3.77 animals/km², or 773 animals throughout the reserve. If a 30 m cut-off is used, that estimate drops to 2.51 animals/km² or 515 animals throughout the reserve. These estimates differ from the similar maximum reliable observer-to-animal distance...
method. For this method, a cut-off of 30 m yields an estimated population density of 1.78 animals/km² or 365 animals throughout the reserve. If a cut-off of 50 m is used, the estimate drops to 1.45 animals/km² or 296 animals throughout the reserve.

**DISCUSSION**

The National Research Council of the United States determined that the most reliable protocols for determining population density are the maximum reliable perpendicular distance method and the maximum reliable observer-to-animal distance method (National Research Council Subcommittee on Conservation of Natural Populations 1981). Regardless of the method used, the estimated density of *G. moholi* at LDNR is lower than the estimate of 95 animals/km² reported by Bearder & Doyle (1974) (Table 2). Cold temperatures, a higher latitude, higher altitude, and decreased activity of *G. moholi* during winter months may have resulted in underestimates of the population. Because no study to date has noted such extreme differences in population structure between seasons (Bearder & Doyle 1974; Harcourt 1980), and because this study occurred during mating season, it is not likely that the season alone accounts for the substantial difference in population estimates. The galago population at LDNR could also experience more ecological stress than populations at lower latitudes and altitudes. Some stress may be a result of the dam and its effects on microhabitats within the reserve as well as documented water pollution in the dam (Oberholster et al. 2011; Dabrowski et al. 2013). It is also possible that population numbers have declined since the previous studies were conducted nearly fifty years ago. More studies at a greater number of sites are imperative for understanding galago population distribution and ecology.

Nash & Whitten (1989) discuss density estimates of the similar *Galago senegalensis* in Kenya (Table 2). Analytical methods used in their study were similar to the present study, though data were collected on foot rather than from a driven vehicle (Nash & Whitten 1989). The population density estimate for the area was found to be 1.5 animals/ha, or approximately 150 animals/km² (Nash & Whitten 1989). This estimate, while still lower than Bearder & Doyle’s (1974) estimates, is substantially greater than the estimated population density of LDNR.

Off et al. (2008) also reported population densities of *G. senegalensis* in another area of Kenya, and used the same methods as the present study (Table 2). Their analysis resulted in estimates similar to those found by Nash & Whitten (1989). *Galago senegalensis* was found to have a population density of between 40 and 240 animals/km², with variation largely due to differences in dry bush and riverine habitats (Off et al. 2008). The area surveyed at LDNR contained similar proportions of each habitat and included a larger overall area of sampling (Table 2). Individuals were most frequently spotted in riverine areas or trees adjacent to known waterways, though the low population density prevented any statistical analysis of this observation.

Vehicular surveys have been used with a wide variety of taxa and terrain, including *Myrmecophaga tridactyla* in Brazil (de Miranda et al. 2006); *Loris tardigradus* in Sri Lanka (Nekaris & Jayewardene 2004); *Sus scrofa, Capreolus capreolus,* and *Vulpes vulpes* in Belgium (Morrelle et al. 2012); *Trachypithecus auratus* in Indonesia (Leca et al. 2013); and *Macaca mulatta* in urban India (Acharya et al. 2015). There is debate over the utility of
Table 1. Estimated Species Density of *G. moholi* Using Multiple Analytical Techniques.

<table>
<thead>
<tr>
<th>Analytical Method</th>
<th>Estimated Density (animals/km²)</th>
<th>Estimated Population in Reserve (animals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Perpendicular Distance</td>
<td>1.58 ± 0.03</td>
<td>324 ± 7</td>
</tr>
<tr>
<td>Maximum Reliable Perpendicular Distance (15m)</td>
<td>3.77 ± 0.14</td>
<td>773 ± 30</td>
</tr>
<tr>
<td>Maximum Reliable Perpendicular Distance (30m)</td>
<td>2.51 ± 0.07</td>
<td>515 ± 15</td>
</tr>
<tr>
<td>Maximum Observer to Animal Distance</td>
<td>0.96 ± 0.02</td>
<td>197 ± 5</td>
</tr>
<tr>
<td>Maximum Reliable Observer to Animal Distance (30m)</td>
<td>1.78 ± 0.07</td>
<td>365 ± 15</td>
</tr>
<tr>
<td>Maximum Reliable Observer to Animal Distance (50m)</td>
<td>1.45 ± 0.04</td>
<td>296 ± 9</td>
</tr>
<tr>
<td>Mean Perpendicular Distance</td>
<td>5.02 ± 0.11</td>
<td>1029 ± 23</td>
</tr>
<tr>
<td>Mean Observer to Animal Distance</td>
<td>2.97 ± 0.06</td>
<td>609 ± 13</td>
</tr>
</tbody>
</table>

population surveys conducted on foot and those conducted from a vehicle. We believe that, because similar results were obtained by Nash & Whitten (1989) and Off et al. (2008), both methods are comparable with regard to galago research. Recent fieldwork on strepsirrhines in southern Africa has revealed that our understanding of galago distribution and ecology still contains many gaps (Génin et al. 2016). One major development is the recent discovery of *Galagoides granti* (the Mozambique lesser bushbaby) populations within South Africa (Génin et al. 2016). The species was previously believed not to be present near the South African border, let alone within South Africa, which means that the published distributions of *G. moholi* and *O. crassicaudatus* in southern Africa need to be revised.

We have noted the marked absence of *O. crassicaudatus* from many areas of its range (Ray et al. unpublished data). In particular, *O. crassicaudatus* was not observed in the area of the Tuli Block of Botswana during preliminary field excursions for future projects. Because the habitat at LDNR is similar to other nearby areas where *O. crassicaudatus* is known to exist, it is unclear why that species has not been found at this study site as well (Bearder 2008). Regardless, the lack of *O. crassicaudatus* at LDNR suggests that the low population sizes of *G. moholi* are not due to competition from larger-bodied strepsirrhines, or that *G. moholi* out-competes *O. crassicaudatus*.

CONCLUSIONS

The density of *G. moholi* at Loskop Dam Nature Reserve, at an estimated 2.5-3.8 animals/km², is particularly low compared both to the density observed at other sites in southern Africa and to other *Galago* species in Africa (Bearder & Doyle 1974; Nash & Whitten 1989; Off et al. 2008). These findings highlight the lack of knowledge on the ecology and distribution of galagids, especially those within southern Africa. Further, recent work on *G. moholi* suggests that we have a great deal to learn still about galago dietary ecology (Scheun et al. 2014; Ray et al. 2016). This study contributes to that gap in knowledge by providing current data on galago population size and distribution in southern Africa.

ACKNOWLEDGEMENTS

We would like to thank Ruby Malzoni and Michele Mignini for their assistance in conducting the population survey. We are also grateful for the aid provided by Jannie Coetzee and the staff of the Applied Behavioural Ecology and Ecosystem Research Unit (ABEERU) of the University of South Africa (UNISA), and for being allowed to work at Loskop Dam Nature Reserve.

LITERATURE CITED


Table 2. Estimates of *Galago* Population Densities in Africa.

<table>
<thead>
<tr>
<th>Species</th>
<th>Location(s)</th>
<th>Method</th>
<th>Population Estimate (individuals / hectare)</th>
<th>Area Sampled (hectares)</th>
<th>Number of Observations</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Galago senegalensis</em></td>
<td>Ewaso Nyiro River, Kenya</td>
<td>maximum perpendicular</td>
<td>0.4 - 2.4</td>
<td>25.2</td>
<td>185 individuals</td>
<td>Off et al. 2008</td>
</tr>
<tr>
<td></td>
<td>ABC Mutara Cattle Ranch, Kenya</td>
<td>direct count of focal groups</td>
<td>1.5</td>
<td>3.5</td>
<td>n/a</td>
<td>Nash &amp; Whitten 1989</td>
</tr>
<tr>
<td><em>Galago moholi</em></td>
<td>South Africa, Rhodesia</td>
<td>unreported</td>
<td>0.878 - 5.0</td>
<td>unreported</td>
<td>unreported</td>
<td>Bearder &amp; Doyle 1974</td>
</tr>
<tr>
<td></td>
<td>South Africa</td>
<td>radio telemetry</td>
<td>0.31</td>
<td>100</td>
<td>9000 positional records</td>
<td>Bearder &amp; Martin 1979</td>
</tr>
<tr>
<td></td>
<td>Loskop Dam Nature Reserve, South Africa</td>
<td>maximum perpendicular</td>
<td>0.01</td>
<td>284.3</td>
<td>29 individuals</td>
<td>present study</td>
</tr>
</tbody>
</table>


Received: 9 April 2016
Accepted: 13 January 2017
Appendix 1. Sighting of *Galago moholi* at Loskop Dam Nature Reserve, South Africa.

<table>
<thead>
<tr>
<th>Sighting Location</th>
<th>Distance to Animal (m)</th>
<th>Degrees off Transect</th>
<th>Perpendicular Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S 25°25.2902' E 29°18.0666'</td>
<td>43</td>
<td>272°</td>
<td>42</td>
</tr>
<tr>
<td>S 25°25.8526' E 29°18.1345'</td>
<td>25</td>
<td>245°</td>
<td>1</td>
</tr>
<tr>
<td>S 25°24.6606' E 29°19.0892'</td>
<td>18</td>
<td>338°</td>
<td>17</td>
</tr>
<tr>
<td>S 25°23.7967' E 29°19.6454'</td>
<td>15</td>
<td>35°</td>
<td>6</td>
</tr>
<tr>
<td>S 25°24.2260' E 29°20.7792'</td>
<td>43</td>
<td>284°</td>
<td>41</td>
</tr>
<tr>
<td>S 25°24.4770' E 29°20.8126'</td>
<td>60</td>
<td>0°</td>
<td>0</td>
</tr>
<tr>
<td>S 25°24.4770' E 29°20.8126'</td>
<td>36</td>
<td>7°</td>
<td>24</td>
</tr>
<tr>
<td>S 25°24.7977' E 29°18.8458'</td>
<td>15</td>
<td>123°</td>
<td>7</td>
</tr>
<tr>
<td>S 25°25.1446' E 29°18.4181'</td>
<td>5</td>
<td>323°</td>
<td>3</td>
</tr>
<tr>
<td>S 25°24.5522' E 29°19.1752'</td>
<td>95</td>
<td>355°</td>
<td>0</td>
</tr>
<tr>
<td>S 25°24.6681' E 29°20.6992'</td>
<td>25</td>
<td>75°</td>
<td>10</td>
</tr>
<tr>
<td>S 25°24.8473' E 29°20.4168'</td>
<td>33</td>
<td>343°</td>
<td>18</td>
</tr>
<tr>
<td>S 25°25.0282' E 29°20.3030'</td>
<td>13</td>
<td>90°</td>
<td>12</td>
</tr>
<tr>
<td>S 25°24.4531' E 29°19.0862'</td>
<td>15</td>
<td>321°</td>
<td>8</td>
</tr>
<tr>
<td>S 25°24.6125' E 29°19.0329'</td>
<td>19</td>
<td>338°</td>
<td>18</td>
</tr>
<tr>
<td>S 25°24.9950' E 29°17.9791'</td>
<td>68</td>
<td>122°</td>
<td>34</td>
</tr>
<tr>
<td>S 25°24.3271' E 29°20.7715'</td>
<td>19</td>
<td>285°</td>
<td>15</td>
</tr>
<tr>
<td>S 25°24.8282' E 29°18.8129'</td>
<td>24</td>
<td>60°</td>
<td>7</td>
</tr>
<tr>
<td>S 25°24.9700' E 29°18.3440'</td>
<td>39</td>
<td>310°</td>
<td>33</td>
</tr>
<tr>
<td>S 25°24.6516' E 29°20.7517'</td>
<td>11</td>
<td>80°</td>
<td>11</td>
</tr>
<tr>
<td>S 25°24.7895' E 29°20.4585'</td>
<td>44</td>
<td>55°</td>
<td>44</td>
</tr>
<tr>
<td>S 25°24.8258' E 29°20.4275'</td>
<td>14</td>
<td>45°</td>
<td>12</td>
</tr>
<tr>
<td>S 25°25.0305' E 29°20.2947'</td>
<td>55</td>
<td>65°</td>
<td>45</td>
</tr>
<tr>
<td>S 25°24.0658' E 29°20.7500'</td>
<td>5</td>
<td>270°</td>
<td>1</td>
</tr>
<tr>
<td>S 25°24.0658' E 29°20.7500'</td>
<td>18</td>
<td>50°</td>
<td>5</td>
</tr>
<tr>
<td>S 25°24.3191' E 29°20.7726'</td>
<td>20</td>
<td>313°</td>
<td>18</td>
</tr>
<tr>
<td>S 25°26.0207' E 29°15.4519'</td>
<td>53</td>
<td>10°</td>
<td>29</td>
</tr>
<tr>
<td>S 25°24.3478' E 29°21.0374'</td>
<td>39</td>
<td>310°</td>
<td>33</td>
</tr>
<tr>
<td>S 25°23.9261' E 29°19.0912'</td>
<td>68</td>
<td>350°</td>
<td>65</td>
</tr>
</tbody>
</table>
Presence of Alkaloids and Cyanogenic Glycosides in Fruits Consumed by Sympatric Bonobos and the Nkundo People at LuiKotale/Salonga National Park, Democratic Republic of Congo and Its Relationship to Food Choice

Nono Bondjengo¹,²,³, Gaby Kitengie¹,², Dieudomé Musibono⁴, Constantin Lubini³, Gottfried Hohmann¹ and Barbara Fruth¹,⁵,⁶

¹ Max Planck Institute for Evolutionary and Anthropology, Leipzig, Germany; ² Institut Congolais pour la Conservation de la Nature, Kinshasa, DRC; ³ Université de Mbandaka, Faculté des Sciences, Département de l’Environnement B.P 10, Mbandaka, DRC; ⁴ Université de Kinshasa, Faculté des Sciences, Département d’Environnement, Kinshasa, DRC; ⁵ Ludwig Maximilian University of Munich, Faculty of Biology / Department Biology II, Germany; ⁶ Centre for Research and Conservation/KMDA, Antwerp, Belgium

Abstract: The importance of secondary compounds remains poorly studied in wild plants eaten by bonobos (Pan paniscus) and humans. As part of this study, alkaloids and cyanogenic glycosides (cyanide) were investigated in wild fruits consumed by bonobos at LuiKotale in Salonga National Park. In high concentrations, the two components can become toxic. Therefore, we investigated whether the bonobos and the Nkundo people avoid high concentrations of these components in their food. To analyze alkaloids and to detect the presence of cyanogenic glycosides, we used semi-quantitative methods. Of the 75 species of fruit analyzed, 28 species (37%) were revealed to have alkaloids at different proportions and 47 species (63%) were shown to be without alkaloids, 12 species (16%) with low concentrations (+), 14 species (19%) with moderate concentrations (++), and two species (3%) with high concentrations (+++). Of the 75 species, 60 were eaten, of which 46 were consumed only by bonobos, 13 were eaten by both bonobos and the Nkundo people, and one species (Piper guinensis) was eaten only by the Nkundo people. In total, bonobos ate 59 species and the Nkundo people 14 species. Of the 60 species consumed, the majority, i.e., 39 species (65%) did not show the presence of alkaloids, while 11 species (18%) showed a low concentration and 10 species (17%) moderate concentrations. As for cyanogenic glycosides (cyanide), this was detected in only three of the 75 species of fruit analyzed. Two species, Camptostylus mannii and Dasylepsis seretii, belong to the Achariaceae family, with Oncoba welwitschii in the Salicaceae family. The two species of Achariaceae both contain alkaloids and cyanogenic glycosides. No species eaten by the Nkundo contained cyanogenic glycosides. Hence, we infer that bonobos and the Nkundo people both avoid eating fruit species that contain high concentrations of alkaloids and cyanogenic glycosides, and this might have relevance linked to the evolution of seed dispersal.

Key words: Secondary compounds, fruits, bonobo, Nkundo, Salonga National Park

Résumé: L’importance des composés secondaires dans les plantes sauvages consommées par Pan paniscus (bonobo) reste encore peu étudiée. Dans le cadre de cette étude, les alcaloïdes et les hétérosides cyanogénétiques (cyanures) ont été recherchés dans les fruits consommés par la population Nkundo et les bonobos de Luikotale,
Parc National de la Salonga ainsi que dans ceux qui ne sont pas consommés. A travers cette étude, nous avons cherché à connaître si les bonobos et les Nkundo évitent de fortes concentrations en ces éléments dans leur nourriture. Notre méthodologie a consisté à rechercher les alcaloïdes et les glycosides cyanogénétiques en utilisant la méthode semi-quantitative. Sur les 75 espèces de fruits analysées, 28 (37%) ce sont révélées avec alcaloïdes à différentes proportions et 47 (63%) espèces de fruits ce sont révélées sans alcaloïdes. Parmi les 75 espèces de fruits analysées, 60 ont été mangées dont, 59 ont été mangés par les bonobos parmi lesquelles, 13 ont été mangées par les Nkundo et par les bonobos et une espèce (Piper guineensis) a été mangée uniquement par les Nkundo. Parmi les 60 espèces mangées, la grande majorité, soit 39 espèces (65%) n'ont pas montré la présence d'alcaloïdes, onze espèces (18 %) ont montré une faible concentration et dix espèces (17%) ont montré une concentration moyenne. Quant aux hétérosides cyanogénétiques (cyanures), les tests fait sur les 75 espèces de fruits nous ont permis d'identifier trois (4%) espèces qui en contiennent. Parmi ces trois espèces, deux d'entre elles appartiennent à la famille des Achariaceae, il s'agit de: Camptostylus mannii, et Dasylepsis seretii. L'espèce Oncoba welwitschii par contre appartient à la famille des Salicaceae. La proportion de fruits sans alcaloïdes était plus élevée que ceux avec alcaloïdes. Ces proportions sont plus élevées pour les glycosides cyanogénétiques. Par conséquent, nous pouvons dire que les bonobos et la population Nkundo évitent de manger des espèces de fruits qui contiennent une forte concentration en alcaloïdes et glycosides cyanogénétiques.

Mots clés : Composés secondaires, fruits, bonobo, Nkundo, Parc National de la Salonga

INTRODUCTION

The forests of the Central Congo Basin contain a diverse mix of plants and animals, including many plants producing a wide variety of fruits, of which most are edible by animals (FAO 2006). Much scientific research looking at animal food choice has concentrated on the nutrient content (e.g., Hohmann et al. 2006; Kamungu et al. 2015). This approach assumes that foraging is focused on optimizing the supply of macronutrients, such as fats, carbohydrates, and proteins (Pasquet et al. 2011).

However, other studies have shown that food choice is influenced by the avoidance of substances that alter the organoleptic quality (Hohmann et al. 2006; Doran-Sheehy et al. 2009). Some field and experimental studies have indicated that the choice of foods as well as food intake efficiency are affected by a number of parameters, including nutritional quality, distribution, and abundance of resources (Carlo et al. 2003; Saracco et al. 2004). Some studies even suggest that the presence of secondary compounds may be the major driver of food selection by animals (Alm et al. 2000; Clauss et al. 2003). For example, fruits may occasionally contain undesirable substances for nutrition, such as secondary compounds, and depending on their concentration, these substances may become toxic for their consumers. These include very active plant poisons with a specific action, some of which can be used medicinally (Hopkins 2003; Irina et al. 2012).

Bonobos (Pan paniscus) live only in the equatorial forests south of the Congo River (IUCN & ICCN 2012). These forests provide a high diversity of ligneous plants bearing fruit, 85 % of which produce fleshy fruits to attract animals for primary seed dispersal (Beaune et al. 2013). In addition, the habitat is not markedly seasonal, providing fruit throughout the year. This is similar to Rubondo National Park, an island in the southwestern corner of Lake Victoria, Budongo Forest, and Bwindi Impenetrable National Park in Uganda, where important chimpanzee fruit foods are available across all months, with no distinct periods of habitat-wide fruit scarcity (Newton-Fisher 1999; Newton-Fisher et al. 2000; Stanford & Nkurunungi 2003; Moscovice et al. 2007). Thus, as bonobos are primarily frugivores (Badrian et al. 1981; Kano 1983; Wrangham 1986), it is likely that they avoid foods containing high concentrations of antifeedants, and rather select for macronutrients, including sugars. This avoidance of toxic secondary metabolites may be triggered by an unpleasant taste, which for most primates has been shown to correspond to a primary rejection reaction by the gusto-facial reflex, considered as an adaptation for avoiding more or less toxic plant products (Hladik 2002).

The prevalence of secondary metabolites, including alkaloids and cyanogenic glycosides, in wild plant foods consumed by bonobos and the local Nkundo population is almost completely unknown. As with other secondary metabolites, there are a number of arguments in favor of a defensive (antifeedant) role for alkaloids (Hartmann 1991; Lebreton 1982; Douglas & Martin 1998). However,
alkaloids also have diverse medicinal properties (Bernhoft 2008).

Cyanogenic glycosides are present in some species of plants and offer an immediate chemical defense against herbivores and pathogens causing damage to the plant tissue (Moller 2010). Nevertheless, the sensitivity of animals towards cyanogenic glycosides varies considerably, depending on the species (Jones 1988).

Here, we investigate alkaloids and cyanogenic glycosides in both fruits consumed and not consumed by bonobos and the Nkundo population, the local human inhabitants of the neighboring area. Through this investigation, we seek to understand whether bonobos avoid high concentrations of alkaloids or the presence of cyanogenic glycosides in their food. In addition, we investigate bonobo and human food choice with respect to the concentration of these components.

MATERIALS AND METHODS

This investigation was conducted between June 2007 and March 2008 at the study site of LuiKotale, located at the southwestern fringe of Salonga National Park (2° 45.160 S, 20° 22.723 E; Hohmann & Fruth 2008; Figure 1). The study site was started in 2002 and hosts projects focusing on plant diversity and bonobo behavioral ecology, conducted by shifting teams of researchers, students, and volunteers. The

Figure 1. Location of the study site at LuiKotale, in Salonga National Park, Democratic Republic of Congo. Map courtesy (http://scalar.usc.edu/works/graphics-for-conservation/media/LuiKotale_781.jpg).
climate is equatorial with abundant rainfall (>2000 mm/year), a short dry season in February and a long dry season between May and August. The monthly average temperature ranges between 18 and 29° C, with a minimum of 15.7° C and a maximum of 37.3° C (Fruth et al. 2014).

We focused our investigation on those species that produce fruits seasonally. Identification was confirmed with the help of a reference herbarium, established during the framework of the long-term project, "The Cuvette Central as a reservoir of medicinal plants" (Fruth 2011). After cross-checking, plant samples were deposited at the herbarium of the INERA, located at the University of Kinshasa.

Fruits were collected along standardized phenological transects, as well as opportunistically outside transects when following bonobos, and brought back to camp for analysis (Figure 2). Only ripe fruit was taken into consideration as the state that is eaten by both bonobos and the Nkundo people. Alkaloids were identified following a semi-quantitative method described by Ganzhorn (1989) using three reagents: Dragendorff’s, Wagner’s, and Mayer’s. The fruit pulp was crushed using a porcelain or steel mortar. Sulfuric acid (0.1 M) was added, and the solution was passed through filter paper (Rotilabo R, 80 mm in diameter). A drop of the filtrate was deposited in each of four petri dishes. One served as a control. Next, a drop of each reagent was pipetted onto the filtrate. The reaction was either immediate or took up to a few minutes to occur. In the cases where alkaloids were present, the reaction produced a precipitate. The concentration of alkaloids in the filtrate was ranked on a scale of 0 – 3. When almost all the reagent reacted with the filtrate, it was assigned a 3 or +++, when half of the filtrate reacted it was assigned a 2 or ++ and when 1/3 of the filtrate reacted, it was assigned a 1 or +. When there was no precipitate formation in the filtrate it was assigned a 0.

Similarly, semi-quantitative analyses were used for the detection of cyanogenic glycosides according to the method of Feigl and Anger (1966). This simple field detection method detects the presence of cyanide from small amounts of plant material. Fruits were crushed in a mortar, mixed with distilled water, and poured into a tube. Feigl-Anger paper was placed in the tube without contacting the solution, and the top was sealed. Within approximately five minutes, if cyanide was present, a reaction turned the paper from white to blue.

RESULTS

1. Alkaloids

Almost 2/3 of the 75 species (63%) did not show the presence of alkaloids, while 28 species (37%) revealed alkaloids of different proportions: 12 species (16%) showed a low concentration (+), 14 species (19%) showed an average concentration (++), and 2 species (3%) had a high concentration (+++). Of the 75 species of fruit analyzed, 60 were eaten, of which 46 were eaten only by bonobos, 13

Figure 2. (A) Analyses of the alkaloids and cyanogenic glycosides in the laboratory at Luikotale, (B) Results of the analysis of alkaloids in the fruit of Picralima nitida.
were eaten by both bonobos and the Nkundo people, while one species (*Piper guinensis*) was eaten only by the Nkundo. In total, bonobos ate 59 species and the Nkundo consumed 14 species. Of the 60 species eaten, 11 species (18%) showed a low concentration (+) of alkaloids, while 10 species (17%) showed a moderate concentration (++). No species of fruit consumed by bonobos and the Nkundo people showed an alkaloid abundance rank of +++ (Table 1).

Table 2 indicates the number of species consumed by humans and bonobos. Looking at the alkaloid content, nine (64%) of the 14 species consumed by the Nkundo people had no alkaloids, while four species (29%) contained low (+) concentrations, with just one species (7%), *Canarium schweinfurthii*, having a moderate concentration (+++) of alkaloids. None of the fruits consumed by the Nkundo had a high concentration (+++) of alkaloids.

As for the fruits not consumed by the local people and bonobos, these comprise a total of 15 species. Of these, seven species (47%) contained alkaloids, with three fruit species found to have a high concentration (+++), three species with an average concentration (++), and one species with a low concentration (+). The eight remaining species (53%) did not contain alkaloids (Table 3).

2. Cyanogenic glycosides

Table 4 indicates the results of the 75 species of fruits analyzed for cyanogenic glycosides content. Only 3 (4%) of the 75 species tested contained cyanogenic glycosides: *Camptostylus mannii*, *Dasylepis seretii* and *Oncoba welwitschii*. The first two species belong to the Achariaceae family and *Oncoba welwitschii* is in the Salicaceae family.

DISCUSSION

Out of the 75 species of fruit collected, we have identified 59 species of fruit consumed by bonobos, of which 13 are consumed concurrently by both bonobos and the Nkundo, and one species consumed only by the Nkundo people (*Piper guinensis*). These results show that bonobos consume a larger number of species compared to the local Nkundo population. This can be explained partly by the fact that fruits comprise only a minor part of the human diet, and that a number of cultivated fruits are also available such as oranges, papayas, mangoes, pineapples, etc. In contrast, wild fruits form the main component of the bonobo diet (Rafert & Vineberg 1997). Like chimpanzees, bonobos are primarily frugivorous, with fruit accounting for 49-63% of their diet (Badrian *et al.* 1981; Kano 1983; Boesch *et al.* 2002). The fruits observed to be consumed here are also consumed by bonobos elsewhere: most of these species are cited by Idani *et al.* (1994) as part of the bonobo diet at Wamba/Lopori, while the fruit of *Dialium zenkeri* is noted in other studies (Yamamoto *et al.* 2009; Beaune *et al.* 2013).

The alkaloid tests carried out on 75 different species of fruit showed that 47 species (63%) did not show the presence of alkaloids, while 28 species (37%) contained alkaloids of different proportions: 12 species (16%) showed low concentration (+), 14 species (19%) a moderate concentration (++), and 2 species (3%) a high concentration (+++). Of the 60 species of fruit consumed by bonobos and the local population of Nkundo people, 39 fruit species (65%) did not contain alkaloids; 11 species (18%) showed a low concentration (+) and 10 species (17%) a moderate concentration (++), but no species contained alkaloids in high concentration. To confirm the presence or absence of alkaloids, our procedure involved using three reagents, including Dragendorff, Wagner and Mayer. Chapman *et al.* (2003) used only Dragendorff’s reagent to test for the presence of alkaloids, which sometimes produces false positive results (Waterman 1993).

In Gabon, tests carried out on samples of 382 plant species collected at random in the Ipassa-Mingouli rainforest and on 38 plant species eaten by chimpanzees gave only 15% positive results for the presence of alkaloids, using Mayer and Dragendorff reagents (Hladik & Hladik 1977). These results indicate that chimpanzees, like bonobos, showed little selection against plants containing alkaloids (Clutton-Brock 1977).

According to Whitten (1980), the Kloss gibbon (*Hyllobates klossi*), found on islands off the west coast of Sumatra, has been observed to eat the fruits of *Arenda obtusifolia* which contain oxalate, though the gibbon may avoid toxicity by careful selection of ripe fruit. Moreover, Waser (1977) recorded that mangabeys (*Lophocebus albigena*) avoid the alkaloid-rich fruits of *Rauvolfia* and *Strychnos*. Similarly, chimpanzees avoid alkaloid-rich fruits of *Picralima* (Hladik & Hladik 1977). Meanwhile, Remis *et al.* (2001) concluded that lowland gorillas in the Central African Republic appear to avoid nitrogen-based alkaloids, even when preferred foods are scarce.

The chimpanzee’s food selection strategy may be to prefer non-poisonous alkaloid-free foods, ingest astringent foods when they are also sweet, and consume some foods containing alkaloids when they have some nutritional or possibly medicinal...
Table 1. The 75 species of fruits, indicating the presence of both alkaloids and cyanides, as well as consumption by bonobos and humans.

<table>
<thead>
<tr>
<th>Families</th>
<th>Species</th>
<th>Nkundo name</th>
<th>BFT</th>
<th>HS</th>
<th>FrDr</th>
<th>FrMa</th>
<th>FrWa</th>
<th>Result</th>
<th>HCN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achariaceae</td>
<td>Camptostylus mannii</td>
<td>Bonkasa ya esobe</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Achariaceae</td>
<td>Dasylepis cfr.seretii</td>
<td>Imbedzi ya pembe</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>Antrocaryon nannanii</td>
<td>Bokongwende</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sorindea sp.</td>
<td>Trichoscypha arborescens</td>
<td>Bohungwu</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Anonaceae</td>
<td>Anonidium mannii</td>
<td>Bodzingo</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Enantia olivacea</td>
<td>Friesoldielsia enghiana</td>
<td>Impimbo ya pembe</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Polyalthia suaveolens</td>
<td>Bodzinda</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>++</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Uvariopsis letestui</td>
<td>Bodzungu IIa</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Uvariopsis solheidii</td>
<td>Bodzungu IIb</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Apocynaceae</td>
<td>Dictyophleba ochracea</td>
<td>Baole</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Landolphia owariensis</td>
<td>Botsuotope</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Picralima nitida</td>
<td>Pleiocarpa pycnantha</td>
<td>Elongo kodzi ya moindo</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>+++</td>
<td>0</td>
</tr>
<tr>
<td>Tabernanthe iboga</td>
<td>Canarium schweinfurthii</td>
<td>Boele</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Burseraceae</td>
<td>Canarium schweinfurthii</td>
<td>Boele</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>++</td>
<td>0</td>
</tr>
</tbody>
</table>

BFT: Bonobo Feeding Tree, FrDr: Fruit analyzed with Dragendorff’s reagent, FrMa: Fruit analyzed with Mayer’s reagent, FrWa: Fruit analyzed with Wagner’s reagent, CN: Cyanide, Hs: Homo sapiens, Pp: Pan paniscus.
Table 1. The 75 species of fruits, indicating the presence of both alkaloids and cyanides, as well as consumption by bonobos and humans. (Cont.)

<table>
<thead>
<tr>
<th>Families</th>
<th>Species</th>
<th>Nkundo name</th>
<th>BFT</th>
<th>HS</th>
<th>FrDr</th>
<th>FrMa</th>
<th>FrWa</th>
<th>Result</th>
<th>HCN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chrysobalanaceae</td>
<td><em>Parinari congensis</em></td>
<td>Bondzale</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Parinari excelsa</em></td>
<td>Bodzilompongo</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Clusiaceae/</td>
<td><em>Garcinia chromocarpa</em></td>
<td>Botendo</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Clusiodeae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ebenaceae</td>
<td><em>Garcinia punctata</em></td>
<td>Bosepe</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Garcinia smeathmannii</em></td>
<td>Itatalongo</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Mammea africana</em></td>
<td>Bokoli</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td><em>Drypetes gossweileri</em></td>
<td>Bopambe</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>+++</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Drypetes leonensis</em></td>
<td>Kalanga ya pembe</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Phyllanthus pynaerti</em></td>
<td>Bontepfu</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Plagiostyles africana</em></td>
<td>Bondenge ya zamba</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fabaceae/</td>
<td><em>Dialium angolense</em></td>
<td>Maku pembe</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Caesalpinioideae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Dialium corbisieri</em></td>
<td>Maku rouge</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Dialium zenkeri</em></td>
<td>Maku rouge II</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Macrolobium fragrans</em></td>
<td>Atsangila</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Tessmannia africana</em></td>
<td>Buaka</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fabaceae/</td>
<td><em>Pterocarpus soyauxii</em></td>
<td>Bofulu</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Faboideae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irvingiaceae</td>
<td><em>Irvingia gabonensis</em></td>
<td>Boseki ya pembe</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Klainedoxa gabonensis</em></td>
<td>Boseki ya moindo</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

BFT: Bonobo Feeding Tree, FrDr: Fruit analyzed with Dragendorff’s reagent, FrMa: Fruit analyzed with Mayer’s reagent, FrWa: Fruit analyzed with Wagner’s reagent, CN: Cyanide, Hs: Homo sapiens, Pp: Pan paniscus.
Table 1. The 75 species of fruits, indicating the presence of both alkaloids and cyanides, as well as consumption by bonobos and humans. (Cont.)

<table>
<thead>
<tr>
<th>Families</th>
<th>Species</th>
<th>Nkundo name</th>
<th>BFT</th>
<th>HS</th>
<th>FrDr</th>
<th>FrMa</th>
<th>FrWa</th>
<th>Result</th>
<th>HCN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linaceae</td>
<td>Irvingia grandifolia</td>
<td>Loote</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>Hugonia gilletti</td>
<td>Bomposo ya pembe</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>Ceiba pentandra</td>
<td>Londaa</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>Cola griseiflora</td>
<td>Bonkasa ya mai</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>Grewia coriacea</td>
<td>Bopfumo</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Marantaceae</td>
<td>Hypselodelphis poggeana</td>
<td>Bomomongo</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>Sarcophyrium schweinfurthianum</td>
<td>Nkokoloko</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Meliaceae</td>
<td>Trichilia heudalottii</td>
<td>Eonge</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Menispermaceae</td>
<td>Stephania laetificata</td>
<td>NID (B 3000)</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Fabaceae/</td>
<td>Pentaclethra macrophyla</td>
<td>Boimbo</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mimosoideae</td>
<td>Treculia africana</td>
<td>Boimbo</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moraceae</td>
<td>Ficus sp.</td>
<td>Lokomo</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Myristicaceae</td>
<td>Staudtia kamerunensis</td>
<td>Bokolombe</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Not identified</td>
<td>Not identified</td>
<td>Enkendu ya bundo</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Olacaceae</td>
<td>Strombosiopsis zenkeri</td>
<td>Bongondo</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Piperaceae</td>
<td>Piper guineensis schum.</td>
<td>Boleleko</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>+</td>
<td>0</td>
</tr>
</tbody>
</table>

BFT: Bonobo Feeding Tree, FrDr: Fruit analyzed with Dragendorff’s reagent, FrMa: Fruit analyzed with Mayer’s reagent, FrWa: Fruit analyzed with Wagner’s reagent, CN: Cyanide, Hs: Homo sapiens, Pp: Pan paniscus.
Table 1. The 75 species of fruits, indicating the presence of both alkaloids and cyanides, as well as consumption by bonobos and humans. (Cont.)

<table>
<thead>
<tr>
<th>Families</th>
<th>Species</th>
<th>Nkundo name</th>
<th>BFT</th>
<th>HS</th>
<th>FrDr</th>
<th>FrMa</th>
<th>FrWa</th>
<th>Result</th>
<th>HCN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polygalaceae</td>
<td>Carpolobia glabrescens</td>
<td>Boseke</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rubiaceae</td>
<td>Colletoecema dewevrei</td>
<td>Isilalongi</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Massularia acuminata</td>
<td>Welo</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Vangueriella orthancantha</td>
<td>Lilala ya dzamba</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Salicaceae</td>
<td>Oncoba welwitschii</td>
<td>Saake</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Sapindaceae</td>
<td>Blighia welwitschii</td>
<td>Booso</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Pancovia laurentii</td>
<td>Botende</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Pancovia sp</td>
<td>Mpanda</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Placodiscus paniculatus</td>
<td>Etende Nkema</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Sapotaceae</td>
<td>Gambeya lacourtiana</td>
<td>Bopambu</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Manilkara obovata</td>
<td>Boonya</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Synsepalum longecuneatum</td>
<td>Bopfunga</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Synsepalum subcordatum</td>
<td>Bopfunga totodu II</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Synsepalum sp.</td>
<td>Pepepe</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Tridesmostemon omphalocarpoideas</td>
<td>Bosanga</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Thymeleaceae</td>
<td>Zeyherella longepedicellata</td>
<td>Ilonge Pambu</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Dicranolepis disticha</td>
<td>Bontole badzumba</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vitaceae</td>
<td>Cissus dinklagei</td>
<td>Botaatata</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Cissus sp</td>
<td>NID (comme Botaatata)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zingiberaceae</td>
<td>Aframomum albiovaleaum</td>
<td>Mbole ya mai</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

BFT: Bonobo Feeding Tree, FrDr: Fruit analyzed with Dragendorff’s reagent, FrMa: Fruit analyzed with Mayer’s reagent, FrWa: Fruit analyzed with Wagner`s reagent, CN: Cyanide, Hs: Homo sapiens, Pp: Pan paniscus.
value, as observed in Mahale National Park, western Tanzania (Nishida 2012). This may similarly explain the absence of a high concentration of alkaloids in the fruits consumed by bonobos and humans in this study. Among the species eaten by the Nkundo people, only Canarium schweinfurthii showed a moderate concentration of alkaloids in the raw state as consumed by the bonobo. However, before being eaten by humans, the fruit is softened in hot water (Bondjengo 2011). Therefore, it is likely that the fruit of Canarium schweinfurthii is not only cooked to be softened, but also to eliminate some alkaloids that give a bad taste to the fruit in its raw state. This treatment is also known to occur in Cameroon (Njoukan 1998; Tchouamo et al. 2000). According to Irina et al. (2012), humans have used alkaloid-containing plants and animals since ancient times as poisons, stimulants, aphrodisiacs, and medicines. Indeed, alkaloid-containing plants have been – and still are – part of our regular diet (Irina et al. 2012). However, it is not only alkaloids that give a bad taste to fruits, but also other compounds (such as tannin) that may prevent bonobos from eating these fruit species (Hladik et al. 2011). Nevertheless, great apes may be more tolerant to bitter tastes than humans. For example, Hladik and Simmen (1996) showed that Pan troglodytes can drink bitter solutions containing almost 150 micromoles of quinine, a concentration four times higher than the median threshold measured for humans. Furthermore, Nishida et al. (2000) found that chimpanzees are able to tolerate food species that to humans taste unpleasant, bitter, or astringent, as well as others that are neutral or sweet. But, in general, a diverse environment such as the LuiKotale Forest reveals few fruits rich in alkaloids (Hladik et al. 2011). Abiodun et al. (2014) reported that high alkaloid content causes toxicity when ingested by human beings, which is linked primarily with their ability to interfere with various neurotransmitters (Krief 2003). Alkaloid over-consumption could be the origin of many cases of poisoning in veterinary medicine, as is the case in domestic herbivores after ingestion of excessive amounts of lupine, rich in alkaloids known as quinolizidiniques (Mazid et al. 2011). These items when consumed in small amounts have been referred to as ‘medicinal foods’ by Huffman (1997), and by Masi et al. (2012) as unusual items of consumption; both propose some kind of medicinal value. The great ape diet is indeed rich in plants containing secondary compounds of non-nutritional, sometimes toxic, and medical value (Huffman 2003).

Regarding cyanogenic glycosides, we used the same test of Feigl-Anger as Chapman et al. (2003). Only three species were found to contain these substances out of the 75 species surveyed. Our results are in line with Bouquet and Fournet (1975), who also found the same species with cyanogenic glycosides: Oncoba welwitschii, Camptostylus mannii and Dasylepis cfr. seretii. The two species of the Achariaceae family contain both alkaloids and cyanogenic glycosides. Indeed, Bouquet (1972) confirmed that all Congolese species of the Salicaceae family contain cyanogenic glycosides. However, according to Conn (1979), cyanogenesis appears to be limited only to certain families such as the Leguminosae, Rosaceae, Euphorbiaceae and

<table>
<thead>
<tr>
<th>Species</th>
<th>Hs</th>
<th>Pp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species with</td>
<td>7 (50%)</td>
<td>20 (34%)</td>
</tr>
<tr>
<td>Species without</td>
<td>7 (50%)</td>
<td>39 (66%)</td>
</tr>
<tr>
<td>Sample size</td>
<td>14</td>
<td>59</td>
</tr>
</tbody>
</table>
Table 4. Number of species consumed by humans and bonobos, with respect to cyanogenic glycosides content.

<table>
<thead>
<tr>
<th>Species</th>
<th>Hs</th>
<th>Pp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species with</td>
<td>0 (0%)</td>
<td>3 (5%)</td>
</tr>
<tr>
<td>Species without</td>
<td>14 (100%)</td>
<td>56 (94%)</td>
</tr>
<tr>
<td>Species size</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

Passifloraceae. Nevertheless, our study reconfirms the work of Bouquet (1972) that some species in the Achariaceae and Salicaceae families contain cyanogenic glycosides.

Rothman et al. (2006) analyzed the chemical content of a total of 127 food plant parts, representing 84 plant species, eaten by two groups of mountain gorillas, from Bwindi Forest National Park, Uganda, but found only two foods that contained cyanogenic glycosides.

Thus, the small proportion (5%) found among the fruits consumed by bonobos at LuiKotale is in line with what has been reported elsewhere, e.g., the results found by Bouquet and Fournet (1975) in the study of the Congolese flora and the investigation by Rothman et al. (2006). Similarly, independent findings show that red colobus monkeys in Kibale National Park, Uganda also avoid plants with high levels of secondary compounds (Chapman & Chapman 2002).

In summary, the results provided here show that none of the ingested fruit species showed high concentrations of either alkaloids or cyanogenic glycosides. Using semi-quantitative analyses of bonobo and local human fruit foods, we have provided an overview into the presence/absence of two major secondary metabolite groups in the diet. However, future studies should quantify and qualify these compounds to assess their importance for the health of bonobos and humans. This investigation has contributed to our understanding the food choices in bonobos and the Nkundo people, as they relate to the presence or absence of alkaloids and cyanogenic glucosides. Furthermore, we have contributed valuable data about the presence of secondary compounds in the fruits of certain species from the African rainforest.

ACKNOWLEDGMENTS

We thank the Max Planck Institute for all the logistics and financial support for conducting this research. We also acknowledge the Institut Congolais pour la Conservation de la Nature (ICCN) for allowing access into the study site and accepting us as researchers. Our gratitude also goes to the villagers of Lompole, particularly Booto Lambert and Etike Joseph Mara for contributing to the data collection. We would like to acknowledge the international staff of Luikotale, who have contributed also to data collection during the habituation of bonobos during our study period: Cintia Garai and Andrew Fowler. We give special thanks to Barbara Decrosac who agreed to complete our analysis in the field and to our colleague Musuyu Desire for his advice. We would like to thank also Lys Alcayna Stevens who quickly agreed to read this work. Lastly, we thank Jo Thompson for editorial assistance and our reviewers Michael A. Huffman and Alex Chepstow-Lusty for their insightful suggestions.

LITERATURE CITED


Behvioral Diversity in Chimpanzees and Bonobos. Cambridge University Press.


Alkaloids and Cyanogenic Glycosides in Bonobos / 21

Laboratoire de Phytochimie, Université de Lyon 1.


Received: 18 April 2016
Accepted: 1 September 2017
Primate Communities Along a Protected Area Border: A Two-site Comparison of Abundance and Hunting Response in Bioko, Equatorial Guinea

Daniel L. Forrest1,2,3, Fermin Muatiche3, Cirilo Riaco3, Mary Katherine Gonder2,3,4, and Drew T. Cronin3,5

1Department of Ecology, Evolution, and Natural Resources, Rutgers, The State University of New Jersey, New Brunswick, NJ, USA; 2Department of Biodiversity, Earth and Environmental Science, Drexel University, Philadelphia, PA, USA; 3Bioko Biodiversity Protection Program, Malabo, Bioko Norte, Equatorial Guinea; 4Department of Biology, Drexel University, Philadelphia, PA, USA; 5SMART Partnership, Wildlife Conservation Society, Bronx, NY, USA

Abstract: Bioko Island, Equatorial Guinea is home to seven diurnal primate taxa, threatened with extinction largely due to high rates of illegal bushmeat hunting. The Gran Caldera Scientific Reserve (GCSR), one of two protected areas on Bioko, is the only remaining site where all seven taxa can be found. Historically, much of the wildlife in the GCSR has been passively protected due to its isolation, but a lack of effective law enforcement has allowed hunting to proliferate, and recent road and infrastructure development threatens more hunting in the future. Many calls have been made for the development of a comprehensive management plan to effectively protect the GCSR, but data are needed to understand the dynamics of the varying human-wildlife systems along its borders to develop well-informed and cost-effective management strategies. This study investigated the abundance and species richness of primates along the GCSR border near the village of Moka over four years (2011-2014), and compared results to those of a previous study near a similar GCSR-border village, Belebu. Although we found considerable inter-annual variation in the relative abundance of primates at Moka, the overall relative abundance there was significantly higher than at Belebu. We attribute this primarily to the higher observed hunting intensity at Belebu, differences in historical hunting patterns and accessibility, and the presence of a long-term research site and activities at Moka, which may deter hunters in the area. Further research is needed to provide greater resolution on complementary factors influencing abundance and distribution patterns. However, our results highlight the persistence of a notable primate community near Moka and emphasize the importance of understanding dynamics along protected area borders when planning for conservations. Relatively similar sites may require different approaches for effective management.

Key words: Bioko, hunting, bushmeat, surveys, protected areas

INTRODUCTION

Bushmeat, or the meat of wildlife from forests, has long been a dietary staple of people in tropical African forests (Asibey 1977; Afolayan 1980; Fa et al. 2002; Robinson & Bennett 2004). While wild harvest can be a sustainable and accessible protein-source (Albrechtsen et al. 2007), accelerating human population growth, increased use of firearms, and greater accessibility to remote forests has led to the commercialization of the bushmeat trade (Abernethy et al. 2013; Albrechtsen et al. 2007; Fa et al. 2005; Ziegler et al. 2016). The rapid growth of the bushmeat trade now threatens many taxa with
extinction (Oates et al. 2004). In central Africa, hunting is one of the leading causes of decline of most larger-bodied mammals, especially primates and ungulates (Oates et al. 2004). Diurnal primates are among the most heavily hunted taxonomic groups in the region, comprising approximately 10-20% of carcasses recorded in market studies (Fa et al. 2000, 2006; Cronin et al. 2015). Extinction or decline of primate species can lead to negative cascading ecological effects in their communities (Wright et al. 2000, 2007; Abernethy et al. 2013, Effiom et al. 2013). Many primates have a primarily frugivorous diet, and thus provide crucial ecosystem maintenance functions, such as seed dispersal (Chapman & Onderdonk 1998; Lambert 2001; Poulsen et al. 2001, 2002). Tree diversity in hunted forests is lower than in non-hunted forests, and their composition is significantly different from non-hunted forests, largely due to the absence of large-bodied frugivores (e.g., primates) (Sork 1985; Chapman & Chapman 1996; Chapman & Onderdonk 1998; Effiom et al. 2013).

Bioko Island, Equatorial Guinea (Figure 1) is home to numerous endemics, namely, six diurnal primate subspecies, and one endemic primate species (Table 1), all of which are threatened with extinction (IUCN 2016). The primary threat to these species is bushmeat hunting to supply the capital city of Malabo, where there is a large, thriving bushmeat market (Fa et al. 2000; Albrechtsen et al. 2007; Cronin et al. 2015). Over 100,000 kg of bushmeat are consumed annually on Bioko alone, according to several estimates (Fa et al. 2000; Albrechtsen et al. 2007), of which primates comprise approximately 20% of all carcasses (Cronin et al. 2015). While the causes of decline in diurnal primates on Bioko are well established, government led conservation efforts and management plans on Bioko have yet to lead to any profound successes, despite a presidential decree that bans primate hunting (Republic of Equatorial Guinea 2007). Approximately 40% of the island falls within the borders of two protected areas, giving Bioko great potential for conservation. The protected areas, however, have done little to impede hunting, as protected area borders are not well-marked, and environmental legislation is not strongly enforced (Colell et al. 1994; Cronin et al. 2010; 2016; Grande-Vega et al. 2013, 2016). Over time, the threat to primates on Bioko has continued to increase, due to an increase in hunting and demand for bushmeat (Butynski & Koster 1994; Fa 2000; Hearn et al. 2006; Cronin et al. 2010, 2015).
Several previous surveys (Schaaf et al. 1990; Butynski & Koster 1994; Hearn et al. 2004; Cronin et al. 2013) focused primarily on remote areas of the island, and especially on areas within the GCSR. Primate abundance and hunting levels in areas bordering the reserve, however, have gone relatively understudied, with the exception of a brief study at Moka by Colell et al. (1994), undergraduate surveys as part of annual field courses at the Moka Wildlife Center (MWC) over the past decade, and surveys conducted by Cronin et al. (2016) at Belebu, another town bordering the GCSR. Colell et al. (1994) studied hunting in the Moka area by both surveying hunters and conducting hunter follows in 1992, finding that hunters more commonly used traps than guns, and that hunters gradually increased the length and extent of their hunting trips over the course of their study. At Belebu, Cronin et al. (2016) encountered dramatically fewer primates and more hunting signs than at other more remote sites, which was attributed to its long-term history of organized bushmeat hunting and transport and its close proximity to Luba, Bioko’s second largest city.

This study makes use of student survey data from 2011-2014 at Moka, and incorporates data collected by Cronin et al. (2016) at Belebu to compare differences in primate abundance and hunting intensity between the two sites to inform conservation planning. We sought to: 1) describe primate abundance and species richness at Moka; 2) quantify the hunting intensity at the site, and, if possible, its impact on Moka’s primate community (e.g., decreased abundance or reduced species richness); 3) compare data from Moka and Belebu to evaluate differences in primate abundance, species richness, and gun hunting between the two sites; and 4) provide recommendations to improve the efforts to conserve Bioko’s primate populations.

**METHODS**

**Study Area**

Bioko Island, Equatorial Guinea (2017 km²), a volcanic, continental island, located 37 km off of the coast of Cameroon (Figure 1), is a biodiversity hotspot and a key site for the conservation of African primate diversity (Oates 1996; Myers et al. 2000; Oates et al. 2004). Bioko spans an elevational range from 0-3,011 m asl, and a north-south precipitation gradient from 2,000 mm/year in the north to over 10,000 mm/year in the south (Font Tullot 1951; de Terán 1962). Two protected areas, Pico Basilé National Park (330 km²; PBNP) and the Gran Caldera Scientific Reserve (510 km²; GCSR), encompass approximately 40% of the island’s land area. The GCSR encompasses the southern 25% of the island, which has far less human development and impact than the northern end of the island. Aside from the village of Ureka (< 80 individuals), no permanent human settlements exist within the GCSR.

This study took place near the village of Moka, located along the northeastern border of the GCSR at an elevation of 1,400 m asl on the eastern slope of Pico Biao. Moka is largely surrounded by an agricultural mosaic which transitions into montane forest away from the village. Annual precipitation at Moka is estimated to be 3,700 mm/year, with approximately 131 mm falling on average each November (when the surveys were conducted).
(Font Tullot 1951). Moka is a key agricultural site on Bioko, predominantly inhabited by the Bubi ethnic group, with an established history of hunting (Colell et al. 1994), although Bubis have restricted gun access (Butynski & Koster 1994; Grande-Vega et al. 2013). In recent years, agricultural activities have expanded greatly around the town (D.T. Cronin, pers. obs.), despite its location on the border of the GCSR.

Data Collection

Surveys were conducted from 2011 to 2014, between 04 November and 26 November of each year along established multi-use footpaths near the Moka Wildlife Center (MWC) (a facility operated by the Bioko Biodiversity Protection Program, an academic partnership between Drexel University and the National University of Equatorial Guinea). Reconnaissance (“recce”) walk methodology (Walsh & White 1999) was used following Cronin et al. (2013, 2016) to travel more quickly, cover more ground, avoid unnecessarily cutting trails/destroying habitat, and to increase the likelihood of primate encounters. In recce sampling, two to four researchers walk along the path of least resistance through the forest, following natural geographic features, and existing human and game trails to maintain a general compass bearing, and cutting vegetation only when necessary (Walsh & White 1999). Three recce transects were surveyed, San Joaquin, Balacha Sur, and Balacha Norte, all of which were approximately 4 km in length. Transects were measured and marked by researchers prior to beginning surveys using either a hip chain or 50 m tape measure. Surveys were conducted at a speed of approximately 1.15 km hr⁻¹, similar to the 1 km hr⁻¹ rate established by Whitesides et al. (1988), and used in previous surveys on Bioko (Butynski & Koster 1994; Cronin et al. 2013, 2016). One transect was surveyed each day, twice per day (once in each direction), from approximately 0700–1100, and 1400–1800, unless faced with an extenuating circumstance (e.g., heavy rain). We alternated transects each day, in order to walk each transect an approximately equal number of times within our study period.

All survey data were collected by students trained by DTC (including DLF) and FM, who was present for all surveys, and recorded using a customized Cybertracker (v3.2.28) data collection program (Steventon 2002). Primate groups were counted to estimate relative primate abundance following Schaaf et al. (1990) and Cronin et al. (2013, 2016) due to difficulties associated with detection of hunted primates in steep terrain with dense vegetation (Whitesides et al. 1988). Upon each primate encounter, the following data were recorded: (1) time of observation (2) type of encounter (visual/auditory), (3) location (GPS coordinates), (4) elevation, (5) species, (6) number of individuals, (7) sex of individuals, (8) vocalization type, (9) height in trees/canopy (Schaaf et al. 1990; Butynski & Koster 1994; Cronin et al. 2013). Any encounter within 50 m of the previous encounter was considered part of the same group (same species) or a polyspecific association, and was not recorded separately (Oates et al. 1990).

To quantify hunting pressure, any sign of hunting, such as shotgun shells, traps, batteries, hunting camps, carcasses, and gun shots were tallied categorically, and summed (Linder 2008; Cronin et al. 2013). Each individual sign was treated as a separate encounter, and no signs were collected to avoid detection, hostility from hunters, and hunter interference in data quality (picking up shotgun shells, batteries, etc.) (Linder & Oates 2011; Cronin et al. 2013, 2016).

Data Analysis

Sighting frequencies were calculated as the number of social groups, including solitary primates, sighted per kilometer of transect walked. We did not analyze the data to produce sighting frequencies of individuals, as estimating group size of primate groups in hunted forests is particularly unreliable (Ferrari et al. 2010), and previous primate surveys conducted on Bioko calculated group, not individual, encounter rates (Butynski & Koster 1994; Cronin et al. 2010, 2013, 2016). Sighting frequency (groups/km) is a measure of relative density, used in place of absolute density measurements (groups/km²) due to small sample sizes of each species and inherent difficulties in detecting hunted primates in dense forest (Fashing & Cords 2000; Marshall et al. 2008). Sighting frequencies and hunting sign encounter rates were compared to surveys conducted by Cronin et al. (2016) at Belebu, to compare abundance and hunting patterns between the two sites.

Primate sighting frequencies were compared among survey sites and years using the non-parametric test (Wilcoxon–Mann–Whitney test (Linder & Oates 2011; Cronin et al. 2013, 2016). The alpha level was set at 0.05 for all statistical tests and adjusted using Bonferroni correction procedures. All statistical analyses were conducted using R (v3.2.2; R Core Team 2015).
RESULTS

Sighting frequency and temporal change in Moka

The three transects were surveyed a total of 57 times (San Joaquin: 24 surveys - 81.28 km; Balacha Norte: 13 surveys - 46.66 km; Balacha Sur: 20 surveys - 70.26 km), resulting in a total survey effort of 198.2 km and 151 total encounters, for an average encounter rate of 0.75 groups/km. Visual identifications were confirmed for 119 encounters, resulting in a sighting frequency of 0.56 groups/km. Five of the seven diurnal primate species occurring on Bioko were encountered in the Moka area: Cercopithecus erythrotis, C. pogonias, C. nictitans, Allochrocebus preussi, and Mandrillus leucophaeus. The two colobine species present on Bioko, Colobus satanas and Procolobus pennantii were not encountered.

Overall sighting frequencies of all primate species each year in Moka were compared to every other year using the Wilcoxon–Mann–Whitney test. Sighting frequency was significantly higher in 2013 (0.82 groups/km) and 2014 (0.72 groups/km) than in 2011 (0.45 groups/km), and significantly higher in 2013 (0.72 groups/km) than in 2012 (0.37 groups/km) (Wilcoxon–Mann–Whitney: 2011-2013: \( W = 101.5, p < 0.005 \); 2011-2014: \( W = 157, p < 0.01 \); 2012-2013: \( W = 61.5, p < 0.05 \) (Table 2).

In all four years, C. erythrotis was the most frequently sighted primate (Table 2). In 2011, the only other primate species sighted was M. leucophaeus (Table 2). In 2012, the only other sighted primate species was A. preussi (Table 2). In 2013, three species were sighted at relatively low frequencies (M. leucophaeus, A. preussi, and C. nictitans) (Table 2). In 2014, three species were sighted, again, at relatively low frequencies (M. leucophaeus, C. nictitans, and C. pogonias) (Table 2; Figure 2).

Species richness in Moka

Species richness (i.e., the number of species encountered) varied by year, and by transect. More species were observed in 2013 and 2014 (4 species) than in 2011 and 2012 (2 species), but within years, the composition of species encountered varied among transects (Figure 2). The most species were observed on Balacha Sur in 2011 (2 species), 2013 (3 species), and 2014 (3 species) (Figure 2). In 2012, the most species were sighted on San Joaquin (2 species) (Figure 2). Across all years, the fewest species were sighted on Balacha Norte, as only C. erythrotis was sighted on this trail (Figure 2).

Hunting in Moka

Both gun hunting and trapping signs were encountered on all trails each year, with some
Table 2. Primate sighting data for each species from 2011 to 2014 (N = number of groups sighted, S.F. = sighting frequency (groups/km), % = percentage of all sightings).

<table>
<thead>
<tr>
<th>Species</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>Belebu*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>S.F. (grps/km)</td>
<td>%</td>
<td>N</td>
<td>S.F. (grps/km)</td>
</tr>
<tr>
<td>Cer</td>
<td>30</td>
<td>0.43 (0.10)</td>
<td>94</td>
<td>16</td>
<td>0.31 (0.078)</td>
</tr>
<tr>
<td>Cpo</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cni</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Apr</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0.085 (0.021)</td>
</tr>
<tr>
<td>Mle</td>
<td>1</td>
<td>0.014 (0.003)</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Csa</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unk</td>
<td>1</td>
<td>0.14 (0.003)</td>
<td>3</td>
<td>1</td>
<td>0.016 (0.004)</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>0.45 (0.11)</td>
<td>21</td>
<td>0.39 (0.098)</td>
<td>29</td>
</tr>
</tbody>
</table>

*Mle - *Mandrillus leucophaeus*; Csa - *Colobus satanas*; Ppe - *Piliocolobus pennantii*; Cer - *Cercopithecus erythrotis*; Cpo - *Cercopithecus pogonias*; Cni - *Cercopithecus nictitans*; Apr - *Allochrocebus preussi*. 
variation by trail and year (Table 3). Hunting signs largely comprised of shotgun shells, followed by traps, batteries, and miscellaneous hunting signs (e.g., carcasses, entrails). The highest gun sign encounter rate occurred in 2013, with a considerable decrease in 2014 (Table 3). Snares were encountered an average of 4.07 times more frequently in 2011 and 2012 than in 2013 and 2014 (Table 3).

**Differential species composition and sighting frequency per site**

While species richness was comparable at both sites (Belebu, 4 species; Moka, 5 species), the overall primate sighting frequency was significantly higher at Moka (0.56 groups/km) than Belebu (0.18 groups/km) (Wilcoxon–Mann–Whitney: W = 534, p <0.00001) (Figure 3). All individual species sighting frequencies were higher at Moka, except for *C. satanas*, of which no sightings were made at Moka, while a single sighting occurred at Belebu resulting in a sighting frequency of 0.016 groups/km. Two species were sighted at Moka that were not sighted at Belebu (*M. leuocophaeus*, 0.017 groups/km; *C. nictitans* 0.009 groups/km).

**Differential response to gun hunting per site**

Belebu (5.56 signs/km) had a higher overall hunting sign presence than Moka (1.22 signs/km), a higher gun sign encounter rate (Belebu, 2.89 signs/km; Moka, 0.83 signs/km), and a higher trap sign encounter rate (Belebu, 2.66 signs/km; Moka, 0.40 signs/km). Overall sighting frequency of primates was higher in Moka, where fewer hunting signs were encountered.

**DISCUSSION**

While several other studies have documented primate abundance and hunting pressure on Bioko Island and Cronin *et al.* (2015) assessed the impact of gun hunting on Bioko’s diurnal primate species, this is the first study to highlight and assess relative abundance of primates and hunting pressure near two semi-urbanized towns on Bioko. Prior to this study, no primary data in the Moka area on Bioko was published. Overall primate sighting frequency was higher in Moka, where fewer hunting signs were encountered; however, differences in elevation (Cronin *et al.* 2016), distance from roads (Cronin *et al.* 2017) and habitat may also play a role, and require further research. A prominent hunting presence was revealed at both of the census locations in this study (Belebu, 5.56 signs/km; Moka, 1.22 signs/km). According to Cronin *et al.* (2015), primates have become a key portion of the bushmeat market in Malabo, the capital of Bioko.

Of Bioko’s seven diurnal primate species, our surveys revealed the presence of five species persisting at Moka, and four at Belebu (Cronin *et al.* 2016). While species composition and abundance in our surveys varied from year to year, the regularity with which primates were encountered at Belebu suggests that five species continue to persist in the area, and the comparably sparse encounters at Belebu suggest the contrary. *C. erythrotis* was the most commonly sighted species at Moka and Belebu, in accordance with previous studies on Bioko (Butynski & Koster 1994; Cronin *et al.* 2016), while the other five species (*A. preussi* (Moka, Belebu), *C. satanas* (Belebu), *C. pogonias* (Moka, Belebu), *C. nictitans* (Moka), and *M. leuocophaeus* (Moka)) were encountered at a much lower frequency. *P. pennantii* and *C. satanas* were not encountered in the Moka area, implying extremely low densities, as in the case of *C. satanas*, or extirpation in the areas surrounding Moka, as has been suggested for *P. pennantii* (Cronin *et al.* 2013, 2016, 2017). *C. satanas* has recently been observed opportunistically near Moka along the rim of the Biao crater (1 individual; D. Montgomery, pers. obs. 2013), and on the northwest flank of Pico Biao (1 individual: D. Venditti, pers. obs. 2016; 2 groups: D. L. Forrest, pers. obs. 2017). Colell *et al.* (1994) described a single *P. pennantii* carcass, reported to be taken near Pico Biao in 1992; however, *P. pennantii* is now believed to be restricted to a single small population in the southwestern corner of Bioko (Cronin *et al.* 2016, 2017). Colobus monkeys are largely understood to be highly sensitive to hunting, due to their large body size, their sluggish and conspicuous manner of movement, and low level of visual alertness (Oates 1996). On Bioko, Cronin *et al.* (2016) found that both *C. satanas* and *P. pennantii* are the most vulnerable species to hunting. Examples with other colobine species from mainland Equatorial Guinea (Kümpel *et al.* 2008), Uganda (Struhsaker 1999), Tanzania (Marshall 2007), and a comprehensive analysis of all red colobus species (Struhsaker 2005) substantiate this claim. The high vulnerability to hunting of both colobine species on Bioko likely account for their absence at our study site.

Despite the higher sighting frequency at Moka, the primate communities of both Moka and Belebu are reflective of hunted forests on Bioko (Cronin *et al.* 2016) and the Congo Basin (Linder & Oates 2011; Rovero *et al.* 2012). As in other recent surveys on the island (Cronin *et al.* 2013, 2016), the majority of sightings consisted of smaller bodied primates...
Table 3. Hunting sign totals and encounter rates per km during surveys at Moka (2011 – 2014; this study) and Belebu (2011-2012; Cronin et al. 2016).

<table>
<thead>
<tr>
<th>Hunting Sign Type</th>
<th>Moka</th>
<th>Belebu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011</td>
<td>2012</td>
</tr>
<tr>
<td><strong>Gun Hunting Signs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balacha Norte</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>Balacha Sur</td>
<td>22</td>
<td>18</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>All Trails</td>
<td>38</td>
<td>51</td>
</tr>
<tr>
<td><strong>Trap Hunting Signs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balacha Norte</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Balacha Sur</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>All Trail</td>
<td>33</td>
<td>34</td>
</tr>
<tr>
<td><strong>Total Hunting Signs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balacha Norte</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>Balacha Sur</td>
<td>40</td>
<td>28</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>26</td>
<td>17</td>
</tr>
<tr>
<td>All Trails</td>
<td>71</td>
<td>85</td>
</tr>
<tr>
<td><strong>Gun Sign E. R. (km⁻¹)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balacha Norte</td>
<td>0.69</td>
<td>1.13</td>
</tr>
<tr>
<td>Balacha Sur</td>
<td>1.07</td>
<td>1.05</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>0.30</td>
<td>0.77</td>
</tr>
<tr>
<td>All Trails</td>
<td>0.59</td>
<td>0.96</td>
</tr>
<tr>
<td><strong>Trap Sign E. R. (km⁻¹)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balacha Norte</td>
<td>0.00</td>
<td>1.70</td>
</tr>
<tr>
<td>Balacha Sur</td>
<td>0.40</td>
<td>0.58</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>0.88</td>
<td>0.00</td>
</tr>
<tr>
<td>All Trails</td>
<td>0.51</td>
<td>0.64</td>
</tr>
<tr>
<td><strong>Overall Hunting Sign E.R. (km⁻¹)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balacha Norte</td>
<td>0.69</td>
<td>2.83</td>
</tr>
<tr>
<td>Balacha Sur</td>
<td>1.95</td>
<td>1.64</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>0.97</td>
<td>0.77</td>
</tr>
<tr>
<td>All Trails</td>
<td>1.25</td>
<td>1.60</td>
</tr>
</tbody>
</table>
(e.g., *C. erythrotis*), while larger, more conspicuous species were encountered at either low rates (e.g., *M. leucophaeus, C. satanas*), or not at all (e.g., *P. pennantii*). *C. erythrotis* is the smallest diurnal primate occurring on Bioko (Butynski et al. 2009), and is most resilient to hunting pressure (Cronin et al. 2016). In contrast, the larger-bodied species, *M. leucophaeus, C. satanas*, and *P. pennantii*, are all vulnerable to hunting pressure and, thus, are expected to be encountered at lower frequencies (Cronin et al. 2016). *P. pennantii* and *C. satanas*, respectively, had the highest and second-highest vulnerability indices of all of Bioko's primates (Cronin et al. 2016) and, accordingly, were only opportunistically encountered or absent in our surveys. The high proportion of *C. erythrotis* encountered during our surveys relative to larger-bodied primate taxa lends further support to Cronin et al.'s (2016) suggestion that *C. erythrotis* may compensate for the loss of other diurnal primate taxa on Bioko. Other recent studies in Cameroon (Linder & Oates 2011) and Tanzania (Rovero et al. 2012) have shown similar trends with respect to the primate community composition in highly-hunted versus lesser-hunted forests (fewer larger-bodied primates, chiefly colobines, and equal or greater smaller-bodied primates, chiefly cercopithecines). Both Linder & Oates (2011) and Cronin et al. (2016)

**Figure 3.** Comparison of primate sighting frequencies at Belebu and Moka. Notches indicate standard deviations from the mean sighting frequency values.
propose that this phenomenon could be attributed to competitive release, which may also be the case in our study.

Habitat degradation is often cited as a leading cause of primate population decline in west and central Africa (Oates 1996; Rovero et al. 2012; Barelli et al. 2015) and may play an important role in primate community dynamics at both of our study sites. The abandonment of former pastureland in Moka in the early 1990s allowed secondary forest to reclaim some areas of previously lost or degraded habitat. This potentially led to increased habitat, in some areas around Moka (Butynski & Koster 1994). However, in recent years, there has been considerable habitat loss near both Moka and Belebu, concentrated along their primary access roadways (main road to Luba and Malabo, Moka; Luba-Ureka road, Belebu), due to agricultural expansion (D.T. Cronin, D.L. Forrest, pers. obs.). Net habitat gain may be insignificant or even negative, as a result, but it is also likely that hunting efforts will be, at least in the short term, concentrated in areas just beyond agricultural expansion and along roads, due to easier accessibility.

While both the towns of Moka and Belebu are positioned along the border of the GCSR, relative primate abundance and hunting sign encounter rates differed between the two, likely due to the accessibility and land-use history of these towns. Our results indicate a higher hunting presence in Belebu than in Moka, and correspondingly fewer primates in Belebu than in Moka. The forest near Belebu is more accessible to most hunters, as Belebu is only 7.5 km from Luba, Bioko’s second largest town, on the Luba-Ureka Road, and, as a result, nearer to Malabo, the largest town and location of the main bushmeat market. Belebu also has a long history of plantation agriculture of both cocoa and palm, fueling both forest loss and/or conversion, and gun hunting for bushmeat and management of agricultural pests, e.g., squirrels (Butynski & Koster 1994). Small-scale commercial agriculture also occurs in Moka, but expansion has occurred more recently, and a greater amount of intact forest remains directly surrounding the town (D. T. Cronin, D. L. Forrest, pers. obs.). Elevation is often considered an important environmental predictor of primate abundance, as higher elevation are typically associated with lower densities of primates (Barelli et al. 2015). This holds true on Bioko (Cronin et al. 2016); however, our high elevation site (Moka) had a higher sighting frequency than the lowland site (Belebu). Higher sighting frequency on trails around Moka (montane forest) than Belebu (lowland forest) indicate that hunting pressure likely has the dominant impact on primate abundance. Other environmental factors may also play a role in the species richness and abundance at each site, and further research is necessary to investigate the impact of these ecological differences.

The results from these two towns on the boundary of the GCSR support the persistence of a number of significant issues: (1) the borders of the GCSR are permeable to hunters; (2) the legal existence of protected areas on Bioko is not sufficient to deter hunting, especially of threatened primates, which are critically important to the maintenance of ecosystem processes; and (3) the development of management strategies for the GCSR needs to account for site-specific differences in accessibility, long-term history, hunting patterns, and species assemblages, such as prioritization of the location of forest patrols, and selective positioning of bushmeat checkpoints. With the understanding of the limitations in implementing a management strategy for a protected area (limited funding, personnel, equipment, etc.), it is imperative to consider key access points, hunted areas, and the current ecological state of the area. Belebu and Moka are two of only four large towns within 2 km of the GCSR, and are the most accessible of the four. By studying the primate abundance and hunting levels in key locations nearing the reserve borders, we can better understand the pathways of entry into the reserve, level of use in different portions of the reserve, and prioritize limited resources. We contend that the difference between primate abundance in Belebu and Moka is due, in large part, to the greater accessibility and history of hunting in Belebu.

With this understanding, the current expansion of agriculture at Moka, and the completion of the new road through the GCSR to Ureka, we reiterate the recommendation made in Cronin et al. (2017) that the implementation of a management plan for the GCSR is of critical importance to the preservation of its diurnal primate taxa. Included in their recommendations were the creation and implementation of ‘ranger bases’ at primary access points to the GCSR and ‘bushmeat checkpoints’ along key transit routes between protected areas. Belebu, situated 7.5 km from the entrance to the Luba-Ureka road (Figure 1), is highly accessible to hunters coming from Luba. A checkpoint directly after Belebu along the Luba-Ureka road, coupled with vehicle searches by INDEFOR-AP, the protected area management authority would limit the amount of off-take by preventing vehicle access to the reserve. There are two major roadways leading directly to
Moka, and an extensive trail system surrounding the town. While this accessibility, coupled with the Moka Wildlife Center, have provided the infrastructure for ecotourism, and has already lead to some success in this area, heavy hunting pressure and subsequent decreases in primate abundance near the town threatens to reduce, if not eliminate, the ecotourism market in the town. Increasing the number of eco-guard patrols in the area, coupled with military support may decrease the hunting presence.

Both Belebu and Moka were put forth as sites in Cronin et al.’s (2017) GCSR conservation strategy, and our study highlights the importance of these two sites to primate conservation along the GCSR border, and as access points for illegal activities. Continued hunting and defaunation in towns like Belebu and Moka along the GCSR border will, in time, lead to hunters moving further into the GCSR, reaching core areas which still maintain high densities of all 7 diurnal primate species (Cronin et al. 2017). The newly constructed road from Luba to Ureka has already enabled hunters to have vehicle access to formerly remote areas of the GCSR and contributed to increased hunting activity in the southern extent of the reserve (D.T. Cronin, unpublished data, 2015-2016). Forest patrols by INDEFOR-AP should be targeted in areas of known hunting, including Moka, Belebu, and other easy-access areas of the GCSR.

Finally, long-term research sites and the associated presence of researchers and students have been shown to contribute to significantly higher primate abundance and lower hunting intensity (Campbell et al. 2011; N’Goran et al. 2012). The Moka Wildlife Center has been a site for long-term research, educational, and conservation activities since 2006, and the consistent presence of researchers and students have likely contributed to the lower levels of hunting and higher primate abundance observed at Moka relative to Belebu in our study. Furthermore, all of the surveys at Moka were carried out by students conducting research at the Moka Wildlife Center, revealing the value of student research for informing conservation in an understudied area of the island. These student surveys occur annually, and provide a consistent source of data to frequently update the status of primate populations, as well as the effects that hunting and agriculture are having on primate populations at Moka. While much of the scientific literature has focused on more remote areas of the island, our results detail the persistence of notable primate populations, and highlight the importance of understanding the dynamics of wildlife populations in more disturbed, human-dominated landscapes on Bioko when planning for conservation.

ACKNOWLEDGEMENTS

We would like to thank the government of Equatorial Guinea and la Universidad Nacional de Guinea Ecuatorial, including H.E. Carlos Nse Nsuga and Jose Manuel Esara Echube for permission to conduct this research. We thank the people of Moka, as well as Julia Dagum, Gustavo Mbomio, Rachael Disciullo, Piotr Jurgielewicz, Angel Etame Etame, Stephen Dench, Faith Roser, and Erica Tuttle for assistance with data collection. The Bioko Biodiversity Protection Program is supported by the ExxonMobil Foundation and Mobil Equatorial Guinea, Inc.

LITERATURE CITED


Schaaf, C. D., T. B. Butynski & G. W. Hearn. 1990. *The Drill (Mandrillus leucophaeus) and Other Primates in the Gran Caldera Volcanica de Luba: Results of a Survey conducted March 7-22, 1990*. A Report to the Government of Equatorial Guinea, Zoo Atlanta, Atlanta, GA.


Received: 20 July 2016

Accepted: 13 September 2017
The First Sightings of the Red-Bellied Guenon (Cercopithecus erythrogaster erythrogaster) on the Western Edge of Southwestern Nigeria

Reiko Matsuda Goodwin¹, Jacob Oluwafemi Orimaye², Francis E. Okosodo³, Babafemi G. Ogunjemite³, and Mariano G. Houngbedji⁴

¹Department of Sociology and Anthropology, Fordham University, Bronx, NY, USA; ²Department of Forestry, Wildlife and Fisheries Management, Ekiti State University, Ado-Ekiti, Nigeria; ³Department of Ecotourism and Wildlife Management, Federal University of Technology, Akure, Nigeria; ⁴Organisation pour le Développement Durable et la Biodiversité, Cotonou, Benin

Abstract: To better understand the status and distribution patterns of threatened anthropoids, we conducted walking surveys and interviews on the western edge of southwestern Nigeria. As we surveyed, we recorded all sightings of the monkeys and evidence of anthropogenic disturbance. We also examined the extent of forest in the southern part of our study area, in particular, Eggua Forest Reserve and Ohumbe Forest Reserve, using Landsat 8 band images. The number of anthropoid species encountered during the surveys varied from zero to four. We sighted C. erythrogaster at Atola community forest (Encounter rate = 0.27 group/km), Royal Forest (private forest) (Encounter rate = 0.08 group/km), and Bola Camp community forest. These are seasonally inundated or riverine forests. The bellies of the C. erythrogaster individuals we saw at the two latter localities indicate that they are C. erythrogaster erythrogaster. No other threatened anthropoids were sighted. At Igboju community forest (part of Eggua FR), where an interviewee stated that C. e. erythrogaster occurs, we only saw mona monkeys (Cercopithecus mona). Bola Camp and adjacent communities, where about 9 km² of riverine forest still remains and hunting is limited, have a potential to develop a conservation program. Creating corridors to connect Igboju, Royal Forest, and southern forest fragments in Eggua FR for the conservation of C. e. erythrogaster is also recommended. With our new information, the distribution range of C. e. erythrogaster has now been expanded to east of Benin, but it is still uncertain how widespread this subspecies is. The future of this taxon in this region, however, does not look bright considering the levels of hunting, logging, farming, cattle herding, and fire set by cattle herders that we witnessed. Thorough surveys along Yewa River including Igboju, and fragmented forests in two forest reserves are necessary in the near future.

Key words: Nigeria, red-bellied guenon, Nigeria white-throated monkey, conservation, reconnaissance survey, semi-structured interview, community forest, forest reserve

Résumé: Dans une visant à mieux comprendre le statut et la répartition des espèces de singes menacés, en se concentrant sur Cercopithecus erythrogaster, nous avons réalisé des randonnées de 49,5 km et des entretiens sur le bord ouest du sud-ouest du Nigeria. Au cours des prospections pédestres, nous avons enregistré toutes les observations et vocalisations de singes et les signes de perturbation anthropique. Nous avons par la suite examiné la superficie de la forêt dans la partie sud de notre zone d'étude, en particulier la Réserve Forestière d’Eggua et la Réserve Forestière d’Ohumbe, sur des images de Landsat 8. Le nombre d'espèces des singes anthropoïde rencontrées lors des prospections pédestres varie de zéro à quatre (moyenne = 1,6). Nous avons observé C. erythrogaster dans la forêt communautaire d'Atola (0,27 groupe/km), dans la Forêt Royale (forêt privée)(0,08 groupe/km) et

Correspondence to: Reiko Matsuda Goodwin, Department of Sociology and Anthropology, Fordham University, Bronx, NY, USA; E-mail: reikogoodwin@gmail.com.
INTRODUCTION

The western edge of Southwestern Nigeria (hereafter “our study area”) in Ogun and Oyo states is a transition zone from the moist Lower Guinean Forest to the drier Dahomey Gap climate (White 1983). The vegetation of this region is a mosaic of lowland rain forest, riverine forest, swamp forest, seasonally inundated forest, savanna woodland, and thicket (Ern 1988). It is a poorly studied area in regard to biodiversity. Nevertheless, it is an area that has been said to harbor at least eight anthropoid species: the red-capped mangabey (Cercocebus torquatus); white-thighed colobus (Colobus vellerosus); olive colobus (Procolobus verus), which is the smallest colobine; white-throated monkey (Cercopithecus erythrogaster); mona monkey (Cercopithecus mona); tantalus monkey (Chlorocebus tantalus); patas monkey (Erythrocebus patas); and the olive baboon (Papio anubis). Additionally, the putty-nosed monkey (Cercopithecus nictitans) may be included. The 2008 IUCN Red List categorized the species C. erythrogaster as Vulnerable (Oates et al. 2008a) while the red-bellied subspecies, the red-bellied guenon (C. e. erythrogaster) was categorized as Endangered (EN) (Oates & Butynski 2008a) and the gray-bellied subspecies, the Nigeria white-throated monkey (C. e. pococki) as Vulnerable (VU) (Oates & Butynski 2008b). Because C. erythrogaster, C. torquatus, C. vellerosus, and P. verus are all threatened species (Oates et al. 2008a, b, c, d) they are referred to as the “threatened anthropoids of the region” in this paper. The status of these anthropoids in this region has been largely unknown, although some anecdotes and reports suggested that at least some of these species occur (Ogunjemite 2014).

This report focuses on C. erythrogaster, which is one of the anthropoid species present in the Dahomey Gap. The Dahomey Gap is the area of low rainfall and lower biodiversity situated between the Upper Guinean Forests and the Lower Guinean Forests in West Africa (Jenik 1994). During the Pleistocene, large rivers such as the Niger River in the east and Ouémé in the west did not act as effective physical barriers for the distribution of this species (Oates 1988, Harcourt & Wood 2012). The presence or absence of one or both subspecies of C. erythrogaster in our study area has not been examined since Oates (pers. comm. 2014) searched for this species by interviewing communities neighboring Eggua Forest Reserve (FR) in 1992, but the results of interviews were not promising. For this reason, in 1994 and 1995, Oates (1996) went to look for the species’ presence in southern Benin and discovered the red-bellied guenon in the Lama Forest (44.47 km², 7.017°-6.857° N, 2.078°-2.217° E) (Figure 1). The Nigeria white-throated monkey is known to occur east of Lagos in Sapoba, Okomu, Gilli-Gilli, Udo, Ohosu, and Omo Forest Reserves, probably a few other forests, and in the Niger Delta (Oates 1985, 2011a; Grubb et al. 1999). The red-bellied guenon has been known to occur only in eastern Togo and southern Benin. In Togo, it occurs in Togodo National Park (1.333° - 1.667° E, 6.666° - 6.833° N), and Godjin-Godjè sacred forest (1.520° E, 6.719° N) (Matsuda Goodwin et al. 2017a; G. Segniagbeto pers. comm. 2016). In Benin, it occurs at several localities in the south (e.g., Lama, Lokoli, Bonou, Togbota) (Matsuda Goodwin 2007; Nobimè et al. 2011; Matsuda Goodwin et al. 2017a). It is not known whether the distribution ranges of the two subspecies have been allopatric or parapatric with a potential zone of hybridization somewhere in our study area. Without precise knowledge of the two subspecies’ distribution limits, the Primates of West Africa (PWA) (Oates 2011a) mapped the eastern...
First Sightings of the Red-Bellied Guenon in Nigeria

limit of *C. e. erythrogaster*’s range as discontinuous from the western edge of the range of *C. e. pococki*, while the 2008 IUCN Red List mapped the limit along the border of Benin and Nigeria (Oates et al. 2008a).

Both subspecies of *C. erythrogaster* are known to inhabit a variety of lowland habitats; rain forest, semideciduous forest, seasonally inundated semideciduous forest, riverine forest, and swamp forest. In particular, *C. e. erythrogaster* often is found in riverine and swamp forest (Oates 1985, Nobimé et al. 2009). As long as hunting pressure is low, *C. erythrogaster* can even inhabit areas that have been somewhat disturbed and modified by human activities (Matsuda Goodwin, pers. obs., Oates 2011a).

To obtain data and local knowledge regarding the status and the distribution patterns of the threatened anthropoids of the region, we conducted reconnaissance surveys and semi-structured interviews. We then examined the current extent of forests in our study area using a Landsat 8 composite image taken during the major dry season.

We sighted *C. erythrogaster* at three new localities...
in this region, but we observed no other threatened monkey taxa. We discuss the significance of our observations, revise distribution range maps of *C. e. erythrogaster* and *C. e. pococki*, make conservation recommendations, and address some factors that should be carefully considered when conducting semi-structured interviews.

**METHODS**

Following initial scouting (i.e., visiting communities to conduct informal interviews) in our study area on January 5 - 10, 2015, we selected eight localities to conduct reconnaissance surveys (Figure 1). Old Oyo National Park (OONP) is outside the distribution range of *C. erythrogaster*, but because we were also searching for *C. vellerosus*, which Happold (1987) had reported occurred there more than 25 years ago, it was included in our study localities. Iwoye riverine forest at the intersection of Imeko FR and Okpara FR was also surveyed in our search for *C. vellerosus*. At each survey locality, we noted signs of human modification and five to ten commonly occurring tree species we observed as a rapid measure of describing the habitat characteristics (Table 1).

At each survey locality, we walked slowly at 1-1.5 km/hr on bush paths or hunter paths, noting the mammalian species we encountered, along with the time, GPS coordinates, and the mode of detection (heard or seen) (White & Edwards 2000). As much as possible, when an animal was sighted in a tree, we recorded the height (HT) of the tree, HT of the individual from the ground, the sighting distance, and the number of individuals seen. Each survey was 0.3 - 3.74 km in length and the paths were approximately linear. We obtained presence or absence information from the recce surveys and group encounter rates (*R*) (*R* = *N* groups sighted/distance walked). We reported encounter rates where we walked ≥ 1 km. During our foot surveys, we tried to record vocalizations of the monkeys using a Zoom H2N digital recorder with a Sennheiser ME66/K6 super-cardioid microphone. As we walked, we also recorded and photographed evidence of anthropogenic disturbance (e.g., spent shotgun cartridges, hunters’ footprints, gunshots, hunters’ camps, burned logs, felled trees) and estimated the date of occurrence. These are reported as frequencies rather than indices of occurrence; i.e., herds of cattle that crisscross a forest leaving numerous footprints cannot be easily quantified.

In addition, we conducted semi-structured interviews at seven villages that lie adjacent to or inside the surveyed forests to obtain complimentary information regarding the presence or absence of anthropoid species (Bernard 2006; Kühl 2008). The location of each interview was georeferenced. We did not conduct interviews at the Royal Forest in Eggua, a small private forest belonging to the Onigua (king) of Eggua, HRM Oba Adeleye Dosunmu. The Onigua has been protecting the forest and planting trees such as teak since 1991, but natural forest comprises less than one third of the forest. Hunting is prohibited, but there was no one willing to talk with us. We were careful in the manner we conducted the interviews; what questions to ask and in what order (Kühl 2008; Meijsaar et al. 2011). The interviews were conducted one hunter at a time. Even when other villagers surrounded an interviewee, we asked them not to intervene by asking questions, commenting, or providing an answer while an interview was being conducted. Because we wanted to hear his own opinion not influenced by others, we had explained this protocol to each interviewee before we began. However, when multiple villagers were interviewed, second and later interviewees had already heard the answers given by previous interviewees. This represents a potential bias regarding the answers given by later interviewees that we could not avoid. We asked them to provide the names of different monkeys, to describe various body parts of each monkey, when they had last seen the monkeys, and to imitate the calls of each monkey. We used images of the anthropoids of the region from PWA or PWA pocket guide (Oates 2011a, 2011b) only when we felt the use of images would clarify some ambiguities. Our experience was that small color images of the monkeys confused many hunters in rural areas who were not used to seeing them in two-dimensional space. We determined whether the interviewees’ answers provided credible local knowledge by finding out how many years the interviewees have hunted in the forest and by also comparing what we know about the names, pelage patterns, activity levels, and behavior of the monkeys and their responses.

In order to examine the extent of remaining forested areas in the southern part of our study area, in particular Eggua FR and Ohumbe FR, as an *a posteriori* analysis, we first downloaded and examined the maps of the two forest reserves from the World Database on Protected Areas (WDPA) (IUCN & UNEP-WCMC 2015). However, we found large discrepancies in the reserve size between officially declared size and downloaded polygons. The official sizes of Eggua FR and Ohumbe FR are 41.47 km² and 46.08 km², respectively (Ogun
<table>
<thead>
<tr>
<th>Localities</th>
<th>Latitude (N)</th>
<th>Longitude (E)</th>
<th>Altitude (m)</th>
<th>Size (km²)</th>
<th>Habitat Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iwoye, Imeko FR</td>
<td>7.918</td>
<td>2.693</td>
<td>133.8</td>
<td>751.4*</td>
<td>Much of the forest has been converted to farms, pastureland, and villages; The only remaining forest is along the Okparo River; Common trees include <em>Afzelia africana</em>, <em>Blighia sapida</em>, <em>Khaya senegalensis</em>, <em>Millettia thomningii</em>, <em>Ficus thomningiana</em>, and <em>Daniella oliveri</em>; Hunting occurs.</td>
</tr>
<tr>
<td>Old Oyo NP (Marguba)</td>
<td>8.454</td>
<td>3.773</td>
<td>307.3</td>
<td>2.512*</td>
<td>Degraded and fragmented into farm bush, savanna, and woodland; Common trees are <em>Afzelia africana</em>, <em>Anthocleista liebrechtsiana</em>, <em>Ceiba pentandra</em>, <em>Dialium guineense</em>, <em>D. oliveri</em>, and <em>Ficus spp</em>.; Cattle grazing, tree burning, and hunting occurs.</td>
</tr>
<tr>
<td>Old Oyo NP (Yemoso)</td>
<td>8.448</td>
<td>3.998</td>
<td>354.3</td>
<td></td>
<td>Similar to Marguba, but there are more forested areas; Common trees are: <em>Brachystegia nigerica</em>, <em>Cola gigantea</em>, <em>Entandrophragma angolense</em>, <em>Milicia excelsa</em>, and <em>Spondias mombin</em>; Destruction is due to cattle grazing and forest burning; Hunting occurs.</td>
</tr>
<tr>
<td>Igboju CF (Eggua FR)</td>
<td>6.998</td>
<td>2.923</td>
<td>21.7</td>
<td>1.5**</td>
<td>Severely degraded narrow strip of the riveine forest; A part of Eggua FR; Common trees are <em>Musanga cerropoioides</em>, <em>Myrianthus arboreus</em>, <em>Albizia zygia</em>, <em>Alchornea cordifolia</em>, <em>Canthium hispidum</em>, <em>C. gigantea</em>, and <em>Diospyros alboflavescens</em>; Cattle grazing and forest burning are the major forces of destruction; Nonhuman primates are not hunted.</td>
</tr>
<tr>
<td>Royal Forest PF; Eggua</td>
<td>7.046</td>
<td>2.928</td>
<td>34.4</td>
<td>1</td>
<td>Seasonally inundated forest surrounded by farmland and buildings; Only 1/3 is forested; The remaining area is a mixture of shrubs, farm bush, teak plantation, and bare land; Common tree species are <em>D. oliveri</em>, <em>Parkia biglobosa</em>, <em>D. guineense</em>, <em>Brachystegia nigerica</em>, <em>Diospyros sp.</em>, <em>Albizia lebbeck</em>, <em>Ficus exasperata</em>, <em>Khaya ivorensis</em>, and <em>C. pendandra</em>; Hunting is officially prohibited, but cattle herders illegally enter into the forest on a daily basis.</td>
</tr>
<tr>
<td>Atola CF</td>
<td>6.964</td>
<td>3.077</td>
<td>61.4</td>
<td>11**</td>
<td>Seasonally inundated forest, farm bush, and derived savanna; Some common trees are: <em>Alchornea cordifolia</em>, <em>Anthocleista nobilis</em>, <em>Funtumia elastica</em>, <em>Cola millenii</em>, and <em>D. guineense</em>; Severely degraded due to logging, cattle grazing, and burning; Hunting occurs.</td>
</tr>
<tr>
<td>Odoafanla CF</td>
<td>6.731</td>
<td>2.928</td>
<td>25.4</td>
<td>2.4**</td>
<td>Degraded due to farming and cocoa plantations; Dominant plants are <em>Myrianthus arboreus</em>, <em>A. cordifolia</em>, <em>Alstonia boonei</em>, and <em>Raphia africana</em>; Hunting occurs.</td>
</tr>
<tr>
<td>Bola Camp CF</td>
<td>6.768</td>
<td>2.863</td>
<td>69.3</td>
<td>9**</td>
<td>Degraded due to farming and cocoa plantations; Remaining forest is in the riverine forests where humans cannot enter; Common plants are: <em>Ficus exasperata</em>, <em>Cola ginganta</em>, <em>M. arboreus</em>, <em>A. cordifolia</em>, <em>Uapaca guineensis</em>, and <em>R. africana</em>; Bola Camp villagers do not hunt, but there is no prohibition against hunting in neighboring communities.</td>
</tr>
</tbody>
</table>

FR = Forest Reserve; NP = National Park; CF = Community Forest; PF = Private Forest

Table 1. Habitat characteristics of survey localities. (*Official size; **Estimated size.)
Forestry Dept. 2016), while the WDPA maps show 49.4 km² and 98.32 km², respectively. For this reason, we georeferenced the scanned images of the 1971 physical maps (1:100,000) of Nigeria (Sheets 278 and 259) using the polynomial 1 transformation type with the Nearest Neighbor resampling method (Grosso 2010; Fleet et al. 2012). The image resolution of the northern section (Sheet 259) was 1700 × 2338 pixels and the southern section (Sheet 278) was 2337 × 1699 pixels. The locations of many villages were used as ground control points (GCP) during georeferencing. Small differences in reserve size remained, however. The sizes of Eggua FR and Ohumbe FR calculated from the georeferenced map were 44.25 km² (6.7% greater than the official size) and 45.22 km² (8.5 % smaller than the official size).

Then, we used the Semi-Automatic Classification PlugIn (SCP) v. 5.0.8 in QGIS v.2.18.2 to download and process the cloud-free Landsat 8 OLI/TIRS band images dated December 8, 2015 (Scene No. LC81910552015342LGN00, WRS Path = 91, WRS Row = 55, USGS 2016) during the long dry season in this region from the US Geological Society (https://earthexplorer.usgs.gov/). The band images 2-7 were preprocessed for radiometric calibration and DOS1 (Dark Object Subtraction 1) atmospheric correction (Chavez 1996), converted to surface reflectance, and viewed as color composite raster images using bands 3-5 (Congedo & Munafò 2012; Congedo 2016). Land cover classifications were established using the Region of Interest (ROI) tool within the SCP based upon different spectral signatures and analyzed with the maximum likelihood method (Congedo 2016). 0.3 % and 0.1 % of the land covers of Eggua FR and Ohumbe FR, respectively, were unclassified. The results of land cover classification were raster images that were converted to polygons, and from which measurements of the size of classified areas were taken. By using the vector editing tools in QGIS, we manually delineated fragmented forests in the two forest reserves.

RESULTS

Table 2 shows the results of our surveys. Path lengths walked were 0.03-3.74 km. The total length walked was 49.46 km. The number of primate species encountered varied from zero to four. C. mona was most frequently seen, with the average encounter rate of 0.65 (range = 0.26 - 1.5) group/km. The highest encounter rate of 1.5 group/km of this species was found at Igboju community forest, two-thirds of which belongs to Eggua Forest Reserve. Ch. tantalus, E. patas, and P. anubis were seen only at Marguba Range of OONP, with an encounter rate of 0.62, 0.26, and 0.88 group/km, respectively. We confirmed the presence of C. erythrogaster at three localities, Atola community forest (0.27 group/km), Royal Forest (private forest) in Eggua (0.08 group/km), and Bola Camp community forest (encounter rate is not given because we walked less than 1 km). No other threatened anthropoids of the region were observed. On December 28, 2015, at Atola, we sighted a group of C. mona and C. erythrogaster more than 100 m away from us in a degraded seasonally-inundated forest and recorded a loud call of the adult male C. erythrogaster, but we were unable to determine the color of the belly. At the Royal Forest, a fleeing red-bellied monkey (C. e. erythrogaster) was sighted once on December 30, 2015. At Bola Camp, we saw two red-bellied individuals in a group once on January 3, 2016. This was an interspecies interaction where members of a C. mona group were locomoting in a ~8 m HT Bombax buonopozense tree. Then, as a group of C. e. erythrogaster was approaching the C. mona group, the adult male of the C. e. erythrogaster group began giving the loud call, which was immediately followed by an adult male C. mona’s loud call. We recorded this chorus of loud calls.

Table 3 shows the result of interviews and Appendix 1 lists the binominal terms and the local names of the anthropoid taxa of the region. Because Holi Nagot, Egun, and Egba are spoken in our study area, this complicated our work of deciphering what each interviewee stated, and it was not always possible to find villagers who could act as interpreters. At all sites, almost all interviewees stated C. mona occurred. There are a few uncertainties regarding the result. For example, at Oloka, a village adjacent to the Marguba range of the OONP, the interviewee gave us the name “Kure”, but we could not conclude what it meant, even though the mother tongue of one of us (FEO) is Yoruba. Given the fact that we observed C. mona, Ch. tantalus, P. anubis, and E. patas here, and this interviewee gave the first three species’ names, “Kure” may mean the patas monkey, but his description that it has a white belly, a dark back, and a black tail does not match E. patas, and he imitated the call of C. mona. At Igboju, one interviewee described that “Okele” has the whitish-white back, and a black tail does not match C. mona's loud call. We recorded this chorus of loud calls.
Table 2. Survey results with group encounter rates. (*Encounter rates are given for walks > 1 km.)

<table>
<thead>
<tr>
<th>Localities</th>
<th>Date</th>
<th>Path length (km)</th>
<th>Survey freq.</th>
<th>Total walked (km)*</th>
<th>Ce</th>
<th>Cee ssp.</th>
<th>Cto</th>
<th>Cv</th>
<th>Pv</th>
<th>Cn</th>
<th>Cm</th>
<th>Chal</th>
<th>Ep</th>
<th>Pa</th>
<th>Pt</th>
<th>No. of Taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iwoye, Imeko FR</td>
<td>12/20/15</td>
<td>1.77, 1.84</td>
<td>2</td>
<td>3.61</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.50</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Old Oyo NP (Marguba)</td>
<td>12/22-12/24/15</td>
<td>2.0-3.74</td>
<td>4</td>
<td>11.45</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.71</td>
<td>0.62</td>
<td>0.26</td>
<td>0.88</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td>Old Oyo NP (Yemese)</td>
<td>12/24/15</td>
<td>2.0</td>
<td>4</td>
<td>8.00</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0</td>
</tr>
<tr>
<td>Igboju CF (Eggua FR)</td>
<td>12/26-12/27/15</td>
<td>0.3-1.1</td>
<td>3</td>
<td>2.50</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1.50</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Royal Forest PF; Eggua</td>
<td>12/29-12/31/15</td>
<td>0.5-1.9</td>
<td>5</td>
<td>18.80</td>
<td>0.08</td>
<td>Cee</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.26</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Atola CF, Ibese</td>
<td>12/28/15</td>
<td>1.8</td>
<td>2</td>
<td>3.60</td>
<td>0.27</td>
<td>?</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.27</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Odoafanla CF</td>
<td>01/02/16</td>
<td>0.9</td>
<td>1</td>
<td>0.90</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Bola Camp CF</td>
<td>01/03-01/04/16</td>
<td>0.3</td>
<td>2</td>
<td>0.60</td>
<td>+</td>
<td>Cee</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2</td>
</tr>
</tbody>
</table>

FR = Forest Reserve; NP = National Park; CF = Community Forest; PF = Private Forest; Ce = Cercopithecus erythrogaster (Cee = Cercopithecus erythrogaster erythrogaster, Cep = Cercopithecus erythrogaster poccok), Cto = Cercocebus torquatus, Cv = Colobus vellerosus, Pv = Procolobus verus, Cn = Cercopithecus nictitans, Cm = Cercopithecus mona, Chal = Chlorocebus tantalus, Ep = Erythrocebus patas, Pa = Papio anubis, Pt = Pan troglodytes; + = Present or – = Absent if no encounter rates are given.
Table 3. The results of interviews.

| State | Locality | Lat (N) | Long (E) | Alt. (m) | Date    | Age | Cred-ability | Cee | Cep | Cto | Cv | Pv | Cn | Cm | Cht | Ep | Pa | Pt | UNK | No. of Sp. |
|-------|----------|---------|----------|----------|---------|-----|--------------|-----|-----|-----|----|----|----|----|-----|----|-----|----|-----|-----|----------|
| Oyo   | Jabata*  | 7.886   | 2.683    | 167.6    | 12/19/15| 35  | Yes                   | ✓   | ✓   | ✓   | ✓  | ✓  | ✓  | ✓  | ✓   | ✓  | ✓   | ✓   | ✓       | 3        |
|       | Oloka (OONP, Marguba) | 8.456 | 3.772 | 309.3 | 12/23/15 | 35 | Yes | ✓ | ✓* | ✓   | ✓  | ✓  | ✓  | ✓  | ✓   | ✓  | ✓   | ✓   | ✓       | 4        |
|       | Oloka (OONP, Marguba) | 6.997 | 2.927 | 21.7 | 12/27/15 | 20 | No | ✓ | ✓   | ✓   | ✓  | ✓  | ✓  | ✓  | ✓   | ✓  | ✓   | ✓   | ✓       | 3        |
|       | Oloka (OONP, Marguba) | 6.997 | 2.927 | 21.7 | 12/27/15 | 42 | No | ✓ | ✓   | ✓   | ✓  | ✓  | ✓  | ✓  | ✓   | ✓  | ✓   | ✓   | ✓       | 3        |
|       | Oloka (OONP, Marguba) | 6.997 | 2.927 | 21.7 | 12/27/15 | 56  | No | ✓ | ✓   | ✓   | ✓  | ✓  | ✓  | ✓  | ✓   | ✓  | ✓   | ✓   | ✓       | 3        |
| Ogun  | Ibeju  | 7.010   | 2.799    | 93.2     | 12/25/15| 68  | Yes | ✓ | ✓   | ✓   | ✓  | ✓  | ✓  | ✓  | ✓   | ✓  | ✓   | ✓   | ✓       | 1        |
|       | Igboju  | 6.997   | 2.927    | 21.7     | 12/27/15| 45  | Yes | ✓ | ✓   | ✓   | ✓  | ✓  | ✓  | ✓  | ✓   | ✓  | ✓   | ✓   | ✓       | 2        |
|       | Igboju  | 6.997   | 2.927    | 21.7     | 12/27/15| 35  | Yes | ✓ | ✓   | ✓   | ✓  | ✓  | ✓  | ✓  | ✓   | ✓  | ✓   | ✓   | ✓       | 2        |
|       | Ibeju  | 6.957   | 3.039    | 89.8     | 12/27/15| 55  | Yes | ✓ | ✓   | ✓   | ✓  | ✓  | ✓  | ✓  | ✓   | ✓  | ✓   | ✓   | ✓       | 4        |
|       | Ibeju  | 6.703   | 2.933    | 51.3     | 01/02/16 | 45  | No | ✓ | ✓   | ✓   | ✓  | ✓  | ✓  | ✓  | ✓   | ✓  | ✓   | ✓   | ✓       | 2        |
|       | Ibeju  | 6.763   | 2.865    | 69.3     | 01/03/16 | 45  | Yes | ✓ | ✓   | ✓   | ✓  | ✓  | ✓  | ✓  | ✓   | ✓  | ✓   | ✓   | ✓       | 2        |

Lat = Latitude; Long = Longitude; Credibility: Yes (credible); No (not credible); Cee = Cercopithecus erythrogaster erythrogaster, Cep = Cercopithecus erythrogaster pococki, Cto = Cercocetus torquatus, Cv = Colobus vellerosus, Pv = Procolobus verus, Cn = Cercopithecus nictitans, Cm = Cercopithecus mona, Cht = Chlorocebus tantalus, Ep = Erythrocebus patas, Pa = Papio anubis, Pt = Pan troglodytes; UNK = unknown species (species' local names given by interviewees are written in appropriate cells); #This is the closest village to Iwoye in Imeko FR we surveyed; ##A migrant from Ghana; √ = Present; * = The interviewee gave us the name “aiya kaka”. “Aiya” is the term for Ch. tantalus. However, “kaka” means C. e. erythrogaster in Yoruba. Thus, we are unsure if our interpretation is correct; ‡ = Ashanti names for baboon, arboreal monkey, and squirrel; ‡‡ = “Iga” in Yoruba means high or large. We can only speculate that the interviewee meant to say it is an adult C. mona or another large-sized primate species. ** = The interviewee gave us the name “aiya”, which means Ch. tantalus, but he imitated the loud call of adult male C. mona.
species do not match with any monkeys in our study area. Also, the 42-yr-old hunter here described three monkey species only in relation to large, medium, and small body size, and the 56-yr-old hunter, who was a migrant from Ghana, gave us three monkey names, “Kwagyedu (baboon),” “Asorob a (arboreal monkey),” and “Opro (squirrel)” in Ashanti, one of the Ghanaian languages. With help from an anonymous reviewer of this manuscript we were able to decipher the meaning of these words. The 35-yr-old hunter gave us an unknown monkey name, “Iga,” which means high or tall in Yoruba, but we could not decipher which species he was referring to. Furthermore, although the 45-yr-old hunter gave us the name for the red-bellied guenon, “Ogbé” with a red belly, the only monkey we saw at Igboju was C. mona. At Atola, the interviewee told us that when “Okaka” (= C. e. erythrogaster) comes to raid the bananas, unripe mangos, and unripe plantains, they shoot them. Lastly, the interviewee at Ajieté village stated that the mona monkey and the red-bellied guenon occur in the Odoafanala community forest, but our short survey found only mona monkeys there.

At almost all sites there was evidence of negative human activities except at Odoafanala, where we spent very little time (Table 4). Six gunshots we heard at the Royal Forest occurring beyond the boundary of the forest indicate high hunting pressure in the surrounding area. The one gunshot we heard at Bola Camp also occurred outside the community forest. Furthermore, at all sites except Odoafanala and Bola Camp, we either encountered herds of cattle or saw numerous footprints made by cattle.

The Landsat 8 composite image and land cover classifications show that within Eggua FR and Ohumbe FR there is a lack of large areas of contiguous green color, which indicates forest, and forests are fragmented (Figures 2-4). The forested area in Eggua FR encompasses about 7.1 km², which is 16.1 % of the total area (Figure 3). Almost all fragmented forests are small (less than 1 km²). Total fragmented forests within Ohumbe FR encompass only 3.6 km² or 7.9 % of the total area (Figure 4). Although we attempted to resolve the size discrepancies of the two reserves between our calculations and the gazetted size (both reserves were gazetted in 1931) by contacting forestry officials, our attempts were unsuccessful. Our land cover classifications should be considered preliminary until we obtain ground-verification data and conduct accuracy assessment. Bola Camp and neighboring communities appear to have about 9 km² of forested area and Igboju, about 1.5 km² (Figure 2).

**DISCUSSION AND CONCLUSION**

We confirmed the presence of *C. erythrogaster* in patches of lowland seasonally inundated forest in southwestern Nigeria during our surveys. *C. erythrogaster* has been assumed to occur here for a long time (Oates 1985, 1996, 2011a), but this is the first confirmation of the red-bellied subspecies’ occurrence at two forests, Royal Forest and Bola Camp, in this region. Still, we cannot be certain to which *C. erythrogaster* ss. the monkeys we saw at Atola belong although the name given by the interviewee suggests it is *C. e. erythrogaster*. The loud call of the adult male *C. erythrogaster* we recorded at Atola cannot resolve this matter because various calls given by different subspecies are usually indistinguishable unless a detailed sound analysis is conducted using adequate samples (Dallmann & Geissmann 2001; J. Fuller pers. comm. 2016).

As of now, the forests where we found *C. erythrogaster* in our study area are small and largely unprotected. Atola, for example, is a small forest where hunting is unregulated. About 15 years ago, logging companies had mostly cut down the large trees (J. Tella pers. comm. 2016). Currently, the remaining forest is severely degraded, although the red-bellied guenon may be somewhat protected in the inundated area, deterring hunters, even during the major dry season. Demonstrated by the interviewee’s description of the crop-raiding behavior of “Okaka” (*C. e. erythrogaster*), if hunting can be curtailed there is a potential for a population increase for this adaptive monkey. However, a limestone quarry site belonging to the Ibeso Cement Plant (7.009˚ N, 3.041˚ E) is not far from this forest. The air is polluted, and oversized vehicles routinely pass along the nearby main road.

The Royal Forest is one of the two forests where we confirmed the occurrence of *C. e. erythrogaster*. The greatest threat to *C. e. erythrogaster* here appears to be the trespassing of the livestock (HRM Oba Adeleye Dosunmu pers. comm. 2016). The cows destroy small trees and tree seedlings (Laurance 2010). The increasing demand for livestock products in this region is threatening the continued existence of small forests like the Royal Forest (Thornton 2010). A hopeful development is that the Onigua organization, which plans to expand the forest by purchasing an adjacent piece of land. Currently, he is not sure how long he can continue to combat external pressures in the face of a lack of financial resources.
Table 4. Frequency of occurrence of anthropogenic disturbance.

<table>
<thead>
<tr>
<th>Localities</th>
<th>Date</th>
<th>Length (km)</th>
<th>Gunshot</th>
<th>Poachers’ camp</th>
<th>Poachers’ footprint</th>
<th>Steel trap</th>
<th>Burned grass</th>
<th>Plucked bird feathers</th>
<th>Pile of logged trees</th>
<th>Felled tree(s) or tree felling</th>
<th>Cattle &amp; footprints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iwoye, Imeko FR</td>
<td>12/20/15</td>
<td>3.61</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Old Oyo NP (Marguba)</td>
<td>12/22-12/24/15</td>
<td>11.45</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Old Oyo NP (Yemeso)</td>
<td>12/24/15</td>
<td>8.00</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Igboju CF (Eggua FR)</td>
<td>12/26-12/27/15</td>
<td>2.50</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Royal Forest PF; Eggua</td>
<td>12/29-12/31/15</td>
<td>18.80</td>
<td>6</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Atola CF; Ibese</td>
<td>12/28/15</td>
<td>3.60</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Odoafanla CF</td>
<td>01/02/16</td>
<td>.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Bola Camp CF</td>
<td>01/03-01/04/16</td>
<td>.60</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

FR = Forest Reserve; NP = National Park; CF = Community Forest; PF = Private Forest.
Figure 2. The Landsat 8 composite image of the southern part of our study area (Ibese is not shown). There is a lack of large areas of contiguous deep green color that indicate old growth (or closed) natural forest. However, there are some small forested areas including riverine forests in Bola Camp and Igboju. Patches of contiguous forest fragments are small in Eggua FR.

Although we did not find *C. erythrogaster* at Igboju, one interviewee gave us the local name for *C. e. erythrogaster*. Given the proximity of Igboju to the Royal Forest, it is probable this taxon occurs in Igboju. The village chief informed us that they used to hunt monkeys, but stopped hunting them about 15 years ago because the wives of the hunters who had eaten the monkey meat during pregnancy often gave birth to deformed newborns; most of these were twin births. To avoid recurring tragedies, he said, they have ceased to hunt any monkeys, although they still continue to hunt other animals such as duikers (genus *Cephalophus*), bushbucks (*Tragelaphus scriptus*), giant pouched rats (*Cricetomys gambianus*), and cane rats (*Thryonomys swinderianus*). If *C. erythrogaster* indeed occurs here, creating a forest corridor to connect Igboju, the Royal Forest, and the southern forest fragments of Eggua FR is recommended and establishing a >10 km² of a faunal reserve. In addition, there still remains about 9 km² of forest around Bola Camp communities where hunting pressure is minimal. Establishing a conservation program to protect the red-bellied guenon is recommended here.
No conservation plan is without challenges. The main road cuts across the potential corridor between the Royal Forest and Igboju where cattle constantly trespass the area. Our guides at Igboju refused to lead us too far away from the village for fear of being killed by Fulani herders’ poison-tipped arrows. To create a corridor also requires rehabilitating the habitat between Igboju and the forest fragments in Eggua FR. These challenges are surmountable if there is the will and the resources, and we plan to submit this recommendation to the community stakeholders and to the government authorities.

As our surveys were limited in scope, time spent at each locality and the number of localities visited and surveyed was less than ideal. Although severely deforested, degraded, and fragmented, surveying the remaining forests in Eggua FR and Ohumbe FR is needed in the near future. Furthermore, we could not adequately conduct a study along the Yewa River (Figure 1), where the Landsat 8 composite image show narrow strips of seasonally inundated riverine forests between south of Igboju and northeast of Bola Camp (Figure 2).

Until now, *C. e. erythrogaster* has been known to occur only in eastern Togo and southern Benin. All the forests where *C. e. erythrogaster* inhabit in Benin and Togo are lowland seasonally inundated forest or riverine forest, reinforcing the idea that this taxon is adapted to such habitats (Nobimé *et al.* 2009; Matsuda Goodwin *et al.* 2017a). Figure 5 shows the

---

**Figure 3.** Land cover classification of Eggua FR.
modified distribution ranges of the two subspecies, incorporating our new information. The growing human populations and the never-ending expansion of farmland exacerbated by mining, illegal logging, cattle grazing, and uncontrolled hunting (Geist & Lambin 2002; NPC Nigeria 2016; World Bank 2016) might have already disconnected the previously contiguous ranges of the two subspecies. If so, we may never be able to find out whether the two subspecies shared any overlapping ranges and the extent of any possible hybridization between them.

Given the fact that the populations of *C. e. erythrogaster* in Togo and Benin have declined by ≥ 80% in the past three generations (27 years) and their habitats have been significantly reduced in the two countries, the 2016 IUCN Red List has elevated the threatened status of this subspecies to Critically Endangered (CR) (Matsuda Goodwin *et al.* 2017a). A similar analysis also elevated the status of *C. e. pococki* to Endangered (EN), and at the species level, the threatened category of *C. erythrogaster* was also elevated to EN (Ikemeh *et al.* 2017; Matsuda Goodwin *et al.* 2017b). The prospect for the conservation of the red-bellied guenon in this region, unfortunately, does not look bright unless all three range-countries take action to install strong conservation measures.

The semi-structured interview has been widely used as a preferred method to obtain local knowledge regarding presence or absence of some
primate species to find potential survey sites (Campbell & Hadley 2005; Urbani 2006; Campbell et al. 2008; Parker et al. 2008; Starr et al. 2011; Chi et al. 2014; Ginn & Nekaris 2014) or even to map distribution ranges of some taxa (Sinsin et al. 2002; Djègo-Djossou & Sinsin 2009; Nobimè et al. 2009; Djègo-Djossou et al. 2014). Often, however, primate field studies that use semi-structured interviews do not provide detailed descriptions of the method. We consider that more serious attention needs to be paid to this method. The variation in responses and varying degrees of credibility of the responses we obtained from interviewing several hunters at Igboju underscores the importance of conducting interviews on multiple hunters at each locality and indicates that preparations of questions and the interpretation of results require care. If we had interviewed only the 42-yr-old hunter, we could not have learned that *C. erythrogaster* might occur (or might have occurred) at Igboju. We recommend that interviews need to be conducted on more than one individual and ideally 5-10 interviews per site are

Figure 5. The modified distribution ranges of *Cercopithecus erythrogaster erythrogaster* and *Cercopithecus erythrogaster pococki* in Nigeria, Benin, and Togo. Green areas show protected areas and forest reserves (IUCN & UNEP-WCMC. 2015). The demarcation line between the two subspecies has now been moved to the east of the Benin-Nigeria border, although how far east the eastern end of *C. e. erythrogaster* goes is still unknown. The growing human populations and never-ending expansions of farmlands and pastureland coupled with deforestation and mining might have already isolated the previously contiguous ranges of the two subspecies. If so, we may never be able to find out whether, where, and how the subspecies shared any overlapping ranges.
recommended to obtain credible information. We also recommend that, when possible, any potential bias that may occur during each interview should be minimized. A limited scope of the study and the brevity of time have precluded us from conducting a systematic broad-scale use of the method, which is gaining ground in primatology (c.f., Anderson et al. 2007a, b; Meijaard et al. 2011). Interviewing young inexperienced hunters or migrants should be avoided. Nevertheless, our study has shown that there are dangers to solely relying upon local knowledge to map primate distribution patterns. Extreme care is needed to assess the costs and benefits of all aspects of the method in order to effectively complement primate surveys in Africa.

ACKNOWLEDGEMENTS

We are grateful to Joseph Asipaiwoye at Imeko FR for giving us permission to conduct a survey at Iwoye. The commissioner of the OONP, Yohanna Seidu kindly gave us permission to conduct a survey in the park and helped us with accommodations. We appreciate Mr. Tamu and Mr. Kola for guiding us in the park and Felicia for providing some valuable information regarding the park. We would like to thank the HRM Oba Adeleye Dosunmu, Onigba of Eggua who gave us permission to conduct our studies at Igboju and the Royal Forest. We appreciate the logistical support we received from Isola Samuel Olugbemiga of Igbofila. Prince Bode Akinola Tella and Jimmy Tella of Ibese kindly guided us to Atola. We are appreciative of the hospitality we received from the Baale (chiefs) and hunters of Igboju, Bola Camp, and Ajilete who facilitated our study. RMG would like to thank Luca Congedo (Sapienza Università di Roma, Italy) and Kasey Wilson (Michigan State University Map Library) for answering many questions regarding the SCP and map transformation, respectively. We thank four anonymous reviewers for their constructive criticism on our earlier manuscript. One of the anonymous reviewers has kindly helped us with the Ashanti language. Evrard Akpla, Allan Gilbert, and one anonymous reviewer generously assisted us with French translation of the abstract. We would like to express sincere gratitude to John F. Oates for his guidance, identification of the giant pouched rat at Igboju, providing the 1971 maps of Nigeria, and reading earlier drafts of this manuscript. This research was made possible by funds and supplies provided by Chester Zoo, Primate Conservation, Inc., International Primatological Society, Conservation International, and Fordham University.

LITERATURE CITED


First Sightings of the Red-Bellied Guenon in Nigeria

...
Appendix 1. Anthropoid names used in southwestern Nigeria. Some of the names differ from Happold (1987) and Oates (2011a). For example, Happold (1987) states ambè is the “white-nosed monkey,” but our interviewee’s description was that of C. mona. In Yoruba, “o” is a prefix, meaning something exists or lives. The list under Yoruba contain names in Holi Nagot, Egun, and Egba.

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Fon</th>
<th>Yoruba</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cercopithecus erythrogaster erythrogaster</td>
<td>zinkaka</td>
<td>ogbè, ubia, kaka, okaka</td>
</tr>
<tr>
<td>Cercopithecus erythrogaster pococki</td>
<td>?</td>
<td>edun olokun, oloyo, Idji oloyo</td>
</tr>
<tr>
<td>Cercopithecus mona</td>
<td>zin hou, zin houm, zin ho</td>
<td>edun, lambè, zin ambè, ambè gidi</td>
</tr>
<tr>
<td>Chlorocebus tantalus</td>
<td>zin ahiwé</td>
<td>aya, aiy aefun</td>
</tr>
<tr>
<td>Erythrocebus patas</td>
<td>iji mere</td>
<td>idji mere</td>
</tr>
<tr>
<td>Cercopithecus nictitans</td>
<td>?</td>
<td>okin</td>
</tr>
<tr>
<td>Colobus vellerosus</td>
<td>zin klan</td>
<td>donko</td>
</tr>
<tr>
<td>Procolobus verus</td>
<td>zin gbo</td>
<td>chike-chike</td>
</tr>
<tr>
<td>Papio anubis</td>
<td>akato, ato</td>
<td>obo (in llobi), akiti, laguido</td>
</tr>
<tr>
<td>Cercocebus torquatus</td>
<td>?</td>
<td>owe, okpe (Ijaw)</td>
</tr>
<tr>
<td>Pan trogloides</td>
<td>loki</td>
<td>etiemi, inaki, elegbebe</td>
</tr>
</tbody>
</table>
Brief Communication:

**Dogs Disrupting Wildlife: Domestic Dogs Harass and Kill Barbary Macaques in Bouhachem Forest, Northern Morocco**

Siân Waters¹,², Ahmed El Harrad², Mohamed Chetuan², Sandra Bell¹, and Joanna M. Setchell¹

¹Department of Anthropology, Durham University, Durham, UK; ²Barbary Macaque Awareness & Conservation, Tétouan, Morocco

**INTRODUCTION**

The domestic dog (*Canis familiaris*) is the most abundant carnivore in the world (Gompper 2014). People and dogs have a complex relationship, with dogs performing important roles in human society (Serpell 1995). Due to their presence in many regions of the world, conflicts involving dogs and wildlife have been cited as a serious problem for wildlife conservation (Young et al. 2011; Hughes & Macdonald 2013; Weston & Stankowich 2014; Peltola & Heikkila 2015). The presence of domestic dogs in rural or protected areas increases the risks of disease transmission to and from wildlife and interferes with the spatial distribution of wildlife populations (Young et al. 2011; Hughes & Macdonald 2013; Sepulveda et al. 2015; Lessa et al. 2016). Reports of domestic dog disturbance and predation on primates are scarce, probably due to the rarity of observing such events in the field. Dogs of undetermined status (i.e., whether feral or free roaming) were reported to kill commensal macaques in India (Anderson 1986) and Japanese macaque (*Macaca fuscata*) infants in Japanese monkey parks (Knight 2011), whilst feral dogs were observed killing a juvenile long-tailed macaque (*M. fascicularis*) in Singapore (Riley et al. 2015).

The Barbary macaque (*M. sylvanus*) is the only macaque species found outside Asia, and is present in Morocco and Algeria, with an introduced population on Gibraltar (Fa 1981; Modolo et al. 2005). Researchers have observed dogs snatching infants from adult Barbary macaques on six occasions in the Middle Atlas Mountains, Morocco (Camperio-Ciani & Mouna 2006). Shepherds and their dogs are reported to harass macaques in Talassentane National Park in north Morocco (Mehlman 1984). Here, we report observations of domestic dogs disturbing and killing Barbary macaques in Bouhachem forest, north Morocco.

**METHODS**

The study site, Bouhachem forest, is an area of mixed oak forest covering ~140km² in north Morocco (Figure 1). The communities around the forest are agropastoralists. There has been no recent census at a household level so no population data are available. Cows graze in the forest unattended but goats are regularly herded into and out of the forest by shepherds. All shepherds use livestock guarding dogs to protect their goats from predators.

We identified and observed four groups of Barbary macaques (Waters et al. 2015) and observed each group for two days a week from February-November 2010, recording all harassment of the study groups by dogs during these observation periods. The length of observation periods depended on the macaque groups’ tolerance of observers, varying from five minutes to >three hours. We supplement this with information on direct dog-macaque interactions up to and including October 2016, obtained during conservation activities, including Barbary macaque monitoring, by the Barbary Macaque Awareness & Conservation team.
RESULTS

Barbary macaques always emitted alarm vocalisations on sighting domestic dogs in the forest, and climbed into trees or onto high rocks to avoid them. We recorded a total of 30 events of dogs harassing macaque groups. The highest rates of occurrence (N = 17) happened during the months of April and May. Shepherds and dogs accompanied the goat herds on their ascent to pastures and dogs harassed any macaque groups they encountered on the way. The general pattern of an interaction involved the sudden appearance of dogs running towards the macaque group. On sighting the dogs, the macaques would alarm call and ascend into trees whilst the dogs ran around and barked beneath. Disturbances lasted from seven minutes to two hours and 15 minutes, with a mean length of 42 minutes (N = 9). When goat herds returned to their villages in the late afternoon, the interactions were much shorter and lasted 8 to 27 minutes with a mean of 15 minutes (N = 21). The mean number of dogs taking part in harassment events was four, with a range of 1 - 18. The dogs were accompanying shepherds and herds on the majority of occasions (59%), with 19% of harassment events by unaccompanied dogs and 19% by dogs accompanying mushroom collectors. It was unclear whether dogs in the remaining 3% of attacks were accompanied, but we did not detect any humans in the vicinity. The largest pack of 18 dogs was unaccompanied.

We recorded three Barbary macaque mortalities that were due (or very likely due) to dogs. In April 2010, we observed a livestock guarding dog carrying an infant macaque’s head. Two weeks later, in early May, we heard the vocalisations of macaques and dogs. When we arrived at the scene, we found a dead male infant with bite wounds. In February 2014, we came across unaccompanied dogs harassing a group of macaques and a male macaque about 9 months old with bite wounds. Both bodies were still warm and dogs were still in the vicinity.

Not all dog-macaque interactions ended in the death of a macaque. In May 2011, MC disturbed a livestock guarding dog with a live infant in its mouth. On sighting MC, the dog dropped the infant and fled. MC was able to return the infant, uninjured, to its group. In March 2015, we were alerted byalarm calls and screams from one of our study groups. We intervened to stop an attack on a young female Barbary macaque by five unaccompanied dogs. The macaque survived, albeit quite badly wounded, and
managed to climb into a tree about 35 minutes after the attack (Figures 2a and 2b). At this point we left the scene, not wanting to disturb the returning group members. Finally, in October 2016, an adult male macaque attacked and bit the throat of a domestic dog attempting to guard fields when macaques were feeding on crops.

**DISCUSSION**

Barbary macaques are mainly terrestrial and thus susceptible to harassment from domestic dogs. The longer morning harassment events in spring may result in increased stress and energetically costly behaviour for lactating or pregnant female macaques, due to the dogs’ presence impeding macaque foraging. Such effects have been observed for other species (Anderson 1986; Gumert et al. 2013; Riley et al. 2015). Barbary macaque infants begin to spend time away from carers at around four weeks old and are not vigilant toward predators, likely leaving them more susceptible than adult macaques to fatal interactions with dogs. Such a lack of vigilance in response to the ubiquitous presence of domestic dogs may have the potential to affect Barbary macaque infant survival in Bouhachem substantially. In Laem Son National Park in Thailand, the presence of domestic dogs is negatively correlated with a low proportion of infants in some groups of Burmese long-tailed macaques (M. fascicularis aurea) although no actual predation events were observed (Gumert et al. 2013).

We also observed a Barbary macaque attack a dog. To the best of our knowledge, this is the first report of a wild Barbary macaque attacking a dog in North Africa. Human-habituated Barbary macaques living on Gibraltar sometimes attack pet dogs (L. Radford, unpublished data), and there are reports of primate males attacking dogs in other regions. For instance, adult male long-tailed macaques (M. fascicularis) attack dogs in Bali (Anderson 1986) and adult male baboons (Papio ursinus) kill dogs when baboons feed on crops in Africa (Butler et al. 2004). Such examples illustrate that primates are not always the victims in dog-macaque interactions.

These physical interactions also present a potential for interspecies disease transmission, particularly rabies. There are also implications for human and macaque health due to the indirect spread of pathogens from dog faeces in both village and forest. Controlling the dog population in Bouhachem and deterring the dogs’ behaviour toward the macaques can only be done by understanding the relationship they have with their owners and developing a mitigation strategy inclusive of such considerations. The success of this strategy may be more likely if it incorporates the provision of salient benefits to people and their dogs.

![Figure 2. a: A young female Barbary macaque, immediately after being attacked by five dogs. b: The same young female 35 minutes later. Photographs by A. El Harrad.](image-url)
ACKNOWLEDGEMENTS

We are indebted to the Royal Zoological Society of Scotland for supporting our research 2009-2012. We thank the Haut Commissariat des Eaux et Forêts et la Lutte Contre le Désertification for granting our research permit and University Abdelmalek Essâadi, Tétouan for assistance with our permit applications. We are extremely grateful to; Association Française des Parcs Zoologiques; Association Beauval Nature; Conservatoire pour la protection des primates France; Folly Farm, UK; GaiaZoo, The Netherlands; Zoo Helsinki, Finland; Tiergarten Schönbrunn, Austria; Parco Natura Viva, Italy; Blair Drummond Safari Park; Ouwehands Zoo, The Netherlands; International Primate Protection League, USA; NaturZoo Rheine, Germany; Alameda Wildlife Conservation Park, Gibraltar; Mohamed Bin Zayed Endangered Species Fund for supporting our research and conservation work. We are very grateful to Lucy Radford and two anonymous reviewers for their comments on an earlier version of this manuscript.

LITERATURE CITED


Received: 17 November 2016
Accepted: 18 January 2017
Brief Communication:

**Pan African Sanctuary Alliance:**
Primate Welfare, Conservation, and Research

Rachel Stokes¹, Gregg Tully¹, and Alexandra Rosati²

¹Pan African Sanctuary Alliance, Portland, Oregon, USA; ²Department of Psychology, University of Michigan, Ann Arbor, Michigan, USA

PASA’S WORK

The Pan African Sanctuary Alliance (PASA), the largest association of wildlife centers in Africa, includes 22 organizations that collectively house more than 3,000 rescued primates (Table 1; Figure 1). Prior to PASA’s formation, these organizations had similar goals and were facing similar challenges, but typically did not communicate with one another. In 2000, conservationists and primatologists arranged a meeting in Uganda to bring these groups together for the first time. The directors of the organizations agreed there was a need for improved ongoing communication and, as a result, PASA was formed. Although PASA’s headquarters is now in Portland, Oregon and it is a registered nonprofit in the United States, it was created by the African wildlife centers.

Despite working in extraordinarily challenging conditions, members of the Alliance are making significant strides in primate welfare and conservation. They collaborate with law enforcement agencies to reduce wildlife crime by rescuing confiscated animals, give lifelong care to primates orphaned by the bushmeat trade and the illicit pet trade, work to stop the hunting and trafficking of endangered species, defend critical habitat from exploitation, and conduct community development and education programs reaching more than 500,000 people each year across Africa. Additionally, PASA member wildlife centers provide employment for nearly 700 Africans and inject millions of dollars into local economies.

PASA’s unique accreditation process brings credibility to wildlife centers, and PASA membership gives them access to a global network of advisors and other specialists. Additionally, PASA helps its members succeed by advocating for them internationally, providing funding and technical support during emergencies, and building their capacity through training in topics such as strategic planning, public education and community engagement, veterinary treatment, and animal care.

In addition to advocating for and supporting its member organizations, PASA collaborates with them on large-scale conservation initiatives. Some of PASA’s newest projects include:

**Cameroon Conservation Education Program:** In 2015, PASA and its member organizations in Cameroon launched the Cameroon Conservation Education Program with the goals of: (1) determining the most effective approach to inspiring Cameroonian children to protect their country’s wildlife and other natural resources, and (2) integrating it into school curricula, so that children in Cameroon will learn the value of protecting animals and their habitats. This is expected to engender a long-term nationwide shift in the population’s attitudes and behavior regarding conservation, resulting in an increase in the number and size of protected areas, stronger legal protections for natural habitat, and an increase in the abundance of endangered species in Cameroon. After a very successful pilot, PASA, Sanaga-Yong Chimpanzee Rescue, and Ape Action Africa are expanding this program to reach 4,500 youth in 2017.

**Edutainment Films Program:** The Edutainment Films Program is a pioneering initiative in Africa...
to distribute high-quality, engaging films that were primarily created for African audiences. The flagship movies of the program were produced by the nonprofit Nature for Kids, which creates entertaining films with messages about environmental conservation. In a pilot program, hundreds of thousands of people in Cameroon saw the films on national television and on the national train system (Figure 2). Following this tremendous success, PASA is expanding this program to include ten African countries.

**Reintroduction Data Synthesis Project:** Currently, PASA is developing a Reintroduction Data Synthesis Project, which will be the first known comprehensive synthesis of successes and failures of African primate release efforts. Although reintroductions can be highly valuable for conservation in that they increase the population sizes of endangered species in the wild and bring stronger protection to their habitats, many reintroductions of African primates have been conducted by trial-and-error, and some are unsuccessful. In order to increase the success rate, it is valuable to outline the best practices for primate reintroductions based on a comprehensive review of the methods and results of releases that have been conducted across Africa. PASA will work closely with the staff of wildlife centers to analyze their data and quantify aspects of individual survival, reproduction, and integration into wild groups.
Figure 2. Staff from Chimfunshi Wildlife Orphanage showing an Edutainment film to students.

Table 1. PASA Member Wildlife Centers.

<table>
<thead>
<tr>
<th>Center</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ape Action Africa</td>
<td>Cameroon</td>
</tr>
<tr>
<td>Centre pour Conservation des Chimpanzees (CCC)</td>
<td>Guinea</td>
</tr>
<tr>
<td>Chimfunshi Wildlife Orphanage</td>
<td>Zambia</td>
</tr>
<tr>
<td>Chimpanzee Eden</td>
<td>South Africa</td>
</tr>
<tr>
<td>Chimpanzee Rehabilitation Project</td>
<td>The Gambia</td>
</tr>
<tr>
<td>Colobus Conservation</td>
<td>Kenya</td>
</tr>
<tr>
<td>Lwiro Primate Rehabilitation Centre (CPRL)</td>
<td>D.R. Congo</td>
</tr>
<tr>
<td>Drill Ranch</td>
<td>Nigeria</td>
</tr>
<tr>
<td>Fernan-Vaz Gorilla Project</td>
<td>Gabon</td>
</tr>
<tr>
<td>HELP-Congo</td>
<td>Congo</td>
</tr>
<tr>
<td>Jeunes Animaux Confsques au Katanga (J.A.C.K.)</td>
<td>D.R. Congo</td>
</tr>
<tr>
<td>Lilongwe Wildlife Centre</td>
<td>Malawi</td>
</tr>
<tr>
<td>Limbe Wildlife Centre</td>
<td>Cameroon</td>
</tr>
<tr>
<td>Lola Ya Bonobo</td>
<td>D.R. Congo</td>
</tr>
<tr>
<td>Ngamba Island</td>
<td>Uganda</td>
</tr>
<tr>
<td>Project Protection des Gorilles-Congo</td>
<td>Congo</td>
</tr>
<tr>
<td>Project Protection des Gorilles-Gabon</td>
<td>Gabon</td>
</tr>
<tr>
<td>Sanaga-Yong Chimpanzee Rescue</td>
<td>Cameroon</td>
</tr>
<tr>
<td>Sweetwaters Chimpanzee Sanctuary</td>
<td>Kenya</td>
</tr>
<tr>
<td>Tacugama Chimpanzee Sanctuary</td>
<td>Sierra Leone</td>
</tr>
<tr>
<td>Tchimpounga Chimpanzee Rehabilitation Centre</td>
<td>Congo</td>
</tr>
<tr>
<td>Vervet Monkey Foundation</td>
<td>South Africa</td>
</tr>
</tbody>
</table>
The combination of PASA’s global network and its member organizations’ local expertise and connections uniquely positions the Alliance to produce lasting changes to protect Africa’s great apes and monkeys (Figure 3).

**PASA WILDLIFE CENTERS WELCOME RESEARCHERS**

In addition to playing an essential role in securing a future for Africa’s primates and their habitat, almost all PASA member wildlife centers are willing to host researchers. Their cooperation with academics has helped to shed light on numerous topics in primatology and evolutionary anthropology.

**Scientific Findings from PASA Member Sanctuaries**

Research in PASA member sanctuaries has helped to elucidate the evolutionary roots of human cognition through large-scale comparisons of how human children and apes solve different kinds of problems. Studies directly comparing the performance of chimpanzees, bonobos, and children on many different cognitive tests have shown that apes and children solve problems involving physical reasoning—for example, distinguishing different quantities, using tools, and remembering the locations of objects—fairly similarly. However, children quickly surpass apes when faced with problems about social reasoning, such as imitating others’ actions or inferring others’ mental states. This has provided support for the “cultural intelligence hypothesis”—the idea that what is special about human cognition is not that we are generally smarter than other species, but that we specifically excel at skills needed for cultural learning and transmission (Herrmann et al. 2007; Wobber et al. 2014).

Additionally, over the past 10 years, research in PASA wildlife centers has reinvigorated the study of ape cooperation, sharing, and helping (Melis et al. 2006a, b; Warneken et al. 2007; Melis et al. 2009; Hare & Kwetuenda 2010; Bullinger et al. 2011; Melis et al. 2011; Rekers et al. 2011; Schneider et al. 2012; Tan & Hare 2013; Bullinger et al. 2014; Engelmann et al. 2015; Engelmann & Herrmann 2016). This work has shown that chimpanzees, in particular, are incredibly sophisticated at working
together to gain mutual benefits (Melis et al. 2006a, b; Melis et al. 2009). Moreover, they help others solve their own problems; for example, by providing conspecifics with access to out-of-reach objects or food (Warneken et al. 2007; Melis et al. 2011). This work has also revealed an important difference between how chimpanzees and humans cooperate. Whereas humans tend to want to solve problems together, chimpanzees often prefer to solve problems individually unless they absolutely need a partner (Melis et al. 2006a; Bullinger et al. 2011; Rekers et al. 2011).

Recent work in sanctuary populations has also been critical for our understanding of bonobos in comparison to chimpanzees. Bonobos and chimpanzees are both equally related to humans, and yet bonobos’ relative rarity means that most models of human evolution focus exclusively on chimpanzees. Research in PASA wildlife centers has provided a major wave of evidence that chimpanzees and bonobos often differ in how they behave socially (Hauser et al. 2007; Wobber, Wrangham et al. 2010; Woods & Hare 2011), make decisions (Rosati & Hare 2012a; Rosati & Hare 2013), remember spatial locations (Rosati & Hare 2012b; Rosati 2015), and even react hormonally to different situations (Wobber, Hare et al. 2010; Wobber et al. 2013). Furthermore, non-invasive biological samples collected from apes living at sanctuaries have allowed researchers to map the bonobo genome, reconstruct the evolutionary history of chimpanzees and bonobos, and identify genetic differences in these species (Prüfer et al. 2012).

Finally, research in sanctuaries has revealed new insights about the course of human evolution. Humans exhibit several special traits compared to other primates, such as a large brain and more frequent reproduction. A comparative study on energy expenditure showed that humans have a higher metabolic rate than other apes, helping to explain how humans evolved these energetically-costly traits (Pontzer et al. 2016). One proposal about this energetic shift in human history is Richard Wrangham’s influential “cooking hypothesis,” arguing that a early adoption of a high-energy cooked diet played a critical role in our species’ ability to grow such large brains (Wrangham 2009). Research in PASA sanctuaries has revealed that chimpanzees possess some foundational cognitive and behavioral skills needed to engage in cooking behaviors, providing important behavioral tests of this hypothesis (Wobber et al. 2008; Warneken & Rosati 2015).

CONCLUSION

Although PASA and its member sanctuaries may be known primarily as animal welfare organizations, they also play a vital role in the conservation of, and research on, African primates. If you are interested in learning more about PASA’s programs, how you can help, or opportunities to conduct research at a PASA-member sanctuary, please visit https://www.pasaprimates.org.

ACKNOWLEDGEMENTS

We thank Brian Hare for providing us with information on noteworthy research projects conducted at PASA-member sanctuaries.

LITERATURE CITED


Melis, A.P., B. Hare & M. Tomasello. 2006b. Engineering cooperation in chimpanzees:


Received: 30 March 2017
Accepted: 31 March 2017
Brief Communication:

**Extending the Northeastern Distribution of Mandrills (Mandrillus sphinx) into the Dja Faunal Reserve, Cameroon**

Madeleine Ngo Bata¹, Julian Easton¹, Oliver Fankem¹, Tim Wacher², Tom Bruce¹, Tchana Eliseé¹, Pierre Augustin Taguieteu¹, and David Olson¹

¹Zoological Society of London - Cameroon, Yaoundé, Cameroon; ²Zoological Society of London - London, United Kingdom

Mandrills (*Mandrillus sphinx*, Linnaeus, 1758) are restricted to forests of the Atlantic Equatorial Forests Ecoregion, eastern portions of the Northwestern Congolian Lowland Forest Ecoregion, and northern portions of the Western Congolian Forest-Savanna Mosaic Ecoregion of Central Africa (Olson *et al.* 2001; Oates & Butynski 2008). The species distribution is imperfectly known, especially the northeastern limits of its estimated range. Here we report on the presence of mandrills in the northwestern region of the Dja Faunal Reserve in south-central Cameroon, a protected area with no known published records for this species.

We found no published records after evaluating available surveys and faunal lists for the reserve (specifically, Bergmans 1994; Lejoly 1995; Williamson & Usongo 1995; Nzoozh Dongmo 1999; MINFOF/IUCN 2015; GBIF 2016) and no reports through consultations with specialists who had worked within the reserve for several years (T. Smith, pers. comm. 2016). The current IUCN Red List description states mandrills are not known east of the Dja River (Oates & Butynski 2008). This new locality documents the species in the northwest sector of the Dja Faunal Reserve (which lies entirely east of the Dja River) and extends the IUCN Red List primary range map approximately 20 km towards the northeast (Oates & Butynski 2008).

An array of 40 infrared-triggered trail cameras (Bushnell Trophy Cam Aggressor), each roughly 2 km apart in a square grid pattern, was in place for approximately 3,725 trap days for a wildlife survey in late 2015 and early 2016. All cameras were in primary tropical lowland rainforest. Two cameras (C11 at N3.2621 E12.83306 and C39 at N3.17567 E12.81618) photographed a single mature male mandrill on March 1, 2016 and April 9, 2016 (Figure 1). It is not known if they are different males or the same individual and if groups of mandrills, in addition to wandering males, also occur east of the Dja River. The two locations were 10.5 km apart. Each camera took six sequential images of each animal within six seconds (Figure 1).

Given the clear documentation of mandrills east of the Dja River presented here, we recommend the primary distribution for the species of Oates and Butynski (2008) and Abernethy and White (2013) be extended to encompass the new localities.

**ACKNOWLEDGEMENTS**

We are grateful for permission and collaboration on this project from the Ministère des Forêts et de la Faune (MINFOF), the Conservator of the Dja Faunal Reserve, the Ecoguards who assisted with camera placement, and retrieval, and the Government of the Republic of Cameroon. We thank E. Milnes for research assistance and F. Maisels and K. Abernethy for technical review. We thank two anonymous reviewers for their helpful contributions.
Figure 1. Male mandrills photographed by two infrared trail cameras in the Dja Faunal Reserve, Cameroon. The black dots on the range map show the approximate location of cameras that documented mandrills. The dark shade represents the IUCN Red List distribution of the mandrill and protected areas are shown in light shade. The disjunct range polygon to the north of the Dja Reserve is likely an error (F. Maisels & K. Abernethy, pers. comm. 2016; range map source: Oates & Butynski 2008). The lower map shows the approximate location of the camera trap grid used in the survey with the cameras that photographed mandrills shown in circles.
LITERATURE CITED


Received: 3 December 2016
Accepted: 16 December 2016
Stuart A. Altmann, Ph.D.
(8 June 1930 - 13 October 2016)

by Susan C. Alberts¹ and Daniel I. Rubenstein²

¹Departments of Biology and Evolutionary Anthropology, Duke University, Durham, NC, USA;
²Department of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ, USA

Stuart Altmann was born in St. Louis, Missouri and grew up in Los Angeles, California. He was both a scientist and an artist, working as a biologist for his professional life and pursuing ceramics expertly as an avocation.

His formal scientific training began at University of California, Los Angeles (UCLA), where he first completed a Bachelor’s degree and then a Master’s degree in Biology in 1953. He studied under George Bartholomew, researching the mobbing behavior of birds. He was drafted into the Army and served from 1954 to 1956 as a research scientist at Walter Reed Army Medical Center.

At the end of his army service, he hitched a ride to Panama on army transport planes and used his carefully accumulated leave time to study the Barro Colorado howler monkeys, publishing a paper that is still cited today for its descriptions of primate vocalizations. He attended Harvard University between 1956 and 1960 as E. O. Wilson’s first Ph.D. student, adopting a decidedly sociobiological perspective that he and Wilson developed in extensive conversations comparing primates and social insects. He conducted his Ph.D. research on the rhesus macaques on Cayo Santiago in Puerto Rico, while he was revitalizing and managing the colony under the sponsorship of W. F. Windle at the National Institutes of Health (NIH).

This research, motivated by his interest in communication, produced a series of papers between 1962 and 1968 that represent a seminal contribution to primate behavioral ecology. The first of these analyzed reproductive behavior; it is still commonly cited in the twenty-first century, and Altmann’s “priority of access” model has greatly influenced subsequent work on the relationship between dominance rank and mating success in male mammals.

What set Altmann apart from his peers was his ability to frame problems conceptually, use mathematical models to make strong predictions and then draw on his natural history insights and systematic observations to test them. What emerged was a new way of thinking and framing of behavioral questions. His quantitative approach transformed the study of primate behavior. In addition, in an era when interest in behavior as an adaptation was burgeoning, Altmann set high standards for a very detailed understanding of the functional consequences of behaviors such as foraging, and of how we evaluate adaptation in nature.
In the summer of 1958, he met his future wife Jeanne when they were both working for the NIH, and they married in 1959. He began his first faculty position at the University of Alberta in 1960, and moved to Yerkes National Primate Research Center in 1965. In 1970, he moved to a joint appointment in the Biology Department (which later became the Department of Ecology and Evolution) and the Anatomy Department at the University of Chicago. He became Emeritus Professor at University of Chicago in 1995, and beginning in 1998 was a Senior Lecturer at rank of Professor in the Department of Ecology and Evolutionary Biology at Princeton University.

In 1963–64, Stuart and Jeanne Altmann made their first trip to what was then the Amboseli-Maasai Game Reserve, later Amboseli National Park, in southern Kenya, to study the Amboseli baboons. They returned to Amboseli for short trips in 1969 and 1970. In 1971, they returned again, and began collecting the longitudinal data on the Amboseli baboon population that is still being collected today. The establishment of the Amboseli research site proved to be a foundational contribution to the study of primates. The research at this site continues to provide new knowledge and insights about primate behavior and
evolution, 54 years after Stuart and Jeanne arrived in Amboseli and 46 years after the establishment of the long-term research.

Stuart was a mentor and friend to us and to many others. Through both his science and his art, he influenced so many lives in complex, unexpected, and remarkable ways. He is deeply missed, and will always be with us in spirit.

A selection of Stuart Altmann’s publications

Obituary:

**Deborah L. Moore, Ph.D.**
(8 October 1964 - 22 March 2016)

by Gráinne McCabe¹ and Carolyn Ehardt²

¹Institute of Conservation Science & Learning, Bristol Zoological Society, Clifton, Bristol, UK;
²Department of Anthropology, University of Texas at San Antonio, Texas, USA

Deborah L. Moore lost her six-year battle with cancer on 22 March 2016, at age 51. With her passing, the primatological community has lost a professional who had, in her all too brief career, contributed in exceptional ways to our understanding of Africa’s great apes, while seeking to translate scientific study to effective conservation for these highly threatened primates.

Born in Montreal, Quebec, Canada, Deb pursued undergraduate training in biological anthropology at Georgia State University, completing a comparative paleoanthropological honor’s thesis examining hominin skeletal morphology with Frank Williams. It was post her BA degree that she first honed and focused her professional interest on the behavioural ecology of chimpanzees, participating in a multi-year research project at the Yerkes National Primate Research Center in association with Drs. Frans de Waal and Kristin Bonnie. Inspired to pursue behavioural ecology research with chimpanzees in Africa and motivated to effectively merge field-based ecological study with conservation, Deb began pursuit of a Ph.D. at the University of Georgia, working with Carolyn L. Ehardt in the Department of Anthropology’s focused doctoral program in Environmental and Ecological Anthropology. Transferring to the University of Texas at San Antonio with Ehardt to become one of the original cohort in UTSA’s new Ph.D. program in Ecological Anthropology, Deb began to formulate a dissertation project which would take her to the savanna-woodlands of the Ugalla region of western Tanzania to investigate the population of Endangered *Pan troglodytes schweinfurthii* in this environment, one of the most seasonal, dry, and open of chimpanzee habitats.

The Ugalla chimpanzees, at the easternmost range of this subspecies, are not only an important population for the conservation of the species, they also represented opportunity to investigate how a population living under significant resource constraints and exhibiting exceptionally large home ranges could differ in their socioecology from the more traditionally studied forest populations. Faced with addressing fundamental questions of population demography and behavioural ecology, such as the stability of male philopatric community structure, in such an unusual and non-habituated population, Deb turned to non-invasive, innovative application of genetic analysis of systematically collected fecal samples. Through demanding field work (during which she first detected the cancer that would ultimately take her life) and genetic analyses in collaboration with Linda Vigilant in the Department of Primatology at Max Planck
Institute for Evolutionary Anthropology in Leipzig, Germany, Deb’s research revealed the efficacy of her innovative techniques and approach in revealing environmentally-stable aspects of socioecology, and contributed valuable data for the Ugalla chimpanzees with direct application to conservation of this important and exceptional population.

Following receipt of her Ph.D. in 2013, Deb began postdoctoral association with the Bonobo Conservation Initiative as a Research Associate and became one of the very first scientists to work with the bonobo population at the Kokolopori Bonobo Reserve in the Democratic Republic of Congo. Excited about this opportunity to again contribute to conservation science for highly threatened primates, and despite the challenges of the field site (echoing what she overcame at Ugalla), she initiated protocols to guide the work, only to again be stricken by cancer. Forced to return home to Canada, Deb exhausted every avenue to combat the recurrence and continue with the research that so highly motivated her as the professional and exceptionally caring person who was admired and cared about by all of her friends, family, and colleagues around the world.

Deb is and will be greatly missed by all who knew her and had the privilege of working with her. To share some of those personal remembrances:

**From Gráinne McCabe:**

I first met Deborah in the Caribbean lowlands of northwestern Costa Rica in the summer of 2005. At the time, she was finishing up her undergraduate degree at Georgia State University, planning to pursue a PhD in the near future. It was my first time as a teaching assistant on a field course and one of Deb’s first experiences studying primates in the wild; an experience that got her hooked.

We didn't meet up again until the fall of 2007 when we bumped into one another in the hallway of Baldwin Hall at University of Georgia. Two brand new PhD students about to embark on a rollercoaster adventure together across several states and continents: from Athens, Georgia to San Antonio, Texas to the forests of Tanzania. The journey would be filled with many highs and lows, great accomplishments and inevitable failures,
Deb will be deeply missed by all who knew her. In her honour, we have established the Dr Deborah Moore Memorial Grant for Early Career Primatologists, which will be hosted by the American Society of Primatologists. This grant will be for researchers that have recently completed their PhDs but have not yet acquired full-time employment in academia. If you wish to donate to the fund, please see https://www.crowdrise.com/o/en/campaign/annual-dr-deborah-moore-memorial-grant-for-early-career-primatologists.

From Carolyn Ehardt:

It was a privilege to have been part of Deb’s journey from student to professional colleague, and to know her as the motivated, dedicated, joyful person she was throughout all phases of that journey. As Deb’s research demonstrated, she had much to contribute to advancing our knowledge of highly threatened primates, including posing seminal questions that only could be addressed through innovative and difficult approaches, free of the risks sometimes attendant to more traditional research strategies. We regret the loss of those certain future contributions to the understanding and conservation of African primates. I also know that a number of colleagues admired and respected how she handled the sometimes unpleasant ‘quagmires’ that can accompany pursuit of research, especially in a field where competitiveness can overshadow collaborative advancement of knowledge. Always the professional, she placed the science and the long-term welfare of the animals first. For all of these reasons, she will be deeply missed.

A selection of Deborah Moore’s publications


The design and implementation of effective conservation measures for primates, warthogs, dik-diks, and hyraxes requires an efficient, low cost, and accessible resource for the identification of species and subspecies. Although photographs cannot replace an adequate museum collection as a resource for assessing species variation, geotagged photographs are a relatively fast, inexpensive, convenient, and unobtrusive means for detecting and assessing phenotypic variation within a species/subspecies over large areas. The use of photographs to document phenotypic characters will become increasingly important as the collection of specimens for hands-on assessments becomes ever more difficult.

Our 15 newly up-graded on-line photographic maps (or ‘PhotoMaps’; wildsolutions.nl), with over 3165 images (November 2017) of African primates, warthogs, dik-diks, and hyraxes, together with the latest distribution maps, provide insight into each taxon’s phenotypic characters, diversity and biogeography. These ‘living’ collections of geotagged images are a practical tool for documenting and discussing diversity, taxonomy, biogeography, distribution and conservation status and, therefore, for planning actions for conservation.

PhotoMaps are useful to those who want to:

- identify species/subspecies;
- know which species/subspecies occur in which areas;
- obtain species/subspecies photographs;
- confirm species/subspecies distribution;
- describe variation within a species/subspecies, especially as it relates to geographic distribution.
If you have photographs of African primates, warthogs, dik-diks, or hyraxes from the less documented areas of Africa (i.e., gaps on the PhotoMaps), please consider contributing them to the PhotoMaps. The photographers’ name is attached to each photograph. Anyone wishing to use a PhotoMap photograph must obtain both permission and the photograph from the photographer. Send your photographs, and the coordinates and/or place name of the site where the photographs were obtained, to yvonne@wildsolutions.nl.

Besides PhotoMaps, the website of the Eastern Africa Primate Diversity and Conservation Program (wildsolutions.nl) hosts the ‘Vocal Profiles for the Galagos’, a joint initiative with the Nocturnal Primate Research Group, blogs, primate and warthog videos, project information, and publications by Thomas M. Butynski and Yvonne A. de Jong.

We thank Arnoud de Jong for his technical expertise and great help with the PhotoMaps.
I would like to introduce the primatology community to ALERT—an international scientific and environmental-advocacy group run entirely by leading scientists and environmental journalists.

I founded ALERT in 2013 after spending some two decades trying to help major scientific organisations—including the Association for Tropical Biology and Conservation and the Society for Conservation Biology—to become more engaged in real-world conservation issues. For various reasons my earlier efforts with traditional scientific organisations were met with mixed success. Still, since its inception in late 2013, ALERT has grown dramatically and now reaches a million or more informed readers worldwide each week.

The following 12 factors have made ALERT successful:

1. Scientific organisations typically generate only a few resolutions or declarations on conservation issues per year. ALERT runs 1–2 major blogs per week and we produce a number of press releases annually on particularly urgent issues.

2. Most actions by scientific organisations are produced far too slowly to respond to fast-changing environmental concerns. This tends to limit them to addressing long-term problems but not the many specific, real-world challenges, such as fast-moving development projects, which can be a grave and direct threat to nature conservation.

3. In my experience some members of traditional scientific groups do not understand the inherently political nature of many conservation issues. This slows and complicates their efforts to produce timely conservation initiatives. ALERT’s core members, however, are world-leading conservation scientists or environmental journalists who understand and accept these political realities.

4. ALERT is very much connected to the journalistic world. Our press releases reach over 800 environmental journalists worldwide and we have invested considerable effort in compiling and automating this distribution list.

5. Many of our blogs are translated into Spanish and Portuguese by allied websites in Latin America, and some are translated into French by another allied website in Europe. Many overseas members actually read the English version but comment in their native language.

6. We use a range of social-media outlets to increase our impact, including our website, Facebook, and Twitter. We pay a part-time social-media strategist to design and update our social-media outlets, and a part-time environmental journalist to help us deal with the rapidly growing volume of material we receive at ALERT.

7. We do not shy away from controversial issues. We openly advocate for nature conservation while carefully maintaining our scientific credibility.

8. Our blogs are written in a simple and engaging manner, so they are easily readable by anyone.

9. We are closely plugged into the broader conservation and NGO communities, so are very well informed about timely and emerging conservation issues.

10. In advocating for environmental conservation we try to build a ‘broad church’, working with groups dealing with indigenous peoples, environmental economics, and social-justice issues, so that our blogs and campaigns appeal to a large segment of society, not just ‘greenies’.

11. ALERT is completely free; we charge no dues or membership fees. ALERT’s efforts are fully supported by external grants from scientific and philanthropic donors.

12. ALERT has a broad global focus. Although most of our initiatives and campaigns focus on terrestrial environments, we work on many issues of conservation importance. Key foci include emerging environmental threats, tropical forests, developing nations, Australasia, climate change, conservation policy, endangered species and the drivers of land-use change.

Joining ALERT is easy. Simply visit our website and insert your email into the box at the top of the page.

Becoming an ALERT member is an excellent way to track key trends and stay on top of the rapidly changing world of nature conservation and environmental sustainability.

William F. Laurance
College of Science and Engineering,
James Cook University
The Nagoya Protocol on Access and Benefits Sharing is part of the international treaty known as the Convention on Biological Diversity (CBD). The CBD was opened for signature at the 1992 Earth Summit in Brazil, and entered into force in 1993. The Nagoya Protocol is a Supplementary Agreement to the CBD that was adopted in 2010. In spite of the 17-year gap between the CBD and the Nagoya Protocol, the purpose of the Nagoya Protocol – the fair and equitable sharing of benefits arising from genetic resources – has been one of the goals of the CBD since its inception.

Aim and implementation of the Nagoya Protocol. The aim of the Nagoya Protocol is to ensure that the benefits associated with genetic resources, and also with traditional knowledge of biodiversity, are shared fairly and equitably. The Protocol formalizes the idea that countries in which genetic resources and traditional knowledge originate should have the option of retaining some rights over those resources and knowledge. Another underlying principle of the Nagoya Protocol is the idea that Access and Benefits Sharing is critically important for conservation and for the sustainable use of biodiversity. By providing countries with fair and equitable access to benefits from the genetic resources and traditional knowledge associated with biodiversity, the Protocol provides incentives for both conservation and research.

The Nagoya Protocol has been ratified by nearly 100 countries, including many UN member states and the European Union. The US has not ratified the Protocol, and hence is not a party to it. However, because many countries worldwide are now parties to this treaty, scientists who export biological materials from one country to another need to be cognizant of the country-specific requirements of the protocol, whether or not their home country is a party to it. Penalties for non-compliance in the countries that are parties to the treaty can be stiff.

Most (not all) countries that are home to nonhuman primates are parties to the Nagoya Protocol. This means that in addition to the research permits, collection permits, and CITES export permits that researchers already obtain, they will also need to be compliant with the requirements of the Nagoya Protocol as implemented in the country where they conduct research.

Resources for learning more about the Nagoya Protocol. Researchers will find the following websites very useful in learning more about the Nagoya Protocol.

1. The Access and Benefit-Sharing Clearing-House (ABSCH) includes valuable general information about the Nagoya Protocol, as well as detailed country-specific information. Under the ‘Country Profiles’ link, 198 countries are listed. Their status with respect to the Protocol is indicated (party versus non-party), as well as each country’s national point of contact for information about the protocol, the national authority that oversees the implementation of the protocol, and a range of other useful information. https://absch.cbd.int/help/about

2. The Convention on Biological Diversity, the umbrella treaty under which the Nagoya Protocol falls, has a comprehensive website with basic information, news links, updates, and program information. https://www.cbd.int/

3. Knowledge about the Nagoya Protocol is highly variable across universities, museums, and captive primate facilities. Consider contacting the central research administration office at your institution to learn what they know, and what types of support they can offer to researchers. If they are new to the Nagoya Protocol, you can give them the information provided here, and also point them to the following link, with information on access and benefit sharing geared towards administrators. https://scbd.unssc.org/course/index.php?categoryid=4

Photo: C. Whittier/MGVP
Deadline for submission of oral, symposium, and poster presentation abstracts and Early Bird registration:

January 5, 2018

The XXVII International Primatological Society (IPS) Congress will be held at the United Nations Office in Nairobi (UNON), Kenya.

The Congress theme is "Global Connectivity to Ensure the Future of Primates." Nairobi's central location in East Africa will offer primatologists from African range states the opportunity to attend.

27th INTERNATIONAL PRIMATOLOGICAL SOCIETY CONGRESS

19-25 AUGUST 2018

http://www.ipsnairobi.org/

The Congress theme is "Global Connectivity to Ensure the Future of Primates." Nairobi's central location in East Africa will offer primatologists from African range states the opportunity to attend.
Bioko Island Study Abroad
Study in Monkey Paradise!

The Bioko Island Study Abroad Program takes place in the Spanish-speaking central African country of Equatorial Guinea and is built upon the long term academic partnership between Drexel University, the Bioko Biodiversity Protection Program (BBPP), and the National University of Equatorial Guinea (UNGE).

The island of Bioko is one of the most beautiful and biologically-significant places in all of Africa. It is home to one of Africa’s greatest concentrations of endangered primates and to numerous unique species of frogs, plants, insects, and many more species. During the dry season (November to February), butterflies gather in the rain forest and endangered marine turtles come ashore to nest on the black sand beaches. Nearly 200 species of birds fly amongst the island’s three volcanic peaks, the highest almost 3000 meters above sea level (~10,000 ft). Located 20 miles (37 km) off the coast of Cameroon in west central Africa, Bioko is a part of the African country of Equatorial Guinea. At Bioko’s northern tip is the country’s capital city, Malabo (population: 100,000), a city pulsing with petroleum wealth and easily accessible from many European capitals. Moving south the island becomes increasingly rural, devolving into large swaths of undisturbed virgin rain forest.

Drexel University’s Bioko Study Abroad Program includes individual field research projects at the Moka Wildlife Center in the southern highlands of Bioko, coursework at UNGE in the capital city of Malabo, and additional fieldwork in the tropical forests, mountains, lakes and beaches of Bioko Island. To maintain the high level of individualized study, the program is offered once yearly (January - March) to a class of ten American students.

Drexel students registering for the course receive a full term of course credits. Students from other other institutions receive a full term of Drexel credits that can usually be transferred to their home institutions.

For more information see:
- BBPP’s Website: www.Bioko.org
- Bioko Study Abroad: https://studyabroad.drexel.edu/index.cfm?FuseAction=programs.ViewProgram&Program_ID=10116
- Video about Bioko Study Abroad: https://youtu.be/g4kkhbrKCGk
- For questions, email Katy Gonder (gonder@drexel.edu) or Hilton Oyamaguchi (hmo28@drexel.edu)

Photo: Bioko red colobus monkey (Piliocolobus pennantii) in the Gran Caldera de Luba Scientific Reserve (by Ian Nichols).
2018 Courses

Wilderness First Aid
Photography for the Outdoors
Surveying Wildlife Populations
Primate Ethology
Field Safety, Wilderness First Aid, & CPR
Vegetation & Habitat Analysis

SEPELA
Field Programs

www.sepela.org
info@sepela.org
In this course, we’ll explore wildlife conservation in Uganda, focusing on chimpanzees and monkeys, as well as other megafauna including elephants, giraffes, lions, and crocodiles. We’ll be based in the Budongo Forest and explore several wildlife sites, including national parks, forest reserves, and wildlife sanctuaries. Lecture and group discussion topics will include:

- Animal Behavior & Ecology
- Wildlife Management
- Community Conservation
- Habitat Fragmentation
- Human-Wildlife Conflict
- Ecotourism

Students will also learn basic skills in: data collection, animal tracking, camera trapping, and GPS use/map-making.

Course Instructor:
Janette Wallis, Ph.D.

Application Deadline:
April 15, 2018

For more information:
Field Projects International
https://fieldprojects.org/course/uganda/#ffs-tabbed-11
info@fieldprojects.org
IPS Grants for Primate Work

The International Primatological Society (IPS) has several grant and award programs. See the IPS web site for details about conservation, research, captive care, and education grants (be sure you submit applications to the grant program that fits your goal to maximize chances for funding). See http://www.internationalprimatologicalsociety.org. The next deadline for grant submissions: March 1, 2018.

Awards for Leadership in Conservation

The annual National Geographic/Buffett Awards for Leadership in Conservation were established by the Society and The Howard G. Buffett Foundation to recognize and celebrate unsung heroes working in the field. Two awards are presented each year: one for achievement in Africa (established in 2002) and the other for achievement in Latin America (established in 2005).

Recipients of these awards have demonstrated outstanding leadership in managing and protecting the natural resources in their regions and countries. In addition, they are each inspirational conservation advocates who serve as role models and mentors. The awardees chosen each year are honored at a ceremony in Washington, D.C., and receive a one-time grant of $25,000 to support their ongoing work.

Nominations are being accepted now through January 8, 2018, for the 2018 awards. Winners will be announced in June. https://www.nationalgeographic.org/awards/buffett.

The African Journal of Ecology will be publishing a themed issue on primates in June 2018 to coincide with the International Primate Society’s biennial congress in Nairobi, Kenya, in August 2018. The journal’s publisher, Wiley, has said that AJE can have a bumper issue packed with the most current research in the field. Papers to be included in the issue should be submitted early in 2018 and will go through the journal’s normal review process. AJE publishes papers on ecology and conservation of indigenous African flora and fauna in three formats: Original Articles, Short Communications and Notes and Records. The journal does not publish papers on taxonomy or species inventories, though lists can be included in Supplementary Information.-

- Jon Lovett and Katherine Abernethy

http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1365-2028

AuthorAID Travel Grants

AuthorAID will award five travel grants (USD 1500 each) for early-career researchers to present their research at an academic conference. The application deadline is 3rd of January 2018. http://www.authoraid.info/en/news/details/1253/.

Primate Films Database Now Available!

The Primate Films Database includes information about films featuring wild primates produced since the beginning of the twentieth century. The database contains entries for films (including feature films), TV specials, TV series, and single episodes of series. Currently the Primate Films Database focuses on films in which the main focus is on primates in wild settings, but it may be expanded in the future to include more films focusing on captive primates. The database includes general information about each film such as runtime, the featured species, and the narrator or host. A brief review of each film is also provided which focuses on the film’s usefulness in teaching and educational settings.

This database was created specifically as a resource for educators, but it may also be useful to members of the general public with an interest in primatology or nature documentaries. It could also be a valuable tool for researchers in primatology, visual anthropology, and film studies. The database will be updated as new films are released. https://anthropology.artsci.wustl.edu/primate-films-database.
IUCN SSC
Primate Specialist Group’s

“Primates in Peril: The World’s Most Endangered Primates - 2016-2018”

Now available!

Pick up a hard copy at the Primate Specialist Group's table at IPS in Nairobi.

Or visit the Primate Specialist Group web site for a digital copy.

http://www.primate-sg.org/special_reports/

Colin P. Groves
24 June 1942 - 30 November 2017

Shortly before this issue of African Primates was finalized, we learned of the passing of our friend and colleague, Professor Colin Groves.

The next issue of African Primates will include a special tribute and obituary for this remarkable man, whose work helped shape the careers and research of so many primatologists.

Visit this page to view a celebration of Colin’s life and achievements: https://colingrovesmemorium.blog/2017/11/30/first-blog-post/#comments


Fujisawa, M., K.J. Hockings, A.G. Soumah, & T. Matsuzawa. 2016. Placentophagy in

---

* This is not an exhaustive list and focuses mostly on publications from peer-reviewed journals. To have your new publications listed in this section of future *African Primates*, please send an e-mail notice to wallis@africanprimates.net.
Recent Publications


Gippoliti, S. 2017. On the taxonomy of *Erythrocebus* with a re-evaluation of *Erythrocebus poliophaeus* (Reichenbach, 1862) from the Blue Nile Region of Sudan and Ethiopia. *Primate Conservation* (31): Published electronically prior to print.


Recent Publications


Recent Publications


Recent Publications


Recent Publications


Send in your contributions

Research Articles and Brief Reports:
See the inside back cover for details.

News: *African Primates* lists grant opportunities, conferences, job announcements, etc. However, please keep in mind that the journal is published only once or twice per year. Thus, dates for time-sensitive announcements should be considered carefully.

Recent Publications: Send the details of any new papers, books, reports published since the last publication of *African Primates*.

Connections - E-News, Web Sites, Social Media: The last three pages of this issue lists ways you can stay connected with the African primatology community. Have we listed your information? Help keep this list up to date and accurate!

All correspondence should be sent to: wallis@africanprimate.net


Africa Biodiversity Collaborative Group
- Website: www.abcg.org
- E-newsletter contact: Kamweti Mutu (kmutu@abcg.org)
- Facebook: www.facebook.com/ABCGconserve
- Twitter: http://twitter.com/ABCGconserve

African Primates (for journal and group)
- Website: www.primate-sg.org/african_primates/
- Facebook: https://www.facebook.com/groups/232900723505713/
- Twitter: http://twitter.com/africanprimates

African Primatological Society
- Twitter: https://twitter.com/AfricanPs

African Wildlife Foundation
- Website: www.awf.org
- Facebook: https://www.facebook.com/AfricanWildlifeFoundation
- Twitter: http://twitter.com/AWF_Official

Amboseli Baboons
- Website: www.amboselibaboons.nd.edu
- Twitter: https://twitter.com/AmboseliBaboons

Barbary Macaque Awareness and Conservation
- Website: www.barbarymacaque.org
- Newsletter: Contact sian@barbarymacaque.org
- Facebook: www.facebook.com/BarbaryMacaqueAwarenessandConservation
- Twitter: https://twitter.com/Barbarymacaque
- Instagram: https://www.instagram.com/barbary_macaque/

The Bioko Biodiversity Protection Program (BBPP)
- Website: www.bioko.org
- Facebook: English - www.facebook.com/pages/Bioko-Biodiversity-Protection-Program/107673299261496; Spanish - www.facebook.com/BiokoBiodiversidad
- Twitter: http://twitter.com/Bioko_BBPP
- Instagram: https://www.instagram.com/bioko_BBPP/

The Bonobo Conservation Initiative (BCI)
- Website: www.bonobo.org
- Facebook: www.facebook.com/bonobodotorg
- Twitter: http://twitter.com/Bonobodotorg

Budongo Conservation Field Station
- Website: www.budongo.org
- Facebook: www.facebook.com/pages/Budongo-Conservation-Field-Station/11160629076237
- Twitter: @Budongochimps (http://www.twitter.com/budongochimps)

Centre de Conservation pour Chimpanzes
- Website: http://www.projetprimates.com/en/
- Facebook: https://www.facebook.com/CentreDeConservationPourChimpanzes

Chimp Eden (JGI Sanctuary, South Africa)
- Website: http://www.chimpeden.com/
- Twitter: https://twitter.com/jgisachimpeden

Chimpanzee Sanctuary & Wildlife Conservation Trust (Ngamba Island)
- Website: www.ngambaisland.com/
- E-newsletter contact: info@ngambaisland.org
- Facebook: www.facebook.com/ngambaisland

Colobus Conservation
- Website: www.colobusconservation.org
- Facebook: www.facebook.com/pages/Colobus-Conservation/137445029669543
- Twitter: http://twitter.com/ColobusConserva

Conservation through Public Health
- E-newsletter contact: info@ctph.org
- Twitter: http://twitter.com/CTPHuganda

Comoe Chimpanzee
- Facebook: www.facebook.com/comoechimpanzee.cp/

The Drill Project
- Website: thedrillproject.org/
- Facebook: https://www.facebook.com/The-Drill-Project-258035237544233/
Connections: E-News, Web Sites, and Social Media

East Africa Primate Diversity and Conservation Program
- Website: http://www.wildsolutions.nl/
- Twitter: https://twitter.com/WildSolutions

Ebo Forest Research Project
- Website: www.eboforest.org
- E-Newsletter contact: ekwoge@eboforest.org

Faléme Chimpanzees
- Twitter: http://twitter.com/FalemeChimps

Filoha Hamadryas Project
- Website: http://larissaswedell.org/filoha
- Facebook: https://www.facebook.com/filoha

Fossey Gorilla Fund
- Website: https://gorillafund.org/
- Twitter: https://twitter.com/SavingGorillas

GAIA – Great Ape Institute for Awareness
- Website: www.gaiasanctuary.org/
- Facebook: https://www.facebook.com/ProtectApes

The Gishwati Foundation
- Facebook: https://www.facebook.com/GishwatiFoundation/

Gorilla Doctors
- Website: http://www.gorilladoctors.org
- Facebook: https://www.facebook.com/gorilladoctors/

Gorillas Across Africa
- Facebook: https://www.facebook.com/GorillasAcrossAfrica

Goualougo Triangle Ape Project
- Website: http://www.congo-apes.org/
- Facebook: https://www.facebook.com/Goualougo-Triangle-Ape-Project-282194681876/

Great Ape Survival Partnership (GRASP)
- Website: www.un-grasp.org
- Facebook: www.facebook.com/grasun?ref=stream
- Twitter: http://twitter.com/grasunep

Guenon Conservation Community
- Facebook: www.facebook.com/pages/Guenon-Conservation-Community/20318009723143?ref=stream

HELP Congo (Chimpanzee Sanctuary)
- Website: www.help-primates.org/
- Facebook: https://www.facebook.com/HELP-Congo-29693148237/

Imfene Education and Conservation (Baboons)
- Website: www.imfene.org/
- Facebook: https://www.facebook.com/ImfeneOutreach

International Gorilla Conservation Programme
- Website: www.igcp.org
- Twitter: http://twitter.com/IGCP

International Primate Protection League
- Website: www.ippl.org
- Facebook: www.facebook.com/InternationalPrimateProtectionLeague
- Twitter: http://twitter.com/ipplprimate

International Primatological Society – Conservation
- Website: www.internationalprimatologicalsociety.org
- Twitter: http://twitter.com/ipsconservation

Jane Goodall Institute
- Website: www.janegoodall.org
- Facebook: https://www.facebook.com/janegoodallinst?_rdr=p
- Twitter: https://twitter.com/JaneGoodallInst

Kasanka Baboon Research Project
- Website: www.kasankababoonproject.com
- Twitter: http://twitter.com/KindaCamp

Kasokwa Forest Project
- Facebook: www.facebook.com/pages/Kasokwa-Forest-Project/159230490821336
- Twitter: http://twitter.com/KasokwaForest

Kibale Chimpanzee Project
- Facebook: https://www.facebook.com/kibalechimpanzeeproject/
- Blog: https://kibalechimpanzees.wordpress.com/

Kyambura Gorge Chimpanzee Community
- Facebook: https://www.facebook.com/Kyambura-Gorge-Chimpanzee-Community-119478481457652/
Connections: E-News, Web Sites, and Social Media

Le Projet Gorille Fernan-Vaz (Gabon)
- Website: www.gorillasgabon.org/
- Facebook: https://www.facebook.com/pgfv.fvgp

Limbe Wildlife Centre
- Facebook: www.facebook.com/pages/Limbe-Wildlife-Centre/504832002861894
- Twitter: http://twitter.com/LimbeWildlife

Lukuru Foundation
- Website: www.lukuru.org
- Facebook: https://www.facebook.com/LukuruFoundation?fref=ts

Lwiro Sanctuary
- Website: www.lwiroprimates.org
- Facebook: www.facebook.com/lwiro
- Twitter: https://twitter.com/lwirosanctuary

Mbali Bai Study
- Website: www.mbelibaistudy.org
- Facebook: https://www.facebook.com/Mbeli-Bai-Study-137426999658859/
- Twitter: https://twitter.com/mbelibai

Ngogo Chimp Project
- Website: www.ngogochimpanzeeproject.org/
- Facebook: https://www.facebook.com/NgogoChimps/
- Twitter: https://twitter.com/ngogochimps

Pan African Sanctuary Alliance
- Website: www.pasaprimates.org
- E-newsletter contact: info@pasaprimates.org
- Facebook: https://www.facebook.com/pages/PASA-Primates/150322194563
- Twitter: http://twitter.com/pasaprimates

Pandrillus (Primate Sanctuary, Nigeria)
- Website: www.pandrillus.org/
- Facebook: https://www.facebook.com/Pandrillus-379304355421353/

PEGG – The South Africa Primatology Association
- Website: www.peggweb.com/index.php
- Facebook: https://www.facebook.com/PEGG-The-South-African-Primatology-Association-112433812122602/

Red-bellied Guenon
- Facebook: www.facebook.com/Cercopithecuserythrogastererythrogaster

Samango Monkey Project
- Facebook: www.facebook.com/groups/samango/

Save the Abandoned Chimps (Liberia)
- Facebook: https://www.facebook.com/abandonedchimps

Society for Conservation Biology – Africa Section
- E-mail list contact: Beth Kaplin bkaplin@anticho.edu

Tacugama Chimp Project
- Website: www.tacugama.com/
- Facebook: https://www.facebook.com/Tacugama
- Twitter: http://twitter.com/Tacugama

Tai Chimp Project
- Website: www.taichimps.org
- Twitter: http://twitter.com/TaiChimpProject

Uaso Nyiro Baboon Project
- Website: http://www.baboonsrus.com/6.html

Ugalla Primate Project
- Website: www.ugallaprimateproject.com

Vervet Monkey Foundation
- Facebook: www.facebook.com/groups/vervet
- Twitter: http://twitter.com/VervetMonkeys

West African Primate Conservation Action (WAPCA)
- WAPCA News contact: andrea.dimpsey@wapca.org
- Facebook: www.facebook.com/pages/West-African-Primate-Conservation-Action/427913537273055

Wild Chimpanzee Foundation
- Website: www.wildchimps.org/
- Facebook: https://www.facebook.com/wildchimps

Please report any changes or additions to this list so the next issue of African Primates can be up-to-date!
AFRICAN PRIMATES - Instructions to Contributors

African Primates, a journal of the IUCN SSC Primate Specialist Group, publishes research articles, field reports, review articles, position papers, book reviews, and other news focused on the nonhuman primates of Africa. We welcome submissions focused on behavior, ecology, taxonomy, or conservation. The journal is produced in both print and digital versions and is provided free of charge. The aim of African Primates is to promote conservation of Africa’s primates by:

1) enhancing interest in Africa’s primates and increasing knowledge about them that is relevant to their survival;
2) transmitting information about factors and situations that promote or work against conservation of African primate species or populations; and
3) providing a forum for discussion and debate regarding all aspects of knowledge relevant to conserving Africa’s primate fauna and their habitats.

African Primates encourages submission of relevant information in the form of research findings, field survey results, advances in field and laboratory techniques, field action alerts, and book reviews, as well as notification of events, funding opportunities, grassroots efforts such as letter-writing campaigns, and recent publications in other formats (including reports and theses). All submissions should be sent to the Editor-in-Chief; research articles will be peer-reviewed before acceptance for publication.

Contributors may consult past issues of African Primates for stylistic guidance. (Previous volumes are accessible through the PSG website. See http://www.primate-sg.org/african_primates/)

The following guidelines are recommended:

- Manuscripts (not to exceed 15 pages) should be in English or French, double-spaced, with 1-inch margins. All articles must include an English abstract. If possible, please provide a French abstract for English manuscripts.
- Authors submitting manuscripts in a language that is not their first are encouraged to seek guidance from a speaker of that language to ensure the manuscript is well-written.
- Manuscripts should be produced with PC-compatible software (e.g., Microsoft Word) and submitted as an e-mail attachment in *doc; *docx, or *.rtf format. All reviews and revisions will be conducted via e-mail.
- Use metric units only and define all abbreviations.
- Current taxonomic classifications should be used. However, if species or subspecies’ names have undergone recent revision, include mention of recent names as a service to readers adjusting to new naming conventions.
- Tables, figures, and photographs are encouraged. All require accurate and concise captions listed on a separate sheet.
- Research articles should be accompanied by a map indicating location of any place names mentioned in the text. Please include a map legend.
- All photographs must be of high quality and submitted electronically. Each should be labeled on a separate page with a caption and photographer credit.
- Maps and sketches should be submitted in electronic form (e.g., jpeg, tif, gif).
- References should be provided in an alphabetical list and conform to the format used in previous issues of African Primates. Examples are shown below.
- Each author should provide name, affiliation, address, telephone and/or fax number, and E-mail address.

Please use the following formats:

Book:

Journal Article:

Book Chapter:

Unpublished Report:

Government Document:

It is recommended that contributors consult recent issues of African Primates for more details on the journal’s format and content.

Janette Wallis, Ph.D.
African Primates, Editor-in-Chief
Phone: +1 405.446.9188
E-mail: wallis@africanprimates.net
Research Articles

Species Density of Galago moholi at Loskop Dam Nature Reserve, South Africa .......... 1
Ian S. Ray, Brandi T. Wren, and Evelyn J. Bowers

Presence of Alkaloids and Cyanogenic Glycosides in Fruits Consumed by Sympatric Bonobos and the Nkundo People at LuiKotale/Salonga National Park, Democratic Republic of Congo and Its Relationship to Food Choice ................................................... 9
Nono Bondjengo, Gaby Kitengie, Dieudomé Musibono, Constantin Lubini, Gottfried Hohmann, and Barbara Fruth

Primate Communities Along a Protected Area Border: A Two-site Comparison of Abundance and Hunting Response in Bioko, Equatorial Guinea ................................. 23
Daniel L. Forrest, Fermin Muatiche, Cirilo Riaco, Mary Katherine Gonder, and Drew T. Cronin

The First Sightings of the Red-Bellied Guenon (Cercopithecus erythrogaster erythrogaster) on the Western Edge of Southwestern Nigeria .......................................... 37
Reiko Matsuda Goodwin, Jacob Oluwafemi Orimaye, Francis E. Okosodo, Babafemi G. Ogunjemite, and Mariano G. Houngbedji

Brief Communications

Dogs Disrupting Wildlife: Domestic Dogs Harass and Kill Barbary Macaques in Bouhachem Forest, Northern Morocco ......................................................... 55
Siân Waters, Ahmed El Harrad, Mohamed Chetuan, Sandra Bell, and Joanna M. Setchell

Pan African Sanctuary Alliance: Primate Welfare, Conservation, and Research .......... 59
Rachel Stokes, Gregg Tully, and Alexandra Rosati

Extending the Northeastern Distribution of Mandrills (Mandrillus sphinx) into the Dja Faunal Reserve, Cameroon ...................................................................................... 65
Madeleine Ngo Bata, Julian Easton, Oliver Fankem, Tim Wacher, Tom Bruce, Tchana Eliseé, Pierre Augustin Taguieteu, and David Olson

Obituary: Stuart A. Altmann .................................................................................. 68
Susan C. Alberts and Daniel I. Rubenstein

Obituary: Deborah L. Moore .................................................................................. 71
Gráinne McCabe and Carolyn Ehardt

Announcements ........................................................................................................... 74
Recent Publications .................................................................................................... 84
Connections: E-News, Web Sites, and Social Media ................................................... 90