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Authors: Covey, Ryan, and McGraw, W. Scott

Source: Tropical Conservation Science, 7(1) : 115-125

Published By: SAGE Publishing

URL: <https://doi.org/10.1177/194008291400700103>

Research Article

## Monkeys in a West African bushmeat market: implications for cercopithecoid conservation in eastern Liberia

Ryan Covey<sup>1\*</sup> and W. Scott McGraw<sup>2</sup>

<sup>1</sup>Department of Anthropology, 308 Condon Hall, 1218 University of Oregon, Eugene, OR, 97403 USA. E-Mail: rcovey@uoregon.edu

<sup>2</sup>Department of Anthropology, The Ohio State University, 4064 Smith Laboratory, 174 West 18<sup>th</sup> Avenue, Columbus, OH, 43210 USA. E-Mail: mcgraw.43@osu.edu

\*Corresponding Author

### Abstract

According to the IUCN [1], four of the nine anthropoid species found in Liberia are classified as either Vulnerable or Endangered and this number is likely to rise in coming years due to an increase in bushmeat hunting and a growing human population. Bushmeat hunting is the primary cause of primate loss in West Africa and current estimated offtake rates combined with habitat loss have placed four taxa endemic to Upper Guinea forests in danger of extirpation. We surveyed one bushmeat market located on the Liberia – Ivory Coast border to assess the general impact of hunting in one area of Liberia. This market, located near the Ivorian town of Taï, receives meat daily from the Konobo District of eastern Liberia. We visited the market eight times over a four month period in 2009/2010, during which we counted 723 animals including 264 primates. According to our surveys of the market, *Cercopithecus petaurista* (Lesser spot-nosed monkey) [25% of all primates] was the most abundant primate, followed by *Cercopithecus diana* (Diana monkey) [19.3%], *Cercocebus atys* (Sooty mangabey) [12.1%], *Colobus polykomos* (King colobus) [11.4%], *Procolobus verus* (Olive colobus) [10.6%], *Cercopithecus campbelli* (Campbelli monkey) [10.2%], and *Procolobus badius* (Western red colobus) [9.5%]. We estimate an average of thirty-three primates were exchanged each day we visited and that a minimum of 9,500 primates are traded annually at this locale (6,900 during formal market days and 2,600 on non-market days). Based on an estimated offtake rate of 2.76%, our preliminary analysis suggests that primates in Liberia's Konobo District are likely being hunted at rates approaching unsustainable levels and are in danger of extirpation.

Key Words: bushmeat market; hunting; Konobo; Liberia; Ivory Coast; Cavally

### Résumé

Selon un rapport de l'IUCN [1], quatre des neuf espèces de primates vivant au Liberia sont considérée comme menacée ou en danger d'extinction, et ce chiffre risque d'augmenter dans les années à venir à cause de l'intensification du braconnage et de l'augmentation de la population humaine. Le braconnage de la viande de brousse et la première cause de disparition des primates en Afrique de l'Ouest, et la consommation actuelle rend quatre taxons endémiques aux forêts de la Haute Guinée en danger d'extinction. Nous avons surveillé un marché de viande de brousse situé à la frontière entre Côte d'Ivoire et Liberia, pour évaluer l'impact général du braconnage sur une zone du Liberia. Ce marché étant situé à proximité de la ville de Taï en Côte d'Ivoire, il reçoit chaque jour de la viande issue du district de Konobo à l'est du Liberia. Nous nous sommes rendus 8 fois sur le marché durant une période de 4 mois en 2009/2010. Nous avons alors recensé 723 animaux dont 264 primates. L'espèce *Cercopithecus petaurista* (Singe hocheur) était l'espèce de primate la plus abondante (25% des primates présents), suivie de *Cercopithecus diana* [Cercopithèque diane] (19.3%), *Cercocebus atys* [Mangabey enfumé] (12.1%), *Colobus polykomos* [Colobe à camial] (11.4%), *Procolobus verus* [Colobe vert] (10.6%), *Cercopithecus campbelli* [Cercopithèque de Campbell] (10.2%), et *Procolobus badius* [Colobe bai] (9.5%). Nous avons estimé le nombre de primates échangés chaque jour à trente trois en moyenne, et donc à un minimum de 9500 primates vendus annuellement à cet endroit (6900 lors des jours de marché et 2600 en dehors). Selon une estimation, la consommation de primates dans le district de Konobo au Liberia atteint un taux certainement trop élevé pour une consommation durable, provoquant un danger d'extinction pour les espèces concernées.

Received: 23 October 2013; Accepted 7 January 2014; Published: 24 March 2014

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**Cite this paper as:** Covey, R and McGraw, W. S. 2014. Monkeys in a West African bushmeat market: implications for cercopithecoid conservation in eastern Liberia. *Tropical Conservation Science* Vol.7 (1):115-125. Available online: [www.tropicalconservationscience.org](http://www.tropicalconservationscience.org)

## Introduction

Primates are frequently used to gauge a region's conservation status because many primates are sensitive to habitat disturbance, they are frequently hunted by humans, and obtaining density data for comparative purposes is relatively easy. Studies conducted over the last twenty five years suggest that primates in most regions of West Africa are threatened due to the effects of both forest loss and hunting for the bushmeat trade [1-8]. Biodiversity loss is a particularly significant problem in Liberia and Ivory Coast, where an expanding human population and political unrest pose acute threats to forests and their inhabitants. Hunting in this region is widespread, including in the Ivory Coast's Taï National Park, despite the presence of several long term primate research field stations there and the park's status as a World Heritage Site [9,10]. Established research sites are known to provide measured levels of conservation [10-12]; however, the researcher presence provides only limited protection, especially when a park/reserve is considerably larger than the study area within it and/or when law enforcement is poor. This is the case in Taï National Park: several studies in Taï have demonstrated that while most hunters do not hunt the anthropoid primates in the zones where two long term primate research projects operate, monkeys and chimpanzees outside these areas, and throughout the remainder of the park, are targeted frequently. Indeed, survey data indicate that due to the effects of poaching, primate densities drop off immediately outside the research areas of the Taï monkey and chimpanzee projects, and that poaching throughout the greater portion of the park is widespread and largely unchecked [11-14].

The Konobo District of eastern Liberia is a high conservation priority because the region has a large amount of forest, is home to several endangered primate taxa, and falls within the Guinea Forest (West Africa) biodiversity hotspot [15,16]. The position of this region between Liberia's Sapou National Park and Ivory Coast's Taï National Park makes it a potentially important corridor for gene flow between animal populations [17], so understanding the population status of its primates will inform future conservation management decisions [18]. Assessing the status of Liberia's forest inhabitants is especially urgent given the recent report that logging concessions have been obtained for up to 25% of Liberia's remaining forests [19]. Table 1 provides a list of Liberian primates found in the Konobo District and their current status according to the IUCN.

Many primates hunted in the Konobo District are transported to a market near the Ivorian town of Taï on the Cavally River, which serves as the border between Liberia and Ivory Coast. The market was established in 1992 in part as a means to relieve hunting pressure within Taï National

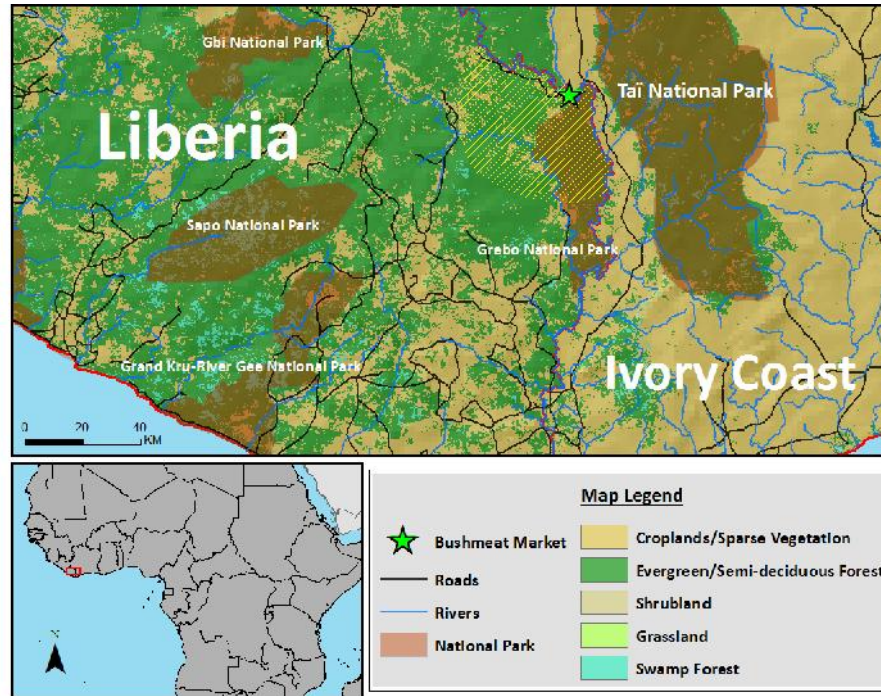
Park [I. Koné, pers. comm.]. It is illegal to hunt anywhere in Ivory Coast; however, given that most remaining primates in the country's western region reside within the park, there is a high probability that if primate meat is obtained from Ivory Coast, then it originated from a population within the park's borders. By providing local residents an alternative meat source, it was hoped that the number of primates killed in the park could be decreased. Meat is transported to the market daily from Liberia and sold to customers who transport it to restaurants (maquis) and/or homes in Ivory Coast. The market's success has drawn traders from throughout Ivory Coast, including towns as far away as Guiglo (87 km from Tai), Daloa (218 km), and Abidjan (570km). In this paper, we use preliminary data on primates brought to this market to highlight how hunting might be impacting primate populations in the Konobo region of Liberia and discuss the potential consequences of their continued decline.

Table 1. List of Liberian anthropoids and their current status according to the IUCN [1].

Species	Scientific Name	IUCN Status	Population Trend
Sooty Mangabey	<i>Cercocebus atys</i>	NT	Decreasing
Campbelli Monkey	<i>Cercopithecus campbelli</i>	LC	Unknown
Diana Monkey	<i>Cercopithecus diana</i>	VU A2cd	Decreasing
Putty-nosed Monkey	<i>Cercopithecus nictitans</i>	LC	Decreasing
Lesser Spot-Nosed Monkey	<i>Cercopithecus petaurista</i>	LC	Unknown
King Colobus	<i>Colobus polykomos</i>	VU A2cd	Unknown
West African Chimpanzee	<i>Pan troglodytes verus</i>	EN A4cd	Decreasing
Western Red Colobus	<i>Procolobus badius</i>	EN A2cd	Decreasing
Olive Colobus	<i>Procolobus verus</i>	NT	Unknown

## Methods

The market surveyed is located on the Cavally River adjacent to the village of Daobly near the town of Tai (Fig. 1). The source for meat exchanged at the market is a forest in Konobo, the largest (4,200 km<sup>2</sup>) of three districts in Liberia's Grand Gedeh County [20]. From informal conversations with hunters and bushmeat sellers, we learned that the only meat brought to the Daobly market is obtained from Liberian forests and from distances not greater than 40 km away. Using a 40 km radius maximum from the Daobly market on the Liberian side of the river, we estimate a source area of approximately 1,950 km<sup>2</sup> [estimated from Google Maps, see Fig. 1]. According to these satellite images, approximately 75% of this region is forested and since the primates of interest are all forest dwellers, we determined that the area yielding primates for the market is approximately 1,460 km<sup>2</sup>. In addition to satellite images, we used estimates from villagers on the extent of logging and farming to determine the proportion of this region that is forested. Forested regions included only areas that have not been developed for farming or incurred major disturbances from logging. Major market days are Friday and Sunday; however, bushmeat flows to the market continually and can be purchased every day of the week. Trading on market days typically occurs between 9:00 a.m. and 3:00 p.m.



**Fig. 1.** The location of the bushmeat market along the Ivory Coast/Liberia border. Hunting range indicated by yellow, diagonal lines. Map by R. Covey.

We visited the market seven times on Fridays between May – July in 2009 and once on a Friday in May of 2010, for a total of eight visits. Data collection during each visit began at 10:00 a.m. and concluded at approximately 1:00 p.m. During our first visit, we explained the purpose of our surveys to actors in the bushmeat trade, assuring participants that their identities would not be revealed. We counted all primate carcasses arriving via dugout canoe from across the Cavally River (Fig. 2a) and recorded the date, species, and preservation state (smoked or fresh) of each primate. Determining age and sex was difficult for smoked carcasses and we did not record data on these individuals; however, based on the size of both smoked and fresh carcasses, we determined that nearly all individuals sold at the market were adults. Two assistants from the Tai Monkey Project [21] based in the nearby Tai National Park (Ivory Coast) aided in identifying primates. Smoked carcasses were identified by their size, pelage, distinguishing facial features, and morphology. Two carcasses were burned to such an extent that species identification was not possible and were labeled as unknown.

To estimate the volume of primates killed in the source region of Konobo, we first calculated the average number of primates brought to the market each Friday. From conversations with market participants, we learned that the daily market lasted an average of six hours, beginning at approximately 9:00 a.m. and concluding around 3:00 p.m. From discussions with participants and our own observations, we determined that the number of primates arriving at the market was constant throughout the day and, since our sampling period was half the length of a typical market day, we doubled our three hour counts to estimate the total primates arriving in a day and then calculated the average for these eight observation days. We were informed that the volume of meat delivered to the market every Sunday was similar to that arriving on Friday and therefore doubled our Friday total to estimate the total primates sold on Fridays and Sundays. We learned



further that, on average, ten primates arrive at the market via the same route on non-major market days. Thus, assuming a constant flow of primates, we estimate 2,600 primates are traded per annum on non-market days.

We used known densities of primates in Ivory Coast's Taï Forest and Sierra Leone's Tiwai Island to estimate primate populations in Liberia's Konobo District [3,11,22]. We first estimated the area of forest cover within the Konobo District and multiplied this by species densities of reference populations in Taï National Park and Tiwai. From this total, we subtracted the estimated annual offtake derived from carcass counts obtained during market surveys. These population estimates were reduced by an additional 20% to account for general population reductions that have occurred in these forests over the last few decades [23]. A reduction of 20% is very likely a conservative adjustment since the reference populations in Taï and Tiwai feature group densities that are higher due to the protection provided by research sites [3,9,12].

The population density ( $P$ ) was calculated as:

$$P = (g \times A) \times .2$$

where  $g$  equals average group size,  $A$  is the area of forest cover within this hunted region of the Konobo District, and  $.2$  represents the 20% reduction.

## Results

During eight visits to the market, we counted 723 animals including 264 primates (Table 2; Figures 2b, 2c, 2d show scenes from the market). Duikers and forest antelope constitute 57% of all meat traded. Of the 264 primates sold, 68% were smoked (i.e., preserved by drying over fire). The most common primate was the Lesser spot-nosed monkey (*Cercopithecus petaurista*) [25%] followed by the Diana monkey (*Cercopithecus diana*) [19.3%]. The least observed primate was the Putty-nosed monkey (*Cercopithecus nictitans*), consisting of a single specimen. The three colobines – Western red colobus (*Procolobus badius*), Olive colobus (*P. verus*), and King colobus (*Colobus polykomos*) – were encountered in similar frequencies, 9.5%, 10.6%, 11.4%, respectively. Two chimpanzees, one freshly killed and one smoked, were encountered and no prosimians were observed during our visits.



**Fig. 2.** Images from the Daobly bushmeat market. 2a: Canoe traveling across the Cavally river to the market. Canoes ferry sellers and their bushmeat from Liberia to Ivory Coast. 2b: Olive colobus (left) and Lesser spot-nosed monkey (right) for sale at the Daobly Market. 2c: Collection of animals for sale including duikers, porcupines, Diana monkey, Lesser spot-nosed monkey, and a collection of dried primate and duiker carcasses. 2d: Western red colobus for sale at the market. Photographs by R. Covey

The average number of primates we observed at the Friday Daobly market during our sample period was 33. Multiplying this by 52 weeks yields a total of 1,716. Doubling this figure to account for the full length of the market day results in a total estimate of 3,432 primates traded per year at the Friday market. This figure is doubled again to include the number of primates sold at the Sunday market, yielding 6,864 individuals (Figure 3). From conversations with market participants we estimate that approximately 10 primates are sold on days other than Friday and Sunday, which yields an additional 2,600 primates per annum. Thus, we estimate that approximately 9,464 primates (6,864 on Fridays and Sundays + 2,600 on non-market days) pass through this market every year.

**Table 2. Number of carcasses observed at the Cavally market. Data from this Ivorian market were collected during 8 visits from May - July 2009 and May 2010.**

<i>Species</i>	<i>Fresh (non-smoked)</i>	<i>Smoked</i>	<b>Total</b>
<b><i>Cercopithecus petaurista</i></b> (Lesser Spot-nosed Monkey)	26	40	<b>66</b>
<b><i>Cercopithecus diana</i></b> (Diana Monkey)	14	37	<b>51</b>
<b><i>Cercocebus atys</i></b> (Sooty Mangabey)	8	24	<b>32</b>
<b><i>Colobus polykomos</i></b> (King Colobus)	10	20	<b>30</b>
<b><i>Procolobus verus</i></b> (Olive Colobus)	11	17	<b>28</b>
<b><i>Cercopithecus campbelli</i></b> (Campbelli Monkey)	12	15	<b>27</b>
<b><i>Procolobus badius</i></b> (Western Red Colobus)	2	23	<b>25</b>
<b><i>Pan troglodytes</i></b> (West African Chimpanzee)	1	1	<b>2</b>
<b><i>Cercopithecus nictitans</i></b> (Putty-nosed Monkey)	1	0	<b>1</b>
Unidentified monkeys	0	2	<b>2</b>
<b>Total number of primates</b>	<b>85</b>	<b>179</b>	<b>264</b>
Duiker/forest antelope	77	335	<b>412</b>
Other (snake, bird, crocodile, civet, etc.)	24	23	<b>47</b>
<b>Total animals observed</b>	<b>186</b>	<b>537</b>	<b>723</b>

The estimated anthropoid population of the hunted area in the Konobo District was ~342,891. An annual offtake of 9,464 primates from the Konobo District represents a 2.76% offtake rate. This offtake rate is almost certainly an underestimate since it does not account for other bushmeat markets supplied by the Konobo primate populations, primates consumed locally (e.g., by hunters families), or natural primate mortality rates.

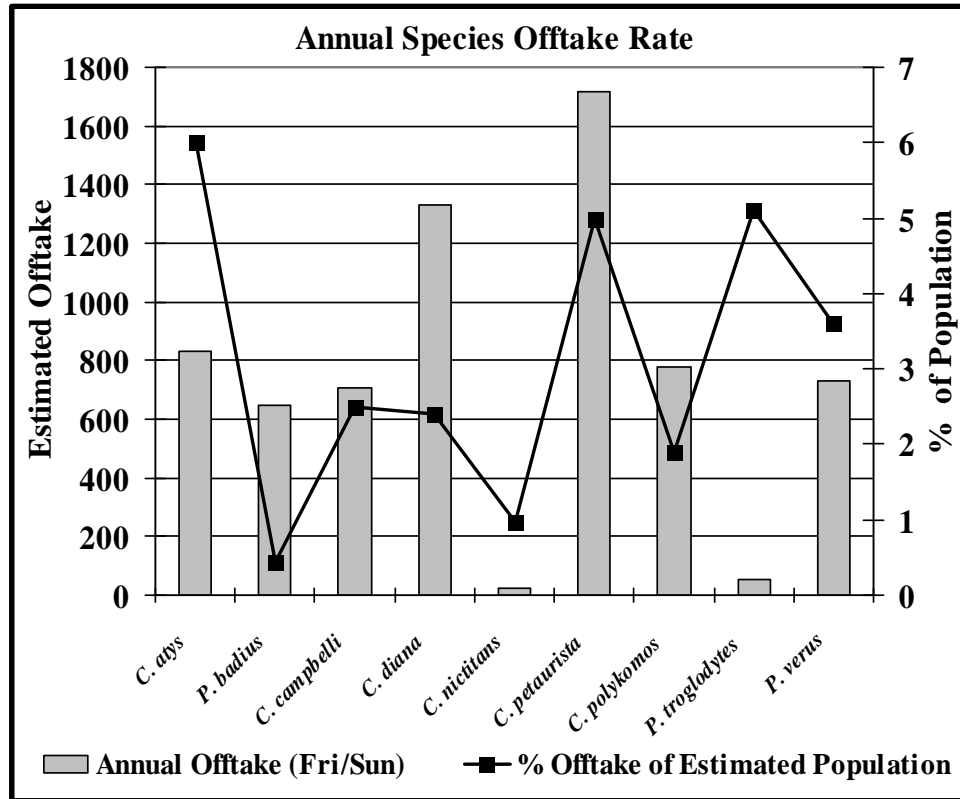


Fig. 3. Estimated annual offtake rates for Friday/Sunday market days. The annual offtake was calculated by doubling the average of the observed Friday offtake, and doubling again to account for the similar volume of primates traded at Sunday markets. This value was multiplied by 52 to provide an estimated annual offtake for the bi-weekly market. Population percentages were based on estimates derived from population data at Tai National Park in Ivory Coast and Sierra Leone's Tiwai Island. See the methods section for further information on primate population estimates of the Konobo District.

### Discussion

Under optimal conditions, an area the size of the forested region within the Konobo District (approximately 1,460 km<sup>2</sup>), would contain an anthropoid population of approximately 428,600 individuals based on population densities provided by Oates *et al.* [20] and Refisch and Koné [3]. This estimate is probably high because it does not account for reductions due to hunting and the fact that densities from reference populations in Tai National Park and Tiwai are high due to the protection afforded by several long term research projects [11,12]. We therefore reduced our population estimate by 20% to account for these factors yielding an adjusted total of ~342,891 anthropoids in the Konobo District. We do not have systematic data on the quantity of meat coming from Liberia on non-market days; however, based on discussion with hunters and other



individuals working in the region we believe our estimate of ten primate carcasses trafficked on non-market days is a good approximation. Even with the 20% adjustment factor, there are several reasons why we believe our estimates are conservative and that, in fact, considerably more primates are being removed from this region. First, there are multiple smaller markets throughout the Konobo District, none of which were surveyed. Many primates hunted in the district are consumed locally and are not destined for markets in Ivory Coast. Also, because there are multiple points along the Cavally river where bushmeat enters Ivory Coast from Liberia, the carcasses we observed in the Daobly market are almost certainly not the only primates from the Konobo District finding their way into Ivory Coast. Recent developments with illegal logging concessions may have further reduced forest cover within the Konobo District, the result being an even greater reduction in our population density estimates.

Three additional observations made during sampling suggest that we are likely underestimating the volume of meat passing through the Daobly market. First, we regularly observed large trucks at the market that had been loaded with bags containing meat purchased prior to our sampling. Owing to the difficulties of accessing these bags, which sometimes numbered in the dozens, we did not attempt to investigate the number of carcasses contained within each bag. Had we done so, our daily bushmeat totals would have been considerably higher. Second, bushmeat unloaded from canoes was typically placed on mats or rice bags to allow prospective buyers better viewing of meat prior to purchase. However, some bags were kept closed, and several buyers and sellers never permitted us to count their bags' contents, further contributing to an underestimate. Finally, although the market typically operated on Fridays and Sundays from 9:00 a.m. – 3:00 p.m., meat is known to be trafficked before and after the main market hours, so it is likely that a significant number of additional primates entered Ivory Coast undetected by us. These caveats to our admittedly crude sampling protocol suggest that considerably more primates may, in fact, be moving through the market from Liberia to Ivory Coast.

Previous studies have shown how hunting can lead to significant declines in wildlife in tropical regions [24,25]. When hunting removes individuals at rates greater than the population is able to reproduce, hunting is regarded as unsustainable and can lead to extirpation or extinction. Our estimated overall offtake rate of 2.76% is based on a number of important assumptions and we recognize a potentially large error factor; however, we believe our estimate is very likely conservative and that one or more species is being hunted at potentially dangerously high levels. Although the preliminary nature of our data preclude us from stating with certainty that any single taxon is being hunted unsustainably, we hope that our market counts might serve as baseline data for additional surveys in Liberia and Ivory Coast in the near future.

Liberia represents a tremendous opportunity for primate conservation. Current deforestation rates are low and Liberia's forest is generally much more intact than that in neighboring Ivory Coast [26,27]; however, recent information indicates that much of Liberia's forests – including that in the Konobo District – is under imminent threat [19,28]. Palm oil plantations, which are responsible for significant habitat and wildlife loss in Southeast Asia, are expanding in Liberia, which will result in increased deforestation and greater pressure on animal populations [29,30]. Although we lack precise data on the extent of forest cover and size of animal populations remaining in this portion of the Konobo District, the region undoubtedly is an important refuge for Upper Guinea biodiversity. The uncertain political situation and continued conversion of forest into cocoa and rubber plantations in Ivory Coast mean that the forested regions of eastern Liberia assume an even greater role in safeguarding animal species, including primates [31]. Protecting

these forests should be a high conservation priority; however, if logging proceeds as anticipated, then this development, combined with continued bushmeat hunting to serve the Cavally River market, could result in the disappearance of an already dwindling primate population in eastern Liberia.

### **Implications for Conservation**

This study highlights the current hunting problem facing primates throughout West Africa. Liberia's Konobo District is located in a West African biodiversity hotspot, but because this region lacks few measures of formal law enforcement, forests and wildlife are essentially unprotected. The bushmeat trade in this region has reduced primate populations because laws prohibiting hunting fail to deter poaching. Additionally, most hunters seeking to provide for their families have few economic alternatives. Data presented here suggest a potentially unsustainable number of primates are currently extracted from Liberian forests to supply bushmeat demands in Ivory Coast. Our minimum estimate, which approaches 9,500 primates per year, does not account for bushmeat sold at other markets along the Liberia/Ivory Coast border, or markets in the Konobo District itself. We have few additional data to compare our estimates with; however, we suggest that without some measure of formal protection, several taxa in this region which are already considered Vulnerable (*Cercopithecus diana*, *Colobus polykomos*) or Endangered (*Pan troglodytes verus*, *Procolobus badius*) could be extirpated in the near future.

We suggest a number of actions to protect primates of the Konobo District. First, population surveys should be conducted to determine primate abundance and distributions throughout this region. This would allow researchers to determine overall population totals as well as identify which areas have the highest primate density and are most important for future protection. Forested regions with substantial primate populations would warrant the establishment of that region as a protected area. The location of the Konobo District between Sapo and Tai National Park would make protected areas within this region an important wildlife corridor for populations inhabiting these two national parks.

Secondly, major markets throughout the Konobo District and additional border markets along Ivory Coast should be monitored to determine trade levels in bushmeat derived from Konobo forests. Understanding the volume of bushmeat traded at these markets will enable researchers to determine offtake levels, distribution networks of bushmeat, and which areas of the Konobo district face the highest hunting levels. This knowledge will allow researchers and law enforcement officials to better direct protection efforts in areas most affected by hunting. These actions could foster the establishment of field sites in areas with high conservation value. Field sites would provide research on previously unstudied groups of primates, monitoring of primate populations, and the employment and education of local people near field sites. Support from local people is necessary for conservation efforts to succeed, and this can be achieved through measures that allow people to benefit from preservation of their wildlife. Without the establishment of protected areas and active protection by law enforcement, primate populations throughout the Konobo District will continue to be hunted extensively and will likely lead to the extirpation of nine primate species in the near future.

## Acknowledgements

This study was supported by funding from the Primate Society of Great Britain, National Science Foundation, and The Ohio State University. We would like to thank the Centre Suisse de Recherche Scientifique for their support and hospitality. A special thanks to Agnès Candiotti for her contribution to this paper. Finally, we gratefully acknowledge the assistants of the Taï Monkey Project for their help during the course of this project.

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