Bushmeat Markets on Bioko Island as a Measure of Hunting Pressure

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Abstract: *Counts of the number of animal carcasses arriving at Malabo market, Bioko Island, Equatorial Guinea, were made during two, 8-month study periods in 1991 and 1996. Comparisons of the availability and abundance of individual species between years showed that more species and more carcasses appeared in 1996 than in 1991. In biomass terms, the increase was significantly less, only 12.5%, when compared with almost 60% more carcasses entering the market in 1996. A larger number of carcasses of the smaller-bodied species (i.e., rodents and the blue duiker* [Cephalophus monticola]*) were recorded in 1996 than in 1991. Although an additional four species of birds and one squirrel were recorded in 1996, these were less important in terms of their contribution to biomass or carcass numbers. Concurrently, there was a dramatic reduction in the larger-bodied species, Ogilby's duiker (*C. ogilbyi*) and seven diurnal primates. We examined these changes, especially the drop in the number of larger animals. We considered the possible following explanations: (1) the number of hunters dropped either because of enforced legislation or scarcity of larger prey; (2) a shift in the use of hunting techniques occurred (from shotguns to snares); or (3) consumer demand for primate and duiker meat dropped, which increased demand for smaller game. Our results suggest that the situation in Bioko may be alarmingly close to a catastrophe in which primate populations of international conservation significance are being hunted to dangerously low numbers. Although there is still a need for surveys of actual densities of prey populations throughout the island, working with the human population on Bioko to find alternatives to bushmeat is an urgent priority.*

Mercados de Carne Silvestre en la Isla Bioko como Medida de la Presión por Caza

Resumen: *Realizamos conteos de los cuerpos de animales llevados al mercado de Malabo, en la Isla Bioko, Guinea Ecuatorial, durante dos periodos de estudio de ocho meses cada uno en 1991 y 1996. Las comparaciones realizadas de la disponibilidad y abundancia de especies individuales entre estos años mostró que más especies y más cuerpos aparecieron en 1996 que en 1991. En términos de biomasa, el incremento fue significativamente menor, solo 12.5% cuando se comparó con un incremento de casi un 60% más de cuerpos que llegaron al mercado en 1996. Se observó un mayor número de cuerpos de especies de tamaño pequeño (por ejemplo roedores, y el duiker azul,* Cephalophus monticola*) en 1996 que en 1991. A pesar de que hubo una adición de cuatro especies de aves y una especie de ardilla en 1996, estas fueron menos importantes en cuanto a su contribución a la biomasa o el número de cuerpos. Al mismo tiempo, hubo una reducción dramática de especies de cuerpo grande, el duiker de Ogilby (*C. ogilbyi*) y siete primates diurnos. Examinamos estos cambios, especialmente la caída en el número de animales grandes y consideramos las siguientes posibles explicaciones: (1) hubo una caída significativa en el número de cazadores debido a la posible ejecución de la legislación o debido a una escasez de presas grandes; (2) hubo un cambio en el uso de técnicas de caza (por ejemplo, el reemplazo de armas de fuego por trampas); o (3) la demanda del consumidor por carne de primates y duikers disminuyó, incrementándose la demanda por animales pequeños. Nuestros resultados sugieren que la situación en Bioko puede estar alarmantemente cerca de una catástrofe en la cual las poblaciones de primates, que son de gran significado para la conservación internacional, han sido reducidas a niveles peligrosamente bajos. A pesar de que aún se necesita llevar a cabo estudios de las densidades existentes de poblaciones de presas a lo largo de la isla, es urgente trabajar con la población humana de Bioko para encontrar alternativas a la venta de carne silvestre.*

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Introduction

Bushmeat, the meat of wild animals, has long been a part of the staple diet of forest-dwelling peoples in Africa. Although this meat is still important to many rural people, it is now also a major source of animal protein for many of tropical Africa's large numbers of town and city dwellers (Feer 1993). In a number of west and central African countries, commercial hunters meet the increasing demand for this traditional item, and traders supply urban markets for profit. Markets in towns and cities are thus the main points of sale for a large volume of species extracted from natural areas. These sale points can offer valuable insights into the supply and demand of bushmeat in human population centers. In some cases, these data can be used to assess the effect of hunting on the bushmeat species if information on prey densities is also available (Fa et al. 1995; Fa 2000; Slade et al. 1998).

Bushmeat is a vital source of protein and cash for the people of Bioko Island (formerly Fernando Poo), Republic of Equatorial Guinea, west Africa. The bushmeat trade in Bioko does not differ from that in other African countries. Producers (hunters) offer their quarry to intermediaries (taxi drivers), who supply the retailer in the market in the main town, Malabo (the country's capital). Some meat is sold or given away in villages, where it is consumed, and passengers buy a proportion of the amount transported by the taxi drivers before it gets to market. Castroviejo (1995) discusses how the dominant ethnic group on the island, the Fang, runs production and commercialization of bushmeat in Bioko. The business triangle, hunter-transporter-retailer, is prearranged and in some cases may involve relatives working together. Women are the principal processors and distributors of bushmeat in the market (Castroviejo 1995). They purchase the meat from the taxi drivers and sell it to the public at a sizeable profit. In Bioko the supply of bushmeat to commercial markets is less complicated than in the larger continental areas (e.g., Nigeria, Adeola & Decker 1987; Zaire, Colyn et al. 1987; Central African Republic, Kalivesse 1991; Ghana, Falconer 1991 and Addo et al. 1994). This is primarily a consequence of the shorter distances (maximum 80 km) involved in transporting meat between source areas and market. Hunters using shotguns and snares have had greater effects on animal populations along roads, a few kilometers away from roads, and in agricultural or settled areas (Wilkie et al., this issue). Bioko's road system provides ready access to much of the lowland rain forest around Pico Basilé and to the northern side of this volcano (Fig. 1). The absence of roads and settlements on the eastern, southern, and western slopes of Pico Basilé and over the southern one-third of the island ensures that these regions are less hunted and have the highest densities of primates, duikers, and other hunted animals on the island (Fa 2000).

Juste et al. (1995), Fa et al. (1995), and, more specifically, Colell et al. (1994) showed that the Malabo market receives a high proportion of the game hunted throughout the island. Their investigations of daily, monthly, and yearly fluctuations in bushmeat at markets can be used in a manner akin to catch-per-unit effort indices of prey density. These indices normally assume a linear regression of absolute density on catch per unit effort (Caughley 1977). Market statistics cannot always presuppose that hunting conditions, efficiency, and gear are standardized, as catch-per-unit effort indices do. However, where these variables are standardized (e.g., in isolated areas or on islands where hunter numbers are relatively constant), markets can be used as barometers of hunting pressure to monitor trends in target species when long-term data are available. Studies that show how the availability of bushmeat has changed over the years and whether species composition has altered are lacking for Africa (Happold 1995). Such data are important if careful management is intended. We present information on numbers and species composition of bushmeat appearing in the Malabo market during two study periods in 1991 and 1996. We examined species abundance and availability from one study period to the next and describe changes during 8 months in the wet season each year.

Study Area

Administratively, Bioko forms part of the insular sector of the Republic of Equatorial Guinea (Fig. 1). The coun-

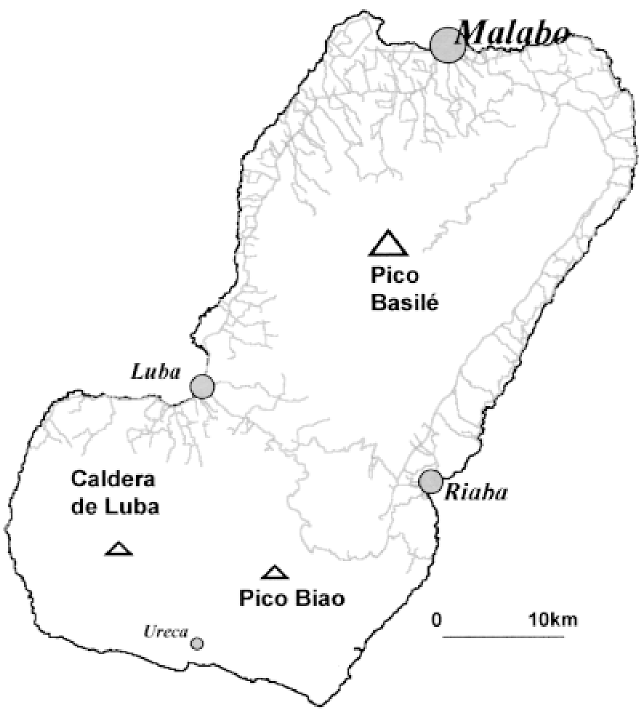

Figure 1. Bioko Island, showing the location of main population centers mentioned in the text, the capital Malabo, and the distribution of roads.

try consists of a mainland section (Rio Muni) on the west African coast and the coastal islets of Corisco, Elobey Grande, Elobey Chico, and of the islands of Bioko and Annobón (Pagalu) in the Gulf of Guinea. Bioko Island is a land-bridge island, rectangular in shape (69 × 32 km), 2017 km^2 in area and 32 km from the Cameroon coast. Its landscape is dramatic, characterized by deep valleys and dominated by two main volcanic massifs, the Caldera de Luba in the southwest and Pico Basilé in the north (Fig. 1). Elevations range from sea level to 3011 m at the summit of Pico Basilé; the southern highlands rise to 2261 m at the Caldera de Luba (the most remote part of the island) in the southwest and to 2009 m at the Pico Biao in the southeast.

Bioko's vegetation is structured in elevational rings and includes formations dominated by Guineo-Congolian rainforest species, with Afromontane elements appearing at higher elevations (FED/DHV 1989; Juste 1992). The climate is tropical equatorial and is strongly influenced by the north-south movements of the Intertropical Convergence Zone. There is a distinct rainy season from March to October, but the southern part of the island may receive over 10,000 mm of rain annually, whereas the north averages just 2000 mm (Nosti 1947). Average annual temperatures at sea level vary from 17° C to 34° C.

The indigenous ethnic groups are the Bantu-speaking Bubis and, since the 1930s, the Fang (Spanish Pamues), who migrated from the mainland. The population has increased from 28,000 in 1932 to 62,000 in 1990; 50,000 people reside in the capital city and in the four largest towns. Most of the population lives in the northern half of the island. Few villages are situated in the midlands and highlands; about one-half of Bioko has no permanent settlements. The human population density is about 93 inhabitants/km^2 in the north, declining to between 8 and 10 inhabitants/km^2 in the southwest and southeast. Villages vary in size, from 44 to 363 in a sample of 13 villages studied by Mas et al. (1995), but most average around 100 inhabitants. The population growth rate is estimated at 2.7% (Juste & Cantero 1991).

Methods

Data on bushmeat entering the Malabo Market were gathered by Juste et al. (1995) for 10 months (n = 263 market days) between October 1990 and October 1991, and by us for 14 months between March 1996 and April 1997 (n = 230 market days). To compare changes in carcass volume for the 5-year period, we used only data available for the same period (March–October) in both years. Carcasses were counted by the authors or by trained local observers familiar with all market entry points and species. Carcasses, smoked meat of identifiable species, and some live animals were recorded as they arrived at the market. The market was visited every day, except Sundays, between 0630 and 1200 hours in both years (no meat arrived at other times). All meat was sold on the day it was taken to market, so no item could be counted more than once. Biomass entering the market, for both periods was calculated by multiplying the total number of carcasses counted by the average body mass of each species. Average body mass (to the nearest 1 kg) of a species was taken as the mean weight of juvenile and adult animals obtained from the literature (Fa & Purvis 1997).

Following Juste et al. (1995), we measured two main attributes of market dynamics, quantity and daily availability of goods, during the study time periods. These measures were expressed quantitatively as (1) daily abundance (hereafter, abundance) of a species as the monthly average number of carcasses per species per day for all days sampled and (2) availability of each species in market (hereafter, availability) as the percentage of market days sampled in which the species appeared.

Results

Carcass Numbers, Biomass, and Species Representation

Significantly more carcasses were counted in 1996 (n = 14,677) than in 1991 (n = 8528) (χ^2 = 1207.9; df = 1; $p < 0.001$; Table 1). Similarly, biomass varied significantly between years (52,529 kg of dressed meat in 1991 and 63,411 kg in 1996 (χ^2 = 386.4; df = 1; $p < 0.001$). This represented an extra 6149 carcasses, or 10,882 kg in 1996, an increase of 72.1% and 20.7%, respectively.

Fourteen species were noted in the market in 1991 and 21 in 1996. The differences can be accounted for by the addition of four bird species, one pangolin, and two rodents. By taxonomic groups, 99% of all carcasses were either rodents (n = 3208, 37.3%), ungulates (n = 3,128, 36.4%), or primates (n = 2,193, 25.5%) in 1991. In 1996, 93% of carcasses were either rodents (n = 6869; 55.7%) or ungulates (n = 4614; 37.4%). In 1991, other animal groups (tree hyrax [*Dendrohyrax dorsalis*] and reptiles) were represented by only 75 carcasses, whereas in 1996 pangolins (n = 169), hyraxes (n = 17), reptiles (n = 16), and birds (n = 10) were more numerous. A highly significant drop in primate carcasses occurred between 1991 and 1996 (−71.2%; χ^2 = 862.6; df = 1; $p < 0.001$). Correspondingly, there was a significant increase in rodents (+114.1%; χ^2 = 1532.3; df = 1; $p < 0.001$), ungulates (+47.5%; χ^2 = 296.1; df = 1; $p < 0.001$), and hyrax (+54.6%; χ^2 = 1.3; df = 1; ns).

In 1991, the blue duiker (*Cephalophus monticola*) was the most abundant species, with 30% of all carcasses, followed by Emin's pouched rat (*Cricetomys emini*, 23%) and the brush-tailed porcupine (*Atherurus africanus*, 15%). In 1996 the same three species were also the most plentiful, but *C. emini* represented over 40% of

Table 1. Summary of total and mean (±SD) number of carcasses and biomass (kg) entering the Malabo market each month in 1991 and 1996.

Year and species	Abbreviation	Total number of carcasses	Mean per month	Total biomass (kg)	Mean per month
1991					
Cephalophus monticola	Cmo	2569	321.1 ± 121.2	12845	1605.6 ± 606.0
Cricetomys emini	Cem	1894	236.8 ± 123.0	3788	473.5 ± 246.0
Atherurus africanus	Aaf	1314	164.3 ± 84.6	5256	665.5 ± 327.9
Cercopithecus erythrotis	Cer	622	77.8 ± 33.9	2658	332.2 ± 145.0
Cephalophus ogilbyi	Cog	559	69.9 ± 9.7	10621	1327.6 ± 184.1
Mandrillus leucophaeus	Mle	429	53.6 ± 27.0	6403	800.4 ± 402.6
Colobus satanas	Csa	392	49.0 ± 11.4	4704	588.0 ± 136.4
Piliocolobus pennanti	Ppe	301	37.6 ± 12.7	2405	300.6 ± 101.9
Cercopithecus nictitans	Cni	224	28.0 ± 23.7	1949	243.6 ± 206.5
Cercopithecus preussi	Cpr	180	22.5 ± 20.4	1737	217.1 ± 196.5
Varanus niloticus	Vni	60	7.5 ± 5.9	60	7.5 ± 5.9
Cercopithecus pogonias	Cpo	45	5.6 ± 2.8	61	7.6 ± 3.7
Dendrohyrax dorsalis	Ddo	11	1.4 ± 3.5	33	4.1 ± 10.5
Python sebae	Pse	4	0.5 ± 0.8	10	1.3 ± 1.9
All species		8528	1066.0 ± 409.1	52529	6574.6 ± 2184.2
1996					
Cricetomys emini	Cem	5000	725.4 ± 1445.4	11606	1450.8 ± 518.5
Cephalophus monticola	Cmo	4191	634.3 ± 1197.8	25370	3171.3 ± 911.8
Atherurus africanus	Aaf	1800	251.9 ± 529.3	8060	1007.5 ± 503.4
Cephalophus ogilbyi	Cog	423	67.4 ± 119.1	10241	1280.1 ± 240.5
Cercopithecus erythrotis	Cer	279	50.1 ± 79.3	1713	214.2 ± 99.2
Phataginus tricuspis	Ptr	169	24.6 ± 48.8	493	61.6 ± 22.1
Colobus satanas	Csa	132	26.6 ± 36.7	2556	319.5 ± 134.8
Mandrillus leucophaeus	Mle	88	14.6 ± 25.8	1746	218.3 ± 131.8
Cercophithecus preussi	Cpr	79	9.9 ± 24.7	762	95.3 ± 92.8
Protoxerus stangeri	Pst	66	8.4 ± 20.7	52	6.5 ± 6.3
Piliocolobus pennanti	Ppe	34	5.3 ± 10.3	336	41.9 ± 32.7
Dendrohyrax dorsalis	Ddo	17	2.9 ± 5.2	69	8.6 ± 7.3
Cercophithecus nictitans	Cni	15	4.3 ± 6.8	296	36.9 ± 53.8
Gypohierax angolensis	Gan	14	1.8 ± 4.5	28	3.5 ± 4.2
Python sebae	Pse	8	1.4 ± 2.4	25	3.1 ± 2.2
Varanus niloticus	Vni	8	4.7 ± 4.2	28	3.5 ± 4.3
Corythaeola cristata	Ccr	5	0.6 ± 1.8	5	0.6 ± 1.2
Cercopithecus pogonias	Cpo	5	0.6 ± 1.9	7	0.8 ± 1.9
Anomalurus derbianus	Ade	3	0.4 ± 1.3	2	0.3 ± 0.8
Ceratogymna atrata	Cat	3	0.4 ± 1.1	6	0.8 ± 1.5
Accipiter tachiro	Ata	2	1.3 ± 1.1	10	1.3 ± 2.1
All species		12341	1834.6 ± 3533.3	63411	7926.3 ± 1926.9

the total number of carcasses counted. Biomass contributed by each species was positively correlated with the number of carcasses of that species appearing in market (1991: $y = 3.49x + 1$, $r^2 = 0.74$, $p < 0.001$; 1996: $y = 4.63x + 1$; $r^2 = 0.41$, $p < 0.01$).

Monthly Variation in Carcass Numbers

The number of carcasses appearing each month (mean ± SD, 1066.0 ± 409.1 carcasses/month or 38.5 ± 10.7 carcasses/day) in 1991 was lower during March–July (range, 573–967 carcasses) than during August–October (range, 1337–1701 carcasses) (Fig. 2). In 1996, monthly carcass numbers (1834.6 ±468.2 carcasses/month; 83.0 ± 59.5 carcasses/day) were also lower during the earlier months of the study (March–May; range, 883–1369) and rose dramatically from June to October (range, 1820–2600). There was a significant difference between years in the monthly number of carcasses ($\chi^2 = 10{,}544$; df = 7; $p < 0.001$). Monthly biomass in markets was significantly and positively correlated with the number of carcasses counted. Regression slopes, however, were different between years (1991: $y = 3.57x + 1275.7$, $r^2 = 0.95$, $p < 0.001$; 1996: $y = 5.29x + 927.4$; $r^2 = 0.97$, $p < 0.001$); in 1991 a higher biomass was extracted for the animals hunted.

There were significant differences in the number of carcasses contributed by each species each month during both years. As expected, *C. emini* and *C. monticola* made up around 20% of the monthly totals in 1991 (Fig. 3). *Atherurus africanus* made up around 10% of the re-

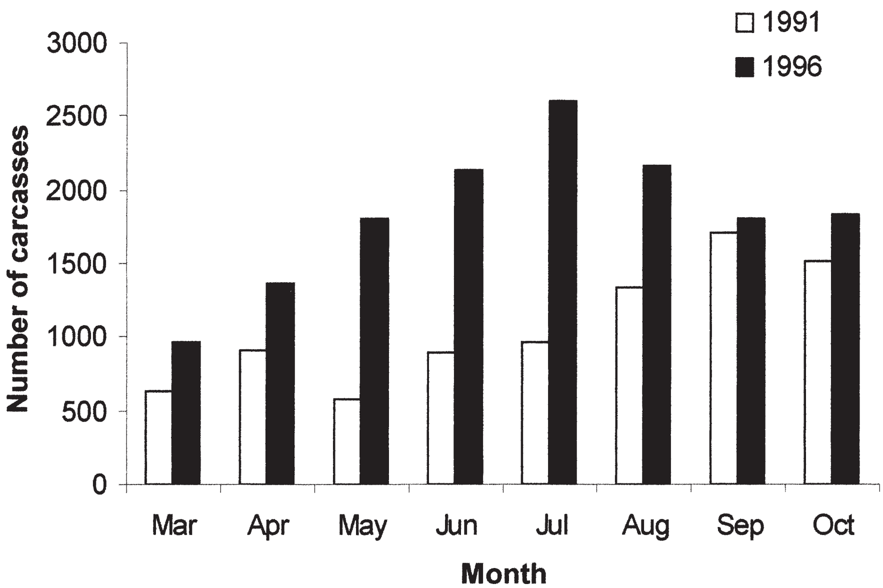

Figure 2. Monthly distribution of the total number of carcasses taken to market in Bioko Island counted in 1991 and 1996.

corded carcasses monthly, but percent contribution fell gradually for all other species. In 1996, *C. emini* and *C. monticola* represented about 30% of the carcasses each month. *Atherurus africanus* was the next most represented species at 10%. In contrast to the 1991 pattern, however, all other species were below 3% of the monthly totals.

Abundance and Availability of Species

By species, average availability (mean ± SD) in 1991 was 36.2 ± 29.1% (median 32.8%) and was not significantly lower in 1996 (31.4 ± 34.1%; median 13.2%) ($\chi^2 = 0.34$ df = 1). Mean daily abundance was not significantly different between years (1991, 7.6 ± 5.8 carcasses/day, median 6.7 carcasses/day; 1996, 5.2 ± 9.2 carcasses/day; median 1.9 carcasses/day) ($\chi^2 = 0.01$ df = 1). The most numerous species, which were the same in both years, increased in total number of carcasses. The rest of the species decreased in number of carcasses, except for the hyrax and python, which had only modest numbers in both years. Of the 14 species found in the 2 years, 5 were more abundant in 1996 than in 1991 (Fig. 4): *C. emini* was represented by almost 200% more; *P. sebae*, *C. monticola*, and *D. dorsalis* by 100% more, and *A. africanus* by 36% more.

In both years, high-availability species were also those that were the most abundant (Fig. 5). There were clear differences in the shape of the regression lines, largely because of a concentration of species of low daily abundance values (1–5 carcasses/day) but of wide-ranging availability values in 1996.

By species, availability in 1991 was highest for *C. monticola* on sale on almost every market day sampled (98.8%). The second most available species was *A. africanus* (81.4%), followed by *C. emini* (73.6%), Ogilby's duiker (*Cephalophus ogilbyi*, 66.9%), and the red-eared guenon (*Cercopithecus erythrotis*, 65.2%). Availability was lower for drill (*Mandrillus leucophaeus*, 50.2%), Pennant's red colobus (*Piliocolobus pennanti*, 49.7%), the black colobus (*Colobus satanas*, 41.7%), and Spot-nosed monkey (*Cercopithecus nictitans*, 31.4%). The least available species were the crowned guenon (*Cercopithecus pogonias*, 7.3%) and the tree hyrax (3.4%). In 1996, *C. monticola*, *A. africanus*, and *C. emini* were available almost daily, with availability of 98.3%, 98.3%, and 97.8%, respectively, followed by *C. ogilybi* (89.3%), *C. erythrotis* (67.9%), and the three-toed pangolin (*Phataginus tricuspis*, 57.9%). Availability was lower for *C. satanas* (39.9%), *M. leucophaeus* (35.9%), and Preuss's guenon (*Cercopithecus preussi*, 24.4%). Other species, such as *C. nictitans* (15.2%), *Varanus niloticus* (15.2%), the African giant squirrel (*Protoxerus stangeri*, 14.6%), *P. pennanti* (12.9%), and *D. dorsalis* (11.2%), were less available. Infrequent species, those with an availability of <10%, were mostly birds: African Goshawk (*Accipter tachiro*, 7.3%), Great Blue Turaco (*Corythaela cristata*, 2.3%), Palm-nut Vulture (*Gypohierax angolensis*, 1.1%), Black-wattled Hornbill (*Ceratogymna atrata*, 1.1%), African python (*Python sebae*, 5.6%), and crowned guenon (*Cercopithecus pogonias*, 2.8%).

Estimated daily abundance of prey species for 1991 showed that the most abundant animals in market were *C. monticola* (11.6 carcasses/day) and *C. emini* (11.6 carcasses/day) followed by *A. africanus* (6.9 carcasses/day) and *C. satanas* (5.3 carcasses/day). Other primate species appeared in the market at between 2.7 carcasses/day for *C. nictitans* and 4.3 carcasses/day for *C. erythrotis.* The least abundant species were *P. sebae* (0.5 carcasses/day) and *D. dorsalis* (0.3 carcasses/day). In 1996, the most abundant species were *C. emini* with 33.9 carcasses/day and *C. monticola* with 29.0 car-

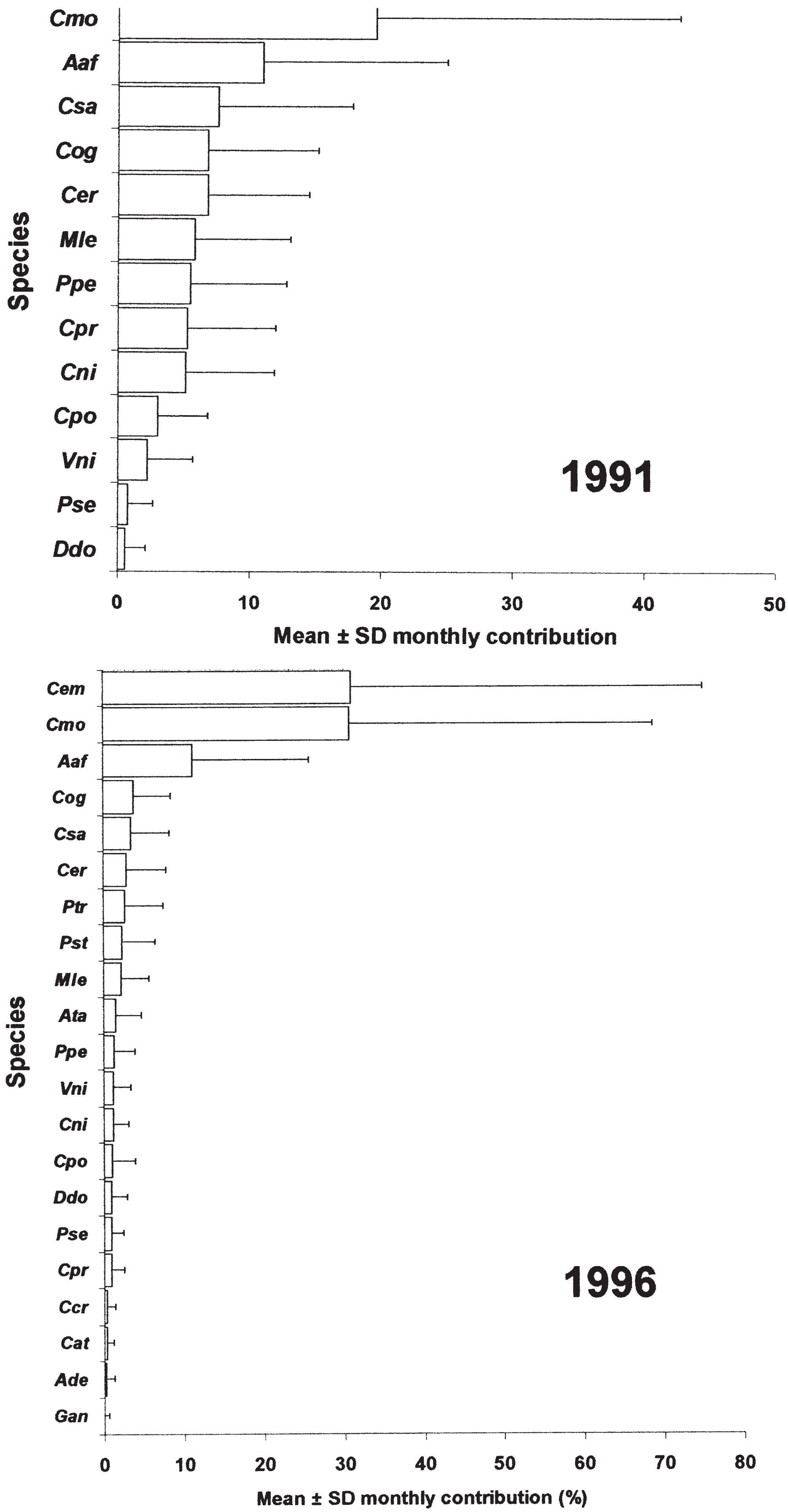

Figure 3. Mean (±SD) percent monthly contribution of carcasses of each species in 1991 and 1996. Species abbreviations are in Table 1.

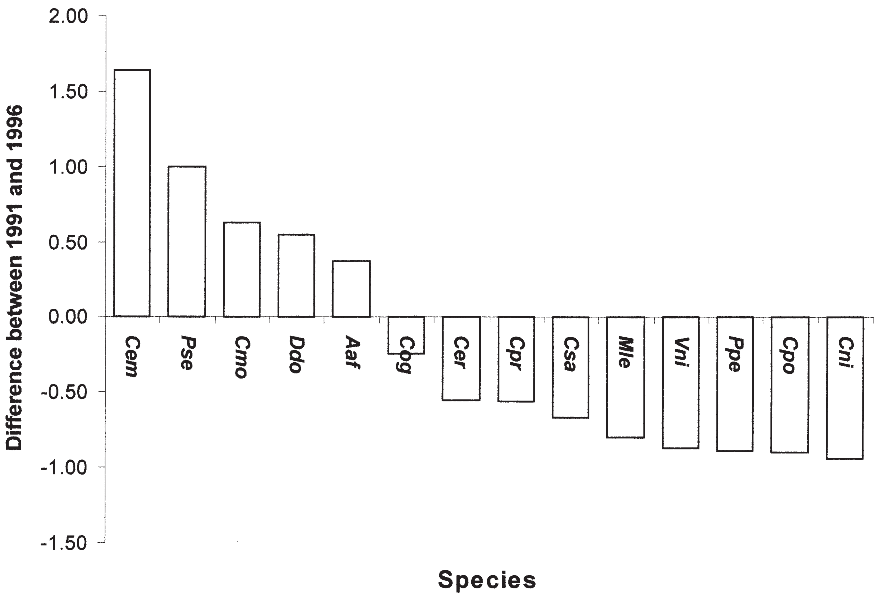

Figure 4. Differences in the total number of carcasses between 1991 and 1996 expressed as the number of times above or below the 1991 figures. Only species that were present in both years are included. Species abbreviations are given in Table 1.

casses/day. The next most abundant species was *A. africanus* (13.0 carcasses/day), but all others ranged between 1.0 carcass/day (*Gypohierax angolensis*) and 3.4 carcasses/day (*C. ogilbyi*).

Discussion

As far as we know, our studies in Bioko are the first to provide longitudinal information on daily composition and quantity of bushmeat supplied to a main consumer town in West Africa. Our data also furnish a unique comparison of two wet seasons separated by a 5-year interval. We found, not unexpectedly, that the predicament of prey populations in Bioko may have worsened considerably between the two dates. This is inferred from the observation that even though almost 60% more carcasses entered the market in 1996, the increase in biomass was significantly less, only 12.5%. The increase in 1996 was due primarily to the appearance of a larger number of carcasses of the smaller-bodied species, including rodents and the blue duiker. Although an additional four bird species and one squirrel were recorded in 1996, these were less important in terms of their contribution to biomass or carcass numbers. Concurrently, there was a dramatic reduction in the larger-bodied species, the Ogilby's duiker and the seven diurnal primates.

Prior to independence, shotguns were common in Bioko. They were used to control tree squirrels in the cocoa plantations, but also to obtain bushmeat. In 1974, civilians were prohibited from carrying firearms. For example, the remote village of Ureca (200–300 people) had about 25 shotguns prior to 1974, but in 1991 had fewer than 100 people and only one shotgun (Butynski & Koster 1994). There is no doubt that the capacity of hunters to shoot animals on Bioko was much reduced after 1974 and that the effects of hunting on wildlife, particularly primates, were greatly dampened (Butynski & Koster 1994).

Since the change of government in 1989, civilians may own shotguns (rifles are not permitted) once they obtain a permit. Ammunition is readily available in the markets. The number of hunters operating in Bioko is difficult to calculate. Juste (1992) and later Castroviejo (1995) estimated around 200 guns operating on the island. There is no indication that the number of firearms has diminished since Castroviejo's study; in fact, there is a strong possibility they have increased. It is certain from information on hunting localities, collected simultaneously with the carcass data (Fa et al., unpublished data), that there has been a displacement of hunting activity away from the Pico Basilé in the north to the southern highlands. This is probably a reflection of the depletion of prey numbers in the Pico Basile areas (Fa 2000), which are the suburbs of the more populated capital city. Presumably because of an increase in hunting in the southern areas over the last 10 years, G. Hearn and co-workers infer a decline in primate encounter rates from surveys in the interior of the Gran Caldera de Luba. Hearn and Berghaier (1996) showed that, from 2.0 groups/km in 1986, encounter rates fell to 1.7 groups/km in 1990 (Schaaf et al. 1990, 1992) and to 1.2 groups/km by 1996 (Hearn & Berghaier 1996). These survey results and our bushmeat market surveys indicate that the larger monkeys (drill, black colobus, red colobus, Preuss's guenon) and the larger duiker are becoming scarcer. Alongside this, there has been no enforcement of the hunting law enacted in 1988 (Ley 8/1988 Reguladora de la Fauna Silvestre, Caza y Areas Protegidas; Castroviejo et al. 1994), which means that hunting activities went unchecked between 1991 and 1996.

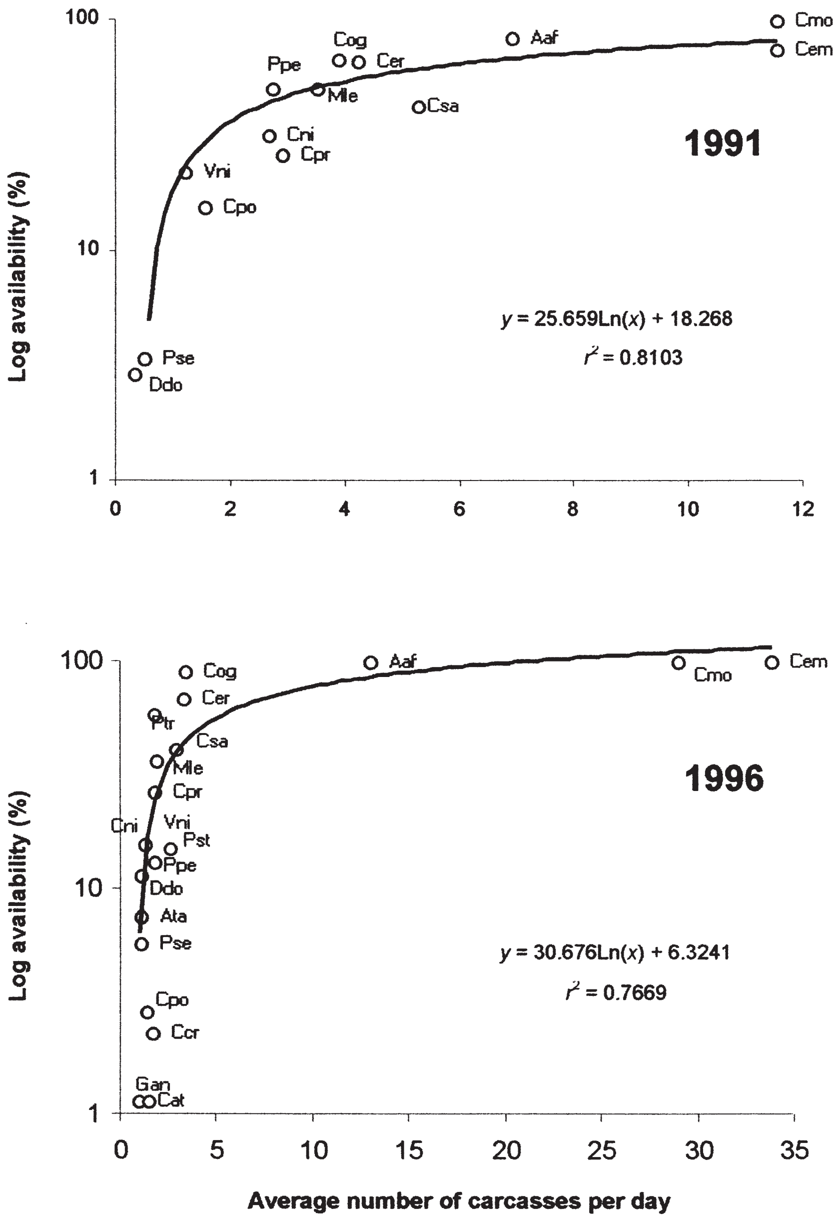

Figure 5. Relationship between the average number of carcasses per day and percent availability for all species recorded in the Malabo Market in 1991 and 1996. Species abbreviations are given in Table 1.

Another reason for the decline in larger prey in the market could be that hunters concentrated on trapping rather than hunting with shotguns. Wire traps (snares) are frequently used to catch blue duikers and smaller mammals, particularly *C. emini* and *A. africanus,* but shotguns are used to hunt primates and the larger duiker (Colell et al. 1994). The probable shift in hunting technique, if there has been one, is much more likely to have been caused by the scarcity of larger prey rather than by a deliberate move by hunters to supply smaller game to the market. This is because the return in terms of kilogram of meat per unit hunting effort is always greater for shooting than for snaring (Noss 1995). In moderately hunted areas in southeastern Bioko, Colell et al. (1994) found that hunters harvested around 2.9 animals/trip (or 25.7 kg of dressed meat/trip) using shotguns; they harvested slightly more animals (3.6 animals/trip) but significantly less meat per trip with snares (14.1 kgs of dressed meat/trip). In Colell et al.'s study, snaring success varied according to the species' propensity for being caught and its relative density: rodents (mostly *C. emini*) were caught at a rate of 0.04 animals/trap, ungulates (mostly *C. monticola*) at 0.02 animals/trap, and primates at 0.003 animals/trap. Weekly yields from snare trapping and hunting averaged 17.9 kg per hunter (Colell et al. 1994), but Castroviejo (1995) thinks it could be up to 70 kg. Assuming that all marketable meat is sold, annual yields in Bioko may average around 240,000–540,000 CFA francs (US$ 1 = approximately 541.61 CFAs, 1997 rate) per hunter (Castroviejo 1995). The upper estimate of such annual earnings is considerably higher than those calculated for Cameroon (350,000

CFAs) by Infield (1988) and for hunters in the Central African Republic (360,000 CFAs) by Noss (1995). Average weekly yields from hunting far exceed the official minimum wage.

Hearn and Berghaier (1996) suggest that most people in Bioko have ready access to an abundant source of saltwater fish protein, which reduces hunting of terrestrial animals for meat. Despite the fact that eating fish could have some buffering effect, fish consumption in Bioko, as in other parts of Africa, is still infrequent (Simoons 1974). The undisputed reality is that in West Africa, bushmeat is preferred over any other source of animal protein (Njiforti 1996). In a study of meat preferences (Fa et al., unpublished data), the most favored meats were generally those of the commonest species in the market: (*C. monticola, A. africanus*, and *C. emini).* If these species are favored, the situation for Bioko's wildlife is more precarious than has been thought.

Although speculative, our 1996 findings could be interpreted as a reflection of buyers demanding the smaller, more commercial species. An alternative explanation is that, in the face of a deteriorating national economy, the increase in supply of cheaper game might have been deliberately brought about by hunters to bolster their profit margins. But if higher prices are likely to be paid for the rarer meat (average prices have indeed increased by about 30% in the last 10 years), this might encourage hunters to pursue these species even more, thus driving them further to extinction. Elsewhere, Fa et al. (1995) and Fa (2000) have shown that the 1991 market harvests already exceeded sustainable levels for most primates and for *C. ogilbyi.* Slade et al. (1998) demonstrated that Cole's (1954) maximum finite rate of population increase formula, used to calculate maximal production rates (Robinson & Redford 1991) by Fa et al. (1995) and Fa (2000), may underestimate overharvesting. This may be so even in highly productive species such as *C. monticola* and *P. pennanti.* Given this, the real picture of faunal exploitation in Bioko is one that should cause alarm and concern.

Although data on the actual condition of prey populations are required, what may be happening in Bioko is a spiraling relationship between diminishing supply and increasing demand for bushmeat. Hence, as the larger, more expensive (and, for hunters, more profitable) prey dwindles, prices for these may rise so that progressively fewer people can afford to buy them, but there will always be some who can pay a high price. This in turn could force hunters to move on to the supply of smaller prey, rats and porcupine. These are likely to be bought by more people because they are cheaper and preferred, thus maintaining the hunters' profits for at least a while until this quarry is exhausted. The shift to smaller game may create a respite for the scarcer large prey. Whether such a forced moratorium benefits these species will depend on the level at which these prey populations are left and if hunters are not forced to look for rare meat species to supply some buyers that may be prepared to pay more. Fa (2000) shows that there is a chance that only nonviable populations of the larger duiker and primates remain.

We hope that our data do not present merely a passive witness to the extinction of many of Bioko's mammals. Our information is an underestimate of the situation because we cannot account for the numbers of animals that are hunted in villages, animals bought on the way to market, and—most important—animals that escape with injuries, decompose in traps, or become food for scavengers. In the only study on the subject, in Bayanga, Central African Republic, Noss (1995) reported up to 40% wastage in some species caught in snares.

Wilkie et al. (1998) suggest that, at least for the less complicated Ituri Forest Reserve, creating protected areas (reservoir areas) without curbing demand for bushmeat outside them is insufficient to prevent the extirpation of bushmeat species. In Africa, defaunation is probably more of a critical worry than is deforestation. Conservation biologists who want to influence policy must realize that it is not enough to amass biological data without reaching a better understanding of the composition and function of the systems that they would like to protect, including the human processes that affect them (Wilkie 1989; Wilkie et al. 1992, 1998, this issue; Noss 1997).

Bioko is of international conservation importance because it contains a number of endemic subspecies of mammals and birds as well as relatively pristine areas (Lee et al. 1988; Fa 1992*a*, 1992*b*; Juste & Fa 1994; Perez del Val et al. 1994). There will be nothing left to conserve if people are not assisted in meeting their daily needs. Lasting changes will come from fundamental alterations in attitudes and behavior. So far, few if any projects have managed successfully to balance the dietary needs of the human population and the conservation of prey species. Multilateral organizations working in agriculture have been somewhat narrow-minded and have had little interaction with resident biologists. Similarly, biologists have not been overly concerned with providing alternative bushmeat (Feron 1995), or they are convinced that enough animal protein will be produced from rearing wild species as "minilivestock" (Emmons 1992; Fa 2000).

The Amigos de Doñana's project (Proyecto de Conservación y Ecodesarrollo en el Sur de la Isla de Bioko) offers some hope in that it has been successful so far. Through active involvement with the Ureca village people, this nongovernmental organization has been able to control sea turtle exploitation by providing alternative employment to villagers and by using villagers to monitor and protect turtle nesting sites. Balancing human needs and protein demands throughout the island is a much taller order. Solutions must be sought that involve all stakeholders implicated in the use of natural resources. Although the situation is complicated, Bioko can provide an excellent opportunity to integrate human development requirements and conservation of wildlife because (1) Bioko is an island and therefore is a more contained situation to work in than the mainland; (2) there are few transport routes to and from market, which makes accurate monitoring of supply possible; (3) urban consumption of bushmeat is restricted essentially to one large town; and (4) other pressures such as deforestation and expanding agriculture are unlikely to occur in the near future to influence wildlife. The intervention and collaboration of all interested parties to promote public awareness and find realistic alternative protein sources for consumers must be financed and achieved immediately if practical approaches to the sustainable management of wildlife in Bioko are to be developed.

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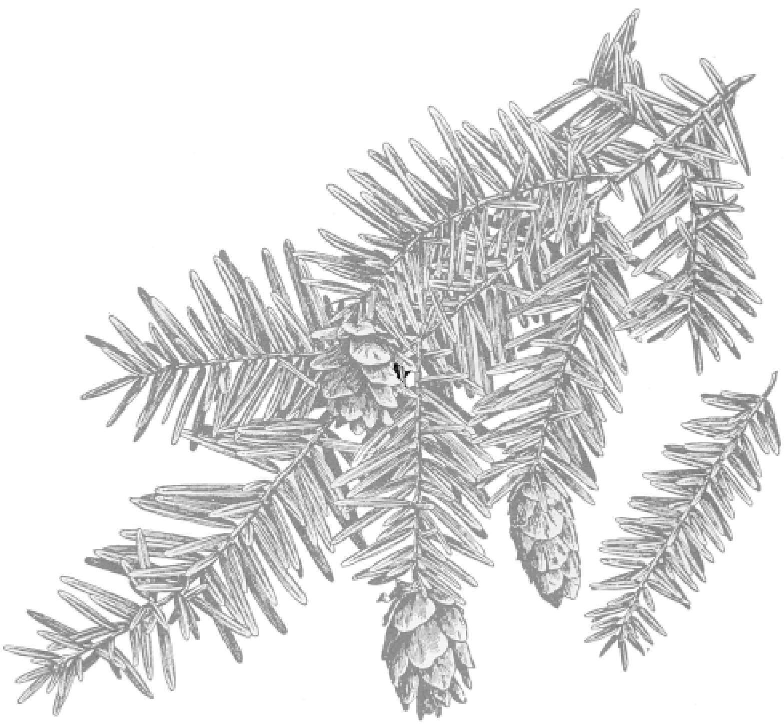

Appendix
Number of bushmeat carcasses counted and estimated biomass per month by species on Bioko Island.

*Year/ taxonomic group/ family/species**	*Body mass (g)*	*Number of carcasses*								*Biomass (kg)*							
		Mar	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*
1991																	
Mammals																	
Artiodactyla																	
Cephalophus monticola	5000	210	257	180	277	289	363	507	486	1050	1285	900	1385	1445	1815	2535	2430
Cephalophus ogilbyi	19000	64	71	54	65	65	78	83	79	1216	1349	1026	1235	1235	1482	1577	1501
Hyracoidea																	
Dendrohyrax dorsalis	3000	0	0	0	1	0	10	0	0	–	–	–	3	–	30	–	–
Primates																	
Cercopithecus erythrotis	4273	33	55	45	77	79	92	138	103	141	235	192	329	338	393	590	440
Cercopithecus nictitans	8700	5	33	8	17	6	35	48	72	44	287	70	148	52	304	418	626
Cercopithecus pogonias	1346	2	5	4	5	6	4	11	8	3	7	5	7	8	5	15	11
Cercopithecus preussi	9650	6	16	4	9	12	27	47	59	58	154	39	87	116	261	454	569
Colobus satanas	12000	44	67	43	34	61	51	38	54	528	804	516	408	732	612	456	648
Piliocolobus pennanti	7989	26	37	26	25	34	44	48	61	208	296	208	200	272	351	384	487
Mandrillus leucopheus	14925	6	30	35	68	66	87	67	70	90	448	522	1015	985	1299	1000	1045
Rodentia																	
Atherurus africanus	4000	68	88	106	131	165	203	233	320	340	352	424	524	660	812	932	1280
Cricetomys emini	2000	162	234	57	185	183	333	464	276	324	468	114	370	366	666	928	552
Reptiles																	
Serpentes																	
Python sebae	2500	1	2	1	0	0	0	0	0	2	5	3	–	–	–	–	–
Sauria																	
Varanus niloticus	1000	9	10	11	0	1	10	17	2	9	10	11	–	1	10	17	2
Total		636	905	573	894	967	1337	1701	1515	4012	5700	4030	5710	6209	8041	9304	9592
1996																	
Mammals																	
Artiodactyla																	
Cephalophus monticola	5000	373	510	708	671	933	814	530	535	1865	2550	3540	3355	4665	4070	2650	2675
Cephalophus ogilbyi	19000	49	67	72	82	74	83	57	55	931	1273	1368	1558	1406	1577	1083	1045
Hyracoidea																	
Dendrohyrax dorsalis	3000	6	0	6	4	3	3	0	1	18	–	18	12	9	9	–	3
Pholidota																	
Phataginus tricuspis	2500	11	17	27	27	18	39	28	30	27	42	68	67	45	98	70	75
Primates																	
Cercopithecus erythrotis	4273	43	79	71	76	49	39	16	28	183	337	303	325	209	167	68	120
Cercopithecus nictitans	8700	19	0	5	2	1	1	2	4	165	–	44	17	9	9	17	35
Cercopithecus pogonias	1346	0	0	0	0	1	0	0	4	–	–	–	–	1	–	–	5
Cercopithecus preussi	9650	0	0	23	22	11	16	6	1	–	–	222	42	106	154	58	10
Colobus satanas	12000	42	39	30	26	32	18	11	15	504	468	360	312	384	216	132	180
Piliocolobus pennanti	7989	8	0	12	5	4	9	2	2	64	–	96	40	32	72	16	16
Mandrillus leucophaeus	14925	17	12	24	31	9	10	9	5	253	179	358	463	134	149	134	75
Rodentia																	
Atherurus africanus	4000	13	202	308	241	395	412	230	214	52	808	1232	964	1580	1648	920	856
Anomalurus derbianus	775	0	0	3	0	0	0	0	0	–	–	2	–	–	–	–	–
Cricetomys emini	2000	373	430	508	934	1040	699	890	929	746	860	1016	1868	2080	1398	1780	1858
Protoxerus stangeri	770	1	0	2	7	18	18	18	3	1	–	2	5	14	14	14	2
Birds																	
Falconiformes																	
Accipiter tachiro	2000	3	0	0	0	0	0	1	1	6	–	–	–	–	–	2	2
Gypohierax angolensis	2000	0	0	1	5	5	0	1	2	–	–	2	10	10	–	2	4
Coraciiformes																	
Ceratogymna atrata	2000	0	0	0	0	2	0	0	1	–	–	–	–	4	–	–	2
Cuculiformes																	
Corythaeola cristata	1000	0	0	3	2	0	0	0	0	–	–	3	2	–	–	–	–
Reptiles																	
Serpentes																	
Python sebae	2500	1	1	2	1	1	1	0	3	3	3	5	3	3	3	–	8
Sauria																	
Varanus niloticus	1000	8	12	3	2	2	0	0	1	8	12	3	2	2	–	–	1
Total		967	1369	1808	2138	2598	2162	1801	1834	4827	6532	8641	9215	10693	9583	6947	6971

**Body mass data are taken from Fa and Purvis (1997). Species name follow Kingdon (1997).*