Impact of Market Hunting on Mammal Species in Equatorial Guinea

JOHN E. FA,* JAVIER JUSTE,† JAIME PEREZ DEL VAL,‡ AND JAVIER CASTROVIEJO†

*Jersey Wildlife Preservation Trust, Les Augrès Manor, Trinity, Jersey JE3 5BF, Channel Islands, email itc@itl.net
†Estación Biológica de Doñana, C.S.I.C., Pabellon del Perú, Apartado Postal 1056, 41080 Sevilla, Spain
‡Cooperación Española, Malabo, Guinea Ecuatorial

Abstract: *The impact of commercial hunting on forest mammals was studied in two regions on Bioko and Rio Muni in Equatorial Guinea, west Africa. Harvests were assessed from carcass counts in the main markets in the areas. A total of 10,812 carcasses of 13 species were recorded in Bioko, and 6160 carcasses of 30 species were recorded in Rio Muni. Biomass of harvested mammals was 111,879.63 kg in Bioko and 66,447.87 kg in Rio Muni. For the 12 prey species selected for study in Bioko, harvests totaled 7.15 animals/km^2 or 62.93 kg/km^2. Harvests for the 17 prey species in Rio Muni were 3.22 animals/km^2 or 24.06 kg/km^2. We used a model developed by Robinson and Redford (1991) to estimate potential harvests based on animal production rates. Total production was 147.90 animals/km^2 and 139.12 animals/km^2 in Bioko and Rio Muni, respectively. Potential harvest figures varied considerably by species. Comparison of actual and potential harvests showed that five primate species (*Cercopithecus erythrotis, Cercopithecus nictitans, Cercopithecus pogonias, Cercopithecus preussi, *and* Mandrillus leucophaeus*) and one ungulate (*Cephalophus ogilbyi*) in Bioko were being hunted unsustainably. Only two of the 17 species (*Cercopithecus nictitans *and* Cephalophus dorsalis*) in Rio Muni were being hunted unsustainably. Percent deviation of actual from potential harvests averaged 4.98 times greater than sustainable harvest in Bioko and 1.03 times greater in Rio Muni. For the two sites together figures ranged from close to 28 times greater than potential to 0.08% of the potential harvest. Although hunting methods and the commercialization potential of species may affect their presence in markets, these figures show that Bioko animals are heavily exploited, some of them unsustainably. This poses severe risks for the conservation of the island's unique fauna that must be addressed immediately.*

Impacto de la caza comercial sobre las especies de mamíferos en Guinea Ecuatorial

Resumen: *El impacto de la caza comercial de mamíferos de la selva fue estudiado en dos regiones, en Bioko y Río Muni, en Guinea Ecuatorial, Africa Occidental. Las cosechas fueron estimadas a partir del conteo de animales muertos en los principales mercados del área. Un total de 10,812 animales muertos de 13 especies fueron documentados en Bioko y 6160 animales muertos de 30 especies fueron documentados en Río Muni. La biomasa de los mamíferos recolectados fue de 111,879 kg en Bioko y 66,447.87 kg en Río Muni. Para las 12 especies de presas seleccionadas para su estudio en Bioko, la recollección totalizó 7.15 animales/km^2 o 62.93 kg/km^2. La recolección para las 17 especies de presa en Río Muni fue de 3.22 animales/km^2 o 24.06 kg/km^2. Utilizamos un modelo desarrollado por Robinson y Redford (1991) para estimar las cosechas potenciales basadas en las tasas de producción animal. La producción total fue de 147.90 animales/km^2 y 139.12 animales/km2 en Bioko y Río Muni respectivamente. Las cifras sobre la cosecha potencial varariaron considerablemente entre las distintas especies. Las comparaciones de las recolecciones reales y las potenciales mostraron que cinco especies de primates (*Cercopithecus erythrotis, Cercopithecus nictitans, Cercopithecus pogonias, Cercopithecus preussi *y* Mandrillus leucophaeus*) y un ungulado (*Cephalophus ogilbyi*) en Bioko estaban siendo cazadas en forma no-sostenible. Solamente 2 de las 17 especies (*Cercopithecus nictitans *y* Cephalophus dorsalis*) en Río Muni estaban siendo cazadas en forma no-sostenible. La desviación del porcentaje de recolección real con respecto al potencial, fue en promedio 4.98 veces mayor al de la recolección sostenida en Bioko y 1.03 veces mayor en Río Muni. Para los dos sitios juntos, las cifras oscilaron entre 28 veces mayor que la co-*

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secha potencial a un 0.08% de la cosecha potencial. Si bien los métodos de caza y el potencial de comercialización puede afectar su presencia en los mercados, las cifras actuales muestran que los animales en Bioko estan severamente explotados, alguno de los cuales en forma no-sostenible. Esto plantea severos riesgos para la conservación de la singular fauna de la isla, por lo que este problema debe ser tratado en forma inmediata.

Introduction

Wild animals are an important source of protein in many tropical forest countries in Africa (Ajayi 1971, 1983; Adeola & Decker 1987). For exploited species, it is important that the rate of harvest does not exceed that of production because over-exploitation leads to depletion. Harvest should be a replaceable form of mortality and should substitute for some of the natural, annual mortality rather than increasing total mortality of a population (Caughley 1977).

Robinson and Redford (1991) developed a simple model to provide estimates of potential (sustainable) harvest rates for different neotropical forest mammals. They focused on species traditionally important to subsistence hunters and calculated maximum production for a species (in numbers of animals/km^2) as the number produced yearly under optimal conditions. They used measures of population density and the intrinsic rate of natural increase to estimate potential harvest rates for different species. This provides a figure for the optimum sustainable harvest when production is at a maximum and harvesting has minimal effects on the natural population. The optimum sustainable population is the number of animals of a species that results in maximum productivity but not exceeding the carrying capacity of the habitat. Assessing the impact of hunting on wildlife populations is thus possible when figures generated by the model are compared to actual harvest data. These comparisons are useful in situations in which detailed life-history parameters for accurate estimates of the effect of hunting on population structure are not available.

In countries where commercial hunting of game for human consumption is important, data from markets can provide short- and long-term insight into the impact of hunting on bushmeat species. In Africa, counts of numbers of mammals, birds, and reptiles entering markets can provide understanding of seasonal and longitudinal dynamics of wildlife use and exploitation (Colyn et al. 1987; Kalivesse 1991) and even the biology of species (Gevaerts 1992). We examined the impact of harvests for some mammal species by relating calculated potential harvests with actual take levels. We examined only those species that comprised a minimum of 1.5% of the total weight of game taken and for which data on density and life-history parameters were available.

Methods

Study Area

Equatorial Guinea consists of a territory on the African mainland, Rio Muni, (26017 km^2) and five islands. Rio Muni is bordered by Cameroon to the north, Gabon to the east and south, and the Gulf of Guinea to the west. The two most important islands are Bioko (formerly Fernando Poo, 2017 km^2) and Annobon (formerly Pagalú, 17 km^2). Intact tropical rainforest is found a few kilometers inland from the coast and still covers most of the country, 59% of Rio Muni and 28% of Bioko. Although the amount of primary rainforest in Bioko is low, because most forest was cut to plant cacao, most of the island is covered in well-conserved, tall secondary forest (Fa 1992*a*).

Harvest Data

Hunting in Equatorial Guinea is practiced openly and intensively by professional hunters, and meat is brought into markets throughout the year. Unlike other West African countries, there are no closed hunting seasons.

From October 1990 through October 1991, harvest information was collected from two market sites (Mundoasi and Central) in Bata, Rio Muni, and from the principal market (Mercado Central) in Malabo, Bioko Island. The latter market is divided into separate sections (Luba and Riaba).

Vertebrate carcasses were counted by the authors and by trained, local observers familiar with all entry points of bushmeat to the markets and the species concerned. Reliability was checked regularly. Species were recorded by their common names to avoid confusion in nomenclature. Sampling was conducted on 424 market days, 212 at each locality. Game was brought in daily by intermediaries between hunters and market-stand proprietors. We visited the markets daily between 0630 hours and 1200 hours because all meat arrives to be sold between 0700 and 1100 every morning. Only fresh carcasses were counted, although some smoked meat is brought in. Numbers of carcasses recorded represent minimum extraction because some game is consumed in villages or sold before it reaches the market (Colell et al. 1995). Age and sex information was not recorded. Nomenclature follows Haltenorth and Diller (1987).

Analysis

Prey species biomass was calculated by multiplying the number of animals by the individual species weights. Because as some of the carcasses for sale are young animals, this method tends to overestimate the total weight of meat sold.

Hunting areas that supply the market sites were designated "reservoir areas." Market species restricted to riverine or swamp forests (collared mangabey, *Cercocebus torquatus*; De Brazza's monkey, *Cercopithecus neglectus*; water chevrotain, *Hymoschus aquaticus*; grey-cheeked mangabey, *Lophocebus albigena*; otter, *Lutra maculicollis*; talapoin, *Miopithecus talapoin*; Bates' dwarf antelope, *Neotragus batesi*; sitatunga, *Tragelaphus spekei*) were not included in these analyses because of difficulties in measuring the size of these areas. The size of terra firme areas was determined, conservatively, from interviews with hunters in both localities.

In Bioko, hunters sending meat to the Luba market section use the Malabo/Luba districts, especially the western slopes of Pico Basilé and the northern slopes of the Gran Caldera de Luba. The island's eastern districts of Baney and Riaba and areas stretching into the south-eastern highlands and coast serve the Riaba market section. In Rio Muni, meat primarily from the Litoral district ($\leq$2,000 km^2) enters both markets. Because Bioko primates are restricted to certain parts of the island, distribution data gathered by Butynski and Koster (1995) were used to calculate reservoir areas for these species.

Production for each species was determined using information on population density at carrying capacity, the maximum rate of population increase, and the density that produces the maximum sustained yield. We used data on observed densities of species, as opposed to predicted densities (see Robinson & Redford 1991). Average densities (number of animals/km^2) were taken from an extensive survey of the relevant literature. No density information was obtained for *Dendrohyrax dorsalis*, Crossarchus spp., *Manis gigantea*, and *Thryonomys swinderianus*, so these species were not included.

Optimum harvest was considered the number of animals of a species that can be removed (per kilometer) by humans every year without altering the size of the standing population and was determined using Robinson and Redford's (1991) harvest model. To calculate production (P_{max}, the addition to the population through births and immigrations), these authors assumed that realistic maximum figures would occur at 60% carrying capacity to accommodate variation related to density dependence and birth rates. Hence,

$$P_{\max} = (0.6\ D \times 1\max) - 0.6\ D,$$

where D is the population density and 1max the maximum finite rate of increase of the species. Maximum finite rate of increase is the exponential of the intrinsic rate of increase ($e_{r\max}$) and is the increase in the population size from time t to time $t \pm 1$. Variables such as density and intrinsic rate of increase in mammals have been shown to be predictably related to their body mass and trophic level occupied (Peters 1983; Robinson & Redford 1986). Maximum finite rate of increase was calculated using age at first birth (a), age at last reproduction (w), and birth rate of female offspring (b) from Cole's (1954) equation.

$$1 = e^{-rm} + be^{-rm(a)} - be^{-rm(w+1)}.$$

For the calculation of r_{max}, female age at first reproduction and total number of infants born per year were taken from a variety of sources. Figures for primates came from references contained in Ross (1988, 1992); those for duikers were derived from Payne (1992). For rodents, pangolins, and carnivores, information was extracted from Estes (1991) and Nowak and Paradiso (1992). Annual female birth rate (number of female offspring born per year) was calculated from mean interbirth interval and litter size, and we assumed that all species have a sex ratio at birth of 1:1. Data on age at last reproduction is not usually available for most species, but longevity is more often recorded. Therefore, maximum recorded longevity, L, was used as a substitute for w when we calculated r_{max}, as employed by Ross (1992). Data used are given in Table 1.

Potential harvest was calculated from production figures. Because the longevity of a species is a good index of the extent to which harvesting takes animals that would have died anyway (species were divided into three categories: long-lived, >10 years; short-lived, 5-10 years; and very short-lived <5 years), Robinson & Redford (1991) assumed that harvest could take 60% of the production in very short-lived species, 40% in short-lived, and 20% in long-lived.

Exploitation levels of each prey species were assessed by comparing production figures for each species with the volume observed in markets. This yielded a figure that was converted to a percentage to denote the deviation of actual from potential harvests.

Results

Thirteen species of mammals in Bioko Island and 29 (including the eight riverine species) in Rio Muni were recorded (Juste et al. 1995). Five species (38.5%), including endemic subspecies such as Preuss's guenon (*Cercopithecus preussi insularis*), russet-eared guenon (*Cercopithecus erythrotis erythrotis*), drill (*Mandrillus leucophaeus poensis*), and red colobus (*Procolabus badius pennanti*), were unique to Bioko, whereas 24 (82.8%) were found only in the continental sites.

Table 1. Body mass, diet classification, and reproductive characteristics of mammal species used as bushmeat in Equatorial Guinea.

Species	*Diet**	*Body Mass (g)*	*Age of First Reproduction (years)*	*Birth Rate (no/year)*	*Longevity (years)*	*Intrinsic Rate of Natural Increase (rmax)*	*Maximum Finite Rate of Increase (lmax)*
Primates							
Cercopithecus cephus	FO	5550.0	4.00	0.33	30.80	0.11	1.12
Cercopithecus erythrotis	FO	4273.0	3.00	0.50	30.80	0.16	1.17
Cercopithecus mona	FO	2733.0	4.00	0.33	30.80	0.11	1.12
Cercopithecus nictitans	FO	8700.0	5.00	0.33	30.80	0.11	1.11
Cercopithecus pogonias	FO	1346.0	5.00	0.33	28.00	0.01	1.01
Cercopithecus preussi	FO	9650.0	4.00	0.33	30.80	0.11	1.11
Procolabus pennanti	HB	7989.5	4.10	0.47	30.00	0.14	1.15
Colobus satanas	FG	12000.0	4.80	0.96	30.50	0.20	1.22
Gorilla gorilla	FH	117549.4	10.00	0.26	50.00	0.07	1.07
Mandrillus leucophaeus	FO	14925.0	5.00	0.81	28.60	0.18	1.20
Mandrillus sphinx	FO	16440.0	4.00	0.69	46.30	0.18	1.20
Rodentia							
Atherurus africanus	FO	4000.0	2.00	3.00	22.90	0.60	1.82
Cricetomys emini	FO	2000.0	0.40	40.32	7.80	0.70	2.01
Artiodactyla							
Cephalophus dorsalis	FH	20000.0	1.67	1.00	8.00	0.20	1.22
Cephalophus leucogaster	FH	13500.0	0.75	1.00	8.00	0.43	1.54
Cephalophus monticola	FH	5000.0	1.09	0.69	7.00	0.49	1.63
Cephalophus ogilbyi	FH	19000.0	1.67	0.38	8.00	0.23	1.26
Cephalophus sylvicultor	FH	62500.0	1.67	1.00	10.30	0.43	1.54
Potamochoerus porcus	FH	60000.0	1.50	15.60	10.00	0.70	2.01
Pholidota							
Manis triscuspis	MY	2500.0	1.00	2.63	13.10	0.70	2.01
Carnivora							
Civecttictis civetta	FO	10000.0	2.00	4.00	13.00	0.69	1.99
Genetta servalina	CA	1000.0	2.00	3.60	12.50	0.66	1.93
Nandinia binotata	FO	2000.0	2.00	3.60	13.00	0.66	1.93

**CA, carnivore, FG, frugivore-granivore; FH, frugivore-herbivore; FO, frugivore-omnivore; HB, herbivore-browser; MY, myrmecophage.*

We counted 17,571 carcasses (10,812 in Bioko and 6760 in Rio Muni), of which artiodactyls (9 species) accounted for 36.7%, followed by primates (16 species, 26.2%) and rodents (3 species, 21.2%) (Table 2).

Annual harvest was 12,974 animals (111,879.63 kg) in Bioko and 8112 (66,447.87 kg) in Rio Muni ($p < 0.001$). Harvests consisted of 6.49 animals/km^2 or 55.94 kg/km^2 in Bioko and 3.89 animals/km^2 or 33.22 kg/km^2 in Rio Muni (chi-square test, $p < 0.001$). The blue duiker (*Cephalophus monticola*) and Emin's rat (*Cricetomys emini*) in Bioko, and *C. monticola* and the brush-tailed porcupine (*Atherurus africanus*) in Rio Muni, accounted for more than half of all carcasses brought into markets (Juste et al. 1995). *Cephalophus monticola* was the most numerous species in both market sites, representing approximately 30% in each. *Cricetomys emini* was the second most common in Bioko but ranked only eighth in Rio Muni. Three species, *C. monticola*, *C. emini*, and *A. africanus* made up almost 70% of all carcasses on sale on the island. *Cephalophus monticola*, *A. africanus*, and the greater white-nosed monkey (*Cercopithecus nictitans*) represented more than 59% of all carcasses in Rio Muni.

Production and potential harvest estimates are given in Table 3. The high production figures were typical of the rodents and artiodactyls; the lowest figures were recorded for primates.

Figure 1 shows the percentage deviation of actual takes from potential harvest for all species in Bioko and Rio Muni markets. Percentage deviation of actual from

Table 2. Number of species (*S*) and individuals (*N*) in mammalian groups available in market sites in Bioko (Luba and Riaba) and Rio Muni (Central and Mundoasi).

Group	*S*	*N*	*%*	*S*	*N*	*%*	*S*	*N*	*%*
	Luba			Riaba			Totals		
Artiodactyla	2	2134	34.70	2	1779	38.15	2	3913	36.19
Primates	7	1652	26.87	7	1044	22.39	7	2696	24.94
Pholidota	1	119	1.94	1	73	1.57	1	192	1.78
Hyracoidea	1	7	0.11	1	4	0.09	1	11	0.10
Rodentia	2	2237	36.38	2	1763	37.81	2	4000	36.99
Totals	13	6149		13	4663		13	10,812	
	Central			Mundoasi			Totals		
Artiodactyla	8	1294	41.29	8	1594	43.95	8	2888	42.73
Primates	10	790	25.21	11	738	20.35	11	1526	22.58
Carnivora	4	43	1.37	4	78	2.15	5	121	1.79
Edentata	2	56	1.79	2	56	1.54	2	112	1.66
Hyracoidea	1	1	0.03	1	1	0.03	1	2	0.03
Rodentia	3	950	30.31	3	1160	30.86	3	2110	31.22
TOTALS	28	3134		29	3627		30	6759	

Table 3. Comparisons of observed harvest, calculated production, and sustainable harvest for bushmeat species in Equatorial Guinea.

Site and Species	*Observed Density (no/km²)*	*Observed Harvest (no/yr)*	*Animals Harvested (per km²)*	*Biomass Harvested (gms/km²)*	*Production (no/km²)*
BIOKO					
Primates					
Cercopithecus erythrotis	24.70	781	0.16	683.68	2.64
Cercopithecus nictitans	22.70	254	0.49	4263.00	0.12
Cercopithecus pogonias	14.40	52	0.56	753.76	0.08
Cercopithecus preussi	9.90	196	0.65	6272.50	1.51
Colobus satanas	20.40	514	0.29	3480.00	2.72
Mandrillus leucophaeus	6.70	551	0.29	4328.25	0.79
Procolobus pennanti	156.30	348	0.66	5273.07	14.09
Rodentia					
Atherurus africanus	55.00	1581	0.79	3160.00	27.12
Cricetomys emini	134.00	2419	1.21	2420.00	81.49
Artiodactyla					
Cephalophus ogilbyi	13.00	3181	1.59	30210.00	2.02
Cephalophus monticola	22.60	732	0.37	1850.00	8.68
Pholidota					
Manis tricuspis	10.90	192	0.10	240.00	6.63
TOTALS	490.60	10,801.00	7.15	62,934.26	147.90
RIO MUNI					
Primates					
Cercopithecus cephus	17.30	430	0.22	1193.25	1.18
Cercopithecus mona	13.00	67	0.03	91.56	0.89
Cercopithecus nictitans	22.70	523	0.26	2275.05	1.55
Colobus satanas	20.40	152	0.08	912.00	2.72
Gorilla gorilla	0.70	3	0.00	176.32	0.03
Mandrillus sphinx	6.70	262	0.13	2153.64	0.79
Pholidota					
Manis triscuspis	10.90	93	0.05	116.25	6.63
Artiodactyla					
Cephalophus dorsalis	3.80	491	0.25	4910.00	0.50
Cephalophus leucogaste	4.10	6	0.00	40.50	1.31
Cephalophus sylvicultor	0.90	6	0.00	187.50	0.29
Cephalophus monticola	22.60	2107	1.05	5267.50	8.57
Potamochoerus porcus	3.10	93	0.05	2790.00	1.89
Rodentia					
Atherurus africanus	55.00	1698	0.85	3396.00	27.12
Cricetomys emini	134.00	390	0.20	390.00	81.49
Carnivora					
Genetta servalina	0.80	32	0.02	16.00	0.45
Nandinia binotata	3.60	72	0.04	72.00	2.01
Civecttictis civetta	2.80	15	0.01	75.00	1.68
TOTALS	322.40	6440.00	3.22	24,062.57	139.12

potential harvests averaged 498.99% in Bioko and 103.27% in Rio Muni. Hunting levels differed between taxonomic groups; Primates and ungulates appeared to be the most exploited. In Bioko, estimates of actual take for all except four primates and one ungulate (30.7% of all recorded species) were below potential harvests. Takes ranged from 28 times greater than sustainable harvest for the crowned guenon (*Cercopithecus pogonias*) to 0.96 times less than the sustainable harvest for Emin's rat.

Rio Muni presents a different picture than Bioko because only two species (11.77%) were being exploited in an unsustainable manner: *Cercopithecus nictitans* and the bay duiker (*Cephalophus dorsalis*). Most species were hunted below sustainable harvests. Takes ranged from 13 times greater than potential harvest for *C. dorsalis* to 0.67 times below potential harvest for *Cephalophus leucogaster*.

Discussion

There are few detailed studies at present on the impact of human exploitation on game animals in west African countries. Assessments of optimal sustainable harvests using the Robinson and Redford (1991) model can offer well-founded baseline information for regulating population-use levels. As suggested by Robinson and Redford

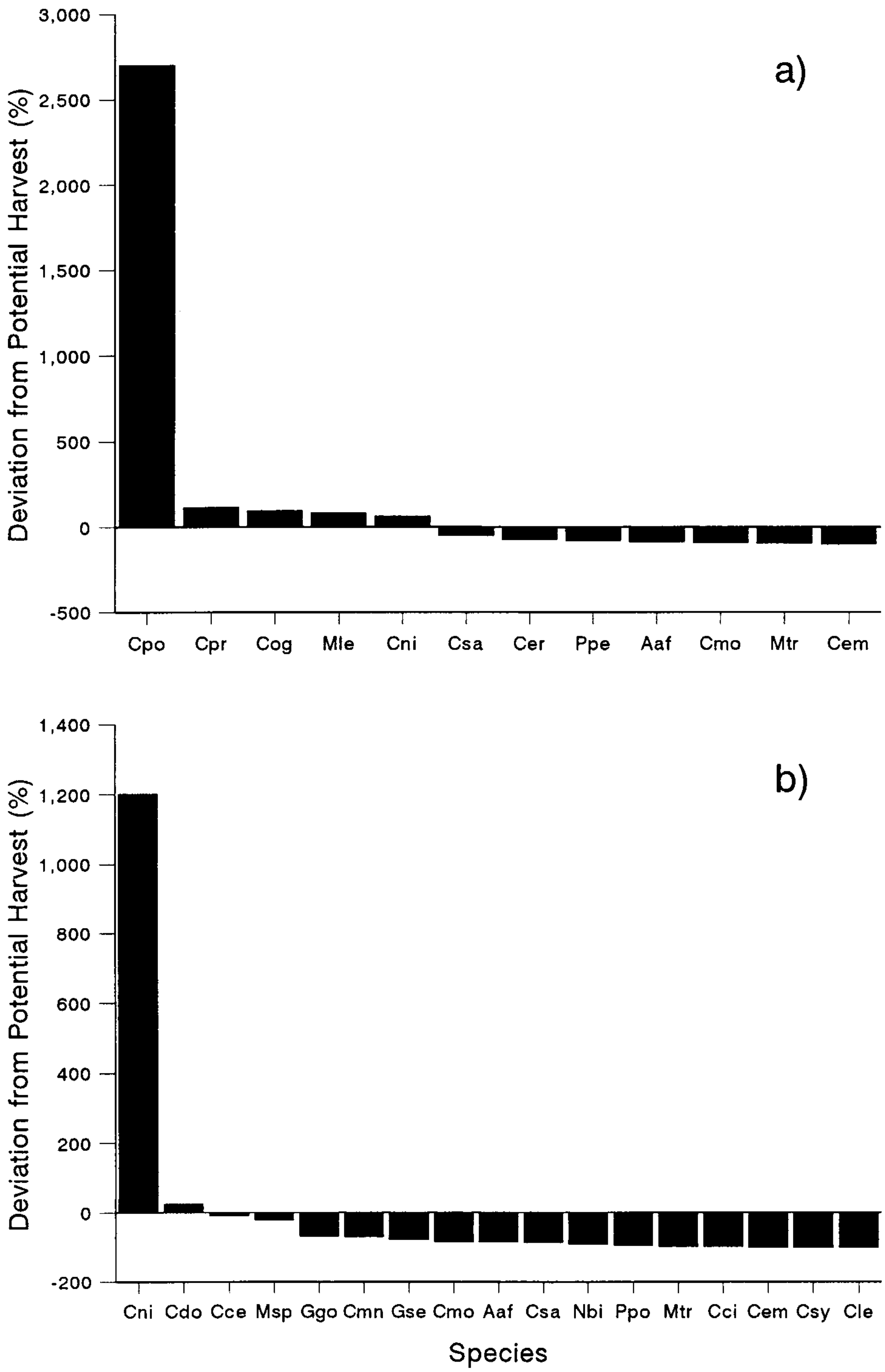

Figure 1. Deviation of actual harvest from calculated potential harvests for bushmeat species in Bioko (a) and Rio Muni (b). Species abbreviations: Aaf, Atherurus africanus; *Cce,* Cercopithecus cephus; *Cci,* Civecttictis civetta; *Cdo,* Cephalophus dorsalis; *Cer,* Cercopithecus erythrotis; *Cem,* Cricetomys emini; *Cle,* Cephalophus leucogaster; *Cmn,* Cercopithecus mona; *Cmo,* Cephalophus monticola; *Cni,* Cercopithecus nictitans; *Cog,* Cephalophus ogilbyi; *Cpo,* Cercopithecus pogonias; *Cpr,* Cercopithecus preussi; *Csa,* Colobus satanas; *Csy,* Cephalophus sylvicultor; *Ddo,* Dendrohyrax dorsalis; *Ggo,* Gorilla gorilla; *Gse,* Genetta servalina; *Mle,* Mandrillus leucophaeus; *Msp,* Mandrillus sphinx; *Mtr,* Manis tricuspis; *Nbi,* Nandinia binotata; *Ppe,* Procolobus pennanti; *Ppo,* Potamochoerus porcus.

(1991), even though the data are subject to variation as a result of inaccuracies in estimation, the assumptions in the model are in line with productivity and harvest information from other ecosystems. A cautionary note is necessary, however. Potential harvests, the maximum biologically possible production for a given species under ideal conditions calculated herein, incorporate figures that relate to reproduction parameters assumed to be accurate and that use average population densities.

Current data point to a clear difference in exploitation of species between Bioko and Rio Muni. Variance in total number of prey species recorded between island and continental markets relates directly to the richer vertebrate fauna in Rio Muni (Fa 1992*a*). But it is clear that all markets rely heavily on the sale of two species, an antelope (*Cephalophus monticola*) and a rodent (*Cricetomys emini*) in Bioko and the same antelope and another rodent (*Atherurus africanus*) in Rio Muni.

Unless reproductive parameters reported herein are very different from actual figures, the current rate of hunting is certainly far beyond the ability of some species to sustain populations. Our figures for the duiker species in Bioko, are below those observed by Payne (1992) from a study in nearby Korup, Cameroon. Payne (1992) calculated a higher take of 11.5–13.2 times greater than the sustainable harvest for *C. ogilbyi* (1.96 times greater in our study) and 1.3–2.2 times greater for *C. monticola* (0.11 times greater in our study). The situation is different for primates because levels for some Bioko species are around two times above potential harvest, but take for *C. pogonias* is 28 times above sustainable harvest. This species, together with *C. nictitans*, *C. perussi*, and *Mandrilluleucophaeus*, is unsustainably exploited; the last two species are among the most endangered primates in Africa (Oates 1986; Lee et al. 1988).

Exploitation levels generated from the model assume generally unhunted conditions, but in reality actual densities are well below what the model assumes, and therefore the effect of hunting on these species must be seen as even more worrisome. Because any disruption of the population (skewed sex ratios, isolated small groups of animals, or increased mortality of pre-reproductive animals) may have already affected production in the reservoir areas, over-hunting of some species may be even more severe than we have shown. Furthermore, because actual harvest figures are minimal (more animals than appear in markets are taken), current rates of hunting far outstrip the ability of some populations to replace the animals killed. Data from Colell et al. (1995) demonstrate that whereas 80% of antelopes caught in villages in southern Bioko were sent to market, just 10% of the smaller game (*Cricetomys*, *Manis*) were sold at market. This has also been observed in Zaire (Colyn et al. 1987).

Our study has further confirmed the importance of bushmeat as a substantial source of animal protein in Equatorial Guinea (Castroviejo et al. 1986; Juste & Cantero 1991; Fa 1992*a*). Nevertheless, protein deficiency exists, particularly away from the main urban centers (Cooperation Française 1984), because half of all protein in the urban areas is derived from bushmeat whereas the same amount in villages comes from protein-rich oleaginous grains (peanuts and squash). This seeming contradiction is the result not of a low per-capita availability of meat in rural areas but of an emphasis on selling prey in towns because of the greater purchasing power there. This is clear if one compares the volume of extracted meat between localities. The meat volume at the Malabo markets in Bioko was 70% higher than the volume in Bata, despite only a slight difference in population size between Malabo and Bata (52,000 and 55,000, respectively; data from FNUAP). Malabo is the seat of government and foreign aid organizations; therefore, it has a more urbanized population with greater buying power. Thus, the rate of meat extraction responds to the economic potential of a proportion of the urban population rather than to the nutritional demands of the population at large.

Attributes of species that influence hunters' prey choice are difficult to determine, but species found in markets both on the island and in continental areas may represent only those animals that fall within a particular weight range, dictated by hunting choice or economic constraints (such as transport costs) rather than—or as well as—market preferences. Juste and Cantero (1991) argue for the existence of an optimal prey spectrum determined by meat sale prices between 1000 and 1500 FCFA per kg ($US 3–5). Thus, smaller prey such as squirrels (8 species in Bioko and 11 in Rio Muni) and bats (Fa 1992*a*), as well as the large animals (>200 kg) are excluded, and more emphasis is put on medium-sized animals. Both size extremes require specialized hunting techniques. The larger species (for example, the forest buffalo [*Syncerus caffer nanus*] and the forest elephant [*Loxodonta africana cyclotis*] require an exaggerated investment in extraction and transport to market. Hence, species appearing in markets are generally easily extracted through the use of traps and snares (rats, porcupines, duikers) or have acceptable economic returns. Peoples' preference for certain meats may also affect selection of species taken to markets (Sabater Pi & Groves 1972). A combination of these factors affects the varying proportions of species sold in markets.

Hunting technology and method (snares versus guns) are related to the size of the animal. Therefore, a plausible argument to explain over-exploitation of the arboreal guenons and forest baboons is that hunters actively stalk these animals. Snare trapping does not require much effort and can be undertaken simultaneously with gun hunting. Snares are checked at one-week intervals; thus, hunters have more time to stalk arboreal game (Colell et al. 1995).

In Rio Muni, over-hunting seems less severe, but as early as 1968 Sabater Pi and Groves (1972) noted that heavy predation of guenons by humans had made these small monkeys rare in some areas. A further indication of the impact of hunting on Bioko guenons is that densities in undisturbed areas are shown to be three to four times higher than in areas where hunting is present (Butynski & Koster 1995), despite the fact that guns and ammunition are not readily available (Juste & Cantero 1991).

If harvest controls are not imposed, increases in human population, changes in aboriginal subsistence means, and subsequent deforestation will impoverish native fauna, as they have in other tropical countries (for example, Panama; Bennett 1968). In general, faunal exploitation for subsistence in West Africa is considered high by several authors (Mittermeier 1989), but it is the greater emphasis on hunting for profit that is disquieting. This has become more commonplace because commercial hunting offers a significant monetary incentive to rural people. Wilkie et al. (1992) has shown that hunting in Congo constitutes the major revenue for up to 51% of the employees of a major logging company. Without these earnings many families would be unable to buy basic cooking utensils, clothing, medicine, and educational materials for school-age children.

An effective way to protect and exploit game sustainably in Equatorial Guinea may be the maintenance of already decreed protected areas, especially on the island, where control of hunting is vital for conserving the endemic fauna. Established, protective boundaries (Castroviejo et al. 1986; Fa 1992*a*, 1992*b*) must be made effective, although exploitation in some areas could continue on a rotational basis in which fallow areas serve as reproductive refuges. Most areas, however, at least in Bioko, are being hunted continuously and intensively, and few sites may remain as source populations that could repopulate the heavily hunted areas. Data on actual densities and harvest rates from specific sites are urgently needed. More important, although it will be more difficult, hunting and monitoring regulations need to be established.

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