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Body Measurements for the Monkeys of Bioko Island, Equatorial Guinea

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Abstract: Bioko Island, Equatorial Guinea, has a rich (eight genera, 11 species), unique (seven endemic subspecies), and threatened (five species) primate fauna, but the taxonomic status of most forms is not clear. This uncertainty is a serious problem for the setting of priorities for the conservation of Bioko's (and the region's) primates. Some of the questions related to the taxonomic status of Bioko's primates can be resolved through the statistical comparison of data on their body measurements with those of their counterparts on the African mainland. Data for such comparisons are, however, lacking. This note presents the first large set of body measurement data for each of the seven species of monkeys endemic to Bioko; means, ranges, standard deviations and sample sizes for seven body measurements. These 49 data sets derive from 544 fresh adult specimens (235 adult males and 309 adult females) collected by shotgun hunters for sale in the bushmeat market in Malabo.

Key Words: Bioko Island, body measurements, conservation, monkeys, morphology, taxonomy

Introduction

Comparing external body measurements for adult individuals from different sites has long been used as a tool for describing populations, subspecies, and species of animals (see, for example, Eisentraut 1973; Dandelot 1974). Although most of Africa's primate taxa were first collected, described and named well over 100 years ago (Waterhouse 1838; Groves 2001, 2005; Grubb *et al.* 2003), identification was usually based on phenotypic characters (for example, color, pattern, texture, and length of the pelage) and measurements of the teeth and skull. While external body measurements from fresh specimens were sometimes available, the samples generally comprised but one or a few specimens. External body measurement data sets that are adequate for statistical analyses are still absent for many of the African primates. Indeed, for some species not even one full set of standard body measurement data from a fresh adult male specimen has been published (for example, golden-bellied mangabey *Cercocebus chrysogaster*, white-naped mangabey *Cercocebus lumulatus*, Sanje mangabey *Cercocebus sanjei*, kipunji *Rungwecebus kipunji*, southern talapoin monkey *Miopithecus talapoin*, dryad monkey *Cercopithecus dryas*, rolway monkey *Cercopithecus rolway*, djam-djam *Chlorocebus djamdjamensis*, and Udzungwa red colobus *Procolobus*

gordonorum), and surprisingly few such data exist even for some of the more widespread species (for example, Allen's swamp monkey *Allenopithecus nigroviridis*, northern talapoin monkey *Miopithecus ogouensis*, and grivet *Chlorocebus aethiops*).

Bioko Island (formerly Fernando Poo), Equatorial Guinea, is a continental island located about 32 km off the coast of Cameroon in the Gulf of Guinea (Fig. 1). Bioko (03°48'–03°12'N; 08°25'–08°57'E) has a surface area of about 2,017 km², an altitudinal range of 0–3,008 m, and a high mean annual rainfall that ranges from about 200 cm on the north coast to >1000 cm on the south coast. The primate fauna of Bioko is diverse, unique, and threatened (Basilio 1952; Eisentraut 1973; Oates 1988, 1996; Butynski and Koster 1994; Oates *et al.* 2004; Hearn *et al.* 2006). Based on all recent taxonomies (for example, Kingdon 1997; Groves 2001, 2005; Grubb *et al.* 2003), there are 11 species of primates on Bioko, five of which are threatened (Table 1; IUCN 2009). Of these, one is Critically Endangered, Pennant's red colobus *Procolobus pennantii* (Fig. 2), and two are Endangered, Preuss's monkey *Allochrocebus preussi* and drill *Mandrillus leucophaeus* (Fig. 3 and front cover of this issue of *Primate Conservation*). Nine of the 11 species of primate present on Bioko are usually regarded as represented either by subspecies endemic to Bioko (seven subspecies), or by subspecies

endemic to Bioko and to a small region on the immediately adjacent mainland (two subspecies; Eisentraut 1973; Oates 1988; Gautier-Hion *et al.* 1999; Groves 2001, 2007; Grubb *et al.* 2003; Oates *et al.* 2004). Of the nine subspecies of primates on Bioko, six are Endangered and three are Vulnerable (Table 1; IUCN 2009).

The primary threat to the monkeys of Bioko has long been, and remains, hunting with shotguns for the bushmeat trade (Fig. 4; Butynski and Koster 1994; Fa *et al.* 1995; Hearn *et al.* 2006). For its size, and based on current taxonomy (for example, Grubb *et al.* 2003), there is probably no single site in the world with more taxa of threatened primates than Bioko. In view of this situation, the IUCN/SSC Primate Specialist Group's action plans for African primates have consistently given high priority to the conservation of Bioko's primate fauna (Oates 1986, 1996; Lee *et al.* 1988).

One serious impediment to the conservation of Bioko's primates is the inadequate understanding of the taxonomic status of every one of the 11 primate taxa. It is safe to say that there is no community of primates in Africa for which there is more taxonomic confusion and uncertainty, or for which there is greater urgency for answers to taxonomic questions. For example, there is debate as to whether Pennant's red colobus and Allen's galago *Sciurocheirus alleni* of Bioko are endemic at the species (Groves 2001, 2005, 2007) or at the subspecies levels (cf. Dandelot 1974; Hill and Meester 1974; Napier 1985; Grubb *et al.* 2003). Similarly, it is far from clear as to whether the putty-nosed monkey *Cercopithecus nictitans*, crowned monkey *Cercopithecus pogonias*, and Demidoff's dwarf galago *Galagoides demidovii* on Bioko are endemic subspecies (Oates 1988; Gautier-Hion *et al.* 1999; Groves 2001). Until the many taxonomic questions surrounding the primate fauna of Bioko are resolved, it will remain difficult to set priorities for conservation, not just for the primate fauna of Bioko but also for the related primate fauna of western Central Africa (i.e., Nigeria, Cameroon, Equatorial Guinea, Gabon; Gautier-Hion *et al.* 1999; Oates *et al.* 2004).

That the taxonomic status of the primates on Bioko remains uncertain is partly due to the lack of significant samples of external body measurements both from Bioko and from mainland populations (Fig. 1). A review of the literature indicates that sets of external body measurement data for Bioko's primate taxa range from none (for example, Thomas's dwarf galago *Galagoides thomasi*) to six (for example, crowned monkey and red-eared monkey *Cercopithecus erythrotis*).

Here we present a new, large, set of seven body measurements for each of the seven species of monkeys present on Bioko.

Methods

From August 2006 into October 2007, we obtained five body and two tooth measurements from 1,039 monkeys in the Malabo ('Semu') Bushmeat Market. Malabo, the capital of Equatorial Guinea, is on the north coast of Bioko. More

than 90% of the approximately 200,000 people on Bioko live in Malabo and in nearby towns and villages. Recently killed (as well as 'smoked') monkeys obtained for the bushmeat trade by shotgun hunters are brought to the Malabo Bushmeat Market daily from all parts of Bioko. The body measurement data presented in this article come solely from monkeys brought to this market. No measurements were taken from smoked monkeys.

The vast majority of the immature monkeys were readily separated from the overall sample based on their small body size. Where there was a question as to whether a specimen

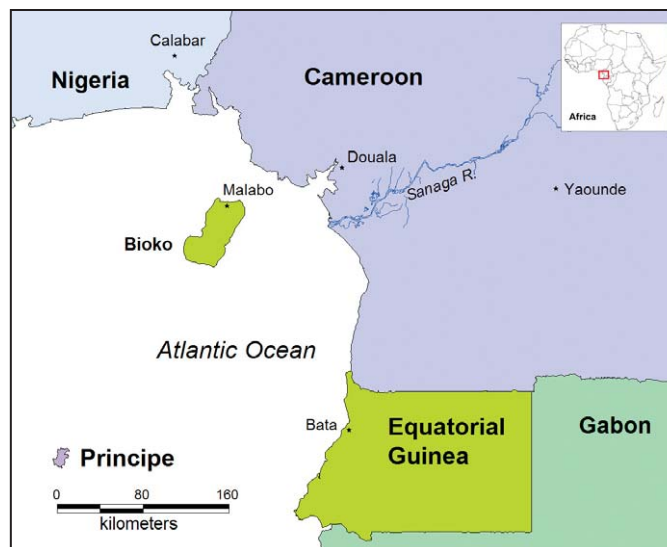


Figure 1. Location of Bioko Island (formerly Fernando Poo), Equatorial Guinea, in the Gulf of Guinea, western Central Africa.



Figure 2. Adult male Bioko red colobus *Procolobus pennantii pennantii*. This is a Critically Endangered species (IUCN 2009) and one of five threatened species of monkey on Bioko Island, Equatorial Guinea. This subspecies is limited to the southern-western corner (ca. 20%) of Bioko Island. Photograph © Tim Laman.

was immature or adult, the specimen was separated from, or included in, the ‘adult sample’ based on length of the canines, and on length of the nipples or width of the scrotum. Of the 1,039 monkeys measured, 544 were adults (235 adult males and 309 adult females).

Total body weight (mass) was recorded to the nearest 0.1 kg and the six linear measurements were recorded in millimeters (mm). The four linear body measurements were taken in the standard fashion (Martin *et al.* 2001):

Head-body length – From tip of nose to proximal base of tail (when tail is bent up at a right angle to the body).

Tail length – From the proximal base of tail (when tail is bent up at a right angle to the body) to the distal end of the last

tail vertebra (i.e., exclude protruding hairs). Tails which were incomplete were not measured.

Hindfoot length – From back edge of heel to tip of longest toe.

Ear length – From notch at base of inner ear to farthest point on edge of pinna. Damaged ears were not measured.

In addition to the above four measurements, *Upper canine length* and *Lower canine length* were recorded (from gum line to tip of canine). Broken canines were not measured.

Unfortunately, red colobus and black colobus *Colobus satanas* are usually eviscerated by hunters soon after being shot. For these two species the weights of the eviscerated



Figure 3. Juvenile Bioko drill *Mandrillus leucophaeus poensis*. This is an Endangered species (IUCN 2009) which is represented on Bioko Island, Equatorial Guinea by this endemic subspecies. This is the preferred prey of the commercial bushmeat hunters on Bioko. The total number of drills on Bioko as of 2009 is unlikely to be more than 4,000. Photograph by BBPP/Andrea Durcik. A photograph of an adult male Bioko drill appears on the front cover of this issue of *Primate Conservation*.



Figure 4. Bioko Preuss's monkey *Allochrocebus preussi insularis* for sale at the Malabo (‘Semu’) Bushmeat Market, Bioko Island, Equatorial Guinea. This is an Endangered species (IUCN 2009) which is represented on Bioko by an endemic subspecies. Note the short tail which is characteristic of this subspecies. All five of Bioko's threatened species of monkey are sold at this market. No fewer than 2,940 monkeys were sold here during the first 6 months of 2009. Photograph by Thomas M. Butynski.

Table 1. The primates of Bioko Island, Equatorial Guinea, and their degree of threat status at the species and subspecies levels (IUCN 2009). The taxonomy and vernacular names used here follow Grubb *et al.* (2003) except that we allocate Preuss's monkey to the genus *Allochrocebus*, not to the genus *Cercopithecus*.

Vernacular name	Scientific name	Degree of threat of species	Degree of threat of subspecies
Bioko black colobus*	<i>Colobus satanas satanas</i>	Vulnerable	Endangered
Bioko red colobus*	<i>Procolobus pennantii pennantii</i>	Critically Endangered	Endangered
Bioko drill*	<i>Mandrillus leucophaeus poensis</i>	Endangered	Endangered
Bioko Preuss's monkey*	<i>Allochrocebus preussi insularis</i>	Endangered	Endangered
Bioko red-eared monkey*	<i>Cercopithecus erythrotis erythrotis</i>	Vulnerable	Vulnerable
Golden-bellied crowned monkey	<i>Cercopithecus pogonias pogonias</i>	Least Concern	Vulnerable
Stampfli's putty-nosed monkey	<i>Cercopithecus nictitans martini</i>	Least Concern	Vulnerable
Bioko needle-clawed galago*	<i>Euoticus pallidus pallidus</i>	Least Concern	Endangered
Bioko Allen's galago*	<i>Sciurocheirus alleni alleni</i>	Least Concern	Endangered
Demidoff's dwarf galago	<i>Galagoides demidovii</i>	Least Concern	-
Thomas's dwarf galago	<i>Galagoides thomasi</i>	Least Concern	-

*Recognized by Grubb *et al.* (2003) as subspecies endemic to Bioko.

Table 2. Seven sets of body measurements from fresh adult male and adult female specimens for each of the seven species of monkeys on Bioko Island, Equatorial Guinea (August 2006–October 2007).

Species	<i>Colobus satanas satanas</i>							
	Male				Female			
Sex	Mean	Range	SD	N	Mean	Range	SD	N
Head-body length (mm)	595.4	510–675	35.6	37	576.4	500–680	39.0	48
Tail length (mm)	759.0	690–840	39.5	37	741.8	600–825	54.4	47
Hindfoot length (mm)	174.4	160–188	7.1	38	169.7	154–190	8.1	46
Ear length (mm)	32.3	28–40	3.4	38	30.4	26–36	2.0	47
Upper canine length (mm)	14.7	10–18	2.0	28	6.4	4–10	2.0	43
Lower canine length (mm)	10.7	6–14	1.9	28	5.0	3–8	1.4	43
Weight (kg)	10.3	7.3–13.1	1.8	12	8.2	6.6–10.0	1.2	7
Weight when eviscerated (kg)	7.8	5.0–11.0	1.7	19	6.8	5.2–8.2	0.7	27

Species	<i>Procolobus pennantii pennantii</i>							
	Male				Female			
Sex	Mean	Range	SD	N	Mean	Range	SD	N
Head-body length (mm)	504.7	470–554	23.0	12	518.8	470–583	24.0	48
Tail length (mm)	587.2	520–630	32.1	12	639.1	600–710	31.4	48
Hindfoot length (mm)	153.8	142–162	6.7	12	157.7	140–176	8.2	51
Ear length (mm)	29.8	26–35	2.9	12	29.8	26–33	1.7	50
Upper canine length (mm)	17.1	15–20	1.9	12	6.8	4–12	2.2	41
Lower canine length (mm)	11.8	10–16	2.0	12	4.7	3–8	1.3	40
Weight (kg)	11.0	–	–	1	10.0	–	–	1
Weight when eviscerated (kg)	6.2	5.2–8.0	0.9	9	5.8	5.0–7.0	0.6	38

Species	<i>Mandrillus leucophaeus poensis</i>							
	Male				Female			
Sex	Mean	Range	SD	N	Mean	Range	SD	N
Head-body length (mm)	668.1	600–740	41.8	28	537.7	470–620	40.7	41
Tail length (mm)	84.7	65–100	10.4	31	63.3	40–90	9.3	40
Hindfoot length (mm)	181.8	160–200	11.5	30	149.1	140–165	7.7	38
Ear length (mm)	37.2	30–44	3.6	30	31.7	28–41	3.1	41
Upper canine length (mm)	35.7	28–40	4.6	26	7.3	4–16	3.1	30
Lower canine length (mm)	21.8	18–28	2.5	30	5.7	3–11	2.3	30
Weight (kg)	20.0	14.5–27.0	3.5	26	8.5	6.5–12.0	1.5	39

Species	<i>Allochrocebus preussi insularis</i>							
	Male				Female			
Sex	Mean	Range	SD	N	Mean	Range	SD	N
Head-body length (mm)	483.9	420–540	32.0	23	402.8	370–440	19.1	40
Tail length (mm)	552.7	500–600	29.4	23	476.6	410–560	41.2	42
Hindfoot length (mm)	140.1	130–150	5.5	24	123.1	110–145	8.8	42
Ear length (mm)	31.0	28–35	2.4	23	29.0	24–35	2.3	43
Upper canine length (mm)	17.3	13–22	2.4	23	10.7	6–16	2.6	39
Lower canine length (mm)	11.8	10–14	1.4	24	7.0	3–12	2.5	41
Weight (kg)	5.5	4.7–6.5	0.5	24	3.5	2.9–4.7	0.5	42

Table 2. continued

Species	<i>Cercopithecus erythrotis erythrotis</i>							
Sex	Male				Female			
Measures	Mean	Range	SD	N	Mean	Range	SD	N
Head-body length (mm)	420.1	390–500	23.2	66	384.1	360–430	15.9	64
Tail length (mm)	608.7	490–730	50.7	67	552.7	460–660	41.2	62
Hindfoot length (mm)	124.0	112–144	7.8	67	113.5	105–130	6.0	64
Ear length (mm)	27.6	24–31	1.9	67	27.2	22–32	2.0	64
Upper canine length (mm)	14.0	12–18	1.6	65	10.4	6–14	2.6	59
Lower canine length (mm)	9.1	7–12	1.1	64	7.0	5–11	1.7	59
Weight (kg)	3.7	3.0–5.6	0.6	64	3.1	2.4–5.4	0.5	64

Species	<i>Cercopithecus pogonias pogonias</i>							
Sex	Male				Female			
Measures	Mean	Range	SD	N	Mean	Range	SD	N
Head-body length (mm)	407.0	370–480	19.3	46	372.4	340–410	18.4	40
Tail length (mm)	624.0	560–730	36.1	47	556.6	480–610	33.7	42
Hindfoot length (mm)	123.8	118–140	6.5	47	114.2	110–120	4.3	41
Ear length (mm)	26.9	22–30	1.9	47	26.5	22–30	1.6	41
Upper canine length (mm)	14.2	10–20	2.1	48	10.2	7–14	2.2	32
Lower canine length (mm)	9.6	6–13	1.7	48	7.3	4–12	2.6	33
Weight (kg)	3.7	3.0–5.1	0.6	45	2.8	2.2–3.8	0.4	39

Species	<i>Cercopithecus nictitans martini</i>							
Sex	Male				Female			
Measures	Mean	Range	SD	N	Mean	Range	SD	N
Head-body length (mm)	484.6	420–570	44.9	14	439.1	400–500	28.0	20
Tail length (mm)	739.8	700–790	26.3	13	647.9	558–700	46.3	19
Hindfoot length (mm)	138.9	130–150	7.3	14	125.1	112–132	6.1	18
Ear length (mm)	30.2	28–35	2.3	15	28.6	26–32	1.6	20
Upper canine length (mm)	15.7	12–20	2.8	13	9.4	6–12	1.8	16
Lower canine length (mm)	10.7	10–12	1.0	13	6.5	4–10	2.2	18
Weight (kg)	5.1	4.0–6.0	0.6	14	4.1	3.0–5.6	0.7	20

individuals were recorded and are presented here in addition to a smaller number of weights from intact specimens.

Results and Discussion

The means, ranges, standard deviations, and sample sizes for these seven body measurements are presented in Table 2. Through the presentation of these data we hope to encourage and facilitate further research on the systematics and diversity of the monkeys of Bioko, and of their counterparts on the mainland. These data should also provide insights into the extent to which insular primate taxa undergo size changes (the 'Island Rule' or 'Foster's Rule') and changes in degree of sexual size dimorphism (Isaac 2005; Bromham and Cardillo 2007). As such, we plan to apply these data in a series of papers that will examine the validity of the current taxonomy for the monkeys of Bioko and of the possible effects of insularity on this primate fauna. In this planned series of papers, the body measurement data presented here will be supported (1) by a thorough review of the literature for each taxon, (2) by our detailed descriptions of the pelage pattern and coloration of the primates of Bioko, (3) by reference to the hundreds of close-up photographs that we have taken of the primates of Bioko, and (4) by our observations on the ecology and behavior of free-living primates on Bioko.

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