BRIEF REPORT

Note on Drill (*Mandrillus leucophaeus*) Ecology and Conservation Status in Korup National Park, Southwest Cameroon

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We report preliminary findings on drill population ecology, feeding ecology, primate associations and conservation status in Korup National Park, Cameroon, based on analysis of data collected during 1,346 km (620 field hours) of trail patrols from February to June 2006. We encountered drills on 25 occasions and collected 304 fecal samples. Group size was estimated on four occasions (≥25, ≥40, ≥67, ≥77), and multiple males were heard emitting the characteristic two-phase grunt of mature male drills in two of these groups. We saw a solitary male drill once. Examination of fecal samples indicated a seasonally variable diet consisting mainly of seeds, fruit pith, leaves and insects (especially ants and termites). *Irvingia gabonensis* and *Musanga cecropioides* fruits showed the highest percentage of occurrence in May (96%) and March (75%) samples, respectively, and could be a major food source for drills at that time. Drills were in association with at least one additional primate species during 57.9% of observations. These associations involved all of the diurnal primates found in Korup (*Cercopithecus mona*, *Cercopithecus nictitans*, *Cercopithecus erythrotis*, *Cercopithecus pogonias*, *Piliocolobus preussi* and *Cercocebus torquatus*) except chimpanzees (*Pan troglodytes*). We discuss our findings in terms of existing knowledge about drill ecology and highlight the urgent need for the protection of the significant drill population in Korup National Park. Am. J. Primatol. 70:306–310, 2008. © 2007 Wiley-Liss, Inc.

Key words: *Mandrillus leucophaeus*; group size; feeding ecology; primate associations; Korup National Park

INTRODUCTION

Found only in Lower Guinean rainforests between the Sanaga and Cross rivers in Cameroon and Nigeria and on the island of Bioko, the drill (*Mandrillus leucophaeus*) faces increasing pressure from hunting and a shrinking habitat, earning the distinction of being one of the African primates most in need of conservation action [Oates, 1996]. Yet, since Gartlan’s [1970] preliminary notes on drill ecology, there have been few publications of research on wild drills. More recent primate studies in Cameroon [Steiner et al., 2003; Waltert et al., 2002; Wild et al., 2005], Nigeria [Gadsby, 1990] and on the Bioko island [Hearn & Morra, 2001; Maté & Colell, 1995; Schaaf et al., 1990] offer some insight mainly on the status of drills.

Drill group size and social organization is probably the most debated topic of drill ecology. Drills are encountered in relatively small groups (five to 30 animals) and much bigger aggregations referred to as hordes [Gadsby, 1990; Gartlan, 1970]. It is not clear, however, whether small groups form the basic single-male social units of a population, or if larger multimale hordes show temporal continuity. A radiotelemetry study in Lopé, Gabon by Abernethy et al. [2002] reported year-round hordes for the mandrill (*Mandrillus sphinx*)—the drill’s sole and allopatric congener. Solitary adult males have been reported for both species [Hoshino et al., 1984; Wild et al., 2005]. No data exist on drill home range size, whereas estimates for the mandrill are in the range of 5–50 km² [Hoshino et al., 1984; Jouventin, 1975]. The data scarcity on drill group structure is mirrored in feeding ecology, for which only sporadic and inconclusive information exists. Hunter interviews [Gadsby, 1990; Steiner et al., 2003] and mandrill [Hoshino, 1985; Rogers et al., 1996] studies suggest a diverse diet of seeds, fruits, leaves, insects and arthropods. Studies of sympatric

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primates in Cameroon reported associations for both drills and mandrills with *Cercopithecus* and *Cercocetus* species [Gartlan & Struhsaker, 1972; Mitani, 1991].

Korup National Park (KNP) is currently the only fully protected area within the drill’s geographic range in Cameroon. Yet, illegal hunting, often using dogs, has probably already driven drills to extinction in parts of the park’s support zone [Steiner et al., 2003; Waltert et al., 2002]. In this study, we present preliminary findings on drill population ecology, diet, associations with other primates and conservation status in KNP, based on analysis of data collected during a 5-month period in 2006. Drills in Korup are part of a distinct lowland forest primate community [Oates et al., 1987], which includes the also endangered *Piliocolobus preussi* and *Pan troglodytes* species, making primate studies there of special primatological and conservation interest.

**METHODS**

KNP is located in southwest Cameroon (Fig. 1) and extends over 1,250 km² of mostly undisturbed primary forest (4°54’ to 5°28’ N latitude and 8°42’ to 9°16’ E longitude). It is contiguous with Ejagham Forest Reserve in the north and Nigeria’s Cross River National Park (Oban Division) in the west. The study area is located in the southern section of KNP and covers 63 km² (37.7 km² of more intensively patrolled core area). Hunting pressure is light to moderate, possibly because of the area’s distance from villages (>5 km) and the presence of researchers [Linder, personal communication].

Average annual rainfall at the southern section of KNP exceeds 5,000 mm. There is a single wet season from May to October (peak in August) and a distinct dry season from December to February. Temperature varies little throughout the year and the average annual maximum is 30.6°C. Vegetation at the study area is characterized as Biafran coastal forest, a closed canopy lowland moist forest dominated by Caesalpinioideae species [Letouzey, 1968]. Flowering and fruiting of trees show strongly seasonal patterns [Chuyong et al., 2004].

We patrolled a 57-km network of existing trails for a total of 1,346 km (in 620 hr over 89 field days) from February to June 2006. Drills were not habituated to human presence. We tracked groups mainly by vocalizations and foraging signs, following them off-trail to their sleeping sites when possible. We calculated group size conservatively as the minimum visual count, and distinguished between multimale and single-male groups by the number of animals emitting the two-phase grunt (2PG), a characteristic call restricted to *Mandrillus* adult males [Kudo, 1987]. We defined the association of primate species as proximity (≤50 m) rather than social interaction, because the presence of other species was mostly determined from calls. Fecal samples were collected fresh, washed and dried within 48 hr, and food remains examined. Each sample is likely from a separate animal, based on location (>1 m apart) and shape. Opportunistic field observations provided additional data on drill

Fig. 1. Location of Korup National Park, study area and drill encounters.
feeding ecology. We calculated the minimum number of groups within the study area by the number of same day drill encounters or fresh foraging signs $\geq 4.5$ km apart, the maximum daily travel distance reported by Hoshino et al. [1984] for mandrills in humid lowland forest.

RESULTS

We encountered drills visually 16 times, once a solitary male and 15 times as a group (0.008 groups/km, $n = 11$ excluding nonrandom sleeping site encounters), and by sound nine additional times (0.007 groups/km) (Fig. 1). Group counts were possible on four occasions ($\geq 25$, $\geq 40$, $\geq 67$, $\geq 77$), all done early in the morning at sleeping sites. The groups of $\geq 40$ and $\geq 77$ had multiple males emitting the 2PG, whereas the smallest group had one adult male calling. We could not determine whether the remaining group was multimale or not. All four groups consisted of juvenile and adolescent animals, adult females, some with ventral infants, and multiple subadult males. Adult males were first to flee to the ground and were rarely seen. The minimum number of drill groups within the study area was estimated at two, based on one simultaneous encounter of fresh foraging signs and a group by different teams at a distance of $\sim 5$ km.

Group fission and fusion was best documented in two incidents. The $\geq 40$ multimale group was observed, in the evening before the count, split in two subgroups converging toward a common sleeping site, emitting antiphonically a mixture of crowing, scream, 2PG and roar calls [Gartlan, 1970; Kudo, 1987]. Call frequency was very high with $> 55$ calls between 15.39 and 17.54, when calling ceased and the two groups were presumed to have joined each other for the night. On another occasion, a small ($< 10$) subgroup split from the main group ($> 150$ m apart) and was foraging separately for 30 min. Following two unidirectional crowing calls from the main group, the subgroup moved quietly and joined the main group.

We collected 304 fecal samples during the study period to examine drill feeding ecology. The average fresh weight of feces was 19.8 g (range 1.1–89.7 g). Analysis indicated that seeds, fruits, insects, green leaves and to a lesser extent mushrooms were eaten by drills. Seeds, crushed or intact, were present in most samples and a total of 20 seed types have been distinguished, six of which were identified to species (Table I). Fibers from Irvingia gabonensis fruit (bush mango) were present in 96% of fecal samples in May, often accounting for most of the samples’ volume, but were totally absent in samples of the 3 previous months (Table II). Another important food source for drills was the fruit of Musanga cecropioides, eaten throughout the study period, with a higher percentage of occurrence reported in March (75%). Leaf remains were mainly grass blades and less frequently from leaves of trees and forbs. Mushrooms were found in low amounts in 5% of the samples. Insect remains were present in 70% of samples and consisted mainly of ant, termite and cricket parts. Overall, there are seasonal variations in diet, but plant matter almost invariably makes up the majority of a fecal sample’s volume.

With the exception of chimpanzees (P. troglodytes), we observed drills in association with all the KNP’s diurnal primate species. During 19 drill encounters for which we could determine possible associations, drills were alone eight times, with one more species twice, and with two, three and four species three times each. White-nosed guenons (Cercopithecus nictitans) were present most frequently during drill encounters (44%) (Table III). Adjusting for how common a species was in our study area, drills were present in only 3% of white-nosed guenon encounters. Drills show highest association with red-capped mangabeys (Cercocebus torquatus), being present in 14% of total mangabey encounters.

DISCUSSION

Using the four group counts, the average group size was 52.3 members, which is similar to that of Gartlan [1970; 63.5, $n = 12$] and in the midrange of the reported extremes of Dunn and Okon [2003; 9.1, $n = 16$] and Wild et al. (93.1, $n = 105$). The difference with the Dunn and Okon value is striking considering that their surveys were conducted in transect lines (P, Q, R, S) adjacent to our study area (Fig. 1). It likely reflects a limitation of transect surveys in accurately counting drill groups, as observers are restricted to the transect and a set walking pace. We were able to follow groups for an extended period of time and obtained all our group size estimates at sleeping sites.

Our observations of multimale groups and group fission and fusion add to Gartlan’s [1970] report of multimale hordes, which occasionally dissolve into subunits for part of the day and use mostly crowing calls antiphonally to facilitate relocation later on. The fact that only one male was heard emitting the 2PG in the smaller group is not sufficient to confirm the existence of single-male groups, but their presence can certainly not be discounted by our data. Further examination of the social structure of small groups is needed to decide whether drills have a multimale or a multileveled social structure.

We see strong similarities when comparing the type, diversity and seasonal variation of items consumed by drills in our study with those from Hoshino [1985] mandrill study. In both species, fruits, seeds, leaves and insects are the staple foods of an omnivore diet. The fact that drills forage on the ground probably explains the prevalence of nonflying insects associated with lower forest strata and...
decaying fallen logs. By contraries, we see no evidence of a drill diet specialization for hard decaying seeds on the forest floor, as Fleagle and McGraw’s [1999] morphological analysis suggests. The answer may lie with the crushed, unidentified, seed remains found in most samples. The marked seasonality of *I. gabonensis* fruit fiber in the fecal samples is explained by the coinciding fruiting peak for the species, whereas the more even distribution of *M. cecropioides* remains reflects the species’ asynchronous fruiting during the study period. Four identified plant species (*Oncoba glauca*, *Pentadesma butyracea*, *I. gabonensis* and *Morinda morindoides*) have been reported in the mandrill diet [Hoshino, 1985; Jouventin, 1975; Rogers et al., 1996].

The reported close association of drills and red-capped mangabeys seemingly suggests no spatial segregation between the two species. This is puzzling because the *Cercocebus* and *Mandrillus* genera are closely related evolutionarily, forming a distinct phylogenetic clade within the Papionini tribe [Disotell et al., 1992], and consist of large, semiterrestrial species adapted to use a similar dietary niche—hard seeds [Fleagle & McGraw, 1999]. There could be benefits in traveling together that counter the cost of sharing resources. However, given our limited ecological knowledge of the two species, we can neither explain possible trade-offs nor say with certainty if the associations are long-lasting in nature or just copresence near common resources.

The larger home range of red-capped mangabeys compared with forest guenons [Mitani, 1991] supports the feasibility of long-term associations with drills.

On the basis of the reported average group size and a minimum of two groups in the study area, drill density could be estimated at 1.7 drills/km². Even though we must be cautious in extrapolating these figures to the entirety of the park, applying conservatively the calculated drill density only to park areas >5 km from villages (664 km²) suggests that KNP could be home to 1,130 drills—admittedly a

### TABLE I. Plant Species Consumed by Drills, Identified Through Analysis of Fecal Remains¹ and/or Field Observations²

<table>
<thead>
<tr>
<th>Family</th>
<th>Species (common name)</th>
<th>Plant type</th>
<th>Part(s) consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cecropiaceae</td>
<td><em>Musanga cecropioides</em> (Parasol tree)</td>
<td>Canopy tree</td>
<td>Fruit with seeds¹</td>
</tr>
<tr>
<td>Placouriaceae</td>
<td><em>Oncoba glauca</em></td>
<td>Canopy tree</td>
<td>Seeds¹,²</td>
</tr>
<tr>
<td>Placouriaceae</td>
<td><em>Scotellia klaineana</em></td>
<td>Emergent tree</td>
<td>Fruit with seed¹</td>
</tr>
<tr>
<td>Guttiaceae</td>
<td><em>Pentadesma butyracea</em> (Butter tree)</td>
<td>Emergent tree</td>
<td>Seed¹</td>
</tr>
<tr>
<td>Irvingiaceae</td>
<td><em>Irvingia gabonensis</em> (Bush mango)</td>
<td>Emergent tree</td>
<td>Fruit pulp¹,²</td>
</tr>
<tr>
<td>Moraceae</td>
<td><em>Treculia obovoidea</em></td>
<td>Canopy tree</td>
<td>Seeds²</td>
</tr>
<tr>
<td>Rubiaceae</td>
<td><em>Morinda morindoides</em></td>
<td>Vine</td>
<td>Fruit with seeds¹</td>
</tr>
</tbody>
</table>

### TABLE II. Monthly Variation in the Percentage of Occurrence of Some Food Items in Drill Feces

<table>
<thead>
<tr>
<th>Month</th>
<th>Insects</th>
<th><em>Irvingia gabonensis</em></th>
<th><em>Musanga cecropioides</em></th>
<th>Mushrooms</th>
</tr>
</thead>
<tbody>
<tr>
<td>February</td>
<td>77% (n = 33)</td>
<td>0% (n = 0)</td>
<td>65% (n = 28)</td>
<td>9% (n = 4)</td>
</tr>
<tr>
<td>March</td>
<td>92% (n = 33)</td>
<td>0% (n = 0)</td>
<td>75% (n = 27)</td>
<td>3% (n = 1)</td>
</tr>
<tr>
<td>April</td>
<td>39% (n = 17)</td>
<td>0% (n = 0)</td>
<td>43% (n = 19)</td>
<td>2% (n = 1)</td>
</tr>
<tr>
<td>May</td>
<td>64% (n = 46)</td>
<td>96% (n = 69)</td>
<td>29% (n = 21)</td>
<td>7% (n = 5)</td>
</tr>
<tr>
<td>June</td>
<td>78% (n = 85)</td>
<td>25% (n = 27)</td>
<td>47% (n = 51)</td>
<td>3% (n = 3)</td>
</tr>
<tr>
<td>Total</td>
<td>70% (n = 214)</td>
<td>24% (n = 96)</td>
<td>52% (n = 146)</td>
<td>5% (n = 14)</td>
</tr>
</tbody>
</table>

### TABLE III. Polyspecific Associations of Diurnal Korup National Park Primates With Drills

<table>
<thead>
<tr>
<th>Species</th>
<th>Times present in 19 drill encounters</th>
<th>Total encounters of species</th>
<th>Percent of encounters with drills present(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cercocebus torquatus</em></td>
<td>5 (28%)</td>
<td>37</td>
<td>14</td>
</tr>
<tr>
<td><em>Piliocolobus preussi</em></td>
<td>2 (11%)</td>
<td>44</td>
<td>5</td>
</tr>
<tr>
<td><em>Cercopithecus mona</em></td>
<td>2 (11%)</td>
<td>78</td>
<td>3</td>
</tr>
<tr>
<td><em>Cercopithecus nictitans</em></td>
<td>8 (44%)</td>
<td>288</td>
<td>3</td>
</tr>
<tr>
<td><em>Cercopithecus pogonias</em></td>
<td>6 (33%)</td>
<td>92</td>
<td>7</td>
</tr>
<tr>
<td><em>Cercopithecus erythrotis</em></td>
<td>6 (33%)</td>
<td>132</td>
<td>5</td>
</tr>
</tbody>
</table>

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significant population. Presently, however, the drill’s future in Korup region is far from guaranteed. An earlier primate monitoring study by Walters et al. [2002] in the northern section of KNP’s support zone indicated a decline in drill populations there and concluded that the species may be facing local extinction. We believe that ensuring the drill’s future in Korup will require decisive antipoaching efforts inside the park and long-term educational activities in villages in KNP’s periphery.

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