Ecology and Status of the Drill (*Mandrillus leucophaeus*) in Korup National Park, Southwest Cameroon: Implications for Conservation

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Abstract

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The drill (*Mandrillus leucophaeus*) is a terrestrial primate endemic to the Cross-Sanaga-Bioko rainforests of Central Africa whose survival is endangered by increasing pressure from hunting and habitat loss. Few studies have ever examined the ecology of wild drills and our current understanding of the conservation needs of the species is limited. This dissertation presents the findings on wild drill ecology of a twelve month field study in a 63 km^2 section of Korup National Park in southwest Cameroon. It also evaluates the status and threats of the drill in the greater Korup region with the intent of improving the species' protection. Finally, the appropriateness of assuming near-identical ecologies between the drill and its better studied, allopatric, and sole congener – the mandrill (*M. sphinx*) – is assessed.

Analysis of fecal samples and feeding remains show that the drill maintains a diverse, yet not indiscriminate, omnivorous diet throughout the year consisting primarily of fruits and seeds, and to a lesser extent leaves, mushrooms and insects. Drills ingested and dispersed intact seeds from 110 seed types primarily during periods of fruit abundance, while there was a shift towards increased seed predation during the pronounced fruit-scarce dry season.

Visual and audio encounters of drill groups during 3,284 km of trail patrols provided information on group structure and primate associations. Mean group size was 43.3 ± 18.4 (range 25-77) and groups with both one and multiple males emitting the adult male specific two-phase-grunt were observed. Solitary males were encountered twice. Drills were in association with at least one additional primate species at some time during most of the encounters, involving all of the diurnal primates in Korup (*Cercopithecus mona*, *C. nictitans*, *C. erythrotis*, *C. pogonias*, *Procolobus pennantii preussi* and *Cercocebus torquatus*) except the chimpanzee (*Pan troglodytes*).

The total drill population was conservatively estimated at 950-1450 within Korup National Park and 2,500-3,000 in the entire Korup region, which makes the region a stronghold for the species' survival. However, drill sub-populations are becoming increasingly isolated within the ever more fragmented landscape and are under hunting pressure everywhere. Eight core areas are identified across the region as priorities for protection. Interviews with local communities offered insight on the destructive practice of hunting with dogs as well as the socioeconomic role of dogs – information needed for effectively managing this major threat to drill survival. The drill was also found to suffer from a limited local recognition of its current status and legal protection, which is unfavourable for conservation. A series of short to medium term drill-focused initiatives are recommended for the protection of the species in the Korup region.

Zusammenfassung

Von Christos Astaras

Betreuer: Michael Mühlenberg

Der Drill (*Mandrillus leucophaeus*) ist ein terrestrischer Primat mit endemischer Verbreitung in der Cross-Sanaga-Bioko Regenwald-Region Zentralafrikas. Sein Fortbestand ist gefährdet durch zunehmenden Jagddruck und Habitatverlust. Bisher wurden nur wenige Studien zur Ökologie wilder Drills durchgeführt und unser gegenwärtiger Kenntnisstand über Anforderungen für einen erfolgreichen Schutz sind beschränkt. Die vorliegende Arbeit umfaßt Ergebnisse zur Ökologie wilder Drills basierend auf einer zwölfmonatigen Feldstudie in einem 38 km² großen Ausschnitt des Korup Nationalparks in Südwestkamerun, und evaluiert den Status und die Gefährdung des Drill in der Korup-Region mit der Absicht, den Schutz der Art zu verbessern. Darüber hinaus wird bewertet, ob es angemessen ist, anzunehmen, daß der Drill eine nahezu identische Ökologie mit seinem besser untersuchten, allopatrischen und einzigen congenerischen verwandten, dem Mandrill (*M. sphinx*) besitzt.

Analysen von Kotproben und Nahrungsresten zeigen, daß Drills eine diverse, aber nicht wahllose, omnivore Ernährung durch das ganze Jahr aufrechterhalten, welche

Primär aus Früchten und Samen, und zu einem geringeren Teil aus Samen, Pilzen und Insekten besteht. Drills nahmen auf und verbreiteten Samen von 110 Typen, vorzugsweise während Perioden hoher Fruchtdichte, während in der frucht-armen

Trockenzeit ein Wechsel hin zu einem höheren Anteil an Samenprädation beobachtet wurde.

Visuelle und optische Beobachtungen von Drill Gruppen während insgesamt 3284 km an Begehungen ermöglichten Informationen zu Gruppengröße und Primaten-Assoziationen. Die mittlere Gruppengröße betrug 43.3 ± 18.4 (Spannweite 25-77) und Gruppen sowohl mit einem als auch mehreren Männchen, die den spezifischen Ruf adulter Männchen ausstießen, wurden beobachtet. Solitäre Männchen wurden zweimal beobachtet. Während der meisten Beobachtungen waren Drills mit mindestens einer zusätzlichen Primatenart assoziiert, wobei alle tagaktiven Primaten des Korup Nationalparks (*Cercopithecus mona*, *C. nictitans*, *C. erythrotis*, *C. pogonias*, *Procolobus pennantii preussi* und *Cercocebus torquatus*), außer Schimpansen (*Pan troglodytes*), nachgewiesen wurden.

Die Größe der Drill-Population wurde für den Korup National Park auf konservative 950-1450 individuen geschätzt und auf 2500-3000 für die gesamte Korup-Region. Die Region ist damit wichtigster Stützpunkt für das Überleben der Art. Jedoch werden Teile dieser Population in der fortwährend fragmentierten Lanschaft zunehmend isoliert und unterliegen überall starkem Jagddruck. Acht Kernzonen höchster Schutzpriorität wurden in der Region identifiziert. Interviews in lokalen Dorfgemeinschaften bestätigten die für Drills destruktive Praxis der Jagd mit Hunden, sowie die sozio-ökonomische Rolle von Hunden – Informationen, die für effektives Management dieser Hauptgefährdung benötigt werden. Der Drill leidet außerdem auch unter einer begrenzten Anerkennung seines derzeitigen Status und für seinen Schutz unzureichenden legalen Schutzbemühungen. Eine Reihe kurz- und mittelfristiger, auf den Drill fokussierter Initiativen werden zum Schutz der Art in der Korup-Region vorgeschlagen.

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2PG:	Two-phased grunt (a characteristic call of adult *Mandrillus* males)
BBPP:	Bioko Biodiversity Protection Program
CAFECO:	Cameroon Agriculture and Forestry Exploitation Company
CFA:	see FCFA
CIRMF:	Centre International de Recherches Médicales de Franceville, Gabon
CITES:	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CRES:	Conservation and Research for Endangered Species of the Zoological Society of San Diego
CRNP:	Cross River National Park
DED:	German Development Service (Deutscher Entwicklungsdienst)
DRBC:	Drill Rehabilitation and Breeding Center
FCFA:	Francs de la Communauté Financière Africaine (a.k.a. CFA), currency
FR:	Forest Reserve
GTZ:	German Society for Technical Cooperation (Deutsche Gesellschaft für Technische Zusammenarbeit GmbH)
IUCN:	International Union for Conservation of Nature and Natural Resources (until 2008 a.k.a. World Conservation Union)
KFDP:	Korup Forest Dynamics Plot
KFW:	German Development Bank (Kreditanstalt Für Wiederaufbau)
KNP:	Korup National Park
LWC:	Limbe Wildlife Center
NGO:	Non-Governmental Organization
NP:	National Park
NTFP:	Non-Timber Forest Product
MINFOF:	Ministry of Forestry and Wildlife (Cameroon)
MINEF:	Ministry of Environment and Forestry (Cameroon, split in MINFOF and MINEP)
MINEP:	Ministry of Environment and Nature Protection (Cameroon)
MINRESI:	Ministry of Scientific Research and Innovation (Cameroon)
pers. comm.:	personal communication
pers. obs.:	personal observation
PSMNR-SWP:	Programme for the Sustainable Management of Natural Resources in the Southwest Province
PZ:	Peripheral Zone (of KNP)
SPSS:	Statistical Package for the Social Sciences
TOU:	Technical Operation Unit
TRC:	Transformation Reef Cameroon (logging company)
WAZA:	World Association of Zoos and Aquariums
WCS:	Wildlife Conservation Society
WWF:	World Wide Fund for Nature

Chapter 1: Introduction to the dissertation

1.1 Introduction to drill ecology and conservation

1.1.1 Physical description, range and taxonomy

The drill (*Mandrillus leucophaeus*) is a large, terrestrial, forest dwelling member of the cheek-pouch (Cercopithecinae) sub-family of Old World monkeys (Cercopithecidae). Like its sole congener the mandrill (*Mandrillus sphinx*), the drill is highly sexually dimorphic, with adult males weighing over three times as much as females (Hill, 1970; Setchell *et al.*, 2001). Large canines, short tails, and strikingly colourful perineal hair and skin (red, blue, violet) in adult males are characteristics shared by both *Mandrillus* species. In contrast to the male mandrill's bright blue and red coloration of facial skin, the male drill has a jet black face with prominent cheek flanges and bony paranasal ridges, which is contrasted by a white hair rim around it and a scarlet red strip below the lower lip. Drill pelage is grey/brown compared to olive/brown for mandrills.

Due to their large body, stout-build, pronounced sexual dimorphism, and quadrapedal stance, the *Mandrillus* species were historically considered to be forest baboons, and were even placed by some in the *Papio* genus (Hill, 1955; Buettner-Janusch 1966; Jolly, 1970; Delson, 1975; Wolfheim, 1983). More recent morphological (Fleagle and McGraw, 1999; 2002) and molecular studies (Disotell *et al.*, 1992; Disotell, 1994; Harris and Disotell, 1998; Telfer *et al.*, 2003) however showed that *Mandrillus* species form together with *Cercocebus* mangabeys a distinct phylogenetic clade within the Papionini tribe (mandrills, drills, baboons, mangabeys and macaques). To the exclusion of the *Papio*, *Theropithecus* and *Lophocebus* genera, members of the *Cercocebus-Mandrillus* clade share a range anatomical traits that suggest reliance on hard object foods and "habitual aggressive use" of the forelimbs while foraging on the ground (Fleagle and McGraw 1999; McGraw and Fleagle, 2006). Specifically, molar cusps point towards a specialization for cracking open hard, resistant to decomposition seeds found on the forest floor, allowing utilization of a unique dietary niche during periods of food scarcity. Moreover, forelimb bone features are indicative of "powerful wrist and elbow flexion and rotation" which is thought to permit breaking open decaying logs in search of insects (Fleagle and McGraw, 1999; 2002). Jolly (1970) also reported that mandrills have larger forearm muscles relative to baboons, which is in agreement with the reported skeletal adaptation for frequent forelimb use.

Although the position of the *Cercocebus-Mandrillus* clade within the Papionini tribe is now well established, the phylogenetic relationship between the clade is less so. There is some evidence from cranial examination that the drill and the mandrill are closer phylogenetically to the red-capped mangabey (*Cercocebus torquatus*) than other *Cercocebus* species, but this relation is not supported by molecular findings (Fleagle and McGraw, 2006). The red-capped mangabey is sympatric to both the drill and the mandrill.

The drill and the mandrill were once thought to be sympatric, but a review of museum specimens by Grubb (1973) has defended the allopatry of the species with Sanaga River in Cameroon being the natural boundary in their distribution range. The mandrill range extends south of the Sanaga to the Congo River, across parts of south Cameroon, Equatorial Guinea (Rio Muni), Gabon and the Republic of Congo. The drill range is considerably more restricted extending north of the Sanaga River in Cameroon to Cross River in southeast Nigeria, and on the Island of Bioko of Equatorial Guinea (Figure 1.1). Remaining habitat suitable for the drill within its range is thought not to exceed 50,000 km^2, fragmented in approximately 50 forest fragments (IEA, 1998). Roughly 80% of the species' range is in Cameroon (Wild *et al.*, 2005). The Bioko drill (*Mandrillus l. poensis*) is currently recognized as a subspecies to the mainland drill population (*Mandrillus l. leucophaeus*) (Oates and Butynski, 2008). Although typically associated with lowland rainforests, the drill can be found across an elevational gradient that ranges from the sea coast in places like Bioko (Hearn and Morra, 2001) to premontane, montane forests and even mountain grasslands at 2000m in Bakossiland, Cameroon (Wild *et al.*, 2005).

1.1.2 Previous research and current knowledge of drill ecology

Despite its taxonomic distinctiveness and endangered status, the drill remains until today sparsely investigated. Remarks such as "an unfamiliar primate to many", "least-known" and "of low international profile" invariably characterize the introductory paragraphs of the limited drill literature (i.e. Gadsby, 1990; Cox, 1997; Steiner, 2000). Since the studies of Gartlan and Struhsaker on southwest Cameroon primates – including the drill – four decades ago (Struhsaker, 1969; Gartlan, 1970; Gartlan and Struhsaker, 1972; Gartlan, 1975), our understanding of the drill's natural

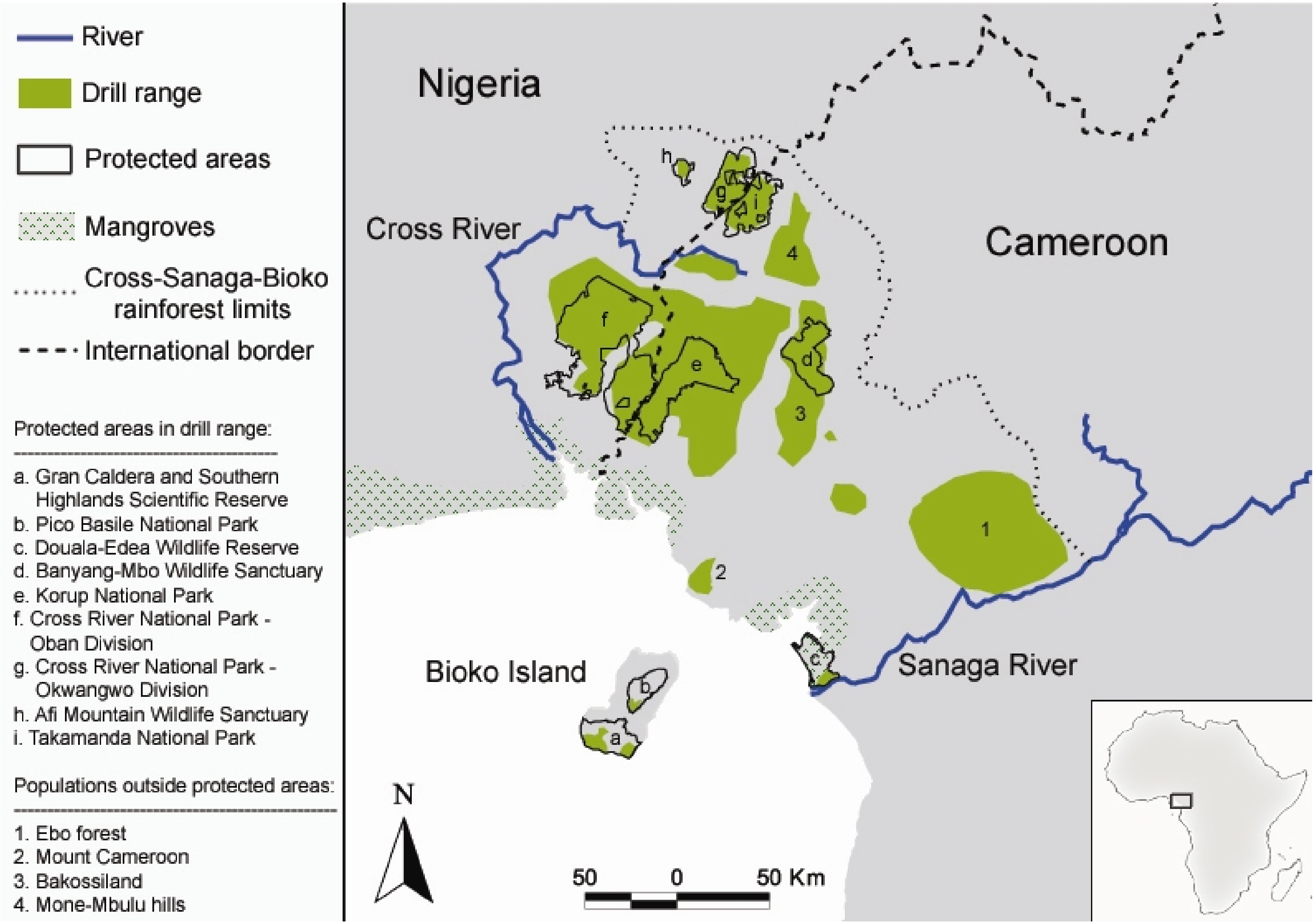

Figure 1.1: Extent of drill range and location of protected areas within the Cross-Sanaga-Bioko rainforests zone.

history and ecology has relied on studies of captive or semi-free groups (Böer, 1987; Hearn *et al*., 1988; Gadsby and Jenkins, 1997; Terdal, 1996; Wood, 2007), primate surveys (i.e. Faucher, 1999; Forboseh, 2007; Linder, 2008) and interviews with hunters (Gadsby, 1990; Steiner, 2000; Willcox, 2002). The scarcity of studies on wild drills is thought to reflect the species' restricted distribution and the inherent difficulties of studying a shy, terrestrial primate with large home ranges under the low visibility conditions of rainforests.

Not surprisingly, our natural history understanding of the drill is incomplete. The following paragraphs introduce major knowledge gaps, while aspects of drill ecology and status addressed by this study are introduced in depth in the respective chapters (Ch. 3-6).

Although feeding is a fundamental interaction of an animal and its environment, affecting multiple aspects of a species' natural history (i.e. socioecology, ranging, evolution) (Milton, 2006), no study has examined to date the diet of drills in the wild. Species specific information is limited to anecdotal field reports and information obtained from hunters (Gadsby, 1990; Schaaf *et al*., 1990; Steiner, 2000). Relying on mandrill diet studies (Hoshino, 1985; Lahm, 1986; Rogers *et al*., 1996; Tutin and White, 1998; White, 2007) and the reported dental and post-cranial morphological adaptations of the *Mandrillus* species (Fleagle and McGraw, 1992), it is widely accepted that the drill forages predominantly on the forest floor searching through rotting fallen wood and leaf litter for arthropods, fruits and seeds. No quantitative information exists on the relative importance of these foods for the drill.

Our understanding of drill ranging patterns is also poor. Malbrant and Maclatchy (1946) suggested that groups wander randomly without a fixed home range. Gartlan's (1970) field observations provided evidence against this view. Once again, it was mandrill studies in Cameroon (Hoshino *et al*., 1984) and Gabon (Rogers *et al*., 1996; Abernethy *et al*., 2002; White, 2007) that provided the basis for our current drill assumptions. Radio-tracked mandrill hordes at Lopé National Park, Gabon ranged over large areas (>100 km^2) in search of fruit sources, exhibiting large seasonal foraging and ranging differences. However, the savanna-gallery forest habitat of north Lopé NP is not typical of any current drill population, which raises concerns about how representative these findings may be for forest-dwelling drill groups.

Probably the most debated issue about the drill is its social system. It is not clear whether the basic social unit is the single-male group that occasionally coalesces with others to form the well documented larger groups (hordes), or if these large aggregations are permanent multi-male associations. Gartlan (1970) believed that his field observations on group size, fission and fusions, and vocalizations supported a multi-levelled rather than a multi-male drill social system. Similar evidence for mandrills in Campo, Cameroon (Hoshino *et al.*, 1984) strengthened this interpretation until recent findings from the radio-tracked mandrill hordes in Lopé NP, Gabon seriously challenged its universality in the genus. Lopé hordes are year round formations consisting of adult females, subadult males, juveniles and young, with only seasonal presence of mature males (Abernethy *et al.*, 2002; White, 2007). It is still unclear to what extent is this social system unique to the Lopé mandrill population.

Reports of polyspecific primate associations have been reported both for the drill (Gartlan and Struhsaker, 1979; Faucher, 1999) and the mandrill (Sabater Pi, 1972; Jouventin, 1975; Hoshino *et al.*, 1984; Mitani, 1991) during community-level primate association studies. As these studies did not focus on specific species, their analysis typically included only few encounters of rare primates such as the drill or the mandrill. Nevertheless, all studies reported drills and mandrills associating with most of the sympatric primates, including mangabeys (*Cercocebus - Lophocebus*), guenons (*Cercopithecus spp.*) and colobus (*Procolobus*) species. No study has examined whether the frequency of these associations are due to chance encounters alone or their possible ecological function.

A shared characteristic of *Mandrillus* species is the diverse vocal repertoire, which includes the unique to the genus crowing and 2-phase grunt (2PG) vocalizations (drill: Gartlan, 1970; mandrill: Kudo, 1987). The 2PG is emitted only by mature males, while crowing seems to be mainly a call of females and sub-adults. The k-alarm, screams, and roar are also unique drill and mandrill vocalizations among sympatric primates, but according to Kudo (1987) correspond to known baboon calls. Gartlan reported that crowing and 2PG calls seem to function as contact calls for the drill, with Kudo adding for the mandrill that that the former is used within distanced sub-groups and the latter for maintaining group cohesion on the onset of group movement. Kudo’s mandrill vocalization study was more comprehensive than the