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A preliminary report on feeding and nesting behavior of swamp gorillas in the Lac Télé Community Reserve

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A large population of the critically endangered *Gorilla gorilla gorilla* (Savage and Wyman 1847) has been found to thrive in the northern swamp forests of the Republic of Congo (Stokes et al. 2008, Walsh et al. 2008, Rainey et al. 2009). In the past, swamp forest has been largely ignored in research and conservation because of its inaccessibility and difficult terrain. In addition to gorillas (Fay et al. 1989, Fay and Agnagna 1992, Blake et al. 1995, Poulsen and Clark 2004), the Likouala swamps of northern Republic of Congo support high population densities of diverse aquatic and mammalian fauna (Poulsen and Clark 2002). Owing to the lack of commercially viable timber species and logistical complications of logging in a swamp forest, it is easier to protect from exploitation than other forest types (Poulsen and Clark 2002). Thus, swamp forest is a large, mainly intact haven for many animals that are otherwise threatened by logging and its associated threats. Our objective is to compare how *G. gorilla gorilla* in the Lac Télé Community Reserve (LTCR) in northern Republic of Congo nest in swamp and terra firma forest and to compare diet composition and food species obtained from each forest type during the low water season. We are primarily interested in assessing habitat variables that could explain any nesting patterns and whether the terra firma forest or the swamp forest provides the majority of food items consumed during the low water season.

The project site is the Lac Télé Community Reserve (1°21′N, 17°27′ E) in northern Republic of Congo. The Likouala-aux-Herbes river naturally divides the reserve into two sectors (for a detailed description of LTCR, see Poulsen and Clark 2002, 2004). This project was conducted in the northern sector of the LTCR along the swamp forest-terra firma ecotone from a camp located 1°16′ N, 17°23′ E. The ecotone is a transitional zone between the terra firma and swamp forest with a sharp change in habitat characteristics (Thomas and Packham 2007). Data were collected from 2nd May to 16th July 2008 during the low water season with the swamp forest inundated with 0.4–0.6 m of water. The core study zone encompassed 50 km^2 of primary mixed terra firma and swamp forest on either side of the ecotone, with approximately equal number of days spent tracking gorillas in each forest habitat. During the study we directly observed seven gorilla groups and lone males (Kalan and Rainey 2009). Data were collected on trails cut at fixed compass bearings along and perpendicular to the ecotone; however, most samples were collected along fresh gorilla trails. Methods included collecting, washing, and weighing fresh fecal samples and recording fresh feeding remains found along gorilla trails, as has been done in many studies of *Gorilla gorilla gorilla* ecology (Goldsmith 1999, Rogers et al. 2004). When fecal samples were collected from a fresh nesting site a maximum of two samples were taken, one of the silverback and the other of an adult. Fecal diameter size was assessed using Schaller's (1963) criteria. Detailed observations of sleeping nest sites encountered followed White and Edwards (2000) definitions of nest type and age class.

During this season almost half of the dry weight of gorilla fecal samples (44.55±3.73%) consisted of fruit remains including skins and seeds. On average, the number of fruit species per sample was 2.32±1.31 containing 14.20±1.90 seeds (n=56). There was no significant difference in the percent of fruit between forest types (χ^2=1.61, d.f.=2, p=0.45). The number of seeds and number of fruit species per sample were significantly different (χ^2=6.74, d.f.=2, p<0.05 and χ^2=9.27, d.f.=2, p<0.05, respectively). More fruit species were found in samples collected from the terra firma forest; however, average seed count was greatest in swamp forest fecal samples. It is worth noting there was no significant difference in fecal diameter size between the three habitats (χ^2=0.85, d.f.=2, p=0.65) and that the size of a fecal sample had no significant influence on percentage of fruit (r_s=-0.03, p=0.82), number of seeds (r_s=0.06, p=0.64), or number of fruit species (r_s=0.14, p=0.30) in a sample.

Overall, 96% of all samples contained whole seeds and 20% remnants of invertebrates. The presence of ants (χ^2=37.79, d.f.=2, p<0.01) and termites (χ^2=20.64, d.f.=2, p<0.01) in gorilla feces was significantly different because all remains were found in terra firma samples. Half of the swamp forest fecal samples included terra firma fruit species and 39% of terra firma samples contained remains of swamp forest fruits. The gorillas consumed *Uapaca* sp. and a similar sized unidentifiable fruit from the swamp forest. The diversity of fruit species consumed from the terra firma forest included *Chrysophyllum* sp., *Landolphia* sp., *Myrianthus*

arboreus, *Strychnos angolensis*, *Tabernaemontana* sp., *Tetrapleura tetraptera*, and two other fruits from the families Annonaceae and Menispermaceae. Feeding remains of two terra firma fruit species were the most frequently observed: *Myrianthus arboreus* and *Chrysophyllum* sp. (Figure 1).

A total of 255 nests were observed from 51 nesting sites (Table 1). Overall, there were 191 nests built on flat ground, 26 nests built upon decaying mounds of organic matter, and 26 nests built in trees. Four nest types were built on flat ground: 179 herbaceous, 10 mixed, one zero construction and one detached-woody. Only two nest types were built on mounds: 25 herbaceous and one mixed nest. Approximately 60% of all tree nests were found in the swamp forest. The remainder of nests was six mixed nests built in vegetation tangles and six herbaceous nests built on fallen trees in the swamp forest. Construction class of nests was significantly different among the three habitats (χ^2=70.80, d.f.=2, $p<0.05$). Herbaceous nests were more frequently observed in terra firma forest and tree nests were more frequent in swamp forest. Nest site reuse was observed at two sites in the terra firma forest where nine fresh gorilla nests were built upon very old decayed nests.

The number of plant species used for nest construction ranged from zero to five with ground nests containing significantly more plant species than those nests built above ground, specifically tree and mound nests (Z=-2.21, $p<0.05$). Overall, nest height had a strong negative correlation with the number of species used in nest construction (r_s=-0.17, n=255, $p<0.01$). The diameter at breast height (DBH; >10 cm) of the nearest tree to a nest was significantly different among the three habitats (χ^2=9.40, d.f.=2, $p<0.05$) with larger trees found more commonly on terra firma forest in the study area. Similarly, heights of trees containing nests were greater in terra firma forest although this was not significant (Table 1). An analyses between nests built under an open (n=243) or closed canopy (n=12) showed a significant difference in nest construction class (Z=-4.00, $p<0.05$) and location (Z=-2.58, $p<0.05$). Open canopy nests were more frequently herbaceous and within the terra firma forest, whereas closed canopy nests were often tree nests found in swamp forest.

This study shows western lowland gorillas at LTCR are facultative frugivores during the low water season. This is consistent with the past 30 years of research on western lowland gorillas where gorillas seek out succulent fruits, reducing their dependence on herbaceous species (Williamson et al. 1990, Remis 1997, Rogers et al. 2004), although a long-term dietary study is needed. Even during a period of intense fruiting on the terra firma the gorillas still rely on herbaceous species (Nishihara 1995, Kuroda et al. 1996). Particularly interesting was the unprecedented observance of gorillas targeting the *Tetraponera* sp. of ants which inhabit the myrmecophyte *Barteria fistulosa*. We found feeding site remains of this tree three times, once within a gorilla nesting site. As no evidence of tool use could be found it is believed the gorillas used their fingers to retrieve ants or ate the ants directly from the hollow branches of the tree. It is believed that the ingestion of insects compliments protein intake which is otherwise obtained from leaves (Williamson et al. 1990).

Our descriptions of nest building by *Gorilla gorilla gorilla* at LTCR show significant construction patterns associated

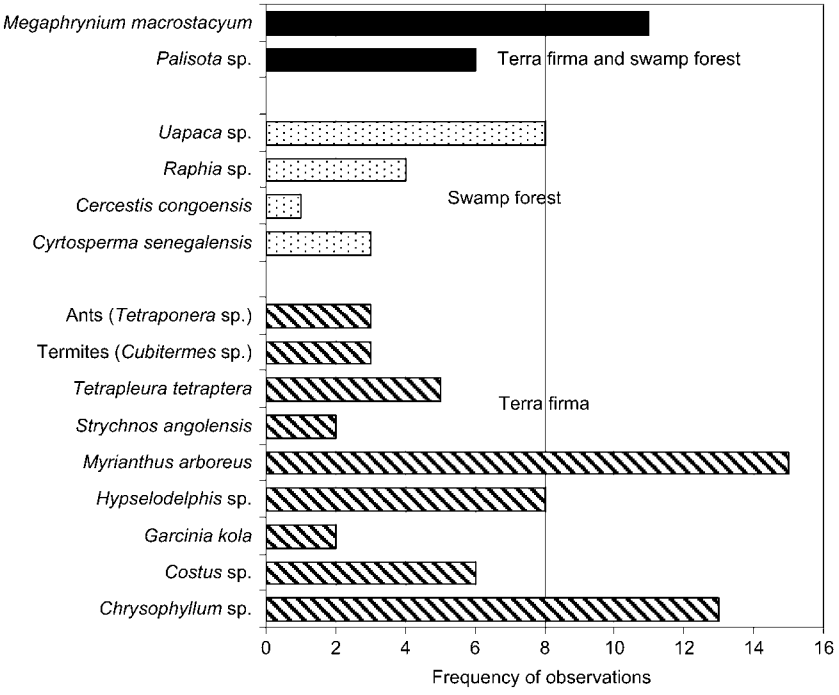

Figure 1 Frequency of observed *Gorilla gorilla gorilla* feeding remains (n=90) found in the study area categorized by forest habitat. Fruiting species were specific to their forest environment, whereas some herbaceous species grow in both forests.

Table 1 Gorilla nesting characteristics.

	n	Mean±SE	Total
Nest group size			5.00±0.66
Terra firma	34	5.62±0.87	
Swamp forest	8	5.00±1.68	
Ecotone	9	2.67±0.80	
Nest height (m)			1.84±0.40
Terra firma	191	1.18±0.42	
Swamp forest	40	5.88±1.43	
Ecotone	24	0.29±0.12	
Number of species			1.76±0.05
Terra firma	191	1.71±0.05	
Swamp forest	40	2.00±0.18	
Ecotone	24	1.79±0.21	
Tree height[a] (m)			18.06±2.27
Terra firma	9	24.03±4.51	
Swamp forest	16	15.69±2.26	
Ecotone	1	2.15	

[a]For trees with nests (n=26).
The results of a two-tailed Kruskal-Wallis test were non-significant for all variables.

with each forest type. In general, there is a preference for building open canopy, herbaceous nests in terra firma forest and tree nests with a closed canopy in swamp forest. The comparatively low sample size of swamp forest nests in the study area can be partially explained by nesting preference as well. Swamp forest nests were not found within 1 km of the ecotone and only one nesting site was found within 2 km. Nests were also absent from favorable herbaceous clearings in the swamp forest, located within 1 km of the ecotone. This could suggest that once the gorillas are within proximity to the ecotone they prefer to nest on the terra firma. This could maximize comfort by avoiding the inundated swamp forest but it could also be an energy saving strategy assuming constructing a tree nest requires more work than a ground nest. Additionally, the gorillas demonstrated a preference to incorporate more plant species when building a nest on the ground where it is not particularly strenuous. A greater number of construction species could serve to provide increased insulation and comfort from the rain (Anderson 1998).

Our data support the hypothesis that nest height is dependent on the size of available trees (Schaller 1963, Tutin et al. 1995). Gorillas could build ground nests more often owing to the lack of suitable trees if all other variables are equal. A suitable tree is not necessarily bigger but perhaps depends on accessibility and strength of the wood. Herbaceous Marantaceae and Zingiberaceae are most frequently used in gorilla nest construction throughout central Africa (Fay 1997). However, the popular herbaceous species, *Megaphrynium macrostacyum*, is not a significant nest building species in the swamp forest. This could be because its abundance in the swamp forest was comparatively lower. It is replaced with the preference for strong aquatic, herbaceous species such as *Cyrtosperma senegalensis*. Gorillas also used flexible and strong woody species. These species included the small trees (DBH<10 cm) of *Massularia acuminata*, *Dichostemma glaucosens*, and *Thomandersia hensii*, as well as a favored liana species, *Mannuphyton fulvum*. The high density of gorillas at LTCR could have an effect on the regrowth patterns of these preferred nesting species.

Fay (1997) recorded the use of decaying organic mounds in *Gorilla gorilla gorilla* nest construction although he did not see many nests built in this manner. There are many reasons why building a nest on a naturally occurring mound could be beneficial for a gorilla. Firstly, the greater support and cushioning can provide a more comfortable sleep. Secondly, using a natural structure for the foundation of the nest could reduce energy expenditure during the construction process. A positive feedback mechanism could exist whereby building nests on decaying mounds contributes to the build-up of organic matter overtime, promoting the continuous development of mounds. We observed that Marantaceae thickets, a preferred gorilla nesting site across central Africa (Tutin et al. 1995), had a slightly raised soil floor. We suggest that gorillas at LTCR are indirectly creating a favorable forest floor environment for building nests within Marantaceae thickets and therefore continue to prefer these sites for nesting.

The movements of swamp gorillas are an integral part of their ecology. We now have data to support movement of swamp gorillas to and from the terra firma forest during May to July (this study) and November to December (Poulsen and Clark 2004). During the low water season *Gorilla gorilla gorilla* of LTCR range onto terra firma to forage, whereas during the high water season it has been suggested that they take refuge on terra firma to escape flooding in the swamp (Fay et al. 1989, Fay and Agnagna 1992, Blake et al. 1995, Poulsen and Clark 2004). Seasonally, gorillas potentially travel long distances from within the swamp forest which constitutes the majority of the reserve. By contrast, there could be groups which survive solely in the swamp forest. Most importantly, gorillas become easily accessible to local hunters when concentrated on the terra firma; therefore, an understanding of their seasonal and daily ranging patterns is needed to improve conservation management at LTCR.

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