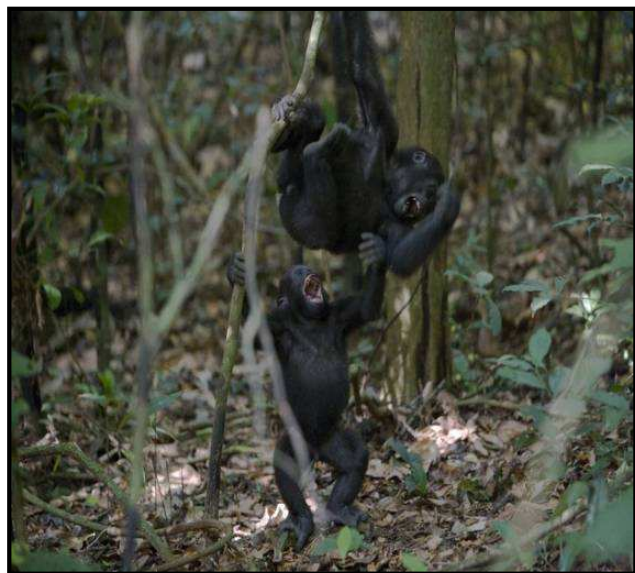
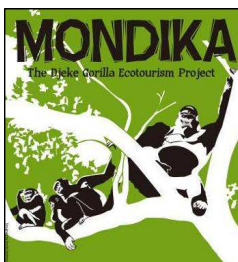
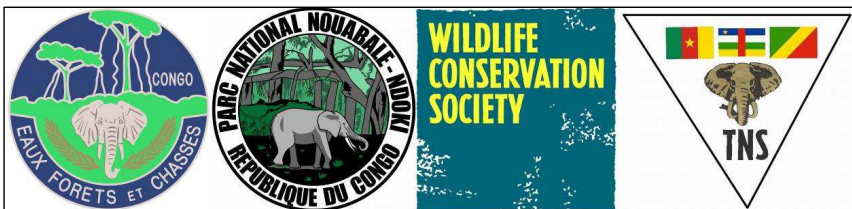


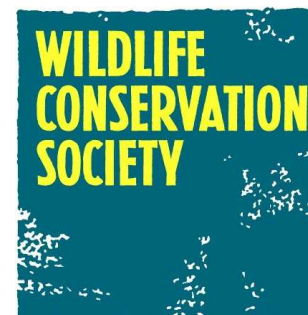


MONDIKA ECOLOGICAL TRAIL

WESTERN LOWLAND GORILLA INTERACTIONS WITH THEIR NATURAL ENVIRONMENT

INFORMATION HANDBOOK

Version 2.0



First Version by Varela Emilie (2008)

**Translated and updated by Thomas Breuer and Mireille Breuer-
Ndoundou Hockemba (2011)**

Further information on the plants was gathered mainly from *Harris & Wortley (2008) Sangha Trees – An Illustrated Identification Manual* and *Doran et al (2002) in Am. J. Primatology* and other literature mentioned in the reference section at the end of the guide. Illustrations of leaves are from *Harris & Wortley (2008)*. Photos are from Breuer, Breuer-Ndoundou Hockemba, Mongo or from Ian Nichols/NGS and Nick Nichols/NGS). Thanks to the Zoo de La Palmyre, the US Fish and Wildlife Service and the Wildlife Conservation Society for the financial support to elaborate the guide.



INTRODUCTION

The Djéké Gorilla Ecotourism Project, the former research centre “Mondika” has been opened to visitors in February 2007 after ecotourism pilot phases to approach wild western gorillas since. The Mondika Research Centre was created in 1995.

The site is under management of the Nouabalé-Ndoki-Project a collaboration of the Wildlife Conservation Society – Congo Program and the Ministry of Sustainable Development, Forest Economy and Environment. Mondika is one of only two successful habituation sites in the whole of the western gorilla geographic range in Central Africa. The site is one of two field program in the Republic of Congo with a group of wild western gorillas that is fully habituated to the presence of humans. There are currently two groups that can be viewed. “Kingo” group has been opened to tourists in 2007; a second group (“Buka” group) has been habituated and visitors have started to experience gorilla tracking with this group in January 2011. Activities in Mondika are developed to enable both behavioral research and ecotourism.

Although the two gorillas groups are the primary attraction, visitors are able to observe the rich assemblage of primates in the surrounding forest. In order to conform to the initial ecotourism objectives of the project, an ecological trail was created around the camp. The objective of this trail is to help tourists and other visitors to understand the ecology of gorillas and the interactions with their environment. The link between gorilla diet and the phenology of plants is also been explained along this information trail. This trail will also serve to highlight particular ecological concepts (plant dissemination, primary/secondary forest types, resource availability and seasonality, forest stratification) and traditional use of various plant parts from different species by local people. The current guide provides detailed information on this ecological trail and complements the Mondika Gorilla guide that provides detailed information on the location and history of the Mondika site.

BACKGROUND ON GORILLA FEEDING ECOLOGY

Much of the day-to-day life of primates is driven by three concerns: getting enough to eat, reproduce and avoid being eaten. Food is essential for growth, survival, and reproduction, and it should not be surprising that primates spend much of every day finding, processing, consuming, and digesting a wide variety of foods.

What do we know about western lowland gorilla?

The gorillas of Mondika belong to **western gorilla** species and *Gorilla g. Gorilla* subspecies. Western gorillas account for over 90% (population estimate 110 000 individuals in the range of Central Africa) of all remaining gorillas in the wild. They occur in the primary and secondary tropical forests but remain relatively poorly known compared to their eastern cousins and to mountain gorillas. Western lowland gorillas differ from mountain gorillas in a variety of ways. This includes their physical appearance (short coat and brown, red cap, smaller body size compared to mountain gorilla), social structure and diet. Diet of western lowland gorilla and mountain differ a lot because almost no fruit is found in the range of mountain gorilla habitat. In contrary western lowland gorilla diet is more diverse than that of mountain gorillas that show very little seasonal variation in their diet and are considered to be herbivores.

Western lowland gorilla diet; frugivory and its effect on ranging behaviour

Western lowland gorilla diet appears similar across sites, but there is great variability between years and seasons. Gorillas at Mondika consume a wide variety of fruits, leaves and piths/stems and some insect species.

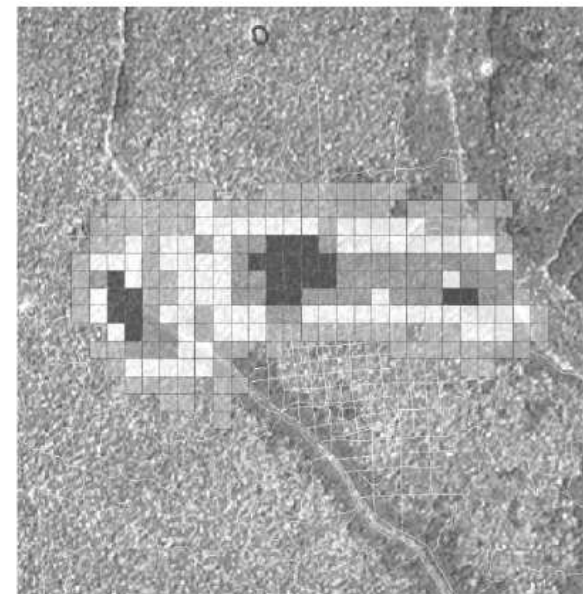
Overall, there are two different periods of dietary needs in western lowland gorillas: period of fruit availability (with more ripe preferred fruits available), and lean fruit period (with low availability of preferred fruits). During the period of low fruit availability (November until March), only some fibrous and unripe fruit are present; and most of preferred fruit is still unripe. In the non fruiting period that

shows very low fruit availability, gorillas concentrate on feeding on a wide variety of leaves, barks and some high-quality and low-quality herbs; and some including some fibrous fruit species which are available. Gorillas increase their consumption on a greater variety and quantity of non preferred fruit (e.g. *Duboscia macrocarpa*; *Tetrapleura tetraptera* and *Klainedoxa gabonensis*), some protein-rich herbs (*Haumania danckelmaniana*) and low-quality herbs (*Palisota sp.*) consumption, and reduce variety of leaves consumption. By the end of March, some fruit species start giving fruits, and this gives opportunity to gorillas to diversify their diet. During the fruiting period (April-October) gorillas eat a great quantity and variety of fruits, and reduce their leave consumption. Fruiting season peaks between July-September at Mondika. Note that there is a small transition period between these two periods, characterized by the scarcity of preferred foods; and gorillas increase the consumption of herb species (Marantaceae and Commelinaceae species). Termites are generally eaten throughout the year.



Female gorilla with infant feeding on ripe fruits (*Chrysophyllum lacourtiana*)

The feeding ecology of western gorillas also affects their habitat use. The ranging patterns of western gorillas are strongly related to the density and distribution of food resources. During periods of fruit availability, gorillas eat more fruit and travel more; their daily path length increases with increasing fruit availability. When fruit availability decreases, the gorillas eat a greater variety of leaf species and herbs that are commonly available at the site, and this has a direct negative impact on daily path length which decreases. In general, the mean daily path length varies from 0.5-2 km per day. At Mondika, the daily path length of gorillas is longer (mean = 2,014 m per day) than that of mountain gorillas (500 m per day), and is largely related to fruit acquisition; and is less during period of fruit scarcity (about 1500 m per day). The home range varies from 10 to 20 km².



Home range use of Kingo group in a one year period (from Doran-Sheehy et al. 2004)

Another ecological factor is swamp use; which influences ranging behaviour at the site. When gorillas visit the swamp they travel more; the daily path length increases. Western lowland gorillas at Mondika, forage in larger areas each month, and revisit them more

frequently and consistently through time compared to mountain gorillas. The annual home range size of our well-habituated group "Kingo" is 15.4 km².

Western gorilla feeding ecology details from Mondika (From Doran et al. 2002 and Doran-Sheehy et al. 2009)

Species	Family	Life Form	Density (No./ha)	DBH
Type I. Long duration, large quantity				
<i>Duboscia macrocarpa</i>	Tiliaceae	Tree, med	2.1	69.3 (36.3)
<i>Tetrapleura tetraptera</i>	Mimosaceae	Tree, med	1.6	52.4 (39.2)
<i>Klainedoxa gabonensis</i>	Irvingiaceae	Tree, big	0.7	111.1 (38.1)
<i>Aframomum</i> spp.	Zingiberaceae	Herb		
<i>Megaphrynium macrostachyum</i>	Marantaceae	Herb		
Type II. Short duration, large quantity				
<i>Landolphia</i> spp.	Apocynaceae	Liana		—
<i>Anonidium mannii</i>	Annonaceae	Tree, small	10.9	49.3 (26.9)
<i>Diospyros ituriensis</i>	Ebenaceae	Shrub	5.2	(13.8)
<i>Dialium</i> spp. (<i>pachyphyllum</i> and <i>senkeri</i>)	Caesalpiniaceae	Tree, small/very small	1.25 and 0.53	(11.6 and 19.6)
<i>Hexalobus crispiflorus</i>	Annonaceae	Tree, med	1.1	67.6 (24.7)
<i>Barteria devevirei/fistulosa</i>	Passifloraceae	Tree, small	2.1	(17.2)
<i>Haumania danielmaniana</i>	Marantaceae	Herb		
<i>Drypetes</i> spp. (<i>diopa</i> and others)	Euphorbiaceae	Small, tree or shrub	0.4 and 3.0	
<i>Diospyros mannii</i>	Ebenaceae	Tree, small	1.2	20.6
<i>Strychnos</i> sp.	Loganiaceae	Liana		
<i>Oncoba (Caloncoba) welwitschii</i>	Flacourtiaceae	Tree, small	2.5	21.6 (22.5)
<i>Pancovia laurentii</i>	Sapindaceae	Tree, small	4.8	36.3 (23.2)
<i>Tabernaemontana</i> spp. (<i>penduliflora</i> and <i>crassa</i>)	Apocynaceae	Tree, small	0.9 and 1.25	(12.0 and 12.1)
<i>Greenwayodendron (Polyalthia) suaveolens</i>	Annonaceae	Tree, small	10.2	38.1 (23.9)
<i>Angylocalyx pynaetii</i>	Papilionaceae	Tree, med	5.2	51.2
<i>Vitex doniana</i> or <i>welwitschii</i>	Verbinaceae	Tree, small	2.1	37.8
Type III. Long duration, small quantity				
<i>Myrianthus arboreus</i>	Moraceae	Tree, small	4.1	36.3 (31.3)
<i>Chrysophyllum (Gambeya) lacourtiana</i>	Sapotaceae	Tree, big	2.3	82.7 (23.8)
<i>Ficus</i> spp.	Moraceae	Strangler		
Type IV. Additional fruits that are present in >5% of feeding trails				
<i>Irvingia excelsa</i>	Sapotaceae	Tree, big	0.7	123.7 (52.9)

Definitions are modified after Nishihara [1995]. Long duration fruits were present in focal samples during $\geq 50\%$ of months. Large quantity occurred in $> 50\%$ of samples in at least a single month or had a mean abundance focal score of ≥ 2 . Sizes of trees include: big (> 80 cm), med (50–80 cm), small (20–50 cm), and very small (< 20 cm). DBH in parentheses is from transects.

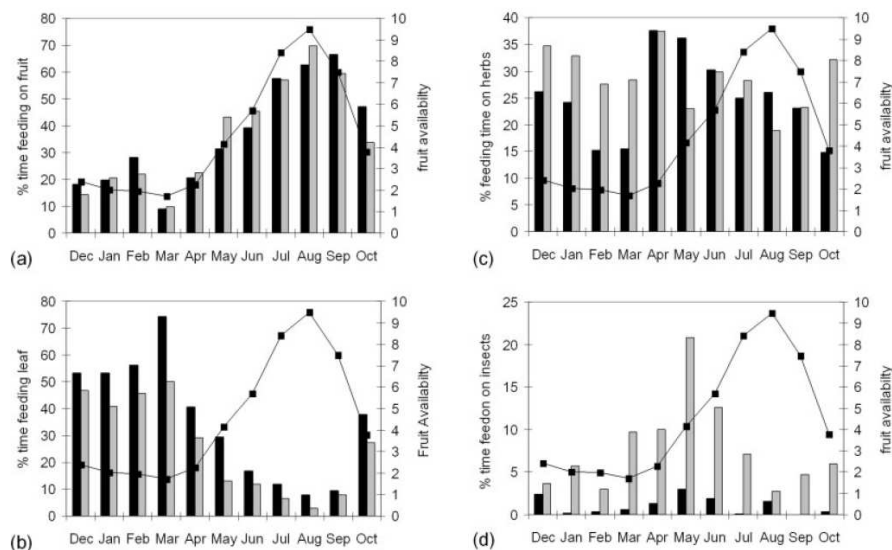
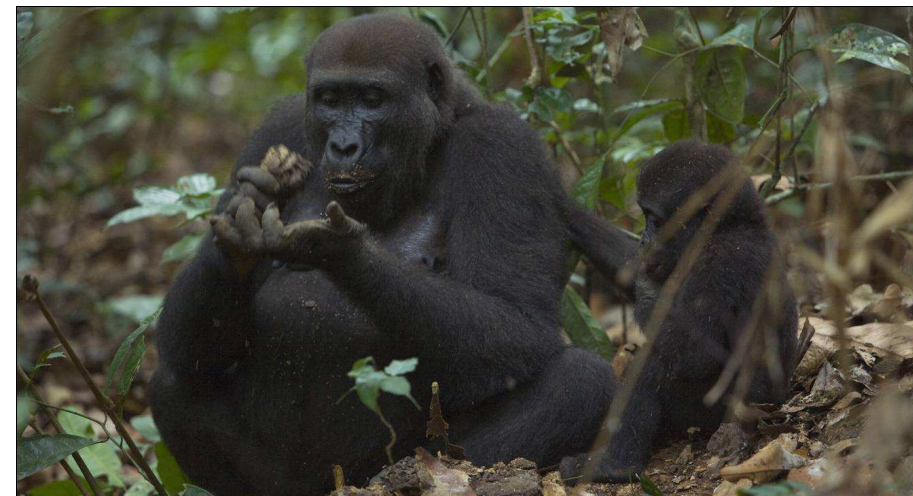


Fig. 2. Mean monthly variation in time spent feeding by male (black bar) and female (grey bar) gorillas on (a) fruit, (b) leaves, (c) herbs, and (d) insects in relation to ripe fruit availability (line). Sample sizes are indicated in Table 1.

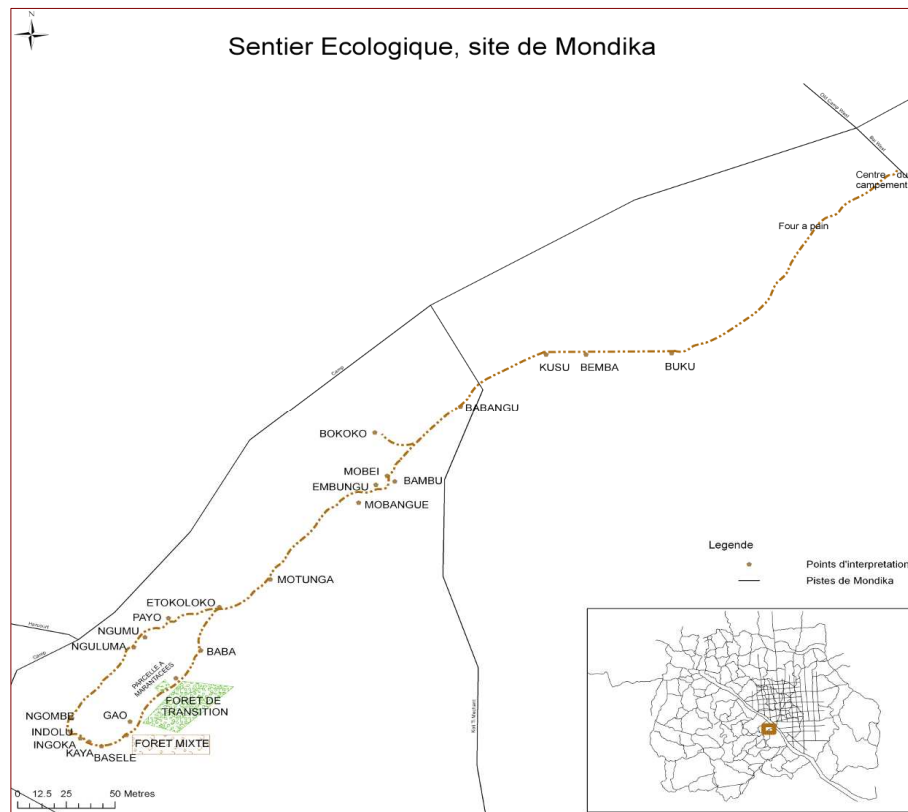
THE ECOLOGICAL CIRCUIT

This ecological trail guide will give tourists the information on each food species eaten not only by gorilla but also by other animals (including humans). This way we hope to provide an introduction into the ecology and environment of gorillas at Mondika; and also the important role that gorillas play in seeds dispersal. Our ecological trail passes through three of the four habitats used by gorillas at Mondika site. Each food species was marked (with local and scientific name and family), its characteristics, use by gorillas and fruiting patterns. Our ecological trail was created based on previous findings on western lowland gorilla feeding ecology and diet at Mondika. To this end, about 20 plant and one animal species (termites) were selected from a list of important and preferred food items at our site.



Female gorilla with infant feeding on termites

The Ecological Circuit Map



Some basics about tropical forest ecology



The tropical forest is divided into distinct categories or strata according to the high of the plant species. They are five distinct categories: 3 strata of trees, one stratum with fewer trees, and one stratum with herbaceous plants (see photo of stratification of forest).

Each stratum gets less sunlight than those above. To catch little light, plant species in each strata have developed different strategies for growing early in life. Plants are called “autotrophic”, because they are capable to produce their own nutrients from water and sunlight. Solar energy is crucial for their survival.

Therefore, sunlight is the only element that can limit the growth of plants species. Most tropical forests have a “closed canopy”, which means that the branches of canopy trees are close together. Because there are so few “gaps” in the canopy, not much sunlight reaches the forest floor where the seeds and seedlings need it. Tropical rain forest trees must compete for sunlight until they, themselves, reach the canopy. This competition has led different species of trees to adopt different “strategies” for growing early in life.

Some species, called “shade-loving or shade-tolerant” species, grow slowly with little available light, surviving in spite of the constant shade. Mature trees of these species tend to produce a small number of large seeds. The seeds are large in order to support a seedling long enough to produce leaves large enough to catch what little light is available. “Shade-loving plant” species tend to grow into trees that dominate the canopies of mature forests. Thus, these species will reproduce successfully, even if only a few of the seedlings from each mature tree grow to become canopy trees.

Species called “shade-intolerant or light-loving” species wait for direct sunlight to reach the forest floor. They grow very quickly, and tend to produce many small seeds so that when by chance a tree fall occurs, some of the seeds already will be in the right place at the right time and can start growing the moment direct sunlight hits the forest floor. Light-loving plants species grow tall quickly and reproduce at a young age. Usually, each tree will not live more than a few decades.

A tree fall gap is always dominated by light-loving species, since they grow quickly in full sunlight. As the light-loving species or shade-intolerant species grow and produce a more closed canopy, the shade-tolerant species continue to grow

beneath them, whereas shade-intolerant species no longer regenerate and become rarer. As the shade-intolerant species age and die, the shade-loving species will once again come to dominate the undisturbed canopy.

The strategies of shade-loving and light-loving species represent extremes, and are used here to emphasise the compromises that are required of a tree growing with limited resources. Many tree species have growing strategies that fall somewhere in between the two extremes.

The tropical rainforest canopy system feature increases the diversity of the species by creating new niches as new sources of food, new shelters, new hiding places, and new areas for interaction with other species. In fact, it is estimated that 70-90% of life in the rainforest is found in trees. The leaves of the canopy, act as miniature solar panels providing an energy source in the forest by converting sunlight into energy through photosynthesis. In addition to epiphytes, other plant species including lianas and climbers, offer new opportunities to terrestrial animals to access the resources of the canopy.

In contrast, in mountain forest, ground vegetation is dense and rich. This vegetation consists of small and medium trees, and the canopy is usually open. Thus herbaceous vegetation develops up to 2 m high. The Western lowland gorilla is terrestrial and arboreal. During fruit season, they used to climb up to the trees, reaching sometimes 30-35 m high. In comparison mountain gorilla habitat is less arboreal than western lowland forests and consists mostly of herbaceous rich vegetation on ground.



Aerial view of tropical rain forest in the Nouabalé-Ndoki National Park

Typical forest types at Mondika

There are several forest types which can be found in the Mondika study site. Our ecological circuit includes two major forest types and on transition forest. Obviously our trail does not pass through the swamp forest, but you can get a picture of that habitat type from the camp site.

1. MONDOMINANT GILBERTIODENDRON FOREST

This forest type is dominated by stand of a single species – the *Gilbertiodendron dewevrei* (locally called Bemba; commercial name: Limbali) – The canopy is almost always closed and the understorey is relatively open. Leaf litter can be a lot and visibly in this forest type is increased. The presence of monodominant *Gilbertiodendron dewevrei* forest is common as patches among the mixed moist semi-evergreen lowland rain forest (White, 1983) and occurring from south eastern Cameroon to eastern Congo (Harris, 2002). In the Ndoki forest, it is often situated along swamp forest and therefore a good indicator for proximity to water, albeit their can be large stands of inland Bemba forest. *Gilbertiodendron dewevrei* is a shade tolerant species with large and poorly dispersed seeds, and under the presence of a major disturbance will regenerate at a lower rate than mixed forest species (Hart et al., 1989). Factors leading to and maintaining this monodominance are not yet fully understood and range from soil conditions (Peh, et al., 2011) to the presence of ectomycorrhizal network associated with monodominant species (McGuire, 2007), creation of an extremely shaded understorey, less variable levels of light, more leaf litter, slower rate of decomposition, etc) (Torti et al., 2001) or large-scale disturbance events (Lovett et al., 2007), such as fire (Hart et al., 1996). Preliminary palaeoecological analysis in northern Congo showing presence of high peak of charcoal around 100-200 cal yr BP might support the disturbance hypothesis (Tovar, 2010).

2. MIXED SPECIES FOREST

The mixed forest is the most widespread and the most diverse of the vegetation types occurring in and around the Nouabalé-Ndoki National Park. It can usually be identified by the presence of many large and medium sized trees, creating a complex structure with high species diversity. The structure of the forest is made up of emergent tall trees (up to 50 m) with separate crowns and a range of shorter trees of different heights growing between them. The canopy cover is not always closed and light gaps can create dense patches of Marantaceae forest. Mixed forest consists of a variety of emergent (>40m), tall (30-40m), medium-sized trees (15-30m), shrubs, lianas and giant herbs (Harris, 2002). Soil type seems to affect the distribution of several tree species in northern Congo (Guillot, 1981). The mixed forest presented here is the mixed forest with open under-storey; what many would call “primary or mature forest”. Here we show just a sample of mixed forest located on our ecological trail. A typical mixed forest is being crossed by visitors on their way back to Bomassa.

3. TRANSITION FOREST

Here the transition forest is a kind of “Marantaceae forest”, which is located between the mono-dominant Bemba forest and the mixed forest with opened under-storey. This transition forest consists of a relatively closed upper canopy, sparse middle-storey and dense herbs layer on the ground dominated by Marantaceae and Zingiberaceae plants species (such *Haumania spp.*, *Aframomum spp.*), including some Commelinaceae (*Palisota spp.*) and Arecaceae (*Laccosperma spp.*) species. The *Megaphrynium macrostachyum* patches in this area appear to be maintained by disturbance by elephants and gorillas. Western lowland gorillas like this type of habitat, where it's dense and closed; this allows for the protection during the night against predators (especially leopard).



This transition forest is characterized by a dense ground vegetation made up of free standing and lianescent species of herbaceous plants, mostly Zingiberaceae (*Aframomum spp.*), Maranthaceae (*Haumania dankelmaniana*, *Megaphrynium spp.*, *Sarcophrynium spp.*), Commelinaceae (*Palisota spp.*), and Arecaceae (*Laccosperma spp.*). These form an almost impenetrable thicket about 2-3 m tall, but which occasionally climbs up to 10 m or more, forming towers which engulf small trees and dead stumps.

The only way to penetrate this habitat is along well worn elephant trails or using knives to cut small herbs when tracking gorillas. Marantaceae plots are the result of disruptions affecting trees on forest block. In general, Marantaceae forests are tightly packed when one tree falls down it often brings down several of its neighbours, forming large gaps in the canopy which allow light to penetrate. These provide ideal conditions for the growth of herbaceous plants species (Marantaceae, Zingiberaceae, Commelinaceae, and Arecaceae species), which explode to fill the gap on the ground, whilst trees close to the gap are finally able to spread their

branches out. In general, in young Marantaceae forests the canopy is still dominated by the colonisers, but as time progresses, it becomes more diverse. This process gradually results in an increase in the diversity and structural complexity of the forest. There comes a point when the trees above begin to shade out the Marantaceae forest. As ground vegetation becomes less dense more and more trees establish, and the Marantaceae forest gives way to mature forest. Gorillas at Mondika have more preference to this type of habitat, not only because it allows for protecting themselves against predators, but also because this transition Marantaceae forest provides a wide variety of herbaceous plant species which are rich in protein and water. During the non-fruit period, gorillas at Mondika use more this dense forest type and also prefer to build their nests in these patches.

Typical herbaceous plant species present in the Marantaceae plot are:

- Njokoko/Njombo:** *Aframomum spp.* (Zingiberaceae). Gorillas eat pith (stem) and fruits.
- Mangabo:** *Palisota brachythyrsa* (Commelinaceae). Gorillas eat stem.
- Doto:** *Palisota ambigua* (Commelinaceae). Gorillas eat stem.
- Ngungu:** *Megaphrynium spp.* (Marantaceae). Gorillas eat shoots, fruit and stem.
- Basele:** *Haumania danckelmaniana* (Marantaceae). Gorillas eat stem and seeds.
- Gao:** *Laccosperma spp.* (Arecaceae). Gorillas eat stem.
- Indolu;** *Whitfieldia elongata* (Acanthaceae). Gorillas eat leaves.
- Ingoka:** *Thomandersia hensii* (Thomandersiaceae). Gorillas eat leaves.



Western gorillas feeding on *Hydrocharis chevalieri* in swamp.

4. SWAMP FOREST

The frequency of swamp use at Mondika is not only influenced by the presence of herbaceous aquatic herbs (such as *Hydrocharis chevalieri*, *Aframomum spp.*, but also by *Grewia oligoneura* and including *Nauclea sp.*, during swamp fruit availability. These two trees species constitute one of the factors in increasing daily path length at Mondika site. Gorillas frequent more in swamp forest during fruit availability in flooded forest. In swamp forest, there are many small clearings, called “Bai” in Ba’Aka pygmy language. The Bai is an open, fairly safe environment. This offers individuals good visibility of the rest of the group and anyone else who may be present. Gorillas mainly visit swamp forest/clearings to feed on aquatic herbaceous vegetation (AHV). The vegetation has very high mineral contents (particularly Sodium) and also high protein content. Minerals are rare in the forest environment but essential for many physiological processes within an organism. Amongst the plants that you may see the gorillas feeding are: *Hydrocharis chevalieri*, *Aframomum sp.*; they also feed on a range of leaves and fruits from trees around and into swamp (*Grewia oligoneura*, *Nauclea sp.*, and *Landolphia sp.*). The clearings or Bai offers a unique opportunity for demography, population dynamics studies/life-histories of different gorillas groups, including the encounters between groups. The only good example of the study of gorillas in Bai is the Mbeli Bai Study (see photo below).



Two blackback gorilla groups during an encounter at Mbeli Bai

1. BEMBA

Scientific name: *Gilbertiodendron dewevrei*; **commercial name:** Limbali

Family: Leguminosae-Caesalpinioideae

Habitat: Terra firma forest

Characteristics

Type: Tree

Height: Up to 45 m

Trunk: Generally straight and cylindrical, diameter: > 60cm

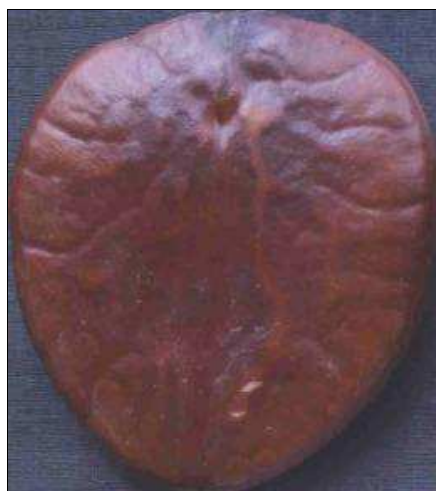
Leaves: Green colour; new leaves are red

Fruit: The fruit is a large explosive pod brown which contains large seeds thrown away after explosion. This species does give fruits almost every year; fruit contains large seeds which attract other mammals – flowering and fruiting might be triggered by low temperature in January. When flowering, there can be many bees in the forest. Below is a table that indicates the period of fruits/seeds and leave consumption by Mondika gorillas (+ occurs; ++ more common)

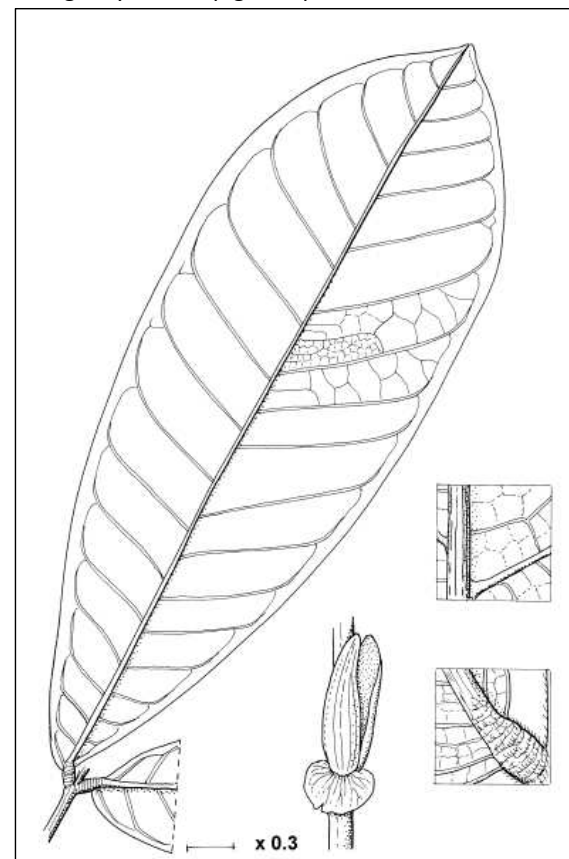
	March	April	May	June	July	August	Sep	Oct	Nov	Dec	Jan	Feb
Bemba	++	+	+	+	++	+	+	+	+	+	++	++
	Consumption of fruits/seeds											
	+	Consumption of non fruit part (leaves)										



Bemba's fruit and mature seed.



USE: *Gilbertiodendron dewevrei*, (local name in pygmy Ba'Aka language: Bemba – sometimes also called Malapa). As you see we are in Bemba forest, primary forest (Terra firma forest). The forest consists of large trees (reaching 30-45 m high) with small understory trees and shrubs. The Bemba covers a thousand of km² from the Republic of Congo, Gabon, Central African Republic, and Cameroon to the northern of Democratic Republic of Congo; and is restricted to forest along rivers and streams – occasionally Bemba forms **monodominant** stands away from rivers. Gorillas eat leaves and seeds (see photo). During the low fruit season, when fruits are scarce, gorillas eat new leaves. The fruit is a large pod (about 30 cm long), covered in golden brown velvet. The seeds are thrown away from the parent tree when mature, and then the pod dries out and splits. This species doesn't give a lot fruit all the year, but when fruits are abundant, especially in June, July and August, there are a large quantity of seeds which attract different mammal species, such as Chimpanzees, mangabeys, bush pigs, elephants and buffaloes. During this period gorillas become



seeds-eaters. New leaves are regularly consumed (by gorillas and other primates, such as *Colobus*) since they have no secondary compounds. Mast fruiting is common and is possibly triggered by low temperatures in January and February. Elephants, bongos and buffaloes love the shoots of the seedlings. Humans also eat boiled Bemba seeds or as peanut or by putting in water for one night after smoking. Bark is used for roofing. Bemba wood/timber is used for carpentry and joinery. Limbali is not a commonly exploited species, and still occurs in large patches throughout northern Congo.

2-KUSU

Scientific name: *Cubitermes termites*

Family: *Insects*

Period of consumption

Termites are rich in protein and can account for up to 20% of daily gorilla diet. Gorillas at Mondika consume termites almost throughout the year.

The termites Kusu are not aggressive. Gorillas and chimpanzees are insect-eaters, but their termite-eating habits differ in terms of prey species and feeding technique. Animal protein consumption is lower in gorillas than in chimpanzees, considered to be more carnivorous than gorillas. Gorillas do not use any tools when eating on termite. Gorillas usually fed on *Cubitermes heghi* by breaking open their nests by hands. Nest of *Cubitermes* can be free-standing or build against trees. In contrast, chimpanzees use tool set of perforating stick and fishing brush to get termites from their underground nests. Chimpanzees in the Ndoki forest modify stems of *Marantaceae* plants to create brush-tipped probes. Termites from the genus *Macrotermes* are most often extracted from their nests with the aid of tools (both epigeal and subterranean nests), whereas the mounds of *Pseudacanthothermes* and *Cubitermes* are toppled and the termites are eaten by hands. *Thomandersia hensii* sticks are commonly used for penetrating subterranean termite nest (various references from Sanz and Morgan from their long-term study in the Goulougo Triangle).



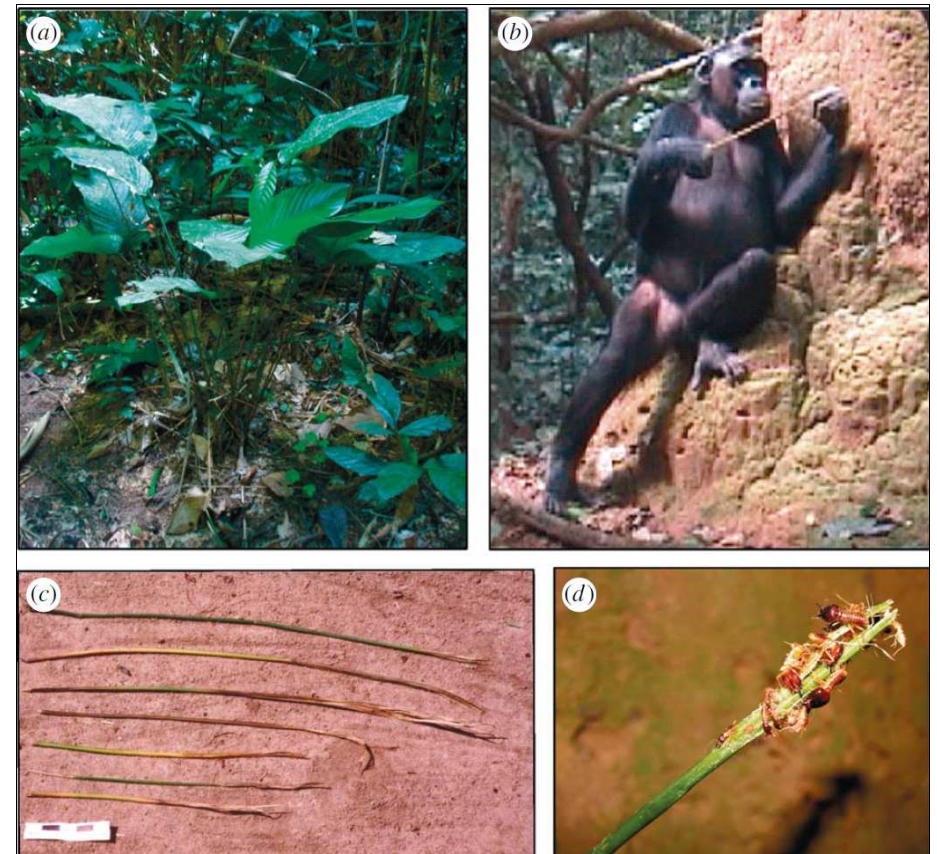
Nest types of *Cubitermes* in the Ndoki Forest

Apart of termites, gorillas also feed on weaver ants (*Oecophylla longinoda*), eaten mostly during the rainy season at Mondika.

Gorilla also often show soil scratching behavior, particularly in the Bemba forest which is possible related to the consumption of mycorrhizal mushrooms along roots.

Some basic Termite Ecology

There are almost 20 species of termites and the majority live in tropical rain forest. Termites eat wood which contains cellulose and lignin; these two nutrients are difficult to digest. There is a relationship between some micro-organisms and termites. The micro-organisms eat cellulose and then provide substances important for termites. Termites and these micro-organisms live in symbiosis, a reciprocal dependence for both species. Termites are considered to be active destroyers of dead trees in forest. Termites and microscopic bacteria, including mushrooms contribute to the decomposition of organic matter which contains plant and animal debris. All these debris are important nutrients for plants in forest.



Chimpanzee termite fishing behaviour from the Ndoki Forest: (from Sanz et al. 2009 Biol. Letters)

3-BABANGU

Scientific name: *Diospyros iturensis*

Family: Ebenaceae

Habitat: Terra firma and Bemba forest

Characteristics

Type: understory tree growing up 12-15 m in height and 8-12 m in diameter; small branches and leaves

Trunk: Thin relatively straight – maximum diameter: around 30cm;

Bark: Grey-black; timely fissured, bark finely rough, slash red

Fruit: Fruits are berries, bright-yellow-orange turning slightly red when ripe.

Use: Gorillas and many other primates eat fruit (April-August).

	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Babangu												
			Fruit consumption period									



Diospyros iturensis



Diospyros mannii



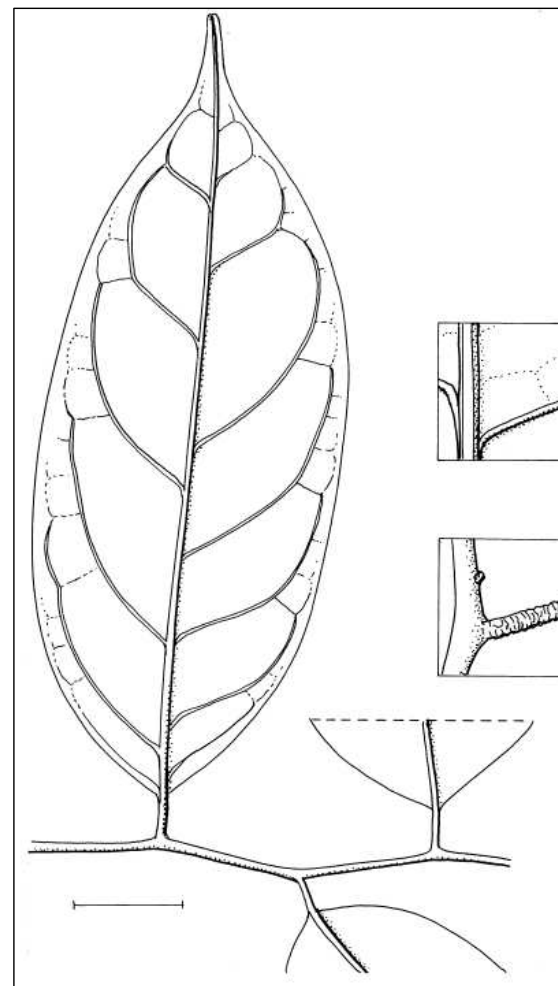
Diospyros crassiflora

Background on ebony wood: The family *Ebenaceae*, the ebonies, is represented by one genus, *Diospyros*, with over 450-500 species worldwide and 10 species in the Sangha Trinational. The ebonies often have black heart-wood which is locally commercialized for carving and carpentry. They are mostly shrubs and small trees found in rain forest. The ebonies are very important trees which are used in carpentry but they have slow growth, one of the reasons why they are endangered. They produce fruits which are eaten by all of the frugivorous primates (including western lowland gorillas). Their immature seeds are eaten by gorillas and chimpanzees in poor fruit years. They are very seasonal, and do not give fruit every year at Mondika. Two species of *Ebenaceae* family, *Diospyros crassiflora* (African Perssimon or Gabon Ebony) and *Diospyros manii* are among what we called

“preferred fruit” at Mondika. *D. crassiflora* is considered endangered.

Importance of rain forests for current and future generation

Although rains forests are known to play a key role as natural habitat for animal species, they serve so many life-sustaining functions by providing food such as fruit, nuts, and meat, building materials and medicines for local uses, as well as timber to people who live in and around them. In addition, they play a key role as intact rain forests stabilise, reducing erosion and hence providing clean water to drink, and regulating climate, both locally and globally. That's why we have to avoid destroying these forests; thus the deforestation of forests by humans could lead to serious consequences on our natural environment and the health of our own species worldwide.



4-BOKOKO

Scientific name: *Klainedoxa gabonensis*; **Commercial name:** Eveuss

Family: Irvingiaceae

Habitat: Terra firma forest

Characteristics:

Type: Large tree

Trunk: Straight sometimes with several large buttresses which extend quite high up the trunk; maximum diameter > 60cm

Bark: when you see up close the bark is purplish-grey

Height: Very large tree growing to 50 m or more in height with large, spreading branches.

Flowers: Small and pale, but highly visible.

Fruits: Fruits are large drupe. When mature they are about the size of an apple, with four or five distinct lobes, each surrounding a stone, shape like a large garlic clove, containing a seed. The dry, fibrous fruits are green, with purple hue, and without odour. When ripe they taste a little like sugar cane.

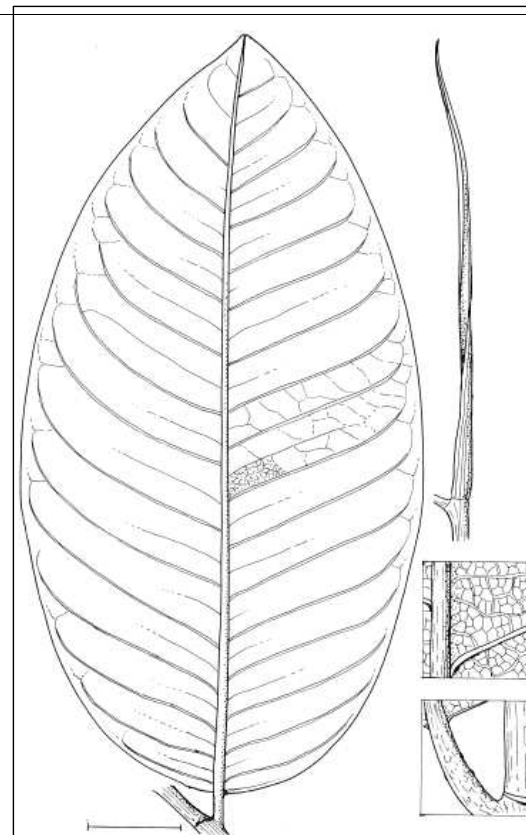
Use: Western lowland gorillas eat fruits. The silverback gorillas occasionally disperse their large triangular seeds. Fruits are also eaten by many of the frugivorous mammals, but yellow-backed duikers and elephants disperse their large seeds. Humans eat seeds. Seeds are extracted from the hard stone and pounded into a paste which is used in cooking, like peanuts. The bark is used for rheumatism treatment and in carpentry.

	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Bokoko												
		Fruit and seed consumption period										



K. gabonensis is a species which, despite its name, occurs right across the rain forest belt of Africa from Sierra Leone to Uganda. In the Republic of Congo it occurs in most forest types from the North to the South. Many species of *Klainedoxa* possess stipules, but rarely are they so well developed and prominent. *K. gabonensis* is a good example of plasticity of tree form. The bark is used against the treatment of rheumatism, and the timber is used as rail sleeper for railway construction.

Sometimes we can see termites' nests (especially another species of termites, *Macrotermes muelleri*) on



the trunk of the tree. We've no evidence of gorillas at Mondika site, eating this termite species. These termites are consumed by chimpanzees; knowing that they are more aggressive than other species; chimpanzees use tool set of perforating stick and fishing brush to get *Macrotermes muelleri* termites from their underground nests (see also previous section on Kusa). *K. gabonensis* has fibrous fruit which contain seeds that are rich in lipid. At Mondika, gorillas eat fruits from March to the beginning of December; these include of course other frugivorous mammals (such as yellow-backed duikers and elephants, including occasionally silverback gorillas that disperse their large triangular seeds). Humans consume the seeds of *K. gabonensis* cooking like peanuts.

Seed-eaters and fruit-eaters

The distinction between seed-eaters and fruit-eaters during the dissemination of seeds is very crucial. Seed-eaters destroy seeds; this has a direct impact on plant germination; but fruit-eaters contribute to seed dispersal, since they eat and swallow only a fleshy part and do not destroy seeds; and then all seeds disseminated in the forest can regenerate normally. Seed dispersal is very important for plant reproduction and regeneration, and allows for understanding species distribution. The majority of tropical forest plant species (70%-80% in forest of low altitude; 50% in mountain forest), are disseminated by animals (especially birds, bats, primates, duikers and elephants). There is inter-dependence between forest and animals. Not only animals need forest as their natural environment, forest also needs animals for its natural regeneration. Forest could not be regenerated without the crucial role played by animals in terms of seeds dispersion. Animals in turn use forest like their natural habitat. We all know the important role played by primates in terms of maintaining the dynamics and structure of natural forests. All plants and animals species belong to an ecosystem in which there is a complex interaction network that should not be destroyed. Forests without animals have no future!!!

5-BAMBU

Scientific name: *Chrysophyllum lacourtiana* (former name *Gambeya africana*)

Commercial name: Longhi

Family: Sapotaceae

Habitat: Mature terra firma forest

Characteristics:

Type: Large tree up to 1.5-2 m of diameter. Easy identified by bark/slash

Height: 40-50 m tall

Trunk: Is straight and cylindrical with several high, thin buttresses; the timber is used in carpentry.

Bark: Grey-brown with quite deep, regular fissures

Leaves: simple, alternate, and green-dark above.

Flowers: Small cryptic

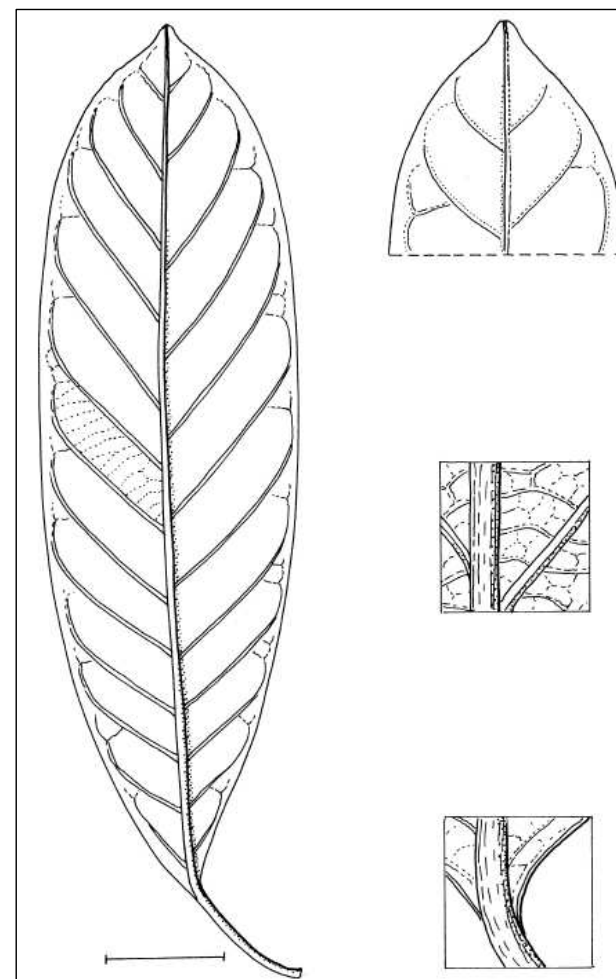
Fruits: Red when ripe, the juicy flesh around the seeds is sweet and eaten by many animals. Become mature by April-June, and reach the peak in July-August.

	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
		Fruit consumption period										



Bambu is a large tree, reaching 40-50 m high. The tree presented in our trail is still young. Bambu provides the fleshy fruits, which are indehiscent and red when ripe. Fruits are eaten by gorillas and other mammals (elephants, duikers, monkeys and chimpanzees). Bambu is among gorillas' preferred food at Mondika site. The tree is not evenly distributed in the study site. Gorillas usually travel long distances, moving from tree to tree to search for Bambu fruit.

Fruits are also eaten by human and sold in the markets. This species is commercialized. There is evidence that there is a kind of inter-specific competition including for access to food resources. Bambu provides a timber which is used in carpentry, and for making furniture. Bambu tree is recognized for his pharmaceutical property. The bark is used for the treatment of pregnant women, to avoid the false childbirth; and also used for stopping hemorrhages and vagina inflammation. Bark of roots is used for hearing problems, and also for rheumatism, arthritis and kidney problems and for stopping hemorrhages and treats vaginal inflammation.



The Forest Pharmacy

As you see, the forest offers a rich pharmacopoeia with medicinal virtues that are traditionally known. These medicinal plant often collected by women allow for the treatment of physiological diseases, such as coughing, fever, parasites and worms. Some treat snake's bite, and are used for making love and aphrodisiac potions.

All these pharmaceutical property interest in particular the laboratories that are interested in medicinal research in tropical forest. Additionally, women sometimes collect some plant for the purposes of aesthetic for making tattoo, and kitchen utensil (baskets and gallows) using plant fiber. Thus, we all know that forests offer

multiple goods and services to populations living in and around the area.

6. MOBEI

Scientific name: *Anonidium mannii*

Family: Annonaceae

Habitat: Mature forest

Characteristics:

Type: Medium-large tree

Height: 30-35 m high and up to 1, 5-2 m of diameter

Trunk: Is straight and cylindrical with no buttresses

Bark: smooth and dark

Leaves: simple, alternate, medium green; large (20 x 10 cm)

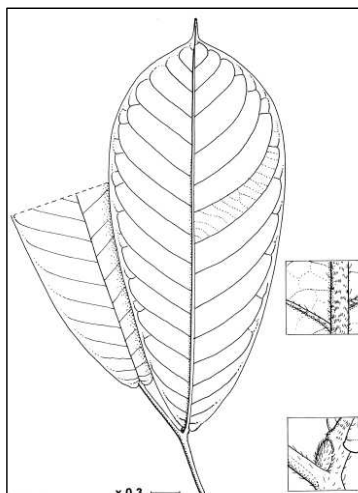
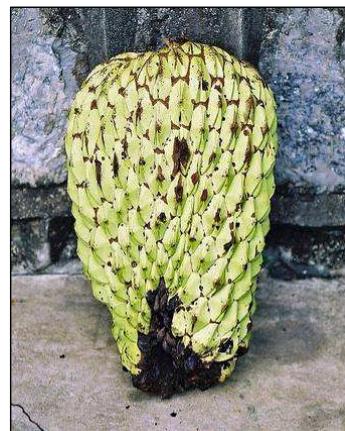
Flowers: Small cryptic

Fruits: Large, yellowish when ripe (up to 50 X 30 cm). Fruit contains many seeds inside; each surrounded by yellow mango-like pulp.

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Mobei												

Fruit consumption period

Use: Mobei is a medium large tree (up to 30-35 m high, with 1.5-2 m of diameter). The tree is also called “forest Sour sop”, and is much appreciated by animals and humans. Fruits are like pineapple, very sweet (but sometimes sour) and are eaten by many animals, including gorillas, monkeys, chimpanzees, elephants and humans. Monkeys usually consume unripe fruit from the tree (except for *Cercocebus agilis* and *Lophocebus sp.*) they feed on ripe fruits which are most of the time on the ground); in contrast all great mammals (elephant, chimpanzees and gorillas) used to feed on ripe fruit on ground. In the Republic of Congo, the bark is used as anti-inflammatory and for the treatment of gastrointestinal problems. In other parts of Africa, bark, fruit, roots, latex, seeds are used for the treatment of coughing, rheumatism, snake bites, wounds, dysentery, convulsions, tooth decay, angina, epilepsy, vertigo, making easier childbirth, treatment of hemorrhoid, constipation, and feminine sterility, diarrhea and asthma.



7. EMBUNGU

Scientific name: *Strombosia nigropunctata/pustulata*

Family: Olacaceae

Habitat: Terra firma forest

Characteristics:

Type: Medium-large tree

Height: 30-35 m high with 70 m of diameter

Trunk: Is straight and cylindrical with irregular buttresses

Bark: Is grey and easily recognized because of numerous thin scales flake off. Bark dimpled with reddish and whitish patches

Leaves: variable in sizes (4-5 x 2-6.5 cm)

Flowers: Small greenish white

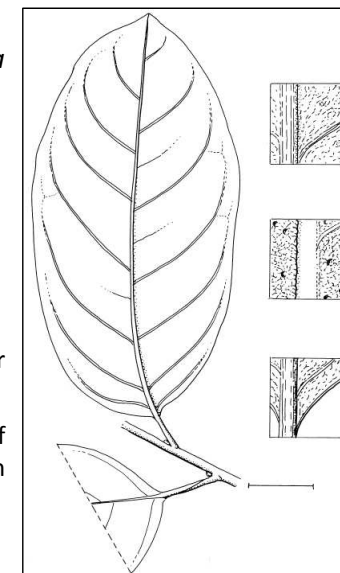
Fruits: small, yellow –green when ripe. Fruit contains a single seed with a hard, pitted shell.

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Embungu												

Fruit consumption period

Use: The tree provides small drupes which are yellow-green when ripe, and are consumed by gorillas during the wet season which coincides with the fruit period at Mondika site. People use its timber for the construction. The wood is very resistant against insects' attacks. *Strombosia* is one of the most common trees in the Ndoki forest.

Most of the trees in this species, not all, have superficial roots, which are a special adaptation with two main objectives: 1) Firstly, to enable the tree to get firm grip to the ground, and keep it stable, to avoid the uprooting during the rainy season and violent wind. 2) Secondly, superficial roots allow for capturing nutrient. Some trees have developed symbiosis with mushrooms which are in and against roots. This association root-mushroom is called “mycorrhize”. Symbiosis is a specific relation between two living species with mutual benefit.



8. MOBANGUI

Scientific name: *Strychnos* spp.

Family: Loganiaceae

Habitat: Terra firma forest

Characteristics:

Type: Liana, up to 25-35 m long

Fruit: small (2 cm), orange when ripe, with a single seed

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Mobangui												
		Fruit consumption period										

Use: Mobangui is a liana up to 25-35 m long, with a pale grey stem up to 10 cm diameter, which starts life as a clambering shrub. This liana snakes up from the ground high into the canopy. This allows for getting light in canopy. Mobangui is consumed also by other animals, such elephants and mangabeys (*Cercocebus agilis* and *Lophocebus* sp.). Seeds are eaten by Duikers.

Other important liana species are *Landolphia* and other species in the genus *Strychnos*. Most of them have never been identified to species level.



Three *Strychnos* and one *Landolphia* species (at the extreme right) are regularly consumed by gorillas. Human also do eat on *Landolphia* and *Strychnos*; they have a juicy sweet flesh around the seeds. Competition for light loving plants species is crucial. Each plant species has developed strategies to capture the light in the canopy. Lianas are particularly abundant in the Ndoki forest.

8. MOTUNGA

Scientific name: *Greenwayodendron suaveolens*
(former name *Polyalthia* s.)

Family: Annonaceae

Habitat: Terra firma forest

Characteristics:

Type: Medium-large tree

Height: 35-40 m high with 50cm of diameter

Trunk: Straight, no buttresses or widening at base

Bark: Is pale brown, with a strong resinous odour.

Leaves: (15 x 6 cm) with bold lateral nerves, are covered in very short brown hairs on their undersides

Flowers: Small greenish brown

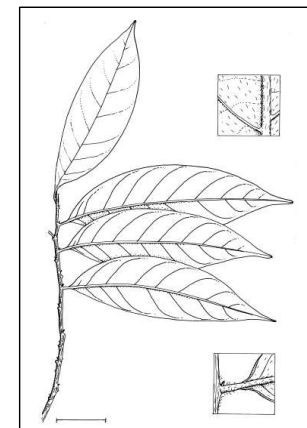
Fruits: small, spheres (about 1.5 cm diameter), with characteristics seeds. Fruits are crowded along the larger branches, and blue-dark when ripe.

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Motunga												
		Fruit consumption period										

Use: Motunga is a medium-large tree up to 30-35 m high. Fruits are small pulp with a single seed, and are consumed during the rainy season by gorillas and other animals (such as elephants).

Bark is used as braid by pygmy for sleeping in forest. The powered bark is a remedy for stomach aches. The wood is very hard and resists insects attack, so is a favoured timber for construction and furniture making.

Motunga is among the commercial trees. One of the major threats is the exploitation for timber. The exploitation of timber leads to the destruction of habitat, including habitat fragmentation. As human populations increase steadily, more and more land is need for agriculture; and as technology advances, exploitation for timber, hunting (including disease, such as Ebola fever) and other forest products becomes more and more intensive and damaging. Under this scenario, natural resources within and around protected areas need to be conserved to ensure sustainable management of biological diversity.



10. ETOKOLOKO

Scientific name: *Tabernaemontana penduliflora*

Family: Apocynaceae

Habitat: Terra firma forest

Characteristics:

Type: Small tree

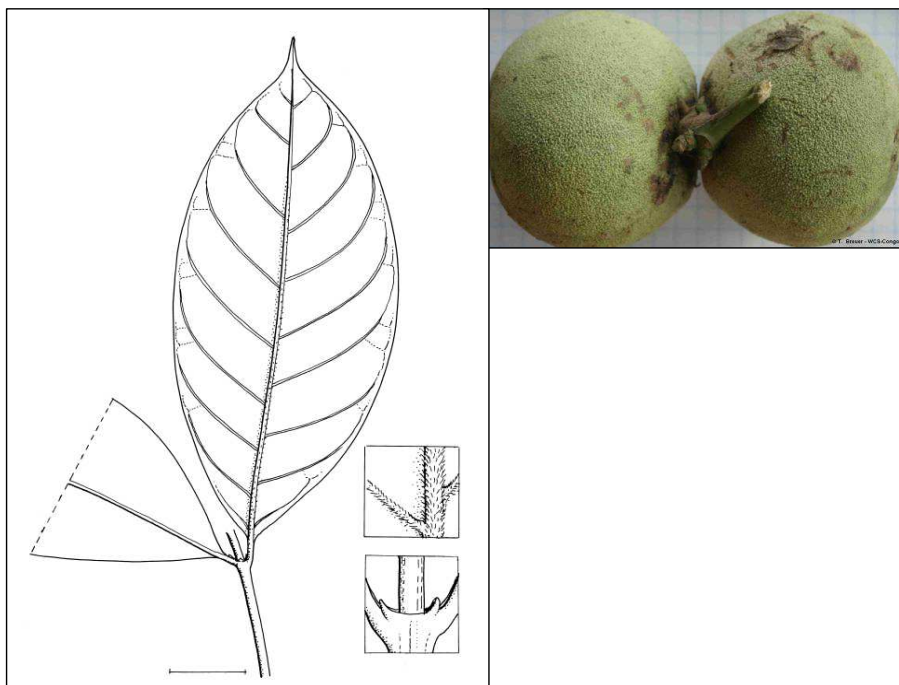
Height: 10-15 m high with 10-15 m of diameter (30cm max.)

Bark: Is pale grey.

Fruits: Dark green with paler dots; indehiscent, consisting of 2 separate subglobose follicles (about 5-6 cm diameter), with black lacerate brown seeds when ripe.

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Etokoloko												
			Fruit consumption period									

Use: Gorillas at Mondika consume fruits of Etokoloko when mature (ripe). Fruits are spherical and hard. Etokoloko is a small tree up to 10-15 m high. The tree presented in our trail here has already reached the maturity.



11. BABA

Scientific name: *Santiria trimera*

Family: Burseraceae

Habitat: Terra firma forest

Characteristics:

Type: Medium-large tree

Height: 20-30 m high

Trunk: Straight. Have characteristic thin, vertically flattened, arched, and stilt roots at base, maximum diameter around 50cm

Bark: umber coloured, which flakes off in irregular patches; with a strong resinous smell like that of young mangoes

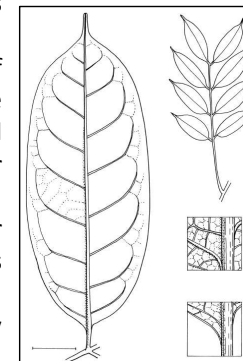
Leaves: Have 2-4 pairs of generally quite large leaflets and a single terminal one with a longer stalk.

Flowers: Small yellow-green about 5 mm across, on narrow panicles, which mostly develop from the leaf-axils

Fruits: Flattened, about 3 cm. They are red-purple when ripe and contain a characteristic seed surrounded by a thin pulp.

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Baba												
			Fruit consumption period									

Baba is a medium-size tree up to 20-30 m high, found in tropical rain forest, and his latex has a strong resinous smell like that of young mangoes. Baba belongs to the same family as Okoumé (*Aucoumea klaineana*), the most exploited tree species by foresters in Gabon, and is restricted to the southern two thirds of Gabon, although it just crosses the frontiers with the Republic of Congo, Cameroon and Equatorial Guinea. Their juicy fruits are drupe, and are eaten by gorillas from April-August. Humans also appreciate their fruit which smell of turpentine, but taste like wine. In some parts of Africa Baba is cultivated and its fruits sold at markets. The oily seeds are also consumed by man in some places, and used for cooking. His latex is also used for making incense or torch (mostly by pygmy). As other trees species of tropical rain forest, Baba has developed different strategies or adaptations. The tree has superficial roots at base. This adaptation is mostly seen with the trees of lower stratum (such as swamp and mangroves trees species). One can say that superficial roots play a key role in capturing oxygen, important for the life of the tree.



13. NGUNGU

Scientific name: *Megaphrynium macrostachyum*

Family: Marantaceae

Habitat: Marantaceae plot (transition forest)

Characteristics:

Type: Herbaceous vegetation

Leaves: Single spade-shaped leaf of variable size, generally 30-60 x 12-30 cm, but occasionally up to 90 cm long.

Flowers: Yellow with red centre, borne on a stalk which grows off the leaf petiole.

Fruits: Red when ripe or black capsules in 3 sections. They contain 3 seeds with a sugary white flesh.

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Ngungu	++	++	++	++	++	++	++	++	+++	+++	+++	+++
			Fruit consumption period									

Use: Apart from gorillas, fruits are also dispersed by other animals (e.g. apes, mandrills, and elephants). The leaves are put to many uses by humans. They are collected in large quantities for use as roof tiles, as food wrappers and as “ecological tin foil” which is wrapped around food to be cooked in the embers of fire. Stems are used for making braids; shoots are cooked and consumed as vegetables. In Ivory Coast, latex and extract of leaves are used to treat epilepsy and poisoning cases. In general, gorillas eat those parts that are easy to digest or rich in nutrients, and then reject those that are more toxic or difficult to digest. For Ngungu, gorillas at Mondika eat shoots and fruits, but they reject stem and leaves. Shoots are easily digestible than leaves, and contain less lignin. Gorillas also choose for rich-protein herbaceous plant species with less fiber. Leaves of trees contain more digestive inhibitors than those of herbaceous plant species. Leaves consumed by western lowland gorilla contain more tannins than those consumed by mountain gorillas.



In the non-fruit season Gorillas' diet is dominated by “non-fruit foods”, which include low-quality herbs (e.g., *Aframomum spp.*, and *Palisota spp.*), and high-quality herbs or “protein-rich herbs” (e.g., *Haumania danckelmaniana*), a wide variety of leaves, and *Celtis spp.* bark, dominating their diet. These resources are commonly available, and those in trees (particularly *Celtis spp.*) occur in patches large enough to permit many gorillas to feed. These are among what we call “fallback foods”.

14. NJOMBO

Scientific name: *Aframomum limbatum*

Family: Zingiberaceae

Habitat: Marantaceae plot (transition forest)

Characteristics:

Type: Herbaceous vegetation

Flowers: Are held up to about 30 cm above the ground on fleshy stems.

Fruits: Are berry which are red when ripe. They contain multiple tiny seeds.

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Njombo	++	+	+	+	+	+	++	++	++	++	++	++
		Fruit consumption period						+	Herbaceous parts consumption period			

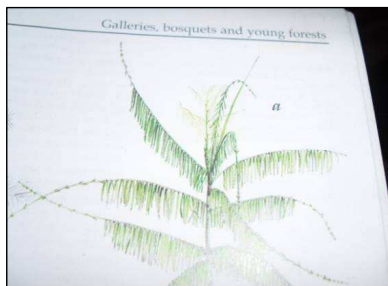
Use: Njombo is a herbaceous plant species which belongs to the family of Zingiberaceae (wild gingers). In general, the genus *Aframomum* is represented by about 20 species. At Mondika there are a minimum of 3 species of *Aframomum* (*Aframomum limbatum*, which is found in terra firma, also near water; *Aframomum polyanthum*, found in flooded area, in swamps; and *Aframomum subsericum*, which is found in terra firma forest. The genus *Aframomum* is currently under revision as more species and differentiation is being discovered. Zingiberaceae are herbaceous plant species with large leaves including underground rhizomes. Rhizomes are fleshy stems which grow up horizontally underground, and accumulate nutrients. This underground part produces roots on lower face and stems on the upper face. In comparison to roots, rhizomes possess buds which produce leaves and stems. Some Zingiberaceae species produce edible rhizomes in which one's extracts spices (e.g. gingers). Elephants appreciate these rhizomes. If you crush the leaf or break the stem of plants in this family there is usually a strong aromatic smell, somewhat like that of ginger. *Aframomum* species such as Njombo are the first species to thrive in gaps in Marantaceae forest; there are called “pioneers species”. Together with other herbaceous plants, they constitute the dominate gorilla foods. At Mondika, gorillas consume stem (pith), throughout the year, including fruit when available. In addition, leaves of Njombo are sometimes used for nest construction when gorillas decide to spend the night in Marantaceae forest. Therefore, Zingiberaceae species constitute not only food resources for gorillas, but also used as material for nests construction at Mondika. Thus, gorillas at Mondika have 3 main activities: travelling, feeding and resting (or sleeping).



15. GAO**Scientific name:** *Laccosperma secundiflora***Family:** Arecaceae**Habitat:** Marantaceae forest/thickets**Characteristics:****Type:** Liana, herbaceous vegetation**High:** Up to 20-25 m

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Gao	++	+	+	+	+	+	++	++	++	++	++	++
	+	consumption period										

Use: Gao is in the same family with *Raphia spp.*, species in which leaves once mature the leaflets are plaited into roof tiles; and the leaf mid ribs are used in construction and to make furniture. Gao is a liana, gorillas consume the pith of young plants, but humans consume the pith of mature plant of Gao. It has thorny stems, which it uses to wrap around nearby trees, enabling it to grow to heights of over 30 meters. The local population harvests the trees, and uses them to make palm oil and palm wine, as well as canes (similar to rattan) for furniture, mats and baskets.

**16. BASELE****Scientific name:** *Haumania danckelmaniana***Family:** Marantaceae**Habitat:** Light gaps, roadside vegetation and old fields**Characteristics:****Type:** Herbaceous vegetation**High:** To 10 m**Flowers:** white**Fruit/Seeds:** trigonous, spiky; seed without aril

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Basele	++	+	+	+	+	+	++	++	++	++	++	++
	Seeds consumption period							+	Herbaceous parts consumption period			

Use: Gorillas at Mondika consume herbaceous part of *Haumania danckelmaniana*, stem (pith) and the fruits. This species belongs to the family of Marantaceae. *Haumania danckelmaniana* is considered to be one of the staple foods at Mondika site, which is protein-rich herb (consumed year-round). Like Zingiberaceae species, Basele is also used by gorillas for nests construction. Some



scientists argue that the density of gorillas is related to the density of terrestrial herbaceous vegetation (THV) and in particular to the density of Haumania. Haumania density in Mondika is high as well as gorilla density (more than 4 weaned gorillas per km²).



Gorilla Nesting patterns

In general, gorillas usually build their nests in the closed under-storey; to protect themselves against predators (especially leopard) and potentially against other gorillas. Previous study on nests building done in Lopé National Park (Gabon), demonstrated that most of nests (about 50%) were built using herbaceous plants, in which about 80% were built using *Megaphrynium spp.* (Ngungu) materials. In contrast, gorillas at Mondika have no preference to where they can build their nests; depends to where they are in forest. All types of materials (shrubs, herbaceous plants, small branches of small-sized trees) of distinct habitats are used by gorillas for building nests. Thus, there are many types of nests, which are defined as follows:

-Tree: Nests built in trees, constructed by pending and breaking branches to form a sleeping platform. This type is mostly used by chimpanzees; gorillas also do make nest in tree, but not very often.

-Woody: Nests built on the ground made entirely of wood vegetation from bent lianas, shrubs or saplings.

-Herbaceous: The nest consists of several stems of herbaceous plants.

-Mixed: Similar to “Herbaceous”, but woody vegetation (lianas, shrubs and branches of small trees) have been incorporated into the nest.

-Minimum: Consists of one or two stems of herbaceous plants.

-Zero: No nest structure exists. Gorillas have slept on the ground. This type of nest is difficult to identify. The presence of feces, hair, and sometimes the smell of gorilla, helps in identification of the nest.

The nests “Zero” are rapidly destroyed by other animals, and become difficult to identify during tracking.



17. KAYA

Scientific name: *Sarcophrynium schweinfurthianum*

Family: Marantaceae

Habitat: Terra firma forest

Characteristics:

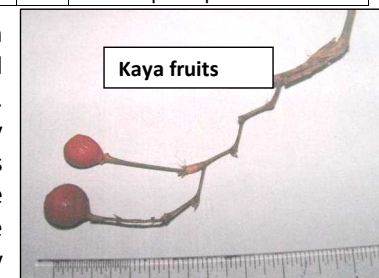
Type: Herbaceous vegetation

High: Up to 2 m high

Fruits:

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Kaya	+	+	+	+	+	+	+	+	+	+	+	+
	+	Fruit consumption period							+	Herbaceous parts consumption period		

Use: Gorillas at Mondika consume fruits from October to February during the non-fruit period (period of fruits scarcity), including shoots. Leaves are collected in large quantity by pygmy people for use as roof tiles. This species has developed diverse adaptations for capturing the light, which is important for their survival. The evidence is that, leaves of under-storey herbaceous plants species are large compared



to those of opened under-storey herbaceous plants species. The enlargement of leaves allows for the absorption of the light and for improving photosynthesis process. Photosynthesis is a chemical process which allows green plants to produce their nutrients from solar energy, water, and carbon dioxide. The photosynthesis takes place inside chloroplasts. For capturing maximum of light, leaves can change their orientation during the day. It was demonstrated that in tropical forest, photosynthesis doesn't occur only inside leaves; some trees have roots which contain chloroplasts that allow them to contribute to photosynthesis process.

Another characteristic of tropical forest is the fact that it's raining throughout the year. Plants receive large quantity of water which one lead to many problems, such the increase of leaves weight. Constant humidity leads to leaves decomposition.

18. INGOKA

Scientific name: *Thomandersia hensii*

Family: Thomandersiaceae

Habitat: Terra firma forest

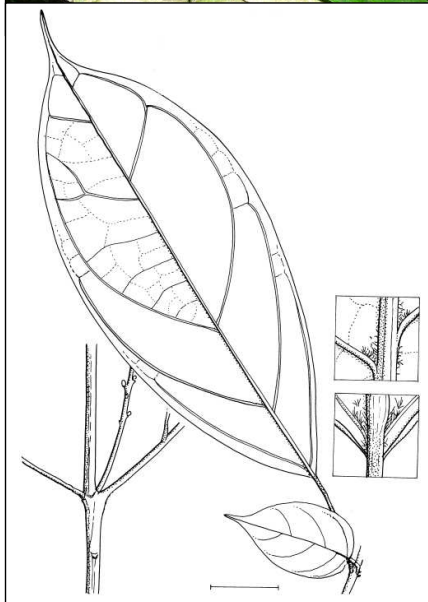
Characteristics

Type: Small tree, maximum diameter < 15 cm

High: up to 5-6 m

	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Ingoka	++	+	+	+	+	+	+	+	++	++	++	++
	+	Leave consumption period										

Use: This small-sized tree can reach 5-6 m high. At Mondika gorillas consume leaves year-round. Leave consumption increases during dry season which coincides with the period of fruit scarcity at the site. Leaves are also consumed by elephants. Humans use leaves to treat gastrointestinal distress and parasite infection and bark ear aches. We can say that plants species used by humans to treat their pains are also used by primates for the same properties. There is evidence that animals may treat themselves using natural resources. This is known as zoopharmacognosy or more simply, self-medication by wild animals. Till now there is only one study about plant self-medication by western gorillas (Masi et al., 2011). In contrast many studies on zoopharmacognosy were done on the chimpanzees at the Mahale Mountain National Park in Tanzania for over a decade. It has been demonstrated that leaves and roots used by primates are used widely by human to treat gastrointestinal distress, parasite infection, and malaria.



19. NGOMBE

Scientific name: *Celtis mildbraedii*

Family: Cannabaceae

Habitat: Terra firma

Characteristics

Type: Tree

High: Up to 35 m high

Trunk: with buttresses up to 3 m high – maximum diameter > 60 cm, bark is smooth, sometime falling to leave dimples

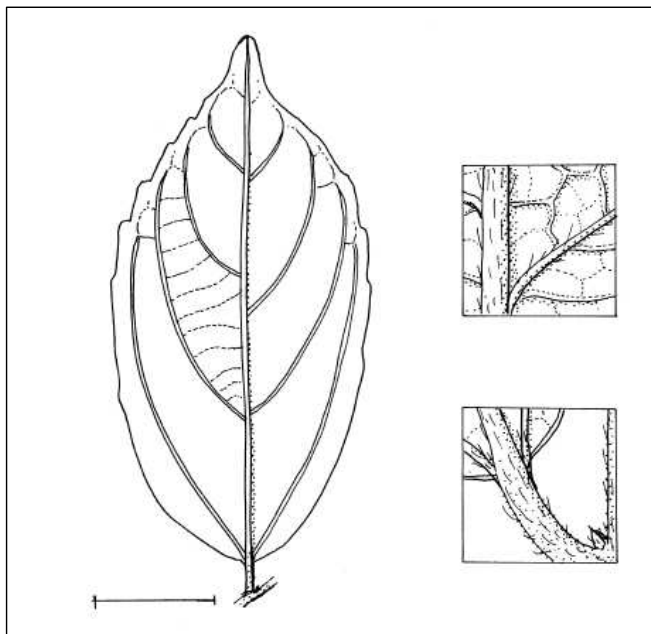
	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Ngombe	+	+	+	+	+	+	+	+	++	++	++	++
	+	Leave and bark consumption period										

Use: Leaves are consumed by gorillas, chimpanzees, and elephants. Gorillas consume also bark. Timber is used in carpentry and construction. At Mondika, consumption of leaves and bark usually increase from November to February, Ngombe is among gorillas preferred foods at Mondika, and is rich in protein.

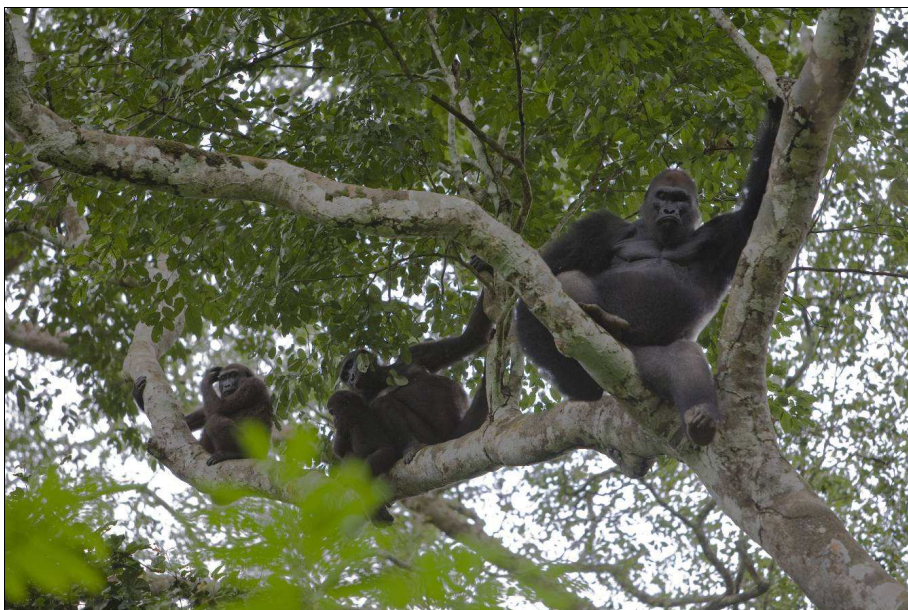


Primates have evolved a number of adaptations to enhance their ability to process and digest certain types of foods. Their morphological dietary specializations include specific adaptations of teeth and gut; and are also reflected in the size and shape of the molars. Folivore gorillas (such mountain gorillas), have the most specialized digestive systems because they must deal with large quantities of cellulose and secondary plant compounds. Because primates cannot digest cellulose or other structural carbohydrates directly, folivores maintain colonies of micro-organisms in their digestive systems that break down these substances. Colobines, for example, have an enlarged and complex stomach divided into a number of different sections where microorganisms help process cellulose. Frugivores tend to have simple digestive systems, but frugivorous species with large bodies (e.g. western gorillas) have capacious stomachs and long guts to hold large quantities of leaves they consume along with the fruit in their diet. Additionally, gorillas eat high quality herbs which are rich in protein and easily digestible.

In general, gorillas' body size and their dietary specializations based on leave consumption mean that they spend much of their time finding, processing,



consuming, and digesting a wide variety of foods to maintain normal metabolic processes. Foliage is normally more abundant and evenly distributed than fruits. As a result, folivorous species (such as Mountain gorillas) are more stable and cohesive than western lowland gorillas that have a much more diverse diet.



Western gorilla group high up in a tree

20. NGULUMA

Scientific name: *Duboscia macrocarpa* vel sp. aff.

Family: Malvaceae

Habitat: Mixed forest/secondary forest/Marantaceae forest

Characteristics

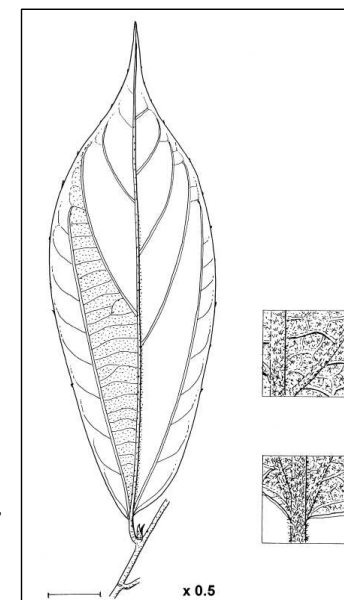
Type: Tree

High: Up to 35 m high

Trunk: Is irregularly fluted with a twisted, tortured form – diameter can be over 60 cm.

Flowers: Are borne on short stalks opposite the leaves. Between 3-6 pale bracts enclose 2-3 flowers, each with 4 hairy, pink sepals and numerous anthers which are red at the base and white above.

Fruits: Are up to 5 cm long with 5-8 angular ribs.



	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nguluma												
	+	Fruits consumption period										

Use: Nguluma is one of the most distinctive trees at Mondika site. There are two distinctive species of *Duboscia*; the *Duboscia macrocarpa* (brown Nguluma which is presented here) and *Duboscia viridiflora* (green Nguluma). Fibrous fruits are consumed both by gorillas, chimpanzees, grey-cheeked mangabeys, and elephants, including other animal species. Fruits have strong odor like that of an apple pie cooking in the oven.



The Nguluma is a good example of a species with asynchronous flowering and fruiting. Studies of phenology at Mondika site demonstrated that each individual has a well established rhythm, flowering every 17-18 months immediately after changing its leaves. However, different trees do not flower in synchrony and fruits ripen in a staggered fashion over several months. In general, we need at least 10 years of phenology studies to determine phenological properties of plants species. At Mondika, Nguluma species is one of a good example of foods called “fallback foods”; eaten throughout the year, but fruit consumption increase normally during the non-fruit period. Humans use fruits and bark to treat coughing.

21. NGUMU/DOBO

Scientific name: *Ficus spp.*

Family: Moraceae

Habitat: Terra firma forest/secondary forest

Characteristics

Type: Strangler liana

Trunk: Is consists of the ramifications of roots knitted against the host tree.

Flowers: There are 3 types of flowers in *Ficus* or figs: male flowers which produce pollen; female flowers in which seeds develop; and gall flowers, specially designed to accommodate the eggs and larvae of fig wasps.

Fruits: Small fruits about 1 cm diameter

	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Ngumu												
			Fruit consumption period									

Use: Ngumu/Dobo is one of strangler lianas, also called “epiphytes plants”. They adopted a special strategy to reach the light. Figs species (figs) are a classic example of co-evolution where two species are dependent upon one another for survival. Ngumu species starts its life as a small epiphyte growing on the trunk or in the branches of a forest tree. It sends aerial roots down to the ground and takes advantage of its lofty start to put branches above the canopy of its host. Once its roots reach the ground and begin to take up nutrients it grows rapidly, gradually covering the host with a tentacle-like “trunk”. The fig species begins to restrict the growth of its host tree, like a python squeezing the breath from its prey. Finally, in this way, the strangler liana kills its host, which gradually rots away, leaving the ficus species as a free standing tree in its own right, with high, intricate buttresses and large spreading branches. This growth mode is said to be hemi-epiphyte

Fig species fruit asynchronously; different individuals of the same species have flowers and fruits at different times of year. Thus, fig fruits are available to some extent at all times of the year, including the dry season. Many species of frugivorous mammals (e.g. chimpanzees and elephants) and birds feed on figs. Figs are rich in calcium, a mineral which is critical for growth of strong bones and egg shells, and which is in scarce supply in the rain forest. So, not only do they provide a source of fruit in times of scarcity, but they also contain key minerals. When figs are abundant, they become one of the most important foods for many animals supplying a reliable, year round source of nutritious fruits. In contrast, during fruit availability, there is an inter-specific competition; figs attract many animals (gorillas, chimpanzees, elephants, monkeys and birds). As we said, ficus species (or figs) are a

classic example of co-evolution, where two species are dependent each other. In fact, the fruits we know as figs start their lives as peculiar “sacs”, the inner sides of which are lined with numerous flowers. At the apex there is a narrow entrance protected by scales. For every species of *Ficus* there is a corresponding species of small fig wasp, each only about 1 mm long. There are three types of flower in figs: male flowers which produce pollen; female flowers in which seeds develop; and gall flowers, specially designed to accommodate the eggs and larvae of fig wasps.

At mature age, fig wasps fly search for flowering fig of the right species around the forest. When they find one they struggle through the scaly opening and lay their eggs on the gall flowers. One female can lay up to 300 eggs before she finally dies of exhaustion. The eggs develop into larvae which eventually hatch, releasing adult wasps into the fig’s inner chamber. Wingless males mate immediately with females and die, never leaving the fruit. At this time, the male flowers on the fig open, and the female wasps load pollen into special receptacles on their bodies. They then burrow their way out of the fruit and fly off in search of another flowering fig tree of the same species: thus the cycle is full circle.

EPIPHYTES PLANTS:

Epiphytes plants also called “air plants are those plants which like parasites, grow on a host, without taking nutrients from the tree itself but rely on nutrients they pick up from the air, falling rain, and the compost that lies on tree branches. Epiphytes grow everywhere but can be found mainly on the branches, trunks, and even the leaves of trees. Moreover, different types of epiphytes may grow on the same tree. Many species of epiphytes can successively grow on each other. This group of plant is represented by Orchids, ferns, and members of the pineapple family (Bromeliaceae), Moraceae (*Ficus* genus), lichens, mosses, liverworts, algae, mistletoes (which are partly parasitic on their host plants, are sometimes considered to be epiphytes) The members of this family begin their life in the canopy from seeds or spores transported there by birds or winds.

Epiphytes also help trees they live on, by increasing the humidity of the tropical rainforests. Although this group is represented by many families, in our ecological trail, we will talk only about *Ficus* from the Moraceae family.

22. PAYO

Scientific name: *Irvingia excelsa*

Family: Irvingiaceae

Habitat: Terra firm

Characteristics

Type: Large tree

Trunk: With the base invariably scarred and swollen from elephant damage. It's often lightly fluted, particularly in larger trees, with slight buttresses – can reach over 60 cm diameter

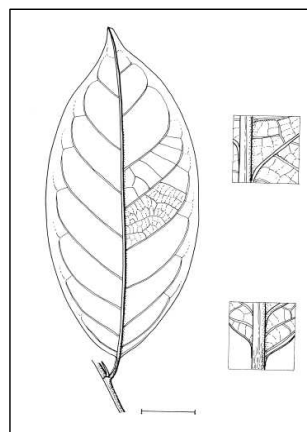
Bark: Is pale

Fruits: The fruit is 5-7 cm long, somewhat resembling a mango, yellow-green when ripe.

	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Payo												

Fruit consumption period

Use: Payo is a large tree (up to 40-45 m high) found at Mondika site. The base of the trunk is invariably scarred and swollen from elephant damage. The base is often lightly fluted, particularly in larger tree, with slight buttresses. The fruit is 5-7 cm long, somewhat resembling a mango. Fruits are eaten by many animals, including chimpanzees, elephants, gorillas and monkeys. At Mondika, fruits are consumed during the dry season and at the beginning of rainy season. Humans use timber in construction and carpentry. Almonds contained in the stone are used as peanut by humans. The almonds are comestible and oleaginous. Pulp is rich in vitamin C. The harvesting of Payo fruit represents one of the main productions of the forest by pygmies. In traditional pharmacopoeia, bark is used to treat diarrhea and dysentery. Payo is deciduous species which loses leaves at anytime. Fructification is followed by the production of new leaves. Wet evergreen forest constitutes a very remarkable environment with particular conditions of plant life. There is no winter, none season is disfavor, and all vital process, such as germination, flowering, production of leaves and fructification can occur at anytime of the year. Production of leaves is asynchronous in some plant species (trees can lose or produce leaves at different period of the year); hence, the dense forest is always green, since all trees don't lose leaves at the same period. Production of leaves occurs progressively, and varies between plants species.



23. BUKU

Scientific name: *Grewia oligoneura*

Family: Malvaceae

Habitat: Flooded forests/swamp forest/forest rivers

Characteristics:

Type: small sized tree, maximum diameter around 50cm

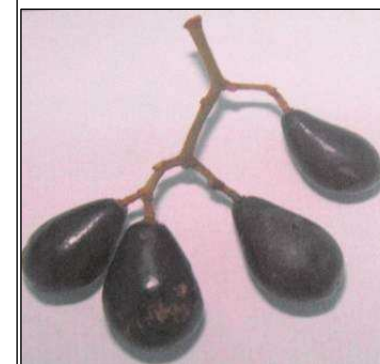
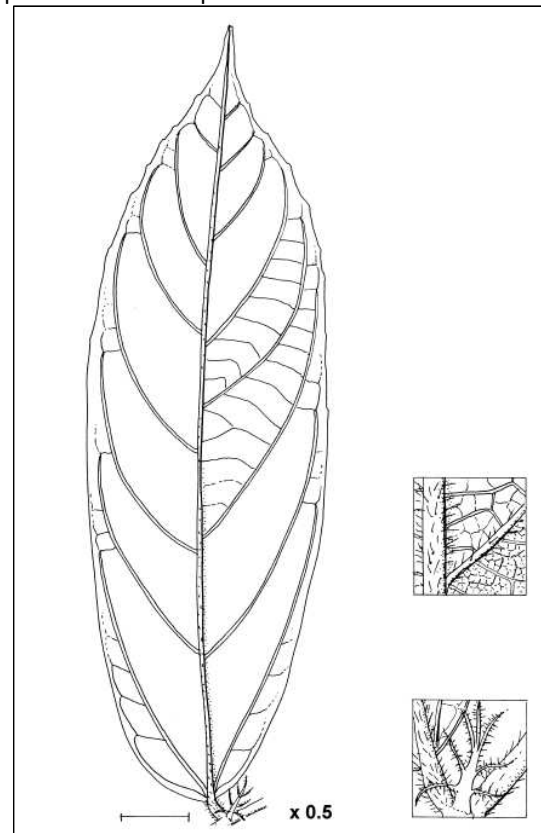
Fruits: berry

	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Buku												

Fruit consumption period

Use: In general there are two species of *Grewia* at the site (*Grewia pinnatifida*, found in terra firma, and *Grewia oligoneura*, which is mostly found in swamp forest (or flooded forest) or along rivers. Here we present the flooded species of Buku. The presence of this species in the mono-dominant Bemba forest is simply due to the

dissemination by animals. It's also a favorable environment with good conditions for this species to grow up. At Mondika, there are many Buku trees in the swamp (up to 15-20 m high).



CONCLUSION

Western lowland gorilla diet at Mondika is influenced by three main factors: rainfall, length of dry season, and fruit availability which are seasonal at the site. These may be similar to other western lowland gorillas' sites. In terms of diet variation, we distinguish three annual time periods at Mondika. During the first period (November–February), which is restricted to the dry season at the site, fruit availability is usually low. This period is called “Non-fruit period”; and gorillas feed on low-quality herbs (e.g., *Aframomum spp.* and *Palisota*), and high-quality herbs (*Haumania danckelmania*), considered as staple foods at the site. During this period diet is dominated by a wide variety of leaves, herbs and barks (especially herbaceous plants species); including some fibrous trees (e.g.; *Duboscia macrocarpa*, *Tetrapleura tetraptera*, *Klainedoxa gabonensis etc...*) as fallback foods.

The second period (April–June) is characterized by increased rainfall and fruit availability. Gorillas respond by eating a greater quantity and variety of fruit, and reduced variety of leaf species, including protein-rich (*Haumania danckelmania*) and lower-quality herb, and termites. Gorillas feed on succulent fruit (e.g. *Gambeya lacourtiana*), including two fibrous fruit species *Duboscia macrocarpa* and *Klainedoxa gabonensis*.

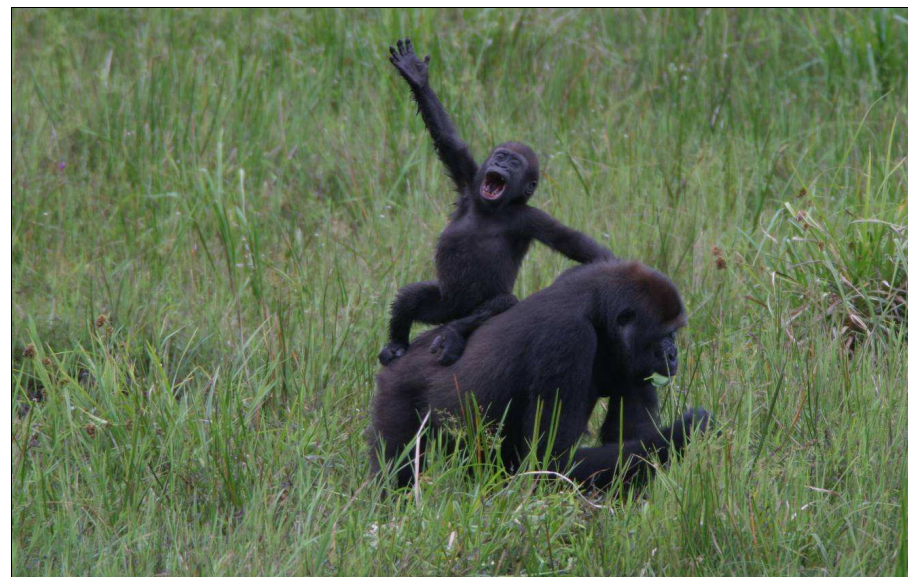
The third period (July–September), corresponds to peak fruit availability. Fruit consumption is usually high, and herb (with one exception), leaf, and bark consumption is low.

Thus, throughout the year gorilla diet at Mondika consists of fluctuating proportions of herbs, leaves, fruit, and insects. Fruit remains a consistent component in the diet during fruit availability.

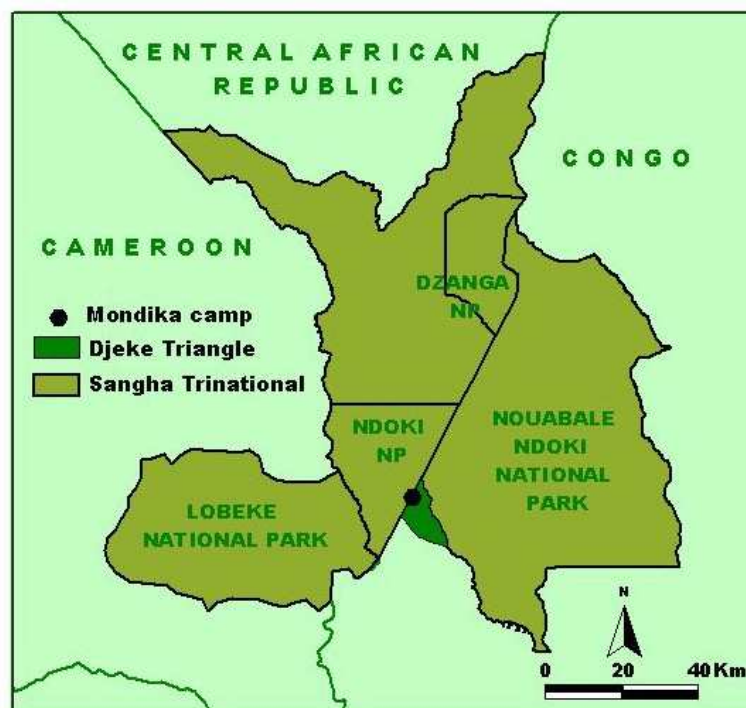
Even in periods of low fruit availability Gorillas' diet at Mondika is diverse. Gorillas consume fruit for energy; leaves, herbs and insects for protein. Gorillas play an important role in seed dissemination and dispersal; thus they contribute to the regeneration of forest. Habitat lost leads to changes in botanical composition and structure and eventually the disappearance of animal species. Forests are valuable and serve many life-sustaining functions. They do provide food (fruits, nuts and meat to people who live in the peripheries). Additionally, the forest provides construction material and pharmacopoeia for local use. Intact forests stabilize soils, reducing erosion and hence provide clean water to drink. Forests also play a key role in regulating climate, both locally and globally. Thus, the only way to avoid the decline animal populations in tropical forest is the durable and rational management of natural resources.

RECOMMENDATIONS: This ecological trail aims to show to visitors the relevance of conserving tropical forests and its inhabitants, in particular western lowland gorillas. The interpretation of this ecological trail, will allow visitors to understand how gorillas interact with its environment and to discover the ecosystem thanks to useful information regarding gorillas at the Mondika site. The ecological trail will enable visitors to understand not only how individuals interact with each other and their habitat; but also to understand what gorillas eat and how changes in availability of resources influence diet. In addition, the ecological trail will help to better understand the rain forest how to protect it. Thus, the role of this naturalist guide is to pass on a simple, pertinent, and attractive message.

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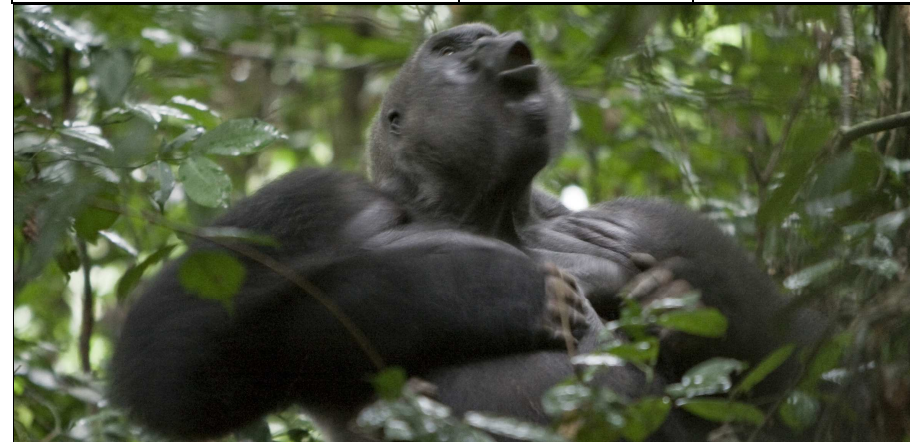


Location of Mondika Camp



List of all foods species presented in the Ecological Trail

Scientific Name	Local name	Family
<i>Anonidium mannii</i>	Mobei	Annonaceae
<i>Greenwayodendron suaveolens</i>	Motunga	Annonaceae
<i>Tabernamontana penduliflora</i>	Etokoloko	Apocynaceae
<i>Laccosperma secundiflora</i>	Gao	Arecaceae
<i>Santiria trimera</i>	Baba	Burseraceae
<i>Gilbertiodendron dewevreii</i>	Bemba	Leguminosae-Caesalpinioideae
<i>Celtis mildbraedii</i>	Ngombe	Cannabaceae
<i>Diospyros iturensis</i>	Babangu	Ebenaceae
<i>Cubitermes termites</i>	Kusu	Insects
<i>Klainedoxa gabonensis</i>	Bokoko	Irvingiaceae
<i>Irvingia excelsa</i>	Payo	Irvingiaceae
<i>Strychnos spp.</i>	Mobangui	Loganiaceae
<i>Duboscia macrocarpa</i>	Nguluma	Malvaceae
<i>Grewia oligoneura</i>	Buku	Malvaceae
<i>Megaphrynium macrostachyum</i>	Ngungu	Marantaceae
<i>Haumania danckelmaniana</i>	Basele	Marantaceae
<i>Sarcophrynium schweinfurthii</i>	Kaya	Marantaceae
<i>Ficus spp.</i>	Ngumu/Dobo	Moraceae
<i>Strombosia pustulata</i>	Embungu	Olcaceae
<i>Chrysophyllum lacourtiana</i>	Bambu	Sapotaceae
<i>Thomandersia hensii</i>	Ingoka	Thomandersiaceae
<i>Aframomum limbatum</i>	Njombo	Zingiberaceae



Foods Consumed by Gorillas at Mondika site

	Main Fruiting period						Period of Fruits Scarcity					
	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Bemba	++	+	+	+	+	+	+	+	+	+	++	++
Kusu												
Babangu												
Bokoko												
Bambu												
Mobei												
Embungu												
Mobangui												
Motunga												
Etokoloko												
Baba												
Ngungu	++	++	++	++	++	++	+++	+++	+++	+++	+++	+++
Basele	++	++	++	++	++	++	+++	+++	+++	+++	+++	+++
Mangabo	+	+	+	+	+	+	++	++	++	++	++	++
Njokoko	++	+	+	+	+	+	++	++	++	++	++	++
Kaya								+	+	+	+	+
Njombo	++	+	+	+	+	+	++	++	++	++	++	++
Gao	+	+	+	+	+	+	++	++	++	++	++	++
Ingoka	++	+	+	+	+	+	+	+	+	++	++	++
Ngombe	+	+	+	+	+	+	++	++	++	++	++	++
Nguluma												
Dobo/Ngumu												
Indolu	+	+	+	+	+	+	++	++	++	++	++	++
Payo												
	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb

	Fruits/Seeds consumption period
+	Herbaceous parts consumption period
	Bark consumption period

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Recommendations for ecological trail interpretation:

Demonstration

The naturalist guide can demonstrate or help visitors to participate; for example:

- To show the young plants of Bemba tree
- Asking them for smelling a particular odour of Zingiberaceae (such as *Aframomum spp.*)
- The uses of each plant (for example in construction, carpentry, and for natural pharmacopoeia)
- Tasting fruits while showing distinct parts eaten by gorillas

Notes: Photos of distinct fruits are used just in case if there are no fruits available in the ecological trail. Don't cut or damage any plant species in front of visitors

Positioning

- Be opposite to the group of tourists
- Make sure all the group can see the interpretation point (plant species you are interpreting); they can see the sign or notice, and listen to your comments or explanations
- Make sure everyone is in good position before starting to comment
- Don't be in front of the interpretation point.

Interpretation

- The ideal duration for the talk is 3 minutes
- Note that duration time varies in relation to how important is the interpretation point you're describing. Naturalist guide will need more time for example at the marantaceae plot which consists of many different herbaceous plant species; thus, there is more information to give to visitors.
- Be careful, don't monopolize a word (talk); otherwise, tourists won't be attentive any more
- Don't spend more time at one interpretation point.
- Speak slowly and loudly.

Attitude

- Don't look on the ground during interpretation
- Look at the tourists alternatively while speaking. Don't stare at one person. This could feel ill at ease this person.
- Be enthusiast and joyful when speaking to visitors.

Warm and kindly reception

- Be smiling and courteous with visitors.
- Be polite and friendly, but not too familiar.
- Don't be concentrated on one or two person of the group; do it for the whole group.
- No subjects susceptible to shock visitors (e.g. politics, religion and sex).

Patience

The fact that tourists or visitors ask questions is a good sign. This means that they are more interested to your topics, and then would like to get more information.

As you know some of them have never been in forest. They arrive for the first time to visit the tropical forest.

If you can't respond to any questions asked by visitors, take time, don't hesitate, and then reply later after getting more information about.

You will see that tourists very often used to ask the same questions. Don't lose yourself, just take everything in easy.

Tolerance

- Don't criticize or make negative remarks to tourists on their appearance. Some tourists can understand African native languages, such as Lingala, Kituba and Sango. You need to be cautious in your comments.