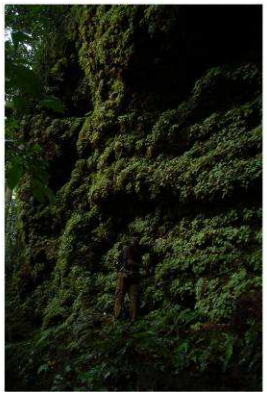
The Biodiversity of the Belinga Montain Range



Missouri Botanical Garden

The biodiversity of the Belinga Mountains

Prepared by

Dr **M.E.** Leal

Field team:
D. Nguema, E. Mounoumoulossi, P. Bissiemou

Missouri Botanical Garden
Gabon 2008

Prologue

Missouri Botanical Garden was awarded a National Geographic Society grant to carry out botanical expeditions “in search for rare and endemic plants on isolated mountain tops in Gabon”. This particular topic was chosen since the rain forest on these mountain tops is threatened by global warming and in danger in disappearing over the next 30 years.

Among these endangered mountain tops are also the Belinga Mountains, exposed not only to global warming, but also to mining. This range is a geological formation which is exceptionally very rich in iron. Therefore, the Belinga Mountains were prioritized to record as much as possible before this unique forest disappears for the ever demanding need of raw material for the Chinese booming economy. Access roads were in the process of getting shut off and therefore this is probably the last biodiversity assessment done in the Belinga Mountains.

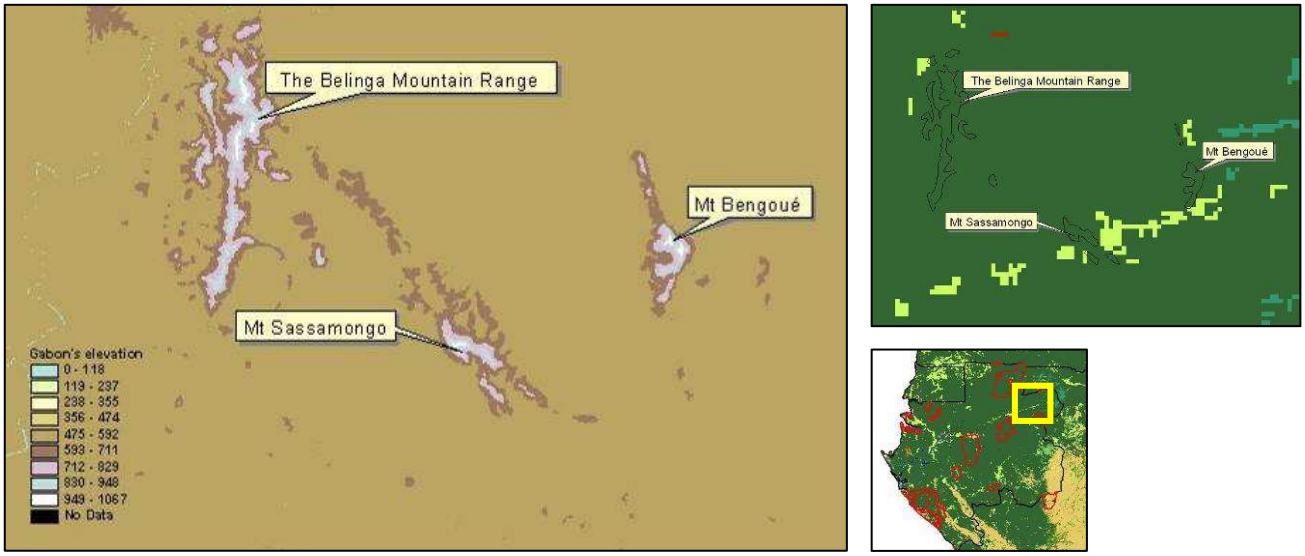
This report not only accounts about the outstanding botany, but also mentions the discovery of two caves with archeological artifacts. The regional archeologist R. Oslisly was much enchanted by their discovery, because these caves by geological standards are already unique but the vast abundance of flints and on the cave floors and pottery indicates to their importance to Stone Age cultures and later Iron Age cultures.

In terms of geology, botany and archeology the Belinga Mountains have all the star qualities to become a world heritage site, alas.

Miguel E. Leal

March 2008

Introduction

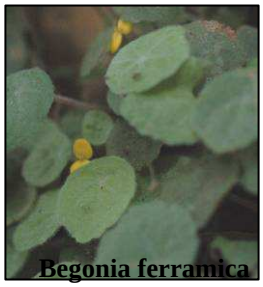


Topography of the mountain complex and surrounding plateau in north east Gabon (above), and the forest cover in Gabon (dark green) with the National Parks (outlined in red) and the NE Mts of Gabon.
source Mayaux et al. 2003

The Belinga Mts Range

The Belinga Mountain Range is situated in the NE corner of Gabon and together with Mt Sassamongo and Mt Bengoué Range. They form the NE Gabon Mountain Complex, which is the most easterly mountain range in western Central Africa until the Ruwenzori at the far end of the Congo Basin.

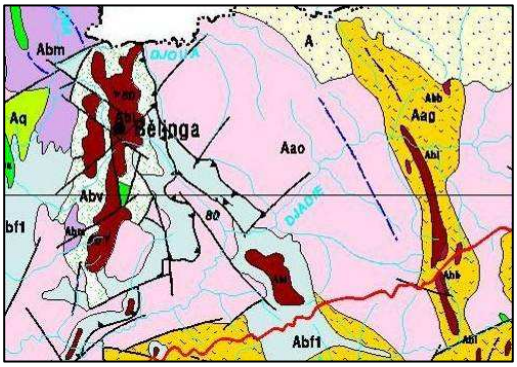
The first botanical activities in the Belinga Mts date back to the early sixties when geological surveys discovered that the Belinga Mts were one large iron deposit. Newly build roads and a research station allowed botanists and other researchers to explore this outstanding mountain range.


Begonia ferramica

Consecutive years of collecting showed that the forest contained a fair number of endemic species. One of the more prominent and appropriately named endemic species is *Begonia ferramica*, the **Iron Begonia**. Within the same period also species composition of the forest was studied and a typical dwarf forest was discovered on the hardest iron stone bedrock ridges.

The exceptional high content of iron in the Belinga Mountains made mining profitable, but the idea was abandoned after the independence of Gabon and for many years the booming oil business postponed its exploitation. This has changed now that the Belinga Mountains have become a Chinese mining concession which prompted this biodiversity assessment.

the former research station



Geology

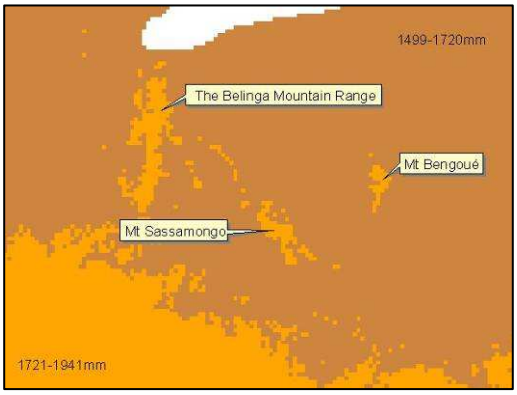
The geological formation of Belinga is very special and one of the only three places in the world. The mountains consist of itabirites (Abi) with around it green schists (Abv), which date back to 3200-2700 Ma and they point back to the time when for the first time in the earth's history oxygen occurred in the atmosphere. From then on metals started to rust, including these mountains.

Map showing the geology in the NE part of Gabon.
Source Thomas et al. 2000

Geomorphology

This geological formation is very tough and does not erode easily, which explains why they still stand out (850 and 1000^{+} m) on the plateau (500-600m). Around 700 m rocky cliffs occur forming a belt of cascades and small to larger caves around the range. These are the rocks with the highest iron content as large sparks light up with the strike of a machete. The cliffs are also often covered by the endemic *Begonia ferramica*.

Map showing in more detail the north part of the Belinga Mountains.
Source National geographical institute



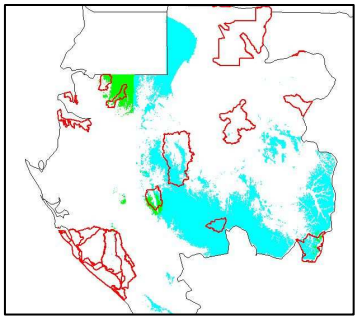
Rainfall

Mean annual rain fall in the NE corner is among the lowest rates for the country. But mean annual rainfall in the mountains is higher than in the surrounding lowland, roughly above or below 1700mm. This is due to the orographic effect, where outstanding features intercept additional precipitation.

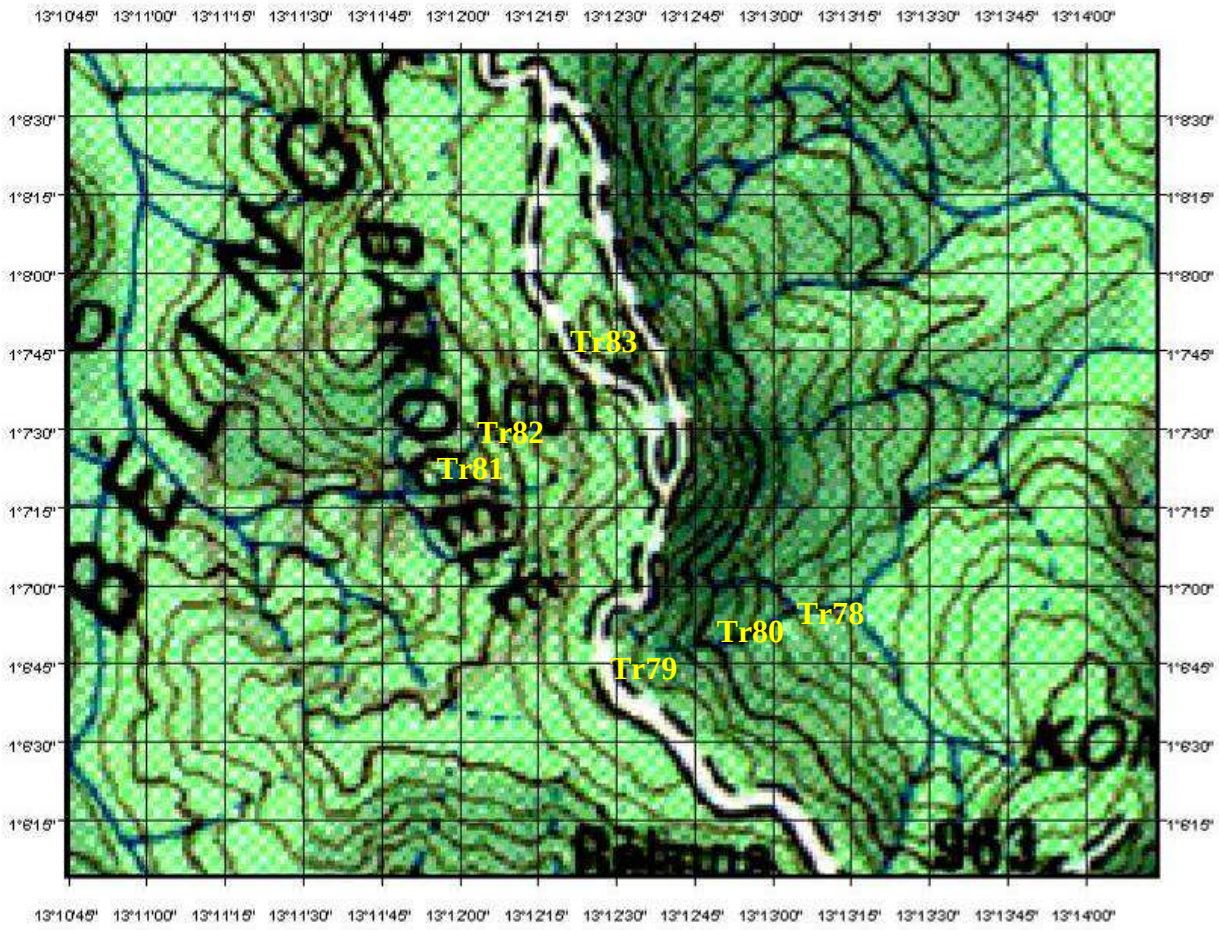
Mean rainfall in north east , (gradient from dark green to orange= wet to drier. Source Worldclim Hijmans et al. 2005

Pleistocene forest refugia

The Gabonese rain forest shows a high level of biodiversity and endemism because of the high abundance of former Pleistocene forest refugia (climatically stable forests). In a model developed to locate Pleistocene forest refuge areas within the present-day forest, the Belinga Mountain Range does not show up, but the presence of narrow endemics like *Begonia ferramica* indicates that forest must have persisted during the Last Ice Age (18,000 years ago).



Map of Gabon showing the humid refuge areas (light blue) and wet refuge areas (green).



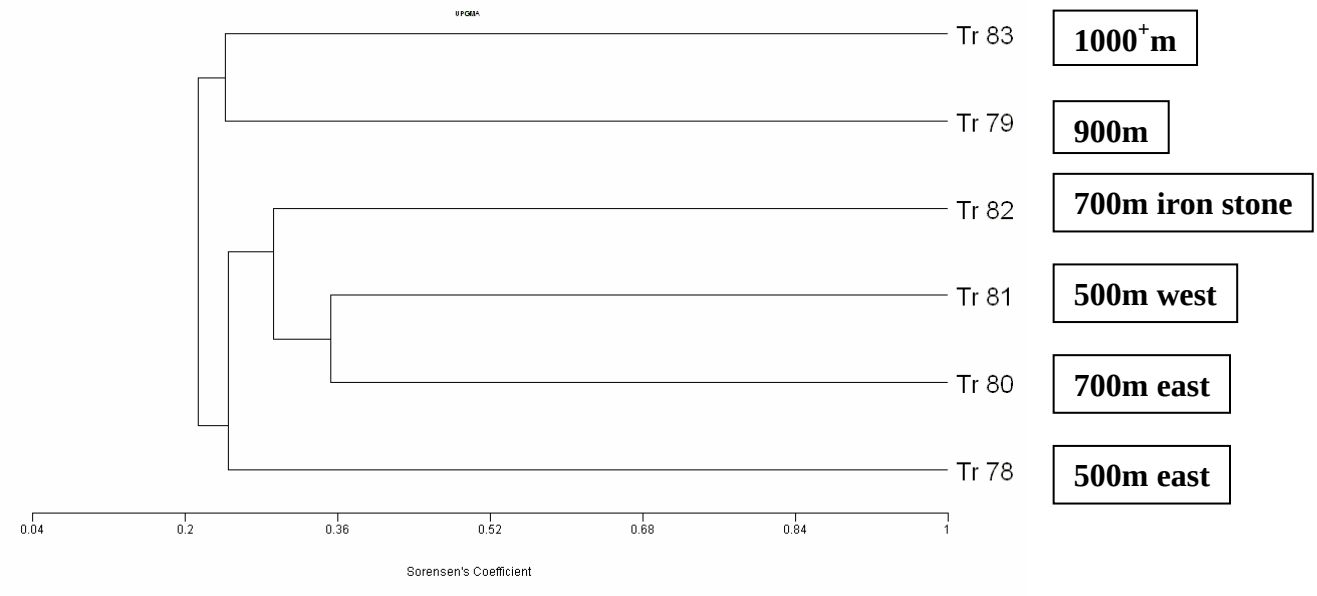
Map showing the transects (Tr) above.

Transect layout

Topography is a strong force driving species composition. Therefore, transects were positioned along the eastern and western slope at 500m, 700m and on or close to the main ridge at 900m and 1000m. Because previous research in the Belinga had revealed a special type of forest, a kind of dwarf-like forest, on ironstone bedrock the area was prospected to find more of this kind of forest. Unfortunately, such a forest was not found, but similar conditions were encountered on a shoulder below the main ridge (Tr82).

Methods

The transects used to record species composition were 200 m long and 5 m wide. Every individual with a diameter at breast height (dbh) of 5 cm and greater was recorded and identified or vouchered for identification in the herbarium of Libreville. Often voucher specimens were without flowers or fruits in which case species were identified only on sterile e.g. leaf characteristics. Such identifications are less confident and revered to as morpho-species. Similarity between the transects was calculated by using the Sørensen index.
Sørensen index is $S_{12}/[0.5(S_1+S_2)]$ where S_{12} is the number of shared species between two transects and S_1 is the total number of species in transect 1 and similarly S_2.



Belinga	**Tr 79**	**Tr 81**	**Tr 83**	**Tr 80**	**Tr 78**	**Tr 82**	**average**
Fisher-alpha	64.1	49.9	45.3	51.1	29.4	45.4	47.5
spp	72	64	68	72	44	66	64
n	133	130	158	158	102	149	138
endemic	38	27	38	33	20	30	31
endemic %	52.8	42.2	55.9	45.8	45.5	45.5	47.9

Results

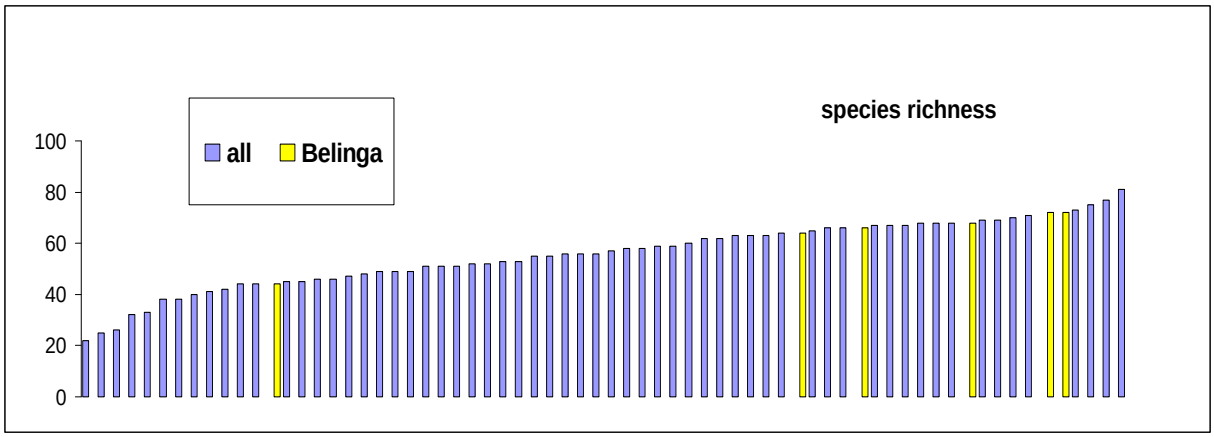
General characteristics

On the six transects 255 species were recorded. On average 64 species were present on a transect and differences are relatively small for most transects with the exception for Tr78 (see the above table). The highest score was 72 species on Tr79 and Tr80 and the lowest 44 species on Tr78.

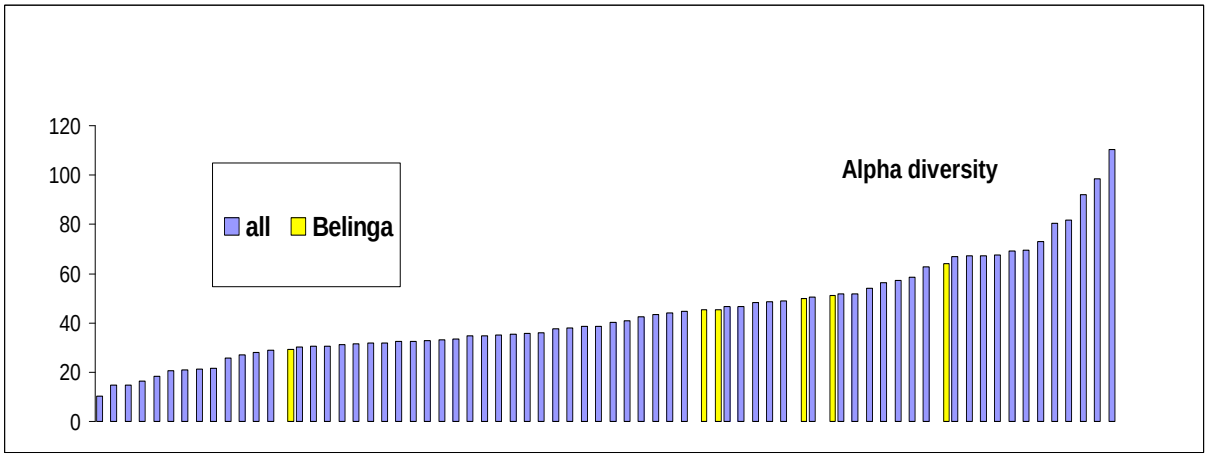
Species restricted to a single transect (endemic) varied between 20 and 38, or in percentages between 42.2 and 55.9. The number of trees on a transect was lowest on Tr78 at 500m on the east side and highest both on Tr80 on the summit and Tr83 on the iron rock. Fisher- alpha-diversity varied between 29.4 and 64.1 with the lowest value from 500m on the east side (Tr78) and the highest value at 900m on also the eastern slope (Tr79).

Similarity

The cladogram (see above) shows that the two transects (Tr79, Tr83) close or on the main ridge group out from the rest of the transects. There seems to be a clear difference in species composition of the forest above and below 800m. The transect most different from all other transects is not the one of the iron rock, but the one on the east slope at 500m (Tr78).



Graph showing species richness on the plateau (yellow bars) and other sites in Gabon (blue bars).



Graph showing Alpha diversity on plateau (yellow bars) and other sites in Gabon (blue bars).

Discussion

Species richness
Species richness on most of the Belinga transects is above average compared to the other transects in Gabon and approaching the high end of the spectrum (see graphs above). The exception is Tr78 on the eastern slope at 500m which has values for species richness and Fisher-alpha diversity well below average. The other transects descend in range in terms of Fisher-alpha diversity, but are still above average. Differences in ranging between transects going from species richness to Fisher-alpha diversity is related to differences in tree densities.

Similarity
The cladogram clearly shows a difference in species composition between the forest below (Tr78,Tr80, Tr81, Tr82) and above 800m (Tr79, Tr83). Similarity in species composition was highest between the eastern mid slope (Tr80) and lower western slope (Tr81), which is remarkable as they are on opposite sides of main ridge.

The outliner in the data set is again Tr78, beside a lower species richness and Fisher-alpha diversity also its species composition is most different from the rest. It remains to be verified whether all the forest at the eastern slope around 500m is as different as on Tr78. The lower diversity may be linked the geological formation of green schists around the Belinga Mountain Range.

Surprisingly, enough the forest on the typical hard iron rock (Tr82) is not very much different from the rest than the forest. The reconnaissance trips to locate the previously mentioned existence of dwarf forest on ironstone were unsuccessful. The habitat is probably destroyed with the construction of the roads which follows the main ridge, which is also the main occurrence of the habitat. It needs to be seen whether similar habitat exists on adjacent mountains around the Belinga Mountains.

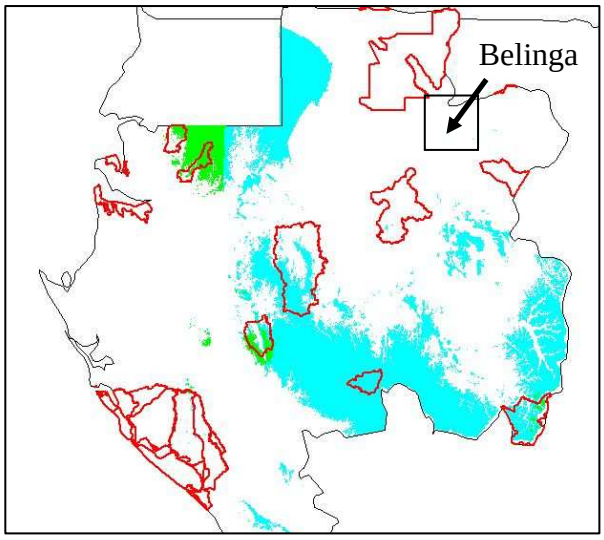
Conclusion

The biodiversity of the Belinga Mountain Range shows little difference in species composition is between the east and west side, which may be linked to its isolated location on the plateau. The main difference in species composition is above and below 800m in altitude. More data is needed to verify whether species composition around and below 500m on the east side is consistently different from the forest higher up or whether this transect is an outliner. Biodiversity in terms of species richness and Fisher-alpha diversity is high considering it is not a typical refuge forest.

General collecting

113 species were collected (Leal *et al.* 2060-2173), their full identification is still pending and field notes are being entered into the database. Listed below are the endemic species in the Belinga Mountain Range (extracted from the Plants of Gabon database).

The relatively high number of endemic species (36) and in particularly the relatively high number of narrow endemics (18), species unique for the Belinga Mountain Range has given rise the postulation of the existence of a new type of forest refuge area.



Map showing the reconstructed Pleistocene forest refugia, humid (blue) and wet (green).

***Ardisia belingaensis* Taton**

The model developed to locate the former Pleistocene forest refuge areas within the present-day rain forest mainly focused on elevated areas (above 500m) with mean rainfall either more than 2000mm or 2300mm, the humid (bleu) and wet refuge areas (green), respectively. Between the larger forest refugia the tropical rain forest would have been reduced to gallery forest or turned into semi-deciduous forest.

An exception to this rule could have been mountainous areas where due to orographic effect rain forest with drought sensitive plant species like *Ardisia belingaensis* and *Begonia ferramica* received sufficient moisture from clouds colliding against the high slopes; the so-called **orographic refuge forest**.

***Begonia ferramica* N.Hallé**

Endemic species in the Belinga Mountain Range

* narrow endemics species restricted to the Belinga

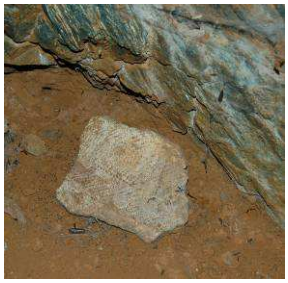
Allophylus hallaei Fouilloy [Sapindaceae]*
Allophylus poungouensis Pellegr. [Sapindaceae]
Ardisia belingaensis Taton [Myrsinaceae]*
Ardisia lethomasiae Taton [Myrsinaceae]*
Artabotrys le-testui Pellegr. [Annonaceae]
Aulacocalyx subulata (N.Hallé) E.Figueiredo [Rubiaceae]*
Begonia ferramica N.Hallé [Begoniaceae]*
Coccinia gabonensis Keraudren [Cucurbitaceae]
Cola mayimbensis Pellegr. [Sterculiaceae]
Cuviera latior Wernham var. *evorombila* N.Hallé [Rubiaceae]*
Desmostachys tenuifolius Oliv. var. *angustifolius* Pellegr. ex Villiers [Icacinaceae]
Eugenia imbricato-cordata Amshoff [Myrtaceae]
Gilbertiodendron barbulatum (Pellegr.) J.Léonard [Leguminosae-Caes.]*
Megaphrynium gabonense Koechlin [Marantaceae]
Memecylon collinum Jacq.-Fél. [Melastomataceae]
Memecylon salicifolium Jacq.-Fél. [Melastomataceae]
Monanthotaxis le-testui Pellegr. var. *hallei* (Le Thomas) Le Thomas [Annonaceae]
Nephrangis bertauxiana Szlach. & Olszewski [Orchidaceae]*
Octoknema klaineana Pierre [Olacaceae]
Pauridiantha siderophila N.Hallé [Rubiaceae]*
Piptostigma glabrescens Oliv. var. *lanceolata* Le Thomas [Annonaceae]
Psychotria fleuryana E.M.A.Petit [Rubiaceae]*
Psychotria rhizomatosa De Wild.[Rubiaceae]
Rhaptopetalum belingense Letouzey [Scytopetalaceae]*
Salacia belingana N.Hallé [Celastraceae]*
Salacia ferrifodina N.Hallé [Celastraceae]*
Sericanthe testui (N.Hallé) Robbr. var. *pseudosalacia* (N.Hallé) Robbr. [Rubiaceae]*
Sherbournia kiliotricha N.Hallé [Rubiaceae]*
Tarenna calliblepharis N.Hallé [Rubiaceae]*
Toussaintia hallei Le Thomas [Annonaceae]*
Tricalysia concolor N.Hallé [Rubiaceae]*
Uvariodendron molundense (Engl. & Diels) R.E.Fr. [Annonaceae]
Uvariopsis le-testui Pellegr. [Annonaceae]
Vanilla hallei Szlach. & Olszewski [Orchidaceae]*
Virectaria belingana N.Hallé [Rubiaceae]*

Archeological finds

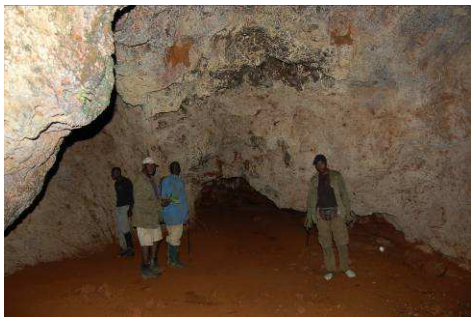
During exploration trips collecting botanical specimens and searching for the ironstone bedrock, two new caves were discovered east and west of the main ridge which contained archeological artifacts, i.e. quarts flints and pottery. On the west side it was a complex of larger and smaller caves and cavities with above it the iron stone bedrock ridge on top of which transect Tr 82 was laid out.

Caves have been found before and they are all situated in a belt at 700m around Belinga Moutain Range. This is a belt characterized by cliffs covered by *Begonia ferramica*, watersfalls and cavities.

The formation of these cavities is geologically some what enigmatic as the itabirites are very resistant and therefore the caves may indicate to the presence of less resistant incrusted formations like silica or quarts.



The presence of quarts will have undoubtedly attracted Stone Age man to the Belinga Mountains, as quarts is fairly rare in the surrounding plateau. Later in the following Iron Age these same caves would have been a source of iron, due to the fact that the secretions of bats living in these caves would have concentrated the iron contain in the rocks below.



Presently, only a small portion of the cave belt has been prospected and only a few caves have been properly excavated. These are privileged circumstances as most archeological artifacts in the rain forest are not or poorly conserved. This area is rich in finds and more research in this area would contribute to a greater understanding of the pre-European history of Central Africa.

Acknowledgements
Missouri Botanical Garden Central Africa Program thanks the Herbier National, IPHAMETRA, IRET, and CENAREST for facilitating this mission and the permission to do research in these extra ordinary mountains. This mission was funded by National Geographic Society.