International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

Diversity of Rodents (Rodentia: Mammalia) in the Kandolo Forest Reserve (Maniema Province, DR Congo)

Morgan, Mukobya[1], Sylvestre Gambalemoke[2, 3], Jean-Claude, Mukinzi[2], Nicolas, Violaine[4], Rainer Hutterer[5], Erik, Verheyen[6, 7]

[1]Faculty of Science, Department of Geology, Middle Lualaba University, BP.136 Kalima, Rural Municipality of Kalima, Pangi Territory, Maniema Province, DR Congo

[2]Faculty of Sciences, University of Kisangani, DR Congo. Department of Biology, Faculty of Sciences, University of Kisangani, DR Congo. B.P. 190 Kinshasa XI, DR Congo

[3]Biodiversity Monitoring Center, University of Kisangani, DR Congo

[4] Institute of Systematics, Evolution, Biodiversity (ISYEB), National Museum of Natural History, CNRS, Sorbonne University, EPHE, University of the Antilles, CP51, 57 rue Cuvier, 75005 Paris, France

[5]Zoological Research Museum Alexander Koenig, Bonn, Germany

[6]Royal Belgium Institute of Natural Sciences, Operational Direction taxonomy and Phylogeny, Brussels, Belgium

[7]Evolutionary Group, Biology Department, University of Antwerp, Antwerp, Belgium

Author contact: Morgan Mukobya Wakyata: *wamumorgan[at]gmail.com*

Abstract: ***Our work entitled: Diversity of Rodents (Rodentia: Mammalia) in the Kandolo Forest Reserve (Maniema Province, DR Congo) aimed to assess the biodiversity of Rodents in the Kandolo Forest Reserve while comparing the specific diversity during two capture sessions and in the two prospected habitats (Mixed primary forest (FPM) and Gilbertiodendron dewevrei primary forest (FPG) Finally, assess the distribution of Rodents in the two habitats (FPG and FPM) prospected by sex. These objectives have been achieved. To achieve this, only one method was used in the field, the only in-line trapping using two types of traps including Sharmen and Pitfall. Two habitats were explored (primary mixed forest and primary forest at Gilbertiodendron dewevrei) during 2 capture sessions. After processing the data, the results presented 153 captured Rodents synthesized as follows: For a total of 153 individuals captured in the two habitats prospected during the two capture sessions, the first capture session carried out in the FPM, totaled 40 individuals of Rodents including: Praomys cf. jacksoni is the most represented with 22 individuals captured or 55%. In contrast, Graphiurus lorraineus, Lophuromys luteogaster and Saccostomus campestris are the least represented with a score of an individual captured, 2,5%. On the other hand, during the second session which took place in the FPG, it emerges the following: For the 113 individuals captured, Praomys cf. jacksoni is the most represented with 69 individuals captured, or 61,06%. Lophuromys dudui, on the other hand, is the least represented with a score of one specimen, ie 0,88%. In comparison with habitats and capture sessions, the following is concluded: the FPG is the best represented quantitatively and qualitatively (113 specimens, TS = 7,06%, Ep = 1600 trap nights and 10 species) with Praomys cf. jacksoni which ranks first with 69 individuals out of 113 carcasses captured. Unlike the FPM which occupies the second position (40 specimens, TS = 2,5%, EC = 1600 trap nights,) with 9 species caught. But for the indices of specific diversity, it appears that, in the two habitats there is the probability of randomly drawing 2 individuals to have 2 different species because Simpson tends towards1 everywhere. And in the two habitats, the species are not evenly distributed (E tends towards 1). Also, the specific richness evaluated at the level of the two different habitats reveals that there is not a significant difference between the populations of Rodents (Kuskal-Walis test, H = 2,802; p = 0, 09055). Finally, taking into account the sex distribution of the Rodents caught in the two habitats during the two sessions, it has been shown that, the Rodents sampled are marked by the dominance of the males in percentage as the females. Thus, in the FPM the dominance of the males is expressed at 70% against 30% of the females and in the FPG 69, 91% of the males against 30, 09% of the females.***

Keywords: Biodiversity, Wildlife endemism, Forest ecosystem, Trapping effort, Kandolo Forest Reserve

1. Introduction

Around 11 million hectares are seriously affected or even destroyed worldwide, roughly a third of which is located in Africa (Barrière et al, 2005). To do this, knowledge of forest ecosystems is today more than essential to establishing a satisfactory basis for their use, sustainable and rational management.

In Africa's tropical forest ecosystems, there is growing interest in the problem of biodiversity loss.

Tropical forests are the richest terrestrial ecosystems on the planet, but they are subject to intensive disturbances, for example for timber extraction or for conversion to agricultural land.

These anthropogenic changes in forest habitats have many direct and indirect effects on animal communities, such as

changes in the richness or abundance of species (Bentley et al. 2000; Shanker 2001; Estrada and Coates-Estrada 2002; Mathieu and al. 2005; Pineda et al. 2005).

The impact of forest degradation on animal communities depends on the type of forest, the size and shape of the degraded area (Bentley et al. 2000; Goodman and Rakotondravony 2000; Laidlaw 2000; Ramanamanjato and Ganzhorn 2001; Watson et al. 2004a).

The Low Altitude African Forests (FBAA) have a great diversity of animals and plants and a complexity of functional structures which seem to stabilize over time, giving these forests a quality of three-dimensional ecosystems (Le Gal, 1991). These forest ecosystems are reputed to have enormous potential in biological diversity (Myers et al, 2000).

These forests represent, in the collective imagination, the last resort against pollution and the greenhouse effect (World Bank, 2004 in Bapeamoni, 2014) and their destruction are causing global anxiety (Janzen et al, 1991).

Currently, studies on the factors influencing the natural recovery process and forest restoration strategies are being organized directly or indirectly.

The purpose of these studies is; knowledge of biodiversity, habitats and their evolution over time and space (Holl et al. 2000; Leopold et al. 2001; Parrotta and Knowles 2001; Feyera et al. 2002; Holl 2002a, b; DeWalt and al. 2003).

The Democratic Republic of Congo (DRC) is counted among the 17 regions of the world which are home to areas of high biodiversity of flora and fauna (Gaston, 2004; Gambalemoke et al, 2008a; Masudi et al, 2016).

The Kandolo Forest Reserve is located in the central Congolese basin of the Congo basin, constitutes a biosphere of mega-biodiversity and wildlife endemism (Asimonyio et al, 2015).

Unfortunately, many species and some habitat types continue to be threatened with extinction before they are known (Janzen and Vasquez-Yañes, 1991).

One of these groups affected by this threat is the Rodents which, given their importance, constitute one of the important components of the fauna of terrestrial ecosystems totaling nearly 42% of the mammal species in the world (Katuala, 2009). However, their unspectacular and often cryptic lifestyle makes them go unnoticed, and as a result they are often overlooked. However, they play an important role in the functioning of ecosystems in general, and that of forests in particular.

In detail; they are an important link in the food webs, involved in the dissemination of seeds and the destruction of their surplus, the spread of mycorrhizae, the destruction of insects, many of which are harmful (Caray and Johson, 1995). They constitute reservoirs and / or vectors of several infections and parasites of animals including humans, such as plague, murine typhus, Lassa fever, bubonic fever, and other viral, bacterial and parasitic Protozoan infections or Helminthes (V. Nicolas et al, 2008).

From all the above, no scientific study on this zoological group has attracted the attention of scientists in the Kandolo Forest Reserve and yet the latter created since 05/28/1937 has not yet been the subject of internationally funded conservation.

Thus, pioneering studies in this ecosystem can allow researchers to have a database of the genus concerned on the said reserve.

In this article, we present the results on the evaluation of the biodiversity of Rodents in the said reserve while comparing the specific diversity during the two capture sessions and in the two prospected habitats including: Mixed primary forest (FPM) and Primary forest to Gilbertiodendron dewevrei (FPG).

Finally, we compared the distribution of the sexes according to the species caught in the two habitats surveyed. More specifically, we tested the hypotheses according to which (1) the richness and abundance of Rodent species vary between habitats (2) the two habitats surveyed would be rich in both male and female individuals.

2. Materials and methods

The biological material consists of 153 Rodents all captured in the Kandolo Forest Reserve. It is a reserve located 37 km from Kalima road towards Kindu in front of Village Pension Biliza (Figure 1).

The in-line trapping method was used with two types of trap installed in combination for the capture of small mammals. In particular the pitfall trap (PF) and Sherman (SH) installed in a 105m transept with a 20-day night trap for the two capture sessions.

Each line was armed with 20 PF and 20 SH buckets installed. The SH was placed at a distance of 1 m from FP. Since there were 20 stations, the SH followed one another in the left / right position of the PF, according to the orientation of the tarpaulin which crossed the PF buckets. sessions.

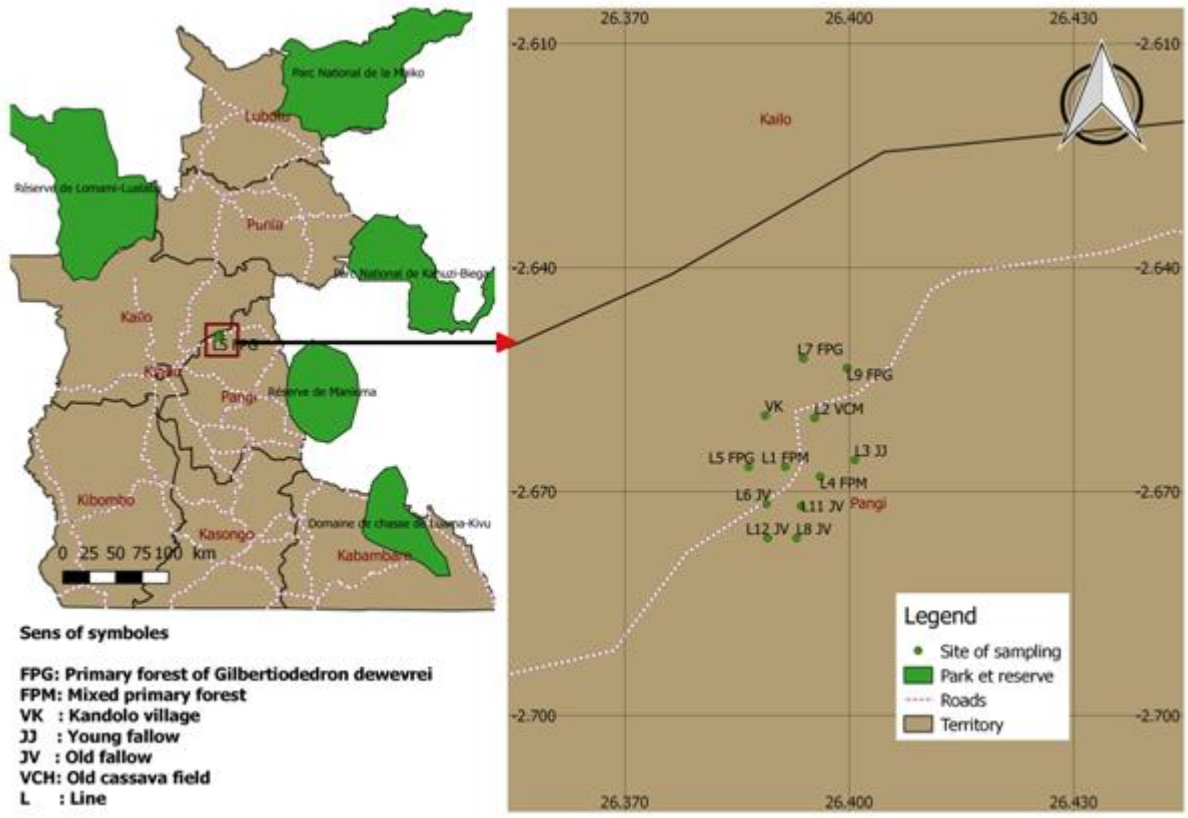

Figure 1: Map of Pangi territory with the research site (Kandolo Forest Reserve)

During the two capture sessions the prospected habitats were made up:

- Primary mixed forest (FPM) with species such as *Gilbertiodendron dewevrei*, *Fagara macrophylla* (Oliv), *Cola gigantea*, *Fagara macrophyla* (Oliv).
- Primary forest at *Gilbertiodendron dewevrei* with a strong dominance of *Gilbertiodendron dewevrei.*

The identification of Rodents was made on the basis of external morphological characters using the guide of African Mammals (Kingdon, 1997; Kingdon, 2006; Kingdon, 2010) and the identification key of Rodents in the Kisangani region. Five measurements were taken on each Rodent carcass. It's about:

The body biomass (BMC) was taken using a portable mechanical scale of the Pesola brand weighing 2 to 200 grams. The length of the left ear (LO) and the length of the left hind foot (LP) were taken using the EZCal Digital caliper IP 54 brand electronic caliper,

Tail length (LQ) and total body length (LT) were taken using a 30 and 50 cm graduated slat.

Figure 2: Measurement of the foot length of a *Hybomys* cf. *lunaris* with calipers and a *Praomys* cf. *jacksoni* captured in a Pitfall (Photos from left to right)

The biodiversity indices were calculated by determining the trap success (TS) was deduced from. The trapping effort (Ep = Nn x Np, where Nn is the number of trapping nights and Np is the number of traps), trapping success (TS = N / Ep x 100, where N is the number of rodents captured) and relative abundance or frequency of each species (i.e. the percentage

of individuals of a species out of the total number of individuals captured) were calculated per habitat. In addition, the Shannon-Wiener alpha index (Ha), specific richness (RS) of Rodent stands in a given habitat, while the beta index (Hß) made it possible to compare the populations of Rodents caught in two different habitats (young secondary forest and young fallow).

The Shannon-Wiener index is suitable for the comparative study of SR since it is relatively independent of the sample size. It varies directly depending on the number of species and the numbers observed. Rare species weigh much less than the most common species.

The formulas used to calculate (Ha), (Hß), the Fairness Index (E) are taken from Ramade (1984).

(1) $H_a = -\sum_{i=1}^{s} p_i Log_2 p_i$

(a) Ha = alpha index of biological diversity

(b) $p_i = \frac{n_i}{N}$, it is the probability of meeting the species which occupies an ième rank.

(c) N = total number of individuals caught and (ni) = number of specimens of the ith species in the sample studied.

(2) $H' = Log_2 S$

(d) (H ') = evenly distributed or maximum Fairness index, which corresponds to the case where all species are represented by the same number of individuals.

(e) S = total specific wealth

(3) $E = \frac{H_a}{H'}$

(f) (E) = Fairness index which varies between 0 and 1. It tends towards zero, when almost all the numbers correspond to a single species of the stand and it tends towards 1, when each of the species is represented by the same number of individuals.

(5) $H_b = H_{a(1,2)} - 0{,}5(H_1 + H_2)$

(g) (Hß) = interbiotop similarity index (interhabitat); it makes it possible to measure the difference between two stands which colonize two neighboring biotopes; (Hß) tends to zero, when the 2 stands are identical and (Hß) tends to 1, when the 2 stands are entirely different (no common species); Ha (1,2) is Shannon-Wiener's alpha index for samples 1 and 2 combined.

Finally, the results were compared by a series of analyzes using the statistical test such as the Kuskal-Walis Test H, which makes it possible to compare the distribution of Rodents by catching session and by habitat type, respectively. If necessary, the post hoc test (Tukey or Mann-Whitney Pairwise Comparisons) was used (when p <0.05), to determine the habitat pairs showing significant differences.

3. Results

3.1. Composition of the catch stand in the three habitats

We captured 153 Rodents.

3.1.1. Overview of the composition of Rodents in the two prospected habitats (FPG and FPM) during the two sessions (Session 1 and Session 2).

Table 3.1: Distribution of rodents captured in the Primary Forest at *Gilbertiodendron dewevrei* (FPG) and Primary Mixed Forest (FPM) during the two capture sessions (Session 1 and 2)

N°	Species	FPG	FPM	Total	%
1	*Deomys ferrugineus*	11	0	11	7,19
2	*Grammomys kuru*	0	2	2	1,31
3	*Graphiurus lorraineus*	0	1	1	0,65
4	*Hybomys lunaris*	6	3	9	5,88
5	*Hylomyscus aeta*	2	0	2	1,31
6	*Hylomyscus stella*	5	0	5	3,27
7	*Lophuromys dudui*	1	0	1	0,65
8	*Lophuromys luteogaster*	0	1	1	0,65
9	*Malacomys longipes*	6	4	10	6,54
10	*Praomys* cf. *jacksoni*	69	22	91	59,48
11	*Praomys musonei*	4	2	6	3,92
12	*Hylomyscus parvus*	2	0	2	1,31
13	*Saccostomus campestris*	0	1	1	0,65
14	*Stockomys longicaudatus*	7	4	11	7,19
	Grand total	**113**	**40**	**153**	**100,00**
	Number of traps	80	80	160	
	Trapping effort (Ep)	1600	1600	3200	
	Trapping success(Ts)	7,06	2,5	1,59	
	Specific	10	9	14	
	Simpson_1-D	0,6043	0,665		
	Fairness	0,631	0,7099		
Test of Kruskal-Wallis			H = 2,802; p = 0,09055		

Table 3.1 shows a constant double according to which:

For a total of 153 Rodents captured, the FPG is the most represented with a total of 113 carcasses captured where *Praomys* cf. *jacksoni* is the most represented with a score of 69 individuals and *Hylomyscus stella* is the least represented with a single individual captured. On the other hand, the FPM is poorly represented with 40 individuals captured where always *Praomys* cf. *jacksoni* is the most represented with 22 individuals and *Graphiurus lorraineus*, *Lophuromys luteogaster* and *Saccostomus campestris* are the least represented with a single individual captured. But for the proportion of species caught, *Praomys* cf. *jacksoni* is the most captured with a proportion of 59,48% and *Graphiurus lorraineus*, *Lophuromys dudui*, *Lophuromys luteogaster* and *Saccostomus campestris* are the least represented with an individual captured ie 0,65%.

Also, the FPG is the best represented quantitatively and qualitatively (113 specimens, TS = 7,06%, Ep = 1600 trap nights, Ep = 1600). *Praomys* cf. *jacksoni* which ranks first with 69 individuals out of 113 and qualitatively with 10 species caught. Unlike the FPM which occupies the second position (40 specimens, TS = 2 ,5%, EC = 1600 trap nights) with 9 species caught.

But for the indices of specific diversity, it appears that, in the two habitats there is the probability of randomly drawing 2 individuals to have 2 different species because Simpson tends towards1 everywhere. And in the two habitats, the species are not evenly distributed (E tends towards 1).

Finally, the specific richness evaluated at the level of the two different habitats reveals that there is not a significant difference between the populations of Rodents (Kuskal-Walis test, H = 2,802; p = 0,09055).

3.3. Distribution of Rodents caught in the two habitats by sex

Table 3.2: Distribution of Rodents captured in the Kandolo RF by sex

N°	Species	FPG					FPM					TG	Ar
		F	M	Tot FPG	%F	%M	F	M	Tot FPM	%F	%M		
1	*Deomys ferrugineus*	6	5	11	54,55	45,45	0	0	0	0	0	11	7,19
2	*Grammomys kuru*	0	0	0	0	0	2	0	2	100	0	2	1,31
3	*Graphiurus lorraineus*	0	0	0	0	0	1	0	1	100	0	1	0,65
4	*Hybomys lunaris*	1	5	6	16,67	83,33	1	2	3	33,33	66,67	9	5,88
5	*Hylomyscus aeta*	1	1	2	50	50	0	0	0	0	0	2	1,31
6	*Hylomyscus stella*	4	1	5	80	20	0	0	0	0	0	5	3,27
7	*Lophuromys dudui*	0	1	1	0	100	0	0	0	0	0	1	0,65
8	*Lophuromys luteogaster*	0	0	0	0	0	0	1	1	0	100	1	0,65
9	*Malacomys longipes*	3	3	6	50	50	1	3	4	25	75	10	6,54
10	*Praomys* cf. *jacksoni*	15	54	69	21,74	78,26	4	18	22	18,18	81,82	91	59,48
11	*Praomys musonei*	1	3	4	25	75	0	2	2	0	100	6	3,92
12	*Hylomyscus parvus*	2	0	2	100	0	0	0	0	0	0	2	1,31
13	*Saccostomus campestris*	0	0	0	0	0	1	0	1	100	0	1	0,65
14	*Stockomys longicaudatus*	1	6	7	14,29	85,71	2	2	4	50	50	11	7,19
	Grand total	**34**	**79**	**113**	**30,09**	**69,91**	**12**	**28**	**40**	**30**	**70**	**153**	**100,00**
	Specific wealth	**10**					**9**					**14**	

Legend: FPG = primary forest at *Gilbertiodendron dewevrei*; FPM = mixed primary forest; F = female; M = male; Tot = total; TG = grand total; % = percentage, Ar = Relative abundance.

Table (3.4) shows that in all the habitats, the Rodents sampled are marked by the dominance of males in percentage than females.

Thus, in the FPM the dominance of the males is expressed at 70% against 30% of the females and in the FPG 69,91% of the males against 30,09% of the females.

So, in each habitat, limiting ourselves to the best represented species, the numbers of males dominate those of females especially in FPM (81,82% of males against 45,5% of females for *Praomys* cf. *jacksoni* followed by *Hybomys lunaris* with 66,67% of males and 33,33% of females Also, for the FPG, males dominate females for the most represented species with successive scores of 85,71% of males against 14,29% of females for *Sackostomys longicaudatus* followed by *Hybomys luanaris* with 83,33% of the males against 16,67% of the females and 78,26% of the males against 21,74% of the females in *Praomys* cf. *jacksoni*.

On the other hand, by limiting itself to the least represented species, on the one hand, the females dominate the males in the FPM (100% of the females in *Graphiurus laurraineus* and *Sackostomys longicaudatus*) on the other hand the males dominate the females with 100% males in *Lomphuromys luteogaster*. In the FPG, males dominate females with a score of 100% of males in *Lomphuromys dudui*.

4. Conclusion

At the end of our study entitled: Diversity of Rodents (Rodentia: Mammalia) in the Kandolo Forest Reserve (Maniema Province, DR Congo) we have reached our objective; to compare the specific diversity during the two capture sessions and in the two prospected habitats (Mixed primary forest (FPM) and *Gilbertiodendron dewevrei* primary forest (FPG). Finally, assess the distribution of Rodents in the two habitats (FPG and FPM) prospected by gender.

From our investigations, we draw the following conclusions:
The results provided a total of 153 individuals captured in the two prospected habitats.

During the two capture sessions, the following emerges:
During the first capture session carried out in the FPM, a total of 40 individuals of Rodents including, Praomys cf. jacksoni is the most represented with 22 individuals captured or 55%. On the other hand, *Graphiurus lorraineus*, *Lophuromys luteogaster* and *Saccostomus campestris* are the least represented with a score of an individual captured, 2,5%.

On the other hand, during the second release which took place in the FPG, it emerges the following:
For the 113 individuals captured, *Praomys* cf. *jacksoni* is the most represented with 69 individuals captured, or 61,06%. *Lophuromys dudui*, on the other hand, is the least represented with a score of one specimen, ie 0,88%.

In comparison with habitats and capture sessions, the following is concluded:
The FPG is the best represented quantitatively and qualitatively (113 specimens, TS = 7,06%, Ep = 1600 trap

nights). *Praomys* cf. *jacksoni*, which ranks first with 69 individuals out of 113 and qualitatively 10 species, were caught. Unlike the FPM which occupies the second position (40 specimens, TS = 2.5%, EC = 1600 trap nights,) with 9 species caught where *Praomys* cf. *jacksoni* is best represented with 22 individuals captured out of the 40.

But for the indices of specific diversity, it appears that, in the two habitats there is the probability of randomly drawing 2 individuals to have 2 different species because Simpson tends towards1 everywhere. And in the two habitats, the species are not evenly distributed (E tends towards 1).

Also, the analysis of variances indicates that the 2 habitats demonstrate that there is not a significant difference between the populations of Rodents (Kuskal-Walis test, H = 2,802; p = 0,09055).

Finally, for the evaluation of the sexes, the results show that, the Rodents sampled are marked by the dominance of the males in percentage than the females.

Thus, in the FPM the dominance of the males is expressed at 70% against 30% of the females and in the FPG 69,91% of the males against 30,09% of the females.

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