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Biodiversity of small mammals of Tshuapa-Lomami-Lualaba National Parc, Democratic Republic of the Congo

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Abstract
In this 21st century, the world's attention is focused on the accelerated degradation of the biodiversity. This phenomenon of degradation seems to hasten the process of climate change and habitats that would amplify the lack of biological resources. The main objective of this work was to acquire scientific information on rodents and shrews biodiversity that colonize future Tshuapa-Lomami-Lualaba National Park. The study was conducted in the Congolese Central Cuvette precisely in Obenge village, in this national park the future Tshuapa-Lomami-Lualaba National Park. The trapping was carried out for 5 days, divided as follows: 2 days for traps installed in the secondary forest, 3 days for the traps installed in the village, its surroundings and in the fallow, 5 days for the traps installed in the primary forest. We combined Pitfall, Victor and Sherman traps to form devices to capture Rodents and Shrews. Specific richness, capture effort, trapping success, Shannon-Wiener alpha index and maximum equitability were the ecological indices used. We collected a total of 159 small mammals of which 110 rodents, 43 Soricidae and 6 macroselidae. From this study, CSB brought a new idea regarding the knowledge of rodent as well as shrew biodiversity in Tshuapa-Lomami-Lualaba future National Park and making available data for Natural Resource Managers for a sustainable development.
These results show that body biomass of rodents' ranges between 3 and 31g. The calculated biodiversity indices for different habitats show that rodent communities are less diversified. For the distribution of shrews sampled in different habitats, the most interesting was performed in primary forest at *G dewevrei* (42 out of 49 specimens where *Crocidura sp.* is the most captured with 16 out of 49 specimens). The body biomass ranges between 24 and 190g. The calculated indices of biodiversity for different habitats revealed that shrew communities are less diversified.

Keywords: biodiversity, small mammals, tshuapa-lomami-lualaba, national park, kisangani

1. Introduction
The Democratic Republic of the Congo is one of the 17 regions of the world that contain areas of high biodiversity of flora and fauna [1]. Regular studies along with,a continuous monitoring of animal and plant biodiversity are essential for good planning and sustainable development programs. The creation of the future Tshuapa-Lomami-Lualaba National Park is part of this concern. In this 21st century, the world's attention to its future is focused on the accelerated degradation of the environment and of the biodiversity. This phenomenon of degradation seems to hasten the process of climate change and habitats that would amplify the lack of biological resources [2]. Despite their great complexity, diversity and richness of biological resources, tropical forest ecosystems are not exempted from this great threat [3].
Currently, it is known that the globe biodiversity is declining at an alarming rate. Thus, it is urgent and useful to study different components of the biodiversity before it is too late [4]. Although the administrative process for Tshuapa-Lomami-Lualaba Future National Park is being finalized, it has to be recognized that little is known about its terrestrial small mammals or micro mammals. Henceforth, the main objective of this work was to acquire scientific information on rodents and shrews biodiversity that colonize this national park in which similar studies are almost nonexistent. In 2009, inventories were carried out in an area between Tshuapa, Lualaba and Lomami rivers and these surveys revealed an unexplored wildlife richness of which a new primate species was described in 2012. A team of Centre de Surveillance de la Biodiversity of University of Kisangani conducted a 5-day prospective mission between 5 and 9 February 2013 in order to survey the terrestrial micro mammals that colonize this national park.

2. Materials and methods
2.1 Study area
The study was conducted in the Congolese Central Cuvette precisely in Obenge village, in the future Tshuapa-Lomami-Lualaba National Park (Figure 1), located at the southwest of Kisangani town in Opala territory at 250 Km from Kisangani. The Central Congolese Basin is subdivided into three faunal regions namely: Central East, Central West and Central South [5].

The future Tshuapa Lomami and Lualaba National Park is in the South Central region. Obenge village is located along Lomami River at 245 km from Opala at Kisangani-Sankuru road at PK 584 [6]. Its geographical coordinates are 25 ° 02'19.3 " E and 01° 22'59.6"E.

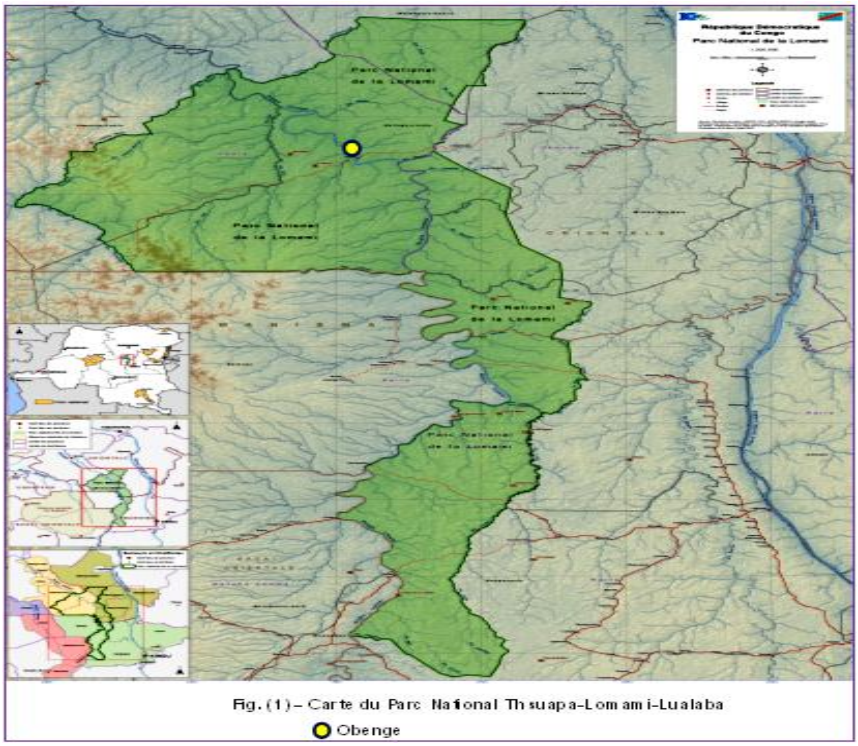

Fig 1: Map of Tshuapa-Lomami-Lualaba National Park

2.2 Material
The biological material used was made of 110 rodents, 43 Shrews and 6 Macroscélidae.

2.3 Methods
2.3.1 Fieldwork
The trapping was carried out for 5 days, divided as follows: 2 days for traps installed in the secondary forest, 3 days for the traps installed in the village in the surroundings of the village and in the fallow, 5 days for the traps installed in the primary forest. We combined Pitfall, Victor and Sherman traps to form the [PT-VT-SH] and [VT-SH] devices to capture Rodents and Shrews.

In the village, Sherman and Victor traps were randomly placed in and around human dwellings. In the secondary forest, traps were installed along the transect of 105 meters each. Victor and Sherman traps were alternately arranged next to the Pitfall buckets which 3 days later were moved in order to form 3 trap lines in primary forest at *Gilbertiodendron dewevrei*. A total of 150 Victor and 150 Sherman traps as well as 60 Pitfall traps were used. The mature palm nut pulp was used as bait in the Victor and Sherman traps in order to capture rodents. The survey was done every morning starting from 7:00 am.

In general, Pitfall traps were deployed to capture shrews and occasionally rodents. As a matter of fact, 60 buckets of 10 liters were installed in the primary forest and were punched at their bottom in order not to retain rainwater. These buckets were placed at a regular distance of 5 m from one another. In addition, these buckets were crossed with an uninterrupted blade of tarpaulin about 45 cm high at their axis of symmetry. The tarpaulin was supported vertically by wooden sticks. The part of the tarpaulin in contact with the ground was pushed down to a depth of about 5 cm in order to form a barrier to the underneath passage of animals.

2.3.2 Identification
On the basis of external morphological characters, a provisional identification was made in the field. For some animals, we used acronyms, for example *Crocidura* cf. *Olivieri*, starting from the morphological resemblance of these animals compared to the reference species but also according to divergences observed at this stage of identification. Therefore, the identification of such specimens should continue. For shrews and rodents, we stopped our identification at the genus taxon in some cases.

2.3.3 Mensurations
The mensurations of freshly killed animals were made after each survey. The body mass (BM) of rodents and shrews was taken using a balance (brand Pesola) and depending on the size of the animal the weight was of 10, 30, 100 or 300g. The digital caliper (brand Mitutoyo) was used to measure the length of the left ear (LO) and the length of the left posterior foot (LP). The metal ruler (brand China Stainless MC 00722058) was used to measure the length of the tail (LQ) and the total length (LT) of the animal. The carcasses of animals were kept in a formalin solution (4%) after being measured.

2.3.4 Preparation of skulls
The preparation of the skulls of specimens is being proved to be of a great importance while studying the diversity of micromammals. That is the reason why the skulls were prepared for subsequent analyses of skull and teeth. The carcasses were

taken out of formalin for skull preparation and were stored in 70% denatured alcohol. Rodent and shrew skulls were extracted from the rest of the body using a bistoury. They were soaked in jars containing tap water in order to soften muscles and other ligaments. Each box containing the skull was labeled in accordance with the original specimen in order to avoid any confusion.

Four days later, the softened flesh was gradually removed from the skull using an entomological forceps. The brain mass was emptied by aspiration using a syringe then a toothbrush was used for the cleaning of the skulls. After all these processes, all skulls were dried under the sun for three hours.

2.3.5 Blood Collection

Blood sampling was done using serobuvar (filter papers) of which the long run objective is to study whether the collected blood is carrying harmful microorganisms (germs) or not. Therefore, the species providing the blood sample might be identified as a potential vector of some diseases.

2.3.6 Final Conservation of Biological Material

Biopsies were stored in Eppendorf tubes containing 96% pure alcohol then skulls were kept in plastic jars. Having extracted skulls, the carcasses were preserved in the 96% denatured alcohol.

2.4 Data analysis

During the treatment of the biological material, we determined the following ecological indices:

1) The specific richness "RS", which is the total number of species in the sample.
2) The capture effort "EC" which is the number of nights multiplied by the number of traps used.
3) The relative density or trapping success (TS), which is calculated as follows:

$$TS = \frac{N}{E}\ x\ 100 \qquad (1)$$

Where, N is the total number of individuals captured and EC is the capture effort.

4) The Shannon-Wiener alpha index (Ha) is used to compare the specific richness of rodents and shrews in a given habitat (e.g. in primary forest) while the beta index (Hb) is used to compare the populations of rodents and shrews captured in different habitats where the survey was carried out.

The Shannon index-is suitable for the comparative study of generic or specific richness since it is independent of the size of the samples. It varies directly according to species and numbers observed. The formulas used to calculate (Ha), (Hb) and the Equitability indices are derived from [7] Ramade (1984)

$$H_a = -\Sigma\ p_i\ Log_2 pi \qquad (2)$$

Where

H_a = biological diversity alpha index

$p_i = \frac{ni}{N}$, is the probability of encountering species that occupy the i^{th} rank.

N = total number of captured animals and Ni = number of specimens of i^{th} species in the studied sample.

$H' = Log_2 S$

5) H '= index of equal distribution or Maximum Equitability, which corresponds to the case where almost all species are represented by the same number of individuals.

$$E = \frac{Ha}{H} \qquad (3)$$

Where

E = equitability index which varies from 0 to 1. It tends to zero, when almost all the numbers correspond to a single species of population and it tends towards 1, when each of the species is represented by the same number of individuals [8].

3. Results

During our fieldwork, we collected a total of 159 small mammals of which 110 rodents, 43 Soricidae and 6 macroselidae. Our analysis involves a total of 159 small mammals including 110 rodents, 43 soricidae and 6 macroselids. The results of our investigations are contained in different tables below.

3.1 The Shrews

The list of shrews captured at Obenge village is presented in table 1 below.

Table 1: List of shrews captured at Obenge village

Species	Sex		Total	%
	M	F		
Scutisorex cf. somereni	2		2	4.08
Crocidura littoralis Heller, 1910	2		2	4.08
Crocidura. grassei Brosset, Dubost &Heim de Balsac, 1965		1	1	2.04
Crocidura. cf. olivieri	11	1	12	24.49
Crocidura. dolichura Peter, 1876	3		3	6.12
Crocidura. cf. yoko nov_ sp	2	1	3	6.12
Crocidura. ludia Hollister 1916	6	3	9	18.37
Crocidura. cf. ludia	2	1	3	6.12
Crocidura. cf. latona	1		1	2.04
Sylvisorex nov_sp		2	2	4.08
S. cf. ollula	4		4	8.16
Petrodromus tetradactylus Peter, 1846	4	2	6	12.24
Paracrocidura schoutedeni Heim de Balsac 1956	1		1	2.04
Total	38	11	49	
%	77.55	22.45	100	

Legend: M = Male, F = Female

Table 1 shows a total of 49 Shrew species of which 38 males (77.55%) and 11 females (22.45%). Three species are best represented: *C. cf. Olivieri* (24.49%), *C. ludia* (18.37%) and *P. tetradactylus* (12.24%). The least represented are *Crocidura grassei*, *Crocidura cf. latona* and *Paracrocidura schoutedeni*, each in the proportion of 2.04%.

3.2 Rodents

The number of rodents captured at Obenge is shortlisted in the table below.

Table 2: List of rodents captured at Obenge

Species	Sex		Total	%
	M	F		
Dendromus cf mystacalis Smith, 1829	1		1	0.91
Funisciurus pyrropus Cuvier, 1833	1	3	4	3.64
Hybomys lunarisThomas, 1906	11	9	20	18.18
Hylomyscus_sp Thomas, 1926	2	5	7	6.36
Lophuromys cf flavopunctatus Peter, 1874	11	6	17	15.45
Malacomys longipes Milne-Edwards, 1877	3	3	6	5.45
Nannomys sp Thomas & Wroughton, 1910	2	7	9	8.18
Paraxerus cf. boehmi Reichenow, 1886		1	1	0.91
Praomys sp Thomas, 1915	12	7	19	17.27
Praomys lukolelae Hatt, 1934	5	2	7	6.36
Rattus Rattus Linnaeus, 1758	7	7	14	12.73
Stochomys longicaudatus Tullberg, 1893	2		2	1.82
Grammomys kuru Thomas, 1907	2	1	3	2.73
Total	**59**	**51**	**110**	**100**
%	**53.6**	**46.4**	**100**	

Legend: M = Male, F = Female, %= Percentage

Table 2 above indicates a total of 110 rodents of which 59 males and 52 females. *Hybomys* lunaris is the most represented genus with 18%. *Praomys sp.*, *Lophyromys cf flavopunctatus* follow with a proportion of 17.2% and 15.45 respectively. The least represented is the genus *Paraxerus cf boehmi* and *Dendromys* each with 0.91% of individuals

Concerning the rodents, 110 specimens were captured using three types of traps namely: 65 specimens were captured by Victor's trap, 35 using Sherman's trap and 10 using Pitfall's trap. The capture was more efficient with Victor's trap (TS=14.68%) than with Sherman's trap (TS=8.86%) and Pitfall (TS=3.33%). Whatever the difference observed in the capture effort, Sherman and Victor traps were efficient for the capture of rodents and not for shrews. These results are similar with those of [14-15] which confirm our first hypothesis.

The results above corroborate with the one of other researchers who stated that the efficiency of these traps is due to the fact the bait used is a ripe palm nut pulp which is clearly visible and could exalt an odor at a certain distance which would attract more rodents than bait which is inside Sherman's trap. The fact that Sherman's trap is made of aluminum which shines in the moonlight and the sunlight could repel animals to some extends and in some circumstances can be used as shelters. The low rate of rodent capture using Pitfall is due to the fact that these traps are not baited either the rodents are not able to jump because only small rodents are captured [14, 15].

Concerning the total number of captured rodents and shrews, it was observed that the number of males exceeded the one of females. [9] And [10] observed similar results. Partially, this would explain by a high capacity of mobility which is noticeable in males than in females. These females are assumed to spend more time around their nests when the parturition is approaching and while breast-feeding. At the end of 1 090 trap-nights, 110 rodents (TS= 10.09%, the overall generic richness is 12) and for shrews with a capture effort of 1 090 trap-nights, 49 specimens were captured (TS=4.5%, the generic richness was more or less of 9 genera). Regarding the short duration of the trapping session, some genera were certainly not captured for both rodents and shrews that colonize this area.

3.2.1 Biodiversity of shrew population in different habitats

Different indices of shrew population biological diversity is presented in the following table.

Table 3: Shrew population biological diversity indices

Obenge village	H_a	H'	E
FP	0.973	1.787	0.8594
FS	0.28	1.332	0.961

Legend:

Ha = alpha index of biological diversity

H '= index of equal distribution or Maximum Equitability

E = Equitability index which varies between 0 and 1

The Shannon-Wiener indices Ha and H' show that the shrew communities that colonize the primary forest is well diversified as well as in the secondary forest. The equitability index for these different habitats tends to 1 for the primary and the secondary forests i.e. each of the genera is represented by the relatively equal number of individuals.

3.2.2 Biodiversity of rodent population in different habitats

Biological diversity indices of rodent populations in different habitats are given in the table below.

Table 4: Biological diversity indices of rodent populations in different habitats

.	Ha	H'	E
FP	3.719	2.059	0.894
FS	3.189	1.715	0.825

Legend:

H_a= Biological diversity alpha index

H'= Index of Equal Distribution or Maximum Equitability

E= Index of Equitability which ranges between 0 and 1

The values of Shannon-Wiener indices Ha and H 'show that the community of rodents captured in different habitats is quite diverse. The index of equitability which tends towards to 1 in different habitats i.e. each of the genera captured is presented relatively by the equal number of individuals.

Species distribution according to habitat preferences show that species are unequally distributed such as *Praomys* was captured more in the primary forest (10 specimens) but also in the secondary forest (8 specimens) and was less found in the fallow (one specimen). In the same line, *Lophyromys* was more captured in the secondary forest (10 specimens) as well as in the primary forest (7 specimens) and *Rattus rattus* was more captured inside the village (8 specimens) as well as in the fallow (one specimen).

The distribution area of *Paraxerus boehmi* seems to be limited only at the right bank of Congo River but needs to be revised [16, 18]. Because a specimen that was taken at Obenge village and was provisionally referred to *P. cf. boehmi* and it resembles it so much (figures 3 and 4). It is the same with the taxonomic position of *Scutisorex cf. somereni* for some researchers suggest the presence of this species in Yoko forest Reserve. Considering the weight, shrews captured in Victor and Sherman traps as well as rodents captured with Pitfall was listed. The weight of shrews captured with Victor and Sherman range between 2 and 190 g. mainly, they tend to capture shrews of high weight made of different species and even Macroscelidae as it is the case of this study.

Regarding the weight of rodents captured with Pitfall's traps and it ranges between 3 g and 31 g. Pitfall's traps capture adults of small size such as *Nannomys*, juveniles, subadults and adults of other rodents such as *Praomys*. In general, Pitfall's traps are efficient for capturing shrews of different species and different weights but also juveniles, subadults and adults of rodents. In our opinion, we think that capturing large size adult rodents with Pitfall's traps would be due to their abnormal physical condition of health, weakness caused by rivalry battle.

Hybomys sp

Malacomys sp

Fig: Annex: Some species of small mammals captured and their habitat

4. Conclusion and suggestions

The survey on the biodiversity of rodents and shrews was conducted in Obenge village located in the future Tshuapa-Lomami-Lualaba National Park by a specific mission of the team of Centre de Surveillance de la Biodiversité. Considering the distribution of rodents in explored habitats, the primary forest having one dominant species *Gilbertiodendron dewevrei* and the secondary forest provided more rodents than in other habitats. For all habitats, the most captured rodents belong to *Praomys* genus with 26 out of 110 specimens while the least captured rodents belong to *Paraxerus* et *Dendromus* (1 out of 110 specimens). These results show that body biomass of rodents ranges between 3 and 31g. The calculated biodiversity indices for different habitats show that rodent community are less diversified. For the distribution of shrews sampled in different habitats, the most interesting was performed in primary forest at *G dewevrei* (42 out of 49 specimens where *Crocidura sp*. is the most captured with 16 out of 49 specimens). The body biomass ranges between 24 and 190g. The calculated indices of biodiversity for different habitats revealed that shrew communities are less diversified.

From this study, CSB brought a new idea regarding the knowledge of rodent as well as shrew biodiversity in Tshuapa-Lomami-Lualaba future National Park and making available data for Natural Resource Managers for a sustainable development. Further studies are required in this area in order to bring out rodent and shrew population composition on a long period of capture.

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