Available online at www.elixirpublishers.com (Elixir International Journal)

Agriculture

Elixir Agriculture 168 (2022) 56341-56347

ISSN: 2229-712X

Rodent and Insectivore Population of the Yangambi Biosphere Reserve

Jean Pierre Ngongo Lushima[1], Augustin Yakayengo Toko[1], Adelar Lonema[2], Kapoli Omba Dan[1], Kintu Mayaka Doudou[1] and Pierre Yuma Madjaliwa[1]

[1]University of Kindu. Faculty of Agronomic sciences. Department of Renewable Naturals Resources Management. B.P 122. Kindu, R.D.Congo.

[2]Forestry Section. National Institute for Agronomic Study and Research (INERA). Yangambi, R.D.Congo.

ARTICLE INFO

Article history:
Received: 30 May 2022;
Received in revised form: 25 June 2022;
Accepted: 5 July 2022;

Keywords
Population,
Biodiversity,
Reproduction,
Structure,
Rodents,
Insectivora.

ABSTRACT

This study aims to contribute to the knowledge of Rodents and insectivora population of the Yangambi Biosphere Reserve (YBR). Some aspects have been treated and are related to diversity, reproduction, structure of Rodents and insectivorous populations aforesaid Reserve. Sampling collection place from 22nd to 25th September 2019 using trapping technic trapping in parallel and horizontal lines using Sherman and small Victor traps. For a total of 489 harm-trap, 43 specimens were captured, with a success of captures of 8,79% testifying an abundance of the Rodents and the Insectivora of the YBR. The 35 captured Rodents belong to 5 genera and 5 species *(Hybomys lunaris*, *Hylomyscus stella*, *Lophuromys luteogaster*, *Praomys. cf. jacksoni and Stochomys longicaudatus*) and 8 Insectivora are regrouped in *Crocidura sp*. On the whole, the ecological indices of Shannon-Wiener, Simpson and Equitability show that the biodiversity of small mammals is high. The analysis shows that the reproduction of males and females is higher, during the period of study. The average of litters varies according to species (1 to 2 embryos). Finely, some stability was observed in the structure of Rodent and Insectivora's populations where the sex-ratio was in balance, because the difference was non significantly among males and females individuals and we had observed some stability in population's structure by the presence of 3 classes who are: the adults (26 individuals), the subadults (2 individuals) and the young (8).

1. Introduction

The rainforests of Central Africa represent one of the world's great biological treasures and one of the most valuable in equatorial Africa. They are classified among the most species-rich biomes. However, they are progressively being degraded and fragmented due to abusive anthropic exploitation (slash and burn agriculture and timber exploitation), thus reducing their rich biodiversity and progressively converting some of their large areas into agricultural zones (Mukinzi, 2014).

The wildlife wealth of the Democratic Republic of Congo contributes to the maintenance of biological balance through the link it forms in the trophic chain (Isangi *et al*., 2016). Small mammals are generally a source of protein for the populations living along the forest areas and they are also used as guinea pigs in experimental laboratories to test serum and vaccine. In addition, Rodents are harmful to humans by acting in two sensitive areas such as agriculture and health (Hadjoudj *et al*., 2012).

Rodents are often carriers (carriers of numerous viruses, such as those responsible for certain hemorrhagic fevers, or of bacteria and protozoa that cause epidemics that are sometimes dramatic) of pathogens for human populations and livestock (Gauthier, 2000).

The YBR is under increasing pressure from the riparian population in search of new and more fertile land. Slash and burn agriculture, hunting, artisanal logging and mining are practiced informally. These practices lead to habitat fragmentation, which impacts species distribution (Iyongo *et al*., 2009).

There is a growing interest in the problem of biodiversity loss in tropical forest ecosystems. Thus, studies directly or indirectly related to this phenomenon are increasingly carried out in order to know the biodiversity of habitats and its evolution in space and time in the light of the degradation and the accelerated fragmentation of ecosystems. The knowledge of the biological diversity of rodents and insectivores as well as other zoological groups in the Yangambi Biosphere Reserve is crucial for its responsible and sustainable management. To achieve this, the present investigation aims to answer the following questions: Are rodents and insectivores abundant in the Yangambi Biosphere Reserve? What is the degree of biodiversity of rodents and insectivores in the Yangambi Biosphere Reserve? What is the status of reproduction and population structure of rodents and insectivores in Yangambi Biosphere Reserve?

2. Materials and Methods

2.1. Study environment

The Yangambi Biosphere Reserve is located between 0° 38' and 1° 10' N, 24° 16' and 25° 08' E, 100 km west of Kisangani city in the territory of Isangi (Boyemba, 2011). Being located in the forest zone of the central basin, the Yangambi Biosphere Reserve benefits from the Afi type of climate according to Köppen's classification (1936).

Tele:
E-mail address: fistonngongo1@gmail.com

The system was installed in a primary second-growth forest. Our biological material consists of 43 specimens including 35 rodents and 8 insectivores.

2.2 Methods Trapping

Sampling was conducted from 22 to 25 September 2019. We used the parallel and horizontal line trapping technique using Sherman traps (H.B. Sherman Company manufacture, Box 683, DeLand, Florida, USA; SH = 229x89x76 mm) and small Victor (Woodstream Corp. manufacture Lititz, Pennsylvania, USA, pVT = 98x46x6 mm). In total, we used 163 traps of which 114 were Sherman and 49 were small Victor.

We trapped on 17 open lines. Each line was 100 m long except the last line which was 40 m long. On each of the lines, the Sherman traps were placed first and then, following them, the small Victor traps were placed. Each trap was 10 m apart. The traps were baited with palm nut pulp (*Elaeis guineensis* Jacq).

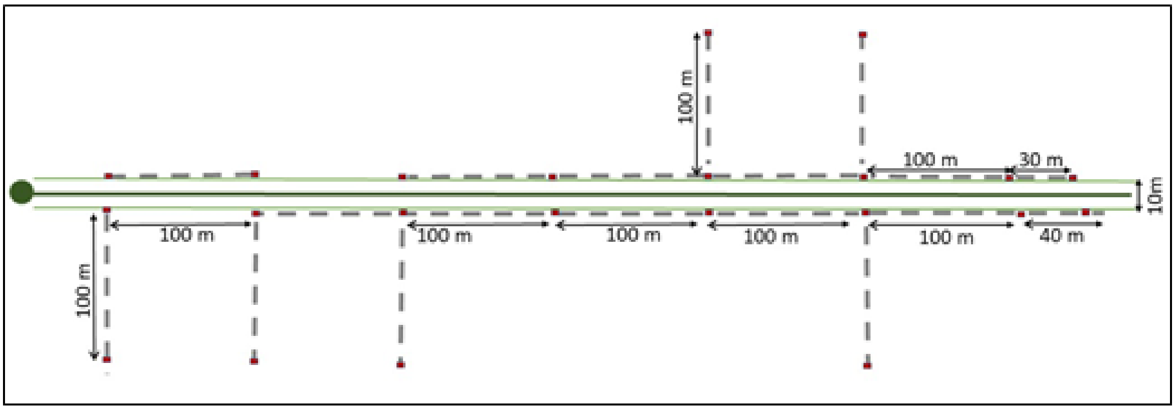

Fig. 1 . Trapping device

Material Processing and Measurements

The traps were collected every morning around 9:00 a.m. once a day. During the surveys, each animal caught was placed in a bag with a label on which the line number, the type of trap and the station number were written. Traps that had captured animals were cleaned directly and then re-baited. Provisional identification was made in the field on the basis of external morphological characteristics. The specimens were combed to collect the ectoparasites, using an entomological forceps. Then the weighing was done with Pesola branded scales of 60 g and 100 g depending on the weight of the individual. For the measurements, we took the total length (LT) and the tail length (LQ) using a tape measure graduated to within 50 cm, the length of the left ear (LO) and the length of the left hind leg (LP) using the caliper Stainless Hardened of Mitutoyo brand, precision 0,01mm.

After measurements were taken, the animals were disemboweled to take biopsies from certain organs (liver, kidney) for later identification based on molecular analysis, and then to check the sexual status of female individuals. The heart was also cut to sprinkle the blood on the serobuvard papers for the study of probable diseases. Then each animal was tagged on its backside.

Conservation

After the different treatments, the carcasses of the animals were placed in a 4% formalin solution and the biopsies and ectoparasites were placed in Eppendorf tubes containing 96% and 70% alcohol respectively.

Ecological indices and statistical analysis

The following parameters were calculated:

- Species richness (SW) which expresses the number of species captured in a habitat.
- Capture effort expressed by the following formula:

Capture effort = Number of traps × Number of nights trapped

- Trapping success: It is the ratio between the total number of individuals captured and the capture effort. It is calculated by the following formula: $Dr = \frac{N}{Ec} \times 100$

Où, Dr = densité relative ou succès de piégeage

Ec = catch effort

N = total number of individuals

- The Shanon-Wiener alpha index (Hα') from the following formula:

Hα'= -∑pi. Log2pi

pi = ni/N

ni = number of individuals of a given species in the sample;

N = total number of individuals caught for the entire sample.

- Equitability by the formula

E = Hα'/Hmax

Hmax = Log2S

S = species richness.

The Equitability index varies from 0 to 1. It tends towards 0 when almost all the numbers are concentrated on one species. It tends towards 1 when all species have the same abundance.

- Reproductive analysis: the reproductive status of each specimen was determined by external and internal observations of both males and females in the fresh state.

External observation in females consisted of observing the condition of nipple and vagina. When the vagina is open, the individual is sexually active. Adults with developed nipples are those that are either pregnant or lactating. The analysis was done by exerting a slight pressure on the nipple which let out a milky liquid; proving that the female is lactating.

In males, the testes are abdominal in rodent juveniles and in all Insectivores, they are in the process of scrotalization in subadults and are scrotal and well developed in adults.

Internal observation consisted of checking the condition of the uterus of the females and for those individuals whose external organs were gnawed, we check their internal organs to determine sex.

Reproduction rate:

Tr = ∑Emb/Fad

With:

Tr: reproduction rate; ∑Emb: sum of embryos and Fad: adult female.

- **Sex ratio**: is the ratio of the total number of males (M) to the total number of females (F). The determination of the

difference between the sexes, was done by the chi-square (X2) test (Lellouch et al (1974). $\chi^2=\sum(0-C)2\ C$ where:
0 = observed value
C = calculated value
$\alpha = 0.05$; If $p < \alpha$: Significant difference (D.S)
If $p > \alpha$: non-significant difference (D.N.S)
- **Age structure**: it is not well known, but based on the explanations provided by Amundala (2000), we have grouped the individuals into three classes as follows :

- Juveniles: these are immature individuals; the weight limit of the class is determined by the absence of sexual maturity characters.
- Subadults: the characters of maturity of the sex are detected.
- Adults: these are the oldest individuals that are breeding adults

.

3. Results

Table 1. Relative Abundance of Insectivores and Rodents Captured

Genus/Species	Overall total	%
Insectivores		
Crocidura sp Wagler, 1832	8	18.60
Subtotal	8	18.60
Rodents		
Hybomys lunaris (Thomas 1906)	2	4.65
Hylomuscus stella(Thomas, 1911)	5	11.63
Lophuromys luteogaster Hatt (1934)	4	9.30
Praomys cf, jacksoni [P. jacksoni (De Winton, 1897)]	22	51.16
Stochomys longicaudatus (Tullberg, 1893)	1	2.33
Rongeur sp	1	2.33
Subtotal	35	81.40
Overall total	43	100.00
%	100.00	

It follows from table (1) that 43 specimens were caught. The most abundant species is *P. cf. jacksoni* with 22 specimens or 51.16%, followed by *Crocidura sp* with 8 specimens or 18.6%, then *H. stella* and *L. luteogaster* with 5 and 4 specimens respectively, *H. lunaris* with 2 specimens and finally *S. longicaudatus* with one specimen.

Catching effort and trapping success

We placed a total of 163 traps (114 Sherman and 49 small Victor) in the study site. During 3 nights of trapping, a capture effort (EC) of 489 trap nights (NP) was found for the total traps. And, a trapping success (TS) of 8.79%.

Diversity indexes

Table 2. Diversity indices

Genus/Species	number
Crocidura sp	8
Hybomys lunaris	2
Hylomuscus stella	5
Lophuromys luteogaster	4
Praomys cf, *jacksoni*	22
Stochomys longicaudatus	1
Rongeur sp	1
Total	43
Specific richness	7
Shannon-Wiener (Hα)	1.445
Simpson (1-D)	0.6782
Equitability	0.7423

It appears from table (2) that the specimens captured are distributed to at least 7 species of which: about one species of insectivores (*Crocidura sp*) and at least 5 species of rodents of which *P. cf, jacksoni, H. stella, L. luteogaster, H. lunaris, S. longicaudatus* and an unidentified individual named Rongeur sp. Equitability tends to 1.

Taxinomy and diagnosis

Table (3) gives the diagnoses of the different species of rodents and insectivores captured in the Yangambi Biosphere Reserve.

Table 3. list of species caught and their diagnoses

Genus/Species	Diagnose
Crocidura sp	Insectivore of large and medium size, characterized by the presence of vibrissae on ¾ of the tail
Hybomys lunaris	Species of rodent, characterized by the presence of a black dorsal line, large, long and dark legs, slightly greenish coat
Hylomuscus stella	Species of rodent, characterized by a wad of bicolored grey and yellow hair, with a yellow ring in the middle. The general color of the coat is yellowish. The length of the legs does not exceed 17mm
Lophuromys luteogaster	Species of rodent, with a short tail, the underside of the coat is reddish
Praomys cf, *jacksoni*	Species of rodent, whose lower hairs have a whitish coloration. The length of the legs oscillates around 22 mm. Females are characterized by the presence of three pairs of teats, two inguinal and one thoracic.
Stochomys longicaudatus	Large rodent species, characterized by a long scaled tail (snake-like), two layers of hair, the second of which is stinging

Reproduction

Reproduction in males

Table 4. Reproduction in male individuals of captured rodents and insectivores

Genre/Species	NTM	Ma	%Ma	MI	%MI
Crocidura sp	5	undetermined	undetermined	undetermined	undetermined
Hylomuscus stella	2	2	100.00	0	0.00
Lophuromys luteogaster	3		0.00	3	100.00
Praomys cf, *jacksoni*	9	8	88.89	1	11.11
Stochomys longicaudatus	1		0.00	1	100.00
Rongeurs sp	1	undetermined	undetermined	undetermined	undetermined

Legend:

- N.T.M : total number of males
- Ma : number of sexually active males
- M.I. : number of immature males.

It appears from table (4) that out of 21 males captured, the sexual status of 6 individuals of *Crocidura sp* and rongeur sp was not determined and for the remaining 15 individuals, 10 were sexually active and 5 were sexually inactive.

Reproduction in females

Table 5 . Reproduction in female individuals of rodents and insectivores captured

Genus/Species	NTF	Fa	%Fa	NFA	%NFA	NFG	%FG	NFI	%FI
Crocidura sp	3	2	66.67	0	0.00	2	100.00	1	33.33
Hybomys lunaris	2	2	100.00	1	50.00	1	50.00	0	0.00
Hylomuscus stella	3	2	66.67	1	50.00	1	50.00	1	33.33
Lophuromys luteogaster	1	0	0.00	0	100.00	0	0.00	1	100.00
Praomys cf, *jacksoni*	12	9	75.00	2	22.22	7	77.78	3	25.00

Legend:

- N.T.F : total number of females.
- Fa : sexually active females
- N.F.A : number of lactating females
- N.F.G : number of pregnant females
- NFI : number of immature females

From table (5), it can be seen that out of 21 females captured, 15 were sexually active (of which 3 were lactating and 11 were pregnant) and 7 were not sexually active.

Number of embryos

Table 6. Number of embryos in females of captured species

Genus/Species	Fa	N.embr	X.embr	TR
Crocidura sp	2	4	2	200.00
Hybomys lunaris	2	2	1	100.00
Praomys cf, *jacksoni*	11	16	1.77	177.78

Table (6) indicates that the reproduction rate in *Crocidura sp* is 200%, it is 100% in *H. lunaris* and is 177.78% in *P. cf. jacksoni*. It follows from this same table that the average number of embryos in *Crocidura sp* is 2, that of *H. lunaris* is 1 and that of *P. cf. jacksoni* is 1.77.

Population structure

Sex ratio

Table 7 . Sex ratio of captured species

Genus/Species	M	F	n	M/F	X^2	p	α	dl	Decision
Crocidura sp	5	3	8	1.67	0.5	0.4795	0.05	1	DNS
Hybomys lunaris	0	2	2	0.00	2	0.1573	0.05	1	DNS
Hylomuscus stella	2	3	5	0.67	0.2	0.6547	0.05	1	DNS
Lophuromys luteogaster	3	1	4	3.00	1	0.3173	0.05	1	DNS
Praomys cf, *jacksoni*	9	13	22	0.69	0.73	0.3938	0.05	1	DNS
Stochomys longicaudatus	1	0	1	xxx	1	0.3173	0.05	1	DNS
Rongeur sp	1	0	1	xxx	1	0.3173	0.05	1	DNS
Total	21	22	43	1	6.4075	0.3791	0.05	6	DNS

Legend:

- M : Males
- F : Females
- M/F : Sex-ratio
- X2 : chi-square
- P : p-value
- α : threshold probability
- dl : degree of freedom

It follows from Table (7) that by applying the X2 test in the different species caught, the sex ratio is in equilibrium because the difference between the sexes is not significant.

Age structure

Table 8. Age structure of the species caught

Genus/Species	Adults	Subadults	Juveniles
Crocidura sp	11.5-12g (n=2)		10g (n=1)
Hybomys lunaris	47-56g (n-2)		
Hylomuscus stella	18-23g (n=4)		21.5g (n=1)
Lophuromys luteogaster	61g (n=1)	56-58g (n=2)	28g (n=1)
Praomys cf, *jacksoni*	23-52g (n=17)		19.5-32g (n=4)
Stochomys longicaudatus			58g (1)
Rongeur sp			
Total	26	2	8

Table (8) shows that the weight of adults of *Crocidura sp* captured at BYR ranged from 11.5 to 12g and it was 10g for the juvenile. Adults of *H. lunaris* ranged in weight from 47 to 56g, adults of *H. stella* weighed between 18 and 23g and its juvenile weighed 21.5g, for *L. luteogaster*, the adult weighed 61g, subadults weighed between 56 and 58g and the juvenile weighed 28g. For *P. cf. jacksoni*, the adult weights ranged from 23 to 52g and juveniles ranged from 19.5 to 32g. Finally, the juvenile of S. longicaudatus weighed 58g.

Discussion

The capture session whose results are discussed in this item was done from September 22 to 25, 2019, at Yanganmbi Biosphere Reserve. The sampling provided a total of 43 specimens among which 35 Rodents and 8 Shrews.

In general, we had a total capture effort of 489 trap nights and a capture yield of 8.79%. The trapping success is 8.79%. This shows that the traps as well as the bait used were effective. Mukinzi (2014) studying Shrews in Yoko Forest Reserve found a trapping success of 6.68%. This is low compared to that found by (Dupuy *et al*., 2007) which was 14.8% in the Val d'Allier National Nature Reserve in France in their study of 6 species of small mammals. The difference observed between our results and those of Dupuy *et al*., 2007 would be related to the number of days of capture and the type of habitat. This observation allows us to confirm the first of our study.

Overall, the Shannon-Wienner, Simpson and Equitability ecological indices show that the biodiversity of small mammals is high in the Yangambi Biosphere Reserve.

The specimens captured are divided into 6 genera and at least 6 species, including one genus of Soricomorphs and 5 genera of rodents, except for the single unidentified rodent.

Insectivores are represented by 8 specimens (18.6%) of the genus Crocidura, grouped as *Crocidura sp*. Its presence in the collection is justified by the fact that it is the most diverse genus in species (Hutterer, 2005; Wilson and Reeder, 2005), and its low abundance (18.6%) is justified by the fact that the different types of traps used are not adapted to capture shrews except for large shrews, whose weight allows for the triggering of Sherman trap systems. These observations were made by Stanley *et al.* (1996), Hutterer (2005), Nicolas *et al.* (2005), Mukinzi *et al.* (2005), and Gambalemoke (2008, 2014).

The 35 rodent specimens are divided into 5 genera and at least 5 species (*H. lunaris, H. stella, L. luteogaster, P. cf. jacksoni and S. longicaudatus*) except for the single unidentified rodent individual and at least 6 species. *P. cf. jacksoni* is the best represented species numerically. This observation was also made by Dudu (1981) and Katuala (2005, 2009).

The genera Praomys and Hylomyscus are each represented by a single species (*P. cf. jacksoni*) whereas previous work in the Kisangani region notably Dudu, 1991; Katuala (2005, 2009) and Amundala, 2013 had reported the presence of 4 species of Praomys including *P. cf. jacksoni, P. misonnei, P. mutoni* and *P. minor* and the genus Hylomyscus is represented by a single *H. stella* whereas Dudu *et al*.,1989 Dudu, 1991 and ; Mukinzi *et al*., 2005 found 3 species (*H. aeta, H. stella, H. parvus*). The difference observed between our results and those of the authors cited above would be related to the reduced size of our sample (3 days of surveys) on the one hand and on the other hand by the fact that the identification was done uniquely based on morphological and morphometric characteristics. This proves that the diversity of rodents and insectivores in the Yangambi Biosphere Reserve is great and this confirms the second hypothesis of our study.

For the diagnosis of the species, particular attention was paid to the genera Praomys and Hylomyscus because, more than one person would be tempted to confuse them. Then the size of the adult individuals and the length of the hind leg of Hylomyscus allowed to remove the equivocation. The identification of Hylomyscus had already been the subject of controversy, in Misonne (Misonne, 1969 in Iskandar, Sd), who thought it was a subgenus of Praomys, while other authors such as Robbins *et al*, (1980) and (Rosevear, 1969 in Iskandar, Sd) considered it a genus in its own right (Iskandar, Sd, Kingdon, 2013).

Of the 21 male individuals captured, the sexual status of 15 individuals was examined. Of these 15 males, 10 (66.67%) were sexually active and 5 (33.33%) were sexually inactive.

Of 21 females captured (the sexual status of one individual was not determined), 15 were sexually active (of which 3 were lactating and 11 were pregnant) and 7 were sexually inactive. Our results are similar to those of Aladro (2007) who worked on Sciurid rodents and found that lactating females were less abundant compared to pregnant females. And that sexually inactive males and females were less abundant. Dudu (1986) found that among sexually active females, lactating females were more abundant. The observed difference may be related to the period of observation, the duration of observation and the small size of our sample. Dudu's (1986) observations were in the months of January, March, July, and August while ours is in September.

Amundala (2009, 2013) also reports that reproduction in rodents is continuous and, this is especially observed during wet periods. The presence of juveniles, lactating and pregnant females allows us to confirm the third hypothesis of our research.

The sex ratio of individuals of the different species captured indicates that the difference is non-significant between males and females ($n = 43$; $X^2 = 6.4075$; $p = 0.3791$, $\alpha = 0.05$, dl=6). This finding contradicts that made by several works carried out on rodents notably those of Dudu (1991), Amundala *et al*. (2005) and Amundala (2013) in the Kisangani region report a predominance of males over females which, according to Amundala (2013) the predominance of males is due to the size of their home ranges and, their flexibility (Aladro, 2007). Previous work done on Insectivores by Gambalemoke (2008a, b, c) and Mukinzi

(2009) showed that males were always more abundant than females. This is explained according to Gambalemoke (2014) by the fact that in shrews, males would not spend a long nuptial stay next to females, living next to pregnant, lactating or guarding females. We believe that the difference would be explained by the small size of our sample.

The individuals of the different species of rodents and insectivores captured are grouped into 3 age classes, namely adults (26 individuals), subadults (2 individuals) and juveniles (7). The weight of adults varied between 18-61g, between 56-58g for subadults and 19.5-58g for juveniles. Our results do not corroborate with Amundala (2013) who did not find the subadult class. The difference is related to the fact that the latter had not performed the internal analysis of reproductive organs because his animals were captured by the Capture-Mark-Recapture technique. It should be noted that the age structure of 5 male individuals of Crocidura sp. was not determined. Because the determination of their age structure requires examinations of several characters (the careful analysis of genitalia under the magnifying glass or microscope, dental wear and craniometric structure) (Dudu, 1979; Gambalemoke, 2014 and Mukinzi, 2014).

According to this same author, the presence of juveniles and females explains the stability of the population structure. This fact allows us to partially confirm the fourth hypothesis of this study.

Conclusion

The results presented in this study do not provide exhaustive information on the population of rodents and insectivores in the Yangambi Biosphere Reserve. Thus, we suggest that scientists conduct similar studies over a long period of time in the different habitats of the YBR that will expand the knowledge of the species that abound in the Yangambi Biosphere Reserve. For a capture effort of 489 trap nights, we recorded a capture success of 8.79%. The diagnoses of the different species captured were recorded and are provided in a table. This diagnosis was essentially made on the basis of morphological characters.

The 43 specimens captured are divided into 35 rodents and 8 insectivores. The rodents are divided into 5 genera and 5 species namely: *H. lunaris, H. stella, L. luteogaster, P. cf, jacksoni* and *S. longicaudatus* and, the 8 Insectivores are grouped in *Crocidura sp. P. cf, jacksoni* is the best represented species numerically. Note that one rodent specimen attacked by ants could not be identified.

The Shannon-Wienner (1.445), Simpson (0.6782) and Equitability (0.7423) ecological indices showed that the biodiversity of small mammals is high in the Yangambi Biosphere Reserve.

Among the 43 specimens captured, only the sexual status of 37 individuals was determined. Of the 36, 22 were sexually active (10 males and 12 females) and 14 were sexually inactive (5 males and 9 females). Of these females 9 were pregnant and 3 were lactating. These data show that there is a high reproduction rate.

The sex ratio of the individuals of the different species captured was found to be in equilibrium as the difference between males and females was not significant. The individuals of the different species of rodents and insectivores captured are grouped into 3 age classes, namely, adults (26 individuals), sub-adults (2 individuals) and juveniles (8).

References

Amundala, D.N., 2000 : Nouvelles données sur les peuplements en Rongeurs et en Soricomorphes des milieux insulaires des environs de Kisangani (Mbiye et Mafi, RD. Congo) : structure des populations. TFE inédit Fac. Sci., Unikis, 32p.

Amundala, D.N., Bapeamoni, A., Iyongo, W., Kennis, J., Gambalemoke, M., Kadange, N., Katuala, P. G. B. and Dudu, A., 2005. The Population structure of four Rodent species from a tropical region (Kisangani, D.R. Congo). Belgian Journal of Zoology 135 (Supplement) : 127- 131.

Amundala, D.N, 2013 : Ecologie de population des Rongeurs (Rodentia, Mammalia) dans une perspective de gestion des espèces nuisibles aux cultures dans la région de Kisangani (R.D. Congo), Thèse, 266p.

Aladro M., 2007 : Contribution à l'étude des Sciuridés de la Reserve forestière de la Yoko et ses environs (Ubundu, R D Congo), Monographie inédit, Fac. Sc. Unikis, 30p.

Boyemba, F. (2011). Écologie de Pericopsis Elata(Harms) Van Meeuwen (Fabaceae), Arbre de forêt tropicale africaine à répartition agrégée. Thèse de doctorat. Bruxelles : Service d'Ecologie du Paysage et Systèmes de Production Végétale / Université Libre de Bruxelles.

Dudu. A., 1979 : Contribution à l'Ecologie des rongeurs de l'ile Kongolo (HautZaire), Familles Sciuridae et Muridae, Mémoire inédit, Fac. Sc. UNIKIS, 33p

Dudu, A., 1986. Contribution à l'écologie des Muridae (Rodentia Mammalia) de la région de Kisangani et des îles du fleuve Zaïre entre Maïko et Kasaï. DES. Fac. Sci. Kis. 84 p.

Dudu, A., Van Der Straeten, E. et Verheyen, W.N., 1989. Première capture de Hylomyscus parvus. Brosset, Dubost et heim de Balsac, 1965 au Zaïre avec quelques données biométriques (Rodentia, Muridae). Rev. Zool. Afr. 103 : 179-182.

Dudu.A., 1991 : Etude du peuplement d'Insectivores et des Rongeurs de la forêt ombrophile de basse altitude du Zaïre (Kisangani, Masako). Thèse de doctorat, Université d'Anvers, Anvers,171p.

Gambalemoke, M., 2014 : Phylogénie et biodiversité des Musaraignes (Soricomorpha, Crocidurinae) en Cuvette Congolaise (Kisangani, RDC). Thèse de doctorat inédite, Fac. Sci., Unikis, 214p.

Gambalemoke, M., 2008a. Contribution à l'étude de la biodiversité des musaraignes (Soricomorpha, Mammalia) des blocs forestiers inter-rivières dans la région de Kisangani (R.D. Congo). Dissertation DES inédite, tome 1 texte, Fac. Sci. Unikis, 121p.

Gambalemoke M., Mukinzi, I., Amundala, D., Katuala, G-B, Kennis, J., Dudu, A., Hutterer, R., Barrière, P., Leirs, H., and Verheyen, E., 2008b. Shrew trap efficiency : experience from primary forests, secondary forests, old fallow lands and old palm plantation in the Congo River basin (Kisangani, Democratic Republic of Congo). Mammalia 72 (2008) : 203-212.

Gambalemoke M., Mukinzi, I., Amundala, D., Katuala, G-B, Kennis, J., Dudu, A., Hutterer, R., Barrière, P., Leirs, H., and Verheyen, E., 2008c. Microgeographical distribution of shrews (Mammalia, Soricidae) in the Congo Basin River (Kisangani, DR Congo). Mammalia 72 (2008) : 213-222.

Gauthier, G., 2000. Inventaire et Biogéographie des rongeurs du Niger : nuisance aux cultures, implications dans certains problèmes de santé publique et vétérinaire, p7.

Hadjoudj M., Manaa, A., Sekour M., Souttou, K., Merzouki Y. et Doumandji, S., 2012. Place des rongeurs dans le régime trophique de la chouette effraie *Tyto alba* dans la région de Touggourt (Algérie). Revue des BioRessources. Vol 2,33-40.

Hutterer, R., 2005 : Order Soricomorpha. In Wilson, D.E. and D.A. Reeder (Eds), Mammal Species of the World: a Taxonomic and Geographic Reference. Third Edition, Vol. 1 : 220-311. Baltimore, Johns Hophins University Press.

Isangi, Y.E., Katungu, M.E., Mukirania, M.C., Kosele, K. J, Baelo, P., Bugentho, P.E, Gambalemoke, M.S., Asimonyio, A.J. et Ngbolua, K.N., 2016 : Biodiversité des rongeurs et musaraignes de la forêt de Yasikia (Opala, République Démocratique du Congo). *International Journal of Innovation and Scientific Research.* 161-168

Iskandar, J.-M. D. (Sd). Mise en Cvidence de deux espèces jumelles sympatriques du genre Hylomyscus dans le nord-est du Gabon. Mammalia, 126-130.

Iyongo W.M., Visser M.,Verheyen E., Leirs H., Iyongo B., Ulyel A. et Bogaert, J, 2009. Etude préliminaire des effets de la fragmentation des forets sur la similarité des habitats et leurs richesses en espèces de rongeurs (MASAKO, R.D. CONGO). Ann. ISEA. Vol 4, 177-186

Katuala, G., 2005 : Contribution à l'écologie des Rongeurs et Soricomorphes de la Reserve de Faune à Okapi, Ituri (R.D. Congo), DES inédit., Fac. Sc., Uniskis, 71p.

Katuala, G-B.P., 2009. Biodiversité et biogéographie des Rongeurs myomorphes et sciuromorphes (Rodentia, Mammalia) de quelques blocs forestiers de la région de Kisangani (RD Congo). Thèse de doctorat en sciences inédite, Fac. Sci. Unikis, 149p.

Kingdon, J., 2013 : Guide des Mammifères d'Afrique. Plus de 3000 espèces illustrées. Editions Délachaux et Niestlé, Paris, 172.

Misonne, X. (1969). African and Indo-Australian Muridae ; Evolutionary trends. Mus.Roy. d'Afrique Cent.Tervuren, Zool., 1-219.

Mukinzi, I., P.G.B. Katuala, J. Kennis, M. Gambalemoke, N. Kadange, A. Dudu, M. Colyn, et R. Hutterer. 2005. Preliminary data on the biodiversity of Rodents and Insectivores (Mammalia) in the periphery of Kisangani (R.D. Congo). 9th International African small Mammals Symposium, Skoine University of Agriculture, Morogoro, Tanzania. Belg. J. Zool., 135 (Supplement) : 21-29.

Mukinzi, I., 2009. Composition et structure du peuplement de Soricidae (Soricomorpha, Mammalia) de la Réserve Forestière de la Yoko et de ses environs (Kisangani, RD Congo). Dissertation de DES inédite, Fac. Sci. Unikis, 68p.

Mukinzi, I., 2014 : Biodiversité et Ecologie des Musaraignes (Soricomorpha, Mammalia) de la Réserve Forestière de Yoko et ses milieux perturbés (Kisangani, R.D. Congo). Thèse de doctorat inédite, Fac. Sci., Unikis, 218p.

Nicolas, V., Barriere, P., Guimondou, S., & Colyn, M. (2005). Seasonnal variation in population and community structure of shrews in a tropical forest of Gabon. *Journal of Topical Ecology*, 161169.

Robbins, L.W., Choate, J.R. et Robbins, R., 1980. Nongeographic and interspecific variation in four species of Hylomyscus (Rodentia : Muridae) in Southern Cameroon. Ann. Carnegie Mus. 49 (2) :31-48.

Rosevear, D. (1969). The rodents of West Africa. Trustees of the British Museum (Natural History), 604p.

Stanley, W.T., Goodman, S.M., and Hutterer, R., 1996. Notes on the insectivores and elephant shrews of the Chome Forest, South Pare Mountains, Tanzania (Mammalia : Insectivores and Macroscelidae). Zool. Abhandl. Staal. Mus. Tierk. Dresden 49 :131-147.

Wilson, D.E. and Reeder, D. A. 2005 : Mammal species of the World : A taxonomic and geographic reference. Third Edition, vol. 2 : 1447-1448.