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Impact of Human Activities on the Rodent Species Specific Richness in the Masako Reserve Forest in Kisangani, Democratic Republic of the Congo

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Abstract: Slash-and-burn shifting agriculture, still common in Africa, is one of the major causes of deforestation in regions where excessive population pressure has accelerated the rate of agricultural rotation. The transformation and fragmentation of natural habitats, affects the structure and functioning of the forest ecosystem, leading to erosion and biodiversity loss. The main purpose of this research was to analyze capture, marking and recapture techniques, the specific richness of the rodent population in some habitats selected on the basis of an anthropogenic gradient in Masako forest reserve. The study was conducted in Masako Forest Reserve located in the Northeast of Kisangani city, Province Orientale, Democratic Republic of the Congo between February and June 2018. In fact, rodents were captured in different habitats namely primary forest, secondary forest, old fallow and young fallow where square grids were installed with Sherman traps. The number of trapping days depended on the habitat and an alphanumeric code was used for each individual for identification. Five campaigns of trapping were performed while different indices of biodiversity were used to assess the specific richness. The findings showed that a total of 545 specimens were collected distributing into 10 species. The most abundant species were: *Praomys spp, Hylomys spp*., *Deomys ferrugineus* and *Lophyromys dudui* but *Praomys spp.* was the most predominant and the most motile of identified species in the studied habitat. From different similarity indices used, it was found that the secondary forest has a large number of individuals while the high number of species was observed in the secondary forest and young fallow respectively. It was observed that the most important recaptures were obtained in primary and secondary forests while in both fallows the recapture rate was weak. Thus, human activities such as slash-and-burn shifting, although modifying the environment, and also acting on relative abundance, appear at the current stage, is not significantly affecting the rodent community.

Keywords: Slash-and-burn Agriculture, Rodent, Specific Richness, Kisangani, Democratic Republic of the Congo

1. Introduction

Humankind's overexploitation of natural resources as a result of high population growth has jumped in the last 40 years, leading to huge changes in ecosystems, which also have repercussions on climate, biodiversity and land use [1]. This rate of consumption of natural resources exceeds their rates of renewal [2]. However, slash-and-burn shifting agriculture, still common in equatorial Africa, is one of the major causes of deforestation in regions where excessive population pressure has accelerated the rate of agricultural rotation [3]. The active issue of deforestation as a disruptive phenomenon in the continuity of ecological systems began in the 20th century when researchers became aware of the fragility of natural ecosystems [4]. The transformation and fragmentation of natural habitats, caused mainly by agricultural activities, affects the structure and functioning of the forest ecosystem, leading to erosion and biodiversity loss. The effects of these changes also affect animal communities (some of which are still poorly understood) both qualitatively and quantitatively. The most affected are species which are dependent on specific habitats. However, due to global climate change and increasing deforestation linked to human activities [5-6], there is a growing interest in the problem of biodiversity loss (modification) in African tropical forest ecosystems [6]. Yet, studies directly or indirectly related to this phenomenon are increasingly being conducted [7]. These studies aimed to understand the habitat biodiversity and its spatial and temporal evolution in the light of the accelerated degradation and fragmentation of ecosystems, which are recognized as one of the major phenomena that marked most landscapes during the 20th century [8].

In the Democratic Republic of the Congo (DRC), the annual rate of deforestation is estimated at 0.20% per year [9]. The main cause of this deforestation but also the main threat is therefore food agriculture. However, the planned development of industrial plantations (notably oil palm trees) poses an additional threat to the forest massif of the DRC and the Masako Forest Reserve is not spared to this phenomenon. This forest reserve is under increasing pressure from the surrounding population, always in search of new fertile land. In fact, the knowledge of relationships between human land use and land cover is changing in the Masako Forest Reserve and it is still in its beginning. However, environmental disturbances resulting from deforestation leading to major changes in vegetation structure and composition affect the biophysical nature of the ecosystem [10]. Matlack, [11] and Murci, [12] questioned that are studies on the impact of anthropization essential to assess the possibilities for the conservation and rational management of natural resources? Considering this approach, the aim of this study was to analyze capture, marking and recapture techniques, the specific richness of the rodent population in some habitats selected on the basis of an anthropogenic gradient in Masako Forest Reserve.

2. Methodology

2.1. Study Area

The study area was the Masako Forest Reserve located in the Northeast of Kisangani city, Province Orientale, DRC and it covers an area of 2 105 ha. The habitat types constituting the reserve are: primary and secondary forests along with young and old fallows. The rich hydrographic network of the Masako Forest Reserve is dominated by a single large river called Tshopo river, and the presence of 13 streams which pour into this large river. Among these streams can be mentioned: Amakasampoko and Masanga-Mabe on the right of the main post office while on the left, it can be observed Magima, Amandje, Mayi ya Chumvi, Masanga-Mabe and Masako 1. From the name of the last stream that the reserve got its name [1, 13-16].

2.2. Biological Material

The biological material consisted of 545 rodents captured in different habitats namely Primary Forest, Secondary Forest (SF), Old Fallow (OF) and Young fallow (YF). Four square grids were installed in these different sites and were used for rodent trapping. Inside these grids of 1 ha each were open 10 tracks, equidistant by 10 m, which contained a total of 100 Sherman traps. The first three grids (SF, OF, YF) were installed 75 m apart to observe the interactions between the grids and thus measure the degree of connectivity of the landscape. The fourth grid (FP), a control grid, was installed 500 m from the others. It serves as a control to understand the effects of human activities in the Masako Forest Reserve.

The technical material used consisted of three machetes for opening and cleaning trapping nets, Sherman traps for rodent capture, blue-white striped bags for signaling trapping stations along the tracks, palm nuts as bait to attract rodents to the traps, sharp dissecting scissors to cut the ends of the phalanges, eppendorfs tubes and good quality alcohol (70%, preferably more than 85%) to keep the phalanges, and the balance (Pesola brand): 30g, 100g, 300g, to weigh captured individuals.

The number of trapping days depended on the nature of the habitat, usually 5 days to reach a fairly high capture rate. The traps were checked early in the morning, before 9 a.m., the animals were permanently marked by cutting off the ends of the phalanges, according to an existing numbering system, i.e. the alphanumeric code for each individual. All data were always recorded on the capture, marking and recapture forms. Animals were released to specific capture stations as soon as possible, on the same day of capture. Animals which were found dead in traps were treated like sampled animals. The marking technique used was individual: each individual was provided a unique mark (alphanumeric code) which allowed the animal to be identified, and it is essential for long term studies and analyses of population dynamics. Five campaigns of trapping sessions were performed between February and June 2018 at the Masako Forest Reserve, Province Orientale, DRC.

2.3. Treatments

The similarity coefficient calculation allows to quantify the level of similarity between two sites. Although there are several measures of similarity coefficients reported in the literature, Jaccard coefficient was used for this study. Several measures of similarity coefficients exist in the literature [17-18]. This coefficient represents the number of cases of simultaneous presence of two considered species, divided by the number of cases or at least one of two is present [16-21]. It is calculated using the following formula:

$$C_j = \frac{a}{a+b+c} \quad (1)$$

Where: a = number of species present in the two habitats

b and c: number of species absent in one of the two habitats.

Margalef's index measures specific richness of habitats and it is calculated using the following formula:

$$R_{Mg} = \frac{(s-1)}{\ln N} \quad (2)$$

Where: s: number of species of the considered habitat,

N: total number of individuals for the same habitat.

The Simpson Diversity Index measures the probability that two randomly selected individuals belonging to the same species. It is calculated using the following formula:

$$P_i = \frac{ni}{N} \quad (3)$$

Where: ni = number of individuals of a given species for a specific habitat

N = total number of individuals for the same habitat.

Finally, the Simpson equitability index, used to measure the regularity of species distribution within the habitat and this was calculated as follows:

$$E_{1/D} = \frac{1}{(S-D)} \quad (4)$$

Where: D = Simpson's diversity index for a considered habitat

S = number of species for the same habitat.

2.4. Data Analysis

The relative abundance of species was calculated, and expressed as a percentage on the basis of the relative proportions "Pi" obtained for each species and in each habitat. It is divided into five classes of abundance:.

Pi>10%: very abundant species;

5%<Pi<10%: abundant species ;

10%<Pi<5%: not rare species ;

Pi<1%: rare species;

Pi= 0%: absent species.

3. Results and Discussion

3.1. Frequency of Species Capture per Habitat

The frequency of rodent species abundance captured during the five trapping campaigns performed in the habitats studied at Masako Forest Reserve is given in table 1.

Table 1. *The frequency of species capture per habitat.*

Species	Habitats				Total
	PF	SF	OF	YF	
Deomys ferrugineus	31	22	4	1	58
Graphiurus lorraineus	1	1	0	0	2
Hybomys cf lunaris	2	14	8	2	26
Hylomyscus spp	15	13	8	44	80
Lemniscomys striatus	0	0	0	1	1
Lophuromys dudui	2	5	14	9	30
Malacomys longipes	0	1	0	0	1
Nannomys cf grata	0	0	3	20	23
Praomys spp	66	104	67	78	315
Stochomys longicaudatus	2	2	2	3	9
Total	119	162	106	158	545

Legend: PF: Primary Forest, SF: Secondary Forest, OF: old fallow, YF: Young fallow

From the table above, it is clearly shown that the most abundant species is *Praomys spp*, i.e. this species was captured in all the habitats and had many specimens (57.8%). It seems that *Praomys spp.* is the most abundant species in this ecoregion.

Meanwhile *Hylomyscus spp.* and *Deomys ferrugineus* are the second most important species in this reserve. Mutombo *et al.* [22] reported similar findings as to the current study. It should be noted that the highest number of captures (162 specimens) was in the secondary forest, followed by the young fallow where 158 specimens were captured. While 119 specimens of rodents are captured in the primary forest and last 106 specimens are captured in the old fallow. Concerning the specific richness (number of species), from all the specimens captured was identified 10 species, out of which 7 species are present in the primary forest and old fallow meanwhile 8 species in the secondary forest and young fallow.

3.2. Relative Abundances of Species Capture per Habitat

The relative abundances of rodent species captured during the study period is presented in the table below.

Table 2. *Relative abundance of rodent species in the studied habitat.*

Species	Habitats			
	PF	SF	OF	YF
Deomys ferrugineus	26.05	13.58	3.77	063
Graphiurus surdus	0.84	0.62	000	000
Hybomys cf lunaris	1.68	8.64	7.55	127
Hylomyscus spp	12.61	8.02	7.55	27.85
Lemniscomys striatus	0.00	0.00	0.00	0.63
Lophuromys duduii	1.68	3.09	13.21	5.70
Malacomys longipes	0.00	0.62	0.00	0.00
Nannomys cf grata	0.00	0.00	283	12.66
Praomys spp	55.46	64.20	63.21	49.37
Stochomys longicaudatus	1.68	1.23	1.89	1.90
	100	100	100	100

Legend: PF: Primary forest, SF: Secondary forest, OF: old fallow, YF: young fallow

It was observed from the above table that *Deomys ferrugineus* is doubly abundant in the primary forest than in the secondary forest while it could be found as well in the old fallow and very rare in the young fallow. *Graphiurus surdus* is absent from fallows (old and young) and rare in forests (primary and secondary). *Hybomys cf lunaris* is not rare in primary forests and young fallows but abundant in secondary forests and old fallows. *Hylomyscus spp* is very abundant in young fallow as in primary forest and abundant in secondary forest and old fallow. *Lemniscomys striatus* is a rare species in young fallow and absent in other habitats. *Lophuromys duduii* is very abundant in old fallow, abundant in young fallow, not rare in primary and secondary forests. *Nannomys cf grata* is absent in forests (primary and secondary), not uncommon in the old fallow and very abundant in the young fallow.

3.3. Abundance of Rodent Species Captured Per Habitat Monthly

Table 3 compares the abundance of captures per habitat monthly.

Table 3. *Frequency of capture in the four habitats and trapping per month.*

Month	Habitats				Total
	PF	SF	OF	YF	
February	56	82	35	62	235
March	22	34	21	23	100
April	16	22	26	28	92
May	10	12	6	17	45
June	15	12	18	28	73
Total	119	162	106	158	545

Legend: PF: Primary forest, FS: Secondary forest, OF: old fallow, YF: young fallow

As shown in the table above, the evolution of the new captures performed from February to June 2018. Eventually, it demonstrated how new captures decrease as capture sessions increased. The number of individuals increased in the secondary forest with a total of 162 individuals and young fallow for a total of 158 individuals, followed by the primary forest with 119 individuals and old fallow with 106 individuals.

3.4. Sex ratio of Captured Rodents Per Habitat

The distribution of captured rodents per habitat and per sex is given in the table below.

Table 4. *Distribution of captured rodents per habitat and per sex.*

Months	Habitats			
	PF	SF	OF	YF
	M/F	M/F	M/F	M/F
February	32/34 (1.33:1)	41/41 (1:1)	19/16 (1.18:1)	40/22 (1.8:1)
March	12/10 (2.2:1)	17/17 (1:1)	(2:1) 11/15	13/15 (0.92:1)
April	11/5 (2.2:1)	15/7 (2.14:1)	(0.73:1)	(0.87:1)
May	8/2 (4:1)	9/3 (3:1)	4/2 (2:1)	8/9 (0.89:1)
June	9/6 (1.5:1)	9/3 (3:1)	14/4 (3.5:1)	17/11 (1.54:1)
Total	72/47	91/71	62/44	89/69
Sex-ratio	(1.55:1)	(1.28:1)	(1.40:1)	(1.28:1)

Legend: PF: Primary forest, SF: Secondary forest, OF: Old fallow, YF: Young fallow

In general, it was observed that the sex ratio is not balanced, there are many males than females. This implies that the renewal of the rodent population in these different habitats is performed without any difficulty. However, at the level of fallows and especially in young fallows, it is observed during rainy periods that females were the most captured than males. This would be due to the search for food and/or the search for males for mating.

3.5. Frequency of Recaptures

The number of recaptures is presented in the table below.

Table 5. *Number of recaptures realized per session of capture and per habitat.*

Trapping per month	Habitats			
	PF	SF	OF	YF
	M/F	M/F	M/F	M/F
February	32/20	32/28	34/13	10/10
March	56/56	45.54	24/25	22/16
April	34/23	83/73	16/32	26/26
May	84/69	62/65	35/42	9/5
June	49/48	59/61	24/40	47/31
Total	255/216	281/281	133/152	114/88

Legend: PF: Primary forest, SF: Secondary forest, OF: Old fallow, YF: Young fallow

It is observed that the most important recaptures were obtained in primary and secondary forests while in both fallows the recapture rate is weak. The sex ratio is balanced in secondary forest (1:1), slightly unbalanced in favor of males in primary forest (1.18:1) and old fallow (1. 29:1) there is more females than males in young fallow (0.87:1).

3.6. Number of Individuals Recaptured Per Habitat and Per Month of Trapping

The number of individuals recaptured per habitat is presented in the table below.

Table 6. *Numeric frequency of captured individuals per habitat, capture session and sex ratio.*

Month	Habitats			
	PF	SF	OF	YF
	NC M/F	NC M/F	NC M/F	NC M/F
February	3217/15	36 19/	14 6/8	25 1717/8
March	44 25/19	49 24/25	23 12/11	24 12/12
April	34 19/15	59 31/28	26 13/13	24 9/15
May	50 30/20	54 29/25	9 5/4	37 18/19
June	43 24/19	55 30/25	45 25/20	36 15/21
Total	203 115/88	253 133/120	117 61/56	146 71/75

Month	Habitats			
	PF	SF	OF	YF
	NC M/F	NC M/F	NC M/F	NC M/F
Sex-ratio	1.3	1.1	1.1	0.9

Legend: PF: Primary Forest, SF: Secondary forest, OF: Old fallow, YF: Young fallow, NS; Number of specimens, M/F: Male/Female ratio

It is observed that the number of male individuals is higher than female individuals in the forests than in the fallows. In the primary forest, a number of 115 male individuals and 88 female individuals (1.3) while in the secondary forest, a number of 133 male individuals and 120 female individuals (1.1). Meanwhile in the old fallow is found 61 male individuals and 56 female individuals (1.1); and at last in the young fallow, the number of female individuals is higher, 71 male and 75 female individuals (0.9).

3.7. Jaccard Similarity Coefficient

The similarity coefficient calculated on the basis of the presence-absence of the species within each habitat.

Table 7. *Index of similarity of Jaccard.*

Habitats	PF	SF	OF	YF
PF	1	0.87	0.66	0.75
SF		1	0.6	0.66
OF			1	0.87
YF				1

Legend: PF: Primary forest, SF: Secondary forest, OF: old fallow, YF: young fallow

The findings in the above table indicated that high similarities are obtained between primary and secondary forests and in the young and old fallows on the other hand. In fact, the Jaccard similarity coefficient calculated on the basis of the presence/absence of individuals from each habitat studied reveals that secondary forest and old fallow were much more similar to young fallow than primary forest.

3.8. Population Size, Indices of Diversity and Specific Richness

Different indices od diversity, the population's size and specific richness are presented in the following table.

Table 8. *Indices of diversity and specific richness of Margalef (RMg).*

Indices	Habitats			
	PF	SF	OF	YF
RMg	1.25	1.37	1.28	1.38
D	0.39	0.44	0.43	0.34
E	0.15	0.13	0.15	0.13
N	244	284	96	191

Legend: PF: Primary forest, SF: Secondary forest, OF: Old fallow, YF: Young fallow, RMg: Index of Margalef; D: Index of Simpson; E: Equitabilty of Simpson

The Margalef index value obtained in young fallow is higher than the values obtained from other habitats. The Simpson diversity index obtained in the secondary forest is higher than the others, while the same value was observed between the secondary forest, young fallow and primary forest, old fallow.

3.9. Motility of Rodent Species Between Habitats

The motility of rodents observed between habitats during the study period is presented in the following table.

Table 9. *Mobility of rodents between habitats.*

Species	Number of specimens	Code	Visited Habitats	Sex
Deomys ferrugineus	36	1/330	SF-OF	F
Hybomys cf lunaris	137	1/1640	SF-OF-SF	M
Hylomyscus sp	152	1/1790	OF-SF	M
	248 B	1/25060	OF-YF	M
	437	1/72070	SF-OF	F
	148	1/1750	OF-SF	F
	38	1/340	SF-YF	M
	51	1/430	SF-YF-SF	M
	89	1/810	SF-OF	M
	111	1/3080	SF-OF-SF	F
	127	1/1540	SF-OF	F
Praomys sp	225	1/2870	OF-PF	F
	303	1/33060	SF-YF-SF	F
	316	1/35090	SF-OF	M
	322	1/4550	SF-YF-SF	F
	351	1/4840	OF-YF	F
	365	1/42090	SF-YF	M
	367	1/43090	SF-OF-SF	M
	443	1/73080	SF-YF	M
	449	1/74090	SF-OF	M

Legend: PF: Primary forest, SF: Secondary forest, OF: Old fallow, YF: Young fallow, M: male, F: female

It is observed that the most motile species is *Praomys sp*, this species can move from one habitat to another and then it returns to its original habitat. Concerning *Deomys ferrugineus*, *Hybomys cf lunaris*, and *Hylomyscus* sp, their motility is slow and not frequent between habitats. The case of motility is observed most with males while the female motility are less motile between studied habitats.

4. Conclusion

The main purpose of this research was to analyze capture, marking and recapture techniques, the specific richness of the rodent population in some habitats selected on the basis of an anthropogenic gradient in Masako Forest Reserve. After capturing, marking and recapturing rodents in the Masako Forest Reserve, the findings showed that a total of 545 specimens were collected and distributed into 10 species. The most abundant species were: *Praomys spp, Hylomys spp*., *Deomys ferrugineus* and *Lophyromys dudui* but *Praomys spp.* was the most predominant and the most motile of identified species in the studied habitat. From different similarity indices used, it was found that the secondary forest has a large number of individuals while the high number of species was observed in the secondary forest and young fallow. It was also observed that the most important recaptures were obtained in primary and secondary forests while in both fallows the recapture rate was weak. The evolution of new captures decrease as capture session increased. the sex ratio is not balanced, there are many males than females.

However, these rodents were linked to mesological conditions: (i) to the vegetation that nourishes and protects them (especially predators) and (ii) on the ground, of which the qualities are of course decisive, depending on their ecological requirements. It should be noted that climatic variability must always be taken into account in fluctuations in population size. Human activities such as slash-and-burn cultural practice, although modifying the environment, and also acting on relative abundance, appear at the current stage, is not significantly affecting the rodent community.

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