OPEN ACCESS

International Journal of **Biodiversity and Conservation**

March 2018
ISSN 2141-243X
DOI: 10.5897/IJBC
www.academicjournals.org

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International Journal of Biodiversity and Conservation

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Vol. 10(3), pp. 117-121, March 2018
DOI: 10.5897/IJBC2017.1102
Article Number: 57F87BB55975
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Bioprospection of freshwater microalgae from Bonito, MS, Brazil

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Received 2 April, 2017; Accepted 17 January, 2018

The great biodiversity of the Serra da Bodoquena is the result of years of biological evolution. A complex combination of natural factors allows aquatic plants, fish and invertebrates to coexist in absolutely crystalline water springs. Together, organisms form an intricate web of life, connecting a single-celled microalga with large river predators. For better knowledge of the biodiversity of microalgae, an important tool is the bioprospecting and study of novel species, avoiding as much as possible the introduction of exotic species. Thus, the aim of this work was bioprospecting microalgae species from Bonito, MS, Brazil, in order to obtain more information about the local microbial biodiversity. Freshwater samples were collected from two lakes of the municipality. The samples were plated in Basic Basal medium added of bacteriological agar. After plating, the samples were kept in a biochemical oxygen demand (BOD) oven at 25ºC with photoperiod for growth. After isolation of the obtained colonies, the identification of the species was carried out according to the morphological characteristics of cells. Despite the long periods for adaptation, seven microalgae taxa were successfully isolated from the samples collected, four at the genus level and three at the species level; one from the Trebouxiophyceae class, five from the Chlorophyceae class and one from the Bacillariophyceae class.

Key words: Biodiversity, freshwater species, identification, morphology.

INTRODUCTION

Bonito, a city located in the Brazilian State of Mato Grosso do Sul integrates the tourist complex of the Serra da Bodoquena National Park. The dominant vegetation is characteristic of the Brazilian Savannah, contacted with seasonal forest and seasonal deciduous forest. The region belongs to the Paraguay River Basin, Miranda Sub-basin. In Bonito, the rivers have peculiar characteristics: they are transparent due to the crystalline waters as the rivers are originated from mainly from limestone rocks (Boggiani et al., 1999).

A long and complex combination of geological and evolutionary processes made the region's springs natural systems of high biodiversity, with a high degree of unicity (Boggiani et al., 1999). The rich biodiversity of

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Bodoquena allows aquatic plants, fish and all sorts of invertebrates to coexist in crystalline water springs. Together, organisms form an intricate net of life, which connects a single-celled microalga to large river predators, such as golden dorado (*Salminus brasiliensis*) and giant otters (*Pteronura brasiliensis*) (Sabino, 2002). Through the bioprospection and cultivation of microalgae, it is possible to evaluate the ecophysiology of species which could not be observed and monitored in the field, such as the life cycle, plasticity and response to different environmental variables, allowing also to help in the biological systematics of the groups (Lourenço, 2006).

Moreover, the concern with environmental issues has become increasingly evident due to the excessive use of natural resources in productive processes, thus, causing a high potential of pollution (Barcellos et al., 2009). Biological processes have become an interesting alternative against pollution and in the generation of new products, since these processes use microbial metabolism to degrade and remove pollutants (Gadd, 2009), generating products less harmful to the environment. In these processes, there is a range of active microorganisms, including microalgae. In this context, it underlines the importance of bioprospecting new strains and species of microalgae not only with environmental and ecological purposes, as the treatment of effluents and biosorption of toxic metals (Mezzomo et al., 2010; Schmitz et al., 2012) and CO_2 biofixation (Morais and Costa, 2007), but also applications of economic interest, as the productions of lipids (Xu et al., 2006) and biofuels (Xu and Mi, 2011). In addition, bioprospecting of species is a preponderant factor for the knowledge of the local biodiversity and for the local sustainable development, besides avoiding the introduction of exotic species. The bioprospecting generates inventories of microalgae, scarce in certain regions of Brazil, fomenting the creation of collections of microalgae for the these regions (Mendes et al., 2012).

Thus, the aim of this work was bioprospecting microalgae from lakes located in the municipality of Bonito, MS, Brazil, and identifying the species according to their morphological characteristics.

MATERIALS AND METHODS

The samplings were carried out in two lakes located at the coordinates 21°02'18.9"S 56°33'23.7"W and 21°02'21.0"S 56°33'04.3"W in the city of Bonito, MS, Brazil. Both lakes are surrounded by vegetation in their interior, including grasses, shrubs and trees. The soil of the region is limestone and stony, and the water ranging from crystalline to turbid. The samples were collected in 500-mL sterilized pet bottles and stored in a thermal box that was transported to the laboratory. The samples were then plated in Bold Basal Medium (Bischoff and Bold, 1963) with autoclaved bacteriological agar (121ºC, 15 min) and then placed in the BOD (MA 415 Marconi) at 25°C with 8 Klux illumination and aeration.

After growth, colonies were spiked into sterile plates for isolation. It was made by successive pealing with a platinum loop through the technique of stretch-out. An optical microscope (40x objective lens) was used to observe the microalgae and to verify the purity of the colonies. After complete isolation, the strains were cultured in Erlenmeyer flasks with liquid Bold Basal medium for identification. Flasks were maintained in biochemical oxygen demand (BOD) equipped with orbital rotatory stirrer (200 rpm) and illumination. The cultures were then placed in Petri dishes with culture medium and stored in BOD at 3°C.

The species were identified according to their morphological characteristics observed with the aid of an optical microscope, based on images and information from microalgae databases, e.g. Algae base, Culture Collection of Autotrophic Organisms, Online Bookstore, and literature references (Round et al., 1990; Komárek and Marvan, 1992; Comas, 1996; Menezes and Bicudo, 2006, 2008; Fanés et al., 2009; Godinho et al., 2010; Mendes et al., 2012; Ramos et al., 2012).

RESULTS AND DISCUSSION

As a result of the bioprospection, seven microalgae taxa were isolated from the collected samples: four at the genus level and three at the species level. The six first species isolated are representative of the Class Chlorophyceae while the last one belongs to the Class Bacillariophyceae. Their characteristics are described below:

(1) *Chlorella* sp. (Figure 1a) from family Oocystaceae, was identified from the ellipsoid format in the young cells and spherical in the adults. They cells were found isolated or in small transient clusters. The single chloroplast, parietal, do not always occupy the whole cell, with presence or absence of pyrenoid. The reproduction was of 2-4-8 elliptical autospores.

(2) *Chlorococcum* sp. (Figure 1b) from family Chlorococcaceae was identified by the presence of spherical cells with varying sizes, solitary or forming groups, without mucilage. The pituitary choroplast or in the form of a sphere internally fulfills the entire cell. As the genetic material increases, size increases and the chloroplast assumes the star shape. They had pyreneo with discontinuous starch coating, contractile vacuoles and reproduction by ellipsoidal zoospores.

(3) *Coelastrum* sp (Figure 1c) from family Scenedesmaceae was identified by the variety of spherical, ellipsoid, pyramidal, cuboid, tetrahedral to polygonal shaped cells, with rounded conical poles. The spherical domes had cells attached directly by their walls. The single chloroplast, parietal, presented pyrenoid. The asexual reproduction was presumed by a number of appendages more or less long that join cells together. The only chloroplastidium in each cell has the form of a cup (poculiform) and a more or less central pyrenoid.

(4) *Desmodesmus brasiliensis* (Figure 1d) from family Scenedesmaceae was identified by the elliptical cells with rounded poles. They had coenobies with four cells linearly aligned, cell wall with, sometimes, discontinuous longitudinal ribs and single chloroplast, parietal with pyrenoid. Tiny spines were found around the coenoby if not absent.

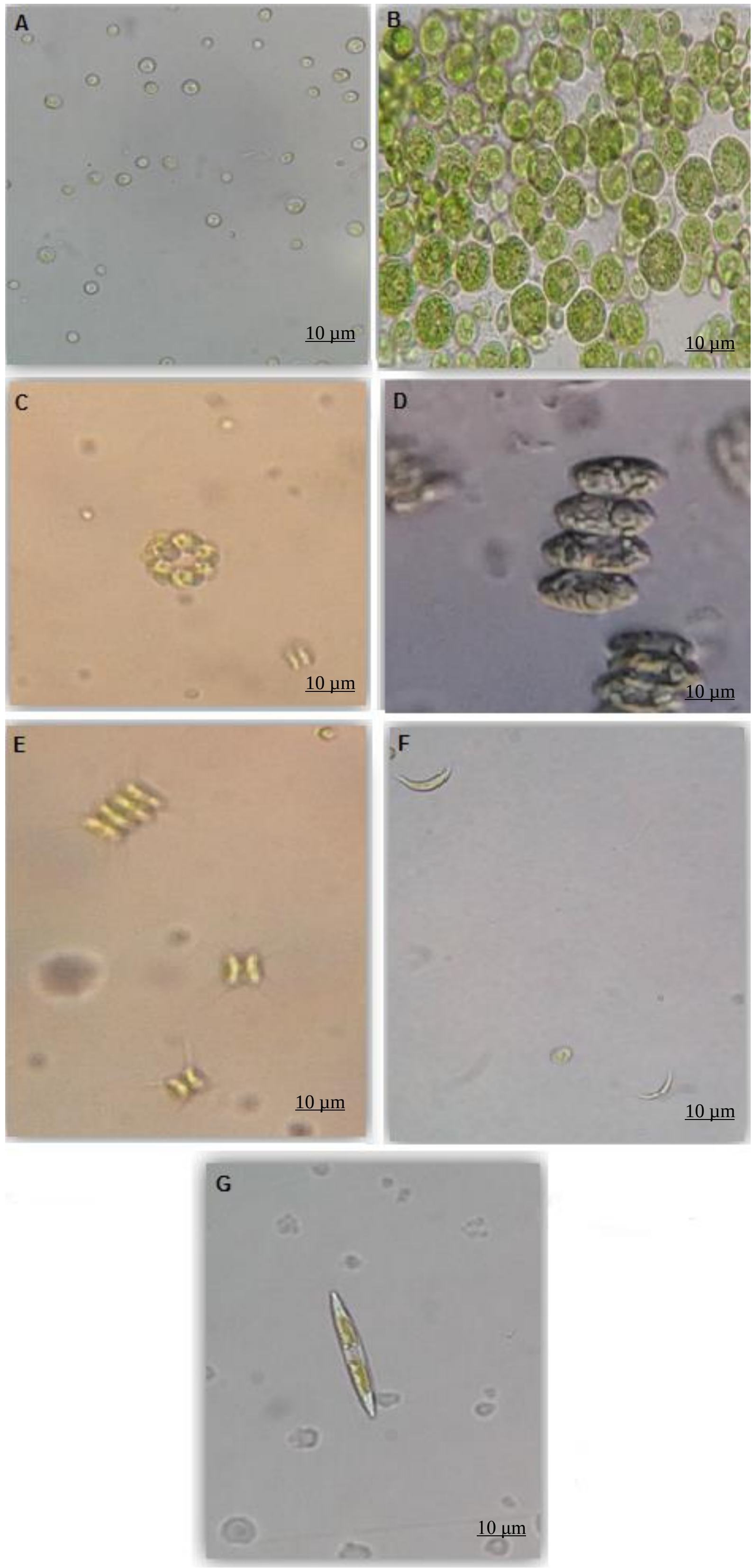

Figure 1. Bioprospected microalgae, where: 2a *Chlorella* sp; 2b *Chlorococcum* sp; 2c *Coelastrum* sp; 2d *Desmodesmus brasiliensis*; 2e *Desmodesmus communis*; 2f *Monoraphidium caribeum*; 2g *Nitzschia* sp.

(5) *Desmodesmus communis* (Figure 1e) from family Scenedesmaceae was identified by the cells with four or more cells aligned linearly grouped inside the coenoby. The elliptic cells presented rounded poles, obtuse/truncated, differentiated by the presence of spines at their extremities, usually four spines. Quite variable characteristics in this species are the dimensions of cells and spines. It was formerly known as *Scenedesmus quadricauda* (Turpin) Brébisson sensu Chodat (1913, 1926), being renamed by Hegewald (1977) for *S. communis* Hegewald and later for *D. communis* Hegewald (Hegewald, 2000). He included most of the taxonomic varieties of *S. quadricauda* in this new classification, remaining this way up till now without any other change.
(6) *Monoraphidium caribeum* (Figure 1f), from family Selenastraceae was identified by the solitary cells, arched in a semicircle and slightly tapered at the extremities. Parietal chloroplast was absent of pyrenoids. This species is found mainly in plankton and periphyton of eutrophic aquatic environments (Ramos et al., 2012).
(7) *Nitzschia* sp. (Figure 1g) from family Bacillariaceae was identified by the cylindrical shape with rounded apices, with two plastids arranged symmetrically one on each side of the transapical medial plane.

All the species presented here were able to develop in the culture medium, but not all the species found in the ponds were adaptable to the in vitro culture conditions. The difficult was evident as only few strains were successfully isolated. The microalgae species isolated here took a long time to adapt themselves to the given conditions of cultivation in the laboratory, since the culture medium does not meet the specific conditions of their natural habitat. The waters of the region of Bonito present a high concentration of calcium carbonate. They are subject to receiving fragments of rocks existing in the surface of that sediment in the water, and a small amount that enters in suspension is soon deposited by the precipitation of the carbonate. This characteristic turns the water of the rivers very clear, favoring the biological activity and, consequently, the precipitation of carbonate (Boggiani, 1999). The development of a medium that faithfully reproduce the same conditions would allow the isolation of a higher microbial biodiversity.

Studies involving the isolation and identification of microalgae in the region of Mato Grosso do Sul are not frequently reported. It is challenged by knowledge of the local biodiversity within the scope of promising species of microalgae that can be further studied. Mendes et al. (2012) report the need for the creation of new collections of microalgae from the Brazilian scarcely studied biomes.

The bioprospection of local microalgae is the first step for more complex studies and obtaining viable algal raw material. In addition, it is a preponderant factor for the knowledge of local biodiversity and for the sustainable development. The bioprospected species are now part of a collection of microalgae, which may be accessed for other researchers.

Conclusion

Seven microalgae taxa were isolated from samples. Adaptation of the species was a limiting factor to obtain a greater number of strains, since not all the microalgae species found in the lakes have this capacity, requiring a long period for this adaptation and often resulting in loss of the species. The development of appropriate media would facilitate the isolation of a higher microbial biodiversity.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors gratefully appreciate the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Fundação de Apoio ao Desenvolvimento do Ensino, Ciência e Tecnologia do Estado de Mato Grosso do Sul (FUNDECT) and Coordenação de Aperfeiçoamento Pessoal de Nível Superior (CAPES) for the financial support.

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Vol. 10(3), pp. 122-130, March 2018
DOI: 10.5897/IJBC2017.1165
Article Number: 82C300155979
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Livestock depredation by wild carnivores in the Eastern Serengeti Ecosystem, Tanzania

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Received 14 November, 2017; Accepted 17 January, 2018

Livestock losses caused by wild carnivores foster negative attitudes and promote retaliatory killings, threatening the future of carnivore populations. Measures to bring about coexistence between humans and carnivores are of great importance to carnivore conservation. The study questionnaire survey involved 180 respondents from Eastern Serengeti tribes (Maasai and Sonjo), all of which owned livestock. Reported livestock depredation in 2016 by the Maasai tribe (pastoralists) was higher than that by the Sonjo tribe (agropastoralists) because the Maasai own many livestock and live closer to the Serengeti National Park boundary. Most livestock depredation occurred during the day when livestock were out feeding and during the dry season. Spotted hyenas *(Crocuta crocuta)* were the most commonly reported carnivore responsible for livestock depredation. Livestock depredation caused by lions (*Panthera leo*) and cheetahs (*Acinonyx jubatus*) was only reported by the Maasai tribe. Leopards (*Panthera pardus*), jackals (*Canis spp.*), and African wild dogs (*Lycaon pictus*) were responsible for more livestock depredation of the Maasai livestock. A similar study was performed six years earlier, in 2010. Therefore, this study brings insight to the temporal changes of livestock depredation patterns and changes of carnivorous species causing livestock depredation in the Eastern Serengeti ecosystem. The Maasai and Sonjo are the main tribes living in the Eastern Serengeti ecosystem. The Maasai preferably use knives and/or spears, whereas the Sonjo use bows and poisoned arrows to protect their livestock against depredation by wild carnivores, and both tribes prefer the use of multiple techniques to increase the efficiency of livestock protection.

Key words: Boma, herding, Maasai, preferences, Sonjo, tribe, weapons.

INTRODUCTION

Human-wildlife conflict presents an increasing challenge to conservation biology worldwide, and developing novel solutions for the coexistence between humans and different species, particularly carnivores, has been a research focus (Dickman, 2010; Gehring et al., 2010; Woodroffe et al., 2005).

Conflicts escalate when carnivores attack livestock, thereby hampering carnivore conservation (Gehring et al., 2010; Megaze et al., 2017; Treves & Karanth, 2003; Woodroffe et al., 2005). Livestock depredation by large carnivores negatively impacts coexistence between humans and such species (Holmern et al., 2007; Karlsson and Johansson, 2010; Mwakatobe et al., 2013). Livestock represents a source of income to pastoralist communities (Mwakatobe et al., 2013). Hence, if depredation incidences increase, household livelihood quality tends to be compromised (Ogada et al., 2003). Additionally, as the human population grows, particularly in third world countries, human-carnivore conflict increases (Pirie et al., 2017) which hampers the future of large carnivores.

In rural areas, especially those close to protected areas, land for livestock husbandry is open access, which attracts pastoralists to such places. Most people in Africa live in rural areas and there are many trade-offs encountered by people living adjacent to protected areas. The livelihoods of such societies have been compromised due to the costs associated with wildlife interactions (Adams and Hutton, 2007; Nana and Tchamadeu, 2014; Vedeld et al., 2012). Thus, people living adjacent to protected areas tend to have negative attitudes towards wildlife as they impact their livelihoods negatively (Dickman et al., 2014; Romanach et al., 2007; Røskaft et al., 2007). For instance, some communities tend to respond to attacks on their livestock by killing carnivores (Kissui, 2008; Lindsey et al., 2013; Mwakatobe et al., 2013).

Living close to protected areas may have enormous costs, and the human-carnivore conflict in such communities is high (Carter et al., 2012; Holt, 2001; Lindsey et al., 2017). To reduce livestock depredation, local people may employ various traditional husbandry techniques to kill problematic carnivores, with certain techniques being more effective than others (Ed and John, 2001; Lyamuya et al., 2016b; Mwakatobe et al., 2013). Most of these techniques are temporary and inefficient, therefore a long-term solution is needed (Dickman, 2010).

Measures to curb livestock depredation by wild carnivores includes different approaches depending on the culture and livestock keepers (Dickman, 2010). Countries with no consolation schemes for livestock losses from predators use herders, who have developed different guarding techniques. Guarding livestock against depredation has been a successful tool in countries where labour is cheap (Lyamuya et al., 2016b). In the modern world, however, as in Norway, livestock are allowed to roam freely without shepherds because labour costs are high (Widman et al., 2017).

Livestock guarding elsewhere, for instance in the Maasai and Sonjo communities in Tanzania, is a family obligation and is mostly performed by boys and girls who are denied access to school by their parents (Ikanda and Packer, 2008). Thus, they might be less motivated to perform their duties effectively due to lack of incentives (Maclennan et al., 2009). Additionally, the Maasai and Sonjo communities own large flocks of livestock, and herding a large flock might reduce protection from predation. It is easier for carnivores, such as African wild dogs, which normally move in packs, to sneak in and attack large herds of livestock (Lyamuya et al., 2016b).

Many studies in Africa have focused on quantification of reported livestock depredation by wild carnivores in relation to the distance from protected areas. Such studies have been conducted in low human density areas adjacent to protected areas (Holmern et al., 2007; Kissui, 2008; Mwakatobe et al., 2013; Patterson et al., 2004; Rasmussen, 1999). Few studies have evaluated how tribe, age and education may affect how people report numbers of depredated livestock. Each tribe has its own way of living which may influence how people report livestock depredation by wild carnivores. Age can be a predictor of wealth associated with livestock in pastoralist tribes, while education will elucidate whether educated people have more efficient methods of protecting their livestock against depredation. We performed a comparison study between the two tribes (Maasai and Sonjo) to quantify reported livestock depredation by wild carnivores and assess the techniques preferred by both communities in protecting their livestock against depredation.

The presence of large carnivores in any ecosystem is important due to their vital ecological and economical roles (Durant et al., 2011). Monitoring livestock depredation (Spira, 2014) and assessing the preferred techniques used by local communities to safeguard their livestock is therefore relevant to develop good, solid coexistence measures that will enhance the future of all existing carnivore species in the face of human populations. In this study, we addressed three objectives:

(1) To assess if tribe (Maasai and Sonjo), age and education have an effect on the number of livestock reported depredated in a questionnaire;
(2) To determine wild carnivore species responsible for livestock depredation and;

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(3) To assess the preferred techniques of protecting livestock from carnivores within the two ethnic groups.

MATERIALS AND METHODS

Study area

The study was conducted in the Eastern Serengeti ecosystem, in the Loliondo Game Controlled Area (LGCA; Figure 1). The LGCA lies between 1°40′S and 2°50′S and 35°10′E and 35°55′E, covering a total area of about 4,500 km^2 in the Maasai land (Lyamuya et al., 2014a). On the northern side, it borders Narok County (Kenya), on the western side it borders Serengeti National Park (SNP), and on the southern side it boarders the Ngorongoro Conservation Area (NCA). The area includes diverse vegetation types, ranging from forests, woodlands, wooded grasslands, shrub lands, and grasslands (Lyamuya et al., 2016a). Administratively, the area is under control of the District Council, and the District Game Officer (DGO) manages tourism hunting in the LGCA. Hunting without a licensed permit is illegal (MNRT, 2013), and hunting concessions are under the Ortello Business Company of Saudi Arabia. LGCA is the home to the Maasai and Sonjo tribes, the former tribe being dominant. The Maasai people are pastoralists, whereas the Sonjo people are agro-pastoralists (Lyamuya et al., 2014a; Maddox, 2003), where both tribes keep cattle, sheep and goats. An increase in the human population has reduced the available grazing space and resulted in the increasing livestock population grazing on a smaller piece of land results in land and environmental degradation (Lyamuya et al., 2014a). The Maasai people live close to the park boundary, while the Sonjo people live slightly further away (Lyamuya et al., 2016b). Thus, carnivore abundance is higher in the Maasai land compared to the Sonjo land (Maddox, 2003).

Data collection

Data collection was performed from September to November 2016. A sample size above 100 respondents tends to give a broader idea about the information given by respondents, and reduces the biasness of the data (Delice, 2010). We collected data from six villages, in each of which we randomly selected 30 respondents to acquire better details and to ease the data collection work. To be objective we employed a random sampling technique which reduces bias and allows us to cover most of the villages.

A total of 180 respondents were interviewed from six villages, including three villages from the Maasai tribe (Ololosokwan, Oloipiri, and Soitsambu) and three from the Sonjo tribe (Yasimdito, Samunge, and Sale). From each village, 30 respondents were randomly selected. Only one respondent was interviewed from each household. We used local people to introduce us to all interviewed households to acquire confidence and readiness to speak openly. After arriving at a household, we introduced the project and asked if they were ready to answer the questions regarding livestock depredation by wild carnivores. All interviewed persons agreed to give the requested information and we assured them to use their information only for the purpose of our research and as advice to the government. Additionally, we assured their anonymity by hiding their identities. More males were interviewed than females because in the Maasai and Sonjo tribes, men speak on behalf of the household. Females are never allowed to speak openly in the presence of their husband.

Therefore, the sample included more male (*n = 144*) than female (*n = 36*) respondents, as females were interviewed only in the absence of their husband. The survey was conducted through a semi-structured questionnaire employing face-to-face interviews, and questions were in both closed-ended and open-ended. The language of the interview was Swahili for those respondents who spoke it well, and sometimes, a mix of Maasai and Sonjo languages were used by local translators for those respondents who did not understand Swahili clearly.

The information gathered from the respondents was: tribe, gender, age, education level, whether their livestock had been attacked by large carnivores over the last twelve months in the boma or in the pasture (yes, no), when was the last livestock depredation (year), what was the time of depredation, where did the depredation occur, what type of livestock were depredated (cattle, sheep, and goats), what was the number of livestock depredated, what was the carnivore species responsible for the depredation, and what were their herding equipment preferences (Figure 1).

Data analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 21 (IBM, 2012).The significance level was set to be below 0.05 ($p < 0.05$). Binary logistic regression analysis (enter method) was performed to determine the probabilities of perceived number of carnivore-induced depredations. Independents variables in the model were (tribe, age and education).

One-way analysis of variance (ANOVA) tests were carried out on the perceived number of livestock depredation and depredation rate between the Maasai and the Sonjo tribes. Chi-square tests determined the differences between the two ethnic groups on the following variables: year of livestock depredation, time (day/night) of depredation, where (boma/pasture) depredation occurred, season (dry/wet) of depredation, type of livestock that was depredated, number of livestock that were depredated, identity of the carnivore responsible for the depredation and herding equipment preferences.

RESULTS

Demographic variables

The sampled population was from two ethnic groups (Maasai and Sonjo), and respondents were above 18 years old. Age categories were youth (18 to 35 years; Maasai; n = 45, Sonjo; n = 37), adult (36-49 years; Maasai; n = 21, Sonjo; n = 37) and elder (>50 years; Maasai: n = 24, Sonjo; n = 16). Educational level for the respondents ranged from no education (Maasai; n = 32, Sonjo; n = 12), primary education (Maasai; n = 48, Sonjo; n = 72) and secondary education (Maasai; n = 10, Sonjo; n = 6).

We interviewed 180 household members (90 respondents from each tribe), of which 135 (75.0 %) had experienced livestock depredation and 45 (25.0 %) had not experienced livestock depredation over the previous 12 months. A total of 662 livestock (cattle = 105, goats = 310, and sheep = 247) were depredated by wild carnivores ($\bar{x}$ = 13.2±23.9, n = 135 per household, excluding zeros).

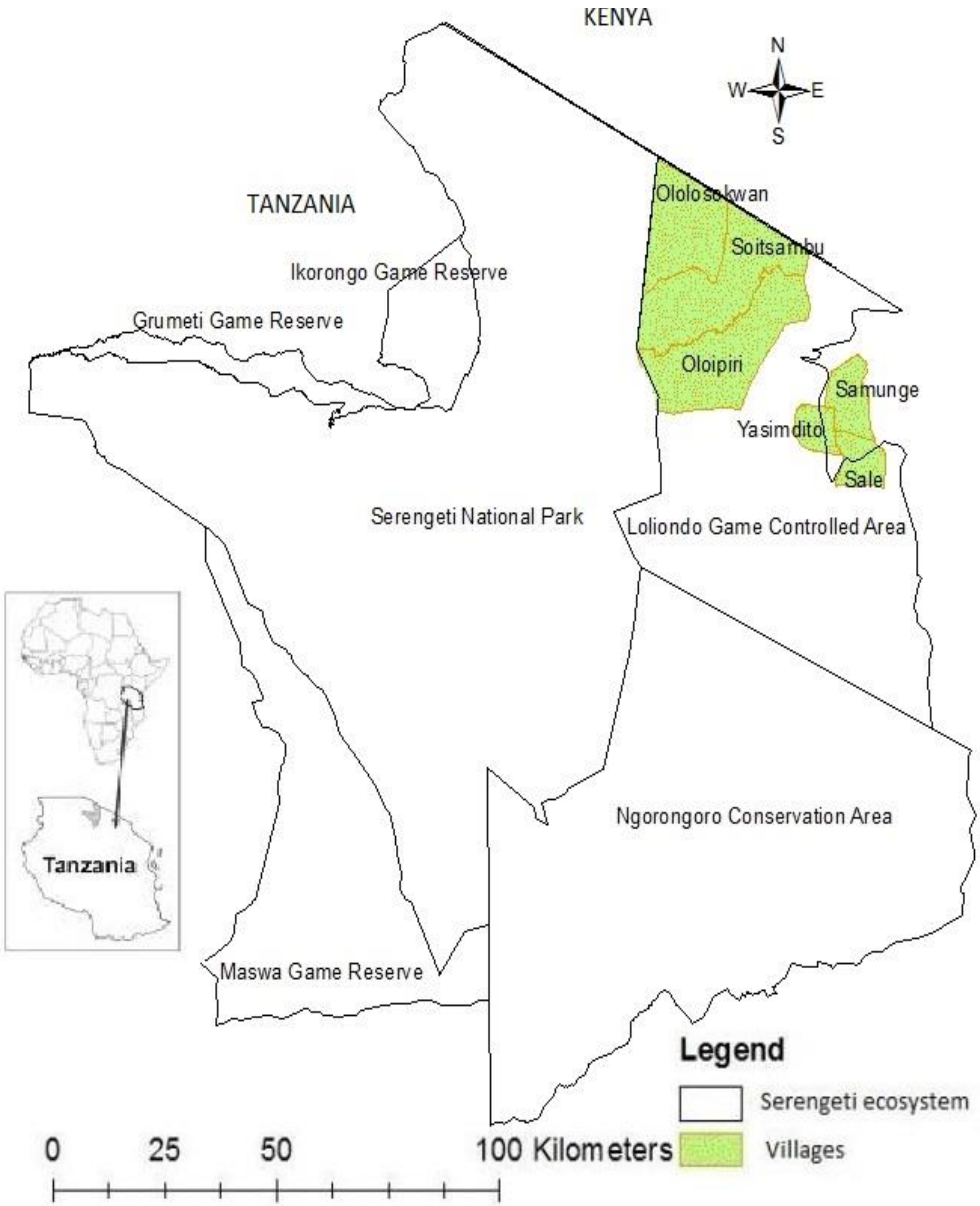

Figure 1. Map showing the study villages (Ololosokwan, Soitsambu, Oloipiri, Samunge, Sale, and Yasimdito) in the Eastern Serengeti ecosystem.

Tribe

Different tests (excluding zeros) were carried out with reported livestock depredation number versus age, education and tribe. Tribe was the only predictor variable that significantly explained the number of livestock

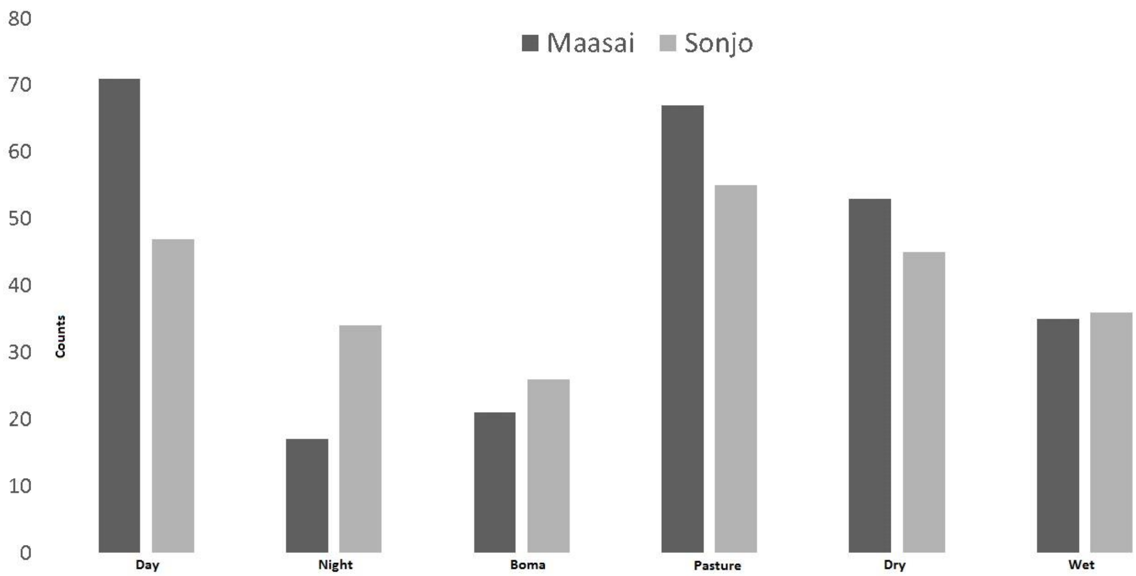

Figure 2. Livestock depredation depending on the time of depredation, where it occurred and in what season it occurred.

Table 1. Carnivore species reported for livestock depredation.

Tribe	Spotted hyena	Leopard	Jackal	Lion	African wild dog	Cheetah	Total depredation
Maasai N	51	33	34	38	14	11	181
%	28.2	18.2	18.8	20.9	7.7	6	100
Sonjo N	32	16	6	0	10	0	64
%	50	25	9.4	0	15.6	0	100

*Some respondents had more than one attack.

depredations (t-test; t = 6.696; df = 133, p < 0.0001). The other two variables were insignificant (age; rho = -0.014, p = 0.869; education; F = 1.379, df = 2 and 132, p = 0.255). The reported rate of depredated livestock (yes, no) was significantly different between the two tribes (yes: Maasai=60%, Sonjo=40%; and no: Maasai=20%, Sonjo=80%) (χ^2= 23.1, df = 1, p < 0.0001). The Maasai tribe ($\bar{x}$ = 19.1±29.2, n = 81) experienced much higher livestock depredation than the Sonjo tribe ($\bar{x}$ = 4.3±4.0, n = 54) (F =13.6, df = 1 and 133, p < 0.0001). The Maasai own more livestock ($\bar{x}$ = 295±306.5, n = 90) than the Sonjo ($\bar{x}$ = 72.2±55.4, n = 90). Additionally, the livestock depredation rate per 1000 livestock was significantly higher in the Maasai ($\bar{x}$ = 6.9±10.8, n = 78) than in the Sonjo ($\bar{x}$ = 0.4 ± 0.5, n = 54) (F = 19.8, df = 1, p < 0.0001). More incidences of depredation occurred during 2016 (75%), compared to previous years (25%) (χ^2= 32.3, df = 1, p <0.0001). Depredation occurred most frequently during the day in both tribes; however, it was significantly more common during the night in the Sonjo tribe (χ^2 = 10.3, df = 1, and p = 0.001) (Figure 2). In addition, livestock depredation occurred more frequently in the pasture land than in the boma (χ^2 = 6.2, df = 1, p = 0.046; Figure 2). Finally, livestock depredation occurred more frequently during the dry season (Figure 2).

Carnivore species responsible

A significant difference was found in the frequency of attacks by different carnivore species (that is, lion, cheetah, leopard, spotted hyena, African wild dog, and jackal) between the two tribes (χ^2 = 27.7, df = 5, p = 0.002; Table 1). In both ethnic groups, spotted hyena was the most common predator (Table 1). Lions and cheetahs were only found to cause livestock depredation in the Maasai land (Table 1), while leopards and jackals caused more livestock depredation in the Maasai tribe than the Sonjo tribe (Table 1). Similarly, livestock depredation by African wild dogs was higher in the Maasai tribe than the

Table 2. Herding equipment preferences with the responses (yes or no) regarding whether the household had experienced livestock depredation.

Livestock depredation	Tribe	Spear and/or knives and club	Combination	Bow and poisoned arrows	Use of domestic dogs	No equipment	Total
-	Maasai N	25	49	0	14	2	90
	%	27.8	54.4	0	15.6	2.2	100
	Sonjo N	0	41	33	15	1	90
	%	0	45.6	36.7	16.7	1.1	100
Yes	-	23	70	20	21	1	-
%	-	92	77.8	60.6	72.4	33.3	-
No	-	2	20	13	8	2	-
%	-	8	22.2	39.4	27.6	66.7	-

Sonjo tribe, though the difference was not statistically significant ($\chi^2 = 0.8$, df = 1, $p = 0.38$; Table 1).

Preferences of herding equipment

The study results revealed a difference in the preferences of herding equipment between Maasai and Sonjo herders ($\chi^2 = 69.9$, df = 5, $p < 0.0001$; Table 2). Only three herders did not use any weapon (Table 2). Maasai herders (n = 25) used more spears and/or knives and clubs (Table 2), whereas Sonjo herders (n = 33) preferred to use bows and poisoned arrows (Table 2). Both tribes rarely used domestic dogs, which would alert them to the incoming carnivores during the night or while in the pastures (Table 2). There was a statistically significant difference in the use of herding equipment and the livestock depredation frequencies (yes, no) ($\chi^2 = 10.7$, df = 4, $p = 0.03$; Table 2).

DISCUSSION

A study similar to the present study was performed in 2010 by Lyamuya et al. (2016b) who studied livestock and herding efficiencies in relation to the livestock loss caused by wild carnivores. This study adds value in assessing the temporal change six years after the last study and providing insight into predation patterns. African wild dogs at that time were the main predator causing livestock losses in the Sonjo land; however, our results found a different pattern. Spotted hyenas were the most common predator among both tribes due to their higher density in the Serengeti ecosystem and ability to commute in both protected and unprotected areas (Goymann et al., 2001). The frequency of livestock depredation by hyenas was higher than that of any other predator (i.e. lion, cheetah, leopard, African wild dog and jackal), as also found in the western Serengeti by Holmern et al. (2007) and Mwakatobe et al. (2013). Maasai herders used knives and/or spears whereas Sonjo used bows and poisoned arrows to protect their livestock against depredation by wild carnivores. Both tribes preferred the use of multiple, rather than single, techniques to increase the efficiency of livestock protection.

Tribe

The study results revealed that more attacks were found to occur in the Maasai tribe lands than in the Sonjo tribe lands because the Maasai own more livestock and live closer to the Serengeti National Park boundary, where there are higher influxes of different wild carnivores (Lyamuya et al., 2016b; Lyamuya et al., 2014b). The frequency of livestock depredation was higher during daytime while herding, with increased rates during the dry season. During the dry season, herders normally take livestock far from home in search of green pastures, which is a predisposing factor for livestock depredation.

Compared to Lyamuya et al. (2016b), this study recorded a higher rate of livestock depredation. Lindsey et al. (2013) found that human tolerance towards carnivores was higher in areas with high wildlife densities. With wild prey numbers declining in the area, carnivores will switch to the available prey (that is, livestock) (Patterson et al., 2004; Souza et al., 2017). Areas with low numbers of wild prey tend to experience increased livestock depredation compared to areas with large numbers of wild prey (Woodroffe et al., 2005). Prey diversity and abundance enhance choices and where different carnivore species will find their favourite wild prey (Per et al., 2009).

Furthermore, prey diversity enhances carnivore-human coexistence due to low livestock depredation incidences (Carter et al., 2012). In some instances, areas with low diversities of wild prey may experience skewed livestock predation (sheep and/or goat) (Woodroffe et al., 2005). Prey preferences of some carnivores, such as hyenas and jackals, which are common in the Maasai and Sonjo areas, are biased towards goats and sheep because of their higher numbers than cattle; thus, the chance of depredation is density dependent (Okello et al., 2014).

Previous studies have found that the absence of compensation and/or consolation schemes worsens the relationship between these communities and carnivores (Dickman et al., 2014; Wanga and Macdonald, 2006). Areas with livestock husbandry see carnivores as a threat to their livelihood (Musiani and Paquet, 2004) and not as tourist benefits, as perceived by the government and investors. In the Maasai and Sonjo communities, there has been a long-standing consolation claim over livestock depredation to the authorities with no rewards, and currently, these communities have developed reporting fatigue to such attacks due to ongoing disappointments.

Responsible carnivore species

Livestock depredation is higher in the Maasai land than the Sonjo land, which correlates with greater numbers of livestock and higher carnivore densities. Similar findings were found in villages around Jigme Singye Wangchuck National Park in Bhutan, where high carnivore densities correlated with increased livestock depredation (Wanga and Macdonald, 2006). Livestock depredation occurred more frequently in pastures than in bomas and during the daytime. Livestock depredation was mainly caused by spotted hyenas, followed by leopards. Livestock depredation by leopards increased during the dry season (Lyamuya et al., 2014a), and this might be due to the fact that livestock are taken into thick bushes and forested areas while searching for green pastures at this time of the year, which are preferred habitats for leopards. The frequency of livestock depredation by African wild dog was minimal and different from previous findings, in which the Sonjo experienced more livestock depredation (Lyamuya et al., 2016b). Livestock depredation by lions was skewed to cattle in the Maasai land, which is similar to the findings of Lyamuya et al. (2016b) in 2010. Livestock depredation by lions and/or cheetahs did not occur in the Sonjo land due to habitat degradation, which has displaced their home ranges. With regard to the livestock numbers, as noted before, the Maasai have greater numbers of livestock than the Sonjo (Lyamuya et al., 2016b). Thus, even a small loss among the Sonjo will have a large impact on household livelihood. This means that the livestock depredation costs are much higher in the Sonjo.

Preferences in herding equipment

Mitigation measures to foster coexistence with carnivores and to tolerate livestock losses should be in place to cultivate positive attitudes towards carnivore conservation (Dickman, 2010; Jacobs and Main, 2015). The use of multiple livestock guarding techniques was rated as the best method to reduce livestock depredation, which agrees with other findings (Lyamuya et al., 2016b). Different communities have different techniques to keep their livestock safe from carnivores (Patterson et al., 2004; Wanga and Macdonald, 2006). Hence, non-lethal techniques to inhibit livestock depredation need to be thoroughly investigated to minimize dwindling carnivore population trends (Ed and John, 2001). For instance, the use of sticks by the Maasai and Sonjo is only for herding livestock, while carrying defensive weapons helps to scare predators away and can sometimes be used to kill them. However, carnivore killing is very challenging because they silently sneak into groups of livestock that are out in the pasture or inside a boma at night. Although the herding equipment preferences differ between the Maasai and Sonjo communities, the use of weapons is biased to men because they are the ones who take on livestock protection responsibilities. While herding livestock, the Maasai people use spears and/or knives, whereas the Sonjo prefer the use of bows and poisoned arrows. The use of domestic dogs can help to deter predators from attacking livestock (Gehring et al., 2010; Spira, 2014). However, in pastoral communities in Eastern Serengeti, dogs are inadequate at performing this task (Lyamuya et al., 2014a), probably because most of them are in poor condition from starvation and lack of health care. The use of a single method to guard livestock is not effective compared to the use of multiple techniques (Ed and John, 2001). Therefore, implementing livestock surveillance and monitoring practices will help to predict depredation patterns and to develop management measures over time (Patterson et al., 2004; Spira, 2014).

Conclusion

This study concludes that there are significant differences in the livestock depredation rates and patterns between the Maasai and Sonjo areas. Livestock depredation was more common among the Maasai tribe, which correlated with higher carnivore densities. Understanding livestock depredation patterns and contributing factors will help pastoralists to adopt the best coexistence measures. Protecting livestock against depredation requires further research, which will unravel the long history of human-carnivore conflict. For protection, it is recommended that both tribes use multiple techniques to herd their livestock.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

We would like to thank the Tanzania Wildlife Research Institute (TAWIRI) and the Wildlife Division (WD) for permission to conduct our fieldwork in the Loliondo Game Controlled Area (LGCA). We express our sincere thanks to the European Union's Horizon 2020 research and innovation programme, grant agreement No. 641918 for their financial support through the African BioServices project, without which support this study would not have been possible.

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Vol. 10(3), pp. 131-144, March 2018
DOI: 10.5897/IJBC2017.1160
Article Number: C7152AF55982
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

The effect of land use type on butterfly diversity at Masako Forest Reserve, Kisangani, Democratic Republic of Congo

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Received 17 October, 2017; Accepted 18 January, 2018

The effect of land use type on butterfly abundance, species richness, and biodiversity was studied at Masako Forest Reserve in Kisangani, Democratic Republic of Congo. The study was conducted in a primary (PF) and secondary forest (SF), fallow (FW), and an agricultural field (AF). Three bait traps were used; each trap had a cylinder consisting of two metal rings of 30.48 cm diameter and 106.68 cm length with a 15.24 cm cone top. The cylinder and top were nylon mosquito netting with a 55.88 cm zipper sewn into the seam of the cylinder to provide access into the trap to remove butterflies. Traps with rotten bananas as baits were placed at three sites in each of the land use type for 24 h. Trapped butterflies were counted, identified, photographed and released. Results showed that land use type significantly affected butterfly species abundance (p=0.0003) and alpha biodiversity (p=0.0001). The fallow had the highest butterfly species abundance and biodiversity. *Cymothoe caenis* was the most dominant and *Acrea lycoa* the least abundant species. Butterflies biodiversity indices significantly correlated with longitude (0.58 to 0.79). These results suggested that land use type and geographic coordinates may have an impact on butterflies at Masako Forest Reserve. More studies are needed to better understand the effect of land use type and longitude on butterfly biodiversity.

Key words: Butterfly, forest, land use type, species, abundance, biodiversity.

INTRODUCTION

Butterflies are very important to ecosystems. They play significant ecological roles, perform essential ecosystem services (Schmidt and Roland, 2006), especially in the recycling of nutrients (N, P, K) highly needed by crops (Munyuli, 2012). Butterflies are well-known indicator taxa due to their sensitivity to environmental perturbations, relevance to ecosystem functioning and relative ease in sampling (Brown and Freitas, 2002; Blair, 1999; Hamann and Curio, 1999). They are considered as good ecological indicators for other invertebrate taxa and as surrogate representatives of environmental quality changes (Kumar et al., 2009; Kremen, 1992; Munyuli, 2012). It has been estimated that about 90% of butterfly species live in the tropics (Munyuli, 2012). However, despite their diversity, ubiquity and importance particularly with regards to their ecology, behaviour and functional role, they remain relatively less studied in the tropics as compared to temperate ecosystems (Marchiori and Romanowski, 2006; Van Swaay et al., 2012). The relative scarcity of studies on tropical butterfly species hampers the ability to effectively conserve them, particularly as pollinating agents in agricultural systems (Munyuli, 2012). Butterflies are also known to be highly sensitive to climate change (Parmesan and Yohe, 2003) and recent studies showed that they react faster than other groups such as birds (Devictor et al., 2012). A reason for this is because butterflies have relatively short generation times and are ectothermic organisms, meaning that their population dynamics may respond to temperature changes more directly and more rapidly (Van Swaayet al., 2012). Therefore, changes in environmental conditions caused by deforestation and forest disturbance have negative effects on butterflies, including declines in diversity and abundance (Hamer et al., 1997; Hamer et al., 2003; Nkwabi et al., 2017), changes in species assemblages (Hamer et al., 2003), loss of species guilds (Canaday, 1997), and extinction (Magsalay et al., 1994; Castelletta et al., 2000; Brook et al., 2003). However, modified habitats may still actually retain some forest biodiversity (Hughes et al., 2002; Horner-Devine et al., 2003; Sodhi et al., 2005), but their conservation value still needs to be assessed. It has also been reported that the numbers of butterfly species and individuals were high in disturbed and regenerating forests and low in natural forests (Spitzer et al., 1993; Van Lien and Yuan, 2003). There were few butterfly species in the habitat with thick forest canopy and, vice versa, more butterfly species in the habitat with less forest canopy (Warren, 1985). The diversity of butterflies increased with increasing habitat scale and vegetation structure complexity (Schmidt and Roland, 2006). Finally, it has been suggested that our understanding of which types of disturbance most adversely affect tropical biota and which taxonomic groups are most susceptible to disturbance is still poor (Dunn, 2004). Therefore, to protect and conserve the remaining biodiversity effectively, it is essential to understand how biological communities such as butterflies respond to land use change as caused by anthropogenic disturbances. The objective of this study was therefore to assess the effect of land use type on butterfly abundance, species richness and biodiversity at Masako Forest Reserve, Kisangani, Democratic Republic of Congo.

METHODOLOGY

Study area

The study was conducted from April to August 2014 at Masako Forest Reserve near the City of Kisangani in the Tshopo province of the Democratic Republic of Congo (Figure 1). Masako Forest Reserve (2.105 ha) is located 15 km north-east of Kisangani, on the old Buta's road. One third of the reserve is occupied by primary forest; the remainder consists of old-growth secondary forests, fallow lands and crops. Its geographic coordinates are 0°36'N; 25°13'E. The Masako forests are in the category of equatorial evergreen rainforests (Nyakabwa et al., 1990). It is listed among the biodiversity protected areas of the Democratic Republic of Congo.

Land use types studied

The four major land use types found at Masako Forest Reserve were used in this study. Primary forest (PF) is a land use type essentially composed of *Gilbertiodendron dewevrei* and *Scaphopethalumthonneri*as undergrowth throughout Masako Forest Reserve. However, the wetter areas of the reserve are heterogeneous with *G. dewevrei, Coelocaryonbothryoides, Piptadeniastrum africanum* and *Celstis mildbraedtii*. The undergrowth is dominated by *Cyathogynaviridis* and *Pycnocomainsularis* (Nyakabwa et al., 1990). Secondary forest (SF) is the old-growth secondary forests at Masako Forest Reserve are very diverse, composed of a mixture of trees also occurring in old fallow lands and primary forest (Lomba and Ndjele, 1998). They are characterized by *Zanthoxylum gilletii, Cynometra hankei, Peterstiantus macrocarpus, Musanga cecropioides*, *Terminalia superba, Scorodophloeuszenkeri, Albizia adiantifolia, Uapaca guineensis, Cynometra alexandrii, Panda oleoza, M. cecropioides*, etc. (Mosango, 1991). Fallow (FW) are fallow lands formed essentially by herbaceous groupings consisting of *Panicum maximum, Pennisetum purpureum, P. polystachyon, Spermacoce latifolia* and of shrub associations of *Cnestis ferruginea, Craterispemum cerinanthum, Afromomum laurentii* and *Costuslucanisianus, Triumpheta cordifolia* and *Selaginella myosurus*. Agricultural fields (AF) were composed of a mixture of crops such as cassava, corn, and plantain banana

Butterfly collection and identification

Three bait traps designed for the tropics and sub-tropical parts of the world were used in this study. They were purchased from a limited liability company (LLC), Georgetown, Kansas, United States of America (http://www.leptraps.com). Each trap had a cylinder consisting of two metal rings of 30.48 cm diameter and 106.68 cm length cylinder with a 15.24 cm cone top. The cylinder and top were nylon mosquito netting with a 55.88 cm plastic zipper sewn into

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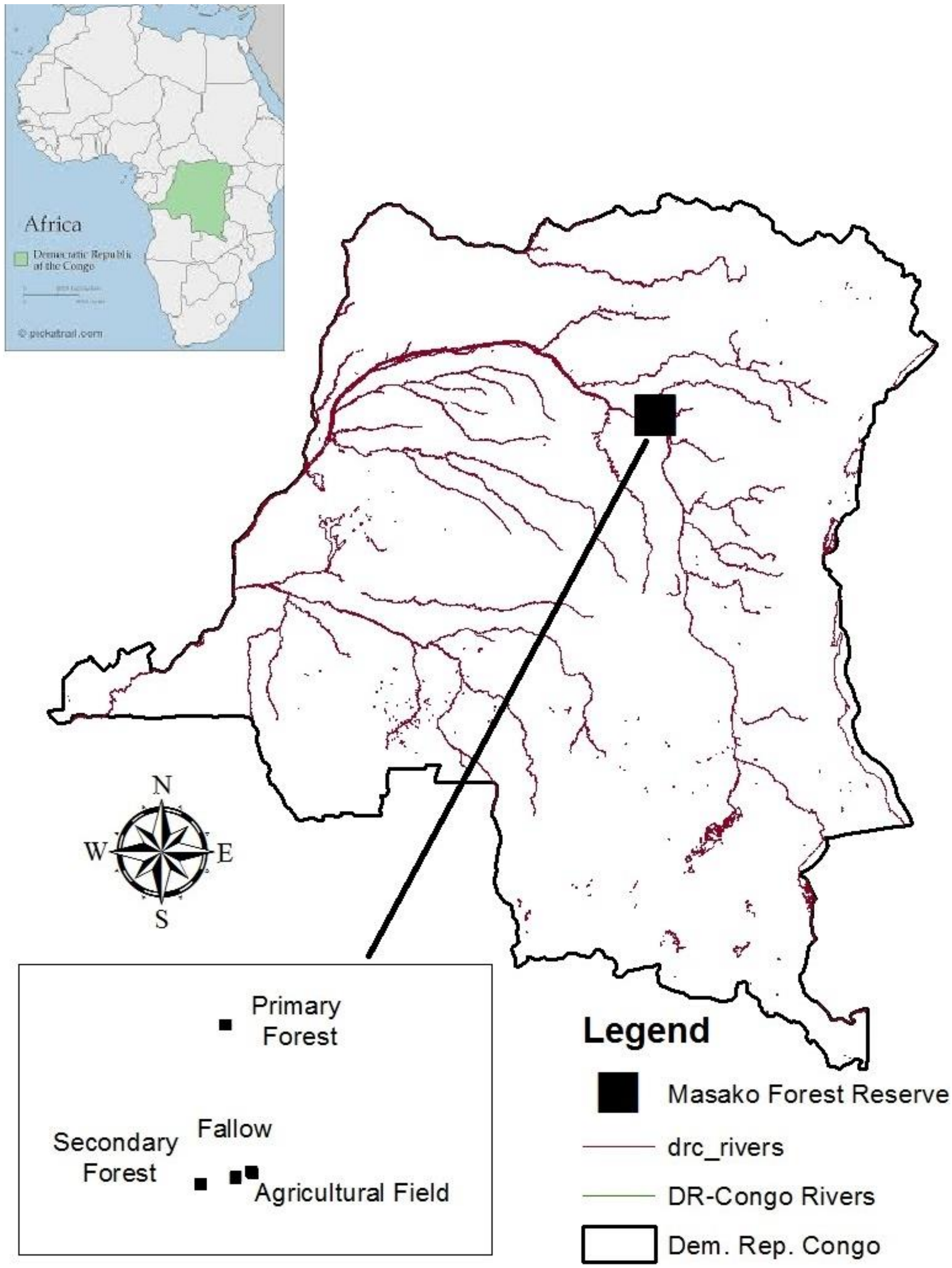


Figure 1. Study site.

the seam of the cylinder to provide access into the trap to remove butterflies. The flat bottom ring was high-density polyethylene (HDPE) white plastic. The ring did snap in and out. The platform was also HDPE white plastic and was suspended from the bottom of the cylinder with "S" hooks and "eye" bolts. The "eye" bolts allowed the opening between the bottom of the cylinder and the

Table 1. Coordinates of the sampling sites.

Site	No.	Latitude	Longitude	Elevation
Agricultural field (AF)	1	0.617091	25.258641	433.118286
Agricultural field (AF)	2	0.617176	25.258728	424.863586
Agricultural field (AF)	3	0.617323	25.258781	423.867889
Fallow (FW)	1	0.617649	25.260882	434.796692
Fallow (FW)	2	0.617861	25.260788	434.241241
Fallow (FW)	3	0.61793	25.260641	433.65683
Primary forest (PF)	1	0.636671	25.25739	405.400513
Primary forest (PF)	2	0.636647	25.257313	427.721039
Primary forest (PF)	3	0.636657	25.257515	426.547058
Secondary forest (SF)	1	0.616287	25.254344	427.766968
Secondary forest (SF)	2	0.616274	25.254264	428.435028
Secondary Forest (SF)	3	0.616286	25.254164	427.698669

platform to be adjustable (1.91 to 0.64 cm). The platform had a 15.24 cm diameter hole in the center for a rubber-maid type 3.2 cup container with a snap seal lid was the bait container. A package of four containers was included with each trap. A bait was prepared with rotten bananas and put in each of the tree containers. The bait could remain in the container with the lid sealed tight and stored in a secure storage bag while traveling. Traps were totally collapsible for easy packing during the travel and the bait could travel with the trap. The sampling started in the primary forest. The white cone top provided a light source. Butterflies were attracted to the bait by the sense of smell. They walked into the shaded area of the trap to feed on the bait. Once they had finished feeding they flew upward towards the light area of the white cone top and became entrapped. Butterflies appeared very reluctant to fly down into the dark screened area of the trap and even when they did, they rested with their head facing up towards. For each of the four of the land use types, traps were installed at three sites at 12:00 pm and removed at 11:00 am the next day. The geographic coordinates of each site in each land use type are shown in Table 1. Butterflies collected within the traps were counted and identified *in situ* and released. Butterflies that could not be identified were stored into zip log bags and identified later. This identification protocol was repeated at all sites for each land use type. Overall, 14 butterfly species were collected. These species were not unique to neither Masko Forest Reserve nor the Democratic Republic of Congo, but are also found in other African countries as well. Their distribution throughout Africa is as shown in Figure 2. None of the 14 butterfly species collected at Masako Forest Reserve was found in the IUCN "Red List" of endangered species as their conservation status has not yet been assessed. However, many of them are listed in the Catalog of Life. Overall, the preferred land use type for all of them was the forest (dry, moist or costal) with a few exceptions for the farmland (http://www.catalogueoflife.org).

Calculation of butterfly abundance, richness and biodiversity indices

Measurement of biodiversity over spatial scales is described in three terms: alpha, beta, and gamma biodiversity (Whittaker, 1972; Hunter, 2002). A biodiversity index is a quantitative measure that reflects how many different types (such as species) there are in a dataset, and simultaneously takes into account how evenly the basic entities (such as individuals) are distributed among those types. Alpha diversity refers to the diversity within a particular area or ecosystem, and is usually expressed by the number of species in that ecosystem. Beta diversity is the change in species diversity between these ecosystems. Gamma diversity is a measure of the overall diversity for the different ecosystems within a region. Three biodiversity indices were calculated: Shannon (SHI) and Simpson (SI) indices for alpha biodiversity and the Absolute Beta Value (ABV) index for beta biodiversity. These indices were calculated using the freely available biodiversity calculator: http://www.alyoung.com/labs/biodiversity_calculator.html. Gamma biodiversity was taken as the total number species. Butterflies abundance was calculated as the total number of butterflies caught at each of the three sites in each of the four land use type while butterfly species richness was the total number of different species present at each site.

RESULTS

The summary of statistics for butterfly abundance, richness and biodiversity in four land use types at Masako Forest Reserve is shown in Table 2. Overall, butterfly abundance ranged from 4 to 173 with an average of 53.67. There was a high variability in butterfly abundance among the land use types as shown by a coefficient of variation of 109.51%, the highest among all parameters studied. The means for butterfly species richness and that of ABV were closer with same standard deviation. The means for SHI and SI indices were closer along with their standard deviations and coefficients of variation (CV). Although land use types were far away from each other, the range in their elevations was only 29.40 m. Overall, the fallow had the highest butterfly species abundance and biodiversity. *Cymothoe caenis* was the most dominant and *Acrea lycoa* the least abundant species.

Butterfly abundance

Data on butterfly abundance was checked for normality

Figure 2. Butterfly species distribution map.

before further analysis. The probability plots for butterfly abundance are as shown in Figure 3a and b. The original data on butterfly abundance (Figure 3a) fitted the line with slight deviations from the straight line at the bottom of the graph, suggesting that it was not normally distributed. After the failure of additional normality checks with the Shapiro-Wilk test and a log transformation of the data as shown in Figure 3a and b, Bartlett test was used and found that the variances were not homogenous (K-squared = 15.35, df = 3, P = 0.0015). Therefore, Kruskal-Wallis non-parametric test was used to compare butterfly abundance among land use types. Table 3 shows the effect of land use type on butterfly abundance at Masako Forest Reserve. There was a significant difference in butterfly abundance among land use type (P=0.0003, F=23.40). A mean separation test suggested that the fallow (FW) had higher butterfly abundance as compared to the primary forest. However, the fallow (FW), agricultural field (AF) and the secondary forest (SF) did not significantly differ in butterfly abundance. Similarly, the agricultural field (AF), primary forest (PF) and SF were also not significantly different in their butterfly abundance.

Butterfly species richness

The probability plots for butterfly richness are as shown in Figure 4a and b. The original data on butterfly richness fitted well the probability plot, but with a slight deviation from the straight line at the top of the graph, suggesting that it was not normally distributed. Therefore, a log transformation of the data was done after a Shapiro test and this improved the degree of normality as shown in Figure 4a and b and also confirmed by the Shapiro test on the transformed data (W = 0.9408, p-value = 0.5089).

Table 2. Summary of statistics for butterflies biodiversity in four land use types at Masako Forest Reserve, Kisangani, Democratic Republic of Congo (May-June 2014).

Variable	Abundance	Richness	SHI[1]	SI[2]	ABV[3]	Elevation
N	12.00	12.00	12.00	12.00	12.00	12.00
Mean	53.67	5.50	1.14	0.97	4.50	427.34
SD	58.77	2.02	0.86	0.75	2.02	7.85
C.V.	109.51	36.78	75.18	77.38	44.95	1.84
Minimum	4.00	3.00	0.15	0.00	2.00	405.40
Median	26.50	5.00	0.98	0.76	4.00	427.75
Maximum	173.00	9.00	2.59	1.85	8.00	434.80
Skew	0.82	0.59	0.28	0.08	0.59	-1.85
Kurtosis	-0.63	-0.67	-1.47	-1.79	-0.67	3.26

[1]SHI: Shannon index; [2]SI: simpson index, [3]ABV: absolute beta value.

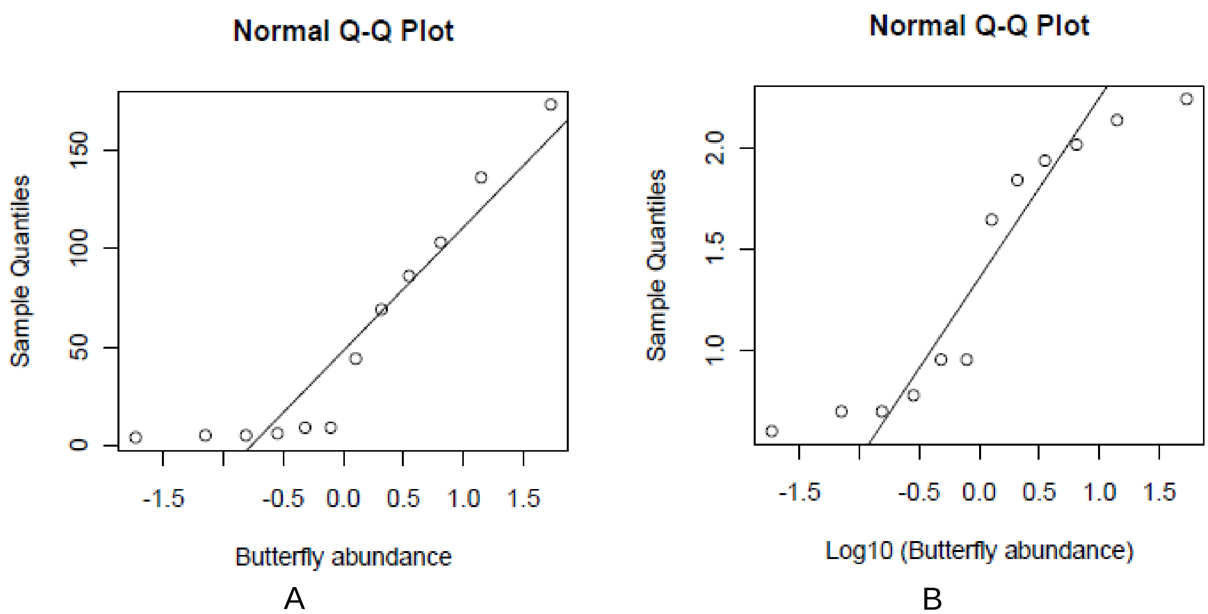


Figure 3. (A) Butterfly species abundance (original data); (B) Log transformed data on butterfly species abundance.

Later, an analysis of variance was conducted followed by means separation, but the results showed that there were no significant differences among land use types for butterfly richness.

Butterfly alpha biodiversity

Butterflies species alpha biodiversity was calculated using the Shannon and Simpson indices. Similarly to data on butterflies abundance and richness, graphical method was also used to determine if the data on butterflies diversity for the SI was normally distributed. The probability plots are as shown in Figure 5a and b. It was observed that the original data (Figure 5a) on SI deviated from the straight line at the bottom as well as at the top of the graph, suggesting that it was not normally distributed. A Shapiro-Wilk test confirmed the lack of normality and the log transformation failed to make the data more normally distributed (Figure 5b). Therefore, as in previous analyses, Kruskal-Wallis test was used to check whether SI was different among land use types. The analysis of variance (Table 4) revealed that there was a significant effect of land use type on butterfly biodiversity as characterized by the Simpson index (P=0.0001, F=35.8). The comparison of means showed that FA had the highest biodiversity as compared to the PF. However, the PF, SF and the AF were not different in their butterfly

Table 3. Effect of land use type on butterfly abundance at Masako Forest Reserve, Kisangani, Democratic Republic of Congo.

Land use type (LUT)	Mean
Agricultural Field (AF)	8^{ab}
Fallow (FW)	11^{a}
Primary Forest (PF)	2.5^{b}
Secondary Forest (SF)	4.5^{ab}

Analysis of variance					
Source	**DF**	**SS**	**MS**	**F**	**p**
LUT	3	127.500	42.5000	23.4	0.0003
Site	8	14.500	1.8125		
Total	11	142.000			

There are 2 groups (a and b) in which the means, are not significantly different from one another.

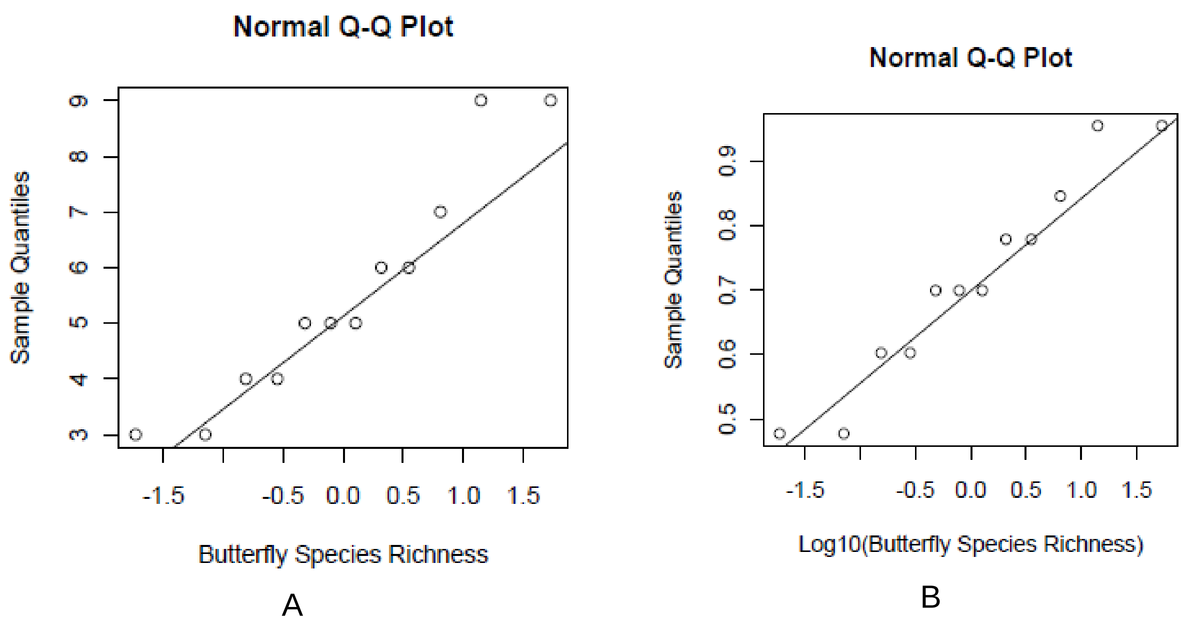


Figure 4. (A) Butterfly species richness (original data); (B) Log transformed data on butterfly species richness.

biodiversity. Finally, AF, FW and SF were also equal in their butterfly biodiversity. Like the Simpson index, data for the SHI was not normally distributed (Figures not showed). Therefore, a further analysis of the data was continued using the Kruskal-Wallis non-parametric test to evaluate whether butterfly biodiversity differed among land use types as assessed by the Shannon index. The analysis of variance (not showed) revealed that there was a significant difference among land use types for butterfly alpha biodiversity (P=0.0074, F=8.40). However, a separation of means test showed that all land use types were equal for their butterfly alpha biodiversity as assessed by the Shannon index.

Butterflies beta biodiversity

Butterfly beta biodiversity was characterized using ABV. The data was checked for normality as shown in Figure 6a and 6b. ABV data was normally distributed. This was also confirmed by the Shapiro-Wilk test (W = 0.9085, p = 0.2039). However, given the little deviation shown in Figure 6a, the data was transformed to improve its fitting of the line. As showed in Figure 6b, the transformation

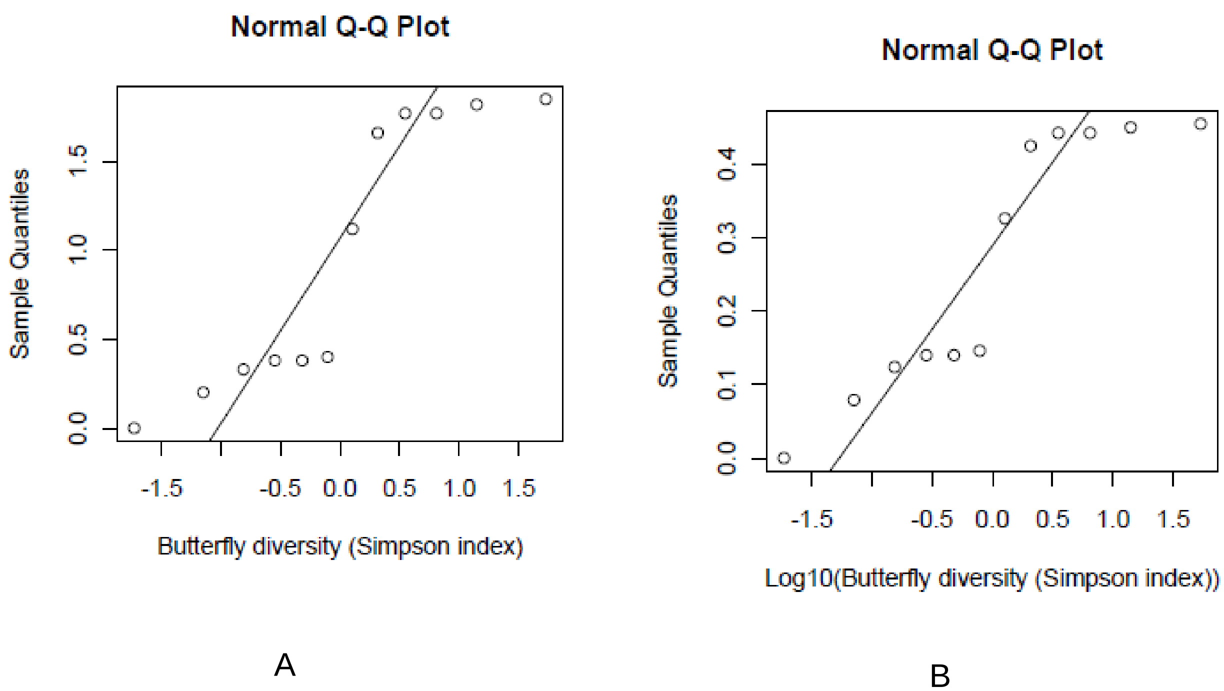


Figure 5. (A) Butterfly alpha diversity (original data); (B) Butterfly alpha diversity (log transformed data).

Table 4. Effect of land use type on butterfly biodiversity (SI) at Masako Forest Reserve, Kisangani, Democratic Republic of Congo.

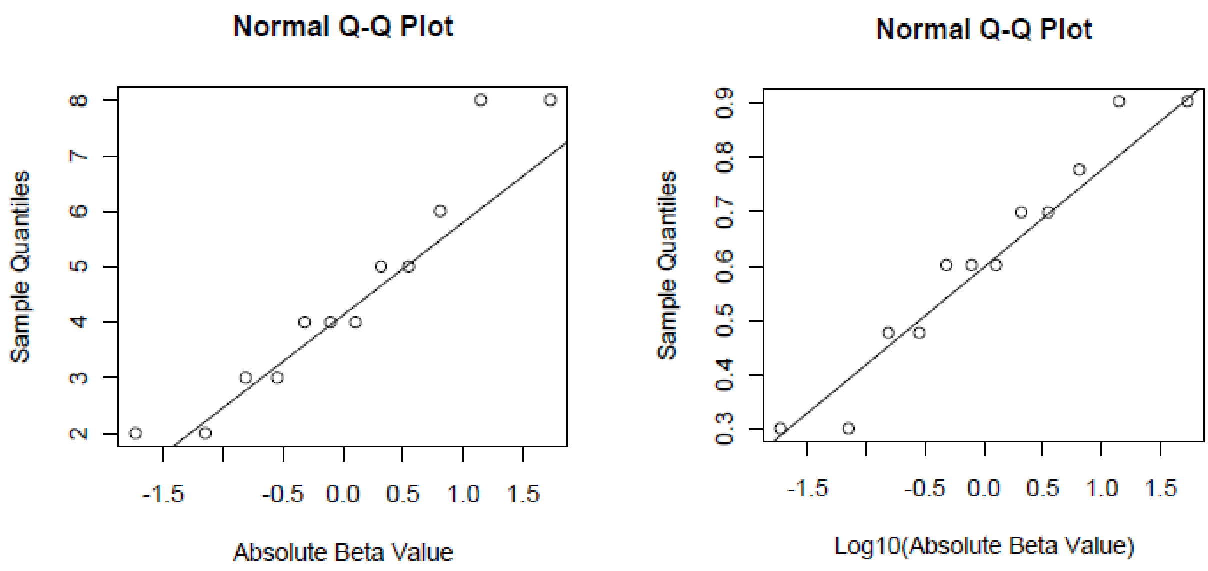
Land use type (LUT)	**Mean**
Agricultural field (AF)	8.17^{ab}
Fallow (FW)	10.83^{a}
Primary forest (PF)	2.00^{b}
Secondary forest (SF)	5.00^{ab}

Analysis of variance					
Source	**DF**	**SS**	**MS**	**F**	**p**
LUT	3	132.167	44.0556	35.8	0.0001
Site	8	9.833	1.2292	-	-
Total	11	142.000	-	-	-

improved the normality and this was also confirmed by Shapiro-Wilk test (W = 0.9395, P = 0.4919). Finally, the homogeneity of variance was checked and the result confirmed that this third assumption for normally distributed data was not violated (Bartlett's K-squared = 0.963, df = 3, P = 0.8102). Therefore, the analysis of variance was further used to evaluate whether butterfly beta biodiversity (ABV) was different among land use types. The analysis of variance showed that there was no significant difference among land use types for the beta biodiversity as characterized by ABV.

Correlation between butterfly abundance, richness, biodiversity and sampling site

Table 5 shows the correlation matrix (Pearson correlation) for butterfly abundance, richness, biodiversity and site geographic coordinates. Butterfly abundance positively correlated species richness (R^2=0.34), SI (R^2=0.82) and ABV (R^2=0.34), but negatively with SHI (R^2=0.64). Therefore, 18 to 64% of variability in butterfly species richness, alpha biodiversity (SI) and ABV, respectively, was due to parameters other than abundance.



A B

Figure 6. (A) Butterfly beta diversity (original data). (B) Butterfly beta diversity (log transformed data).

Table 5. Correlation matrix for butterflies abundance, richness, biodiversity and sampling site.

Variable	Abundance	Richness	SHI	SI	ABV	Longitude	Latitude
Richness	0.582						
p-value	0.0471						
SHI	-0.7744	-0.5513					
	0.0031	0.0632					
SI	0.9043	0.5353	-0.9222				
	0.0001	0.0729	0.0001				
ABV	0.582	1.0000	-0.5513	0.5353			
	0.0471	0.0001	0.0632	0.0729			
Longitude	0.8303	0.5858	-0.738	0.7896	0.5858		
	0.0008	0.0453	0.0061	0.0023	0.0453		
Latitude	-0.4477	-0.3183	0.5647	-0.5898	-0.3183	-0.0294	
	0.1444	0.3133	0.0558	0.0435	0.3133	0.9277	
Elevation	0.5501	0.4669	-0.2864	0.4831	0.4669	0.2954	-0.5557
	0.0639	0.1259	0.3668	0.1116	0.1259	0.3512	0.0606

Butterflies richness was perfectly and positively correlated with ABV (R^2=1.00). A similar strong correlation was also observed between SI and SHI, although both indices were negatively correlated (R^2 = 0.85). All butterfly parameters were also significantly correlated with longitude, but not latitude and elevation

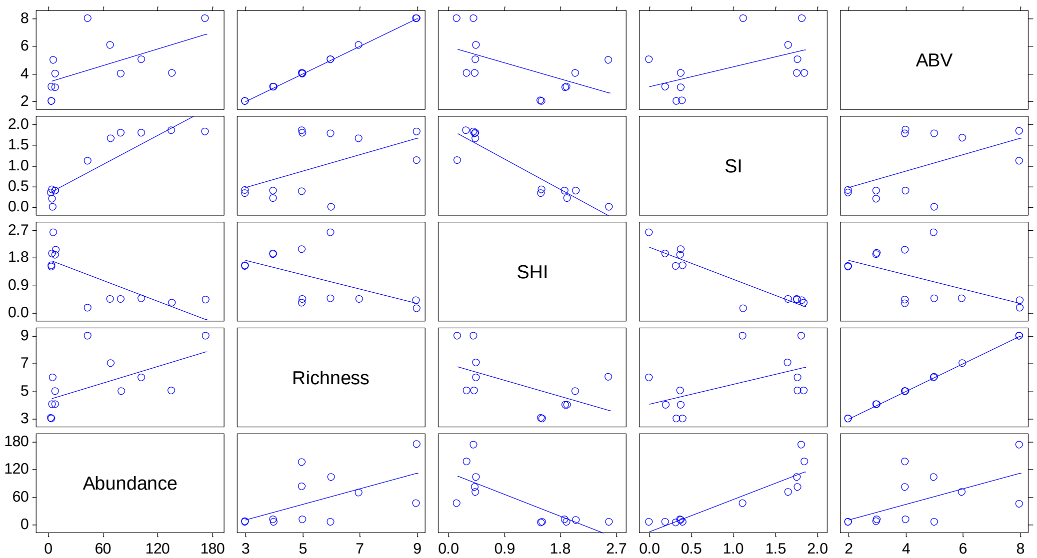


Figure 7. Relationships (linear) between butterflies abundance, richness.

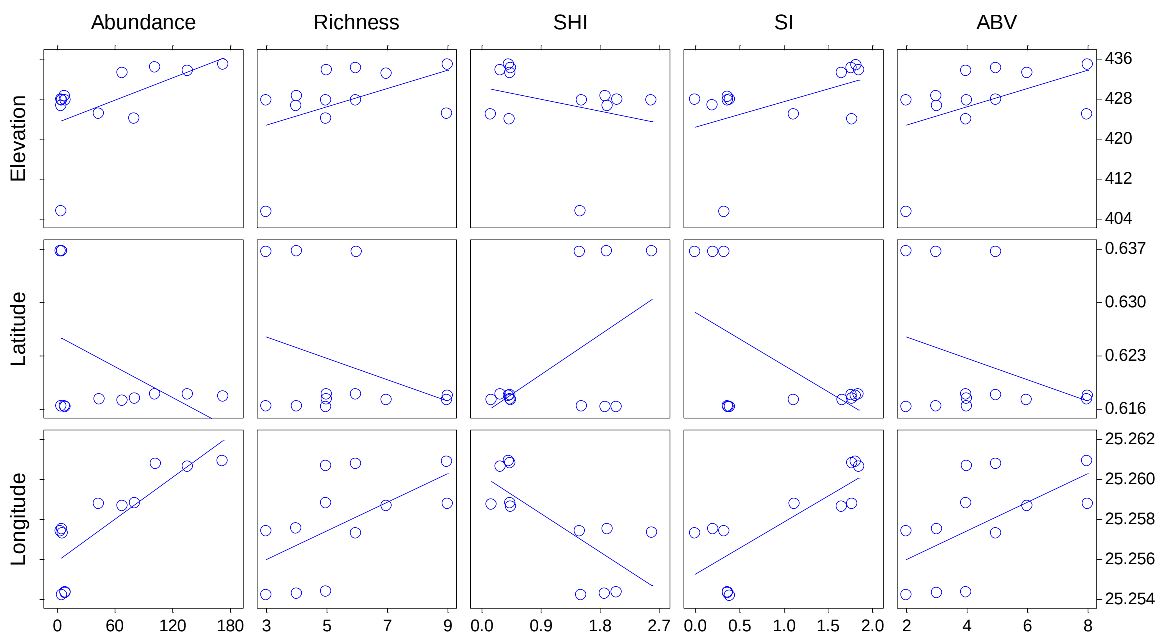


Figure 8. Relationships (linear) between butterflies abundance, richness, and geographic coordinates.

with the exception of SI which negatively correlated with latitude (R^2=0.35). Abundance, richness, SI and ABV either positively or negatively correlated with longitude with coefficient of determination (R^2) ranging between 0.34 and 0.69, implying that 34 to 69% of the variability in butterfly species abundance, richness and biodiversity was due to longitude. The linear relationships between butterflies abundance, species richness and biodiversity are as shown in Figure 7 (among themselves) and Figure 8 for their relationships with geographic coordinates.

Effect of land use type on butterfly abundance and biodiversity as affected by sampling site

To better assess the effect of land use type on butterfly

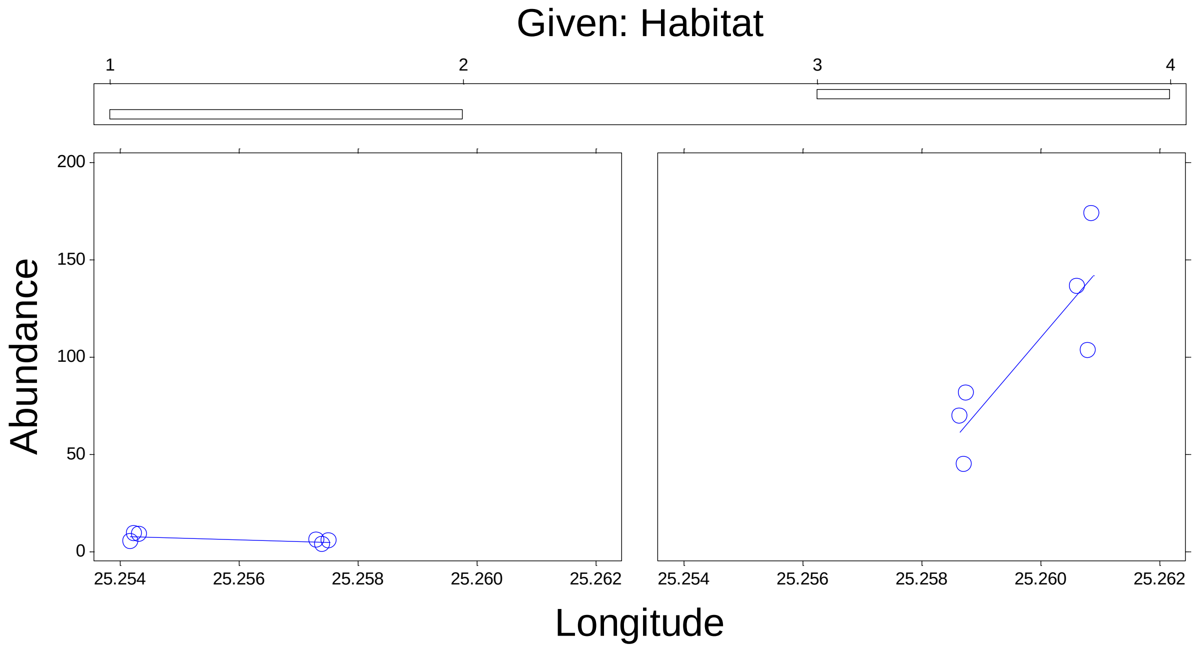


Figure 9. Effect of land use type (LUT) on butterflies abundance as affected by geographic coordinates (longitude). LUT: 1=Primary forest, 2=Secondary forest, 3=Agricultural field, 4=Fallow.

abundance by sampling site as represented by geographic coordinates (longitude), a co-plot was produced (Figure 9). The plot shows that in the primary forest and secondary forest (land use types 1 and 2), butterfly abundance decreased as longitude increased, but the relationship was not strong enough. However, in the agricultural field and the fallow (land use types 3 and 4), butterfly abundance increased as longitude increased with a very clear linear trend. Similar to abundance, a co-plot was also produced (Figure 10) to better assess the effect of land use type on butterfly biodiversity (SI) as affected by geographic coordinates (longitude). The figure shows a similar trend to that observed for abundance in Figure 9, but with more clear results. As for abundance, in the primary forest and the secondary forest (land use types 1 and 2), SI decreased as longitude increased. However, in the agricultural field and the fallow (land use types 3 and 4), SI increased with increasing longitude. It is therefore clear that longitude is a controlling factor for butterfly abundance and biodiversity at Masako Forest Reserve.

DISCUSSION

Butterflies abundance and biodiversity were higher in the fallow as compared to the primary forest. This is understandable as the fallow contained more flowering plants at this time of the year, greater plant diversity and therefore attracted more butterflies. However, our results disagree with those reported by Stork et al. (2003) who studied butterfly diversity and silvicultural practices in lowland rainforests of Southern Cameroon. Their plots included a cleared and unplanted farm fallow, cleared and replanted forest plots, and uncleared forest plots. The replanted plots were line-planted with *Terminalia ivorensis*, but differed in the degree and method of clearance. They found that sites with the greatest degree of disturbance and lowest level of tree cover had the lowest number of individuals and species of butterflies. The farm fallow had substantially fewer individuals and species of butterflies than the other plots. The replanted plots were intermediate between the farm fallow and uncleared forest in terms of abundance, richness and composition. Barlow et al. (2007) evaluated the value of primary, secondary and plantation forests for fruit-feeding butterflies in the Brazilian Amazon. They recorded 10587 butterflies and 128 species in 3200 trap-days. Species richness was the highest in primary forest and lowest in plantations, while butterfly abundance showed the opposite response. Finally, Hamer and Hill (2000) analysed a number of studies comparing tropical butterfly communities in logged and unlogged forests and found that in some studies butterflies abundance and diversity were greater in unlogged forests (Holloway et al., 1992; Hill et al., 1995) while in other studies were less in unlogged forests (Raguso and LLorente-Bousquets, 1990; Hamer, 1997) and sometimes the same in both

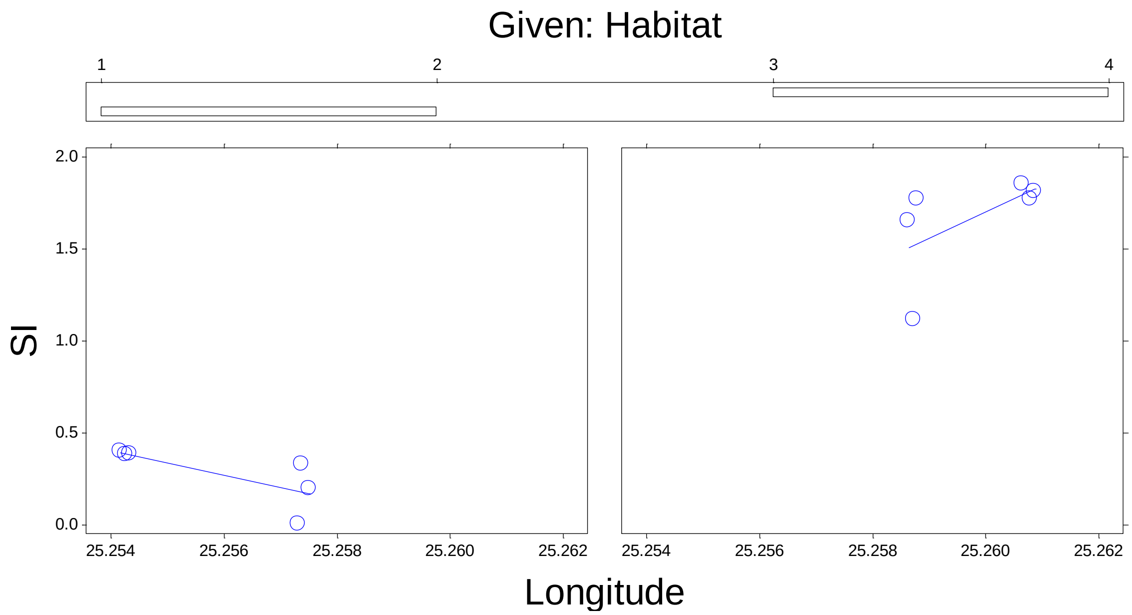


Figure 10. Effect of land use type (LUT) on butterflies biodiversity (SI) as affected by geographic coordinates (longitude). LUT: 1=Primary forest, 2=Secondary forest, 3=Agricultural field; 4=Fallow.

logged and unlogged forests (Wolda, 1987). Their analyses of these studies showed that the effects of forest disturbance on species diversity are heavily scale dependent. They found that both species richness and species evenness increased at a significantly greater rate with spatial scale in unlogged forest than in logged forest. Although, not significantly different, but in magnitude, butterflies abundance and diversity were higher in secondary as compared to the primary forest. Other studies have also examined butterflies in secondary vs. native forest and reported both higher (Bowman et al., 1990; Lawton et al., 1998; Ramos, 2000; Fermon et al., 2005; Bobo et al., 2006) and lower (Schulze et al., 2004; Veddeler et al., 2005) levels of species diversity and richness in the secondary forest as compared to native forest. Butterflies abundance, species richness and biodiversity were all correlated with longitude. Although the latitudinal gradient of species richness is well documented for a variety of taxa in both terrestrial and aquatic environs (Willig, 2000; Brown et al., 1996) and that both environmental and geographical factors affect the distribution of species (Dennis et al., 2000), no study was found assessing the relationship between longitude and butterflies species. However, Storch et al. (2003) studied the distribution patterns in butterflies and birds of the Czech Republic, separating the effects of habitat and geographical position. They reported that latitude and longitude invariably accounted for a large proportion of total variance for butterfly distribution, and their effect was highly significant even after controlling for the effect of all other environmental factors.

Implications for conservation

Previous studies have yielded opposing results as to the effect of land use type on butterfly abundance, species richness and biodiversity (Stork et al., 2003; Barlow et al., 2007; Hamer and Hill, 2000; Holloway et al., 1992; Hill et al., 1995; Raguso and Llorente-Bousquets, 1990; Hamer et al., 1997; Wolda, 1987; Bowman et al., 1990; Lawton et al., 1998; Ramos, 2000; Fermon et al., 2005; Bobo et al., 2006; Schulze et al., 2004; Veddeler et al., 2005). This study has found that the fallow (disturbed) had the highest butterfly abundance and biodiversity as compared to the primary forest (undisturbed), therefore confirming some of the previous results while contracting other ones. The study also found that geographic coordinate (longitude) was a controlling factor for butterfly abundance, species richness and biodiversity, but this relationship varied with land use type. Although similar and opposed results to the findings of this study have been reported by other researchers, it is suggested that further studies be conducted at Masako Forest Reserve.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors would like to thank the University of

Kisangani for allowing access to Masako Forest Reserve to conduct this study. Special thanks to the faculty of the Postgraduate Certificate Program in Ecological Survey Techniques at the University of Oxford for their comments and guidance in the conduct of this work.

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Vol. 10(3), pp. 145-153, March 2018
DOI: 10.5897/IJBC2015.0827
Article Number: 5DD646F56153
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Impacts of anthropogenic pressures on wildlife in the northern sector of the National Park of Mbam and Djerem, Adamaou Cameroon

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Received 3 March, 2015; Accepted 4 November, 2015

The study on the assessment of the scale of human pressure on wildlife in the Mbam and Djerem National Park was conducted between December 2012 and April 2013. This evaluation has relied on a review of seven reports ecological monitoring produced by Wildlife Conservation Society between 2006 and 2012, and direct observations. Results show that: the main causes of the reduction of wildlife are poaching (60.5%), transhumance (16.5%), illegal fishing (10.9%) and uncontrolled bush fires (1.5%). In terms of relative abundance of human activities, it was found that the number of human indexes droped from 232 in 2006 to 109 in 2009 and 109 to 82 in 2012 as well as wildlife or encounter rate per kilometer species activity signs indicated a high relative abundance of elephants has increased from 1,008 in 2006 to 2.18 in 2009 and 2.18 to 5.80 in 2012 followed by buffalo and hocheur general, activities anthropogenic influences negatively but very weak wildlife (r = -0.06). This influence is positive and is higher among *Loxodonta africana* (r = 0.9), *Pan troglodytes* (r = 0.6), Greater spot-nosed monkey (r = 0.4), low in *Syncerus caffer* (r = 0.1) and Red river hog (r = 0.05) between 2006 and 2012, a reduction of human activities 64.7% was observed. To reduce the impact of human activities on wildlife, it is desirable to strengthen the monitoring of livestock in the park and the fight against poaching device.

Key words: Human activities, Wildlife, Mbam and Djerem National Park, ecological monitoring.

INTRODUCTION

The loss of biodiversity is among the issues of concern to humanity (Vounserbo, 2011). The evaluation of the Millennium Ecosystem indicates the considerable loss of biodiversity, with about 10 to 30% of mammal species, avian and endangered amphibians, and degradation of 15 of the 24 services provided by ecosystems (Rhodes and Muller, 2005). The consideration of conservation measures and the implementation of actions to protect the structure, functions and diversity of natural systems become an imperative (Koagne, 2009). In Cameroon, protected areas and hunting areas represent more than 9 million ha or 19.2% of permanent forest estate (Ntsogo, 2011). Unfortunately, while the number and size of protected areas (PAs) increase, biodiversity meanwhile

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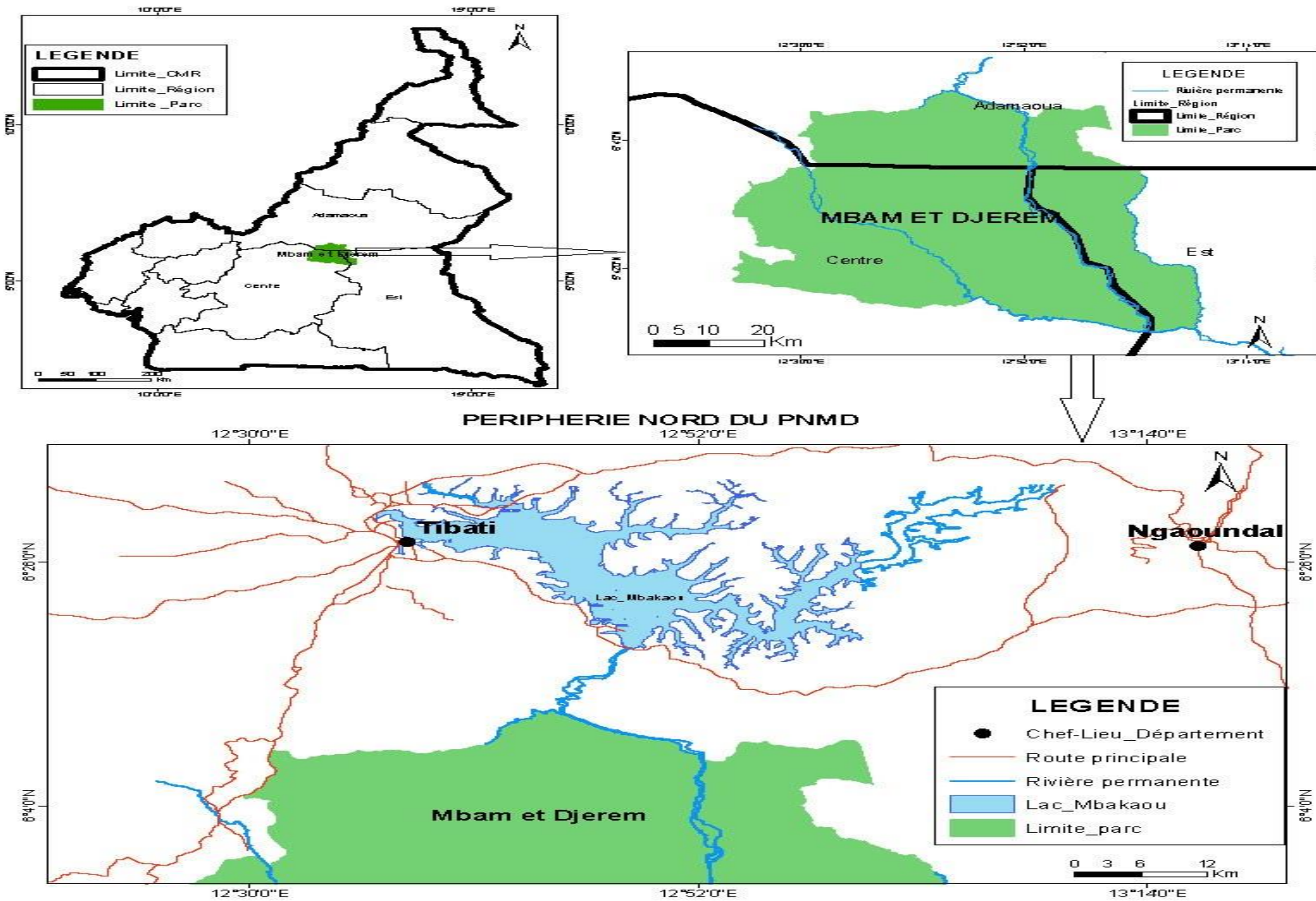

Figure 1. Map of Cameroon showing MDNP and northern study area Map of Cameroon showing the study area.

continues to decline (UNEP / CBD, 2008). Hence,the need for the evaluation of the management efficiency. Located at the ecotone forest - savannah, the Mbam and Djerem National Park (MDNP) abounds important biodiversity including both species of forest, savanna and ubiquitous (MINFOF, 2008). This is an undervalued area for tourism and an important fishing area with an annual production of 171.360 tonnes (Dadem, 2011). Unfortunately, it faces many threats: poaching, overgrazing and uncontrolled bush fires (MINFOF, 2008). This study aims to evaluate the influence of human activities on wildlife in the Mbam and Djerem National Park.

MATERIALS AND METHODS

This study was carried out in the northern sector of the Mbam and Djerem National Park (MDNP) (Figure 1). The climate is Sudano Guinean type, rainfall of 1500 mm/year and the temperature ranges from 23 to 24°C (MINFOF 2008). This park contains the northern boundary of the tropical rainforest, galleries and riparian forests, woodlands, shrublands and marshy meadows. MDNP, due to its location in the contact area forest / savannah, is home to a rich fauna including species suitable for forest and savanna species characteristics and the complex of species associated with transition between mosaics two zones. About 60 species of mammals have been recorded in MDNP (MINFOF, 2008).More than 360 species of birds belonging to 53 families are present in the MDNP (MINFOF, 2008) Approximately,*33*species fish were observed in the MDNP area (Dadem, 2011)

Data collection method to identify the different activities practiced in the park, a survey was conducted among stakeholders and consulted reports. The surveys were supplemented by direct observation. The choice was based on reports of the 08 areas of intervention of the activity. A total of 7 reports were stripped and thus covering 06 axes tracking because some of the ecological monitoring system activities take place simultaneously. The data collected in each report concerned the methodology used; indicators, logistics. These data were grouped according to their period of realization. The data from the results of all related activities in the database given and annual reports of ecological monitoring activities conducted between 2006 and 2012 were used to calculate the Mileage of Abundance Indices (MAI) of human activities and wild fauna in the study area. The correlations between the abundance of different human activities and the wildlife provided an idea about the type of relationship between the variables of the study. Inventory data associated with those questionnaires provided information on human pressure and other factors that threaten the wildlife in the study area.

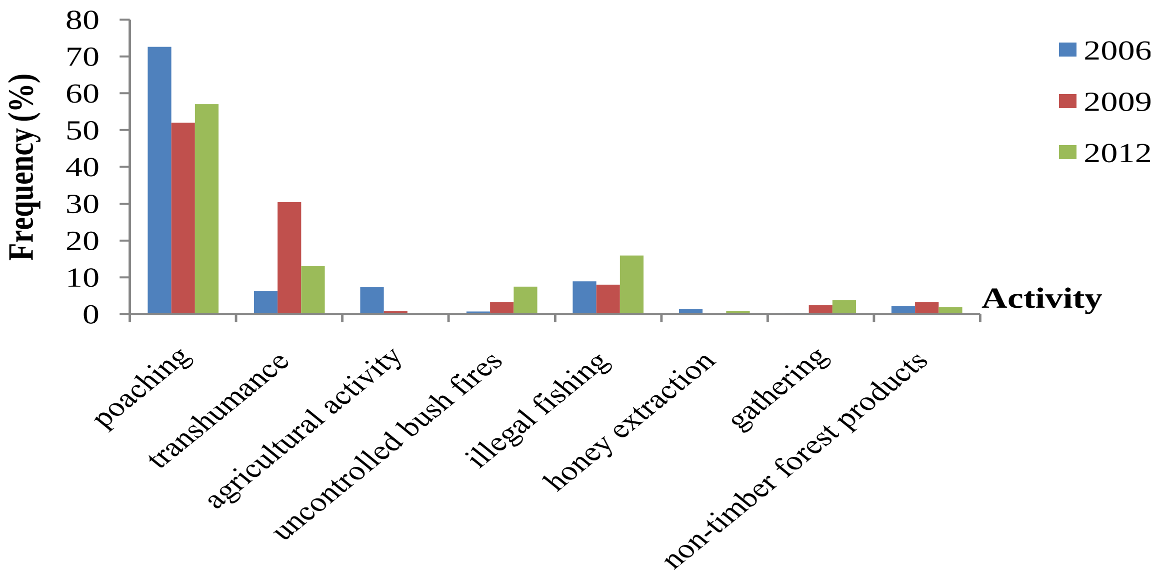

Figure 2. Evolution of human activities in the park in 2006, 2009 and 2012.

Data analysis

The test of Analysis of Variance (ANOVA one way) was used to compare the mean indices MAI (IKA) between years in the Statistica 8.0 software probability level of 5%. The influence of anthropogenic activities on wildlife has been rated according to the Pearson correlation coefficient between AH and MAI wildlife.

RESULTS

Activities practiced in the northern part of MDNP

Eight types of human activities in the northern part of MDNP were identified, all of which are forms of pressure on the natural resources of this protected area. Five of them come from extractive activities carried either on wildlife (it comes to hunting and fishing) on flora (collection of medicinal plants, honey extraction, etc.). Two of them fall under the occupation of the protected area and its transformation to anthropogenic purpose, it is: (a) bushfire made as part of agricultural burning to encourage cattle grazing; (b) transhumance herds. These specific activities are legal and the other illegal.

Legal activities in the park

Fishing and ecotourism are the legal activities taking place in DMNP. This activity is practiced along the river in Djerem MDNP and presents the clauses, sanctions and litigation settlements. Fishing along River Djerem in the park is not always successful in achieving the objectives. They face certain realities (fishing closure period, the complicity of poaching and diversion of materials belonging to the group.) that constitutes obstacles for their good progress, according to the different clauses.

Illegal activities in the park

The evaluation of the integrity of the park through the determination of indices human activities encountered. These indexes are shown in Figure 2.

Human activities such as poaching, agricultural activity, honey extraction were high in 2006. Poaching experienced a decrease or disappearance (honey extraction) in 2009 before recovering in 2012. Activities such as pastoral activity, bush fire, removal of bark, gathering and pickups were low in 2006. Despite these movements, these activities have increased in 2009. Activities such as agriculture in completions disappeared in 2012 while poaching and illegal fishing experiencing an increase in new. This could be justified by several reasons: The year 2006 is the year of preparation of the management plan that aims to guide ecological monitoring activities. Monitoring becomes from that moment better organized in the park. The increase in poaching and illegal fishing in 2012 could be due to the reduction of patrol effort during the year following the reduction in the number of eco-guards. Intensification of bushfires would end search of grazing steers which has increased to 2012.

Influence of human activities in the park

Influence of legal activities

The evolution of the number of fishermen seized in the

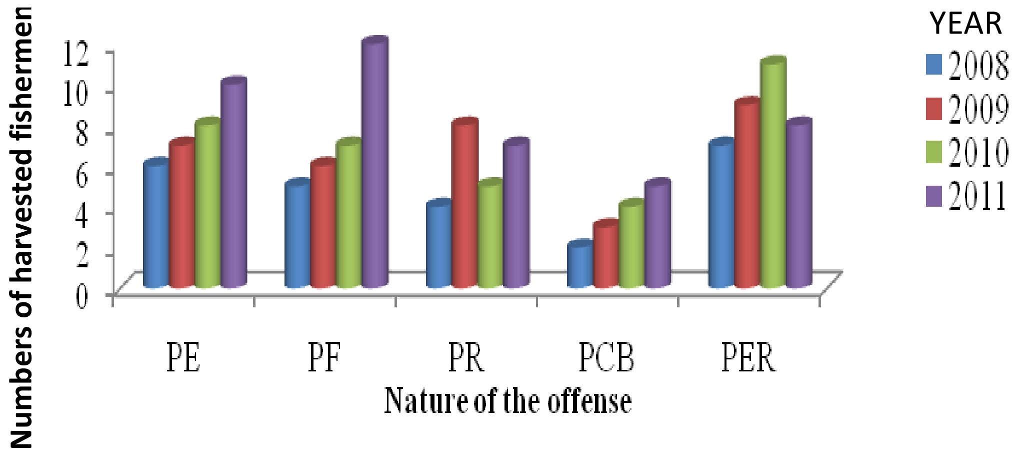

Figure 3. Distribution of fishermen calls the park depending on the nature of the offense from 2008 to 2011. PE = Fishermen carrying hunting in the park, PF = Fishermen in the closing period, PR = Fisherman engaged in breeding area, PCB = Fishermen poaching complicit with persons not members of ICG, PER = Fishermen using unregulated gear.

park depending on the nature of the offense from 2008 to 2011 (Figure 3) up between 2008 and 2011 the number of fishermen - poachers in a closed time fishermen, fishermen breeding area, accomplice fishermen poaching has increased. While between 2008 and 2010 the number of fishermen using unregulated gear increased before falling in 2011. The increase in the number of fishermen in the Park offense could be due to the fact they do not have premium when he denounced cases of infringement and non-regularity of eco-guards along the rivers following the failure of their work force. Faced with the failure of the responsible ICM denounce those responsible infringing or to take appropriate measures, the conservation service decided the suspension of fishing activities for the first year from April to June 2012 (Fotso et al., 2012).

Influence of illegal activities

The comparison of the abundance of signs of human activity between 2006, 2009 and 2012 (Table 1) shows that the number of human indexes rose from 232 in 2006 to 82 in 2012 representing a 64.65% reduction in this part the park. In a general way, MAI human activities are increasing in the northern part of MDNP to the periphery. But average variance analysis of MIA of all human activities, it results in a non-significant difference between years (one way ANOVA: F2; 26 = 0.18823; P = 0.82955). These averages vary from one year to the next (higher in 2006 (0.700) decreases in 2009 (0.458) and increases in 2012 (0.721). Despite its protected area status, local residents of this park does not prevent from entering and hunting. An MIA human activity has undergone a 2009 increase of 0.263 in 2012. The difference in MAI values between the two years is explained by the fact that there are more efforts by NGOs to park conservation in this period. But after this success, the conservatives have provided more extra effort, which has resulted in an enhancement of illegal activities in the park in 2012. Comparing pairs MAI of all human activities in different years, the average MAI of all human activities in 2006 (0.700) is not significantly different from that recorded in 2009 (0.458) (Tukey pairwise test: p > 0.05). Similarly, the average of MAI human activity in 2006 (0.700) is significantly different from that of 2012 (0.721) (Tukey pairwise test: p> 0.05). It is the same, average MIA of all human activities in 2009 (0.458) and those of 2012 (0.721) are also not significantly different (Tukey pairwise test: p = 0.05). These statistical analyzes, we can say that the people in the study area are aware that MDNP is a protected area, so go there sporadically. MAI human activity throughout the study area in 2012 is 0.721.

Trends in abundance of wildlife in the MDNP

MILEAGE index of abundance different wildlife groups encountered (seen and heard) in the study area between 2006, 2009 and 2012 (Table 2) shows that in 2006, the most abundant species are composed of *Cephalophus (ogylbi*, nigrifons, dorsalis) with Meter abundance index (MIA) is 2.318. It is followed by *Syncerus caffer* (1.048); followed *Loxodonta africana* (1.008), *Kobuskob* (0.960) *Cephalophus monticola* (0.606). The least represented species *Cercopithecus erythrotis* (0.007) *Vivera civetta* (0.004), *Hippopotamus amphibius* (0.004). In 2009, *Loxodonta africana* (2,180) heads followed *Syncerus caffer* (0.927) and *Pan troglodytes* (0.343) and *Ceropithecus nictitan* (0.342). *Tragelaphus scriptus* (0.008). In 2012, *L. africana* (5.805) leads followed *S. caffer* (0.839), then *C. nictitans* (0.582) and the *P.*

Table 1. Abundance of signs of human activity between 2006, 2009 and 2012.

Activity	2006			2009			2012		
	N	DP (Km)	MIA	N	DP (Km)	MIA	N	D P(Km)	MIA
Camp	20	331.18	0.060	1	237.58	0.004	0	113.64	0
Shot	2	331.18	0.006	7	237.58	0.029	3	113.64	0.026
Machete cutting	79	331.18	0.238	0	237.58	0	1	113.64	0.008
Cartridge case	3	331.18	0.009	39	237.58	0.164	33	113.64	0.290
Tree barking	1	331.18	0.003	3	237.58	0.012	4	113.64	0.035
Honey extraction	0	331.18	0	0	237.58	0	1	113.64	0.008
Traps	23	331.18	0.069	0	237.58	0	2	113.64	0.017
Track	56	331.18	0.169	7	237.58	0.029	2	113.64	0.017
Presence shepherds	17	331.18	0.051	38	237.58	0.159	14	113.64	0.123
Abandoned village	1	331.18	0.003	1	237.58	0.004	12	113.64	0.105
Footprint	12	331.18	0.036	0	237.58	0	1	113.64	0.008
Fire	2	331.18	0.006	0	237.58	0	0	113.64	0
Direct observation	10	331.18	0.030	0	237.58	0	0	113.64	0
Pick up and picking	5	331.18	0.015	3	237.58	0.012	2	113.64	0.017
Total	232	331.18	0.700	109	237.58	0.458	82	213.64	0.721

DP, Distance; N, Number of indices; MIA, MILEAGE index of abundance.

troglodytes (0.462). The least represented are *T. scriptus* (0.005), De *Cercopithecus neglectus* monkey (0.005), *C. monticola* (0.005) Grivet (0.005), *Cercopithecus ascanus* (0.001).The distribution of the values of the encounter rate per kilometer (MIA) activity signs of these species shows a fairly high relative abundance of elephants, buffaloes and followed hocheur between 2006 and 2012. The other species of large mammals (giant forest dog, black-fronted duiker, Sitatunga, water Chevrotain, water-buck and Kobe are poorly represented and endangered. the sharp decline duikers can be explained by the fact that these species are the most seized during patrols as WCS confirms (2000) shows that around the Bayang-Mbo sanctuary duikers represent about 36% of all animals in the hands of hunters. Based on the comparison of the average attendance indices species recorded by recce made from the analysis of variance, it follows that there is no significant difference between years (One-way ANOVA, F2 26 = 0.397, p = 0.675). The northern part of MDNP keeps better wildlife potential compared to the rest of the site (MDNP). Study for 48 species of large and medium mammals enumerated on the ecological survival 2009 '(Fotso et al., 2009), 22 of these species if found. 2.3. Correlation between human activities and wildlife watching Correlation coefficients were calculated and tested for a threshold of 5%. Correlations between IKA human activities and those of wildlife (Table 3) shows that human activities influence negatively but very weak wildlife (r = -0.06). This influence is positive and is higher among L. africana (r = 0.9), Pantroglodytes (r = 0.6), Greater spot-nosed monkey (r = 0.4), low in *S. caffer* (r = 0.1). This may be due to the type tools used for hunting where the type of plant found in the area.

Correlation between human activity and wildlife observation

Correlation coefficients were calculated and tested at a 5% level in order to know what is the influence of human activities on the presence of wildlife. According to these figures, the correlations between the MIA wildlife and those human activities positive and vary. It there's a very strong positive correlation between the MIA wildlife and human activity between 2012 (r = 0, 87) and the 2006 (r = 0, 59). Positive correlations between MIA wildlife and human activity of 2012 (r = 0.87) and of 2009 (r = 0.29) can be explained by the fact that hunters the study area preferentially operate in areas where game abounds. There is a very low density of animals near villages, who go there are species of primates that refuel in crop fields. As one moves away from the villages, human activities are becoming rarer and wildlife observations increasingly important. Around the poaching camps and in areas of high traffic of livestock, wildlife sightings are rare

DISCUSSION

Poaching

Several lines were encountered including traps, son of steels, active or abandoned encampments, abandoned trophies, fingerprints and even poachers seized between 2006 and 2012. It should be noted that all other activities in the park together for poaching because the farmer or the fisherman may have recourse to wild animals for food. Poaching is as one of the most important show the

Table 2. Comparison: MIA wildlife MDNP in 2006, 2009 and 2012.

Order	Scientific name	Common name	MIA 2006	MIA 2009	:MIA 2012
Probocidae	*Loxodontaafricana*	Elephant	1.008	2.180	5.805
Ungulate	*Synceruscaffer*	Buffalo	1.048	0.927	0.839
Primate	*Ceropithecusnictitans*	Hocheur	0.375	0.342	0.582
Primate	*Pan troglodytes*	Chimpanzee	0.166	0.343	0.462
Primate	*Papioanubis*	Baboon	0.658	0.411	0.389
Ungulate	*potamochoerusporcus*	Bushpig	0.382	0.414	0.328
Ungulate	*Kobuskob*	Cob de buffon	0.960	0.131	0.243
Primate	*Lophocebusalbigena*	Cercojousgrises	0	0	0.197
Ungulate	*Tragelophuseuryceros*	Bongo	0.439	0.463	0.179
Primate	*Colobusguereza*	Colobeguereza	0.185	0.127	0.104
Rodent	*Manis gigantea*	Giant pangolin	0.032	0.199	0.091
Ungulate	*Cephalophus(.ogylbi,. nigrifons,. dorsalis)*	Red Ceph	2.318	0.045	0.070
Ungulate	*Phacochoerusafricanus*	Warthog	0.456	0.074	0.052
Ungulate	*Hippopotamus amphibius*	Hippopotamous	0.004	0	0.049
Primate	*Cercopithecuspogonias*	Monkey courroné	0.029	0.067	0.035
Rodent	*Atherurusafricanus*	Brush-tailed porcupine	0.222	0.082	0.026
Ungulate	*Civettavivera*	Chive	0.004	0.002	0.023
Ungulate	*Cephalophussylvicultor*	Ceph has yellow back	0.279	0	0.011
Primate	*Miopithecustalapoin*	Talapoin	0.010	0	0.011
Rodent	*Orycteropusafer*	Orycterop	0.050	0.042	0.011
Rodent	*Melivoracapensis*	Ratel	0	0	0.006
Ungulate	*Tragelaphusscriptus*	Guibanarche	0.277	0.008	0.005
Primate	*Cercopithecusneglectus*	Brazza monkey	0.014	0.009	0.005
Ungulate	*Cephalophusmonticola*	Ceph blue	0.606	0	0.005
Primate	*Chlorocebusaethiops*	Tantalus	0	0	0.005
Primate	*Cercopithecusascanus*	Monkey ascan	0	0	0.001
Ungulate	*Hylochoerusmeinertzhageni*	Giant forest hog	0.010	0.011	0
Ungulate	*Tragelophusspekei*	Sitatunga	0.036	0.012	0
Ungulate	*Hyemoschusaquaticus*	Water chevrotain	0.021	0	0
Ungulate	*Kobusellipsiprymnus*	Black-fronted Ceph	0.037	0	0
Primate	*Cercopithecuserythrotis*	Kobe defassa	0.007	0	0
	Total		**9.645**	**5.896**	**9.547**

MIA, MILEAGE index of abundance.

traps, guns and smoked meat seized from the hands of poachers. These hunting objects testify heavy pressure from poaching in the area. The talks held with heads of households and hunters have identified the origin and causes of poaching, the development adheres to three main causes:

1. Easy access to firearms;
2. A great demand for bushmeat and marketing of hunting products;
3. Low income and few opportunities for peripheral populations.

Given these factors favorable to poaching, the responses of park managers are more limited: The human resources are too small (fifteen ecoguards) for an area of (90,620 ha) (the material means of monitoring also insufficient (three motorbikes). It is therefore not surprising place irregular intrusion populations within the park, causing heavy poaching.

Pastoral action

The MDNP is covered with lush vegetation that forms an abundant forage and quality. From the transhumance corridor not far from the road, pastoralists are accessing the park. Herds of cattle from Ngaoundere Cameroon and other region are a widespread phenomenon. The number of livestock is increasing every year. This could be explained by: (1) Good control of various animal diseases; (2) The availability of forage with permanent

Table 3. Correlation between IKA wildlife and those of human activities.

Specie	Human activity	Correlation coefficient between HA and MAI Specie (r)
Elephant	Human activity	0.983
Buffle	Human activity	0.106
Hocheur	Human activity	0.401
Chimpanzee	Human activity	0.636
Babouin	Human activity	0.090
Potamochere	Human activity	0.050
Cob de buffon	Human activity	-0.4
Cerco jous grises	Human activity	0.020
Bongo	Human activity	-0.166
Colobe guereza	Human activity	-0.330
Pangolin geant	Human activity	-0.290
Ceph roux	Human activity	-0.364
Phacochere	Human activity	-0.580
Hippopotame	Human activity	0.263
Singe courroné	Human activity	0.090
Atherure	Human activity	0.050
Civette	Human activity	-0.080
Ceph a dos jaune	Human activity	-0.330
Talapoin	Human activity	0.020
Orycterop	Human activity	-0.250
Ratel	Human activity	0.020
Guib anarche	Human activity	-0.177
Singe de Brazza	Human activity	-0.070
Ceph bleu	Human activity	-0.580
Tantalus	Human activity	0.070
singe d'ascan	Human activity	0.290
hylochère	Human activity	-0.364
Sitatunga	Human activity	- 0.58
Chevrotain aquatique	Human activity	-0.270
Céph à front noir	Human activity	-0.315
Kobe défassa	Human activity	-0.430
Toute la faune	Human activity	-0.061

waterholes in the park that are all points of attraction for pets. During the course of several signs recce were found in the area: All pastures, areas around pools, water points, the banks of the river shows many traces of passage of these animals (pruned plant species, the pollarded trees, herder camps, etc.). The herds of cattle met in the park between 2006 and 2012 mainly in the dry season reflect the actual presence of the transhumance in the park. The intense trampling of herds compacts the soil and prevents regeneration. This obviously has implications for the wildlife that must undergo disturbances perpetrated by livestock and humans. The grazing pressure is the second activity after poaching (Figure 3) .This is due to the fact that breeding is the second largest economy of the study area (MINFOF, 2008). It is practiced by a Bororo and is essentially extensive type. The results of the ecological monitoring from 2006 to 2012 estimated the total number of cattle present in the 3536 average headers park, with a minimum of 300 and a maximum of 11,000 head respectively for the years 2012 and 2008 to Inside the park, and the numbers of cattle entered in the livestock service database is 10,000 head for 2012 on the outskirts of the park (MINEPIA, 2012). These results indicate that the protected area is used by farmers as a grazing area.

The presence of livestock in the park is a threat to ecosystems and species due to disturbance of wildlife and flora, competition of wildlife and livestock for food resources, the risk of transmission of Epizooties wildlife, risk of poisoning of large carnivores by breeders, poaching, etc. The penetration of the park by domestic livestock is one of the main activities noted. This pressure significantly disrupts fauna have already experienced the effects of an increase in poaching in the recent past according to several observers (Hassan, 1998; Bene et al, 2007). In the areas most frequented by breeders, there was a very low frequency of wildlife. The cohabitation between wild and domestic fauna entails the risk of contamination of wildlife rinderpest (Depierre and Vivien, 1992). The invasion seems widespread in the region. The herder camps have been observed in other areas when walking inventories of 2006, 2009 and 2012 (Fotso et al., 2012). Practiced too intensely, it can kill trees and initiate the phenomenon of decrease in vegetation cover. The passage of livestock so not only causes a disturbance to wildlife, but also a deterioration of its space (IUCN, 2009). It seems that farmers are heavy users of fires to encourage young shoots appreciated by their livestock. Thus, tree felling and the use of fire may encourage poaching. The various decentralized services of the area must work in synergy in local development to define a grazing area with permanent water in the locality.

Bushfires

Bushfires are a phenomenon of the savannas of the entire Far North region. In general, they are lit by man (farmer, hunter) for the following reasons: Herbaceous carpet cleaning to facilitate access for young volunteers, pasture improvement by removing shrubs, opening vegetation for hunting. They represent the third activity from above park. We can report that there are three types of bush fire early fire, fire midseason and late fire. The most destructive and also the most used is the late fire that can travel dozens of kilometers with the result, destruction of vegetation cover. and wildlife, accelerated erosion, especially in areas rugged and strong rainfall, humus destruction leading to loss of soil fertility, depletion of flora by destroying the seeds of annuals.

Honey extraction

Two main operating techniques are observed in the field. The first is to kill host trees bees (*Uapaca togolinsis*, *Daniellia oliveri*, *Afzelia africana*, *Parkia biglobosa*, *Lannea kerstingii*) and laying them on the ground before honey extraction. The second technique is used if the hive is low: The diameter of the hole is increased without cutting down the tree. This activity is the final activity after picking and gathering (Figure 13). But honey collection poses no problem with the use of fire to chase the bees. And these lights are another serious obstacle to the management of habitats and species. Bushfires are a consequence of ignorance of the issues by the residents of peripheral areas and from the fact that this practice is culturally rooted enough. It is often associated poaching.

Gathering and collection

The collection mainly concerns some bee (*Apis mellifera*) the honey is highly prized and wild yam tubers (Dioscorea sp.) And wine borassus (*Borassus aethiopum*). The collection covers several products: caterpillars, the pepper of Ethiopia (*Xylopia aethiopica*), mushrooms, pepper Africa (Piper guineense), fruits of the Aiélé (Canarium schweinfurthii) foliolles bamboo and rattan. This activity is the fifth activity of the park according to the results of ecological followed.

Bark collection

The collection of medicinal plants: Survey results and observations in the field have shown that local residents use non-timber forest products (roots, bark and leaves) in traditional medicine. Also, the demand for traditional medicines in the study area recorded an increase due to population growth and the high cost of western medicine. This information was given by resource persons (traditional healers) in investigations. According to the results of the recce, this activity represents the fourth activity encountered in the park.

Impact on wildlife

Referring to previous work in the study area, the trend is generally densities to growth for most species, with the exception of primates It is always demonstrated that poaching pressure (Hassan, 1998) are still a threat to the conservation center. On average 0.72 signs of anthropogenic activities kilometer in the National Park of Mbam and Djerem. Compared to sites outside protected areas, MDNP undergoes less human pressure. Nevertheless, the relatively high intensity of human activities sectors correspond low abundances of animal activities. These areas are found near villages and ease of access by river from Djerem. Pressure poles are oriented sectors relatively high abundance of mammals, and are characterized by high values of IKA human activities. These pressure poles are found to the south and east. Furthermore, the central area have relatively stable. They are characterized by encounter rate of wild fauna high enough superimposed on human pressure.

CONCLUSION

The Mbam and Djerem National Park compared to other sites in the region is relatively rich in individuals of species of large mammals and means, and undergoes less human pressure. The encounter rate per km of anthropogenic signs of activity and those of all species of mammals combined is respectively 0.72 and 9.547. The spatial distribution of human activities and those of wildlife generally made out shows a correlation between the relative intensity of human activities and that of animal activities. The main cause of the decline of human activities derive from the supervision and control of the illegal exploitation of wildlife resources from fixed and mobile patrols in the MDNP and its peripheral area between September 2006 and 2012: The patrol effort followed a generally increasing trend;· control in fixed barriers was achieved mainly during the day,· leading to the development by poachers opportunities for circumvention night. Poaching offenses were more observed in the southern and eastern areas, with an increasing trend in the South. The number of destroyed hunting camps followed a growing trend.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

This work was carried out with funding from PAAPNMD/ WCS, with the active collaboration of eco-guards and teachers of the Department of Forestry of the FASA of Dschang University. The authors thank the leaders of these organizations.

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