ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt

International Journal of Applied Sciences and Biotechnology (IJASBT)

Research Article

Assessment of Terrestrial Small Mammals in an Agro-industrial Company Concession, Western Liberia

Kouame Bertin Akpatou[1], Kouakou Hilaire Bohoussou[2]*, Jean-Claude Koffi Bene[3]

[1]Laboratoire de Zoologie et Biologie Animale, UFR Biosciences, Université Félix Houphouët-Boigny, Abidjan, 22 BP 582 Abidjan 22, Côte d'Ivoire.
[2]UFR Ingénierie Agronomique, Forestière et Environnementale, Université de Man, BP 20 Man, Côte d'Ivoire.
[3]Laboratoire de Biodiversité et gestion durable des Ecosystèmes Tropicaux, UFR Environnement, Université Jean Lorougnon Guédé, BP 150 Daloa, Côte d'Ivoire.

Article Information

Received: 12 September 2019
Revised version received: 02 December 2019
Accepted: 09 December 2019
Published: 28 December 2019

Cite this article as:
K.B. Akpatou et al. (2019) Int. J. Appl. Sci. Biotechnol. Vol 7(4): 434-439. DOI: 10.3126/ijasbt.v7i4.25581

***Corresponding author**
Kouakou Hilaire Bohoussou,
UFR Ingénierie Agronomique, Forestière et Environnementale, Université de Man, BP 20 Man, Côte d'Ivoire.
Email: kbohoussouhil@gmail.com

Peer reviewed under authority of IJASBT

Abstract

This study was conducted in a global context of biological assessment of potential oil palm plantation development in western Liberia. It has been recommended as a complementary study to design a biological baseline prior to the development of oil palm plantations. It is based on "Terrestrial small mammals" biological model. Thus, terrestrial small mammal richness and abundance were assessed in Sime Darby palm oil company Concession at Bong and Gbarpolu counties in western Liberia. Conventional live-trapped methods using mainly pitfalls and Sherman traps were used to investigate terrestrial small mammals. The combination of these two methods allowed the capture of 76 specimens belonging to 11 species. The most frequent species was *Crocidura jouvenetae* (39.47 %) followed by *Hylomyscus simus* (14.47 %) and *Hybomys planifrons* (10.53 %). Small mammal communities were globally dominated by forest species (*Crocidura eburnea, Crocidura jouvenetae, Crocidura muricauda, Crocidura obscurior, Dephomys defua, Hybomys planifrons, Hylomyscus simus* and *Mus setulosus*), which indicates the lower level of forest degradation at this area. These species of rodent and shrew are threatened to disappear due to the conversion of their habitats to palm oil plantations. It is highly recommended that the company preserve intact primary forest relics within oil palm plantations in order to conserve representative sample local biodiversity.

Keywords: Rodent; Shrew; Biodiversity; rainforest; Liberia

Introduction

The Upper Guinean Forest, which includes forests from western Guinea to eastern Togo, has been recognized as a global biodiversity hotspot (Myers *et al*., 2000; Küper *et al*., 2004; Monadjem and Fahr, 2007). Liberia covers more forest areas than any other of the seven countries sharing the Upper Guinean ecosystem. For this raison, at a priority-setting workshop for biodiversity conservation in the Upper Guinean forest region, Liberia was identified as the highest-priority country with over 35 % of the country ranked as "Exceptionally High" priority (Bakarr *et al*., 2001; Monadjem

and Fahr, 2007). Liberia indeed supports extensive forest cover providing habitat for numerous threatened plants and animals.

Unfortunately, these forests are under increasing pressures for human use, causing forest fragmentation and destruction. The loss of forest habitats can lead to the extinction of endemic species. Forests in Liberia are under pressure from shifting agriculture and mining activities. Threats have become more disturbing with the establishment of industrial plantations on larger areas. It is the case of Sime Darby oil palm and rubber plantations which should extend over 311,187 hectares.

Facing the challenge of conserving biodiversity and fighting against global warming, environmental and social impact assessments have become a prerequisite to the launching of most important development projects in tropical countries. The biological assessments are increasingly becoming a major component of such studies as recommended by governments and donors (Bene *et al*., 2013).

In order to make this policy more tangible and useful, it has been wise to focus on species that are most sensitive to changes in their environment. This is why several animals are used as biological indicators to assess habitat's quality. Among terrestrial small mammals, shrews and rodents communities have demonstrated their great ability to reflect the state of conservation of their environment (Decher *et al*., 2010; Avenant, 2011; Ofori *et al*., 2016). Thus, survey of shrews and rodents communities has become an integral part of environmental and social impact assessments (Avenant, 2011; Ofori *et al*., 2016).

This paper presents species richness and relative abundances of terrestrial small mammals at four blocks of Sime Darby Gross Concession Area (GCA) showing different environments in Bong and Gbarpolu counties. It's provides baseline data on shrews and rodents from Sime Darby Concession.

Materials and Methods

Study Area

This study was carried out in the south of Gbarpolu County and in the west of Bong County. Like most of Liberia, the climate of Gbarpolu and Bong counties is tropical, with distinct wet (April – October) and dry (November – Mars) seasons. The average temperature is 28 °C.

Bong County is located in the north-central area of Liberia. The County is drained by six principal rivers and a number of small streams. It is part of the high forest belt, which can be divided into an evergreen rain forest zone and the moist semi-deciduous forest zone. The annual rainfall at Bong is about 2032 mm (Bene *et al*., 2013).

Gbarpolu County is located in the western region of Liberia. The County has three main river systems and many large creeks and streams. Gbarpolu contains significant portions of the Upper Guinea Forest. Most of this forest is deciduous and mountain in nature, covering all three main forest classes: forest with small agricultural, open dense forest, and dense forest (Bene *et al*., 2013).

The sampling sites concern four blocks (F, G and H in Gbarpolu County and block E in Bong County) see Fig.1.

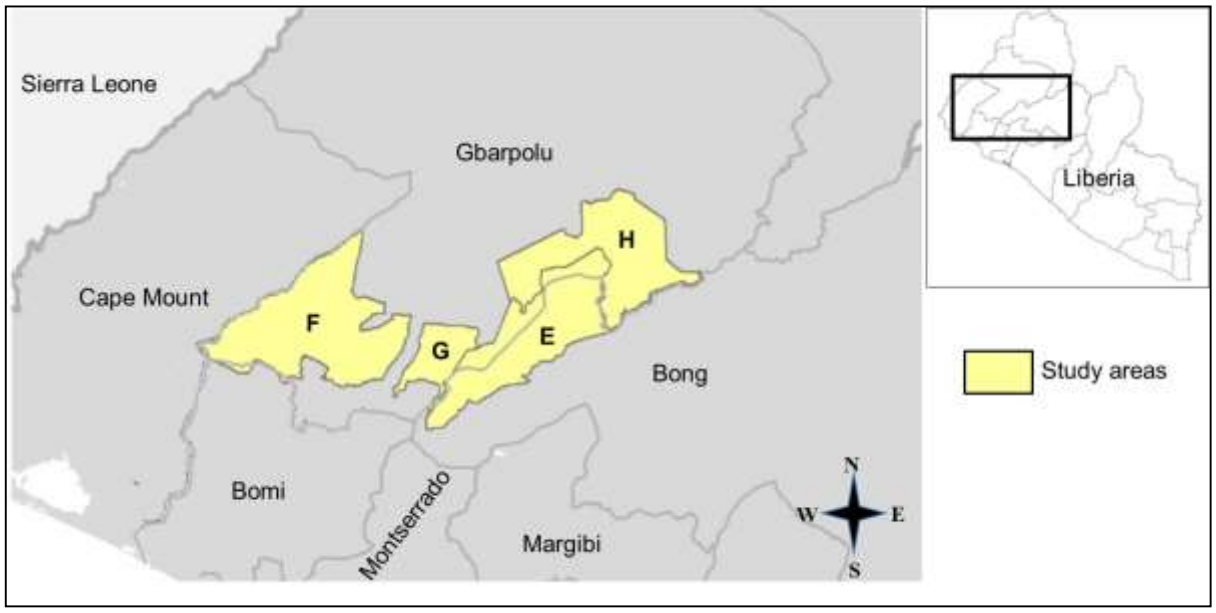

Fig. 1. Localization of the study areas (blocks E, F, G and H).

Table 1. Geographical coordinates of sampling sites in Sime Darby concession in Liberia.

County	Block	Locality	Trapping site coordinates (UTM)			
			Sherman		Pitfall	
			X	Y	X	Y
Bong	E	Palala	355930	779964	355821	780058
Gbarpolu	F	Wealiqua	314888	784443	314995	784420
	G	Small saw mill	337264	770799	337223	770688
	H	Mualekole	-	-	375250	797054

Terrestrial small mammal sampling

The field survey was conducted between November and December 2011. For each of the four blocks, terrestrial small mammals (shrews and small rodents) were sampled mainly with pitfall and Sherman live traps. Sampling sites and their GPS coordinates are given in Table 1.

Pitfall traps comprised 10 litre plastic buckets with small holes in the base to allow water drainage. They were set at 5 m intervals along each 100 m transect line, totaling 20 traps per line. A 0.5 m high plastic drift fence was erected along each transect line to increase the area of catch and guide animals towards the traps (Nicolas *et al*. 2003; Nicolas *et al*. 2009). Pitfall traps were set for three consecutive nights per block, resulting in a total trapping effort of 60 bucket-nights at each block. Due to challenges encountered with local communities in the particular block H with respect to permission to access their lands, only pitfall traps were set.

In addition to pitfall traps, 88 Sherman live traps (7.5 x 9 x 23 cm) were set 5 m apart in a 440 m transect lines for three continuous nights in blocks E, F and G, totaling 264 trap-nights per block. All Sherman live traps were baited with palm nut (*Elaeis guineensis*) that was changed, if necessary, after each trap-nights.

At each site, pitfall and Sherman live traps were checked once a day, early in the morning. After each trap checking session, voucher specimens were identified, sexed, weighed, and standard measures were recorded. Small mammal trapping and handling complied with recommended guidelines and standard methods for mammal fieldwork (Sikes *et al*., 2011). Tissue samples were taken on the tail of shrew specimens, and preserved in 95 % ethanol, for molecular systematic analysis.

Species Identification

Because of many cases of sibling species within small mammals, the identification of most of them should not be limited to references to external characteristics only. Moreover, the systematic and taxonomy of numerous genera of African rodents and shrews are still unresolved (Hutterer, 2005; Musser and Carleton, 2005). Species identification was performed by KBA and KHB by external characteristics, and was confirmed, for most of shrew specimens, by molecular analysis (Cytochrome b gene) at the "*service de systématique moléculaire*" of the "*Muséum National d' Histoire Naturelle*" of Paris, France. We follow the taxonomy of Wilson and Reeder (2005), Happold (2013), and Happold and Happold (2013).

Data Analysis

The species richness (S) represents the number of individual species captured in each block. Trapping success (T) was calculated as the number of captured individuals per 100 trap nights: $T = [n/E] \times 100$, where n is the number of small mammals trapped, and E is the number of traps checked. Shannon index (H'), equitability (J) based on species incidence (presence or absence) were also calculated for each block. All these ecological variables were calculated using EstimateS software version 9.1.0 (Colwell, 2013). The relative abundance of individual species was computed as the ratio of the number of a particular species to the total number of all individuals captured.

Results

Species Richness and Community Composition

A total of 76 terrestrial small mammals representing two orders (Soricomorpha and Rodentia) and eleven species (six shrew species and five rodent species) were trapped in 1032 trap-nights in the present study (Table 2). The most frequently captured species was *Crocidura jouvenetae* (39.47 %) followed by *Hylomyscus simus* (14.47 %) and *Hybomys planifrons* (10.53 %). Overall trap success was 3.28 in Sherman traps and 20.83 in pitfall traps (Table 2).

In block E, 14 specimens belonging to four species were caught in 324 traps-nights. Those are two shrew species (*Crocidura jouvenetae* and *Crocidura buettikoferi*) and two rodent species (*Hylomyscus simus* and *Mus setulosus*). *Crocidura jouvenetae* was the dominant species (42.86 %), (Table 2).

With a similar trapping effort like at block E, a higher number of specimens (24) and species (7) were recorded within block F. The small mammals recorded from this block included three shrew species (*Crocidura eburnea*, *Crocidura jouvenetae* and *Crocidura obscurior*) and four rodent species (*Dephomys defua*, *Hybomys planifrons*, *Hylomyscus simus* and *Lophuromys sikapusi*). The dominant species was the forest-dwelling *Hybomys planifrons* (33.34 %). *Crocidura jouvenetae* (25 %) was the second most abundant species at this block.

Table 2. Number of specimens of each species captured per sampling site, species richness per block, relative abundance per species (in brackets), and trap success per trap line. Trapping effort per block was of 60 bucket-nights for pitfall lines and of 264 trap-nights for Sherman lines.

	Sampling sites				Total	Relative abund. (%)
	Block E	Block F	Block G	Block H		
Shrews						
Crocidura buettikoferi Jentink, 1888	3 (21.43 %)	-	-	-	3	3.95
Crocidura eburnea Heim de Balsac, 1958	-	2 (8.33 %)	-	-	2	2.63
Crocidura jouvenetae Heim de Balsac, 1958	6 (42.86 %)	6 (25 %)	9 (40.9 %)	9 (56.25 %)	30	39.47
Crocidura muricauda (Miller, 1900)	-	-	6 (27.27 %)	-	6	7.90
Crocidura obscurior Heim de Balsac, 1958	-	1 (4.17 %)	1 (4.56 %)	-	2	2.63
Crocidura olivieri (Lesson, 1827)	-	-	-	7 (43.75 %)	7	9.21
Rodents						
Dephomys defua (Miller, 1900)	-	2 (8.33 %)	-	-	2	2.63
Hybomys planifrons (Miller, 1900)	-	8 (33.34 %)	-	-	8	10.53
Hylomyscus simus (Aellen & Coolidge, 1930)	2 (14.28 %)	3 (12.5 %)	6 (27.27 %)	-	11	14.47
Lophuromys sikapusi (Temminck, 1853)	-	2 (8.33 %)	-	-	2	2.63
Mus setulosus Peters, 1876	3 (21.43 %)	-	-	-	3	3.95
Total (shrews + rodents)	14	24	22	16	76	100
Sherman traps only	5	15	6	-	26	
Pitfall traps only	9	9	16	16	50	
Trap success in Shermans	1.9	5.68	2.27	-	3.28	
Trap success in pitfalls	15	15	26.66	26.66	20.83	
Species richness (S)	4	7	4	2	11	
Diversity indexes						
Shannon-Weaver (H')	0.98	1.76	1.21	0.69		
Equitability (J)	0.89	0.90	0.87	0.99		

A total of 22 specimens belonging to four species were caught in block G in 324 traps-nights. The small mammal's community at block G is mainly dominated by shrews (72.73 %). A single rodent species (*Hylomyscus simus*) was recorded in block G (27.27 %).

In block H, 16 specimens from two shrew species were caught in 60 traps-nights. The forest dwelling species *Crocidura jouvenetae* (56.25 %) and the ubiquitous *Crocidura olivieri* (43.75 %) were caught (Table 2).

Species Diversity and Equitability

This survey indicates that block F has the highest diversity indices (S = 7; H' = 1.76), followed, respectively, by those of block G (S = 4; H'= 1.21), block E (S = 4; H' = 0.98) and block H (S = 2; H'= 0.69), (Table 2). Regarding the equitability, it was higher in block H (J = 0.99) than those of block F (J = 0.90), block E (J = 0.89) and block G (J = 0.87). However, the equitability remained high in the four blocks.

Discussion

This study confirmed only five species of rodents and six species of shrews. This result should be considered as a preliminary assessment of small mammals of this area. In fact, the survey was implemented in dry season and lasted very shortly. Thus, it was not reassuring to get a complete picture of terrestrial small mammal's richness and abundance. In addition to that, it is assumed that terrestrial small mammals are less active during dry season than rainy season (Nicolas, 2003; Nicolas and Colyn, 2003). However, those preliminary data follow the general trend of the diversity of terrestrial small mammals obtained during rapid surveys carried out in the Upper Guinea forests. Indeed, Decher *et al.* (2005) recorded 10 and 12 species of small mammals respectively in Cavally and Haut-Dodo classified forests in Côte d'Ivoire. In Ghana, 9 and 11 small mammal species were also collected respectively in Ajenjua Bepo and Mamang River Forest Reserves (Barriere *et al.*, 2006).

In this study, the six species of shrews (*Crocidura buettikoferi*, *Crocidura eburnea*, *Crocidura jouvenetae*, *Crocidura muricauda*, *Crocidura obscurior* and *Crocidura olivieri*) collected were all captured using pitfall traps. This, once again, confirms the effectiveness of this type of trap for catching shrews (Williams and Braun, 1983; Maddock, 1992; Stanko *et al.*, 1999). Based on the 10 and 11 species

of shrews collected respectively in Taï National Park (Churchfield *et al*., 2004) and in Ziama Biosphere Reserve in Guinea (Nicolas *et al*., 2009), it is clear that the Sime Darby concession forests probably harbor several other species of shrews. In fact, some species such as *Crocidura nimbasilvanus*, *Crocidura douceti*, *Crocidura nimbae*, *Crocidura theresae* and *Suncus megalura*, which are quite common in the Upper Guinea forests (Churchfield *et al*., 2004; Nicolas *et al*., 2009), were not collected during this study. The most frequent shrew species was *C. jouvenetae*. It was captured in all the four sampled blocks and is known for its preference for primary and secondary forests (Happold and Happold, 2013).

The forest species *Hylomyscus simus* was the most abundant rodent species. This species is well known for its preference for primary and secondary forests (Happold, 2013; Akpatou *et al*., 2018). The primary forest species *Hybomys planifrons* (Happold, 2013) was the second most abundant species and we only captured it in the primary forest of block F. *Praomys rostratus*, *Malacomys edwardsi*, *Hybomys trivirgatus* and *Mastomys erythroleucus*, which are frequently observed in the Upper Guinea forests (Dosso, 1983; Decher *et al*., 2005; Akpatou *et al*., 2018), were not collected in this study. This does not reflect their absolute absence in these forests, but probably the fact that they have escaped the trapping device.

The low number of rodent species reported in this survey is not only due to the low trapping effort but also to the trapping method. Indeed, unlike Nicolas and Colyn (2003) who trapped in the tree branches, all our traps were placed on the ground. Thus, this has reduced the likelihood of capturing arboreal species.

Small mammal communities in Sime Darby concession area were dominated by forest species (*Crocidura eburnea*, *Crocidura jouvenetae*, *Crocidura muricauda*, *Crocidura obscurior*, *Dephomys defua*, *Hybomys planifrons*, *Hylomyscus simus* and *Mus setulosus*), which indicates the lower level of forest degradation at this area. In fact, the four sampled blocks contain primary forests that are suitable for mammal conservation.

Forests in Liberia are known to harbor numerous endemic mammal species to the Upper Guinea forests and species of conservation concern (Myers *et al*., 2000; Bakarr *et al*., 2004; Bene *et al*., 2013). Results of this study are consistence with these authors. Indeed, four species of shrews (*Crocidura eburnea*, *Crocidura jouvenetae*, *Crocidura muricauda* and *Crocidura obscurior*) and three murid species (*Hybomys planifrons*, *Hylomyscus simus* and *Dephomys defua*) collected are endemic to the Upper Guinea rainforest (Happold, 2013; Happold and Happold, 2013). The conservation statute of terrestrial small mammals is Least Concern (LC) for most of them. Only *Crocidura buettikoferi* is listed as Near Threatened (NT) according to IUCN (2018) Redlist criteria.

This study provides preliminary data on small mammals' diversity and abundance from Sime Darby palm oil company Concession. However, it recommended to reinforce it, given the need to better know the biological diversity of the sites before undertaking major works to set up oil palm plantations.

Author's Contribution

K.B. Akpatou and K.H. Bohoussou participated in all steps of the research work and preparation of the manuscript. Jean-Claude Koffi Bene critical analysed the data, revised and finalized the manuscript. Final form of manuscript was approved by all authors.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

Acknowledgement

Field studies were supported by Sime Darby-Liberia**,** Forest Development Authority of Liberia (FDA) and Fauna and Flora International-Liberia (FFI). We express our gratitude to the Service of Molecular Systematics (UMS 2700) of the National Museum of Natural History of Paris, France, for the molecular identification of shrew species. We thank Violaine Nicolas for assisting with the molecular identification of shrew species and also for reviewing the manuscript. We are grateful to Joel Gamys, Michael Abedilartey, Matthew k. Traore for their successful contribution to this work. We are grateful to people from Wealiqua, small saw mill, Mualekole and Palala for allowing us to work on their land and for their special contributions during the field surveys. We thank the two anonymous reviewers for their invaluable comments on the manuscript.

References

Akpatou KB, Bohoussou KH, Kadjo B and Nicolas V (2018) Terrestrial small mammal diversity and abundance in Taï National Park, Côte d'Ivoire. *Nature Conservation Research* **3(Suppl.2)**: 66-75. DOI: 10.24189/ncr.2018.067

Avenant N (2011) The potential utility of rodents and other small mammals of indicators of ecosystem integrity of South African grasslands. *Wildlife Research* **38**: 626-639. DOI: 10.1071/WR10223

Bakarr M, Bailey B, Byler D, Ham R, Olivieri S and Omland M (2001) From the forest to the sea: biodiversity connections from Guinea to Togo. Conservation International, Washington, DC., 78p

Bakarr M, Oates JF, Fahr J, Parren MPE, Rödel MO, Demey R (2004) Guinean forests of West Africa, *In:* Mittermeier RA, Gil PR, HoffmanM, PilgrimJ, BrooksT, Mittermeier CG, Lamoreux J and Da Fonseca GAB (Eds) *Hotspots Revisited: Earth's Biologically Richest and Most*

Endangered Terrestrial Ecoregions. CEMEX / Agrupación Sierra Madre. Mexico City, 123-130.

Barriere P, Nicolas V and Kwaku O (2009) Rapid survey of the small mammals of Ajenjua Bepo and Mamang River Forest Reserves, Ghana. *Conservation International*: 54-47.

Bene J-CK, Bitty EA, Bohoussou KH, Abedi-lartey M, Gamys J and Soribah PAJ (2013) Current conservation status of large mammals in Sime Darby oil palm concession in Liberia. *Global Journal of Biology, Agriculture & Health Sciences* **2(3)**: 93-102.

Churchfield S, Barriere P, Hutterer R and Colyn M (2004) First results on the feeding ecology of sympatric shrews (Insectivora: Soricidae) in the Taï National Park, Côte d'Ivoire. *Acta theriologica* **49**: 1. DOI: 10.1007/BF03192504

Colwell RK (2013) EstimateS, statistical estimation of species richness and shared species from samples. Version 9.1.0.

Decher J, Kadjo B, Abedi ML, Elhadji OT and Soumaoro K (2005) A Rapid Survey of Small Mammals (shrews, rodents, and bats) from the Haute Dodo and Cavally Forests, Côte d'Ivoire. *In:* Lauginie F, Rondeau G and Alonso LE (Eds) *A rapid biological assessment of two classified forests in South-Western Côte d'Ivoire.Chapitre.* ***Chapter 8,*** RAP Bulletin 34, Conservation International, Washington, DC., 91-100.

Decher J, Norris RW and Fahr J (2010) Small mammal survey in the upper Seli River valley, Sierra Leone. *Mammalia* **74** : 163-176. DOI : 10.1515/mamm.2010.026

Dosso H (1983) Etude des Rongeurs de forêts hygrophiles conservées et des zones anthropisées de la Côte d'Ivoire méridionale. Thèse de doctorat, Université de Cocody, Côte d'Ivoire, 249p.

Happold DCD (2013) Mammals of Africa. Volume III: Rodents, Hares and Rabbits. London: Bloomsbury Publishing, 784p.

Happold M and Happold DCD (2013) Mammals of Africa. Volume IV: Hedgehogs, Shrews and Bats. London: Bloomsbury Publishing, 800p.

Hutterer R (2005) Order Soricomorpha. *In:* Wilson DE and Reeder DM (Eds) *Mammal species of the world: a taxonomic and geographic reference.* Smithsonian Institution Press, Washington, D.C, 220-311.

IUCN (2018) IUCN Red List of Threatened Species. URL: http: // www.iucnredlist.org

Küper W, Sommer JH, Lovett JC, Mutke J, Linder HP, Beentje HJ, Van Rompaey S, Chatelain C, Sosef M and Barthlott W **(**2004) Africa's hotspots of biodiversity redefined. *Annals of the Missouri Botanical Garden* **91**: 525-535.

Maddock AH (1992) Comparison of two methods for trapping rodents and shrews. *Israel Journal of Zoology* **38(3)**: 333-340. DOI: 10.1080/00212210.1992.10688680

Monadjem A and Fahr J (2007) Rapid survey of bats of North Lorma, Gola and Grebo National Forests, with notes on shrews and rodents. *In:* Hoke P, Demey R and Peal A (Eds) *A rapid biological assessment of North Lorma, Gola and Grebo National Forests, Liberia.* ***Chapter 6,*** RAP Bulletin of Biological Assessment 44, Conservation International, Arlington, VA, USA, 47-58.

Musser GG and Carleton MD (2005) Superfamily Muroidea. *In:* Wilson DE and Reeder DM (Eds) *Mammal Species of the World: A Taxonomic and Geographic Reference*. The Johns Hopkins, University Press, Baltimore.

Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB and Kent J (2000) Biodiversity hotspots for conservation priorities. *Nature* **403**: 853-858. DOI: 10.1038/35002501

Nicolas V (2003) Systématique et Ecologie des Communautés Afrotropicales de Muridés (Mammalia: Rodentia) et de Soricidés (Mammalia: Insectivora). Thèse Université de Rennes 1, France, 292p.

Nicolas V and Colyn M (2003) Seasonal variations in population and community structure of small rodents in a tropical forest of Gabon. *Canadian Journal of Zoology* **81**: 1034-1046. DOI: 10.1139/z03-092

Nicolas V, Barriere P and Colyn M (2003) Impact of removal pitfall trapping on the community of shrews (Mammalia: Soricidae) in two African tropical forest sites. *Mammalia* **67(1)**: 133-138. DOI: 10.1515/mamm.2003.67.1.133

Nicolas V, Barriere P, Tapiero A and Colyn M (2009) Shrew species diversity and abundance in Ziama Biosphere Reserve, Guinea: comparison among primary forest, degraded forest and restoration plots. *Biodiversity and Conservation* **18**: 2043-2061. DOI: 10.1007/s10531-008-9572-4

Ofori BY, Daniel K, Attuquayefio, Erasmus H, Owusu and Musah Y (2016) Spatio-temporal variation in small mammal species richness, relative abundance and body mass reveal changes in a coastal wetland ecosystem in Ghana. *Environmental Monitoring and Assessment* **188**: 330. DOI: 10.1007/s10661-016-5320-5

Sikes RS, Gannon WL, Darrin SC, Brent JD, Jerry WD, Michael RG, David WH, Christy M, Daniel KO, Link EO, Sarah R, Robert MT, Stephanie AT and Janet EW (2011) Guidelines of the American Society of Mammalogists for the use of wild mammals in research. *Journal of Mammalogy* **92**: 235-253. DOI: 10.1644/10-MAMM-F-355.1

Stanko M, Mosansky L, Fricova J and Casanova JC **(**1999) Comparison of two sampling methods of small mammals in the margin of a lowland forest. *Biologia, Bratislava* **54:** 595-597.

Williams DF and Braun SE (1983) Comparison of Pitfall and Conventional Traps for Sampling Small Mammal Populations**.** *The Journal of Wildlife Management* **47(3)**: 841-845. DOI: 10.2307/3808622

Wilson DE and Reeder DM (2005). Mammal species of the world: a taxonomic and geographic reference. Baltimore, Maryland: John Hopkins University Press, 2142