Journal of Biodiversity and Ecological Sciences
(JBES©)
Vol.2, Issue 4
ISSN: 2008-9287
Fall 2012

Original Article

Ecological Integrity of the Afadjato-Agumatsa Community Nature Reserve (AACNR) of Ghana after a Decade of Conservation

B.Y. Ofori*
E.H. Owusu
D.K. Attuquayefio,

Department of Animal Biology & Conservation Science,
University of Ghana, Legon,
P.O. Box LG67, Legon, Accra, Ghana.
**Corresponding author.* E-mail: byofori@ug.edu.gh;

Received Date:11/09/2012
Accepted Date:12/15/2012

Abstract

Despite the general acceptance and wide promotion of community-based natural resource management (CBNRM), the success of CBNRM remains debatable, as there is paucity of information on the effectiveness of this management approach. The ecological integrity of the Afadjato-Agumatsa Community Nature Reserve (AACNR) was assessed after a decade of community management. Vegetation cover changes and small mammals were used as bio-indicators. Time series satellite images of the AACNR showed significant increase in the forest cover and decreases in shrub, grass and build-up covers after a decade of conservation. A total of 3,360 trap-nights yielded 82 small mammal individuals belonging to two orders (Rodentia and Eulipotyphla) and two species, *Praomys tullbergi* (soft-furred rat) and *olivieri* (Olivier's shrew), giving a trapping success of 5.5%. *Praomys tullbergi* formed about 98% of the total number of individuals, and recorded a relative abundance of 2.4%. Small mammals diversity at the AACNR was low (***H'*** = 0.119; ***D*** = 0.92). The absence of savanna species like *Lemniscomys* spp. (striped grass rats) and *Mastomys* spp. (multimammate rats) and the widespread and dominance of the forest species *P. tullbergi*, coupled with the changes in vegetation cover suggest that the forest ecosystem of the AACNR is of high ecological integrity.

Key words: Afadjato-Agumatsa community nature reserve, Community-based natural resource management, Forest ecosystem, Ghana, Small mammals

INTRODUCTION

Over the past few decades, governments, development agencies and conservation professionals have recognized the importance of the support of rural communities in the long-term integrity of protected areas (PAs) (Ferraro, 2001). Since then, there has been a major shift from the traditional system of protected area governance, commonly referred to as the "fences and fines", which excluded local people from the management and use of wildlife and other resources within PAs, towards a more people-centred approach, which recognizes local peoples participation in PA management and decision making as crucial to their success (Shackleton, 2002; Balint, 2006). The community-based natural resource management (CBNRM) concept is based on the principle that local people will be more inclined to biodiversity conservation if they are involved in PA management and derive some benefits from conservation. Given sufficient information and support, local people can determine for themselves the most appropriate conservation solutions (Forgie *et al*., 2001). Even though the CBNRM concept is generally accepted and widely promoted, the success of local communities in effectively managing common resources remains an empirical question, as there is a general paucity of information on the effectiveness of the this management approach (Siddhartha *et al*., 2006). The Afadjato-Agumatsa Community Nature Reserve (AACNR) is a globally important bird area in Ghana (Ntiamoa-Baidu *et al*., 2001). The AACNR is managed by the Gbledi and Fodome-Ahor traditional authority in the Hohoe District of the Volta Region of Ghana, with technical support from the Ghana Wildlife Society (GWS). The community-based conservation project started as a collaborative initiative between the Gbledi and Fodome-Ahor Traditional Areas in 1998, with the aim of conserving the forest resources on mountain Afadjato and parts of the Agumatsa Range for socio-economic benefits (Owusu *et al.*, 2006).There is no documented evidence of protection efforts or any silvicultural activities at the Mount Afadjato and Agumatsa Range prior to the launching of the community-based conservation project in February, 1998. Baseline survey in the conservation area recorded over 450 plant species, 350 butterfly species with significant degree of endemism, over 112 birds and 33 mammals including bats. The threats to the area included perennial bushfires, farming encroachment, logging, and hunting (GWS, 2007).Conservation interventions made at the area included creation of a 3.5 km fire belt at the fire prone areas on the range, planting of indigenous timber species mainly *Khaya* and *Terminalia* species at the degraded areas, boundary line and buffer areas, development of the area into ecotourism site and promoting and building local capacity in alternative income generating activities such as beekeeping, poultry farming, cassava processing and ecotourism development. Local people in fringe communities were also educated and made aware of the values and functions of, and services provided by forests and their associated resources (GWS, 2007).The present study was designed to assess the success or otherwise of the local community in the management of the AACNR. Changes in vegetation cover and small mammal species abundance, diversity, composition and distribution were used as measurable surrogates for the ecological integrity of the forest ecosystem of the AACNR. Small mammals respond rather swiftly to changes in habitat structure and composition and hence are good bio-indicators of changes in forest ecosystems (Attuquayefio and Wuver, 2003).The working hypothesis of the present study was that effective conservation of the AACNR should correspond to an increase in the percentage forest cover and a decrease in the shrub, grass and build-up covers. The impact of these should be an increase in forest specialist small mammals that are evenly distributed at the AACNR. The specific objectives of the present study therefore, were to determine for the AACNR (i) percentage changes in the forest and other cover types after 10 years of community-based conservation management and (ii) small mammal species abundance, diversity, composition and distribution.

Materials and Methods

Study Area

The AACNR (6^o 45' - 7^o 15'N; 0^o 15' - 0^o 45'E) (Fig.1) is about 12 km^2 and encompasses the Fodome Ahor and Gbledi Traditional Areas in the Hohoe District of the Volta Region of Ghana. The site, which is south-west of Hohoe, the District capital, is about 250 km from Accra, and covers Mount Afadjato and part of the Agumatsa Range, both of which are part of the Akuapim-Togo Ranges, the highest mountain range in Ghana. Mount Afadjato itself is the highest mountain in Ghana at about 900 m above sea level (Owusu *et al.*, 2006; Owusu, 2008).

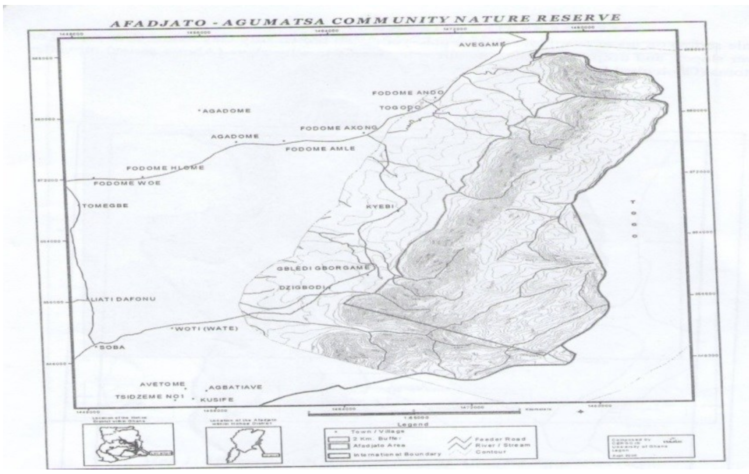

Fig. 1: Map of the Afadjato-Agumatsa Community Nature Reserve (AACNR)

The climate is typical of the Dry Semi-Deciduous Forest, interspersed with Moist Semi-Deciduous Forest in some areas (Hall and Swaine, 1981). There is a single-peak of rainfall between April and October, with higher precipitation in June, September and October. Annual rainfall values range from 1,595 mm to 1,762 mm with mean of 1,650mm. The average relative humidity is 90% and the average temperature ranges between 19^{o}C and 29^{o}C (GWS, 2007).
The area encompasses well-developed Guinea and derived Savanna. The distribution of the main vegetation types follows a characteristic pattern of relief and exposure. The Dry Semi-Deciduous Forest occupies the western slopes, while the steeper eastern sides are dominated by savanna and tree steppe. The low lying area between settlements and the lower slopes of the hills is clearly derived savanna dominated by grasses (GWS, 2007).

The reserve provides habitat for a variety of floral and faunal species including over 450 plant species, 350 butterfly species, over 112 bird species, 53 of which are of conservation concern at different threat levels, and 33 mammal species, including bats (GWS, 2007).

MATERIALS AND METHODS

Two main methods were employed for gathering information for the study; the use of time series satellite images (TSSI) to compute percentage changes in the vegetation cover and live-trapping of small mammals using standard Sherman collapsible live-traps (H.B. Sherman Traps Inc., Florida, USA).

Time Series Satellite Images

Satellite images (TSSI) of the AACNR in 1998, 2002, and 2008 were analysed to compute the changes in forest and other cover types during these periods. The satellite images were obtained from the Centre for Remote Sensing and Geographical Information System (CERSGIS), University of Ghana, Legon.

Live-trapping of Small Mammals

To explore spatial patterns of small mammal abundance and species diversity, the study area was divided into three elevational zones as (i) Lowland zone (LLZ); the lowland area lying at the foot of the mountain, (ii) Midslope zone (MSZ); the area midway between the foot and top of the mountain (about 400 to 500 m up hill) and Submontane zone (SMZ); the area forming the top of the mountain (800-900 m).

Small mammal trapping was conducted from June 2008 to January 2009, along line transects. Two permanent transects, each about 110 m long, were randomly established in each elevational zone. Each transect had 10 trap-stations placed at 10 m intervals. Trap-stations were supplied with standard Sherman collapsible live-trap (7.5 cm x 9 cm x 23 cm) baited with a mixture of corn meal and groundnut paste (peanut butter). Traps were set during the day and checked from 07.00 to 010.00 hours GMT the following morning for seven consecutive nights for eight trapping sessions; one trapping session per month. There were therefore an overall total of 3360 trap-nights. Captured animals were identified, weighed, sexed (using the anal-genital distance, which is longer in males), aged (assigned to three age-classes: juvenile, sub-adult and adult), checked for reproductive condition (abdominal or scrotal testes in males and enlarged nipples, perforate vaginas and pregnancy in female), marked by toe-clipping, and then released at the point of capture. Field identification was based on Rosevear (1969) and Kingdon (2007).

Analysis of Data

Percentage Cover Change (%Cc)

This was calculated as the ratio of the difference between the final and initial area, and the initial area of a cover type multiplied by 100%. Thus

$$\%Cc = \frac{(A_f - A_i) \times 100\%}{A_i}$$

Where $\mathbf{A_f}$ and $\mathbf{A_i}$ are the final and initial area, respectively, of a cover type.

Relative abundance (A_r)

The relative abundance (Ar) was estimated as the total number of individuals captured per 100 trap-nights (a trap-night = 1 trap set for 1 night). Thus,

$$A_r = \frac{N_i \times 100\%}{T_n}$$

Where N_i is the total number of captured individuals and T_n is the total number of trap-nights.

Species Diversity

The species diversity was estimated using the Shannon-Weiner (***H'***) and Simpson's (***D***) Indices (Pianka, 1966; Stiling, 1998) as follows:

$$H' = -\Sigma p_i \ln p_i, \text{ and}$$
$$D = \Sigma p_i^{\,2}$$

Where ***H*** is Shannon-Wiener diversity index, ***D*** is Simpson's diversity index and P_i is the proportion of the *i*th species in the total sample.

RESULTS AND DISCUSSION

Changes in Vegetation Cover

Figure 3 presents time series satellite images on the extent of the vegetation and other cover types at the AACNR obtained in 1998, 2003 and 2008. The AACNR presented four main cover types; Forest, which consisted of a single-canopy and a multiple (two to three) canopy forests, shrub, grass, and build-up (bare ground) covers. Both the single canopy and multiple canopy forest covers increased significantly after 10 years of conservation interventions. The multiple canopy forest cover, which covered about 3.7017 km^2 in 1998 increased to about 7.632 km^2 in 2002 and to about 12.1005 km^2 in 2008, representing about 106% and 227% increase in 2002 and 2008, respectively. The single canopy also increased by 0.4995 km^2 in 2002, and by 2008 had increased from 7.407 km^2 in 1998 to 11.7315 km^2 in 2008 (58%) (Table 1).

Unsurprisingly, the shrub, grass, and bare-ground covers decreased significantly. The shrub, grass and bare ground covers decreased by 13%, 20% and 73%, respectively after five years of community management, and by 2008, had further decreased by about 6.6km^2, 1.6 km^2, and 0.1 km^2, representing a total of about 64%, 60% and 75% decrease for the shrub, grass and bare ground covers, respectively (Table 1).

Table 1: Percentage Changes in Vegetation Cover at the AACNR.

	Area in Square kilometers (km^2)						
Cover type	**1998**	**2002**	**Change**	**%Change**	**2008**	**Total Change**	**%Total Change**
Multiple canopy	3.7017	7.632	3.9303	106	12.1005	8.3988	227
Single canopy	7.407	7.9065	0.4995	7	11.7315	4.3245	58
Shrub	12.8151	11.1915	-1.6236	-13	4.5657	-8.2494	-64
Grass	4.0041	3.1968	-0.8073	-20	1.5984	-2.4057	-60
Bare areas	2.745	0.7461	-1.9989	-73	0.6768	-2.0682	-75

Negative sign (-) means a decrease   Source: CERSGIS, University of Ghana, Legon.

These results support our working hypothesis. The communities' aim of conserving the forest on Mount Afadjato and part of the Agumatsa range has so far been on course. The changes in forest and other vegetation cover types at the AACNR could be attributed to the management interventions made. The planting of indigenous timber tree species at the buffer areas, boundary line and degraded areas may have transformed areas that were previously bare ground, grass and shrub into forest. The development of the AACNR into an ecotourism site and promotion of alternative income generating activities such as beekeeping, poultry farming, and cassava processing in the area may have also reduced the direct dependence of local people on the forest and its associated resources, and thus reducing the negative anthropogenic influence on the forest.

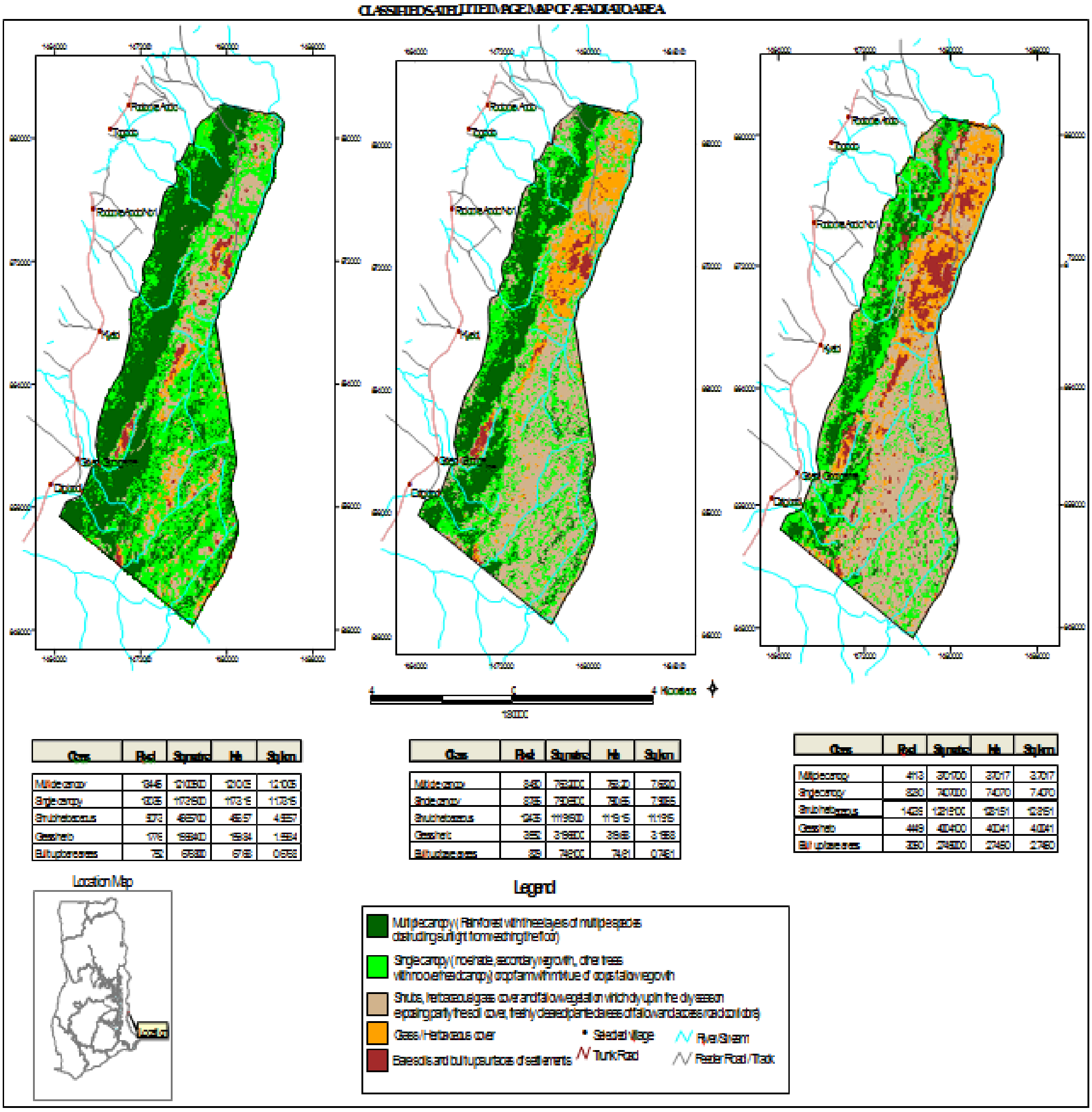

Fig. 2: Classified Time Series Satellite Images of the Afadjato-Agumatsa Community Nature Reserve (AACNR).

Small mammal species abundance, diversity, composition and distribution

A total of 3,360 trap-nights yielded 185 captures of 82 individuals comprising two orders (Rodentia and Eulipotyphla) and two species, *Praomys tullbergi* (soft-furred rat) and *Crocidura olivieri* (Olivier's shrew). The overall trapping success was therefore 5.5%. The Lowland zone (LLZ) recorded 23 individuals of two species, the Midslope zone (MSZ) recorded 25 individuals of one species while the Submontane zone (SMZ) recorded 34 individuals of two species. The diversity of small mammals in the AACNR was low (Shannon-Wiener index = 0.119; Simpson's index = 0.92) (Table 1).

Table 1: Small Mammal Species Abundance, Diversity, Composition, and Distribution at the AACNR

Trapping Zone

Parameter	LLZ	MSZ	SMZ	Total
No. of Species	2	1	2	**2**
No. of individuals	23	25	34	**82**
No. of Captures	50	70	65	**185**
Relative abundance	2.05	2.23	3.04	**2.44**
Shannon-Wiener Index	0.177	0	0.131	**0.119**
Simpsons Index	0.92	1	0.94	**0.92**
No. of Trap-nights	1,120	1,120	1,120	**3,360**
Trapping success	4.5	6.3	5.8	**5.5**

Praomys tullbergi made up about 99% of the total captures and 98% of the total number of individuals. The relative abundance of *P. tullbergi* was highest at the SMZ, followed by the MSZ and the LLZ (Table 1), even though the differences were not significant (ANOVA: N=24, df = 23; $p > 0.05$). The number of captures of *P. tullbergi* increased gradually from the beginning of the study (June 2008) to the end (January 2009). The number of captures however, peaked in August and November, which corresponded with the major and minor wet seasons, respectively (Fig. 2).

Small mammals are always well-adapted to the environment and have a wide distribution because of their high mobility (Liu *et al*., 2008). Their abundance, composition and distribution however, are influenced by, nature and density vegetation for food and shelter (Gebresilassie *et al*., 2004), altitudinal gradient and human disturbance (Liu *et al*., 2008). Coarse woody debris, primarily logs, is also of great importance to many forest small mammals for hiding and escape cover, travel corridors and feeding areas (Pearson, 1999).

The diversity of small mammal species at the AACNR was low and mono-dominant; dominated by the single species *P. tullbergi*. This is usually the case in most forest ecosystems (Williams and Marsh, 1998; Balciauskas, 2005; Pupila and Bergmanis, 2006; Raoul *et al*., 2008). Pianka (1966), postulates an inverse relation between species diversity and standing crop, which is usually related to productivity. Tropical forests are generally believed to be highly productive. It therefore seems that the composition, structure and ecological conditions of the forest of the study area promoted the proliferation of *P. tullbergi.*

The absence of savanna species like *Lemniscomys* spp. (striped grass rats) and *Mastomys* spp. (multimammate rats) and the widespread and dominance of the forest species *P. tullbergi*, also support our working hypothesis, and seem to suggest that the forest ecosystem of the AACNR is of high ecological integrity. The results of the TSSI and small mammal species abundance, diversity, composition and distribution at the AACNR indicate that the forest ecosystem of the area is in good health. The level of success attained may be a direct reflection of the management interventions made and the local communities' interest in ensuring that the conservation project succeeds. Some areas of biodiversity have come proactively rather than reactive. The conservation of the AACNR came about proactively and reactively, as this community nature reserve was initiated by the local people of the area (Owusu, 2008). The keen interest of the local people in the conservation of the forest of the AACNR offered a good prospect and a budding role of positive impact.

The AACNR is a sensitive, fragile and ecologically rich habitat that needs sustained conservation action. The guaranteed support of local people for the conservation of the area will depend on how well their interest is sustained over time (Owusu, 2008). Constant conservation education and awareness creation, and equity in sharing of proceeds from ecotourism may be crucial for sustaining local people's interest for conserving the area and are therefore recommended.

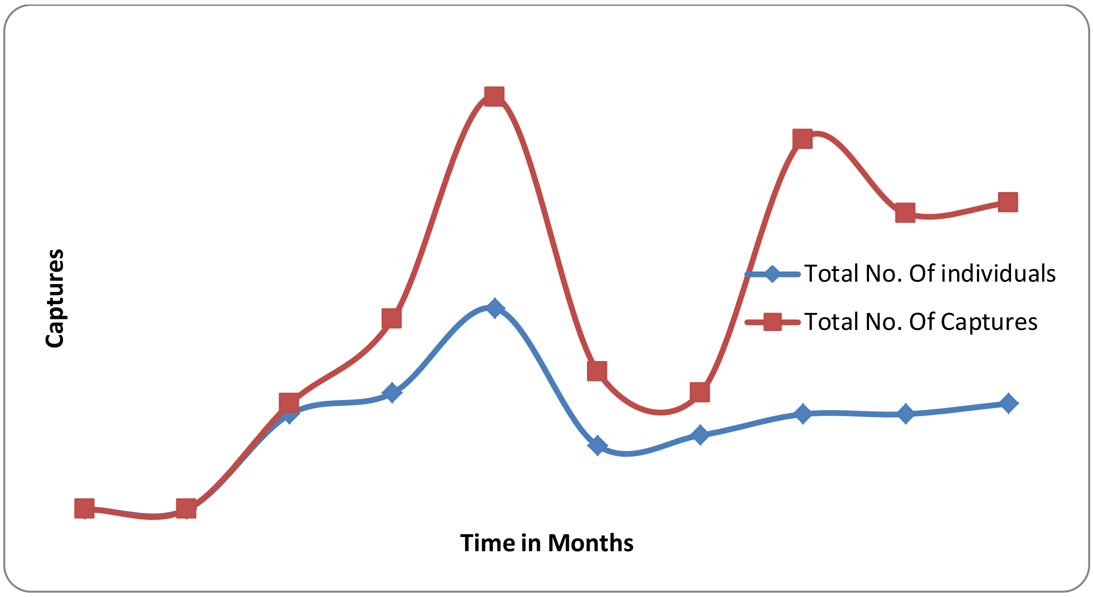

Fig. 2: Capture Trends of *P. tullbergi* in the AACNR

ACKNOLEDGEMENT
I am particularly grateful to Mr. Samuel Adu for assisting in data collection for this research.

REFRENCES

Attuquayefio, D. K.; Wuver, A. M., (2003). A Study of Bushfire in a Ghanaian Coastal Wetland. I. Impact on Small Mammals. *West African Journal of Applied Ecology*, 4: 1-11.

Balciauskas, L., (2005). Results of the Long-term Monitoring of Small Mammal Communities in the Ignalina Nuclear Power Plant Region. *Acta Zool. Lith*., 15: 79-84.

Balint, P. J., (2006). Improving Community-Based Conservation Near Protected Areas: The Importance of Development Variables. *Environmental Management*, 38(1): 137-148.

Ferraro, P. J., (2001). The Local Cost of Protected Areas in Low-Income Nations: Ranomafana National Park, Madagascar. Environmental Working Paper Series No. 2001-006.

Forgie, V.; Horsley, P.; Johnston, J., (2001). Facilitating Community-Based Conservation Initiatives. Science for Conservation 169. Department of Conservation, Willington, New Zealand.

Gebresilassie, W.; Bekele, A.; Belay, G.; Balakrishnan, M., (2004). Microhabitat Choice and Diet of Rodents in Maynugus Irrigation Field, Northern Ethiopia. *African Journal of Ecology*, 42: 315-321.

Ghana Wildlife Society (GWS) (2007). Draft of Management Plan for the Afadjato-Agumatsa Community Nature Reserve. The Ghana Wildlife Society, Accra.

Hall, J. B.; Swaine, M. D., (1981). Distribution and Ecology of Vascular Plants in Tropical Rainforest. Forest Vegetation in Ghana. Geobotany 1. Junk, The Hague.

Kingdon, J., (2007). The Kingdon Field Guide to African Mammals. A&C Black Publishers Ltd, London, UK.

Liu, J., Du, H.; Tian, G.; Yu, P.; Wang, S.; Peng, H., (2008). Community Structure and Diversity Distributions of Small Mammals in

Different Sample Plots in the Eastern Part of Wuling Mountains. *Zoological Research*, 29(6): 637-645.

Ntiamoa-Baidu, Y.; Owusu, E.H.; Daramani, D.T.; Nuo, A.A., (2001). Ghana. In Important Bird Areas in Africa and Associated Islands: Priority Sites for Conservation (L. D. C. Fishpool and M. I. Evans, Eds.), pp 367-389. Newbery and Cambridge, UK: Pisces Publications and Birdlife International (BirdLife Conservation Series No. 11).

Owusu, E.H.; Ntiamoa-Baidu, Y.; Ekpe, E.K., (2006). The Dependence of Local People on Bushmeat in the Afadjato and Agumatsa Conservation Area, Ghana. *Nature & Faune*, 21(1): 33-44.

Owusu, E.H., (2008). The Perceptions of Local Communities towards the Conservation of Birds in an important Bird Area in Ghana. West African Journal of Applied Ecology, 13: 73-79.

Pearson, D.E., (1999). Small Mammals of the Bitterroot National Forest: A Literature Review and Annotated Bibliography. Gen. Tech. Rep. RMRS-GTR-25. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 63 p.

Pianka, E.R., (1966). Latitudinal Gradients in Species Diversity: A review of Concepts. *American naturalist*, 100: 33-46.

Pupila, A.; Bergmanis, U., (2006). Species Diversity, Abundance and Dynamics of Small Mammals in Eastern Latvia. *Acta Universitatis latviensis Biology*, 710: 93-101.

Raoul, F.; Pleydell, D.; Quere, J.P.; Vaniscotte, A.; Reiffel, D.; Takahashi, K.; Bernard, N.; Wang, J.; Dobigny, T.; Galbreath, K.E.; Giraudoux, P., (2008). Small Mammal Assemblage Response to Deforestation and Afforestation in China. *Mammalia*, 72: 320-332.

Rosevear, D. R., (1969). The Rodents of West Africa. London, UK Trustees British Museum of Natural History.

Shackleton, S.; Campbell, B., Wollenberg, E.; Edmunds, D., (2002). Devolution and Community-Based Natural Resource Management: Creating Space for Local people to Participate and benefit. *Natural Resource Perspectives*, 76, March 2002.

Siddharttha, B.B.; Furley, P.A.; Newton, A.C., (2006). Impacts of Community-Based Conservation on Local Communities in the Annapurna Conservation Area, Nepal. Biodiversity and Conservation, 15: 2765-2786.

Stiling, P., (1998). Ecology: Theories and Applications, 3rd edn. Prentice-Hall, New Jersey.

Williams, S.E.; Marsh, H., (1998). Changes in Small Mammal Assemblage Structure Across a Rain Forest/Open Forest Ecotone. *Journal of Tropical Ecology*, 14: 187-198.