

# **BIODIVERSITY MONITORING IN ASUBIMA AND AFRENSU BROHUMA FOREST RESERVES, GHANA**

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ASUBIMA AND AFRENSE BROHUMA  
FOREST RESERVES, GHANA**

**By**

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# **Organizational Profiles**

## **FORM International**

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Form international was established in 1992. FORM International is ISO 9001 certified. The organization provides consultancy on support on sustainable forest management planning, plantation establishments (reforestation) and monitoring services.

## **FORM Ghana**

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FORM Ghana Ltd is a forest plantation management company base in Central Ghana (Kumasi). The firm was established in 2007 and provides services in the field of reforestation and plantation management with financial assistance of the EVD, a high quality model nursery and a pilot plantation were established in Akumadan, 100Km North of Kumasi. FORM Ghana started reforesting parts of the degraded Asubima and Afrensu Brohuma Forest Reserves.

## **Acknowledgements**

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## **Report at a Glance**

### **Expedition Dates**

18 July– 30 September 2011

### **Description of the Areas**

Asubima Forest Reserve lies within a grid reference of 7<sup>o</sup>24.812 N, 1<sup>o</sup>53.244 W near Akumadan, Ghana (Hawthorne and Abu- Juam 1995). It was reserved in 1945 and last logging was recorded in 1989. The Forest Reserve is located within Offinso Forest District in the Ashanti Region. The Reserve covers a total area of 7,870 hectares out of which approximately 1729.9 hectares constitute the area allocated to FORM Ghana Limited for commercial plantation development. The entire Reserve is located within the dry semi-deciduous forest zone (Hall and Swaine 1981).

The Asubima Forest Reserve lies at the northern fringes of the semi-deciduous forest ecological zone of Ghana. The zone has a tropical monsoon climate with alternating wet and dry seasons. The long wet season starts around mid-March and ends in mid-July. It is followed by a short dry season until the end of August. From September till the end of October there is a short rainy season, followed by a long dry season from November till mid-March. Temperatures are generally high and uniform throughout the year. Mean annual temperature is about 26<sup>o</sup> C. February and March are the warmest months.

The Asubima Forest Reserve formally was endowed with diverse plants species such as timber species, grass species and medicinal plant species. The vegetation of the reserve is mostly of the

dry semi-deciduous forest type which contained valuable timber trees such as Wawa, Odum, Sapele and Kokrodua (Amponsa-kwatiah, 1993).

Derived savannah conditions are observed in large areas of the reserve which have resulted from destruction by man. The savannah has virtually taken over the reserve. Due to intensive farming activities and reported annual fires very little of the original forest remains and what is left is secondary forest and with many areas of grass land. Where there is secondary vegetation especially in sparsely population climbers, shrubs and soft woody plants are mainly observed.

Birds, mammals, reptiles and some invertebrates are found in the Forest Reserve (Abeney *et al.*, 2008), but illegal logging of trees and bushfires have resulted in the decline of wildlife species in the Asubima Forest Reserve.

Afrenso Brohuma is a relatively small reserve covering an area of 3260 hectares out of which approximately 1440 hectares constitute the area allocated to FORM Ghana Limited for commercial plantation development. It is on an average elevation of 304 meters above sea level and lies within a grid reference of 7<sup>o</sup>36.667 N, 1<sup>o</sup>88.333 W 9km from Asubima Forest Reserve. It has a minimum temperature of 22 °C and a maximum of 25 °C. The average wind speed of Afrensu Brohuma Reserve is 8km per hour and it has a relative humidity of 85.1%. Both reserves now consist primarily of teak plantation and an indigenous riparian forest.

### **EXPEDITION OBJECTIVES**

FORM Ghana is a reforestation organization committed to managing its plantation in a responsible and sustainable way. Addressing and promoting biodiversity conservation of flora

and fauna in and around its plantation is one of its goals which also comply with the law of Ghana and the Forest Stewardship Council™ (FSC™).

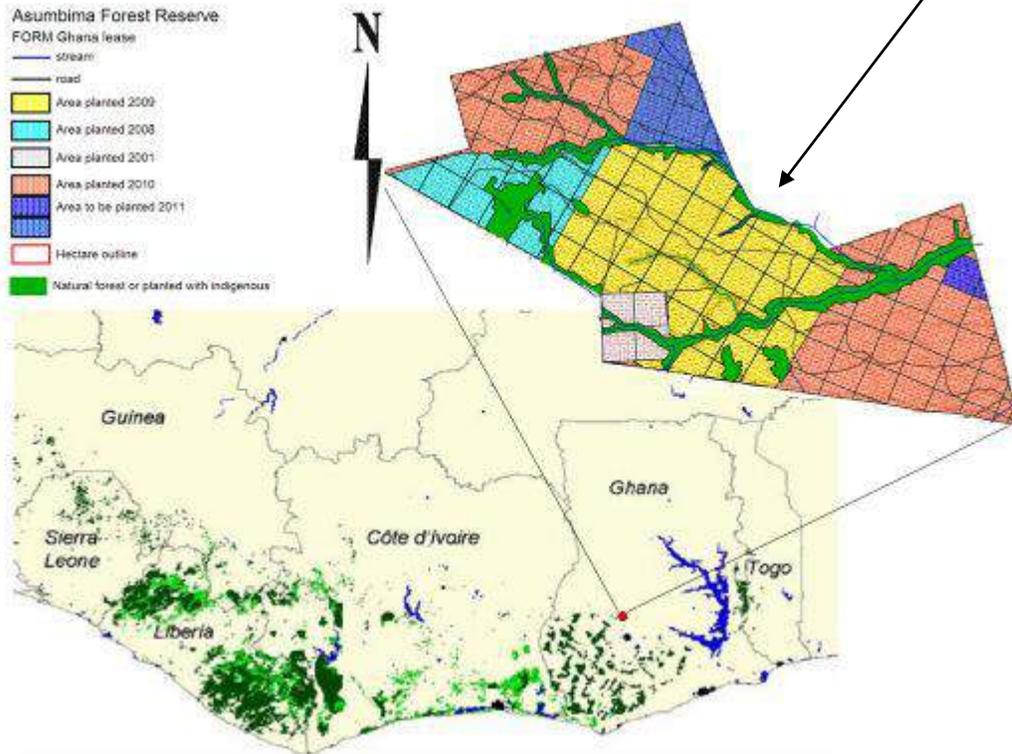
The objective of this Ecological monitoring was to conduct a survey of particular fauna and flora species in Asubima and Afrensu Brohuma Forest Reserves to know their diversity, estimate the significant differences between the current status of the species abundance and diversity to the previous studies done in Asubima (De Laat, 2010; Quansah, 2011 and Abdulai, 2011). This work is also to evaluate the relative conservation importance and threats to this biodiversity within each area, compare the two forest reserves' biodiversity profiles, provide management and research recommendations together with conservation priorities, to establish a baseline for the monitoring of these reserves and to do a follow-up research for Asubima, where such research has taken place before.

## **OVERALL RESULTS**

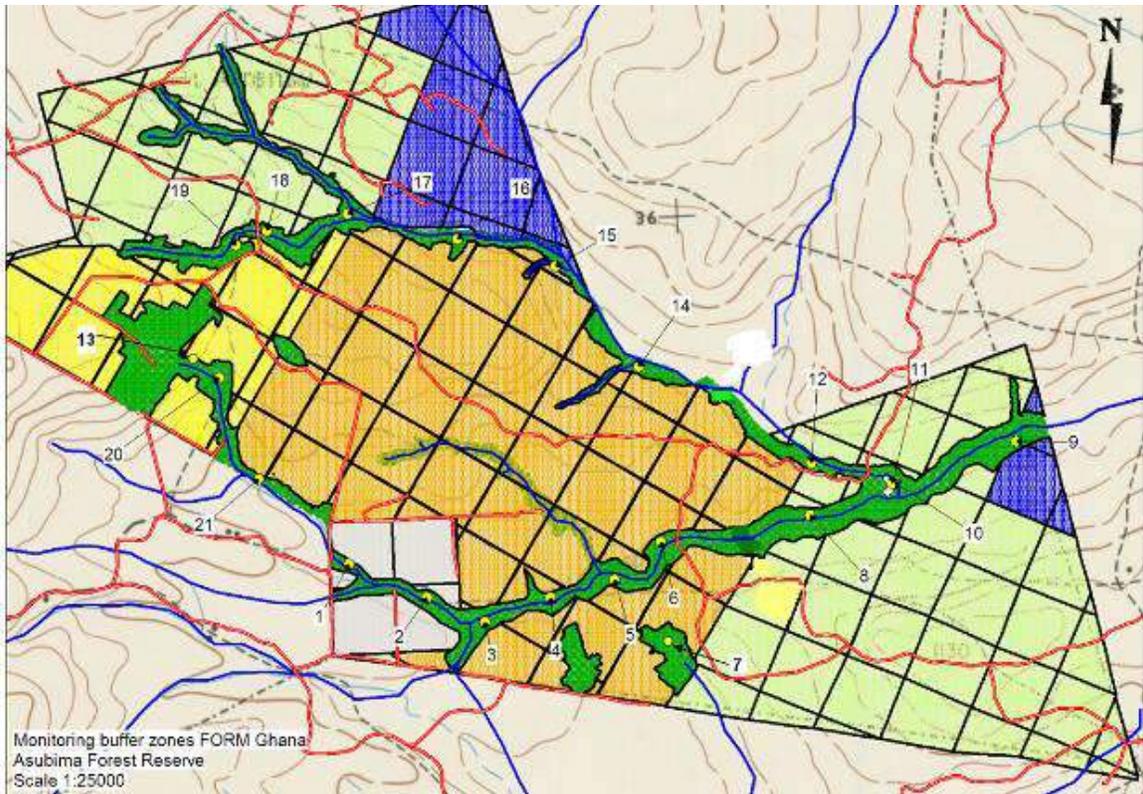
Though Asubima and Afrensu Brohuma was heavily impacted by human influences such as farming, hunting and illegal logging, the forestation program by FORM Ghana has made both reserves to be getting its forest quality and biodiversity apparently. At the end of the surveys, 138 plant species belonging to 47 families were recorded in Asubima Forest Reserve and 114 species of 49 families in Afrensu Brohuma (Appendix 1a). With the small mammal survey, 72 individuals of 14 species belonging to 3 orders (Appendix 2) were recorded in both reserves. 12 species in Asubima FR and 9 species in Afrenso Brohuma (Appendix 2). There was a higher diversity in Asubima FR.

In the avifauna study, 94 species of 32 families were listed in Asubima while 44 species of 21 families were found in Afrenso FR (Appendix 3). Seventy-five species of butterflies were recorded, 60 in Asubima and 41 in Afrenso Brohuma Forest Reserves (Appendix 4a). There were 14 species of Medium mammals in Asubima and 9 species in Afrenso Brohuma FR (Appendix 5).

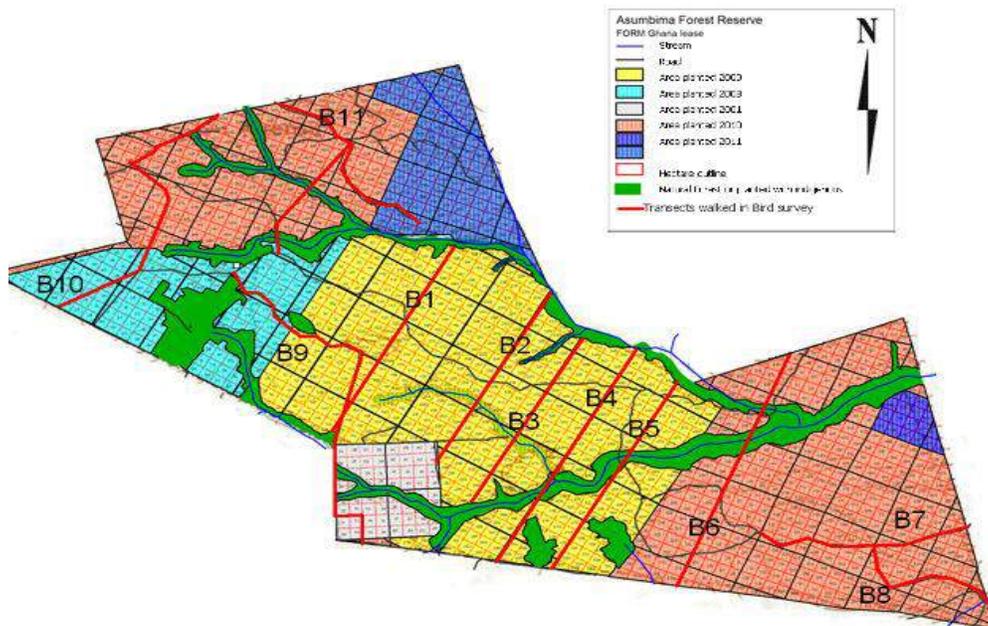
## Maps and Photos



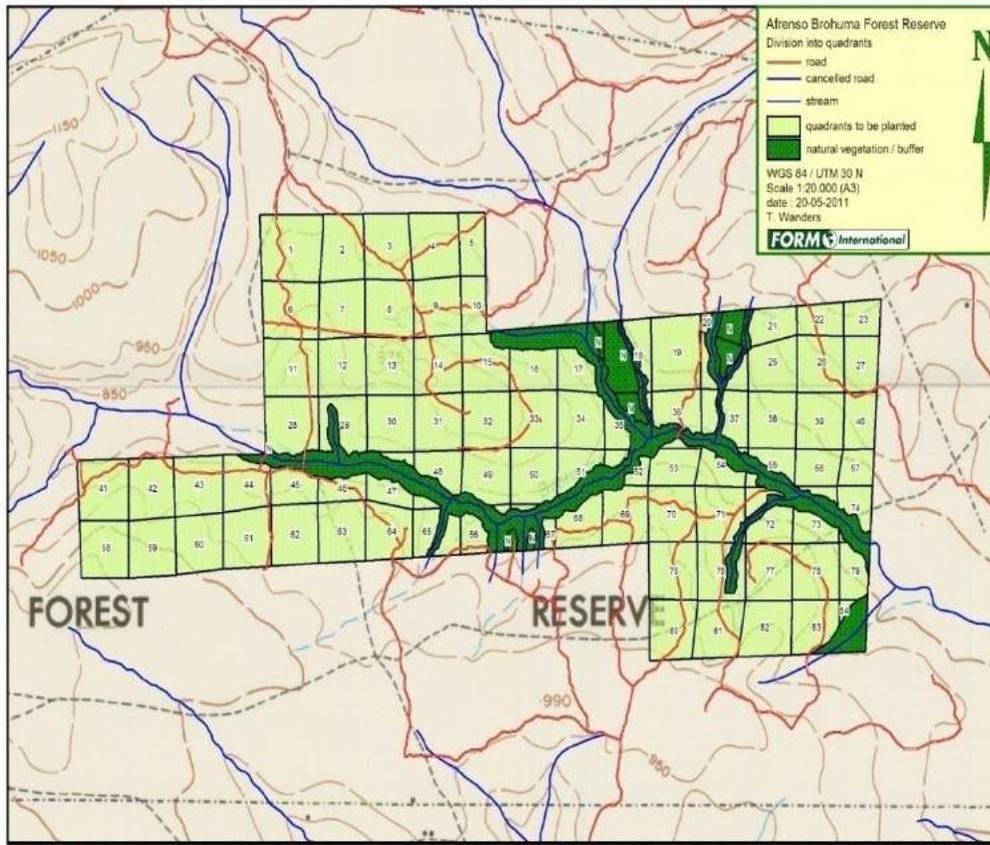
**Figure 1: Asubima Forest Reserve is situated at the northern edge of the Upper Guinean forests in West Africa. (Adapted from Hillers, 2008 and FORM International)**



**Figure 2: Map of Asubima FR. The green areas are buffer zones. Plots where vegetation surveys take place are indicated with numbers 1 till 21(Adapted from Noor, 2010 and FORM Ghana)**



**Figure 3: Map of Asubima Forest reserve with transect B1-B11, the transects we walked in the bird survey**



**Figure 4: Afrensu Brohuma map showing quadrants and buffers**

## PHOTOS



**1: Overview of Asubima Forest Reserve,  
Courtesy Gameli Collins**



**2: Riparian forest**



**3: Foot prints of Warthog  
(coordinates X-0628564 Y-0819210)**



**4: *Anthene rubricinctus***



**5: *Catopsilia florella***



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**7: *C. odorata* plant**



**8: *Griffonia simplicifolia***



**9: *Praomys tullbergi***



**10: Grasscutter's footprints**



**11: Togo hare's footprint**

## CHAPTER 1.0

### BACKGROUND

Ghana is part of the Upper Guinea forest ecosystem region of West Africa, which contains exceptionally diverse ecological communities of forest habitat providing refuge to numerous endemic species. West Africa is one of the world's 25 biological richest and most endangered terrestrial eco regions. A variety of socio-economic factors have led to forest fragmentation which threatens the variability of biodiversity in the region. The region is considered one of the world's top priority regions for conservation because of its high endemism of flora and fauna. The overall forest ecosystem of the region covered approximated 420,000 square kilometers but estimates of existing forest suggest a loss of nearly 80 percent. There is lack of information on the full coverage of biological resources of Ghana (Allortey, 2007). However Sixteen per cent of Ghana's land surface has been set aside to conserve representative samples of natural ecosystem in the form of forest resources, natural parks and other wild life reserves including various traditional forms of conservation.

Ghana was once renowned for its extensive forests and wooded savanna, but the situation has changed drastically. Tropical moist forest originally extended over 145,000 km<sup>2</sup> of Ghana. By the mid – 1970s, more than 90% of the country's high forests had been logged. The current area of intact forest is now estimated at between 10.9 and 11.8% of the original cover and 6.9% of the country's total area (Allortey, 2007). The current rates of deforestation average 22,000 ha/annum or about 1.3% (McCullough *et al*, 2007).

Several initiatives have been set in place to check the deforestation of the countries resources, this include setting up of reserves and wildlife parks, creation of Globally Significant

Biodiversity Areas (GSBAs), introduction of the concept of Important Bird Areas (IBAs), and the signing of regional and international agreements to protect forest biodiversity.

As a requirement for operation and a responsibility, a SEIA was conducted at Asubima in 2007 (Abeney *et al*, 2007) and subsequent surveys has been done by De Laat (2010), Gameli (2011), Quansah (2011) and Abdulai (2011). Since operation, the biodiversity of flora and fauna has been increasing significantly. In order to keep track and as an important component for maintaining a sustainable management scheme and FSC<sup>TM</sup> certificate, monitoring plans has been put in place by FORM Ghana.

**Biodiversity** as defined in the proposed US Congressional Biodiversity Act, HR1268 (1990), "biological diversity means the full range of variety and variability within and among living organisms and the ecological complexes in which they occur, and encompasses ecosystem or community diversity, species diversity, and genetic diversity (Jensen et al 1990). Plant, animal, and insect species interact and depend upon one another for what each offers, such as food, shelter, oxygen, and soil enrichment. Maintaining a wide diversity of species in each ecosystem is necessary to preserve the web of life that sustains all living things. Biodiversity also helps people to adapt to climate change through providing the ecosystem services which reduce their vulnerability and enhance their adaptive capacity to change.

**Monitoring** is the systematic process of collecting, analyzing and using information to track a program's progress toward reaching its objectives and to guide management decisions (Shapiro, 2001). At the program level, the purpose of monitoring is to track implementation and outputs systematically, and measure the effectiveness of the program. It helps determine exactly when a program is on track and when changes may be needed. Monitoring forms the basis for

modification of interventions and assessing the quality of activities being conducted (Stribling and Davie, 2005).

Monitoring can be used to demonstrate that program efforts have had a measurable impact on expected outcomes and have been implemented effectively. It is essential in helping managers, planners, implementers, policy makers and donors acquire the information and understanding they need to make informed decisions about program operations. Monitoring helps with identifying the most valuable and efficient use of resources. It is critical for developing objective conclusions regarding the extent to which program can be judged a “success”. It provides the necessary data to guide strategic planning, to design and implement programs and projects, and to allocate, and re-allocate resources in better ways (Gage and Dunn, 2009).

## CHAPTER 2.0

### SURVEY OF FLORA

Non-botanical forest characteristics, such as steepness of slopes, importance to watershed maintenance, and presence of sacred areas and animal habitats, have been stated as the reasons for the creation of forest reserves in Ghana. Protection of rare plant species and maintenance of biodiversity *per se* was never a stated objective in past designation of forest reserves. However, many of the above mentioned characteristics depend on plant regeneration and redevelopment of tree cover; these in turn influence the ability of animals to flourish in parts of the forest, as well as sustain the source of streams and rivers in the forest landscape. Flora is an important indicator of the climate, stage of ecological succession, soil type and mineral deposits of any particular area. Tropical rainforests are home to a great diversity of plant species, representing many life forms. This diversity creates a wide range of habitat and foods for animals. As evidence for this, plant diversity tends to correlate well with overall species diversity.

#### METHOD

Plots were made in the zones where indigenous species have been planted which are within the riparian buffer zone. These points each represent the middle of a round shaped permanent plot, sized 200m<sup>2</sup> (radius=7.98 m). The centre of plots was indicated with a wooden stick and within each plot 5 temporary subplots of 1 m<sup>2</sup> were made to measure herbs, grass and seedling cover. Considering trees, measurements taken were: species (scientific name/ local name, number per species (only the ones that are higher than 1.30m), DBH, height, distance to the middle of the plot and angle (using a compass). Secondly presence/absence and species names of lianas were

noted down. Thirdly for the shrubs, herbs, grasses and seedlings; species names along with their height and cover in % per species were written down. Coverage was only documented if more than 15-20% of the subplot was covered with a certain species. Lastly the presence of standing and lying dead wood was included. A qualified botanist helped identifying mainly woody species. Furthermore, for trees shrubs and grasses a guide-book was used (Hawthorn and Jongkind, 2008). 21 and 18 GPS points were randomly selected in Asubima and Afrensu Brohuma respectively with the program: “Map info”.

## RESULTS

### Asubima FR

A total of 138 plant species belonging to 47 families were recorded (Appendix 1a). All recorded species were angiospermae to which 83 species were trees, 18, 7 and 1 species were herbs, grasses and rushes respectively. Shrub and Liana (climber) recorded 15 species each. The most represented plant families with between five to eight species were the Euphorbiaceae, Fabaceae, Leguminosae (caes), Malvaceae (Sterculiaceae), Meliaceae, Moraceae and Sapindaceae. Fourteen families were represented by only a single species each. The most commonly occurring plant life-form was tree which made up 60.14% of the total recorded species.

The proportional abundance estimate of trees in the sample plots showed high diversity in the plots.

Table 1: The number of different plant species found per plot in a high to low order.

Plot no.	20	9	3	8	4	6	1	14	12	2	10	18	11	5	15	7	21	13	16	17	19
No. sp. Found	32	30	29	28	26	25	24	23	23	21	20	18	17	15	13	13	11	11	8	8	8

A list of species, their family names, and their life-form (shrub, tree, liana, herb, Grass and rush) is below (Appendix 1a). Appendix 1b shows the species found, in order of appearance. Most common species in the area was York (*Broussonetia papyrifera*), a tree species, present in 14 plots. *Griffonia simplicifolia* (Photo 8 above), a liana found in 13 plots, the second most common species followed by *Chromolaena odorata* (Photo 7above), a herb species found in 12 plots.

A gathered number of species with increasing number of plots enabled the creation of a species-effort curve (Fig.5). Based on the curve, it can be concluded that increasing number of plots increased the number of species record therefore new species are likely to be found when adding more sample plots.

**Afrensu Brohuma FR**

A total of 114 plant species belonging to 49 families were recorded (Appendix 1a). 73 species of the total recorded species were trees, 14, 10, 8, 7, 2 species were herbs, linnae, Shrub, Grass and fern respectively. The most represented families with between five to eight species were the Euphorbiaceae, Leguminosae (caes), Malvaceae (Sterculiaceae) and Meliaceae. Only two species of the Fern life-form was recorded, therefore the least represented life-form. Fifteen families recorded only a single species each. Tree was the most occurring plant life-form with 64. 04% of the total number of species recorded.

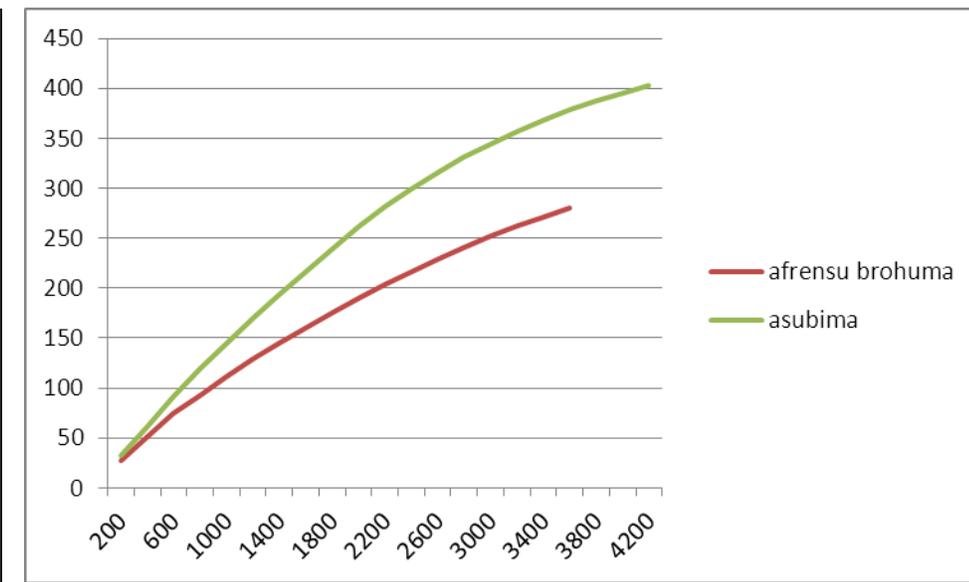
Table 2: The number of different plant species found per plot in a high to low order.

Plot No.	11	18	16	8	14	5	9	2	17	13	6	12	15	4	7	1	3	10
Sp. Found	27	24	23	19	18	18	16	15	15	15	14	13	12	12	11	10	9	9

A list of species, their family names, and their life-form (shrub, tree, liana, herb,

Grass and rush) is below (Appendix 1a). Appendix 1c shows the species founded, in order of appearance. Most common species in the area was *Chromolaena odorata*, a herb present in 13 plots, *Pynanthus angolensis*, a herb is the second most common species.

A gathered number of species with increasing number of plots enabled the creation of a species-effort curve (Fig.5). Based on the curve, it can be concluded that increasing number of plots increased the number of species record therefore new species are likely to be found when adding more sample plots.



**Figure 5: Species-effort plants of Asubima and Afrenso Forest Reserves**

## **DISCUSSIONS**

### **Asubima FR**

In the previous study (De Laat, 2010), 133 plant species of 41 plant families were recorded. Comparatively, there is an increase in species number to 138 and also an increase of families by additional six. Though Liana species decreased there was an increase of about 6.0% tree species from the previous study. Grass species also increased to 7 species from a previous one of 5. This increase may be as a result of the management activities put in place after the last botanical survey which included planting of indigenous tree species in the buffer zone and the security against illegal activities that may have hamper the botanical and zoological structure of the forest.

The highest species (26) per plot which was recorded on plot 8 had increase to 32 species but rather on plot 20 which previously had 25 species in it. Since the old plots and sub-plot were use in this study comparisons made reflect the valuation of management activities. York (*Broussonetia papyrifera*) was still the most occurring species present in 14 plots followed by *Griffonia simplicifolia* in 13 plots. *Chromolaena odorata* previously second became the third in this study present in 12 plots.

### **Afrensu Brohuma FR**

The study was a baseline vegetation survey at this site. The record of 114 plant species shows that though there was excessive degradation, the forest still harbour a good number of plant species in different life-forms. Good management plan will therefore improve to a high level species diversity and abundance of plant species. There was two fern species (not recorded in Asubima), this may be because of the open canopy cover therefore giving way for enough sun

light to the ground for photosynthesis. Grass species was also higher in Afrensu Brohuma FR compare to Asubima FR. This may be because of the open canopy.

## **COCLUSION AND RECOMMENDATION**

The increased species diversity, currently 138 from previous 133(De Laat, 2010), established in Asubima Forest Reserve and also a baseline record of 114 species in Afrensu Brohuma shows a high possibility of increasing diversity and abundance in the future.

The graphs show that there were not enough plots therefore in any future vegetation study more plots can be created to cover a vast percentage of the reserves.

It is therefore recommended that planted indigenous species at the buffer zones of both reserves be replanted when they don't survive and monitoring surveys should be continue to track the changes and plan for any alteration if there is a need.

## **CHAPTER 3.0**

### **SURVEY OF SMALL MAMMAL**

Small mammals (shrews, rodents and bats) were surveyed to assess the biodiversity of Asubima and Afrensu Brohuma forest reserves, in the Offinso North District of Ashanti Region of Ghana.

In this study, small mammal species is defined as mammal species less than 1kg as described by Stuart and Stuart (2006). Small mammal population has a significant relationship to habitat, vegetation cover and flora diversity, higher vegetation cover and diverse flora habitat results in higher abundance and diversity of small mammals (Demers *et al.*, 2003). Small mammals are therefore considered as good bio-indicators of habitat, this is because of their short lifespan, rapid population dynamics and low level of pressure on their populations as a result of hunting in comparison to larger mammals (shrews are never hunted because of the strong, unpleasant smell of their flank glands). They are also good bio-indicators because of the diversity, in tropical Africa, in terms of species and habitat preferences (Barrière *et al.* 2006).

### **SAMPLING METHODS AND STUDY SITES**

In each of the two forest reserves, terrestrial small mammals (shrews and small rodents) were sampled mainly with Sherman live traps, and bats with visual analysis. Sherman live traps were in two sizes Large Fording and Small Folding Aluminum. Sherman traps were baited with peanut butter and fishmeal. A prebaiting period preceded actual trapping (Sutherland, 1996). At the evening of the last prebaiting day, traps were set and checked twice daily, in the morning and

evenings. Trapping lasted for 5 or 6 nights. Captured animals were identified using Stuart and Stuart (2006). The bat species were checked at their abode.

### **Asubima FR**

The area is mainly of riparian forest and teak plantation. The topography of Asubima Forest reserve is undulating and some rocky outcrops are found in the reserve (Sools and Wanders, 2009). Four 1 km transect lines were laid in the study area. Six trap stations with 2 traps per station at a minimum of 200 m spacing were placed on each transect. Each microhabitat (Indigenous forest and teak plantation) had two transects laid in it. Trapping effort was 288 trap-nights, 144 trap-nights in each microhabitat.

### **Afrensu Brohuma FR**

The area consisted primary of teak plantation (average hight-3m) and the indigenous riparian forest. Afrensu Brohuma is more open than Asubima and has a low vegetation canopy cover with sandy- rock patches. Method used in Asubima was the same one used in Afrensu Brohuma. Sherman trap collecting effort was of 288 trap-nights.

## RESULTS

72 individuals belonging to 14 species of 3 orders were recorded; 7 rodent's species, 5 shrew species and two pteropodid bat species (Appendix 2). Eight species of the captured small mammal's species are forest species (*Malacomys edwardsi*, *Praomys tullbergi*, *Crocidura crossei*, *Crocidura juvenetae*, *Crocidura muricauda*, *Crocidura obscurior*, *Epomops franqueti* and *Myonycteris torquata*). 63.9% of the individuals were recorded in Asubima Forest reserve. The two pteropodid bat species were recorded only in Asubima reserve.

### Asubima FR

#### Species richness and abundance

46 individuals belonging to 3 orders of 12 species were recorded in the area (Appendix 2). In total *Praomys tullbergi* was the most abundant (19.6% of the total catch) followed by *Myonycteris torquata* with 13.04 percent of the overall captured individuals. A table of relative abundance and species richness in the sampled area is shown in Table 4.

In the indigenous riparian forest, 26 individuals of eleven species were identified. The species include 6 rodent species, 4 shrew species and a bat species. The most abundant order was the rodents and *Praomys tullbergi* was the most abundant species (19.2%) whilst the *Mus minutoides*, *Crocidura olivieri* and the *Myonycteris torquata* was the least recorded with 3.8% each of the total individual recorded (1 individual).

8 species of 20 individuals were recorded in the teak plantation. The most common among them was the *Myonycteris torquata* (25%) which was one of the least in the indigenous riparian forest. 43.5 percent of the total catch was recorded in the teak plantation. All species recorded tag least

concern in the IUCN Red list of threatened species. Seven species were found in both microhabitats. Species richness was highest in the indigenous riparian forest.

### **Diversity**

Alpha diversity of microhabitats is presented in Table 5. Shannon Indices shows higher small mammal diversity in the indigenous forest (3.292) to the Teak plantation (2.804). There was 7 species overlap.

### **Afrensu Brohuma FR**

#### **Species richness and abundance**

26 individuals of 9 species belonging to 2 orders were recorded in this study area (Appendix 2).

In total 18 species were rodents and 8 species were shrews. *Praomys tullbergi* and *Crocidura crossei* had an equal recorded number of 5 individuals which is the highest. *Lemniscomys striatus* and *Crocidura juvenetae* were the lowest recorded species. There was no bat species recorded in this area. 69.2% of the individuals were recorded in the indigenous riparian forest. *Crocidura crossei* was the highest recorded species (22.2%) in the indigenous forest while *Praomys tullbergi* was the most recorded in the teak plantation. Diversity was highest in the indigenous forest.

**Table 3: Species richness and abundance of Asubima and Afrensu Brohuma forest Reserve**

Species	ASUBIMA FR.				AFRENSU BROHUMA			
	Indigenous forest		Teak plantation		Indigenous Forest		Teak plantation	
	SR	RA	SR	RA	SR	RA	SR	RA
<i>Mastomys natalensis</i>	0.12	0.52	0.1	0.33	0.11	0.33	0.13	0.17
<i>Mus minutoides</i>	0.04	0.17	0.1	0.33	-	-	0.25	0.33
<i>Mus erytholeucus</i>	-	-	-	-	0.17	0.5	-	-
<i>Praomys tullbergi</i>	0.19	0.83	0.2	0.67	0.11	0.33	0.38	0.5
<i>Lemniscomys striatus</i>	0.12	0.5	-	-	0.06	0.17	-	-
<i>Malacomys edwardsi</i>	0.08	0.33	-	-	-	-	-	-
<i>Lophuromys sikapusi</i>	0.12	0.5	0.05	0.17	0.17	0.5	0.13	0.17
<i>Crocidura obscurior</i>	-	-	-	-	0.11	0.33	-	-
<i>Crocidura muricauda</i>	0.12	0.5	0.05	0.17	-	-	-	-
<i>Crocidura crossei</i>	0.08	0.33	0.1	0.33	0.22	0.67	0.13	0.17
<i>Crocidura juvenetae</i>	0.08	0.33	-	-	0.06	0.17	-	-
<i>Crocidura olivieri</i>	0.04	0.17	-	-	-	-	-	-
<i>Epomops franqueti</i>	-	-	0.15	0.5	-	-	-	-
<i>Myonycteris torquata</i>	0.04	0.17	0.25	0.83	-	-	-	-

**Table 4: Small mammals' community parameters in the sampled areas of Asubima and Afrensu Brohuma Forest Reserves.**

Parameters	ASUBIMA		AFRENSU BROHUMA	
	Indigenous Forest	Teak Plantation	Indigenous Forest	Teak Plantation
Number of Trap night	576	576	576	576
Number of Individuals	26	20	18	8
Number of species	11	8	8	5
Average population size	2.364	2.5	2.25	1.6
Shannon-Wiener index (log)	3.292	2.804	2.864	2.156
Shannon-Wiener index (ln)	2.282	1.943	1.985	1.494
Shannon-Wiener index (adjusted)	95.15%	93.46%	95.46%	92.84%

## DISCUSSIONS

Twenty-eight individuals of three species belonging to the order rodentia were recorded in the previous study of small mammal in Asubima forest reserve (Abdulai, 2011). This recent study recorded an increase in species and individuals of Asubima Forest reserve. This agrees with Klapproth *et al.* (1997) as small mammal abundance was monitored overtime in a Virginia Forest reserve. This may be because of improving habitat requirement and fewer disturbances to wildlife through hunting. Moro and Gadal (2010) reported that small mammal diversity and abundance increases with habitat restoration.

There was a higher record in Asubima reserve though trapping effort in this study compared to the previous one decreased, this might be because of the use of two different baits and different traps in this study. The different baits might affect composition and abundance of small mammal capture (Patric, 1970; Cerqueira *et al* 1990). Animals become more attracted to bait resembling their preferred diet (Laurance, 1992) therefore the different baits used was a more effective way to attract and capture a represented parcel of small mammal community in the reserves. Voss and Emmous (1996) stated that the use of different traps increase probability of capturing rare or shy species specially those who avoid a given trap type. The body size of species is also a major determinant in effectiveness of different types of traps. The used of different traps gave capturing possibility of different body sized small mammal species. Since some exclusive arboreal small mammal species occur in several forests (Grelle, 2003) bat species were important to be surveyed in this study and this also may be a reason for the increase species number.

The highest abundance was still in the indigenous riparian forest which was the same in the previous study. A habitat can contain a number of Small mammals base on its existing habitat features (Lin and Batzli, 2001).

Microhabitat diversity also increased in Asubima Forest reserve, 3 different rodent species, 4 shrew species and two migratory bat species has been recorded. Based on the results diversity was lower in the teak plantation and this correlates with Abdullah (1998) and Abdulai (2011) when comparing diversity in teak plantation to other microhabitats. Overlapping of species between microhabitats increased from one from the previous study to seven. This shows positive correlation of small mammal diversity within the Asubima forest reserve.

Comparing Asubima and Afrensu Brohuma Forest reserve, there is a higher species abundance and diversity in former than the latter. This is because small mammals prefer dense and thick vegetation which is considered to be antipredatory strategy against predators (Jedrezejewska and Jedrezejewski, 1990; Longland and price, 1991) since vegetation (canopy) cover in Asubima is higher than Afrensu Brohuma. Small mammal diversity also has a linear relationship with forest productivity and plant diversity (Kotler and Brown, 1998) which outline why diversity is higher in Asubima.

## **CONSERVATION RECOMMENDATIONS**

Both species richness and species abundance of shrew and murid rodent communities point to a higher conservation potential of Asubima than Afrensu Brohuma Forest Reserve. Forest species were more abundant in Asubima than in Afrensu Brohuma. Asubima appears to present better conservation value due to its larger size, and the more structured arboreal vegetation providing more fruit and leaf litter and preventing predatory attack.

Further monitoring should be undertaken, especially in Asubima, and sampling effort should be increase during the rainy season and for a longer time period in order to have a better knowledge of the small mammalian communities and of the rarest species.

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## **CHAPTER 4.0**

### **SURVEY OF AVIFAUNA**

During the field work in Asubima and Afrensu Brohuma forest reserves, 118 bird species were recorded, 94 at the former and 44 at the latter site. Results of the study in Asubima was compared to the previous ornithological study conducted in Asubima by De Laat (2010), also comparisons were made between the two study sites. Only one scarce species *Cuculus canorus*, was found.

#### **INTRODUCTION**

The wealth and quality of data on birds, relative to other taxa, may be used to develop the thinking and lead the way in the development and application of biodiversity indicators at local, national, regional and global levels.

Birds are good indicators of spatial biodiversity and sustainability because they are high in the food chain; these integrate changes at other levels, they occupy a broad range of ecosystem and have varied natural histories. Also a wealth of data has been (or can be) collected by volunteers and professionals, and bird population sizes and trends, and conservation status are often well known relative to other taxa and they are meaningful to a wide audience including the public.

There is therefore increasing interest in the use of ornithology data to indicate the effects of their change on biodiversity. Habitat indicators can be used to assess macro level changes, while indicators for birds and other taxa can also be used to identify more subtle changes in

biodiversity within habitats. By highlighting these changes, bird indicators can point to the need for more detailed research to identify the causes of change in population of different species.

As West African forests are rapidly disappearing, the survival of the birds of the Upper Guinea forests is becoming increasingly dependent on ever fewer areas. Despite a number of field studies conducted in the region in recent years (e.g. Demey and Rainey 2004, 2005; Rainey and Asamoah 2005; De Laat 2010), the avifaunas of the majority of these forests remain inadequately known.

Asubima Forest Reserve theoretically covers an area of 79 Km<sup>2</sup> of moist semi-deciduous, on Latitude: 7° 27' 0 N, Longitude: 1° 52' 0 W (Hawthorne and Abu- Juam 1995; Sools and Wanders, 2009). The forest canopy is close with larger trees reaching up to 50–60 m emerging above a sub-canopy of 10–20 m height. Few small streams occur in the Forest.

Afrensu Brohuma Forest Reserve also consists of moist semi-deciduous forest of similar aspect, but the terrain is mostly undulating. However, the area is much smaller than Asubima and theoretically covers 53 km<sup>2</sup>. Though illegal activities appear to have been from all sides in the past, the remaining forest nevertheless appears less fragmented than at Asubima. Compare to Asubima, the forest canopy is very open and presents numerous large gaps, with emergents reaching up to 40–50 m. No ornithological studies had been conducted previously in Afrensu Brohuma. Six days field work was carried out in each reserve.

## **METHODS**

The principal method used during this study consisted of observing birds by walking slowly along tracks. Notes were taken on both visual observations and bird vocalizations. Some recordings were made for later deposition in sound archives. Field work was carried out from dawn (usually 6:30GMT until 12:00GMT, and in the afternoon from 15:00GMT until sunset 18:00GMT). For each field day, a list was compiled of all the species that were recorded. Numbers of individuals or flocks were noted, as well as basic information on the habitat in which the birds were observed. For the purposes of standardization, we followed the nomenclature, taxonomy and sequence of Sinclair and Ryan (2003).

In Asubima, the 11 transects used in previous study (De Laat, 2010) were the same transects used because of the purpose of monitoring. Ten new transects were laid in Afrensu Brohuma. The transect lines were laid on pre-existing trails, quadrant lines and when necessary path were cut through vegetation.

## RESULTS

### **Asubima FR**

Previous studies at this site recorded 47 species (Abeney et al, 2007) and subsequently 77 (De Laat, 2010). Ninety-four species were recorded in this study; species are listed in Appendix 3, along with threat status. The 94 species belong to 32 different families and are typically savanna species. There were 6 species that are uncommon; *Vidua togoensis*, *Pholidornis rushiae*, *Authreptes longuemarei*, *centropus senegalensis*, *Centropus grillii* and *Aviceda cuculoides*. There was a scarce species recorded; *Cuculus canorus*. Within the 13 km and 505m of transect walked, we recorded 49 individuals per kilometer of 6 species. Twenty-five species were seen just once, while others species like Red Eye Dove recorded as high as 240 individuals. The highest number of species were recorded on transect 8 and the lowest was recorded on transect 5.

### **Afrensu Brohuma FR**

44 species belonging to 21 families were recorded. Within the 13km and 33m walked 3.4 species per kilometer of 32.6 individuals per kilometer were recorded. The highest species number of 15 was on transect 3, which also the highest individual record of 121. Moustached Grass warbler was the mostly recorded species. Three uncommon species were recorded; *Vidua* sp., *Cinnyris cupreus* and *centropus senegalensis*.

## DISCUSSION

Since the same method and transect used in the previous ornithological study (De Laat, 2010) was used, comparison can be made to this study to know if there has been any significant changes. Though some species recorded in the previous study were not found in this study, there is a significant increase in number of species and individuals. Only one (*Vidua togoensis*) of the previously five uncommon species was encountered this time. There were other 5 uncommon species recorded. Species found per kilometer has increase to 6 from 5.7 species per kilometer in De Laat (2010) study. Studies show that forest regeneration in an area results in increased bird's species diversity with regeneration age (Trimble and Aarde, 2010), while overall density remains relatively stable (Kritzinger and Aarde, 1998) as the bird community undergoes a compositional shift from grassland and pioneer species to secondary forest species (Grainger and Aarde, 2011). Thus, from a site-specific perspective, a few species characteristic of early successional stages should decrease over time while many forest species increase as the regenerating vegetation becomes more similar to old-growth forest, some species recorded previously were not identified in this study. Changes in area of vegetation types could therefore result in real changes in population densities (Askins and Philbrick, 1987).

Comparing Asubima to Afrensu Brohuma, there was low species number and individuals in the latter. This is because of the higher canopy cover in Asubima, needed requirement by bird different species were therefore met. Mustached Grass Warbler and other weaver species were abundant in Afrensu Brohuma because there grass species were abundant for bird to use.

Although mixed-species flocks were regularly encountered, they were not particularly common and comprised a relatively small number of individuals.

## CONSERVATION RECOMMENDATIONS

Although neither Asubima nor Afrensu Brohuma appear to have particularly remarkable birds, they still harbour a significant selection of Guinea-Congo forests biome species. Forests like these are becoming increasingly rare in West Africa. Considering the very fragmented state of Afrensu Brohuma, it appears preferable to concentrate conservation efforts on Asubima, which is much larger and less fragmented. Monitoring should be continued and specific locations of particular bird species should be researched to know why they prefer those locations, as this may lead to a specific management decision toward s those particular birds.

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## CHAPTER 5.0

### SURVEY OF BUTTERFLIES

Tropical forest ecosystems are under enormous pressure all over the world. Although the magnitude of biodiversity present on Earth is largely unknown (Dobson 1995) and its estimates remain highly controversial (May, 1990), it is generally accepted that much, if not most, of the global diversity in terms of numbers of species is represented by arthropods inhabiting tropical rainforests (Wilson 1988). There is dearth of data about the effects of forest disturbance upon these species-rich insect faunas (Eggleton et al., 1995). Several studies of butterflies (Hill et al. 1995; DeVries et al. 1997; Wood and Gillman 1998; Bakowski and Doku-Marfo,2006) showed that low disturbance levels have a positive effect on diversity and abundance of rainforest butterflies (Wood and Gillman 1998). These results are in accordance with the intermediate disturbance theory (Connell 1978) and have parallels in temperate forest habitats, where forest management providing a large range of shade levels has been found to increase the number of habitats suitable to different butterfly species (Warren 1985). Although deforestation rates are highest in several West African regions, little is known about the effects of forest disturbance on afrotropical butterflies (Larsen 1995a ).

Butterflies are excellent models for evaluating the status of natural communities in degraded landscapes, especially where knowledge is needed to help steer conservation efforts in the survey area. Because of the ease of collecting and close ties of individual lepidopteran species to host plants and their habitats, butterflies are excellent bio indicators and provide a wealth of information about habitats, associated host plants, and nectar sources (Smith et al., 1994; Debrot et al., 1999). These attributes makes them good for an assessment surveys. Floating across the air

effortlessly, butterflies flutter from flower to flower, providing scientists with a glimpse of an ecosystem's health. Butterflies and many other invertebrate species can help gauge environmental conditions (Brasher, 2009). Butterflies serve as important plant pollinators in the local environment, and help pollinate many economically important plant species. A contemporary discourse regarding butterfly conservation and its importance is however lacking among the public (Sahgal, 2006). This study mainly documents abundance and diversity of butterflies in Asubima and Afrensu Brohuma Forest Reserve in Ghana.

## **METHODS**

### ***Collecting on a transect line***

At both sites of the current survey, 1Km transects were selected within the forest, along trails, on the edges of the forest, and at selected locations in the indigenous riparian forest and teak plantations. Most specimens were physically collected with hand-held nets, except in a few cases when easily recognizable members of the family Papilionidae were identified in flight.

Collecting was done daily, between 9:00GMT and 12:00GMT. Butterflies seen 2.0m either side of the transect route and up to 5m in front were trapped or released after marking when positive identification was possible (Hill et al. 1995).

### ***Fruit bait traps***

Traps used were basically as described by Mühlenberg (1993) and baited with fermented banana. This method yielded a number of species of the Nymphalidae, which are otherwise rather difficult to catch using the net alone (especially members of the genus *Charaxes*). Three baited traps were set, two located in the indigenous forest, and one within the teak plantation (at both

sites). The baited traps were installed 1.0 m above the ground within the study site. Traps were baited with fruits every 24 hours. The traps were regularly moved to cover most of the collecting area.

### **BUTTERFLY IDENTIFICATION AND CALCULATION OF COMMUNITY PARAMETER**

Butterflies collected were identified using 'Butterflies of West Africa' (Larsen 2005). Butterfly diversity was estimated using Shannon-Weiner ( $H'$ ) diversity index (Magurran 1988)

Differences in species richness were compared among the forest reserves.

## RESULTS AND DISCUSSION

### Species richness

Of the two major sampled localities the Asubima Forest Reserve showed a higher species count than within the Afrensu Brohuma Forest Reserve.

In both reserve we recorded 75 species of butterflies in 5 families (Appendix 4a). The majority of individuals were collected using hand-held nets along transect lines (69.1% and 70.7% of the total capture in Asubima and Afrensu Brohuma respectively), while baited traps yielded only about 30.9% and 29.3% respectively. Interestingly, these traps were highly effective in collecting members of the genus *Charaxes*.

A group as heterogeneous in terms of their biology as the Lepidoptera requires a wide range of sampling methods, not all of which could be conducted during this survey. For this reason, most of our sampling effort concentrated on estimating the diversity of easily collected and observed diurnal Lepidoptera.

At Asubima sixty species of butterflies were recorded, whereas in Afrensu Brohuma we recorded forty-one. Of those, 20 and 13 species, respectively, are classified by Larsen (2005b) as species centered on moist evergreen and semi-deciduous forests. Of the total catch, 39.8% and 42.3% were of the family Nymphalidae in Asubima and Afrensu Brohuma respectively. The highest capture was in the indigenous riparian forest with 67.4% and 55.6% of the total individuals in Asubima and Afrensu Brohuma respectively, this agrees with Sundufo and Dumbuya (2007) while comparing habitat of butterflies in the Bumbuna forest. Shannon diversity was higher in the indigenous forests of both reserves compare to the Teak plantations.

**Table 5: Number of species in the different microhabitat**

	Asubima		Afrensu Brohuma	
	Indigenous	Teak	Indigenous	Teak
No. of Species	47	39	31	27
No. of Individuals	203	98	95	76
No. of individuals collected on transect line	147	61	72	49
No. individual collected from traps	56	37	23	27

Larsen also introduced a system of ranking butterfly species according to their rarity, based on the percentage of positive records of a species in relation to the number of visitations to a site. Most of the species of butterflies recorded during the present survey had a ranking of 1–3 (very common to not rare). However, a few species recorded had a high ranking status, indicating their rarity. For example, the following species were ranked as 4 (rare): *Liptena evanescens*, *Charaxes petersi*, *Euriphene incerta*, *Euphaedra inanim*, *Euphaedra eupalus* and *Gretna cylinda*. One species, *Pardaleodes xanthopeplus* was ranked as 5 (very rare). Below are comments of interesting butterfly species recorded (distribution information according to Larsen 2005a.)

1. *Liptena evanescens* Kirby 1887

Recorded in indigenous forest of Asubima. The Pink Liptena is known from eastern Côte d'Ivoire, Ghana, southern Nigeria and the Cross River loop. The habitat of this rare butterfly is forest in good condition.

2. *Charaxes petersi* Van Someren 1969

Recorded in both reserves. A rare butterfly, recorded from Konongo, Tano Offin and Mamang River in Ghana. It is an inhabitant of rain forest in good condition. The species is endemic to the area west of the Dahomey Gap, from Sierra Leone to the Volta Region.

3. *Euriphene incerta* Aurivillius 1912

Recorded in both reserves. This species, distinctly rare west of the Dahomey Gap and in western Nigeria, is found in wetter forests in good condition where it can be found alongside other species of *Euriphene* e.g., *E. barombina*. Recorded in Ghana from Kakum and Mamang River.

4. *Euphaedra inanum* Butler 1873

Recorded in both reserve. This species is known from Guinea-Bissau, Guinea, Sierra Leone, Côte d'Ivoire and Ghana (type locality - Ashanti). Though widespread in all types of forest, in Ghana it is distinctly scarce.

5. *Pardaleodes xanthoepus* Holland 1892

Recorded in the indigenous riparian forest of Asubima. A Ghana sub-region endemic, this species is very scarce, but it may be overlooked in the field because of its similarity to the common *P. tibulus*. In Ghana, individuals have been recorded from Mamang River, Konongo and the Atewa Range.

6. *Gretna cylinda* Hewitson 1877

Recorded in Teak plantation of Asubima. This species usually occurs in open habitats. In West Africa recorded from Liberia to Nigeria. In Ghana recorded from Kakum, Boabeng-Fiema and Mamang River

## **CONSERVATION RECOMMENDATIONS**

Though this is rapid and the first butterfly survey in both reserves, results of these surveys indicate a rich Lepidopteran fauna in both forest reserves. Both include a high proportion of forest species. Asubima is distinctly more heterogeneous in terms of its vegetation coverage than Afrensu Brohuma which has an open habitat therefore Asubima is considered a better candidate for any conservation activity. A longer and more detailed survey of both reserves will help in understanding the distribution and habitat preferences of the Lepidoptera found at both sites. Combined with the changes expected in the vegetation structure of the reserves, the basic, faunistic and taxonomic study of butterflies should become one of the priorities of biological explorations of FORMGHANA.

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## **CHAPTER 6.0**

### **SURVEY OF MEDIUM MAMMAL**

Line transects were used to survey medium mammals within the two reserves and interviews were conducted in nearby villages. A total of 15 medium mammal species were recorded, 14 species in Asubima FR and 9 in Afrensu Brohuma FR. Suggestions are made for improvement of biodiversity conservation in the reserves.

#### **INTRODUCTION**

Many medium mammal species have been exploited locally and are likely to have been driven to local extinction during the past century (Lee et al. 1988, Wilson 1994). The IUCN Red Data book lists noted that many animals found in Ghana are threatened, endangered or extinct (IUCN 2010). Indiscriminate hunting and clearing of forest for agricultural purposes have both played major roles in causing the decline and extinction of wildlife species in the area.

Local communities derive many benefits from the forest for their livelihood as in other parts of West Africa (Sunderland and Ndoye 2004). Mammals help in the maintenance and regeneration of tropical forest through predation, seed dispersion, grazing, and frugivory (Cuaron, 2000). In this study medium-sized mammal was defined as “any mammal whose known average weight is 5kg to 45kg” (Estes, 1991; Stuart and Stuart, 2006). In Ghana, however, there are few records that show the loss of wildlife species in the country. The purpose of this monitoring is to check changes in species abundance and diversity of medium mammals in Asubima Forest reserve and undertake an inventory of medium mammals, in Afrensu Brohuma forest reserves.

## **METHODS**

Transects were walked daily to sections of the reserves to determine the presence of medium mammal species. Mammal species were recorded using both direct observation and indirect observation through identification of footprints and tracks, dung/pellets, feed and feeding sites, and calls of animals to determine their presence. Sighted animals species and geographic location were recorded. Perpendicular distance from the transect line to the sign of the animal was recorded for determining estimated densities of medium-sized mammals. Old shotgun shells were recorded used to assess local hunting pressure within the two forest reserves. Species identification was based on Stuart and Stuart (2006). In Asubima the ten transects of 1km which were used in the previous medium mammal survey (Quansah, 2011) were the same walked on.

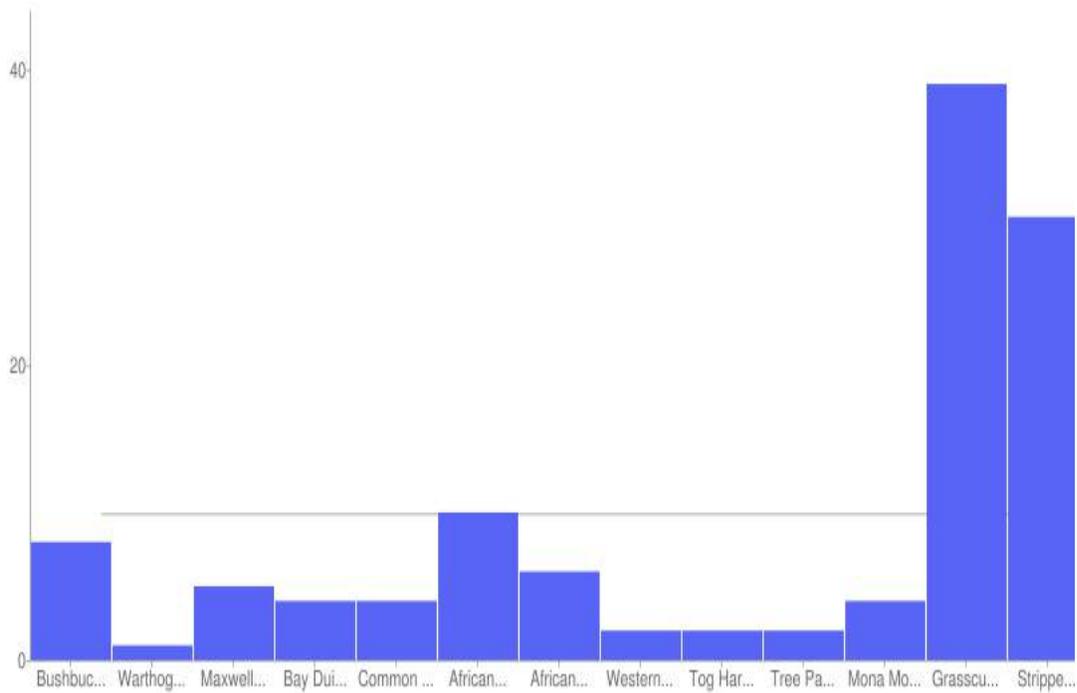
A reconnaissance (recce) survey was conducted in Afrensu Brohuma to have a general view of the area. 10 transects of 1km were laid to cover a large proportion of Asubima Forest Reserve and traverse the vegetation types in the Reserve. Existing tracks, quadrant lines and dirt roads were used in some inaccessible areas and as much as possible when necessary, vegetations were cut through to generate a path.

## RESULTS AND DISCUSSION

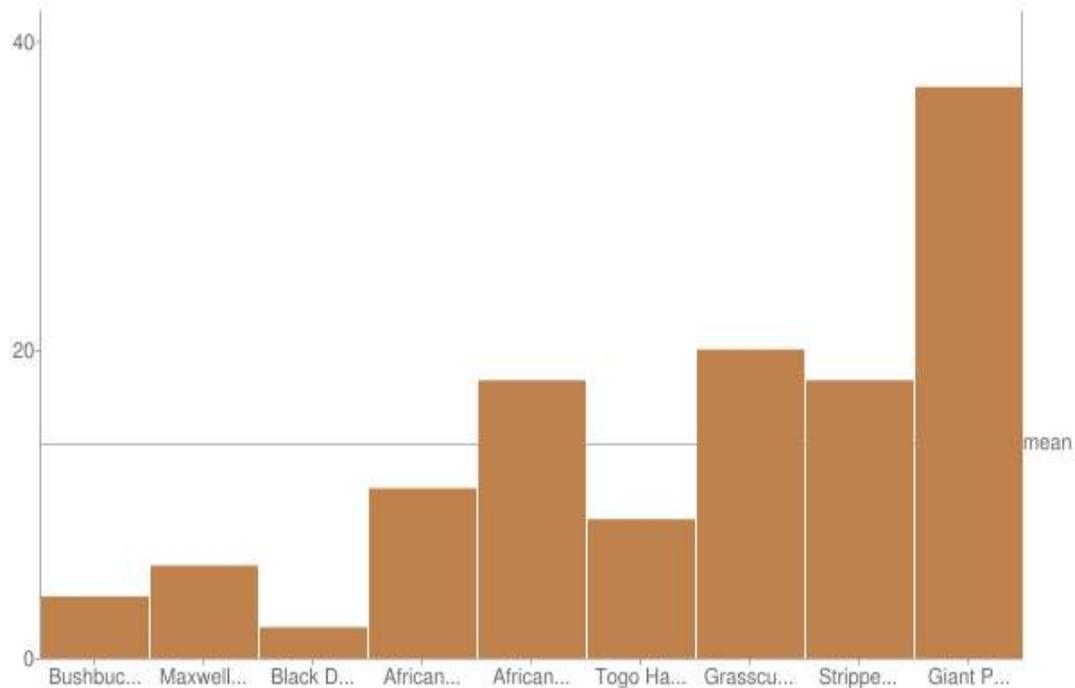
Fourteen and nine medium mammal species were identified from Asubima and Afrensu Brohuma respectively (Appendix 5). The difference in the number of species sighted in Asubima and Afrensu Brohuma is most likely due to the area sizes, vegetation cover and plant diversity of the reserves. Afrensu Brohuma is smaller and has less vegetation cover and diversity than Asubima. Rodent species were the most encountered species (Appendix 5)

The most abundant species in Asubima was grasscutter which was recorded in all microhabitat. Warthog sign was sighted only once and only in Asubima. The most encountered species (3.9) in Asubima was grasscutter and the least was Warthog. Density varied between individual species with Grasscutter recording the highest and Warthog the lowest. There was high diversity of (3.398) in the indigenous riparian of Asubima forest than its Teak plantation but in Afrensu Brohuma the teak plantation recorded the highest diversity of (2.812) to the indigenous forest of (2.449). There was an increase in species in this study at Asubima compare previous study by Quansah (2011). This increase may be because of the increase in vegetation as the indigenous forest and teak plantation have shown increase in diversity and abundance (*refer to Plant survey in Chapter 2*). Encounter rate has increase in Asubima since some selected species were sighted frequently and numerous. The presence of Warthog in Asubima is probably due the increasing variety and abundance of low level grasses therefore suitable forage will be available and even in abundant for the Warthog. Less human interference in the reserve may also be a factor for the warthog record. Warthog likeness to cool- off areas in order to cope with high temperature in the day may also be the reason of its record in Asubima Forest Reserve, increased forest canopy cover has prevented the water bodies in the reserve from drying up.

There was no evidence of Mona monkeys and Warthog in Afrensu Brohuma. The highest encountered species in Afrensu Brohuma was the Giant Pouched Rat which was ranked third after grasscutter and stripped squirrel in Asubima. The least encountered species sign in Afrensu Brohuma was the black duiker which was also only recorded at this site.



**Figure 6: Mammalian Species verse number of individuals in Asubima Forest Reserve.**



**Figure 7: Mammalian Species verse number of individuals in Afrensu Brohuma Forest Reserve.**

Numerous footpaths and three shotgun shells were recorded in the Afrensu Brohuma reserve suggesting hunting in the past and human activities. Black Duiker was recorded only in Afrensu Brohuma. There are clear signs of indiscriminate hunting in the past. The old shotgun shells found in the reserves testify to this. With the interview conducted, most people were ignorant about closed season on hunting stipulated in Ghana's national wildlife regulations. Local communities have easy access to both reserves especially through backdoor paths. The Result show preference of medium mammals to indigenous riparian forest, this may be because of the close water source and variable flora species in the indigenous riparian zone (Zimmerer and Young, 1998).

### **Interesting species**

Many mammal species were not observed, likely as a result of hunting and forest degradation in the past. The black duiker and Warthog seem threatened in Ghana as hunting and habitat destruction are prevalent throughout its range. They are not adaptive to habitat changes like other mammalian species and will decline in disturbed habitats.

### **CONSERVATION RECOMMENDATIONS**

Access to the both reserve should be restricted. The management practices which include curtailing hunting in the reserve must be enforced. The worker and indigenes in the reserve must be educated on the importance of mammalian conservation and associated laws of the country (close season regulations) so that they understand the conservation ideology and effectively help on law enforcement.

**Table 6: List of medium-sized mammal and the number of signs observed within each habitat type.**

COMMON NAME	MODE OF OBSERVATIONS	ASUBIMA		AFRENSU BROHUMA	
		Indigenous Forest	Teak Plantation	Indigenous Forest	Teak Plantation
Bushbuck	FP	5	3	4	-
Warthog	FP	1	-	-	-
Maxwell Duiker	FP	4	1	2	4
Black Duiker	FP	-	-	-	2
Bay Duiker	FP	4	-	-	-
Common Genet	FP	4	-	-	-
African Civet	FP	7	3	7	4
African Palm-civet	FP	4	2	9	9
Western Tree Hyrax	FS	2	-	-	-
Togo Hare	FP	6	15	1	8
Tree Pangolin	FS	2	-	-	-
Mona Monkey	FS	4	-	-	-
Grasscutter	FP,FS	22	17	6	14
Stripped Squirrel	FP,FS	9	21	12	6
Giant Pouched Rat	FP	12	10	29	8

**Table 7: Specific parameters of medium mammals in Asubima and Afrensu Brohuma Forest Reserves.**

	Asubima		Afrensu Brohuma	
	Indigenous Forest	Teak Plantation	Indigenous Forest	Teak Plantation
No. of species	14	8	8	8
No. of Individuals	86	72	70	55
Average population size	6.143	9	8.75	6.875
Shannon-Wiener Index (log)	3.398	2.489	2.449	2.812
Shannon-Wiener Index (ln)	2.355	1.725	1.698	1.949

**Table 8: Number of signs recorded along each transects.**

Transects	No. of signs observed.	
	Asubima	Afrensu Brohuma
1	23	9
2	31	19
3	4	36
4	11	6
5	17	15
6	22	7
7	9	13
8	28	5
9	8	10
10	5	5

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## CHAPTER 7.0

### OVERALL CONCLUSIONS AND CONSERVATION RECOMMENDATIONS

With the number of species found in Asubima, when comparing this study to the previous studies done, there has been significant difference in abundance and diversities of the selected species. Greater species diversity is most likely higher in Asubima due to the comparatively larger size and it been re-forested before Afrensu Brohuma. Asubima is larger than Afrensu Brohuma, providing more area of continuous habitat for flora and fauna. Its larger size makes it have a stronger buffering effect to any negative changes caused by the activity of the inhabitants.

Specific recommended actions:

- Continues monitoring should be done to effectively achieve the aim of biodiversity restoration
- Promote education of workers and local communities regarding hunting regulations (Wildlife Laws) and why they are needed.
- Conduct longer-term surveys for all taxonomic groups particularly in the wetter and rainy seasons.

## APPENDICES

### Appendix 1a: List of Plant Species from the Asubima and Afrensu Brohuma Forest Reserves

FAMILY	SPECIES	LIFE FORM	ASUBIMA	AFRENSU BROHUMA
Acanthaceae	<i>Asystasia</i> sp.	H	X	X
	<i>Eremomastax polysperma</i>	H	X	X
	<i>Justicia extensa</i>	H	X	
	<i>Justicia flava</i>	H	X	
Agavaceae	<i>Dracaena elliotii</i>	SH	X	X
	<i>Dracaena surculosa</i>	SH	X	
	<i>Dracaena phrynoides</i>	SH		X
Anacardiaceae	<i>Lannea welwetschii</i>	T	X	X
	<i>Mangifera indica</i>	T	X	
Annonaceae	<i>Cleistophlis patens</i>	T	X	X
	<i>Monodora myristica</i>	T	X	
	<i>Monodora tennifolia</i>	T	X	X
	<i>Uvaria afzelii</i>	T		X
Apocynaceae	<i>Alstonia boonei</i>	T	X	
	<i>Alabia barberi</i>	L	X	X
	<i>Alabia lucida</i>	L	X	
	<i>Baissea occidentalis</i>	-	X	X
Araceae	<i>Anchomanes difformis</i>	L	X	X
Asteraceae (Compositae)	<i>Chromolaena odorata</i>	H	X	X
	<i>Erigeron floribundus</i>	H	X	
	<i>Vernonia cinerea</i>	H	X	X
Bignoniaceae	<i>Newbouldia leavis</i>	T	X	
	<i>Spatodea campanulata</i>	T	X	
	<i>Stereospermum acuminatissimum</i>	T	X	X
Boraginaceae	<i>Cordia millenaria</i>	T	X	X
Bromeliaceae	<i>Ananas comosus</i>	H	X	X
Bursaceae	<i>Canarium schweinfurthii</i>	T	X	X
Celastraceae	<i>Salacia owabiensis</i>	L	X	
Cleomaceae	<i>Cleome viscosa</i>	H	X	X
Combretaceae	<i>Terminalia ivorensis</i>	T	X	X
	<i>Terminalia superba</i>	T	X	X
Commelinaceae	<i>Commelina</i> sp.	H		X
	<i>Palisota hirsute</i>	R	X	
Connaraceae	<i>Agelaea nitida</i>	L	X	X
	<i>Cnestis ferriginea</i>	L		X
	<i>Cnestis macrantha</i>	SH	X	
Cucurbitaceae	<i>Momordica foetida</i>	L	X	X
	<i>Telfairia occidentalis</i>	L	X	X
Cyperaceae	<i>Scleria boivinii</i>	H	X	X
Dracaenaceae	<i>Dracaena perrottetii</i>	T	X	
	<i>Dracaena ovate</i>	H	X	X
Ebenaceae	<i>Diospyros heudelotii</i>	SH	X	
	<i>Diospyros gabonensis</i>	T		X

Euphorbiaceae	<i>Alchornea cordifolia</i>	SH	X	X
	<i>Alchornea floribunda</i>	SH	X	
	<i>Macaranga barteri</i>	T	X	X
	<i>Macaranga heurifolia</i>	T		X
	<i>Mareya micrantha</i>	T	X	
	<i>Margaritaria discoidea</i>	T	X	X
	<i>Protomegabaria stapfianu</i>	T	X	
	<i>Ricinodendron heudelotii</i>	T	X	
	<i>Spondianthus preussii</i>	T		X
Fabaceae	<i>Albizia adienthifolia</i>	T	X	X
	<i>Albizia ferruginea</i>	T	X	
	<i>Albizia zygia</i>	T	X	X
	<i>Aubrevillea platycarpa</i>	T	X	X
	<i>Griffonia simplicifolia</i>	L		X
	<i>Newtonia duparquetiana</i>	T	X	
Filicineae	<i>Cyclosorus Striatus</i>	Fern		X
Flacourtiaceae	<i>Homalium stipulaceum</i>	T		X
	<i>Ophiobotry zenkeri</i>	T	X	
Graminae	<i>Olyra latifolia</i>	G	X	
	<i>Panicum maximum</i>	G		X
	<i>Saccharum officinalis</i>	G	X	X
	<i>Setaria barbata</i>	G		X
	<i>Sporobus pyramidalis</i>	G	X	X
Guttiferae	<i>Garcinia smeathmannii</i>	T		X
Leguminosae (Caes)	<i>Childlowia sanguine</i>	T	X	
	<i>Daniellia thurifera</i>	T	X	X
	<i>Daniellia ogea</i>	T	X	X
	<i>Dialium aubrevillei</i>	T		X
	<i>Didelotia idea</i>	T	X	
	<i>Distemonanthus benthamianus</i>	T		X
	<i>Gilbertiodendron limba</i>	T	X	X
	<i>Gilbertiodendron splendidum</i>	T	X	X
	<i>Hymenostegia afzelii</i>	T		X
Leguminosae (Mim)	<i>Acacia kumerunensis</i>	L	X	
	<i>Piptadeniastrum africanum</i>	T	X	X
	<i>Tetrapleura chavalieri</i>	T		X
Leguminosae (Pap)	<i>Amphimas pterocarpoides</i>	T	X	X
	<i>Baphia nitida</i>	SH	X	X
	<i>Dalbergia saxatilis</i>	T	X	X
	<i>Desmodium ascendense</i>	H		X
	<i>Milletia zachiana</i>	T	X	
Loganiaceae	<i>Spigelia anthelmia</i>	H	X	
Malvaceae(Bombacaceae)	<i>Ceiba pentandra</i>	T	X	X
	<i>Bombax buonopozense</i>	T	X	
	<i>Rhodognaphalon brevicuspe</i>	T	X	X
Malvaceae(Sterculiaceae)	<i>Nesogordonia papaverifera</i>	T	X	X
	<i>Cola gigantean</i>	T	X	X
	<i>Cola millenni</i>	T		X
	<i>Pterygota macrocarpa</i>	T	X	
	<i>Sterculia rhinopetala</i>	T	X	X

	<i>Sterculia oblonga</i>	T	X	X
	<i>Sterculia tragacantha</i>	T	X	
	<i>Triplochiton scleroxylon</i>	T	X	X
Malvaceae (Tiliaceae)	<i>Glyphaea brevis</i>	T	X	X
Marantaceae	<i>Hypselodelphis velutina</i>	SH	X	X
	<i>Marantochloa congensis</i>	SH	X	
	<i>Marantochloa mannii</i>	SH		X
Meliaceae	<i>Carapa procera</i>	T	X	
	<i>Cedrela odorata</i>	T	X	
	<i>Entandrophragma angolense</i>	T		X
	<i>Entandrophragma cylindricum</i>	T		X
	<i>Entandrophragma utile</i>	T	X	X
	<i>Khaya ivorensis</i>	T	X	X
	<i>Trichilia monadelpha</i>	T	X	X
	<i>Trichilia prieureana</i>	T	X	
Moroceae	<i>Antiaris toxicaria</i>	T	X	X
	<i>Broussonetia papyrifera</i>	T	X	X
	<i>Ficus exasperata</i>	T	X	
	<i>Ficus variifolia</i>	T	X	X
	<i>Milicia excels</i>	T	X	X
	<i>Morus mesozygia</i>	T	X	
	<i>Trilepisium madagascariense</i>	T	X	
Myristicaceae	<i>Pynanthus angolensis</i>	H		X
Nyctaginaceae	<i>Pisonia aculeate</i>	H	X	
Olacaceae	<i>Coula edulis</i>	T	X	X
	<i>Heisteria parvifolia</i>	SH	X	X
	<i>Olax subcorpioidea</i>	T	X	
	<i>Strombosia pustulata</i>	T	X	X
Palmae	<i>Laccosperma opacum</i>	L	X	X
	<i>Raphia palma-pinus</i>	T	X	X
Pandaceae	<i>Panda oleosa</i>	T	X	X
Passifloraceae	<i>Adenia rumicifolia</i>	L	X	X
Poaceae	<i>Acroceras zizanoides</i>	G	X	
	<i>Pennisetum purpureum</i>	G	X	X
	<i>Imperata cylindrical</i>	G	X	X
	<i>Rottboelia exaltata</i>	G	X	X
Pterydophyta	<i>Nephrolepis sp.</i>	Fern		X
Rubiaceae	<i>Chassalia kolly</i>	L	X	X
	<i>Dictyandra arborescens</i>	SH		X
	<i>Geophila afzelii</i>	SH	X	
	<i>Hallea Ledermannii</i>	T	X	
	<i>Rutidea depuisii</i>	L	X	
Sapindaceae	<i>Blighia sapida</i>	T	X	X
	<i>Blighia unijagat</i>	T	X	
	<i>Blighia welwitschii</i>	T	X	X
	<i>Lecaniodiscus cupanioides</i>	SH	X	
	<i>Majidea fosteri</i>	T	X	X
	<i>Puallinia pinnata</i>	SH	X	
Sapotaceae	<i>Chrysophyllum abidum</i>	T	X	
	<i>Chrysophyllum perpulchrum</i>	T		X

	<i>Pouteria alnifolia</i>	T	X	X
	<i>Pouteria altissima</i>	T	X	
Santalaceae	<i>Okonbaka aubrevillei</i>	T		X
Solanaceae	<i>Solanum torvum</i>	L	X	X
Ulmaceae	<i>Celtis adolfi</i>	H	X	X
	<i>Celtis mildbraedii</i>	T	X	X
	<i>Celtis wightii</i>	T	X	X
	<i>Celtis zenkeri</i>	T		X
	<i>Trema orientalis</i>	T	X	
Violaceae	<i>Rinorea afzelii</i>	L	X	X
	<i>Rinorea oblongifolia</i>	T	X	X
Zingiberaceae	<i>Aframomum melegueta</i>	SH	X	
	<i>Aframomum stanfieldii</i>	H	X	X
	<i>Costus dubius</i>	H	X	
Unknown	<i>Adankomilk</i>	H	X	
	<i>Ananse tromohoma</i>	H	X	X
	<i>Toantini</i>	L	X	X
	<i>Odenia rumicifolia</i>	T	X	X
	<i>Fema</i>	T	X	X
	<i>Sope</i>	T	X	X
	<i>Nyemekobere</i>	T	X	
	<i>Osonowesamfee</i>	T	X	
	<i>Kbese</i>	T	X	
			138	114

Life form (H=herb, L=liana, T=tree, R=rattan, S=shrub, F=fern) are displayed. When scientific name is unknown, local name is given in italic.

**Appendix 1b: Plant species found in Asubima FR ranked by frequency**

SPECIES	No. of plots appears with sp.
<i>Broussonetia papyrifera</i>	14
<i>Griffonia simplicifolia</i>	13
<i>Chromolaena odorata</i>	12
<i>Albizia zygia</i>	8
<i>Antiaris toxicaria</i>	8
<i>Celtis mildbraedii</i>	7
<i>Terminalia ivorensis</i>	7
<i>Justicia extensa</i>	7
<i>Khaya ivorensis</i>	7
<i>Asystasia sp.</i>	7
<i>Odenia rumicifolia</i>	7
<i>Cleome viscosa</i>	7
<i>Alabia barteri</i>	7
<i>Adankomilk</i>	7
<i>Newbouldia leavis</i>	6
<i>Stereospermum acuminatissimum</i>	6
<i>Ananse tromohoma</i>	6
<i>Salacia owabiensis</i>	6
<i>Alstonia boonei</i>	6
<i>Dracaena surculosa</i>	5
<i>Baisea occidentalis</i>	5
<i>Canarium schweinfurthii</i>	5
<i>Ficus exasperata</i>	5
<i>Daniellia thurifera</i>	5
<i>Alabia lucida</i>	5
<i>Cordia millennia</i>	5
<i>Monodora tennifolia</i>	5
<i>Terminalia ivorensis</i>	5
<i>Erigeron floribundus</i>	5
<i>Albizia adientifolia</i>	4
<i>Rinorea oblongifolia</i>	4
<i>Telfairia occidentalis</i>	4
<i>Palisota hirsute</i>	4
<i>Cnestis macrantha</i>	3
<i>Terminalia superb</i>	3
<i>Ananas comosus</i>	3
<i>Momordica foetida</i>	3
<i>Newtonia duparquetiana</i>	3
<i>Margaritaria discoidea</i>	3
<i>Scleria boivinii</i>	3
<i>Mareya micrantha</i>	3
<i>Macaranga barteri</i>	3
<i>Dracaena perrottetii</i>	3
<i>Alchornea floribunda</i>	3
<i>Diospyros heudelotii</i>	3
<i>Alchornea cordifolia</i>	3

<i>Albizia ferruginea</i>	3
<i>Daniellia ogea</i>	3
<i>Blighia sapida</i>	3
<i>Blighia welwitschii</i>	3
<i>Aframomum stanfieldii</i>	3
<i>Spatodea campanulata</i>	3
<i>Dracaena elliotii</i>	3
<i>Aubrevillea platycarpa</i>	3
<i>Vernonia cinerea</i>	3
<i>Olyra latifolia</i>	3
<i>Ricinodendron heudelotii</i>	2
<i>Protomegabaria stapfianu</i>	2
<i>Didelotia idea</i>	2
<i>Saccharym officinalis</i>	2
<i>Baphia nitida</i>	2
<i>Gilbertodendron splendidum</i>	2
<i>Sporobus pyramidalis</i>	2
<i>Pennisetum purpureum</i>	2
<i>Acacia kumerunensis</i>	2
<i>Dracaena ovate</i>	2
<i>Amphimas pterocarpoides</i>	2
<i>Gilbertiodendron limba</i>	1
<i>Chrysophyllum abidum</i>	1
<i>Anchomanes difformis</i>	1
<i>Agelaea nitida</i>	1
<i>Childlowia sanguine</i>	1
<i>Spigelia anthelmia</i>	1
<i>Bombax buonopozense</i>	1
<i>Milletia zachiana</i>	1
<i>Pterygota macrocarpa</i>	1
<i>Piptadeniastrum africanum</i>	1
<i>Solanum torvum</i>	1
<i>Mangifera indica</i>	1
<i>Heisteria parvifolia</i>	1
<i>Entandrophragma utile</i>	1
<i>Olex subcorpioidea</i>	1
<i>Rhodognaphalon brevicuspe</i>	1
<i>Nesogordonia papaverifera</i>	1
<i>Ceiba pentandra</i>	1
<i>Cedrela odorata</i>	1
<i>Coula edulis</i>	1
<i>Marantochloa congensis</i>	1
<i>Trichilia prieureana</i>	1
<i>Sterculia oblonga</i>	1
<i>Trichilia monadelphina</i>	1
<i>Dalbergia saxatilis</i>	1

<i>Sterculia rhinopetala</i>	1
<i>Morus mesozygia</i>	1
<i>Ficus variifolia</i>	1
<i>Adenia rumicifolia</i>	1
<i>Laccosperma opacum</i>	1
<i>Milicia excels</i>	1
<i>Chassalia kolly</i>	1
<i>Imperata cylindrical</i>	1
<i>Glyphaea brevis</i>	1
<i>Justicia flava</i>	1
<i>Puallinia pinnata</i>	1
<i>Ophiobotry zenkeri</i>	1
<i>Blighia unijagat</i>	1
<i>Sterculia tragacantha</i>	1
<i>Raphia palma-pinus</i>	1
<i>Panda oleosa</i>	1
<i>Trilepisium</i>	1
<i>madagascariense</i>	
<i>Celtis adolphi</i>	1
<i>Pisonia aculeate</i>	1
<i>Rutidea depuisii</i>	1
<i>Rottboelia exaltata</i>	1
<i>Acroceras zizanoides</i>	1
<i>Pouteria altissima</i>	1
<i>Carapa procera</i>	1
<i>Pouteria alnifolia</i>	1
<i>Celtis wightii</i>	1
<i>Majidea fosteri</i>	1
<i>Strombosia pustulata</i>	1
<i>Triplochiton scleroxylon</i>	1
<i>Cola gigantean</i>	1
<i>Cleistophlis patens</i>	1
<i>Solanum torvum</i>	1
<i>Hypselodelphis velutina</i>	1
<i>Hallea Ledermannii</i>	1
<i>Geophila afzelii</i>	1
<i>Fema</i>	1
<i>Monodora myristica</i>	1
<i>Lecaniodiscus cupanioides</i>	1
<i>Toantini</i>	1
<i>Aframomum melegueta</i>	1
<i>Trema orientalis</i>	1
<i>Eremomastax polysperma</i>	1
<i>Kbese</i>	1
<i>Costus dubius</i>	1
<i>Sope</i>	1
<i>Osonowesamfee</i>	1
<i>Nyemekobere</i>	1

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**Appendix 1c: Plant species found in Afrensu Brohuma FR ranked by frequency**

SPECIES	No. of plots appears with sp.
<i>Chromolaena odorata</i>	13
<i>Pynanthus angolensis</i>	12
<i>Antiaris toxicaria</i>	11
<i>Broussonetia papyrifera</i>	11
<i>Commelina</i> sp.	11
<i>Anchomanes difformis</i>	10
<i>Lanea welwetschii</i>	10
<i>Ceiba pentandra</i>	9
<i>Albizia zygia</i>	7
<i>Cleome viscosa</i>	7
<i>Cnestis ferruginea</i>	7
<i>Griffonia simplicifolia</i>	7
<i>Panicum maximum</i>	7
<i>Pennisetum purpureum</i>	7
<i>Gilbertodendron splendidum</i>	5
<i>Terminalia superb</i>	5
<i>Alabia barteri</i>	4
<i>Aubrevillea platycarpa</i>	4
<i>Baphia nitida</i>	4
<i>Cleistophlis patens</i>	4
<i>Cola millenni</i>	4
<i>Cordia millennia</i>	4
<i>Daniellia thurifera</i>	4
<i>Dialium aubrevillei</i>	4
<i>Sterculia rhinopetala</i>	4
<i>Stereospermum acuminatissimum</i>	4
<i>Uvaria afzelii</i>	4
<i>Celtis mildbraedii</i>	3
<i>Macaranga heurifolia</i>	3
<i>Raphia palma-pinus</i>	3
<i>Rottboelia exaltata</i>	3
<i>Sterculia oblonga</i>	3
<i>Adenia rumicifolia</i>	2
<i>Albizia adienthifolia</i>	2
<i>Amphimas pterocarpoides</i>	2
<i>Ananse tromohoma</i>	2
<i>Celtis adolfi</i>	2
<i>Cola gigantean</i>	2
<i>Coula edulis</i>	2
<i>Dalbergia saxatilis</i>	2
<i>Daniellia ogea</i>	2
<i>Diospyros gabonensis</i>	2
<i>Entandrophragma angolense</i>	2
<i>Entandrophragma utile</i>	2
<i>Glyphaea brevis</i>	2
<i>Hymenostegia afzelii</i>	2
<i>Hypselodelphis velutina</i>	2

<i>Khaya ivorensis</i>	2
<i>Marantochloa mannii</i>	2
<i>Margaritaria discoidea</i>	2
<i>Milicia excels</i>	2
<i>Monodora tennifolia</i>	2
<i>Laccosperma opacum</i>	2
<i>Nepholepis sp.</i>	2
<i>Nesogordonia papaverifera</i>	2
<i>Piptadeniastrum africanum</i>	2
<i>Rhodognaphalon brevicuspe</i>	2
<i>Rinorea oblongifolia</i>	2
<i>Rottboelia exaltata</i>	2
<i>Strombosia pustulata</i>	2
<i>Terminalia ivorensis</i>	2
<i>Tetrapleura chavalieri</i>	2
<i>Trichilia monadelph</i>	2
<i>Aframomum stanfieldii</i>	1
<i>Agelaea nitida</i>	1
<i>Alchornea cordifolia</i>	1
<i>Ananas comosus</i>	1
<i>Asystasia sp.</i>	1
<i>Baissea occidentalis</i>	1
<i>Blighia sapida</i>	1
<i>Blighia welwitschii</i>	1
<i>Canarium schweinfurthii</i>	1
<i>Celtis wightii</i>	1
<i>Celtis zenkeri</i>	1
<i>Chassalia kolly</i>	1
<i>Chrysophyllum perpulchrum</i>	1
<i>Cyclosorus Striatus</i>	1
<i>Desmodium ascendense</i>	1
<i>Dictyandra arborescens</i>	1
<i>Distemonanthus benthamianus</i>	1
<i>Dracaena elliotii</i>	1
<i>Dracaena phrynoides</i>	1
<i>Dracaena ovate</i>	1
<i>Entandrophragma cylindricum</i>	1
<i>Eremomastax polysperma</i>	1
Fema	1
<i>Ficus variifolia</i>	1
<i>Garcinia smeathmannii</i>	1
<i>Gilbertiodendron limba</i>	1
<i>Heisteria parvifolia</i>	1
<i>Homalium stipulaceum</i>	1
<i>Imperata cylindrical</i>	1
<i>Macaranga barteri</i>	1
<i>Majidea fosteri</i>	1
<i>Momordica foetida</i>	1
<i>Odenia rumicifolia</i>	1
<i>Okonbaka aubrevillei</i>	1

<i>Panda oleosa</i>	1
<i>Pisonia aculeate</i>	1
<i>Pouteria alnifolia</i>	1
<i>Rinorea afzelii</i>	1
<i>Saccharum officinalis</i>	1
<i>Scleria boivinii</i>	1
<i>Setaria barbata</i>	1
<i>Solanum torvum</i>	1
Sope	1
<i>Spondianthus preussii</i>	1
<i>Sporobus pyramidalis</i>	1
<i>Telfairia occidentalis</i>	1
Toantini	1
<i>Triplochiton scleroxylon</i>	1
<i>Vernonia cinerea</i>	1

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**Appendix 2: Distribution of small mammal species in Asubima and Afrensu Brohuma Forest Reserve**

Species	Common name	ASUBIMA		AFRENSU BROHUMA	
		Ind. forest	Teak plantation	Ind. forest	Teak plantation
<i>Mastomys natalensis</i>	Multimammate rat	3	2	2	1
<i>Mus minutoides</i>	African Pygmy Mouse	1	2	-	2
<i>Mus erytholeucus</i>		-	-	3	-
<i>Praomys tullbergi</i>	Soft-furred mouse	5	4	2	3
<i>Lemniscomys striatus</i>	Striped Grass Mouse	3	-	1	-
<i>Malacomys edwardsi</i>	Edward's Swamp Rat	2	-	-	-
<i>Lophuromys sikapusi</i>	Rusty-bellied rat	3	1	3	1
<i>Crocidura obscurior</i>	West African Pygmy Shrew	-	-	2	-
<i>Crocidura muricauda</i>	West African Long-tailed Shrew	3	1	-	-
<i>Crocidura crossei</i>	Crosse's Shrew	2	2	4	1
<i>Crocidura juvenetae</i>	Jouvenet's shrew	2	-	1	-
<i>Crocidura olivieri</i>	African Giant Shrew	1	-	-	-
<i>Epomops franqueti</i>	Franquet's Bat	-	3	-	-
<i>Myonycteris torquata</i>	Little Collared Fruit Bat	1	5	-	-
		26	20	18	8

**Appendix 3: List of Bird species recorded in Asubima and Afrensu Brohuma Forest Reserve as described in Sinclair and Ryan (2003) are displayed.**

FAMILY	SPECIES	COMMON NAME	STATUS	ASUBIMA	AFRENSU BROHUMA
Accipitridae	<i>Accipiter tachiro</i>	African Goshawk	Common	X	
	<i>Accipiter badius</i>	Shikra Goshawk	Common	X	
	<i>Melierax gabar</i>	Gabar Goshawk	Locally common	X	
	<i>Accipiter nelenoleucus</i>	Black(great) Sparrow Hawk	Common	X	
	<i>Kaupifalco monogrammicus</i>	Lizzard Buzzard	Least common	X	X
	<i>Aviceda cuculoides</i>	African Cuckoo Hawk	Uncommon	X	
	<i>Aquila wahlbergi</i>	Wahlberg's Eagle	Common		X
Alaudidae	<i>Mirafra rufocinnamomea</i>	Flappet Lark	Common	X	
Alcedinidae	<i>Alcedo semitorquata</i>	Shining blue Kingfisher	Uncommon	X	
	<i>Ispidina picta</i>	African pygmy Kingfisher	Common resident	X	
Alpalodiidae	<i>Apaloderna narina</i>	Narina Trogon	Fairly common resident	X	
Apodidae	<i>Cypsius parvus</i>	African Palm Swift	Common	X	X
	<i>Apus affinis</i>	Little Swift	Common resident	X	
	<i>Apus apus</i>	Common Swift	Common	X	
Bucerotidae	<i>Tockus nasutus</i>	African Grey Hornbill	Common	X	X
	<i>Tockus fasciatus</i>	African Pied Hornbill	Common		X
	<i>Ceratogymna atrata</i>	Black Casqued-wattled Hornbill	Locally common	X	
	<i>Bycanistes subcylindricus</i>	Black and White Casqued Hornbill	Locally common	X	
	<i>Bycanistes brevis</i>	Silvery Checked Hornbill	Fairly common resident	X	
Buphagidae	<i>Buphagus africanus</i>	YellowBilled Oxpecker	Locally common		X
Caprimulgidae	<i>Caprimulgus inornatus</i>	Plain Nightjar	Common	X	
Cisticolidae	<i>Cisticola marginatus</i>	Winding Cisticola	Locally common	X	
	<i>Cisticola lateralis</i>	Whistling Cisticola	Common	X	
	<i>Cisticola juncidis</i>	Zitting Cisticola	Common	X	
	<i>Cisticola brachypterus</i>	Short-winged Cisticola	Locally common	X	
	<i>Cisticola natalensis</i>	Croaking Cisticola	Common		X
Columbidae	<i>Treron calvus</i>	African Green Pigeon	Common	X	
	<i>Columba unicincta</i>	Afep Pigeon	Common		X
	<i>Streptopelia semitorquata</i>	Red eye Dove	Common	X	X
	<i>Turtur tympanistria</i>	Tambourine Dove	Common	X	X
	<i>Columba iriditorques</i>	Western Bronze-napped Pigeon	Fairly common	X	
	<i>Columba guinea</i>	Speckled Pigeon	Common		X
	<i>Streptopelia lugens</i>	Dusky Turtle Dove	Locally common	X	
	<i>Streptopelia turtur</i>	European Turtle-dove	Localised resident		X
	<i>Turtur abyssinicus</i>	Black billed Wood-dove	Common resident	X	
	<i>Streptopelia decipiens</i>	African Mourning Dove	Locally Common	X	

	<i>Streptopelia vinacea</i>	Vinaceous Dove	Common	X	
	<i>Streptopelia senegalensis</i>	Laughing (Palm) Dove	Abundant		X
	<i>Turtur afer</i>	Blue Spotted Wood-dove	Fairly common resident	X	
Coraciidae	<i>Coracias cyanogaster</i>	Blue Bellied Roller	Common resident	X	X
	<i>Eurystomus glaucurus</i>	Broad Billed Roller	Locally common resident	X	X
	<i>Eurystomus gularis</i>	Blue-throated Roller	Common		X
Corvidae	<i>Corvus albis</i>	Pie Crow	Common and widespread	X	X
cuculidae	<i>Chrysococcyx caprius</i>	Dideric Cuckoo	Common resident	X	
	<i>Clamator jacobinus</i>	Jacobin Cuckoo	Common	X	
	<i>Clamator glandarius</i>	Great Spotted Cuckoo	Fairly common	X	
	<i>Cuculus canorus</i>	Common Cuckoo	Scarce	X	
	<i>Centropus senegalensis</i>	Senegal Coucal	Uncommon	X	X
	<i>Centropus grillii</i>	Black Coucal	Uncommon	X	
Dicruridae	<i>Dicrurus adsimilis</i>	Fork-tailed Drongo	Common	X	X
Estrildidae	<i>Spermestes bicolor</i>	Black and White Mannikin	Common	X	X
	<i>Spermestes cucullata</i>	Bronze Mannikin	Abundance	X	X
	<i>Estrilda melpoda</i>	Orange-cheeked waxbill	Common	X	
	<i>Lagonosticta rufopicta</i>	Bar-breasted Firefinch	Locally common	X	
	<i>Lagonosticta rara</i>	Black-bellied Firefinch	Locally common	X	
	<i>Lagonosticta senegala</i>	Red-billed Firefinch	Common		X
	<i>Pyrenestes ostrinus</i>	Black-bellied Seedcracker	Fairly common	X	
Falconidae	<i>Falco vespertinus</i>	Red-footed Falcon	Fairly common	X	
	<i>Falco ardosicicens</i>	Grey Kestrel	Common	X	
	<i>Falco tonnunculus</i>	Common Kestrel	Fairly common	X	
Fringillidae	<i>Serinus mozambicus</i>	Yellow Fronted Canary	Common	X	X
Halcyonidae	<i>Halcyon senegalensis</i>	Woodland Kingfisher	Common resident	X	
	<i>Halcyon leucocephala</i>	Grey-headed Kingfisher	Locally common resident	X	
Indicatoridae	<i>Indicator monor</i>	Lesser Honey	Common		X
Monarchidae	<i>Tersiphone rufiventer</i>	Red-bellied Paradise Flycatcher	Common	X	
	<i>Tersiphone viridis</i>	African Paradise Flycatcher	Common resident	x	
Motacillidae	<i>Macronyx croceus</i>	Yellow Throated Longclaw	Common		X
	<i>Motacilla aguimp</i>	African Pied Wagtail	Locally common	x	
Muscicapidae	<i>Muscicapa striata</i>	Spotted Flycatcher	Common	X	
	<i>Muscicapa comitata</i>	Dusky-blue Flycatcher	Locally common	X	
	<i>Ficedula hypoleuca</i>	Pied Flycatcher	Locally common	X	
	<i>Muscicapa caerulescens</i>	Ashy Flycatcher	Common	X	
	<i>Myrmecocichla albifrons</i>	White-fronted Black Chat	Locally Common		X
Musophagidae	<i>Crinifer piscator</i>	Western Grey Plantain Eater	Common	X	
	<i>Musophaga violacea</i>	Violet Turaco	Locally common	X	
Nectariniidae	<i>Chalcomitra senegalensis</i>	Scarlet-chested Sunbird	Common	X	

	<i>Cyanomitra cyanolaena</i>	Blue-throated brown Sunbird	Common	X	
	<i>Cyanomitra verticalis</i>	Green-headed Sunbird	Common	X	X
	<i>Authreptes longuemarei</i>	Western Violet backed Sunbird	Uncommon	X	
	<i>Cinnyris venustus</i>	Variable (Yellow-breasted) Sunbird	Common	X	X
	<i>Cinnyris coccinigastrus</i>	Splendid Sunbird	Common	X	
	<i>Cinnyris superbus</i>	Superb Sunbird	Common	X	
	<i>Cinnyris chloropygius</i>	Olive-bellied Sunbird	Common	X	
	<i>Cinnyris cupreus</i>	Copper Sunbird	Uncommon		X
Oriolidae	<i>Oriolus nigripennis</i>	Black winged Oriole	Common		X
Passeridae	<i>Passer griseus</i>	Northern Grey Headed Sparrow	Common	x	
Phasianidae	<i>Pternistis bicalcaratus</i>	Double Spurred Francolin	Common	X	
	<i>Peliperdix lathamii</i>	Forest Francolin	Locally common	X	
Phoeniculidae	<i>Phoeniculus purpureus</i>	Green Wood-Hopoe	Common	X	
	<i>Rhinopomastus aterrimus</i>	Black Scimitarbill	Locally common	x	
Picidae	<i>Dendropicops fuscescens</i>	Cardinal woodpecker	Common	X	
	<i>Picooides obsoletus</i>	Brown-backed	Locally common	X	
Ploecidae	<i>Euplectes hordeaceus</i>	Black-wing Bishop	Locally common	X	
	<i>Ploceus cucullatus</i>	Village (spotted-backed) Weaver	Common	X	X
	<i>Ploceus velatus</i>	Southern Masked Weaver	Common and widespread	X	X
	<i>Ploceus luteolus</i>	Little Weaver	Locally common	X	X
	<i>Ploceus melanocephalus</i>	Black-headed Weaver	Locally common	X	
	<i>Ploceus nigerrimus</i>	Vieillots's black Weaver	Common		X
	<i>Anaplectes melanotis</i>	Red-headed Weaver	Locally common		X
	<i>Malimbus ibadanensis</i>	Red-vented Malimbe	Fairly common	X	
	<i>Malimbus erythrogaster</i>	Red-Bellied Malimbe	Locally common		X
	<i>Malimbus malimbicus</i>	Crested Malimbe	Fairly common		X
	<i>Quelea cardinalis</i>	Red-Headed Quelea	Locally Common		X
Pycnonotidae	<i>Pycnonotus barbatus</i>	Common Bulbul	Abundant	X	X
	<i>Andropadus virens</i>	Little Greenbul	Common	X	
	<i>Criniger calurus</i>	Red-tailed Leaflive Greenbul	Common	X	
Sylviidae	<i>Prinia subflava</i>	Tawny-flanked Prinia	Common	X	
	<i>Melocichla mentalis</i>	Moustached Grass Warbler	Locally common	X	X
	<i>Locustella luscinioides</i>	Savi's Warbler	Locally common	X	X
	<i>Acrocephalus arundinaceus</i>	Great Reed-Warbler	Common		X
	<i>Acrocephalus schoenobaenus</i>	Sedge Warbler	Common		X
Sylvioidae	<i>Pholidornis rushiae</i>	Tit-hylia	Uncommon	X	
Threskiornithidae	<i>Bostrychia hagedash</i>	Hadeda Ibis	Common	x	

Tridioliidae	<i>Tricholaema hirsute</i>	Hairy-breasted Barbet	Common	X	
Viduidae	<i>Vidua macroura</i>	Pin-tailed Whydah	Common	X	X
	<i>Vidua togoensis</i>	Togo Paradise Whydah	Uncommon and thinly distributed	X	
	<i>Vidua sp.</i>		Uncommon		X
				94	44

**Appendix 4: List of Butterfly species recorded in Asubima and Afrensu Brohuma**

No.	SPECIES	ASUBIMA	AFRENSU BROHUMA
<b>PAPILIONIDAE</b>			
1	<i>Papilio dardanus</i>	x	X
2	<i>Papilio menestheus</i>	x	X
3	<i>Papilio demodocus</i>	x	X
4	<i>Papilio cyproeofila</i>	x	
5	<i>Papilio zenobia</i>	x	X
6	<i>Graphium polícenes</i>	x	X
<b>PIERIDAE</b>			
7	<i>Catopsilia florella</i>	x	
8	<i>Eurema hecabe</i>	x	X
9	<i>Eurema desjardinsii</i>		X
10	<i>Nepheronia argia</i>	x	
11	<i>Nepheronia thalassina</i>	x	X
12	<i>Nepheronia pharis</i>	x	X
13	<i>Belenois calypso</i>		X
14	<i>Dixeia cebron</i>	x	
<b>LYCAENIDAE</b>			
15	<i>Liptena alluaudi</i>	x	
16	<i>Liptena catalina</i>	x	
17	<i>Liptena evanescens</i>	x	
18	<i>Liptena flavicans</i>		X
19	<i>Liptena helena</i>	x	
20	<i>Liptena similis</i>		X
21	<i>Micropentila adelgunda</i>	x	
22	<i>Mimeresia seminifa</i>	x	X
23	<i>Pentila pauli</i>		X
24	<i>Pentila picena</i>	x	
25	<i>Euliphyra leucyania</i>		X
26	<i>Euliphyra hewitsoni</i>	x	X
27	<i>Anthene radiate</i>	x	
28	<i>Anthene levis</i>	x	
29	<i>Anthene liodes</i>		X
30	<i>Anthene lysicles</i>	x	
31	<i>Anthene rubricinctus</i>	x	X
32	<i>Azanus natalensis</i>	x	
33	<i>Chilades eleusis</i>	x	X
34	<i>Oboronia punctatus</i>	x	
35	<i>Oboronia ornate</i>	x	
<b>NYMPHALIDAE</b>			
<b>Biblidinae</b>			
36	<i>Mesoxanthia ethosea</i>	x	

37	<i>Byblia anvatara</i>	x	
<b>Charaxinae</b>			
38	<i>Charaxes ameliae</i>		X
39	<i>Charaxes anticlea</i>	x	
40	<i>Charaxes bipunctatus</i>	x	X
41	<i>Charaxes boueti</i>	x	X
42	<i>Charaxes cedreatis</i>	x	
43	<i>Charaxes eupale</i>	x	
44	<i>Charaxes petersi</i>	x	X
45	<i>Euxanthe eurinome</i>	x	
46	<i>Palla ussheri</i>	x	X
47	<i>Palla Decius</i>		X
<b>Danainae</b>			
48	<i>Danaus chryssippus</i>	x	
<b>Limnitiidae</b>			
49	<i>Euriphene barombina</i>	x	X
50	<i>Euriphene simplex</i>	x	X
51	<i>Euriphene incerta</i>	x	X
52	<i>Bebearia abesa</i>	x	
53	<i>Bebearia maledicta</i>	x	X
54	<i>Bebearia mardania</i>	x	
55	<i>Euphaedra gausape</i>		X
56	<i>Euphaedra thermos</i>	x	
57	<i>Euphaedra jenetta</i>		X
58	<i>Euphaedra francina</i>	x	X
59	<i>Euphaedra eleus</i>	x	
61	<i>Euphaedra inanum</i>	x	X
62	<i>Neptis metella</i>		X
63	<i>Neptis melicerta</i>		X
<b>Nymphalinae</b>			
64	<i>Junonia stygia</i>	x	
<b>Heliconiinae</b>			
65	<i>Acraea alciope</i>	x	X
66	<i>Acraea rogersi</i>	x	X
67	<i>Acraea umbra</i>	x	
68	<i>Acraea epaea</i>		X
<b>HESPERIIDAE</b>			
<b>Pyrginae</b>			
69	<i>Eretis melania</i>	x	
<b>Hesperiinae</b>			
70	<i>Pardeleodes incerta</i>	x	X
71	<i>Pardeleodes xanthopeplus</i>	x	

72	<i>Xanthodisca astrap</i>		X
73	<i>Acleios ploetzi</i>	x	
74	<i>Meza meza</i>	x	X
75	<i>Gretina cylinda</i>	x	
		60	41

**Appendix 5: Medium Mammal Species Recorded in Asubima and Afrensu Forest Reserves.**

SPECIES	COMMON NAME	Conservation Significance (CITES)	Mode of observation	ASUBIMA	AFRENSU BROHUMA
<b>ARTIODACTYLA</b>					
<i>Tragelaphus scriptus</i>	Bushbuck	II	FP	8	4
<i>Phacochoerinae africanus</i>	Warthog		FP	1	-
<i>Cephalophus maxwelli</i>	Maxwell Duiker	II	FP	5	6
<i>Cephalophus niger</i>	Black Duiker	II	FP	-	2
<i>Cephalophus dorsalis</i>	Bay Duiker	II	FP	4	-
<b>CARVIVORA</b>					
<i>Genetta genetta</i>	Common Genet	I	FP	4	-
<i>Civittictis civetta</i>	African Civet	I	FP	10	11
<i>Nandinia binotata</i>	African Palm-civet	I	FP	6	18
<b>HYRACOIDEA</b>					
<i>Dendohyrax dorsalis</i>	Western Tree Hyrax	II	FS	2	-
<b>LOGOMORPHA</b>					
<i>Lepus capensis</i>	Togo Hare		FP	21	9
<b>PHOLIDATA</b>					
<i>Phatagimus tricuspis</i>	Tree Pangolin	I	FS	2	-
<b>PRIMATE</b>					
<i>Cercopithecus mona</i>	Mona Monkey	II	FS	4	-
<b>RODENTIA</b>					
<i>Thryonomys swinderianus</i>	Grasscutter		FP,FS	39	20
<i>Euxenus erythropus</i>	Stripped Squirrel	II	FS,FP	30	18
<i>Cricetomys gambianus</i>	Giant Pouched Rat	II	FP	22	37
NUMBER OF SPECIES				14	9
NUMBER OF INDIVIDUALS				158	125

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora published three appendices (CITES appendices, 2010) which limits global trade of certain species,

- Appendix I lists species that are the most endangered among CITES-listed species. They are threatened with extinction and CITES prohibits international trade in specimens of these species except when the purpose of the import is not commercial.

- Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. It also includes species of which the specimens in trade look like those of species listed for conservation. International trades in specimens of Appendix-II species may be authorized by the granting of an export permit or re-export certificate. No import permit is necessary for these species under CITES.
- Appendix III is a list of species included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation. International trade in specimens of species listed in this Appendix is allowed only on presentation of the appropriate permits or certificates.