

The Flora and Mammals of the Moist Semi-Deciduous Forest Zone in the Sefwi-Wiawso District of the Western Region, Ghana

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Abstract

The study presents results of a floristic and mammal survey undertaken in the Sefwi-Wiawso District within moist semi-deciduous vegetation zone of the Western Region of Ghana. The floral survey involved estimating the floral distribution, abundance and diversity using the standard indices, Shannon-Wiener, Simpson's, evenness, species richness, similarity, and β -diversity, while the mammal survey was conducted using direct opportunistic observation, live-trapping (small mammals), animal spoors/trophies, and interviews. There were 271 plant species recorded, out of which 174 species comprising 172 species and 67 families of angiosperms (Angiospermae) and two species of ferns (Pteridophyta) were scientifically-named. Forty species of mammals representing eight orders were recorded, with the dominant orders being Rodentia and Artiodactyla. The greatest faunal diversity occurred in the forest reserves, where suitable habitat niches still occur. There were 48 individuals of seven species of rodents and one individual of one insectivore species captured during live-trapping, with the commonest species being common mice (*Mus* spp.) and brush-furred mice (*Lophuromys flavopunctatus*). The greatest threat to the survival of the fauna is habitat destruction. Generally, the Sefwi-Wiawso District is very rich in forest tree species, the commonest being the *Celtis-Triplochiton* Associations, but bad agricultural practices, bush burning, intense logging, fuelwood harvesting and pollution have resulted in poor soil quality and land degradation in certain areas. Hunting of animals for meat, and destruction of habitats were the greatest threats to faunal diversity and abundance in the Sefwi-Wiawso District.

Introduction

It is generally acknowledged that the forests of Africa are gravely threatened largely through anthropogenic influences like unsustainable farming practices, fuelwood over-exploitation, unauthorised logging, bushfire setting and pollution (Holbeck, 1996). The forests of the Western Region of Ghana have, to a large extent, been subjected to increasing degradation over the years due to such unfavourable anthropogenic influences (Martin, 1991; Hawthorne & Abu-Juam, 1993). This situation poses serious threats to the biodiversity of the region, and its socio-economic and ecotourism potential.

Located in the Western Region of Ghana, the Sefwi-Wiawso District faces increasing deforestation due to its high population growth rate and the attendant negative anthropogenic impacts outlined above. The forests of the District are being encroached upon at alarming rates, resulting in the degradation of large sections of hitherto pristine forests. This situation requires detailed and comprehensive biodiversity inventories to ascertain the current ecological status of the District's forests, to assess the extent of the negative anthropogenic impacts, and to provide the requisite data to enable the monitoring of anthropogenic disturbances over time (Bridgewater, 1996).

The specific objectives of this study were to (i) identify and define the biodiversity features of sample areas of contrasting habitats in the District, particularly the floral and faunal (mammal) characteristics, (ii) assess the impact of human activities on the forest ecosystem, and (iii) recommend appropriate guidelines for conservation and sustainable use of the natural resources of the area.

Materials and methods

Study area

The Sefwi-Wiawso District is located in the moist semi-deciduous forest zone of Ghana (Fig. 1). With a total land area of 1,557 km² and altitude ranging from 152–610 m above sea level, the area is characterised by a wet semi-equatorial climate with high annual rainfall amounts ranging between 1,500–1,800 mm. The vegetation consists of dense undergrowth and forest tree species of the *Celtis-Triplochiton* Association, dominated by *Celtis mildbraedii*, *Triplochiton scleroxylon*, *Ceiba pentandra* (silk cotton), *Milicia excelsa* (odum), *Khaya ivoriensis* (African mahogany), *Terminalia ivoriensis* (emire), *Terminalia superba* (ofram) and *Bambusa* sp. (bamboo) (Taylor, 1960).

Demarcation of habitats

Seven different habitat types in the study area were identified and demarcated as follows: (i) primary forest (consisting of tree species indigenous to the area, including sacred groves and forest reserves), (ii) forest fallow stages 1, 2, and 3 (representing a mosaic of various succession phases consisting of all types of woody tree species of less than 3 years – stage 1, between 3–5 years – stage 2, and more than 5 years – stage 3, derived from clearing of natural forest for shifting agriculture and including patches of uncleared forest and agricultural fields), (iii) swamp forest (composed principally of trees, shrubs and herbs within a permanent water body), (iv) bamboo forest (dominated by bamboo – *Bambusa vulgaris*), (v) river belt (principally composed of trees, shrubs and herbs growing along rivers, streams and watercourses (Fig. 1).

Floral survey

The floral survey involved random selection, demarcation, and inventory of five 25 m x 25 m sample plots for each habitat type, with key references being Hawthorne (1990) and Okezie, Akobundu & Agyakwa (1987). Species that could not be easily identified were collected, pressed, and sent to the Kumasi Herbarium for further identification. Three out of the five sample plots in each habitat were deliberately sampled for actual counts of individual species, and count values used to estimate the heterogeneity and floral compositions of the different habitat types as follows (Magurran, 1988):

- species richness
- proportional abundance-diversity
(~~Shannon-Wiener Index~~ $H = -\sum p_i \ln p_i$)
- dominance distribution of species (*Simpson's Index* $(D) = \sum p_i^2$)
- evenness of species distribution within sample plots/areas
(*Pielou's Index* $(E) = H/\ln S$)
- similarity among plots (*Sorenson's Index* $= 2a/(A+B)*100\%$)
- degree of turnover/change (*β-Diversity* $= S/\alpha-1$)
- stratification of woody stands among habitats

(where p_i = relative abundance of each species in each sample, S = total number of species observed in each sample, a = number of species common to two separate sample plots, $[A + B]$ = total species richness in two separate sample plots, and α = average number of species per plot in a sample).

Large mammal survey

Large mammals were surveyed using (i) direct opportunistic observation (recording any opportunistic observations of mammals), (ii) spoors (recording any sign left by a living animal such as a constructed burrow, faecal pellets, footprints, etc.), (iii) trophies (mementos of animals kept by members of the local community), and (iv) interviews of experienced hunters, farmers and a cross-section of the inhabitants of the various local communities.

Small mammal survey

Small mammals were live-trapped using Sherman collapsible live-traps (23 cm x 9 cm x 7.5 cm) (H.B. Sherman Traps Inc., Florida, USA) baited with a mixture of groundnut paste and corn meal, and laid along transects in each survey site at 15 m intervals. The traps were set during the day, and inspected early the following morning for two consecutive nights on each survey site (Table 1). Captured animals were identified on the spot, if possible, euthanised with chloroform, sexed, aged, checked for reproductive condition, weighed to the nearest gram, then preserved in formalin. Species not identifiable on the spot were later identified using Rosevear (1969), Happold (1987), Haltenorth & Diller (1992), and Kingdon (1997). The relative abundance of each captured species in each habitat (number of captures per 100 trap-nights) was calculated as follows:

Relative abundance =

$$\frac{\text{Number of individuals captured}}{\text{Number of trap-nights}} \times 100$$

(one trap-night = one trap set for one night)

TABLE 1

Checklist of known plant species in the Sefwi- Wiawso District

Species	Local (vernacular) name	Life- form
ANACARDIACEAE		
1. <i>Anacardium occidentale</i>	Cashew	Small tree
2. <i>Lannea welwitschii</i>	Kum-nini	Tree
3. <i>Mangifera indica</i>	Mango	Tree
ANNONACEAE		
4. <i>Hexalobus crispiflorus</i>	Duabaha	Tree
APOCYNACEAE		
5. <i>Alstonia boonei</i> Sinuro	Nyamedua/	Tree
6. <i>Funtumia africana</i>	Okae/Powee	Tree

7.	<i>Funtumia elastica</i>	Fruntum	Tree
8.	<i>Rauwolfia vomitoria</i>	Akakapenpen	Tree
ARACEAE			
9.	<i>Anchomanes difformis</i>	Topie/Epe	Herb
10.	<i>Cercestis afzelii</i>	Batatwene	
	Tree		
11.	<i>Culcassia</i> sp.	Nankandabre/ Enwadabre	Herb
12.	<i>Pistia</i> sp.		Aquatic herb
13.	<i>Xanthosoma maffafa</i>		Herb
ASCLEPIADACEAE			
14.	<i>Gongronema latifolium</i>	Nsorogya climber	Woody
ASTERACEAE			
15.	<i>Chromolaena odorata</i> weed	Acheampong Shrub	
AZOLLACEAE			
16.	<i>Azolla</i> sp.		Aquatic herb
BALANOPHORACEAE			
17.	<i>Thonningia sanguina</i>	Kwae-begua	Parasitic plant
BIGNONIACEAE			
18.	<i>Newbouldia laevis</i>		Tree
19.	<i>Kigelia africana</i>	Nufuten	Tree
BOMBACACEAE			
20.	<i>Ceiba pentandra</i>	Onyina	Tree
BROMELIACEAE			
21.	<i>Ananas comosus</i>		Herb
BURSERCEAE			
22.	<i>Canarium Bediwonua schwenfurthii</i>	Tree	
CAESALPINACEAE			
23.	<i>Amphimas Asanfram/ pterocarpoides</i>	Tree Yaya	
24.	<i>Cassia tora</i>	Shrub	
25.	<i>Cassia siamea</i>		Tree
26.	<i>Daniella ogea</i>	Hyedua	Tree
27.	<i>Distemonanthus benthamianus</i>	Bonsamdua/ Avan	Tree
28.	<i>Griffonia Kegya/ simplicifolia</i>	Climber Abrukota	
29.	<i>Guibourtia ehie</i>	Hyedua-nini	Tree
30.	<i>Mezoneuron Fimwa/ benthamianum</i>	Thorny Akobowire/ Ofam/Fima/ Ofua	climber
CAPPARACEAE			
31.	<i>Euadenia trifoliolata</i>	Dinsikro	Tree
CHRYSOBALANACEAE			
32.	<i>Maranthes robust</i>	Afam-bere	Tree
CLEOMACEAE			
33.	<i>Cleome viscosa</i>		Herb
COMBRETACEAE			
34.	<i>Combretum</i> sp.	Hwerema	Small tree
35.	<i>Combretum zenkeri</i>		Small tree
36.	<i>Terminalia ivorensis</i>	Emere	Tree
37.	<i>Terminalia superba</i>	Ofram/Efram/ Aframfram	Tree
COMMELINACEAE			
38.	<i>Commelina</i> sp.		Herb
CONNARACEAE			
39.	<i>Cnestis ferruginea</i>	Aporsen	Shrub
40.	<i>Ipomoea mauritiana</i>		Climber
CURCUBITACEAE			
41.	<i>Momordica charantia</i>		Herbaceous climber
CUSCUTACEAE			

42.	<i>Cuscuta</i> sp.		Parasitic plant
CYPERACEAE			
43.	<i>Kyllinga</i> sp.		Grass
44.	<i>Mariscus</i> sp.		Grass
45.	<i>Scleria</i> sp.	Grass	
DIOSCORIACEAE			
46.	<i>Dioscorea</i> Brokua <i>bulbiphyllum</i>	Climber	
EBENACEAE			
47.	<i>Diospyros</i> sanza <i>mulke</i> Atsuan	Etsua/Atwean/ Tree	
EUPHORBIACEAE			
48.	<i>Alchornea cordifolia</i>	Gyaka/Gyama	Shrub
49.	<i>Discoglyprena calo</i> <i>neura</i>	Fetefre	Tree
50.	<i>Euphorbia hirta</i>		Herb
51.	<i>Macaranga</i> sp.	Pamban/Opam	Tree
52.	<i>Mallotus oppositifolius</i> Nyanyaforwa	Nverwa/	Shrub
53.	<i>Manihot esculenta</i>	Bankye	Shrub
54.	<i>Mareya micrantha</i> Numnafi/ Numvie	Dubrafo/	Tree
55.	<i>Margaritaria</i> <i>discoidea</i>	Pepesia/Pepea	Tree
56.	<i>Phyllanthus amarus</i>	Bomagueakyire	Herb
57.	<i>Ricinodendron</i> <i>heudelotii</i>	Wama	Tree
58.	<i>Ricinus</i> sp.	Herb	
59.	<i>Tragia</i> sp. Kobene/ Brebretim/ Ototin	Shrub	
FLACOURTIACEAE			
60.	<i>Caloncoba</i> sp.	Opam	Tree
GRAMINAE			
61.	<i>Bambusa vulgaris</i>		Tree
		(riverine forest)	
62.	<i>Olyra latifolia</i>	Dodobeng	Herb
63.	<i>Panicum maximum</i>	Aboboya	Grass
64.	<i>Saccharum officinalis</i>		Grass
65.	<i>Setaria barbata</i>		Grass
66.	<i>Sporobolus</i> <i>pyramidalis</i>	Nzenzan	Grass
67.	<i>Vossia cupsidata</i>		Grass
GUTTIFERAE			
68.	<i>Garcinia kola</i> Sorkordua/ Tweapea	Tree	
LABIATAE			
69.	<i>Ocimum gratissimum</i>	Numnum	Shrub
LAURACEAE			
70.	<i>Persia Americana</i>	Avocado	Tree
LECYTHIDACEAE			
71.	<i>Petersianthus</i> <i>macrocarpus</i>	Esia	Tree
LILIACEAE			
72.	<i>Gloriosa superba</i>		Herb
LOGANIACEAE			
73.	<i>Spigelia anthelmia</i>		Herb
LORANTHACEAE			
74.	<i>Tapinanthus</i> sp.		Parasitic plant
MALVACEAE			
75.	<i>Sida acuta</i>	Shrub	
MARANTACEAE			
76.	<i>Hipsoelodelphis</i> <i>poggeana</i>	Kotor-ahaba climber	Woody
77.	<i>Maranthochloa</i> <i>leucantha</i> Babedua	Sibere/Egiri/	Herb

MELIACEAE		
78.	<i>Carapa procera</i> Akindawuse/ Kwa	Krabisi/ Tree
79.	<i>Entandrophragma angolense</i>	Edinam Tree
80.	<i>Entandrophragma candollei</i>	Penkwa Tree
81.	<i>Entandrophragma ivorensis</i>	Tree
82.	<i>Guarea cederata</i>	Kwabohoro Tree
83.	<i>Khaya ivorensis</i>	Mahogany Tree
84.	<i>Trichilia monadelphpha</i>	Tanuro Tree
85.	<i>Trichilia lanata</i>	Tanuro-nini Tree
86.	<i>Turreanthus africanus</i>	Avodire Tree
MENISPERMACEAE		
87.	<i>Sphenocentrum jollyanum</i>	Kramakoti Shrub
88.	<i>Triclisia</i> sp.	Small tree
MIMOSACEAE		
89.	<i>Acacia kamerunensis</i>	Egure/Nwere Thorny climber
90.	<i>Albizia ferruginea</i> semena	Awiemfo- Tree
91.	<i>Albizia glaberrima</i>	Okora-akoa Tree
92.	<i>Albizia</i> sp.	Tree
93.	<i>Albizia zygia</i> Ehure(ke)/ Pampena	Okuro/Ehwule/ Tree
94.	<i>Cyclodiscus gabunensis</i>	Denyao Tree
95.	<i>Mimosa pudica</i>	Herb
96.	<i>Parkia</i> sp. Aswioma	Tree
97.	<i>Piptadeniastrum africanum</i>	Dahoma/Elui Tree
98.	<i>Tetrapleura tetraptera</i>	Prekese Tree
MORACEAE		
99.	<i>Antiaris toxicaria</i>	Kyenkyen Tree
100.	<i>Bosqueia angolensis</i>	Okure Tree
101.	<i>Ficus exasperata</i>	Nyankyerene Tree
102.	<i>Ficus</i> sp. Amma	Tree
103.	<i>Milicia excelsa</i>	Odum/Elui Tree
104.	<i>Musanga Odwuma cecropioides</i>	Tree
105.	<i>Myrianthus arboreus</i> Nyankuma	Nyankama/ Tree
106.	<i>Myrianthus libericus</i>	Nyankuma-nini Tree
107.	<i>Treculia africana</i> Brebretim/ Ototin	Kobene/ Tree
MUSACEAE		
108.	<i>Musa</i> sp.	Tree
MYRISTICACEAE		
109.	<i>Pycnanthus angolense</i>	Otie/Etie Tree
MYRTACEAE		
110.	<i>Psidium guajava</i>	Tree
OLACACEAE		
111.	<i>Strombosia glaucesense</i>	Afina Tree
ONAGRACEAE		
112.	<i>Luwigia</i> sp.	Sufi Aquatic herb
PALMAE		
113.	<i>Calamus deeratus</i>	Demmere/ Domere/Mfia Woody climber
114.	<i>Cocos nucifera</i>	Kube Tree
115.	<i>Elaies guineensis</i>	Abe Tree
116.	<i>Eremospatha macrocarpa</i>	Mfia Thorny climber
117.	<i>Laccosperma</i> sp.	Climber
118.	<i>Raphia</i> sp.	Doka Tree

PANDACEAE		
119. <i>Microdesmis puberula</i>	E-beribi	Tree
120. <i>Microdesmis</i> sp.	Tetica	Tree
PAPILIONACEAE		
121. <i>Abrus precatorius</i>		Climber
122. <i>Baphia nitida</i>	Odwene	Shrub
123. <i>Desmodium ascendense</i>	Aboa-nkatie	Herb
124. <i>Erythrina addisonae</i>	Akuo/Osorowa	Tree
125. <i>Milletia chrysophylla</i>	Fintima	Tree
126. <i>Milletia zechiana</i>	Fafraha/ Nseduanseahuma	Tree
127. <i>Pterocarpus santaloides</i>	Nkradodwa/ Hole	Tree
PASSIFLORACEAE		
128. <i>Adenia lobata</i>	Aherenyama	Climber
PHYTOLACCACEAE		
129. <i>Parquetiana nigrescens</i>	Abakamo	Tree
PIPERACEAE		
130. <i>Hillieria</i> sp.	Anafraneku	Climber
131. <i>Piper guineense</i>		Herb
132. <i>Piper umbellate</i>	Ananse- dodowa/ Kongoahaba/ Amumunya	Herb
POLYGALACEAE		
133. <i>Carpolobia lutea</i>	Geseluwa	Shrub
PORTULACACEAE		
134. <i>Talinum triangulare</i>		Herb
RUBIACEAE		
135. <i>Corynanthe pachyceras</i>	Pamparama/ Pampenama	Tree
RUTACEAE		
136. <i>Citrus</i> sp.		Tree
SAPINDACEAE		
137. <i>Blighia sapida</i>	Akyen	Tree
138. <i>Lecaniodiscus cupanoides</i>	Dwendwena	Shrub
139. <i>Paullinia pinnata</i>	Twentini	Shrub
SAPOTACEAE		
140. <i>Azfelii bella/africana</i>	Papao/Doissie/ Apa	Tree
141. <i>Aningeria</i> sp.	Asamfena	Tree
142. <i>Brevia</i> sp.	Kankama	Tree
143. <i>Chrysophyllum albidum</i>	Akasaa	Tree
144. <i>Chrysophyllum</i> sp.		Tree
145. <i>Tieghemella heckelii</i>	Abeko/Abaku/ Makore	Tree
SIMAROUBACEAE		
146. <i>Hannoa klaeinan/Quassia undulata</i>	Fotie/ Hotrohotro	Tree
SMILACACEAE		
147. <i>Smilax krausianus</i>	Kokora/ Sawoma	Woody climber
SOLANACEAE		
148. <i>Solanum erianthum</i>	Pepediawuo/ Awosea	Tree
149. <i>Solanum torvum</i>	Nsoasoa-dua	Shrub
STERCULIACEAE		
150. <i>Cola clamydantha</i>	Tana-nfre	Tree
151. <i>Cola edulis</i>	Bodwue	Tree
152. <i>Cola gigantean</i>	Watapuo/Wale	Tree
153. <i>Cola nitida</i>		Tree
154. <i>Cola verticillata</i>	Besetro	Tree
155. <i>Mansonia altissima</i>		Tree
156. <i>Nesogordonia papaverifera</i>	Danta	Tree

157. <i>Pterygota macrocarpa</i>	Kotu/Kyereye	Tree
158. <i>Sterculia catapa</i>		Tree
159. <i>Sterculia rhinopetala</i>	Wawabima	Tree
160. <i>Theobroma cacao</i>		Tree
161. <i>Triplochiton scleroxylon</i>	Wawa/Patabue	Tree
TILIACEAE		
162. <i>Christiana africana</i>	Sesedua	Tree
163. <i>Glyphea brevis</i>	Foto	Tree
ULMACEAE		
164. <i>Celtis adolfi-federici</i>	Esa-kosua	Tree
165. <i>Celtis malbraedii</i>		Tree
166. <i>Celtis wightii</i>	Prempem-esa	Tree
167. <i>Celtis zenkeri</i>	Esa pa/Esakoko	Tree
168. <i>Trema orientalis</i>	Sesian	Tree
URTICACEAE		
169. <i>Fluerya aestuanes</i>		Herb
VERBENACEAE		
170. <i>Stachytarpheta</i> sp.		Shrub
VIOLACEAE		
171. <i>Rinorea ilicifolia</i>	Toronsuo	Tree
172. <i>Pleureria</i> sp.		Climber
PTERYDOPHYTA		
173. <i>Cyclosorus afer</i>	Ntorkwaha	Fern
174. <i>Nephrolepis</i> sp.	Fern	

Results

Floral diversity and abundance

A total of 271 plant species were inventoried in the seven habitat types in the Sefwi Wiawso District. Of these, 174 (68%) species comprising 172 species and 67 families of angiosperms (Angiospermae) and two species of ferns (Pterydophyta) were scientifically-named (Table 1). The results indicated a significant decrease in species numbers with increasing number of plant families. The most-represented plant families, with between six to 12 species were the Euphorbiaceae, Sterculiaceae, Graminae, Mimosaceae, Meliaceae, Moraceae, Ceasalpinaceae, Papilionaceae, Palmae and Sapotaceae. Thirty-five families were represented by only a single species each. The most commonly-occurring plant life-forms were trees, which made up 61.5% of all the species (Table 2).

TABLE 2

Floral and life-form diversity

<i>Life-form</i>	<i>No. of species</i>	<i>%Occurrence</i>
Tree	107	61.2
Herb	22	12.7
Shrub	16	9.2
Climber	16	9.2
Grass	8	4.6
Parasitic plant	3	1.8
Fern	2	1.3
Total	175	100

The proportional abundance estimates of trees in the sample plots showed that the primary forest was the most diverse in tree/woody stand ($H = 3.29$), followed by the sacred groves ($H = 3.26$ and 3.25) (Table 3). The dominance distribution of woody species in the three different habitats showed a high and/or closely related pattern ($D = 0.96$, 0.97 , and 0.95).

Overall, the evenness of species distribution is highest in the Anwumere sacred grove (0.86) compared to the closely-related Muro primary forest and the Boako sacred grove as well as in the forest fallow (0.72, 0.76, and 0.71, respectively). The riparian (river belt) forest showed the lowest evenness in species distribution (0.66) among sample plots (Table 3). The riparian and bamboo forests both showed the highest estimates of species similarities among the sample plots ($54 \pm 3\%$ and $52 \pm 12\%$, respectively), followed by the forest fallow with $49 \pm 2\%$, and the primary forest with $41 \pm 3\%$. The two sacred groves also recorded $28 \pm 3\%$ and $19 \pm 3\%$, while the swamp forest showed the least similarity of species ($17 \pm 4\%$) among the sample plots (Table 3).

TABLE 3

Summary of floral diversity status in the different habitats

<i>Parameter</i>	<i>Sampling sites</i>						
	<i>PF</i>	<i>FF3¹</i>	<i>FF3²</i>	<i>FF3³</i>	<i>SF</i>	<i>BF</i>	<i>RB</i>
Tree stand per plot	94	36	43	74	-	-	7
Estimated density per hectare	300.8	110.5	137.6	227.2	-	-	22.4
Mean similarity in species composition	41 ± 3%	49 ± 2%	19 ± 3%	28 ± 3%	17 ± 4%	52 ± 12%	54 ± 3%
Shannon-Wiener diversity (H)	3.29	2.53	3.25	3.26	-	-	1.28
Simpson's probability (D)	0.96	0.90	0.95	0.97	-	-	0.69
Evenness of distribution (E)	0.72	0.71	0.86	0.76	-	-	0.66

Habitats

PF = Primary forest (Muro Forest Reserve)

FF3¹ = Forest fallow 1 (Aboduam)

FF3² = Forest fallow 2 (Anwumere)

FF3³ = Forest fallow 3 (Boako)

SF = Swamp forest (Wiawso, Asantekrom, Danyame)

BF = Bamboo forest (Tanoso, New Adiembra, Fuakyekrom)

RB = River felt forest (Tano, Nsawura)

Bamboo forest showed the least change and/or turnover in species composition (0.7) among sample plots, while the primary, swamp, and riparian forest, as well as forest fallow stage 3 recorded 1.7, 1.5, 1.5 and 1.3, respectively. The two sacred groves re-recorded the highest turnover (2.2 and 2.7) of species among sample plots (Table 4).

TABLE 4

Change in number of species in sample plots per habitat

<i>Parameter</i>	<i>Sample areas</i>						
	<i>PF</i>	<i>FF3¹</i>	<i>FF3²</i>	<i>FF3³</i>	<i>SF</i>	<i>RB</i>	<i>BF</i>
P1	30	27	43	39	24	34	20
P2	24	24	37	36	28	16	14
P3	21	20	31	24	13	31	15
P4	17	21	37	28	-	26	-
P5	24	20	39	25	-	-	-
Average	23.2	22.4	37.4	30.4	21.7	26.8	16.3
Total	62	51	120	113	55	68	28
β-Diversity	1.7	1.3	2.2	2.7	1.5	1.5	0.7

Large mammal diversity and abundance

There were 19 species of large mammals recorded, representing five orders as follows: Artiodactyla (7), Primates (5), Carnivora (4), Pholidota (2) and Hyracoidea (1). These recordings were made using various methods (Table 5). About 90% of the species occurred in the mature forest areas or areas with at least some type of forest cover (i. e. primary forest, sacred grove, river belt and swamp forest). The lowest abundance of large mammal species was recorded in bamboo forest. Majority of the large mammal species recorded in the protected areas were also present in degraded forest (forest fallow) and swamp forest.

TABLE 5

Checklist of Sefwi-Wiawso large mammals

<i>Species</i>	<i>Common name</i>	<i>PF</i>	<i>FF3</i>	<i>FF2</i>	<i>SF</i>	<i>RB</i>	<i>BF</i>
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PRIMATES

1. <i>Galago senegalensis</i>	Senegal galago	*	*	*		@
2. <i>Perodicticus potto</i>	Bosman's potto	*	*	*	*	*
3. <i>Cercopithecus mona</i>	Mona monkey	*	@			
4. <i>Cercopithecus Diana</i>	Diana monkey	*	@			
5. <i>Colobus polykomos</i>	Black-and-white colobus monkey	*	*			

PHOLIDOTA

6. <i>Phataginus tricuspis</i>	Tree pangolin	*	*	*	*	*
7. <i>Uromanis tetradactyla</i>	Long-tailed pangolin	*	*	*	*	*

CARNIVORA

8. <i>Genetta genetta</i>	Common genet	*	*	*	*	*
9. <i>Civettictis civetta</i>	African civet	*	*			*
10. <i>Nandinia binotata</i>	African palm-civet	*	*	*	*	*
11. <i>Herpestes sanguinea</i>	Slender mongoose	*	*	*	*	*

ARTIODACTYLA

12. <i>Hylochoerus meinertzhageni</i>	Giant forest hog	*		*	*	
13. <i>Syncerus caffer</i>	African buffalo	*	@	@		@
14. <i>Tragelaphus scriptus</i>	Bushbuck	*	*b	*	*	*
15. <i>Cephalophus maxwelli</i>	Maxwell's duiker	*	*	@	*	
16. <i>Cephalophus dorsalis</i>	Bay duiker	*	*	*	*	*
17. <i>Cephalophus niger</i>	Black duiker			*		
18. <i>Neotragus pygmaeus</i>	Royal antelope	*	*	*		* b

HYRACOIDEA

19. <i>Dendrohyrax dorsalis</i>	Western tree hyrax	*	*	*	*	*
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Recording methods

* = Interviews; + = Live-trapping;
b = Spoors/Trophies @ = Previously present, current status unknown

Habitats

PF = Primary forest (Muro Forest Reserve)
FF3 = Forest fallow Stage 3 (Boako and Anwumere Sacred Groves)
FF2 = Forest fallow Stage 2 (Nyamebekyere)
SF = Swamp forest (Wiawso, Asantekrom, Danyame)
BF = Bamboo forest (Tanoso, New Adiembra, Fuakyekrom)
RB = River belt forest Tano, Nsawura)

Small mammal diversity and abundance

Overall, there were 21 recorded small mammal species belonging to three orders: Insectivora (1), Chiroptera (2) and Rodentia (18) (Table 6). Live-trapping yielded 49 individual small mammal specimens representing seven species of rodents, two species of bats, and one species of insectivore in 300 trap-nights (trapping success = 16%) (Table 7). Majority of adult rodent females captured were pregnant, while the adult males had scrotal testes. The commonest species recorded were common mice (*Mus* spp.) and brush-furred mice (*Lophuromys flavipunctatus*) with 16 and 15 captures, respectively, together constituting 64% of captures. (Table 6). The least common species were *Praomys tullbergi*, *Dephomys defua*, *Crocidura* sp. with a single specimen each. The highest captures of rodents were recorded in swamp forest, while the relatively undisturbed forests (e.g. sacred grove) registered the lowest captures. Indeed, the sacred grove at Boako recorded no captures (Table 7). Most of the rodents (e.g. squirrels, rats and grasscutters), were reported to be pests of food and cash crops such as cocoa fruits, oil palm seeds, cassava and maize, especially during the dry season.

TABLE 6

Checklist of Sefwi-Wiawso small mammals

Species	Common name	PF	FF3	FF2	SF	RB	BF
INSECTIVORA							
1. <i>Crocidura</i> sp.	White-toothed shrew			*	* +	*	

CHIROPTERA

2. <i>Rousettus aegyptiacus</i>	Egyptian fruit bat	*	*	*	*	*
3. <i>Eidolon helvum</i>	Straw-coloured fruit bat	*	*	*	*	*

RODENTIA

4. <i>Anomalurus beecrofti</i>	Beecroft's flying squirrel	*	*	*		*
5. <i>Anomalurus peli</i>	Pel's flying squirrel	*	*		*	*
6. <i>Epixerus ibii</i>	Western palm squirrel	*	*	*	*	*
7. <i>Protoxerus aubinii</i>	Slender-tailed squirrel	#				#*
8. <i>Funiscurus pyrropus</i>	Fire-footed squirrel	*	*	*		*
9. <i>Heliosciurus rufobrachium</i>	Red-legged sun-squirrel	*	*	*		*
10. <i>Euxerus erythropus</i>	Stripped ground squirrel	*	*	*		*
11. <i>Cricetomys gambianus</i>	Giant pouched rat	* b	* b	*	*	* *
12. <i>Praomys tullbergi</i>	Soft-furred rat	+				
13. <i>Myomys daltoni</i>	Meadow rat	+	+			
14. <i>Dephomyys defua</i>	Dephuya mouse		+			
15. <i>Mus sp.</i>	Common mouse			+	+	+
16. <i>Mastomys natalensis</i>	Multimammate rat			+		
17. <i>Lophuromys flavopunctatus</i>	Brush-furred mouse				+	+
18. <i>Grammomys dolichorus</i>	Narrow-footed mouse					+
19. <i>Thryonomys swinderianus</i>	Grasscutter	*	*	*	*	*
20. <i>Hystrix cristata</i>	Crested porcupine	*	@		*	@
21. <i>Atherurus africanus</i>	Brush-tailed porcupine	*	*	*	*	*

Recording methods

* = Interviews; + = Live-trapping; # = Direct observation
b= Spoons/Trophies @ = Previously present, current status unknown

Habitats

PF = Primary forest (Muro Forest Reserve)
FF3 = Forest fallow Stage 3 (Boako and Anwumere Sacred Groves)
FF2 = Forest fallow Stage 2 (Nyamebekyere)
SF = Swamp forest (Wiawso, Asantekrom, Danyame)
BF = Bamboo forest (Tanoso, New Adiembra, Fuakyekrom)
RB = River belt forest Tano, Nsawura)

TABLE 6

Number of individual small mammal species (Relative abundance in brackets)

Species	PF	FF2	FF3	SF	RB	BF	Total	% Occurrence
<i>Mus sp.</i>	–	4 (10.0)	–	10 (16.7)	2 (5.0)	–	16 (5.3)	33.0
<i>Lophuromys flavipunctatus</i>	–	–	–	11 (18.3)	3 (7.5)	1 (2.5)	15 (5.0)	31.0
<i>Grammomys dolichurus</i>	–	–	–	–	–	7 (17.5)	7 (2.3)	14.0
<i>Mastomys natalensis</i>	–	6 (15.0)	–	–	–	–	6 (2.0)	12.0
<i>Myomys daltoni</i>	1 (2.5)	–	1 (1.3)	–	–	–	2 (0.7)	4.0
<i>Praomys tullbergi</i>	1 (2.5)	–	–	–	–	–	1 (0.3)	2.0
<i>Dephomyys defua</i>	–	–	1 (1.3)	–	–	–	1 (0.3)	2.0
<i>Crociodura sp.</i>	–	–	–	1 (1.7)	–	–	1 (0.3)	2.0
Total	2	10	2	22	5	8	49	100

Legend

PF = Primary forest (Muro Forest Reserve)

FF3 = Forest fallow Stage 3 (Boako and Anwumere Sacred Groves)
 FF2 = Forest fallow Stage 2 (Nyamebekyere)
 SF = Swamp forest (Wiawso, Asantekrom, Danyame)
 BF = Bamboo forest (Tanoso, New Adiembra, Fuakyekrom)
 RB = River belt forest Tano, Nsawura)

TABLE 7

Conservation significance of Sefwi-Wiawso mammals

<i>Species</i>	<i>Common name</i>	<i>Conservation significance</i>	
		<i>International IUCN</i>	<i>National CITES</i>
INSECTIVORA			
<i>Crocidura oliveri</i>	White-toothed Shrew	VU	
CHIROPTERA			
<i>Rousettus aegyptiacus</i>	Egyptian fruit bat		
<i>Eidolon helvum</i>	Straw-coloured fruit bat		
PRIMATES			
<i>Galago senegalensis</i>	Senegal Galago		II I
<i>Perodicticus potto</i>	Bosman's Potto		II I
<i>Cercopithecus mona</i>	Mona monkey		II II
<i>Cercopithecus diana</i>	Diana monkey	EN	I I
<i>Colobus polykomos</i>	Black-and-white colobus	LR/nt	II I
RODENTIA			
<i>Anomalurus beecrofti</i>	Beecroft's flying squirrel		II
<i>Anomalurus peli</i>	Pel's flying squirrel	LR/nt	I
<i>Epixerus ibii</i>	Western palm squirrel	LR/nt	
<i>Protoxerus aubinii</i>	Slender-tailed squirrel		
<i>Funiscurus pyrropus</i>	Fire-footed squirrel		II
<i>Heliosciurus rufobrachium</i>	Red-legged sun-squirrel		
<i>Euxerus erythropus</i>	Striped ground squirrel		II
<i>Cricetomys gambianus</i>	Giant pouched rat		II
<i>Praomys tullbergi</i>	Soft-furred rat		
<i>Myomys daltoni</i>	Meadow rat		
<i>Dephomya defua</i>	Dephuya mouse		
<i>Mus</i> sp.	Common mouse	DD	
<i>Mastomys natalensis</i>	Multimammate rat		
<i>Lophuromys flavopunctatus</i>	Brush-furred mouse		
<i>Grammomys dolichorus</i>	Narrow-footed mouse		
<i>Thryonomys swinderianus</i>	Grasscutter		
<i>Hystrix cristata</i>	Crested porcupine	LR/nt	I
<i>Atherurus africanus</i>	Brush-tailed porcupine		II
PHOLIDOTA			
<i>Phataginus tricuspis</i>	Tree pangolin		I
<i>Uromanis tetradactyla</i>	Long-tailed pangolin		I
CARNIVORA			
<i>Genetta genetta</i>	Common genet		I
<i>Civettictis civetta</i>	African civet		I
<i>Nandinia binotata</i>	African palm-civet		I
<i>Herpestes sanguinea</i>	Slender mongoose		II
ARTIODACTYLA			
<i>Hylochoerus meinertzhageni</i>	Giant forest hog		I
<i>Syncerus caffer</i>	African buffalo	LR/cd	II
<i>Tragelaphus scriptus</i>	Bushbuck		II
<i>Cephalophus maxwelli</i>	Maxwell's duiker	LR/nt	II
<i>Cephalophus dorsalis</i>	Bay duiker	LR/nt	II II
<i>Cephalophus niger</i>	Black duiker	LR/nt	II
<i>Neotragus pygmaeus</i>	Royal antelope	LR/nt	II

Legend. Conservation significance

Global criteria

IUCN: The International Union for the Conservation of Nature and Natural Resources (IUCN) periodically publishes a Red List of Threatened Species List which categorises globally-threatened animals as follows:

- Extinct (EX): When there is no reasonable doubt that the last individual has died.
- Extinct in the Wild (EW): A taxon which is known only to survive in cultivation, in captivity, or as a naturalised population (or populations) well outside the past
- Critically Endangered/Critical (CR): A taxon which is facing an extremely high risk of extinction in the wild in the immediate future.
- Endangered (EN): Species in danger of extinction, because both numbers and habitats have been reduced to a critical level, with survival therefore unlikely if the causal factors continue operating
- Vulnerable (VU): Species believed likely to move to the EN (Endangered) category, if the causal factors continue operating, because of rapidly decreasing populations and extensive habitat destruction.
- Rare (R): Species which are at risk because of small world populations concentrated in restricted geographical areas or habitats, but which are presently not in categories E or V.
- Lower Risk (LR): Taxa which have been evaluated but do not satisfy the criteria for any of the above categories. There are three sub-categories:
 - conservation dependent (cd): Taxa which are the focus of continuing taxon-specific or habitat-specific conservation programmes targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years
 - near threatened (nt) Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable
 - least concern (lc): Taxa which do not qualify for Conservation Dependent or Near Threatened
- Data Deficient (DD): A taxon on which there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well-studied, and its biology well-known, but appropriate data on abundance and/or distribution is lacking
- Not Evaluated (NE): A taxon which has not yet been assessed against the criteria

CITES: The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) publishes a list of three Appendices (CITES Appendices, 1975) which limits global trade of certain categories of animal species.

- Appendix I species are threatened species which cannot be traded in.
- Appendix II species are species for which levels of trade are limited.

National Criteria (Ghana Wildlife Conservation Regulations)

Ghana's Wildlife Laws (Ghana Wildlife Conservation Regulations, 1971, and Ghana Wildlife Conservation (Amendment) Regulations, 1988; 1995) categorise animal species into two main Schedules based on the level of protection required for a particular species:

- ◆ Schedule I species are completely protected (i.e., their hunting, capture or destruction is prohibited at all times).
- ◆ Schedule II species are partially protected (i.e., their hunting capture or destruction is absolutely prohibited between 1st August and 1st December of any season, and the hunting, capture and destruction of any young animal, or adult accompanied by young, is absolutely prohibited at all times).

Conservation significance of Sefwi- Wiawso mammals

Of the total of 40 mammal species recorded, 13 (32.5%) are of international or global conservation significance. Ten of the species are IUCN-listed, while six are CITES-listed (Table 8). Three species (*Cercopithecus diana*, *Colobus polykomos* and *Cephalophus dorsalis*) are both IUCN- and CITES-listed. The most threatened species is *C. diana* (diana monkey), categorized as endangered by the IUCN (Table 8). Twenty-six species (65%) are of national conservation significance (Ghana Wildlife Conservation Regulations).

Discussion

Human activities worldwide have been known to influence biological diversity, with many habitats and once-extensive eco-systems becoming gradually fragmented. Immigration of new species into such fragmented habitats will be impossible if the main sources of recolonisation disappear. Even though it cannot be assumed that the protection of fragmented habitats alone will safeguard the survival of many specialised and sporadically occurring species, maintaining biodiversity in existing fragments is a step in the right direction. This will ensure that the surrounding fragmented patches are able to accommodate the movement of both floral and faunal species.

Generally, the vegetation of Sefwi Wiawso is very rich in forest tree species, the commonest being the *Celtis-Triplochiton* Associations typical of semi-deciduous forest of the Western Region (Taylor, 1960) with the following as dominant species: *Celtis mildbraedii*, *Triplochiton scleroxylon*, *Ceiba pentandra*, *Milicia excelsa*, *Khaya ivoriensis*, *Terminalia ivoriensis*, *Terminalia superba* and *Bambusa* sp. Such species inventoried in this study commonly-occurred in all the fragmented habitats. Bamboo stands, adaptively located in the depressions of the hilly slopes, do not appear threatened, but strategic harvesting and sustainable management could go a long way to protect

this important resource. The swamps, notable roosting places for local and migrant birds, appeared polluted due to solid waste dumping. The riparian forest was generally low in tree density, particularly *Pterocarpus santaloides*, a common tree found in the embankments of freshwater bodies.

In certain areas, farming activities have gradually led to encroachment into the restricted 5 m zone of the Tano river, which if not checked, could result in siltation and eutrophication of the water downstream which is a source of drinking water. The forest fallows need particular attention because of their use as farm lands. The crucial issue is the determination of important trees that combine well with food and cash crops so as to promote the economically viable trees-on-farms policy of the Forestry Commission under the Medium-Term Agricultural Development Programme (MTADP, 1991–2001). It is, therefore, becoming increasingly important to retrain farmers and other stakeholders to implement the best practical agroforestry management tools for improving soil fertility so as to halt and reverse the current trend of soil erosion and land degradation.

Even though the study area had a fairly diverse community of small mammals in the survey area, their particularly high abundance in swamp forest could be attributed to the low incidence or general absence of bushfires during the dry season, and, therefore, a lower likelihood of the rodents being affected either directly (killing) or indirectly (exposure to potential predators). Such swamp forests, being located very close to human settlements and farms, probably provided the rodents with enough food in abandoned farms and storage sites. The low abundance of small mammals in the protected forests was probably due to a correspondingly low abundance of ground litter from which the rodents could obtain their food (seeds, insects, etc.), resulting in their being forced to move to farmland during the onset of the rains. The presence of *Mastomys natalensis* (multimammate mouse), a typical savanna species, and the commensal *Mus* spp. (common mice) in rain forest suggests some level of degradation through anthropogenic influences (Happold, 1987). Intense hunting and poaching activities in the area and the expansion of human settlements could also reduce the population of large mammals or drive them from their original range to refuge areas. The presence of tagged transects and killer traps in primary forest and protected forest were indications of active poaching activities.

Conclusion

The Sefwi-Wiawso District undoubtedly has a rich floral and faunal diversity, but the high rate of growth of human population in the area exerts intense pressure on the fauna of the area. The district is important for future conservation efforts because it provides suitable habitats for several threatened species (diana monkey, black-and-white colobus, duikers, squirrels, etc.). Currently, most of the tree dwelling species, particularly the monkeys, are restricted to some of the protected sites in drastically-reduced numbers. The ground dwelling species are also widely distributed throughout the patches of fragmented forests located within farming areas.

The challenges facing the district in protecting the forest environment are enormous, requiring the concerted efforts of both local and international governmental and non-governmental organisations, traditional authorities, and the local people. For sustain-able management and conservation of the forest ecosystem, the following are recommended:

- creation of buffer zones around the already-zoned or protected areas (e.g. forest reserves, sacred groves), and rehabilitation and conservation of delicate habitats (e.g. degraded bamboo forests and wetlands) and prevent their pollution by providing appropriate disposal sites for both solid and liquid waste.
- initiation of education, awareness, and training programmes for local youth focusing on various biodiversity conservation activities (e.g. floral and faunal identification, tree-planting, data recording, etc.) as well as undesirable anthropogenic influences such as bad agricultural practices (bushfires, slash-and-burn, etc.), illegal hunting, chain-saw logging, mining, etc.
- ensuring effective local participation and enhancement of the socio-economic status of the youth through employment generation.
- initiation of biodiversity research programmes (e.g. biodiversity inventories, conservation and ecological status of flora and fauna, socio-economic and cultural importance, etc.) in collaboration with research institutes, universities, NGO's to gather the necessary baseline information for future monitoring and sustainable management of biodiversity.
- establishment of individual and community plant nurseries of important indigenous timber or medicinal plants as alternative income-generating ventures (e.g. odum – *Milicia excelsa*, edinam – *Entandrophragma*, ofram- *Terminalia superba*, wawa – *Triplochiton sclero-xylon*, etc.), as well as woodlots as alternative sources of household energy and for commercial activities.
- rigid enforcement of anti-bushfire regulations, and strict application of deterrent sanctions to offenders in order to maintain the aesthetics of the hilly slopes of the district, as well prevent the destruction of biodiversity.

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