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The Contribution of Fruit bats, *Eidolon helvum,* to biodiversity on the University of Energy and Natural Resources' Campus, Sunyani, Ghana

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ABSTRACT

The dispersal ability of straw coloured fruit bats (Eidolon helvum), was investigated on the University of Energy and Natural Resources (UENR) Campus in Sunyani from January 2013 to December 2014. A reconnaissance exercise was conducted in the UENR in order to stratify the campus into bat-occupied and unoccupied zones (strata) based on the presence or absence of roost trees occupied by bats. The Wildlife Sanctuary represented the main bat roost site (bat-occupied zone) whilst the rest of the campus constituted the unoccupied zone. Using 64 (4m x 4m) quadrats and 32 seed traps made from plastic sheets were set up randomly in the bat occupied areas. Seeds dispersed were collected on the seed traps and identified. The contribution of the dispersed seeds to the regeneration of the total plant population in the undergrowth wasestimated at 1.7%. Notable species which were dispersed by bats were Mallotus opposotifolius, (16.1%), Broussonetia papyrifera (10.6%), Ficus exasperate (6.6%), Solanum erianthum (6.2%) and Morus mesozygia (4.6%) of total seeds dispersed. These plants were found to have been introduced by E. helvum into the study area and are contributing to the ecological improvement by increasing biodiversity through regeneration.

Key Words: Eidolon helvum, disperse, seeds, reconnaissance

1. Introduction

Fruit bats are known to feed on a wide variety of plant species (Schupp, 2010). Studies on straw-colored fruit bats (*Eidolon helvum*), elsewhere have shown that fruits are their source of food(Funmilayo, (1985) and Heithaus, (1982), while other plant parts like leaves and bark also form a small portion of their diet (Howe *et al*, 2010). The number and diversity of viable seeds found in their droppings (Funmilayo, 1985) support this.

This observation leads to the fact that the straw-colored fruit bat, apart from being a major disperser of seeds is an important frugivore. Similarly, most vertebrates in tropical rain forests belong to this overall category of consumers (Mutere, 1980). Studies on the diet of fruit bats have been conducted in other parts of Africa (Kunz, 1974; Fleming and Heithaus, 1981) but not much has been conducted for many parts of West Africa. Similarly, in Ghana, there is very scanty information on the food utilized by straw-colored fruit bats (Heithaus, 1982). This is largely attributed to the fact that the straw-colored fruit bats are secretive, elusive and unpredictable. Also the nature of their habitat (poor visibility) makes detailed close range studies on its feeding behavior extremely difficult and virtually impossible. According to Heithaus (1982) direct observations of bats in forested habitats are rare, fleeting and time consuming. Because of the difficulty, time involved and the expense of energy and skills required to track and study these animals, most studies involving their foraging ecology is done indirectly through dropping analysis and by associating their signs with parts of plant species consumed Schupp (1993). However, the methodology used in this approach entails a rather high skill of judgment and a thorough knowledge in plant classification. Moreover, it is laborious and requires a lot of patience to efficiently search through droppings for identifiable remains. Despite these difficulties, the importance of an increased knowledge on the foraging ecology of fruit bats and their dependence on seasonal fruit resources cannot be over emphasized. This is useful as a larger proportion of their diet may be bark material whose availability may not match that of fruits (Akite, 2008). Also, ecological studies must still be continued and intensified, especially now that the protection of the species is being significantly developed in Africa and in particular, Ghana. This paper therefore, is to contribute to the critical importance of seed dispersal ability of bats; and the long-term conservation of straw-colored fruit bat populations (Akite, 2008) in Ghana.

1.1 Biophysical Setting

Sunyani falls within the wet Semi-Equatorial Climatic Zone of Ghana. The mean monthly temperatures vary between 23ºC and 33ºC with the lowest around August and the highest being observed around March and April. The relative humidity is high averaging between 75 and 80 percent during the rainy seasons and 50 and 40 percent during the dry seasons of the year which is ideal for luxurious vegetative growth (Ministry of Local Government report, 2010).

1.1.1 The Environs of UENR

The University of Energy and Natural Resources covers an area of 120 acres (48.564ha) lies along the Sunyani Berekum highway. It shares a boundary with the Regional Administration and the closest community is Fiapre towards Berekum. It is directly opposite the Seventh Day Adventist Secondary School and Hospital. The campus is laid out with forest tree outgrowths, made up of indigenous tree species like *Ceiba pentandra, Triplochiton scleroxylon,* and exotic plant species like *Eucalyptus grandifolia, Tectona grandis* and *Senna siamea.*

1.2 Objectives

The objectives of this study are to:

1. Provide a comprehensive list on fruits eaten by straw-colored fruit bats in UENR.
2. Investigate the diversity and quantity of fruits eaten monthly/seasonally by straw-colored fruit bats in UENR.
3. Identify the contribution of seeds eaten by fruit bats to the plant diversity in UENR.

1.3 Methodology

1.3.1 Study Area/Location

The Wildlife Sanctuary of the University of Energy and Natural Resources Campus; has coordinates of Latitudes 7^0 20'N and 7^0 05'N and Longitudes 2^0 30'W and $2^0$10'W (Figure 1) with a total area of 3.6ha and occupies 7.3% of the University Campus.

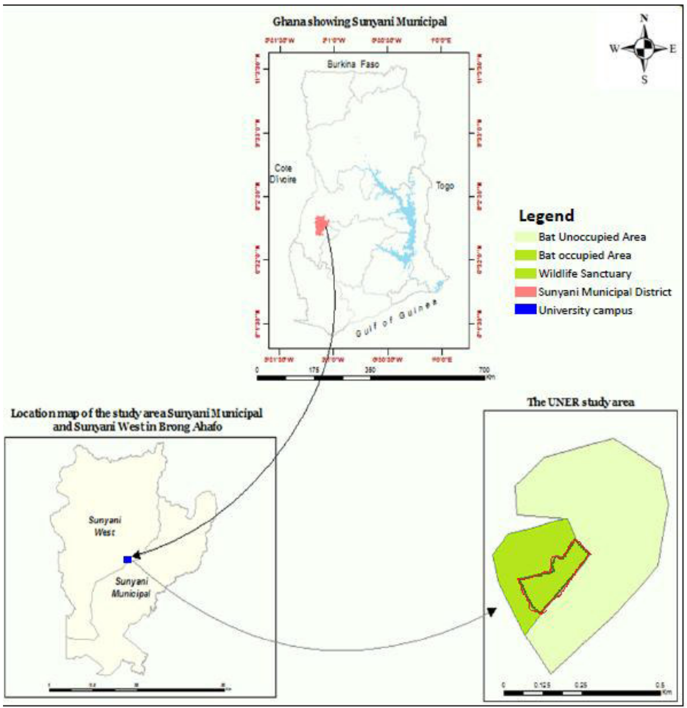

Figure1: Map of Study Area

1.4 Experimental Procedure

A reconnaissance exercise was conducted in the UENR in order to stratify the campus into bat-occupied and unoccupied zones (strata) based on the presence or absence of roost trees occupied by bats. The Wildlife Sanctuary represented the main bat roost site (bat-occupied zone) whilst the rest of the campus constituted the unoccupied zone. Four sample plots, each of size 20m by 20m were systematically distributed in the two strata (i.e. two plots in the bat-occupied zone and the remaining two plots in the unoccupied zone.

i) Thirty one roost trees were randomly selected in the study area and seed traps were placed under each tree to collect seeds dispersed through bat droppings at the bat roosting site. Each seed trap was constructed under the tree canopy using a plastic sheet measuring 4m x 6m **(Plates 1a and 1b)**.

ii) Seeds dispersed through bat droppings on the sheets were identified with a handheld magnifying glass (Irvine and Roberts (1961).

iii) Sixty four quadrats, each 4m x 4m, were randomly laid in the study area and some outside roost trees to compare diversity. All seedlings were identified using their plant-form (climber, creeper etc.) and leaf structure. All seedlings above 30 cm high were classified as trees, Hawthorne (2006).

iv) The species diversity and Evenness were calculated using the Simpson’s diversity (D) and Shannon-Wiener’s (H) indices.

1.5 Data Analysis

All analysis was done using the Minitab computer package.

Descriptive analysis using tables, charts and histogram were used to show the types and quantity of fruits eaten and dispersed by bats.

Shannon-Wiener's diversity index was used to estimate fruit seed and seedling diversity. Paired Sample Statistics of bat occupied and unoccupied areas were done using the t-test to detect the significant difference between the undergrowths.

1.6 Results

A list of food plants eaten by straw-colored fruit bats in UENR

A survey in the study area showed that there are 68 plant species, made up of 45 trees species (66.2%) and 23 species of herbs, shrubs and climbers, (43.8%). Seven tree species (15.6%) had their fruits eaten by *E. helvum*. Two hundred bat droppings were examined and seven seeds were found to correspond to trees found in the study area and four were found exclusively outside the Study area (Table 1).

An initial survey of the species abundance of seedlings in the study area was conducted (Figure 2). *Mallotus opposotifolius* (16.1%) and *Broussonetia papyrifera* (10.6%) were relatively abundant in the area with *Dalbergia hostilis* (0.1%) was least abundant in the study area.

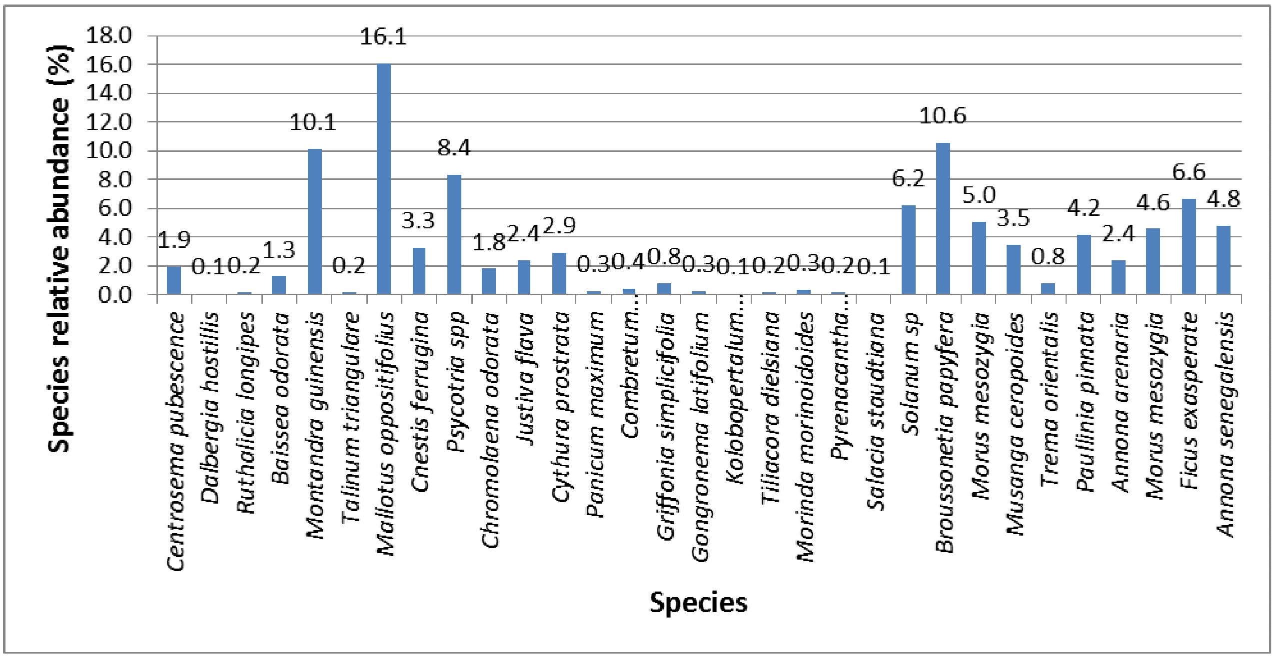

Figure 2: Histogram of relative abundance of seedlings in the study area

Seedling diversity at the study area was assessed and the results were shown in the histogram in Figure 2. The results indicated the relative abundance of each plant species sampled.

There was a high seedling Species Diversity in the study area, Table 1, as revealed by the indices of Simpson's diversity index (D) of 0.92 ± 0.004, coefficient of variation 1.05%; Shannon- Wiener's index (H) of 2.83 ± 0.046%, coefficient of variation 3.50; Evenness (E) was 0.82 ± 0.012, coefficient of variation 3.75% and species richness of 31 in the study area.

Table 1: Table showing Simpson's Diversity (D), Shannon-Wiener's (H) Index and Evenness

Simpson's Index (D)	**Shannon-Wiener's Index (H)**	**Evenness (E)**
0.92 ± 0.004 (1.05 %)	2.83 ± 0.046 (3.50 %)	0.82 ±0.012 (3.75 %)

The mean population estimates of undergrowth seedlings in the occupied area were 32.3 and 25.5 in the unoccupied area. However, Paired Sample Statistics of bat occupied and unoccupied areas were done using the *t*-test and there was no significant difference between the undergrowth seedling compositions in the bat occupied area and the unoccupied area, $t(6) = -0.23$, $p>0.05$ (Tables 2(a) and 2(b)).

Table 2(a):Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	occupied	32.3	7	122.8	74.2
	unoccupied	25.5	7	72.3	90.7

Table 2b : Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 2 a. Occupied b. Unoccupied	16.8	78.2	50.5	36.9	98.4	0.23	6	0.034

Table 3: Plants Seeds eaten by bats on UENR Campus

Botanical Name	**Family**	**Frequency**	**Notes**
Azadiractha indica	Meliaceae	10	Present in bat area
Ceiba pentandra	Bombacaceae	15	Present in bat area
Deloniix regia	Caesalpinaceae	18	Present in bat area
Holarrhena floribunda	Apocynaceae	16	Present in bat area
Newbouldia laevis	Bignoniaceae	10	Present in bat area
Albizia zygia	Mimosaceae	10	Present in bat area
Triplochiton scleroxylon	Sterculiaceae	12	Present in bat area
Ficus exasperate	Moraceae	17	Not present in the study area
Mallotus opposotifolius	Euphorbiaceae	19	Not present in the study area
Solanum erianthum	Solanaceae	11	Not present in the study area
Broussonetia papyrifera	Moraceae	40	Not present in the study area
Morus mesozygia	Moraceae	22	Not present in the study area
TOTAL		**200**	

The plant families found to be more frequently eaten in the study area were Caesalpinaceae, Apocynaceae and Bombacaceae with Sterculiaceae. Meliaceae, Bignoniaceae and Mimosaceae were less eaten (Table 3).

The percent monthly seeds collected during the study period were computed out of the total seeds examined during the study period (Table 4(a) and 4(b)).

Table 4 (a): Monthly number (percent) of seeds eaten by bats in the study area

	MONTHS					
Fruit Species	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Azadiractha indica	23 (12.0)	6 (4.9)	62 (39.1)			
Ceiba pentandra	22 (11.0)	12 (9.7)				
Deloniix regia	1 (0.5)	10 (8.1)	13 (8.2)	4 (6.6)	7 (18.9)	12 (26.0)
Holarrhena floribunda		2 (1.6)	8 (6.5)	4 (6.6)	6 (5.2)	
Newbouldia laevis	8 (6.5)	8 (6.5)	15 (9.5)	17 (27.2)	12 (32.4)	15 (32.6)
Albizia zygia				8 (4.2)	6(6.2)	
Triplochiton scleroxylon	31 (15.5)	11 (8.9)				
Ficus exasperate	23 (12.0)	6 (4.9)	6 (3.8)			
Mallotus opposotifolius	22 (11.0)	12 (9.6)				
Solanum erianthum	39 (19.5)	34 (27.5)	18 (11.3)	12 (19.7)		
Broussonetia papyrifera	30 (15.0)	22 (17.8)	34 (8.2)	18 (29.5)	12 (32.4)	15 (32.6)
Morus mesozygia			2 (1.3)	6 (9.84)		4 (8.68)
TOTAL	**199 (99.5)**	**123 (61.5)**	**158 (79.0)**	**61 (30.5)**	**37 (18.5)**	**46 (23.0)**

Table 4 (b): Monthly number (percent) of seeds eaten by bats in the study area

	MONTHS					
Fruit Species	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Azadiractha indica			28 (15.1)	14 (2.1)	16 (13.1)	33 (33.0)
Ceiba pentandra				12 (1.4)	12 (9.8)	14 (14.0)
Deloniix regia	13 (28.2)	20 (51.2)	20 (10.8)	8 (0.3)	6 (4.9)	2 (2.0)
Holarrhena floribunda			17 (8.5)	10 (1.0)	12 (9.8)	
Newbouldia laevis	20 (43.4)	19 (48.6)	14 (7.6)	12 (0.4)	12 (9.8)	8 (8.0)
Albizia zygia	16 (13.1)					
Triplochiton scleroxylon				3 (0.1)	3 (2.5)	
Ficus exasperate			54 (29.2)	26 (0.9)	16 (13.1)	12 (12.0)
Mallotus opposotifolius				6 (1.0)	13 (10.7)	
Solanum erianthum			18 (9.7)	25 (0.8)	16 (13.1)	8 (8.0)
Broussonetia papyrifera			24 (13)	13 (0.5)	16 (13.1)	23 (23)
Morus mesozygia	13 (28.2)		10 (5.4)			
TOTAL	**46 (23.0)**	**39 (19.5)**	**185 (92.5)**	**129 (64.5)**	**122 (61.0)**	**100 (50.0)**

The number of seeds in the seed rain per month ranged from 37 to 199 (Tables 4 (a) and 4 (b)). The monthly variety of fruits eaten by bats was least (37) in the month of May and highest (199), (185) and (158) in the months of January, September and March.

The most frequently eaten species (throughout the year) were *Newbouldia laevis* and *Broussonetia papyrifera* and *Delonix regia* species (Tables 4 (a) and 4 (b)). However, *Morus mesozygia* and *Triplochiton scleroxylon* were less frequently eaten.

1.7 Discussion

E. helvum is a frugivore that feeds on varieties of fruits at their foraging site. It is well known among tropical ecologists that animal/bats play important role in seed dispersal and pollination in tropical forest succession, distribution, and community composition (Fleming and Heithaus, 1981). Most of these animals dispersed and pollinated plants have great economic and cultural significance in our everyday life (Howe, 1986).

In the UENR campus, this study indicated that bats fed on fruits of *Azadiractha indica, Ceiba pentandra, Deloniix regia, Holarrhena floribunda, and Newbouldia laevis,* which are found in the study area; and also introduce seeds of other plant species from other areas into the study area. Plants like *Mallotus opposotifolius*, *Solanum erianthum*, *Broussonetia papyrifera*, *Morus mesozygia*, and *Ficus exasperate* are not found in the study area.

Newbouldia laevis and *Deloniix regia* found among the roost trees and *Broussonetia papyrifera* not found among the roost trees were common seeds found throughout the year in the seed trap (Tables 4 (a) and 4 (b)).

This dispersal process can lead to heterogeneity in the biodiversity of the study area. It can also produce mixed stands of reproductive plants which can serve as regeneration for succession and forest recovery. *Mallotus opposotifolius*, *Solanum erianthum, Broussonetia papyrifera*, *Morus mesozygia*, *Ficus exasperate*, were identified in the seed rain collected in the colony. The likelihood of these seedlings scattering as incoming recruits to establish under a broader range of conditions in the sanctuary is physically possible. It is important to conduct further studies to determine the conditions for the establishment of these seeds as seedlings in the colony.

E. helvum is capable of moving seeds from its foraging areas into the sanctuary to help in forest restoration. This process over time can help to transport as many uniquely important tree species into the sanctuary to create a heterogeneous stepping stone tree island.

The influx of seeds from other places was notable; because they constitute fruits eaten by bats during the dry and wet season and can evidently serve as recruitment species for regeneration of the landscape. Majority of these trees fruit from October to December, and they are readily available as food sources for *E. helvum*. *Azadiractha indica, Ceiba pentandra, Deloniix regia, Holarrhena floribunda, Newbouldia laevis,* are all fruit trees that are available in the study area.

The seasonality in the food resources availability and the movement of bats is an indication that food resources can be used to determine the presence of bats in study area. The seed collected in study area was very high in January, (199) March (158) and December (100). Therefore apart from other unknown factors it can be predicted that food resource availability accounts for the presence of bats in the study area.

However, other plants of conservation interest can be potentially spared in heterogonous habitats by fruigivores. It is too early to know whether the bat dispersed succession recruitment will persist. It is therefore important to continuously monitor the succession in the landscape over time.

The high species diversity of the plants in the bat occupied area as compared to the non bat occupied area also attest to the fact that the bats are attracted by available food resources. There are more trees for occupation in the bat occupied area than the area not occupied by bats. This suggests that bats find food resources in areas where there are more trees that produce fruits than areas where there are few trees.

1.8 Conclusion

Seed rain of seeds collected indicated that the bats have introduced other plant species into the study area. These plants can for a very long time to come affect the succession of the plants in the study area while improving biodiversity of plants. Introduced species can positively or negatively affect the ecological balance of the study site; this is a potential source of invasive species into the ecosystem.

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Plates

Plate 1a: Seed trap under the canopy

Plate 1b: Seeds dropped on plastic sheet.