THE IMPACT OF BATS ON THE GREENS (LANDSCAPE FEATURES): A CASE STUDY OF OBAFEMI AWOLOWO UNIVERSITY CAMPUS, ILE-IFE, NIGERIA

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ABSTRACT

A study was carried out to identify the areas occupied by bat colonies (*Eidolon helvum*) and to determine the extent and magnitude of damage to trees in Obafemi Awolowo University Campus, Ile-Ife, south western Nigeria. Four 20 x 20 m sample plots were selected. Three plots were in areas affected by bat activities while the fourth plot was in a control area (unaffected by bats).Tree species within each plot were identified, enumerated and the canopy cover, height and tree diameter were determined. The trees in bat affected plots were impacted negatively due to bat resting in large numbers on branches which support the leaves. These actions facilitated premature defoliation, loss of branches and hence reduction in canopy foliage of such host trees. The main physical plant features/attributes that are negatively impacted are the tree canopy size, canopy cover and height and this led to the decline in the ability of the trees to provide many environmental and social services that contribute to the quality of life in cities and to serve as effective wind barrier. The ecological impact of the bat species on its environment could ultimately threaten the long-term viability on its roost.

Keywords: Bats, Defoliation, Impact, Roost, Vegetation

INTRODUCTION

The straw-colored fruit bat, *Eidolon helvum* (Kerr, 1792), is a frugivorous animal in the order megachiroptera (Okon, 1974). A colony of fruit bats with a very large population is observed to have destructive impact on roosting trees and the environment (Ritcher, 2004). *Eidolon helvum* feeds entirely on flowering and fruiting trees (Wilson, 1973). Roosts sites selected during the day are in tall and large trees with scattered branches (Defrees and Wilson, 1988).

Bats induce premature shedding of leaves which could result into the destruction of such trees (by the loss of photosynthetic ability) depending on how long the trees serve as their roost site or camp. This deprives the immediate environment of the complement of such landscape feature i.e. shade and evapotranspiration-lowered air temperature (humification; Wund and Myers, 2005). The aftermath of their camping is an aesthetically unpleasant sight or defacement of such landscape feature (trees). Evaluation of the ecological consequences of the presence of any animal life such as bats on the urban environment reveal that the main victims are the trees and a few associated features. Large roosts cause damage to smaller branches and twigs. *E. helvum* will eat any sweet, juicy fruit, bud and young leaves of certain trees, flowers, nectar and pollen (Kingdon, 1974). They also chew into soft wood to obtain moisture (Nowak and Paradiso, 1983).

Despite destructive feeding habit (Funmilayo, 1979), these fruit bats are helpful in pollinating and promoting outcrossing in flowering plants (Haris and Baker, 1959).They are particularly fond of *Ceiba pentandra* and their habit of moving about in large flocks promotes outcrossing in this widespread and common tree species (Baker and Haris,1959)

Bat populations continue to decline in many parts of the world (Hutson *et al.,* 2001). Factors that contribute to these declines vary regionally but deforestation and conversion of native habitats to intensive agriculture or other human developments pose the greatest threats. Deforestation has reduced the availability of many important roost resources and loss of such roosts is having an enormous impact on the density and distribution of local bat .

The greater the tree cover, the greater the relative importance of trees in influencing the environment of a given city. One of the most cost-effective analyses of urban forest structure is that of tree cover (the proportion of area occupied by tree canopies when viewed from above). Factors that influence overall urban tree cover include ecoregion (i.e. the natural environment in which the city is developed), city age and city size (Mcpherson *et al.*, 1992). Beyond tree cover, other attributes that are important for quantifying urban forest structure include species composition, tree diameter and height distribution, biomass and leaf surface area. However, very little is known about the comprehensive urban forest structure. Most urban forest work has been conducted on street tree populations which often comprise only a small percentage of total urban woody vegetation. Research has quantified species composition and other structural attributes for various parts of urban forests across the world (Lizumi, 1983; Wee and Corlett, 1986; Svanbergson *et al.,* 1988; Profous *et al.,* 1988; Nowak, 1991; Profous, 1992; Jim, 1992).

Urban green space provides many environmental and social services that contribute to the quality of life in cities. Trees can significantly influence the urban environment, although yet relatively little research has been conducted to quantify their effects. In addition, severe defoliation of roost trees could affect tree growth, composition and structure of roosts which may affect their long term viability and may play an important role in forest dynamics. A better understanding of how and to what degree urban trees influence the environment will lead to better management of urban trees, significant monetary savings for urban residents and a more pleasant and healthy urban environment. The present study intends to determine the extent and magnitude of the damages caused to the urban vegetation by roosting colonies of the frugivorous bat *Eidolon helvum*.

MATERIALS AND METHODS

Study area

The study was carried out at Obafemi Awolowo University which is situated in Ile-Ife, an ancient city in the South Western part of Nigeria. It is on longitude $04^{0}33^{'}$E and Lattitudes $08^{0}28^{'}$ N and is 244 m above sea level. The vegetation in its natural state consists of tall trees with thick undergrowth of shrubs and intertwining climbers, which make it hardly penetrable.The area lies in the dry deciduous forest zone (Onochei, 1979). According to White, (1983) the vegetation was described as Guineo-Congolian drier forest type. Agricultural practises including plantation agriculture is very popular in this area. Based on many environmental factors, forest in Ile-Ife like in most parts of the country, has undergone severe deforestation over the years.

Within the vicinity of the academic area are three green areas which are at the receiving end of bat activities, they are the Zoological Garden; which shares common boundary with the mountain range, the buffer zone behind the Biological sciences and the Parks and Gardens which extends towards the University staff quarters.

Data Collection and Analysis

For the purpose of research based on the visible physical state of trees within the study area the deliberate tour of designated green areas was undertaken to assess the level and magnitude of impact of the bats. Three plots (B, C and D) were carved out of the major sites each having a size of 20 m by 20 m. In addition is a control Plot (A unaffected Plot by Bats) to be able to evaluate the ecological cost of bat habitation of green areas. Each plot was divided into four belt transects (5 m x 20 m) for effective coverage of each plot (Figs. 1- 4). Tree density was estimated in each of the four plots by complete enumeration. Every tree and shrub taller than one metre was tagged with number, counted and identified to species level. Indices of similarity and diversity were calculated to know the degree of similarity between the plots and their species diversity.

Girth of woody plants was measured at breast height (GBH) for species greater than three metres high and at mid point for those 3m. The girth measurements were used to calculate the basal area for each plant and for each species. Tree height was measured using Haga altimeter. Tree crown area (canopy) was measured by taking two diameters at right angles to each other across the plants, one of which was the maximum diameter for the plant.The area of each plant canopy was calculated from the formula $A= D^2/4$ where D is the average crown diameter.

The second method for percent canopy cover involved laying of transects. Four 20 m line transects were laid randomly within each plot using a 30 m measuring tape. At each metre point, the presence or absence of canopy was noted. Percent cover was computed as the number of sampling point hits divided by the number of sampling points per transect multiplied by hundred. The vegetation parameters such as tree canopy cover, tree height and tree diameter collected from the the sample plots were used to determine the severity of bats impact on the host trees. These vegetation parameters were subjected to One-way Analysis of Variance with mean separation using Tukey multiple comparison test.

RESULTS

Floristics Composition of the Plots.

There were four tree species and 112 trees per hectare in Plot A (Control, Parks and Garden), eight tree species and 224 trees per hectare in Plot B (Parks and Garden), ten tree species and 224 trees per hectare in Plot C (Zoological Gardens) and seven tree species and 256 trees per hectare in D (Buffer Zone). *Elaeis guineensis* was common to Plots B and D. The Shannon-Wiener species diversity index was found to be high in plot D (H' =1.836); low in plot A (H' = 1.232) and intermediate in plots B and C (H' = 1.447 and 1.798) (Tab. 1).

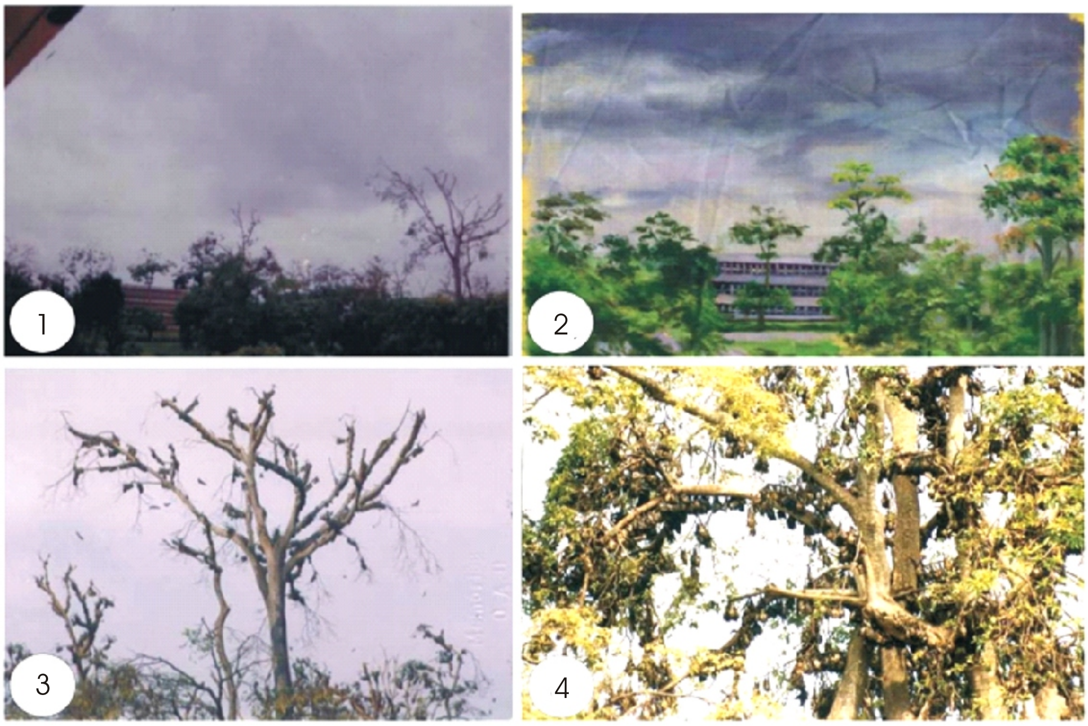

Plate 1: A Cross Section of Trees at the Buffer Zone; 2: An artist impression of what plate 1 used to look like before bat infestation; 3: Make-shift roost site on a tree (*Celtis zenkeri*) at the impacted site; 4: Bat roosting area in the study site

Table 1: Total Number of Tree Species and Species Diversity Index at Different Locations in the Study Site.

S/N	Plots and location	Total number of tree species	Species Diversity Index (H)
1.	Plot A (control; Parks and Gardens)	4	1.232
2.	Plot B (Parks and Gardens)	8	1.447
3.	Plot (Zoological Gardens)	10	1.798
4.	Plot D (Buffer zone)	7	1.836

Table 2: Plant Height, Basal Area and Canopy Cover of Tree Species as Occurred in the Undisturbed Plot.(Plot A)

S/N	Tree species	Basal Area (m² h)	Height (m)	Canopy cover (m²)
1.	*Alstonia boonei*	0.12730	11.33	62.88
2.	*Alstonia boonei*	0.04200	16.00	65.00
3.	*Mangifera indica*	0.09100	13.33	19.62
4.	*Mangifera indica*	0.16500	16.66	189.81
5.	*Persea americana*	0.00910	10.00	168.47
6.	*Persea americana*	0.00910	4.66	5.10
7.	*Terminalia spp.*	0.00224	3.33	29.69
Total	**7**	**0.45**	**75.25**	**540.57**
Mean		**0.064**	**10.75**	**77.22**

Table 3: Plant Height, Basal Area and Canopy Cover of Tree Species as Occurred in the Disturbed Plot.(Plot B)

S/N	Tree species	Basal Area (m² h)	Height (m)	Canopy cover (m²)
1.	*Alstonia boonei*	0.14490	21.30	51.50
2.	*Cola millenii*	0.01270	2.60	0.78
3.	*Delonix regia*	0.03898	12.66	4.90
4.	*Delonix regia*	0.11450	12.66	27.32
5.	*Elaeis guineensis*	0.08600	16.66	20.01
6.	*Elaeis guineensis*	0.0644	13.33	23.74
7.	*Elaeis guineensis*	0.0286	3.20	31.15
8.	*Elaeis guineensis*	0.0795	14.00	6.60
9.	*Elaeis guineensis*	0.0249	3.20	10.45
10.	*Holarrhena floribunda*	0.1428	16.00	70.8
11.	*Holarrhena floribunda*	0.1184	14.66	18.46
12.	*Luecaena leucocephala*	0.0000715	2.50	4.15
13.	*Muraya spp.*	0.000286	2.50	1.88
14.	*Rothmannia longiflora.*	0.0003898	2.50	2.26
Total	**14**	**0.85**	**137.11**	**274.00**
Mean		**0.061**	**9.794**	**19.571**

Table 4: Plant Height, Basal Area and Canopy Cover of Tree Species as Occurred in the Disturbed Plot.(Plot C)

S/N	Tree species	Basal Area (m^2 h)	Height (m)	Canopy cover (m^2)
1.	*Albizia zygia*	0.0688	2.60	52.78
2.	*Antiaris africana*	0.0249	12.66	15.68
3.	Dead tree	0.4970	27.30	-
4.	*Deinbollia pinnata*	0.000286	2.30	1.88
5.	*Deinbollia pinnata*	0.000509	2.70	1.43
6.	*Funtumia elastica*	0.16700	24.66	107.45
7.	*Homalium letetisui*	0.0640	18.66	51.50
8.	*Milicia excelsa*	0.009755	12.66	17.71
9.	*Morinda lucida*	0.00203	3.20	1.43
10.	*Newbouldia laevis* .	0.0286	14.66	6.15
11.	*Newbouldia laevis*	0.0160	4.60	9.60
12.	*Newbouldia laevis*	0.0286	9.30	8.80
13.	*Newbouldia laevis*	0.0640	14.66	7.32
14.	*Pycnanthus angolensis*	0.3670	24.66	143.06
15.	*Solanum erianthum*	0.0030	4.60	8.80
Total	**15**	**1.3**	**179.22**	**433.6**
Mean		**0.087**	**12.801**	**28.907**

Table 5: Plant Height, Basal Area and Canopy Cover of Tree Species as Occurred in the Disturbed Plot.(Plot D)

S/N	Tree species	Basal Area (m^2 h)	Height (m)	Canopy cover (m^2)
1.	*Azadiractha indica*	0.00229	5.66	2.40
2.	*Bombax buonopozense*	0.3670	19.33	65.00
3.	*Dracaena manii*	0.00579	6.66	16.97
4.	*Dracaena manii* .	0.0143	11.00	12.87
5.	*Dracaena manii*	0.2290	18.33	14.85
6.	*Dracaena manii* .	0.0071	8.00	8.80
7.	*Dracaena manii*	0.00814	7.66	5.72
8.	*Dracaena manii*	0.0071	4.33	9.61
9.	*Dracaena manii*	0.0086	9.33	22.05
10.	*Elaeis guineensis*	0.0198	7.33	25.05
11.	*Rauvolfia vomitoria*	0.0133	5.30	24.61
12.	*Ricinodendron heudelotii*	0.376	15.66	73.86
13.	*Voacanga africana*	0.0038	3.33	11.84
14.	*Voacanga africana*	0.0071	4.33	5.30
15.	*Voacanga africana*	0.00229	6.00	-
16.	*Voacanga africana*	0.00715	6.33	14.17
Total	**16**	**1.08**	**138.61**	**313.1**
Mean		**0.068**	**8.663**	**19.569**

Table 6: Percent Cover Per Transect of the Four Study Plots

S/N	Transect Number	Percentage Cover %			
		PLOT A	PLOT B	PLOT C	PLOT D
1..	1	80	40	85	50
2.	2	100	35	65	35
3.	3	75	55	25	55
4.	4	55	25	90	70
Total		**310**	**135**	**265**	**210**
Mean		**77.5**	**33.75**	**66.25**	**52.25**

Table 7: Canopy Cover with Mean Separation among the Plots using Tukey Multiple Compariosn Test

PLOTS	MEAN COVER	P VALUE
PLOT A vs PLOT B	4.76	$P<0.01$*
PLOT A vs PLOT C	3.43	$p>0.05$
PLOT A vs PLOT D	4.36	$P<0.05$*
PLOT B vs PLOT C	1.54	$P>0.05$
PLOT B vs PLOT D	0.49	$P>0.05$
PLOT C vs PLOT D	1.06	$P>0.05$

*significant $p<0.05$

Sorenson's index of similarity (IS) between the plots reveals that only plots B and D show very low similarity (IS = 0.13%) while all other plots were found not to be similar at all.

Consideration of the basal area contribution of each tree species to the overall basal area of the plots showed that in Plot A *Mangifera indica* contributed the largest basal area of 0.256 m^2 ha^1 (57.44% of the total basal area) while *Terminalia spp* had the smallest basal area of 0.1001 m^2 ha^1 and the other two species had intermediate values. In plot B, *Elaeis guineensis* contributed the largest basal area of 0.2834 m^2 ha^{-1} (33.09% of the total basal area) while *Luecaena leucocephala* had the smallest basal area of 0.0000715 m^2 ha^{-1} and the other species had intermediate values. In plot C, *Pycnanthus angolensis* contributed the largest basal area of 0.367 m^2 ha^{-1} (43.45% of the total basal area) while *Deinbollia pinnata* had the smallest basal area of 0.0000795 $m^2 ha^{-1}$ and the other species had intermediate values. In plot D, *Ricinodendron heudelotii* contributed the largest basal area of 0.376 m^2 ha^{-1} (34.85% of the total basal area) while *Azadiractha indica* had the smallest basal area of 0.00229 m^2 ha^{-1} and the other species had intermediate values (Tables 2 - 5).

Percent cover per transect in each plot shows the level of sunlight penetration (as a result of defoliation) within the canopy cover or length. The control plot (plot A) has an average percentage of 77.5 while the three remaining plots (plots B, C and D) have a combined average of 50.83 % (plot B -33.75%, plot C-66.25%, plot D -52.25%) (Tab. 6).

The mean canopy cover in the control plot (Plot A,77.22) was significantly higher ($p<0.05$) than the mean canopy cover of the other three impacted plots (Tab. 7). The mean plant height was highest in plot C (12.801) which was an impacted plot but closely followed by plot A, (the control plot) and plot D had the lowest while plot B was intermediate (Tables 2-5). The impacted plot C which had the highest mean plant height also had the highest mean basal area (0.087).

A total of seven individual trees were encountered in the control plot while a total of 45 individual trees were encountered in the remaining three plots. Of all the parameters evaluated the length of canopy cover was observed to be the most reflective of the level of physical deterioration of trees. The total canopy cover for the control plot (plot A) is 540.57 m^2 while the total for the remaining three plots (plots B, C and D) is 1017.9 m^2; which translates to an average of 339.23 m^2 per plot.

DISCUSSION

Bats threaten plant species when they turn treetops and trunks to their place of abode. Bats impact negatively on plant life by disrupting the photosynthetic process, since they rest on branches which support leaves in large numbers. These actions facilitate loss and premature shedding of leaves and hence the death of some of such host trees, since they have been denied of their ability to respirate. The major casualty as regards the eco-significance of trees are the canopy length,canopy cover and tree height. The decline of these three parameters diminished the ability of trees to provide humification and serve as wind barrier.

The general trend in the canopy length, canopy cover and height of the trees revealed that there was a drastic reduction in these parameter/features in the three impacted plots when compared with the control plot. The bats decimated the canopy length, canopy cover and height of the trees in the disturbed plots. This is because the bats had major impact on the ecosystem where they have selected as their roosting sites. The consumption of the foliage is harmful to the environmemt. This observation is in agreement with the study of Ritcher (2004) who observed that severe defoliation could affect tree growth, composition and structure of roosts which may affect long term viability. The results suggest that the woody species seem to have undergone some form of modification after-defoliation. Canopy patterns in roost areas were very different from undisturbed areas. This can be explained by the fact that *E. helvum* often roost at high densities in tall emergent tress (Rosevear, 1965; Funmilayo, 1976; Kingdon, 1974, Defrees and Wilson, 1988). Funmilayo (1976) comments that the continued use of the same trees for roosting by *E. helvum* prevents the regeneration of branches and this could be seen in the disturbed/impacted sites. This large *E. helvum* aggregation caused branches to break under their weight resulting in lowered canopy height. This also reduced the foliage within the canopy and thus increased the canopy openness.

The decline in the mean plant height in the impacted plot compared to the control plot revealed that the impacted plant species dies from the top to bottom. As the bats prefer to roost in the taller trees, they are the first to become damaged resulting in lower plant height in the remaining trees in the roost. The implication is that very soon more species with higher height will soon be reduced to shorter plant in a matter of time. This is as a result of the continuous defoliation of the plant by Bats roosting on them. This deprives the immediate environment of the complement of such landscape feature i.e. shade, cooling effect and evapotranspiration-lowered air temperature (humification) in agreement with Wund and Myers, (2005).

Shannon-Weiner's index of species diversity used to calculate the diversity of the woody plant species revealed that the three affected plots were not significantly different from one another which is an indication that all the three plots are impacted by the Bats to a similar extent. This is also an indication that the original vegetation has been degraded. Deforestation and habitat fragmentation have long threatened the conservation of bats and other wildlife (Bright, 1993).The expected declines in Bat populations and species richness are likely to have serious consequence for ecosystem function (Pierson, 1998). This has made their presence and abundance incompatible with the host community. Their menace is unaesthetic, which is one of the major characteristics of a planned environment, what is observed are drying-up or defoliated trees. The negative impact of Bats presence in the environment is there-by magnified as a result of the nature of such an environment and the prevailing atmospheric condition.

Protection of forests that provide important roost and food resources for Bats should be an important conservation goal (Pierson, 1998). Forest management practices that focus on conservation of high densities of roost trees and benefit the roosting species as a result of services that both of them provide should be encouraged.

CONCLUSION

The effect of Bat activities on landscape features (trees) as experienced in O.A.U. is a reality in tropical environment. This study has shown the negative impact of Bats on trees in designated green areas. This study has provided emperical data on the extent of vegetation damage occasioned by the activity of Bats. This is evident in the three affected sites as against the control site. Based on the fact that the resilience of the current forest cover is too low to support the Bat population, there is a need for the adoption of strategies that will be capable of deterring them from designated green areas which they degrade to other locations around their natural habitat or roost site, to forestall a reduction in their population and a threat to their survival and eco-significance; since they have been observed to have limited roost sites.

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