The occurrence of the blackflies Simulium damnosum complex Theobald and human onchocerciasis in relation to vegetation zonation in Nigeria

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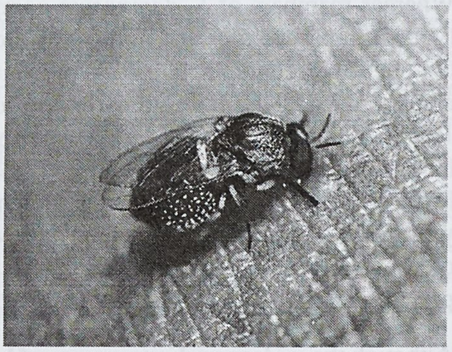
This study aimed at establishing the epidemilogical distinctions in the geographical distribution of the blackflies *Simulium damnosum* complex and human onchocerciasis (river blindness) in the two major vegetation zones in Nigeria, the savanna and forest zones. It is based mainly on information from literature sources and the results of past field surveys in the country over the past five decades. Five of the ten sibling species of the vector blackflies *S. damnosum* complex known in West Africa have so far been recorded in the country. They are among the six most important vector species for the transmission of human onchocerciasis in West Africa and comprise both the savanna types (*S. damnosum s.s, S. damnosum s.s Volta form, S. sirbanum*) and the forest types (*S. yahense* and *S. squamosum*). Altogether the flies cover about one half of Nigeria southward of latitude 13^{0}N with principal foci in the Guinea Savanna, Derived Savanna and Rain forest zones, the prevalence and manifestation of the disease is much more widespread and severe in the savanna zone (41% prevalence) than in the forest zone (15% prevalence). There is also speculation of a geographical variation in the identity of the parasitic causative agent of the disease, *Onchocerca volvulus*, in the country. As a basis for the development of a successful nation-wide control programme for both the vector flies and the disease, the need for more work on the precise identification of both the flies and the parasite, *O. volvulus*, is discussed.

Introduction

Blackflies comprise about 1200 species and belong to the family Simulidae of the insect Order Diptera. The body of a fully mature African blackfly is in the range of 4-11mm is length (Crosskey, 1960). The adult females of most species have mouthparts that are modified for blood feeding, blood meals being required for the maturation of their ovaries and eggs. This haematophagus behaviour enables the female to transmit a variety of viral, protozoan and helminthic infections. Blackflies breed in fast flowing rivers and streams from where the larvae



Similium damnosum

obtain their food (bacteria and unicellular algae) by filter feeding. In contrast, most adults are strong fliers and disperse over long distances from their breeding sites (Walsh, 1983a). They are essentially diurnal, though many are markedly crepuscular and there may be some nocturnal activity.

The blackflies *Simulium (Edwardsellum) damnosum* complex Theobald, 1903 are of great interest in West Africa mainly because, in this region, members of the group are the vectors of the parasitic filarial nematode *Onchocerca volvulus*, the causative organism of human onchocerciasis or river blindness, a disease which is known to occur in all West African countries except Mauritania. As the vector of *O. volvulus, S damnosum* complex occupies the same niche in West and Central Africa as *S. neavei* complex in East Africa, *S. arcticum* complex in North America, *S. metallicum* and *S. amazonium* complex in South America and *S. ochraceum* complex in Central America where the disease also occurs. Each of these blackflies groups was initially thought to be a homogeneous or a single variable species but now established to be a complex of sibling species or cytospecies (Dunbar, 1995). The clinical manifestations of human onchocerciasis include intensely itching rashes, wrinkling, thickening and depigmentation of the skin, characteristic skin nodules in which the adult worms are to be found, and eye lesion leading to blindness which is the most serious consequence of the disease. Heavily infected patients often lose weight and suffer from debilitation and microfilariae of *O.volvulus* may occur in their urine (UNDP/FAO/IBRD/WHO/1973). West Africa is one of the worst endemic zones of the world. Indeed Nigeria is reported to have the largest number of people blinded by the disease, accounting for about 33% of the world cases of onchocercial blindness (WHO, 1995).

Some important epidemiological distinctions have been made in the geographical distribution of the cytospecies of *S. damnosum* complex, the clinical manifestations of human onchocerciasis, and to a lesser extent also, the parasite-vector relationship in the West African region. The most important distinction is found between the endemic areas in the forest and savanna zones of the region (UNDP/FAO/IBRD/WHO-OCP/73.1,1973). Whereas members of *S. damnosum* complex are generally widespread in forest habitats (with both parous flies and nullipars widely dispersed from the breeding sites throughout the year), the geographical pattern of habitation of the flies in the savanna is strongly linear and riverine with the parous flies tending to concentrate nearer the oviposition sites (Hunter, 1980). The life span of the forest species of these vectors is from 12 to 16 days (hence forest species are said to have low vectorial capacity) while savannah species live much longer. The Annual Transmission Potential (ATP) up to 90,000 infective larvae/person/year in the forest zone is not usually associated with high blindness rate or with desertion of affected communities. However, ATP values just above 1,500 are associated with high prevalence of blindness while values of 2,500 and above lead to desertion in the savanna.

Although the widespread occurrence of human onchocerciasis has been known in Nigeria for nearly ten decades (Crosskey, 1956; Budden, 1956), only local efforts were made to control it until the 1970s. Following the establishment of the Federal Capital Territory of Nigeria in 1976, a nationwide control programme was established for both the disease and the vector flies (WHO, 1979). All available data on the various efforts on the biology, distribution of the disease vector all over the country were reviewed at a national workshop held in Kaduna (Kaduna State, Nigeria) in 1982 and again in 1990. Since then, more information has been accumulated by different working groups and individuals (Okwonkwo *et al.*, 1991; Nwaorgu *et al.*, 1994; Umeh, 1996; Gemade *et al.*, 1998; Nwoke *et al.*, 1998; and Ogunrinade *et al.*, 1999). The present study is a review of the available information on the differences in the type and prevalence pattern of both the vector flies and the disease in the two major vegetation zones of Nigeria, the savanna and the forest zones. It is believed that this may have some relevance to the control effort of both the flies and the disease in the country.

Materials and methods

The vegetation of Nigeria

The vegetation zonation of Nigeria by Keay (1959) is the most widely used and cited. By this scheme, the natural vegetation of Nigeria, and almost the whole of West Africa, can be classified into two major types, namely: the forests, and the savannas i.e. tropical grasslands. For convenience, these two vegetation zones are also commonly used to represent the major ecological zones in the country and the West African sub region.

The forest is characterized by luxuriant growth of woody and generally tall plants (over 50 meters high). It is the dominant vegetation in the southern part of the country where sub-equatorial and monsoon types of climate prevail. The soils of the typical forest are moist (for the greater part of the year), deeply weathered, loamy and with relatively high contents of organic matter. The savanna belt corresponds roughly with areas of tropical hinterland and continental type of climate which is characterized by light rainfall, low relative humidities, relatively wide range of temperatures, and pronounced dry season (lloeje, 1972; Ojo, 1977; Kowal and Kassam, 1978). The belt is very extensive in Nigeria, covering over 80% of the entire country and about 60-70% of West Africa. Perhaps because of this, the belt has received much more attention from workers (especially plant ecologists) than the forests. Sanford (1980) reviewed the available ecological works on the savanna zone in Nigeria in particular and West Africa in general.

The belt separating the two major vegetation zones is the derived or transitional savanna i.e the grassland bordering the rain forest zone. If left undisturbed, it tends to revert to lowland rain forest or secondary forest, but under frequent burning, it remains a grassland. Most of it is of good agricultural value and now much cultivated.

Information on the distribution, climate, and general floral characteristics of the different vegetation zones in Nigeria is summarized in Table 1. It is worthy of note that these vegetation zones are not absolutely demarcated from each other. For instance, there are areas of savanna type in parts of the south and patches of forest in parts of the northern region of the country. However, vegetation varies broadly from swamps and forest in the south, through grassland in the heart of the country to sub desert in the extreme north, while montane vegetation occurs on the high plateaus, notably in Jos and Adamawa areas of central Nigeria (White, 1983). In general, vegetation becomes progressively less dense from the south to the north of the country.

Information sources on the occurrence of S. damnosum complex and human Onchocerciasis

Information on the generalized distribution pattern of *S. damnosum* complex and the occurrence of human onchocerciasis in the country is based largely on the available literature over the last five decades (including the early work of Budden, 1956; Crosskey,

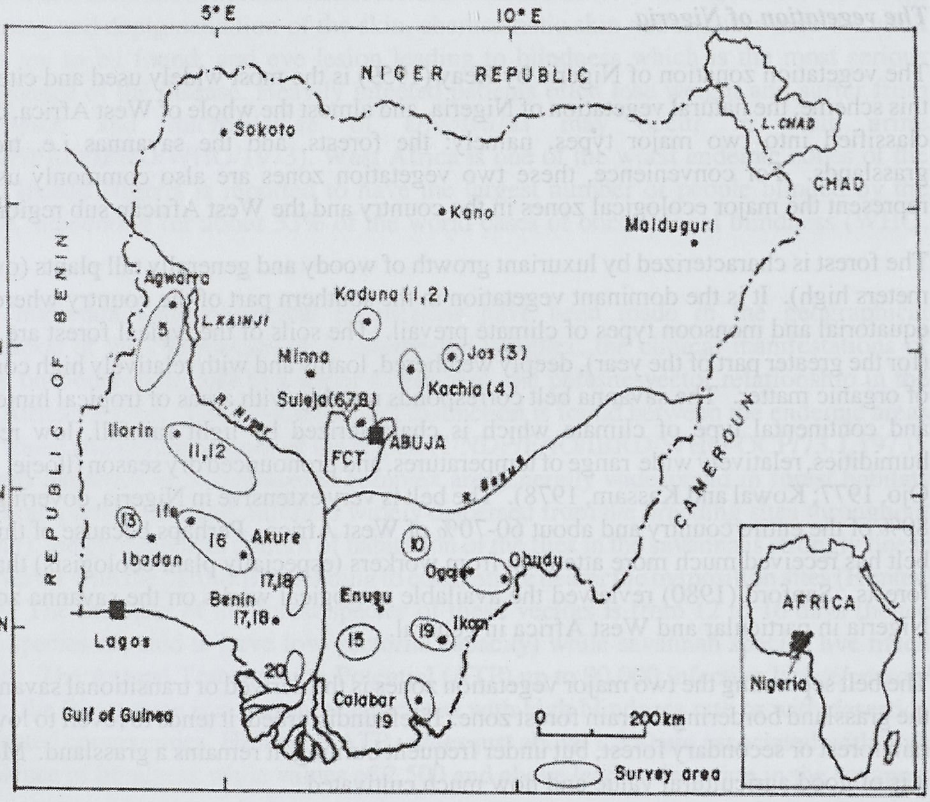


Fig. 1: Map of Nigeria
showing area in which the prevalence of human onchorcerciasis has been reported

1956; Brown, 1962; Davies *et al.*; 1962; Segun, 1981; Soyinka and Abayomi, 1981; and Abayomi *et al.;* 1982). Fig. 1 is a map of Nigeria showing the locations of the various surveys and commissioned projects from which the information so far amassed is derived. Information on the neighbouring Onchocerciasis Control Programme (OCP) of other West African countries (i.e. Benin Republic, Ghana, Ivory Coast, Mali, Niger, Togo, Burkina Faso) and other parts of Africa was also obtained. This was mainly from the work of Grunewald (1976a&b), Vajime (1982), Anon (1989), Boakye (1993), and Boakye *et al.* (1998).

Typically, the method of sampling for the immature stages of the simulid blackflies is as reported by Walsh (1983a). This is based on the examination of substrates (submerged rocks, stones, weeds and others natural and artificial substrates) in stream beds especially at rapids. The separation of *S.damnosum* complex into the sibling species is based on the analysis of the banding sequence on the polythene (giant) chromosomes from the larval salivary glands (Vajime and Dunbar, 1975; and Quillevere, 1975). In Simulidae chromosomes, a single segment inverted relative to the bandy pattern of a closely related species is often sufficient to differentiate species (Ibeh, 2003). In the *Simulium damnosum* complex, the Nyamagasani form of the Sanje group has been arbitrarily chosen as the standard sequence because of its phylogenetically central position. The most preferred method for trapping the adult black flies is by human-bait. By this method, a person with parts of his or her body (usually the legs and feet) exposed sits in a convenient position and catches each blackfly in a small glass or plastic vial as it lands to feed (Walsh, 1983b). This has been found to work especially well for *S. damnosum* complex which are not particularly numerous and which prefer to bite close to the ground. A stationary all-day catch (10 or 12 hour duration) is commonly used. In the large Onchocerciasis Control Programmes (OCP) in the Volta River Basin of West Africa bait collections were carried out by two people working alternate hours from 7.00 – 18.00 hours. The others methods of adult fly sampling include animal-bait catches, the use of chemical attractants, light traps, sticky traps and suction traps (Service, 1977).

The diagnosis of onchocerciasis can be made by three methods. The first is the search for nodules produced by the adult worms, the second method (the most reliable) is the demonstration of microfilariae through skin snip. The microfilariae emerging from the skin snip are easily recognizable under low power of a microscope and the density can be estimated. The third method (called the Mazzotti test) is an indirect diagnosis involving the injection of the microfilarial drug diethycarbomazine (DEC) which illicits itching skin reaction at the site where microfilariae are present.

Table 1: The distribution and characterization of vegetation zones in Nigeria

Vegetation Zone		Other names	% area of Nigeria covered	Climate			Vegetation Characteristics	
Code	Common name			LRS months	annual rain mm	P/E	Physiognomy/ structure	Notable/ common plants
A	SAHEL SAVANNA	Thorn-bush, semi-desert	2.7	<6	<500	≤0.20	Open range, thorny shrubs with thick bark; grass low, predominantly annual; very few trees	Date palms, *Acacia* spp, Gum Arabic
B	SUDAN SAVANNA	True savanna	32.7	6-8	500-1000	0.21-0.40	Few trees, grasses dominant, short, more even and with fewer tussocks	Dum palm, silk cotton, Baobab, shea-butter trees, fan palm
C	NORTHERN GUINEA SAVANNA	Northern rich savanna, orchard bush/ woodland	20.0	6-8	1000-1500	0.40-0.75	Broad-leafed deciduous trees, tall grasses (c. 150cm), often grow in tussocks	*Acacia*, Ironwood, *Euphorbia*, fan palm, locust bean, shea-butter tree
D	SOUTHERN GUINEA SAVANNA	Southern rich savanna / orchard bush / woodland	19.5	6-8	1000-1500	0.40-0.75		
E	DERIVED SAVANNA	Transition savanna	8.8	6-8	1500-1800	0.75-1.00	Mosaic of agricultural land, forest remnant and grassland, mostly decidutous trees	Palm trees
F	RAIN FOREST	High forest	11.7	>8	1500-2000	1.00-1.25	Heterogeneous, vertically in storeys, trees mostly evergreen	Palms, mahogany, walnut, Iroko, Obeche, saplewood
G	FRESH WATER SWAMP FOREST	Lowland forest	2.3	Ntds	2,000	1.25	Moisture-loving plants, heterogeneous	Raffia palms, climbers, ferns, abura, palms, mahogany, sasswood
H	SALINE WATER SWAMP FOREST	Saltwater, mangrove forest	2.3	Ntds	>2000	>1.25	Mainly salt-loving plants	Mangrove (*Rhizophora* spp, *Avecinia* spp)

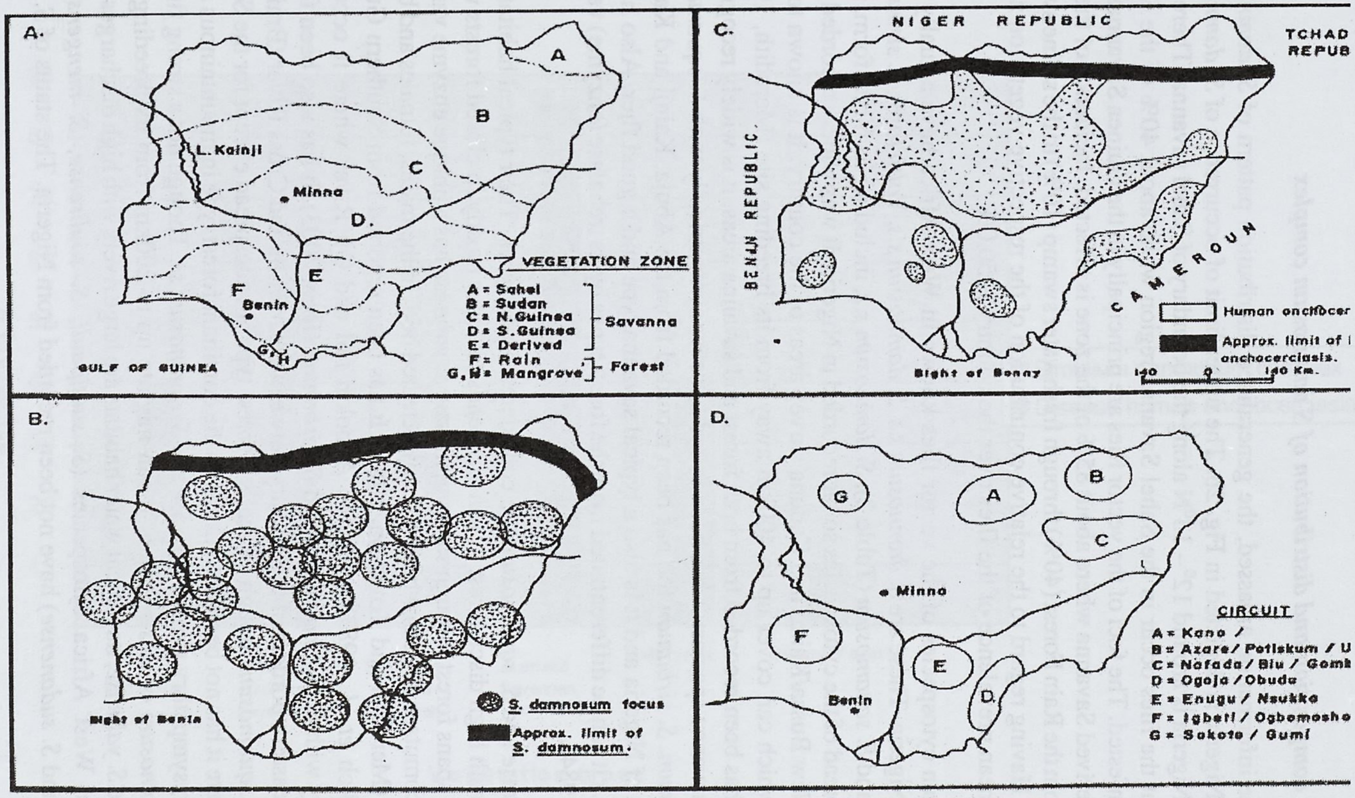


Fig. 2: Vegetation map of Nigeria

Fig. 2b: Foci and approximate limit of *Simulium complex*

Fig. 2c: The distribution and approximate limit of human Onchocerciasis.

Fig. 2d: Areas were *Simulium damnosum* has been recorded *damnosum* but where human on not yet recorded.

Results

Cytospecies composition and distribution of S damnosum complex

Based on the information amassed, the generalized distribution pattern of *S. damnosum* complex in Nigeria is depicted in Fig. 2b. The upper limit of occurrence of *S. damnosum* complex in Nigeria is around 12^0– 13^0N along the boundary of Sahel savanna. There is no evidence that the flies occur in the Sahel Savanna region while about 40% of the Sudan Savanna is infested. The foci of the vector flies are principally in the Guinea Savannas (60-65%) and Derived Savanna where about 85% of the zone is affected. Incidence of the flies decreases from the Rain Forest (40%) through freshwater swamp (10%) to the saline swamp forest (1%). Having regard to the relative contribution of the respective vegetation zones, the overall mean prevalence of the flies over the country is 50.0%

Five of the ten cytospecies of the vector flies known in West Africa have actually been recorded in Nigeria. These are *S. damnosum s.s, S. damnosum s.s. Volta form, S. sirbanum, S. yahanse,* and *S. squamosum* (Table 2). *S. damnosum s.s*, including its Volta form, is the most widespread of the cytospecies so far recorded in Nigeria. It was widely recorded from the Abuja, New Bussa/Kainji and Kaduna survey areas of the country. It is known to be a good flier, which can cover up to 400km away from its breeding site (Meredith, 1984). Although it has been recorded from both forest and savanna areas, it is widely recognized as a typical savanna species. It has been found to occur sympatrically with *S. squamosum* and *S. sirbanum. S. sirbanum* too has been recorded from the Abuja, Kainji and Kaduna survey areas of Nigeria and it is also a typical savanna type and a good flier. Also like *S. damnosum s.s* it can be differentiated from the forest types by its trehalase (enzyme) variant (Meredith, 1984).

Both *S. yahanse* and *S. squamosum* are considered forest types. Their typical habitats are large rivers with high discharges. *S. yahense* tends to occur mostly in closed forests while its full range spans forest through savanna mosaic *S. yahanse* has a unique enzyme variant, phosphoglucomutase (PGM) which is easily detected both in the males, females and blood fed females (Meredith and Townson, 1981). It has been reported from Southern Guinea Savanna (Akoh *et al.*, 1987) and from Agbokin fall and Oji River where it occurred sympatrically with *S. damnosum s.s* and *S. sirbanum* (Ibeh, 2003). It has also been found in the south eastern borders of the country between Oban Hills and Cross River (Braide *et al*, 1987). *S. squamosum* though typically a forest type is widespread except for the Sudan Savanna where it has not been recorded. It is the dominant forest type in mountainous areas and occurs in sympathry with *S. yahense* and *S. damnosum ss.* Though not a strong flier as either *S. damnosum* or *S. sirbanum,* it can migrate up to 200km from its breeding site. However like *S. yahense,* its typical water habitats are large rivers with high discharges. The other known West Africa cytospecies (*S. santipauli, S. soubrense, S. mengense, S. diagurense* and *S. sudanense*) have not been recorded from Nigeria. The status of *S.*

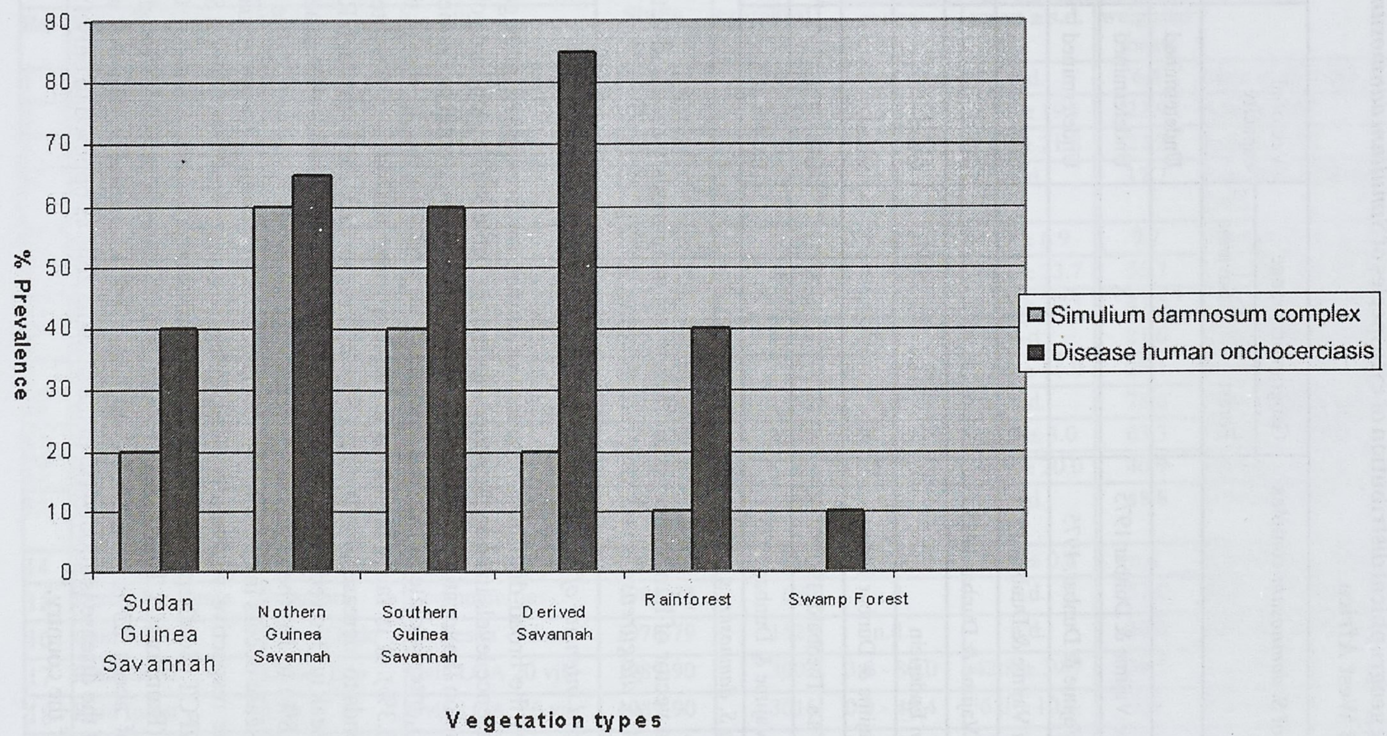


Fig. 3: **Weighted mean prevalence of *S. damnosum* complex and human onchocerciasis in different vegetation zones in Nigeria**

Table 2: The geographical distribution of cytospecies of *Simulium danmosum* complex Theobald in West Africa

Cytospecies of *S. damnosum* complex	Geographical range		Vectorial capacity	Records in Nigeria
	Forest	Savanna		
S. mengense		?	Undetermined	—
S. diaguelense Vajime & Dunbar 1975		X	Undetermined	—
S. sudanese Vajime & Dunbar, 1975		X	Undetermined	—
S. sanctipauli Vajime & Dunbar, 1975	X		Mild	—
S. soubrense Vajime & Dunbar 1975	X		Mild	—
S. squamosum Enderlein	X		Good	+
S. yahense Vajime & Dunbar 1975	X		Good	+
S. damnosum s.s. Theobald, 1903*	X	XX	Excellent	++++
S. sirbanum Vajime & Dunbar 1975		X	Excellent	+

including *S. damnosum s.s.* Volta form

sudanese as a vector of human onchocerciasis is not unanimously accepted yet while the occurrence of *S. diagurense* is still very rare (Vajime, 1982).

Prevalence and intensity of human onchocerciasis (river blindness)

Fig. 2c shows the broad distribution pattern of human onchocerciasis in Nigeria while detailed prevalence levels in endemic areas are given in Table 3. The amplitude of variation in information on the location specific prevalence is highest in Southern Guinea savanna (0.0 – 100.%), intermediate in Derived savanna (13.0 – 67.9%), and lowest in the swamp forests (0.0-6.3%). It is fairly high also in the rain forest (0.0-80%). Weighted-average prevalence tends to increase steadily from Swamp Forests (0.3-1.0%) through Rain Forest (21.2%) to a peak in Derived Savanna (56.7%) and thereafter falls through Southern Guinea Savanna (39.8%) to Northern Guinea Savanna (9.5%) as obvious from Table 4. On the whole, the disease occurs in one-third (~35%) of the entire country. The principal endemic locality in the respective vegetation zones being Kaduna (Northern Guinea Savanna) , Abuja/Suleja/FCT (Southern Guinea Savanna), Kwara State (Derived Savanna), Ovia LGA in Edo State (Rain forest), Isoko area of Delta State (Swamp forest) with weighted mean prevalence of about 23%, 48%, 63%, 40% and 1% respectively. On the whole, the prevalence of the disease is about 41% in the savanna zone as opposed to only 15% in the forest zone of the country.

Table 3: The prevalence of human onchocerciasis in different vegetaqtion zones in Nigeria

	Area of Study			Period of Study	Patients examined	Prevalence			Reference
Ref	Vegetation type	State	Locality			range	mean ± s.d.	weighted mean	
1	N. Guinea savanna	Kaduna	ABU T. Hospital	1978-82	3039	n.d.	n.d.	6.4	Mele *et al.* 1982
2	N. Guinea savanna	Kaduna	3 villages	1982-82	1805	0.5 - 37.2	22.1 ± 19.1	22.9	Amuta 1982
3	N. Guinea savanna	Plateau	2 Jos locations	1981-82	301	1.5 - 58.0	22.9 ± 21.8	22.2	Joshua 1982
4	N. Guinea savanna	Kaduna	Iri Kachia	1981-82	291	n.d.	n.d.	12.7	Braide & Aladesanmi 1982
5	N. Guinea savanna	Niger	Borgu LGA	1986-87	1060	0.5 - 25.0	7.9 ± 6.9	9.7	Edungbola *et al.* 1989
6	S. Guinea savanna	Niger	Suleja Emirate	1955-57	4806	33.3 - 100.0	76.1 ± 23.7	56.7	Cited Davies 1968
7	S. Guinea savanna	Niger	Suleja Emirate	1966	5700	17.4 - 90.0	65.3 ± 22.3	47.5	Cited Davies 1968
8	S. Guinea savanna	Niger	Suleja Emirate	1972-76	1359	n.d.	n.d.	21.0	Cited Mabogunje 1977
9	S. Guinea savanna	F.T.C.	21 villages	1977-78	1173	0.0 - 50.0	27.6 ± 11.0	25.1	Soyinka & Abayomi 1981
10	S. Guinea savanna	Benue	Sat-Ikyov villages	1990	1558	n.d.	n.d.	78.8	Gemade & Utsalo 1990
11	Derived savanna	Kwara, Kogi	6 LGAs	1979-82	8243	58.7 - 67.9	63.7 ± 3.0	63.3	Edungbola 1982
12	Derived savanna	Kwara, Kogi	5 LGAs	1986-87	3380	13.2 - 55.6	35.9 ± 20.0	40.9	Edungbola *et al.* 1987
13	Derived savanna	Kwara, Kogi, Oyo	Idi-Ata, Ibarapa	1981-82	131	n.d.	n.d.	48.8	Ogunba 1982
14	Derived savanna	Cross River	Obudu & Ogoja	1981-82	n.d.	25 - 26.7	26.2 ± 0.8	n.d.	Braide *et al.* 1982
15	Derived savanna	Anambra	3 communities	1981-82	600	n.d.	n.d.	57.0	Ezike & Roberts 1982
16	Rain forest	Osun, Ondo	Ife-Ijesha - Akure	1978-79	1523	n.d.	n.d.	10.0	Abayomi & Soyinka 1982
17	Rain forest	Ondo, Edo	Ovia LGA 20 vil.	1989-90	3007	3.8 - 80.0	42.8 ± 39.7	39.7	Asaolu 1991
18	Rain forest	Edo	Ovia LGA, 26 vil.	1989-90	3016	0.0 - 40.4	6.0 ± 10.2	8.4	Asaolu 1991
19	Rain forest	Cross River	Ikom & Obubura	1981-82	n.d.	8.0 - 22.4	15.2 ± 10.2	n.d.	Braide *et al.* 1982
20	Fresh water/swamp forest	Delta	Isoko LGA 18 vil	1990	3020	0.0 - 6.3	1.3 ± 1.9	1.0	Asaolu 1991
21	Mangrove forest	Cross River	Akampka, Calabar	1981-82	n.d.	3.0 - 3.3	3.3 ± 0.3	n.d.	Braide *et al.* 1991

Table 4: The prevalence of human onchocerciasis in different vegetation zones in Nigeria

Vegetaion zone	Population examined	States	Examination method	Population affected	%
N. Guinea savanna	6496	4	Clinical	814	9.5
S. Guinea savanna	14596	3	Epidemiologica.l	5803	39.8
Derived savanna	12354	5	Epidemiologica.l	7005	56.7
Rain forest	7546	4	Epidemiologica.l	1600	21.2
Freshwater swamp forest	3020	1	Epidemiologica.l	30	1.0
Mangrove/ saline swamp forest	n.d.	1	Epidemiologica.l	n.d.	0.3
Total	44012	18		15252	34.7

There is a significant direct correlation ($p<0.001$) between the prevalence of the vector (*S. damnosum* complex) and that of the disease through the different vegetation zones (Fig. 3). However, there are areas of the country where the vector flies occur but in which the disease has not been recorded (Fig.2d). Such areas are mainly in the Sudan Savanna (including Azare-Potiskum-Unguru, Kano-Zaria, Nafada-Biu-Gombe, and Sokoto-Gumi) and in the Derived Savanna zone (Igbeti-Ogbomoso, and Ogoja-Obudu circuits). Braide *et al.* (1982), and Asaolu (1991) have confirmed the incidence of the disease in the freshwater swamp forest and the mangrove swamp forest area of the country respectively (Table 3). Their studies (Braide *et al.*, 1982; and Asaolu, 1991) also showed that the prevalence of the disease in the swamp forest area generally falls from the north to south, coinciding with a decrease from freshwater swamp to the mangrove (or saline) swamp forest.

The work of Edungbola (1982) gives a comprehensive account of the conditions associated with human onchocerciasis in one of the major endemic areas in the savanna region of the country. They consisted of itching and scratching reaction (49.8%), pachydermy (34.0%), non-scabies papular eruption (30.0%), hanging groin and lymphadenopathy (23.6%), and hyperpigmentation of legs (11.2%). Others conditions were: hernias (7.1%), blindness (6.1%), scrotal elephantiasis (3.1%) and adenolymphocede (0.5%). Comparative study in the Ibadan-Ibarapa Forest area (Ogunba, 1982) gave the following prevalence for some of the conditions: itching and scratching reaction (21%), hyperpigmentation of legs (35%), hanging groin and lymphadenopathy (3.0%), and blindness (0.0%). Using the same methodology, the nature, manifestation and the prevalence of the disease in the typical endemic forest (Ife - Ijesha-Owena area) and typical endemic savanna region (FCT) of the country are compared in Table 5. In this comparison, the prevalence of the disease among males, the incidence of nodules, as well as affliction of the disease in the upper extremity, were several times higher in the savanna than in the forest zone (Table 5). Less significantly, the prevalence of the disease among females, total blindness associated with the disease, infection load over 100 parasites/skin snip, and the rate of infection among children less than 6 years were also higher among patients in the savanna than the forest areas of the country. On the other hand, the relative incidence of infection in the lower body extremity was much higher in the forest than in the savanna.

Table 5: The comparison of thenature, manifestation and the prevalence of human onchocerciasis between the forestand the savanna zones of Nigeria

	Survey information and the prevalence of onchocerciasis	Vegetation zone		Difference degree	
		Savanna	Forest	(S-F)²/S	P
1	Main source of information	Soyinka & Abayomi 1981	Abayomi *et al.* 1982		
2	Study area	Fed. Cap. Terr.	Ife-Ijesha - Akure		
3	Poulation units involved	26 villages	21 villages		
4	Total people skin snipped	1178 - 100%	1523 (100%)		
5	Prevalence of human onchocerciasis in above	297 (25.2%)	152 (10.0%)	9.1	
6	Prevalence in male	200 (17.0%)	67 (4.4%)	9.3	—
7	Prevalence in female	97 (8.2%)	85 (5.6%)	0.8	NS
8	Age group highest affected	61-72	20-49		
9	Age group lowest affected	13-18	n.d.		
10	Visual impairment +	56 (4.7%}	10 (1.3%)	2.5	NS
11	Prevalence of total blindness +	5 (0.4%)	0 (0.0%)	0.4	NS
12	Onchodematitis in male	160 (13.6%)	n.d.		
13	Onchodermatitis in female	85 (7.2%	n.d.		
14	Prevalence of nodles	172 (14.6%	25 (1.6%)	11.5	—
15	Infection load of over100 parasites per skin snip	59 (5.0%)	46 (3.02%)	0.8	NS
16	Parasites load in 95% of 5 above	1-100	10-100	0.8	NS
17	Half-sided involvement (L/R)	n.d.	4 (0.25%)		
18	1-6 year olds infected	20 (1.7%)	6 (0.4%)	1.0	NS
19	Infection in upper extremity	159 (13.52%)	10 (0.66%)	12.2	—
20	Infection in lower extremity	48 (4.08%)	150 (9.87%)	2194	—

Cases of hyperendemic onchocerciasis is also much more prevalent in the savanna than in the forest zone of Nigeria. One of such areas is the Taraba river valley of the old Adamawa province, Nigeria (Akogun and Onwuhiri, 1991). In that survey skin biopsies were taken from 2,876 persons in fourteen communities and examined for the microfilariae of *O.volvulus*. Almost 100% infection rate was recorded in one of the communities, five other communities had prevalence rates in the range of 81.0-94.7% while the rates in three other communities were 44.8-69.1%. The mean microfilariae density in all the communities was 64.7 (range=3.2-167.6).

Discussion

Importance of precise identification of sibling species complex

The present study has revealed that of the ten sibling species of the *S. damnosum* complex known in West Africa (Vajime and Dunbar, 1975; Quillevere *et al.* 1981; and Meredith *et al.*, 1983) five of them have so far been recorded in Nigeria, namely: *S. damnosum sensu stricto, S. damnosum s.s.* Volta form, *S. sirbanum, S. Yahense,* and *S. squamosum.* The vectorial capacity of all these five sibling species for the transmission of human onchocerciasis has been established to vary from good to excellent in the country (Table 2) . These five cytospecies are thus among the six most important vector species of human onchocerciasis in West Africa. These species comprise both the forest types (*S. damnosum s.s, and S. damnosum s.s Volta form, and S. sirbanum*) and the savanna types (*S. yahense and S. squamosum*) which altogether cover over half of the country, mainly from the Sudan Savanna southward to the Rain Forest zone.

As Nigeria typifies West Africa much more than any other country in the sub-region (for instance, all the climate types and the different vegetation zones in the different vegetation zones in the sub-region are well represented in Nigeria) it is probable that many more of the known West African sibling species of the blackflies may be recorded from the country if subjected to intensive and systematic survey as was carried out in the neighbouring West African OCP area. The importance of identifying specifically the members of sibling species complexes has been reviewed by Mayr (1962) and White (1978) while this has been done in respect of some simulid species complexes by Crosskey (1981) and Townson and Meredith (1978). All this shows that the precise identification of a vector species complex is fundamental to the study of the epidemiology of the disease transmitted by the vectors. Many species display considerable intraspecific as well as inter-specific variation with regard to biting behaviour, choice of resting places, etc, which may influence their vectorial capacity (Meredith, 1984).

The precise identification of a vector is crucial to the establishment of a rational basis for vector control. In the case of human onchocerciasis, it is not only the precise identification of all the sibling species of the simulid complex but also that of the different strains of the filarial nematode (*O. volvulus*) they carry which are crucial to the proper understanding of the biology and epidemiology of the disease. In Nigeria, there is virtually no information on the strains of *O.volvulus* in the country. Elsewhere a variety of biochemical techniques has been developed and employed for this purpose. Of these methods, enzyme electrophoresis is one of the most widely used (Omar, 1984). One of the obvious advantages of the enzyme analysis is that a single specimen can be identified. However, a large sample of enzymes (twenty or more) representative of different metabolic classes and degree of variability is necessary for reliable statistical evaluation of genetic differentiation among taxa. An extensive survey of enzyme systems was carried out on larvae, newly emerged adults and human-biting adults collected from the OCP. Only two of the many enzyme systems investigated, phosphoglucomutase (PGM) and trehalase, have been found to be of diagnostic value. *S. yahense* has a unique PGM variant while *S. yahense* and *S. squamosum* can be differentiated from *S. damnosum s.s, S. sirbanum, S. soubrense* and *S. sanctipauli* by their trehalese variants (Meredith, 1984).

In the OCP area, *O. ochengi* has been found in cattle and it is known that this parasite can also be transmitted by *S. damnosum*. There is no way of distinguishing the larvae from that of *O.volvulus* in the vectors. When such enzootic filarial coexist with *O.volvulus*, the effect may confound estimates of annual transmission or severity of human onchocerciasis. This may be a possible reason why the savanna type of human onchocerciasis is generally more severe in the savanna zone (where there are many cattle) than in the forest zone. All this requires proper study before effective long-term control strategies can be developed for both the vector and disease control in Nigeria. Presently the assumption about variation in the parasite *O.volvulus* in Nigeria is based largely on studies outside the country.

Limiting factors in the distribution of S. damnosum and human Onchocerciasis

The present study has also revealed that the northern limit of human onchocerciasis and that of its vector *S. damnosum* complex in Nigeria runs roughly along latitudes 12-13^{0}N. This limit corresponds with the boundary of Sahel Savanna in the country. The limit is generally more southerly than that of the OCP where it extends along latitudes 13-15^{0}N of the member countries. One of the reasons why the flies are absent from the Sahel Savanna may be due to the high temperature in the zone. The daily activity of *S. damnosum* females is known to be slowed down or stopped by temperatures either too low (under 17^{0}C) or too high (over 30^{0}C) as well as by other unfavorable meteorological factors such as strong wind and rain (UNDP/FAO/IBRD/WHO/1973). Information on climatic data from representative towns within the zone, notably Sokoto (13^{0}01^{1}N, 05^{0}15^{1}E), Kano (12^{0}03^{1}N, 08^{0}32^{1}E) and Maiduguri (11^{0}51^{1}N, 13^{0}05^{1}N) shows extreme weather conditions in the area particularly with regard to temperature, rainfall and relative humidity (Udo, 1970). In Sokoto, for instance, there are only three humid months (July-September) in the year while effective annual rainfall (~615mm) is only one third of annual evapotranspiration (1820mm). Runoff occurs usually over two months, August and September, in Sokoto and usually for one month (September) in Maiduguri. In both towns mean annual relative humidity at

12.00hours is 32% while the range of monthly minimum temperature is 12.6^{0}C (Jan) – 25.8^{0}C (May) and monthly maximum temperature is in the range of 29.8 – 40.5^{0}C (Udo, 1970). Such an extreme range of climatic conditions in the Sahel zone cannot support the breeding and other activities of *S. damnosum*.

The relatively low occurrence of *S. damnosum* and human onchocerciasis in the swamp forests of the country can be attributed to the stagnant nature of waterbodies in the zone. The characteristic habitat of *S. damnosum* is clear fast-running water (usually with high oxygen concentration and saturation). In addition to having stagnant waterbodies in the mangrove swamp forests, the waters are also saline in chemical composition for which *S. damnosum* flies are not adapted. All this shows that *S. damnosum* complex has a range of acceptable physical environmental conditions. This also applies to the respective sibling species of the *S. damnosum* complex. A survey in which the set of environmental conditions required by the respective sibling species of *S. damnosum* complex in Nigeria is determined is crucial to effective vector control in the country.

The same reason which explains the absence of *S. damnosum* complex and human onchocerciasis in the Sahel savanna and saline swamp forest zones of Nigeria most probably also applies to their absence in Mauritania, the only country in West Africa in which they are not known. The southern boundary of Mauritania runs roughly along latitude 15^{0}N, which incidentally coincides with the isoyet of 500mm (20 inches) annual rainfall. The country stretches mainly from semi-desert to the desert (Sahara Desert) with annual ranges of temperature over 15^{0}C and diurnal ranges over 27^{0}C. The western coastal area of the country is a sand-bar with a rocky headland, behind which are sand dunes and salt water depression (Harrison Church, 1980; Ojo, 1977).

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THE IFE FRUIT BATS

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The dominant species of fruit bats in the Obafemi Awolowo University campus, Ile-Ife, is the straw-coloured fruit bat, *Eidolon helvum* (kerr). These bats are the second largest West African fruit bats, the largest being the hammer-headed fruit bat, *Hypsignathus monstrosus* H. Allen.

The colony of *Eidolon helvum* predates the movement of the University to its present permanent site in 1968. The bats occupy in their largest numbers, the tall, wide-branching forest trees in two main areas, namely, the large undeveloped quadrangle behind the Biological Science Complex and the expansive Biological Gardens. They also occur in smaller numbers on the forest trees near the Faculty of Agriculture Buildings and those between the Conference Centre and the Horticulture Gardens. In the last few years ,they have spread to the trees behind the staff club, the hostels, the staff quarters, and Road I (Sir Adesoji Aderemi Road).

All told, the bats in the first four areas numbered about one million in the 1970's and 1980's. The present population, which is still building up, is less than that size.

Other fruit bats

A survey carried out several years ago, by some students in the Department of Zoology, showed that at least six other species of fruit bats also occur within the University Campus. They are: *Hypsignathus monstrosus, Epomops frangeuti, Epomops buettikoferi, Rousettus aegyptiacus, Micropteropus pusillus* and *Epomophorus gambianus*. These bats were caught by overnight nettings in the low bushes surrounding the developed central campus. The same study also showed that these bats had preference for the following eleven different species of trees. *Ficus mucose, Bombax bumopozense, Sterculia stragacanth, Trilepisium madagascariense Triplochiton Scleroxylon, Antaris Africana, Ceiba pentandra, Elasis quineensis, Deniellia ogea, Albizia zygia* and *Cola gigantia.*

Behaviour of *Eidolon Helvum*

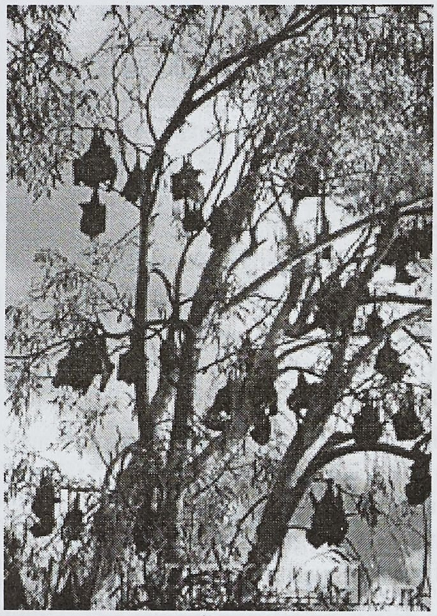
As is well known, the fruit bats, *Eidolons helvum*, are cosmopolitan, highly gregarious and migratory. The colony on the campus exhibits both daily and annual migrations. At dawn each day, they can be seen faithfully converging on the campus trees from all directions, just as they dutifully disperse, en masse, at dusk, to their feeding grounds in villages, several kilometers away, while some do their foraging on fruit trees within the campus.

In the rainy season, around mid-year which also coincides with the onset of their breeding period, the bats migrate away from the campus to return in the dry season, with their babies, towards the end of the year. While on the campus trees the bats hardly roost or rest, as they should be doing, but are chattering, squeaking and flying from one tree branch to another, until some two or three hours to their departure time (i.e. 6:30–7 pm local time), when they become very quiescent and restful, apparently in preparation, physically and physiologically, for their journeys to the feeding grounds.

Bat research at Ife

In the 1970's and up to the mid 1980's before the bats left the campus, considerable research activities were carried out in several Departments and units of the University, taking advantage of the readily available materials provided by the bats. Such research centers included the Departments of Zoology, Biochemistry, Anatomy, Pharmacognosy, and others. Furthermore, in 1981, the 6th International Bat Research Conference was hosted in Ife, with participants from UK. India, USA, Kenya, Uganda and Czechoslovakia.

However, during the mid 1980's, when indiscriminate shooting of the bats for their meat (reputed to be very delicious), became prevalent, the bats left the campus completely for some fifteen years. They returned towards the end of 2000, only to disappear again some six months after, for the same reason. Since November 2001, they have, once again, returned, steadily building up their full force in numbers.



Summaries and conclusion

The Straw coloured fruit bats, *Eidolon helvum*, occurred in the tall forest trees in the ancient city of Ife, Nigeria, long before the establishment of the University at its present site in 1968. The local people have many fascinating stories about the mystical powers of the bats, including the notion that their presence in large numbers in any locality is an omen of peace. The meat from these bats is also a favoured delicacy in the local drinking bars and restaurants.

The bats at Ife Campus are highly gregarious and exhibit daily and seasonal migrations. Their presence provides unique aesthetic scenery to the campus, especially by the beautiful sky-view they constitute during their daily departure en masse, in all directions from the campus at dusk, and their return at dawn. Their restless diurnal activities coupled with their large numbers, however, cause extensive defoliation and even destruction of some of the trees they occupy.

For research purposes, the bats provide ready material for scientists, medical resources, ecologists, behaviorists and environmentalists, as well as mythologists and artists, from within and outside the country. It may also be of interest to inform readers that a recent study carried out in 2006 by this writer and some other experts from UNIPORT and the Federal Ministry of Environment, has shown that a large colony of the same species of bat occurs at the Shell Estate in Ogunnu, Warri, Delta State. Our findings showed that the bats have similar behaviour patterns as the Ife bats. The study was at the instance and sponsorship of Shell Petroleum Development Company of Nigeria.