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Inaugural Lecture Series 74

The World of Bats

by Eyo E. Okon

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Introduction

I chose the topic: "The World of Bats" for my Inaugural Lecture for two principal reasons. First, with so much mystery and superstition surrounding bats generally, and with their wide variety of life patterns, coupled with the fact that with some two thousand species or so, bats are the second most numerous mammals (the first being the rodents), the bats are truly a world unto themselves. Secondly, my name is so much linked with bats that it appears that our two names could soon become synonymous. Indeed, when I was promoted professor a couple of years ago, some of the goodwill messages I received contained more compliments to the bats than to me. For example, one of the telegrams I received on that occasion said: "Congratulations to the Bats". I was left out! So, this public lecture affords me a golden opportunity to show that I am in fact the one who has been working on bats, and not the bats on me! I also intend, during the course of this lecture to show that all I do and know about in Zoology is not just bats.

Accordingly, I would like to present this lecture under the following subheadings:

(1) Bat mythology
(2) Bat biology
(3) Bat research at Ife, and
(4) Other works.

Bat Mythology

The original name given to bats by Oduduwa, the creator of the Yoruba race was *Oluro*, which refers to the habit of bats hanging on the tree with the head down. But the descendants of Oduduwa later changed this name to *Adon*, literally meaning "neither a bird, nor a rat". That is, although bats fly, they are not birds. At the same time, they are not like typical mammals such as the rat. The name is often used in Yoruba parlance to deprecate a person who is unprincipled or indecisive in action. I like to assure the audience, however, that the bat is very principled.

The mystery and superstition surrounding bats as being a creature with some supernatural powers is much in evidence in Yoruba culture in many other respects. For instance, the pregnant female bat forms the main component of the concoction used in treating cases of infertility in women. Also, for increasing the productivity of a farm, the male bat is treated with beans powder ("ekuru") and sprayed in the farm with some incantations. A farm so treated is assured of bountiful harvest.

The belief that bats both feed and defeacate through the mouth is also used to prepare a protective charm which has the power of making the user throw out an enemy's poison also from the mouth as the bat throws out its food, without any adverse effect on the victim. Bats are also believed in Yoruba mythology to have very strong revitalizing efficacy for the sickly and lean person. For such a person, treatment with a preparation from the blood of bat quickly restores his or her vitality and robust physique.

But perhaps the most fascinating folk-lore which demonstrates the spiritual powers bestowed on the bat is that of the bat and the pregnant woman. If a woman has been eating bats during her pregnancy, the baby born of this pregnancy becomes an all night crier, sleeping only in the daytime, because bats sleep only in the day and are active in the night. If, however, a concoction is prepared with the head of a bat for the affected child, the crying instantly stops and it can from then have good night's sleep.

It can be seen from the above that in ancient times bats served only as important items of native medicine. It seems the direct eating of bats was derived from these practices, by which the users of bats must have discovered that apart from the spiritual powers of bat the meat tasted good for consumption. And so, today, bats serve both as an item of indigenous medicine and as good meat for food.

All of the various uses of bat discussed above may be dismissed as mere superstitious folk-lore. But there may well be some sound scientific basis for some of those practices

worthy of serious research. For instance, through our studies of the reproductive biology of *Eidolon helvum*, (the bat on this Campus), we have found evidence of unusually high activity of reproductive hormones in the ovary of this bat. At pregnancy, as we all know, inadequate hormonal function is one of the causes of human infertility, hence, a possible scientific basis for administering pregnant bat tissue concoctions to infertile women!

Bat Biology

Bats belong to the class of Vertebrates, or back-boned animals called MAMMALIA, in which also belong rats and mice, elephants and hippopotamuses, whales and porpoises, as well as monkeys, apes and man. But bats have a number of very unique attributes. First, they are the only mammals that are able to peform true flight by flapping their wings like birds. Their wings, are however, made of skin membrane formed between greatly elongated fingers and the hands and then extending along the arms and between the thighs. It is from this construction of the wing that the scientific name Chiroptera, is derived from two Greek words, 'cheir' meaning a hand, and 'pteron", meaning, a wing. Second, though bats are not blind, contrary to popular belief, many of them are able to fly about in the night without using their eyes, but by means of a mechanism known as echolocation. Third, among bats are those which possess a constant body temperature, like true mammals, while others have variable body temperature, like the lower vertebrates, such as the lizards.

The order Chiroptera into which all bats are grouped has two sub-orders, namely, Megachiroptera and Microchiroptera. Megachiroptera, as the name implies, comprises most of the larger bats. They are the fruit-eating bats and they live mainly on trees. The bats that form one of the three demographic components of the University of Ife Community belong to this group, the other two components being students and staff. Their scientific name is *Eidolon helvum* and they are the second largest West African fruit bats, the

largest being the Hammer-headed fruit bat, *Hypsignathus monstrosus*, which is also easily distinguished by its loud croaking voice from fruit trees at night. The Yorubas call it "Adan-maja".

Fruit bats occur throughout the tropical and sub-tropical parts of Africa, Asia and Australia, and altogether make up about 130 species. In nature, the megachiropterans feed on four major types of food, namely, fruits of both wild and cultivated plants, floral parts, nectar and pollen, but at least one example, *Hypsignathus*, is known to feed on meat and to attack chickens. As a result of their feeding habits, fruit bats constitute an important agent of pollination and dispersal. During feeding, the fruits are usually taken away to a different place to eat, a habit which aids dispersal, and the juice or pulp is the main part required.

Juice extraction is brought about by the combined action of the large rasping tongue, the corrugated palate and the teeth, while the cheek stores and controls the food. Where the food is seeded or fibrous, the juice or pulp is squeezed out and swallowed, while the fibre or seed is rejected. It is this behaviour which lends to the folk-lore that bats both feed and defecate through the mouth! But as we can see, what the bat throws out is the unwanted part of its fruit which never went beyond the mouth. The extracted juice or pulp goes through the normal processes of digestion, absorption and ejestion in the different parts of the alimentary canal. These processes are very fast in bats. Thus, the transit time of food through the gut of a bat is only about twenty minutes, as campared with several hours in some other mammals. This has to do with the need for quick energy turnover for use in the flight.

The other sub-order of bats, Microchiroptera, comprises the insect bats, and the insects preyed upon vary from the hard-shelled beetles to moths, mosquitoes and winged termites. Some members of this sub-order i.e. vampire bats, also feed on blood and fish. Insect bats are not blind but have poor sight. The most interesting thing about the micro-

chiropteran bats is their direction finding mechanism called, echo-location.

The first man to initiate the research which led to the discovery of this mechanism was the brilliant Italian scientist, Lazarro Spallanzani who was interested in how various animals found their way about in darkness. In 1793, experimenting with bats, he observed that blinded bats could still fly and avoid obstacles. Later, his friend, Jurine from Geneva discovered that if the ears of the bat were plugged, their flight was seriously hampered. He thus concluded that bats were able to avoid obstacles by their sense of hearing.

We now know that what happens is that when a bat is in flight, it sends out rapid rythmic pulses of very high frequency sounds that are beyond the human hearing range. The wavelengths of these frequencies are only a few millimeters and so can be easily reflected even by small objects. The echoes of these ultrasounds are then picked up by the bats' specially constructed ears and the direction and speed of flight is adjusted accordingly. It is by this mechanism that microchiropterans catch their insect preys at night. Using the echoes of the ultrasounds, an insect bat can perform amazing feats. It can locate tiny insects, cracks on the wall, strings, and so on; can manouvre split-second corners and other acrobatics to follow and intercept mayflies, moths, beetles and mosquitoes. Experiments have shown that by this mechanism the bat caught as many as 175 mosquitoes in 15 minutes, and could avoid wires of only 0.1mm. thickness.

As already stated, echo-location occurs mostly in insectivorous bats. Fruit bats, are mostly visual in their navigation, and hence have more sensitive eyes than the insect bats. Studies of fruit bat eyes have shown that the fruit bat retina has a unique structure which is of adaptive significance for night vision. Along the outer layers of the retina are minute corrugated mounds containing many thousands of nerve endings connected to light sensitive rod cells. The mounds undoubtedly increase the total surface area of the

retina and this arrangement is thought to improve the night vision of fruit bats.

Finally, on bat ultrasounds, while the human ear can pick sounds of up to 20KHZ, the frequencies of bat sounds in some species are up to 150KHZ. For the study of echo-location mechamism, therefore, special electronic sound equipments are used. These include, a microphone capable of receiving very high frequency sounds; an oscilloscope for watching these pulses on the screen; a high speed tape recorder by which the sounds can be recorded and played back at reduced frequencies within human hearing range, and a sound spectograph, an analyser which translates the sound unto graphic paper for laboratory studies.

Today, the most famous laboratory for the study of echo-location mechanism is based in the Department of Zoology and Comparative Physiology at Queen Mary College, University of London. I like to note with a sense of pride that I have the good fortune of being part of the history of this famous laboratory for three years when it was based at King's College, London under the same scholar. I should also mention that Professor J. D. Pye is also part of the history of this other famous institution, having served here in Ife as one of its pioneer Visiting Lecturers in Zoology.

Bat Research at Ife

The occurrence of a very large colony of the fruit bat, *Eidolon helvum* in this Campus has provided ready materials for research in various disciplines, other than zoology, namely: biochemistry, the health sciences, pharmacy, and agriculture. Mr. E. A. Caxton-Martins, Professor T. A. I. Grillo, and Dr. A. O. Banjo, all of the Department of Anatomy, have researched and published on the anatomy and histochemistry of various organs of the bat. In the Faculty of Pharmacy, the late Professor V.O. Marquis, who did much in his lifetime to promote Comparative Pharmacology, pioneered with some of his students research work on the action of drugs on various tissues of the bat. Considerable work is also in progress on various biochemical phenomena by Doc-

tors O. O. Ogunbiyi, J. O. Folayan, E. O. Ngaha and A. Afolayan, all of the Department of Biochemistry.

In the Department of Zoology, one of the earliest studies on the bats of this Campus was by Professors L. B. Halstead and A.O. Segun, who worked on the general anatomy of *Eidolon helvum* and produced a book on the dissection of its systems. In 1974 Fayemuwo and Halstead also published a paper on the breeding cycle of the same species. More recently, Professor R.A. Balogun has worked and published on the use of bats' wing membrane for rearing tse-tse flies in the laboratory.

My interest in bats dates back to the days of my post-graduate work at King's College, London. Although I was then working on rodents, I must have, perhaps unconsiously, been imbibing a deep bat mentality in those three years, for, my supervisor, Professor J. D. Pye himself works on bats. This load of "bat drive" naturally broke lose on my return to Ife in 1971 to find the large colony of fruit bats on the Campus.

My most concentrated interest in bats is in the area of their nutritive biology. My first research effort was to find out the feeding habits and general activities of the bat, *Eidolon helvum* on this Campus. It was found from this investigation that the bats spend the day on the tall trees within the Campus supposedly roosting or resting, and at dusk migrate en masse to neighbouring villages to spend the night,feeding on fruit trees there, only to return to the Campus at dawn. As many of you would have observed, however, they don't really rest while on these trees, but are extremely noisy, hovering from one branch to another and from tree to tree. This is partly because of the very large number on a single tree and partly because of the activities of catapult hunters and others, some of whom are here present.

If the daily movements of the bats between the Campus and the neighbouring villages are for feeding and roosting purposes, then this should reflect in the quantity of food stored by the bats at different times of the day. My next

move, therefore, was to carry out some biochemical tests of the liver of these bats at different times of the day to determine the changes in the concentration of stored food, i.e. carbohydrate and fat in the liver, which is the principal food storage organ of the body. The results obtained confirmed the hypothesis upon which these experiments were performed. Thus, the highest concentration of glycogen, the storage form of carbohydrate, of 90mg/g was obtained in the liver of bats killed at 6.00 a.m. in the morning, that is, just after their return from the feeding grounds. As a result of their very active roosting behaviour, this quantity decreased to 60mg/g at mid-day, and by 6.00 p.m. in the evening, shortly before their departure from the Campus, the glycogen store had fallen to 35.0mg/g, showing about 61% depletion of glycogen store, during the day.

This work was later extended to insect bats which, apart from feeding on insects which are rich in protein, truly rest during the day and also have labial body temperature. The results on this were most revealing and totally sustained my expositions on the relationship between the feeding behaviour and nutrient ratio of food in the two groupings of bats. My next angle of attack on this problem then shifted to a close comparative study of the anatomy and physiology of the alimentary canal itself, in the two groups of bats. The physiological work which was essentially biochemical in technique was executed jointly with Dr. O. A. Ogunbiyi, and involved a determination of the digestive enzyme pattern of the bats.

The totality of the results obtained so far from my studies as highlighted above, produced a thesis from which I have enunciated the following principles on the biology of bat nutrition:

1. Under natural conditions, the level of nutrient stores of bats is a function of three principal factors, namely, the nutrient ratio of their food sources, their roosting behaviour and the bioenergetics of temperature regulation.

2. The daily drop in the nutrient stores of the fruit bat, *Eidolon helvum* results mainly from their vigorous activity during the day. Therefore, those fruit bats which really rest in roost would not show the marked depletion of their nutrient stores as occurs in *Eidolon helvum*.
3. Some fruit bats obtain much of their fat needs through the endogenous conversion of carbohydrates. Similarly, insectivorous bats build up their carbohydrate reserves partly through glyconeogenesis from fats and proteins.
4. Since the smaller megachiropterans are heterothermic and do go into diurnal torpor, they would show a similar pattern of nutrient changes as the microchiropterans.
5. The feeding, digestive, and absorptive mechanisms of bats are designed principally to cater for high and quick energy demands.

The netting of six other species of fruit bats on this Campus during the last session has provided ready materials to test and elaborate on these principles.

Of great significance in the biology of bat nutrition is my recent discovery of the occurrence of Brown Adipose Tissue (BAT) in *Eidolon helvum*. This fat is different from the ordinary or white fat in its structure, location and function. It was up till now known for its thermogenic functions in animals under cold stress, such as hibernators and newborn mammals. My findings so far on the BAT of *Eidolon helvum* through histological, electron-microscopic and biochemical studies reveal that this fat participates in the daily energy exchange mechamisms of the bat. This discovery has introduced an important new dimension to our knowledge of Brown Adipose Tissue in animal generally. I first announced this discovery in a paper presented two years ago at the last International Colloquium on African Mammals held at the University of Antwerpe, Belgium.

The results obtained from this very composite body of work as highlighted above have been made available to the research world through numerous publications particularly

in three major International Journals, namely, *Physiology and Behaviour* published in New York; *Acta Zoologica*, published in Stockholm, Sweden, and *Comparative Biochemistry and Physiology* published in England. This is in addition to many Conference papers at various international arena. This University was honoured with the hosting of the 6th World Conference on Bat Research in August 1981, which attracted participants from America, United Kingdom, India and East Africa. The Conference was sponsored by the University of Ife Learned Conferences Committee and the Oyo State Government and I wish to use this opportunity to publicly acknowledge this and to express the gratitude of the Conference Organizing Committee to these two bodies for their kindness. I should also add that the Conference Proceedings is nearly ready with the University of Ife Press and we hereby appeal that the University would complete its sponsorship by giving us money to pay the bills from the Publisher. Indeed, the status of research work on bats in Ife is such that there is nowhere in the world where any serious work is being done on bats without some reference to our research activities in Ife.

Other Works

Having expatiated so much on bats, I have most probably misled you into also believing that all I know in Zoology is bats. This is not so. Rather, I have also been engaged, over the years, in considerable work in some other areas of Vertebrate Zoology, which is my main teaching subject, mainly to enhance my teaching input in this area.

Indeed, my first appearance on the world map of research outputs was through four publications in *The Journal of Zoology*, London, derived from my postgraduate work. These had nothing to do with bats but were on the relations of the development of temperature regulation in infant rodents and their production of ultrasounds. In 1975/76 session, I had the honour of serving as a Visiting Scientist at the University of Turku, Finland. During the one year, I took up a study of

the embryonic and postembryonic development of glycogen reserves in the bird, japaneze quails (*Coturnix coturnix japonicum*), which were being developed as laboratory animals in that Department. The results of that work appeared in two publications in the journals, *Comparative Biochemistry and Physiology* and *The Nigerian Journal of Natural Sciences*. In recognition of the significance of the results of that work on the quails, and of course, others which led to my invitation in the first place, I had the great honour of being awarded a medal by the Senate of the University of Turku in 1976.

Furthermore, my book, *The Biology of the Domestic Fowl*, fondly nicknamed by the students "eye Okon" (i.e. Okon's fowl) which was first published in 1975, contains not a word on bats! Lastly, two other books by me, now in the pipeline with the University of Ife Press also deal on subjects in vertebrate zoology other than bats. So I do not speak only the language of bats!

Summary and Conclusions

It is customary to end inaugural lectures in this University at least, with some proposals or suggestions directed to the government. I like to deviate somewhat from this tradition. Rather, my own message is to ourselves as teachers and researchers and I will make the point by recalling an experience during my postgraduate studies, an experience which has had the greatest influence on me as a teacher and researcher. After mapping out my programme of work with my supervisor, Professor J. D. Pye, it turned out that one of the major equipment required was a temperature cabinet for observing the body temperature changes of the animals to be studied. Instead of contacting a Science Equipment Company to purchase one, he took me in his car to an old appliances shop to buy a very old small domestic refrigerator for about £15. Back in the laboratory we set out with his technician to do some repairs and we converted the old fridge into an incubator by inserting a variable thermostat and an electric bulb.

What struck me was why he should do that, when his laboratory had so much funding from various sources out of which he could easily have bought a modern highly sophisticated equipment for my work. To him, simplicity of approach in methodology and technique is the real test of a true researcher, and that the press-botton technique belongs to the lazy, pseudo-scientist. He argued that the simple-appoach method enriches the researcher much more because it enables him to tackle both the problem and the method from first principles which ensures a more profound grasp and understanding of the various dimensions of a research problem. Indeed, this has been the starting point of all the major discoveries of the world.

That was a lesson that I have lived with and strictly applied in all my research efforts so far, and I strongly commend it to all my colleagues, particularly the up-coming ones: **simplicity of approach in methodology and technique in our research efforts.** This is of even greater practical significance in these days of very lean resources for the Universities.

On a wider perspective, my point is that there are inumerable problems around us as scientists and researchers in the laboratories, as teachers in the classrooms, as doctors in the hospitals, as engineers and architects in the field, as agriculturists on the farms, and even as administrators in the offices, which need to, and can be solved, to the profound benefit of knowledge and the ordinary Nigerians without reliance on, or resort to heavy technology as a starting point. All the nations of the world which have made it started this way. Conversely, no nation which has not first learnt to solve its most basic problems with simple techniques can solve them through heavy technolgoical approach. This is the message of my research endeavours. Indeed, it would interest you to know that it has been possible to turn out all that has been presented here and more, during the past thirteen years without seeking any research grant from this University or any other source. Rather, I have relied on what is available. on modifications, improvisions, burrowing and collaborations.

And finally, turning to the bats, what we have heard this evening is only a peep through the window of their world. But I believe you have all had sufficient insight into this fascinating world to agree with me that the ancient wise saying about the ant applies, perhaps even more succinctly to the bat, which saying could then be reconstructed to read thus: **Go to the bats thou sluggard, consider his ways and be wise!**

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