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EARTHWORMS AND THE WAY BACK TO EDEN

44TH INAUGURAL LECTURE
OLABISI ONABANJO UNIVERSITY
AGO-IWOYE

PROF. STEPHEN O. OWA
Tuesday, 2nd September, 2008

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Professor of Applied Zoology

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Mr. Vice-Chancellor.

Deputy Vice-Chancellors.

Principal Officers of the University

Provosts of Post-Graduate School and Colleges.

Deans of Faculties

Heads of Departments

His Royal Highness, The Elegbe of Egbe.

My Lords Spiritual and Temporal.

Gentlemen of the Press.

Distinguished Ladies and Gentlemen

Great OOUites!

Summary

Our biosphere was created originally a perfect environment, in which God placed all the mechanisms for maintenance of the perfection, one of which were the earthworms and other soil animals. The earthworms have been diligent in their function, even against the tinkering activities of the humankind. All of us must protect them and develop a technology to multiply and conserve them. This will enable them serve us in many natural ways.

I and members of my Earthworms Research Team have studied the distribution and ecological functions of the earthworms in the diverse ecological regions across the country. We have found that if we breed and multiply earthworms of the hyperiodriloid group of genera and distribute them over our far northern region of Nigeria, by the nature of their casting the earthworms will bind the soils, reduce their wind erosion, reduce the load of dust rich in nutrients from our northern soils lifted by the Harmattan Wind; thereby we shall conserve the fertility of our soils all over the country. The Federal Government is invited to set up a team of zoologists

botanists and ecologists to work out this suggestion.

The alarming increase in the rate of debilitating diseases such as diabetes, liver and kidney failure, stroke and other cardiovascular diseases, rheumatism and cancer are attributed, in part, to consumption of junk and unnatural foods, foods in which the ionic contents are out of natural balance and consumption of toxic residues. To minimize these, we must protect and encourage the multiplication of the Edenic workers, the earthworms and other soil animals. Our findings show that by following natural 'due process' they diligently maintain our soil fertility, crop productivity, crop health and human health. We will have natural foods if we trust our crops to the able hands of the earthworms.

Our nutritional analyses show that eating earthworm preparations will improve our health. But if we are shy or antipathetic to this, we could do indirect consumption by the food chain via our domesticated livestock, all of which perform well when fed earthworm meals. Results so far from our Earthworm Research Team at the Olabisi Onabanjo University, Ago-Iwoye, suggest that even at the level of food supplementation intake, earthworm meals benefit our livestock.

Our results show that if we develop the technology to produce an acceptable presentation of earthworm meals we shall have the direct benefit of their richness in essential amino acids. Their meat should be relished and cherished. They are very rich in omega-3 oil that improves the functioning of our heart. Our survey shows that all over the southwestern Nigeria, including the Yoruba speaking middle belt, and down to the Delta region, earthworm meal is administered by traditional herbal practitioners to assist women push at child birth. This parturitive effect is now known to result from an oxytocin analogue present in the earthworms whose power is about ten times more potent than that present in women. Approved earthworm preparations can be made to assist in this obstetric area, thereby reducing the duration of labour at childbirth and the need for Caesarian section. In folk medicine earthworm preparations are also administered in the treatment of rheumatism and arthritis of diverse types. Thrombosis (in situ blood clotting) and embolism (wandering blood clots), the major causes of stroke, are treated by a thrombolytic (clot busting) agent present in the earthworms. Thus, if we design some socially acceptable earthworm meal we will be reducing the incidence of stroke, one of the world's highest killer diseases.

These are some reasons why earthworm protection, breeding and multiplication must be encouraged to make available a source of these useful agents.

Earthworm taxonomy provides an evidence in support of an original creation by the Great Designer. Subsequent to creation, gradual and continuous loss of reproductive isolating mechanisms result in speciation, a process better regarded as

catavolution (deteriorative manifestation) than evolution (progressive manifestation). Not only in earthworms, but also in any animals taxonomic studies, empirical data point to catavolution. According to this theory, animals were originally created in fewer kinds than we now know. Catavolution results from a constantly deteriorating environment that negatively affects the genetic apparatus (by mutations). As a result, we have more species and genera today than existed at creation. Such deteriorative production of new species, genera and higher taxa is more of catavolution than evolution.

Introduction

Mr. Vice-Chancellor, Sir, I feel greatly honoured to be nominated to give today's (44th)Inaugural Lecture, one of the days that I have worked hard for, and looked forward to. I feel elated almost like on my wedding day. Yet, as this day approached a humbling reality kept reminding me how little I know about the exciting animals called earthworms. There is still much to learn about the earthworms, but there are too few students. In the light of this paradoxical situation I thought it wise in this Lecture to achieve the following.

1. I intend to set before us that our environment is expected to be of the Edenic Balance, according to its original Designer and Creator. Eden was a perfectly balanced biosphere.
2. I advocate that the earthworms have remained faithful (though losing) in their assignment of working our soils to conserve our Edenic environment. We, in turn, must protect them and other soil animals, and encourage their multiplication so that, as a result of their efficient function, we should minimize dependence on agrochemicals.
3. Realising the useful medicinal components in the earthworms I wish to motivate a multi-disciplinary scientific study of the Nigerian earthworms.
4. On the philosophical side, I wish to show that earthworm taxonomy better supports the traditional Initial Creation Model, a belief that a Creator God, at some time in the past, created only a few kinds (typology) from which many more species arose (ie, speciated) by a process better regarded as catavolution instead of evolution.

If this lecture succeeds in motivating and mobilizing my audience and the society to love and protect the earthworms, if it mobilizes some vigorous young researchers to develop a cheap method of breeding and multiplying earthworms for diverse applications, if it succeeds in securing a worm culture bin in every home and office,

if it succeeds at securing the attention and a little takeoff budget of our governmental planners, then this Lecture would have been worth the effort.

What is Eden?

Eden and Ecological Balance. Eden as used in this context represents ecologically perfect earth. It is referred to as the Garden of God, the Garden of Delight. It is described in the bible as an orchard with fruits. It represented the early Earth and the conditions that God initially planned for it. In that original plan, the Earth, set in its cosmic position, was to be optimally influenced by the heavenly bodies and the environmental conditions set for its biosphere.

Eden, Natural Foods, Good Health and Longevity. Man was initially fruitivorous. From his Edenic garden he had access to natural foods. There was no need for fertilizers. Resulting from his well balanced diet, devoid of junk and additives, man was healthy. He lived close to 1000 years. As his diet excluded animal components, he escaped zoonotic diseases and those related to excessive fat and animal protein. The herbivorous diet ensured access not only to nutrients, but also to prophylactics. The raw consumption ensured access to both thermostable and thermolabile vitamins and enzymes in the diet. Resulting from all these Man lived unbeatable longevity.

Taxonomic Duties in Eden. Two duties were assigned to the occupants of Eden. First, they were to tend the garden. The second duty was a rather temporary one: they were to name all organisms that God had created. It is noteworthy that it was not God Himself that named them, rather, he left that job to the man that he had created. That was a taxonomic duty. It was probable that leaving the taxonomic duties to man was a way of indicating that the basic mature creation was done. Man would thenceforth need to monitor secondary derivatives. And ever since then Man has never stopped naming new kinds.

Earthworms

Earthworms need little introduction as they are very familiar creatures. They are regular occupants of most soils. Somehow, they find their ways into our backyards, under stones and calabashes. In many rural places they even make their burrows in the soil under the mortal and grinding stones, apparently ignoring the vibrations of these locations.

Earthworms are classified in the phylum Annelida, class Oligochaeta, order Clitellata and belong to diverse families. The name Annelida is derived from *annelis*

which means ring, because their body is divided into rings which we call segments.

How I got Recruited in Earthworm Taxonomy

Mr. Vice-Chancellor, Sir, Permit me to share the testimony of how I got recruited into earthworm research. I had just concluded M.Sc. Zoology with specialization in Cell and Molecular Biology under Dr (now Prof) Mark Nwagwu when Ogun State University was founded and advertised. I applied and was interviewed at the then Ministry of Education, Abeokuta, and employed as an Assistant Lecturer. Unfortunately due to academic politics that I could not understand my studentship straight into Ph.D. in that field was disallowed. I switched over in the same Department of Zoology, University of Ibadan, to Molecular Genetics of Leukaemia in Nigeria, to be jointly supervised by Drs (now Profs) Bob Borrofice of the Zoology Department (now at Nigerian Space Research) and Williams of Haematology Department, UCH, Ibadan). Shortly after submitting a proposal, my continuation in that Department was disallowed. Still bent on that field of study, I contacted Prof. Bababunmi, who could not take me on because of my not having an undergraduate degree in Biochemistry, but kindly referred me to his colleague at the University of Lagos Teaching Hospital, Idi Araba. Again due to various reasons I could not continue there. I applied for admission and training in Molecular Genetics under Dr (now Prof.) Adegoke of the Department of Zoology, University of Ife. The belated letter did not arrive until after two and half years when I had already gotten admission for another programme in that same Department. I finally settled to write a proposal on The Herpetofauna of Ogun State and their Agricultural Importance, to be supervised by (Late) Prof. Olufunmilayo of the Department of Agricultural Biology, University of Ibadan. I pounced on the work with all zeal until I wrote and formally defended an application for a research grant at an interview before the professors of the Faculty of Science. The Professors saw too much risk at pursuing snakes, but their final discouraging information was that there was no single true herpetologist resident in Nigeria that was competent to supervise the Ph.D. work.

However, one of the professors (Ademola O. Segun) offered to supervise me if I change topic to Earthworm Taxonomy, an area in which I later learnt that he was the only expert in Nigeria. That was going too far from my dreams and I resisted it until the same professor walked into one of my undergraduate laboratory classes and caught me (mis)teaching the students. In my zeal I had gotten the students dissecting earthworms which I myself could not identify, and which I admitted to the class. But I had also told the students to regard it as *Lumbricus terrestris*. The professor dwelt more on appreciating my efforts than ridiculing me before the class. But that was his

good opportunity to emphasize the need for me to give earthworm taxonomy a serious thought. After that class he collected the undissected earthworms and others that I had collected, analysed them and gave a seminar on his findings on a checklist of the earthworms of this region. He concluded his seminar by acknowledging my collecting the material and seized the opportunity to announce that staff should encourage me to do my Ph.D. on Earthworm Taxonomy. It was obvious that he took delight in me. Many senior colleagues began to scold me in love "for refusing to accept an offer that an elderly professor was obviously too willing to give me." *Vox populi vox Deo?*" I began to give it serious thought.

That was the beginning of the farewell kiss to my dreams of Molecular Biology for which, after all, there were no basic equipments such as a spectrophotometer and an ultra-centrifuge in the new Department and University. Reluctant at first, but I finally and quickly settled down for Earthworm Taxonomy. By the raining season of 1984 I had begun a systematic survey for earthworms around Ogun State in anticipation of my formal admission at the University of Ife (Now Obafemi Awolowo University) Ile-Ife, in 1985.

History of Earthworm Taxonomy in Nigeria

Studies on earthworms of Nigeria (Table 1) have been mainly on members of the family Eudrilidae. Twenty eudrilid genera including 53 species have been recorded from Nigeria. Fifteen of these including 45 species were first described from Nigeria. Some are polytypic and other well defined genera are, as at present, monotypic. As at the early 1990s thirty-four (34) species belonging to nineteen eudrilid genera had been reported from Nigeria (Owa, 1992).

Among these, Beddard erected four genera and described four species from Lagos namely *Heliodrilus lagosensis* Beddard, 1890; *Hyperiodrilus africanus* Beddard, 1891; *Libyodrilus violaceus* Beddard, 1891 and *Iridorilus roseus* Beddard, 1897. All these were from the neighbourhood of Lagos, what today is commonly called south western region.

Michaelsen erected two genera including three species all from Abinsi, about 20 km from Makurdi in the eastern middle belt of Nigeria: the genus *Beddardiella* with two species, *B. dalzieli* Michaelsen, 1910 and *B. busrana* Michaelsen, 1937 and the genus and species *Eutoreutus abinsianus* Michaelsen, 1915.

Taylor described the genus and species *Hippopera nigeriae* Taylor, 1949 from

between Ibadan and Lagos.

Clausen described from Keffi the genus and two species *Keffia nigeriensis* Clausen, 1963 and *Keffia variabilis* Clausen, 1963. She also described the species *mekoensis* Clausen, 1967 in Beddard's genus *Libyodrilus*.

Sims described from the south-western Nigeria the genus and species *Ephyriodrilus afroccidentalis* Sims, 1971.

Segun worked more extensively on the eudrilids from the southwestern and eastern Nigeria. He described five (5) genera and eight (8) species, namely, the genus and species *Agrotoreutus nyongii* Segun, 1976a from Nsukka; the genus and species *Vomia prima* Segun, 1976a from Vom; the species *Hyperiodrilus malakai* Segun, 1976b from Ughelli; *Iriododrilus tonyii* Segun, 1977 from Oron. And from Ile-Ife he described *Eminoscolex nigeriensis* Segun, 1978, *E. ifensis* Segun, 1978, *Hippopera ajokei* Segun, 1978 and *H. ifensis* Segun, 1978. And from eastern Nigeria he described *Digitodrilus nsukkaensis* Segun, 1980, and *Parapolytoreutus obiensis* Segun, 1980.

Segun, (1978) also recorded nine earlier described species from Ile-Ife namely, *Eminoscolex steindachneri* Cognetti, 1909; *Ephyriodrilus afroccidentalis* Sims, 1971; *Eudrilus butteneri* Michaelson, 1892; *Eudrilus eugeniae* Kinberg 1866; *Heliodrilus lagosensis* Beddard, 1890. He also recorded *Hippopera nigeriae* Taylor 1949; *Hyperiodrilus africanus* Beddard, 1891; *Hyperiodrilus millsoni* Beddard, 1893 and *Iridodrilus roseus* Beddard, 1897 from Oshogbo, Igbede-Ekiti, Owo, Okitipupa, Benin, Sapele, Warri and Ughelli.

The most extensive and intensive study of the Eudrilidae in Nigeria was by Owa (1992) on their taxonomy and distribution, covering 104 sampling locations spread over the country. He recorded thirty-six earthworm species belonging to the above-named genera and, in addition, described two new ones. Those records were the genera *Agrotoreutus*, *Beddardiella*, *Digitodrilus*, *Eminoscolex*, *Ephyriodrilus*, *Eudrilus*, *Eutoreutus*, *Heliodrilus*, *Hippopera*, *Hyperiodrilus*, *Ikenmodrilus*, *Iridodrilus*, *Keffia*, *Libyodrilus*, *Nsukkadrilus*, *Parapolytoreutus*, and *Vomia*. The new species described were *Keffia penetrabilis* Segun & Owa, 1990 and *Keffia proxipora* Segun & Owa, 1990.

Owa also described two new genera and several new species from different parts of the country, namely the genus and species *Takunodrilus veyei* Owa, 1995 from Takun; the species *Iridodrilus codonothecoformis* Owa, 1993 and *Iridodrilus condylopapillaris* Owa, 1993, both from Obudu (Cross River State); *Iridodrilus kayodei* Owa, 1993; *Iridodrilus abinsiensis* Owa, 1994; and *Eminoscolex betukwelensis* Owa, 1994; *Beddarddiella soforei* **Owa, 1995 (Fig. 1); *Beddarddiella***

numanensis Owa, 1995 both from Michika and Numan respectively (Adamawa State); *Eminoscolex buraraensis* Owa, 1995; *Nsukkadrilus funmie* Owa, 1996; *Eudrilus milliemosbyae* Owa, 1996 and *Eudrilus sodeindei* Owa, 1996; *Buttneriodrilus dalamui* Owa, 1998; *Eutoreutus metandrica* Owa, 1998 (Fig. 2); *Parapolytoreutus kuyei* Owa, 1998.

Table 1: Eudrilid Genera and Species so far Identified or Described from Nigeria.

Genus	Number of species	Names of species
Agrotoreutus Segun, 1976	1	*nyongii* Segun, 1976
Beddardiella Michaelsen, 1910	4	*dalzielli* Michaelsen, 1910
		busrana Michaelsen, 1937
		soforei Owa, 1996 (See Fig. 1)
		numanensis Owa, 1995
Digitodrilus Segun, 1980	1	*nsukkaensis* Segun, 1980
Eminoscolex Michaelsen, 1896	5	*steindachneiri* Cognetti, 1909
		nigeriensis, Segun, 1978
		ifensis Segun, 1978
		betukwenlensis Owa, 1994
		buraraensis Owa, 1995
Ephyriodrilus Sims, 1971	1	*afroccidentalis* Sims, 1971
Eudrilus Kinberg, 1866	5	*eugeniae* Kinberg, 1866
		buttneri Michaelsen, 1892
		atakpamensis Michaelsen, 1913
		milliemosbyae Owa, 1996
		sodeindei Owa, 1996
Eutoreutus Michaelsen, 1915	3	*abinsianus* Michaelsen, 1915
		armatus Michaelsen, 1915
		metandrica, Owa 1998
Heliodrilus Beddard, 1890	1	*lagosensis* Beddard, 1890
Hippopera Taylor 1949	3	*nigeriae* Taylor, 1949
		ajokei Segun, 1978
		ifensis Segun, 1978
Hyperiodrilus Beddard, 1891	5	*africanus* Beddard, 1891
		millsoni Beddard, 1893
		euryaulus Clausen
		osogboensis Segun, 1976
		malakai Segun, 1976
Ikennodrilus Segun	1	*wurae* Segun
Iridodrilus Beddard, 1897	11	*roseus* Beddard, 1897
		preussi Michaelsen, 1902
		tonyii Segun, 1977
		vomiensis Segun, 1977
		condothecoformis Owa, 1993
		condylopapillaris Owa, 1993
		kayodei Owa, 1993
		abinsiensis Owa, 1994
		abujaensis Owa, 1994
		furcothecata Owa, 1994
		encombopapillare Owa, 1998
Keffia Clausen, 1963	4	*nigeriensis* Clausen, 1963
		variabilis Clausen, 1963
		proxipora Segun & Owa, 1990

		***penetrabilis* Segun & Owa, 1990**
***Libyodrilus* Beddard, 1891**	**2**	***violaceus* Beddard, 1891**
		***mekoensis* Clausen, 1967**
***Nsukkadrilus* Segun, 1977**	**2**	***mbae* Segun, 1977**
		***funmie* Owa, 1996**
***Parapolytoreutus* Segun, 1980**	**2**	***obiensis* Segun, 1980**
		***kuyei* Owa, 1998**
***Vomia* Segun, 1976**	**1**	***prima* Segun, 1976**
***Segunodrilus* Owa, 1995**	**2**	***wukariensis* Owa, 1995**
		***lokojaensis* Owa, 1995**
***Takunodrilus* Owa, 1995**	**2**	***yeyei* Owa, 1995**
***Buttneriodilus* Michaelsen**	**1**	***dalamui* Owa, 1998**

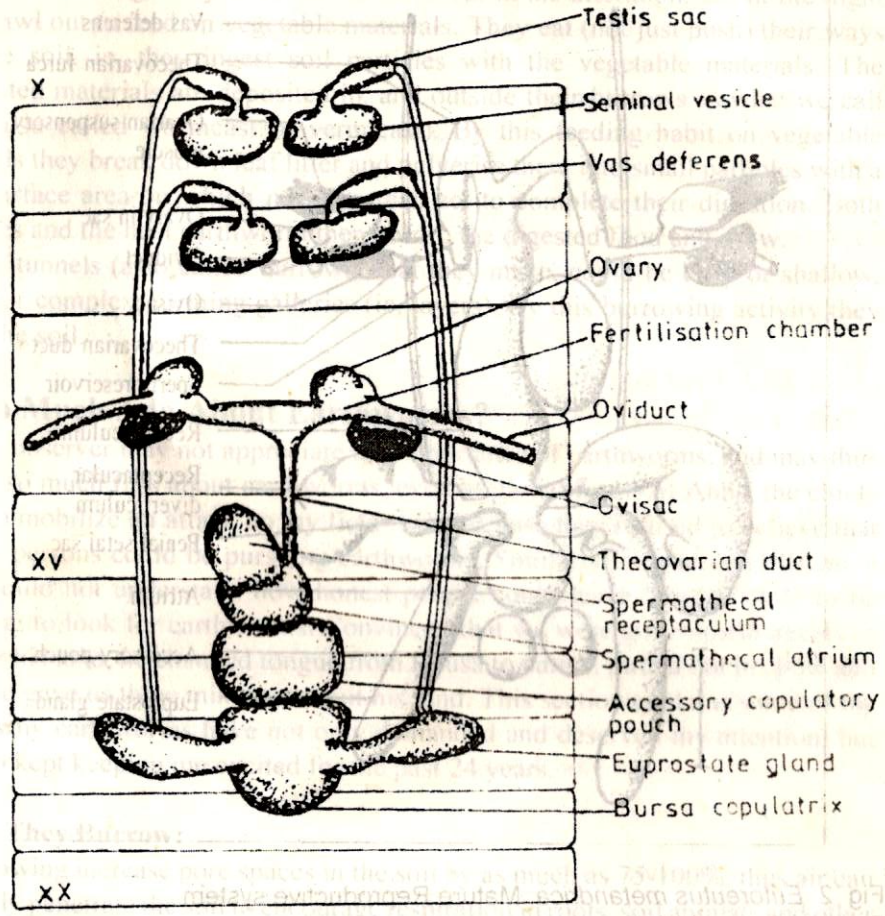

Fig. 1. *Beddardiella soforei*: Mature reproductive system
Source: Owa, 1996

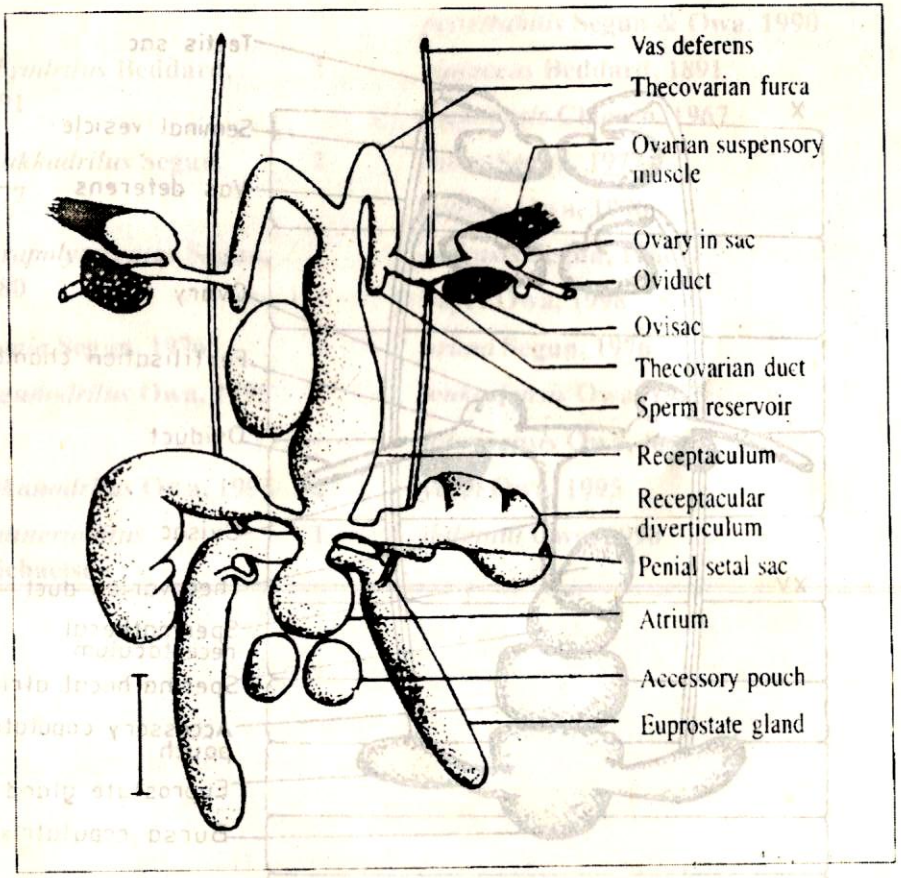

Fig. 2: *Eutoreutus metandrica*: Mature Reproductive system.
Source: Owa, 1998

worms' Ways of Life

orms are light-shy, they do not come out in the afternoon, but in the night
wl out to feed on vegetable materials. They eat (not just push) their ways
soil, ie, they ingest soil particles with the vegetable materials. The
ted materials are deposited in, and outside their burrows as what we call
lso called wormcast or vermicast). By this feeding habit on vegetable
ls they break down leaf litter and pulverise them into small particles with a
rface area on which microbes can act to complete their digestion. Both
s and the host earthworm then absorb the digested food and grow.
tunnels (also called burrows) that they make, could be deep or shallow,
or complex, forming galleries (ie, layers). By this burrowing activity they
he soil.

Much Ado About Earthworms?

observer may not appreciate the importance of earthworms, and may thus
so much fuss about earthworms, even at global level. At Abba, the chiefs
mobilize an attack on my field team because they refused to believe that
persons could be pursuing earthworms. Similarly, in southern Plateau, a
ould not understand how honest people could leave 'Ibadan' only to be
g to look for earthworms. Convinced that we were government agents to
his land, he changed tongue from Hausa to native, pulled out his bow and
d gave us three minutes to quit his land. This section explains some of the
why earthworms have not only demanded and deserved my attention, but
kept keeping me excited for the past 24 years.

They Burrow:

owing increase pore spaces in the soil by as much as 75-100%, thus air can
ly penetrate the soil to encourage respiration in roots, soil animals and other
rganisms.
estimated that an earthworm population of about 1 million can produce
ws whose total length could amount to about 1,200 miles (almost 2,000

r infiltrates the soil better and is held longer. Water infiltration rate could
creased by as much as thrice.
r that could have run off is held in the spaces, thus increasing the water
ing capacity of the soil.
owing activities soften the soil. Hardpan and compacted soils are softened.

vi. The burrows facilitate root penetration into the soil and access to deeper-located nutrients.
vii. The mucus lining of their burrows provides an excellent nutrient to plant roots.

Because They Produce Casts:

i. Wormcasts absorb water faster, hold more water and hold the water longer than parent soil.
ii. Wormcasts can absorb moisture from the air. (ie, they are hygroscopic), thus they keep the soil moist longer than cast-free soils.
iii. Wormcast intercepts the force of rain drops thereby reducing leaching and soil erosion.

Because They Feed on Litters:

i. When they drag leaf litter below the soil surface they reduce the amount that is available to illegal bush burning.
ii. Feeding on litter, they break them down and incorporate nutrients in them into the soil. Thus the litter is turned into natural manure which is not harmful to the soil.
iii. They convert residues and waste products to compost. For example cassava peels, containing cyanide, usually leaves the dump site unproductive. But earthworms, feeding on the peels, make compost out of them. Similarly, corn husks are composted.
iiv. The bacteria, fungi, yeasts and protists living in their gut help to detoxify many toxic chemicals that pass through their gut. Some convert cellulose to nutrients.

Because They Feed on Soil:

i. Earthworm can digest a large amount of soil in one year.
ii. The chemical condition in the gut causes sand grains to be granuiated.
iii. In England it is estimated that about 40 tons of sand pass through earthworm gut per acre everyday. In the U.S.A. about 1.5 million earthworms move 20 tons of earth per year.

Because Earthworms Respire:

i. As much as 30% of field respiration during cold wet winter-spring months is due to earthworms.
ii. In an empirical data collection on a lowland (puddle) rice farm, using a sensitive

(integrated circuit) thermometer, Owa *et al.(2004)* found that earthworms produce a significant increase in the soil temperature in their burrows. Thus, when an earthworm is associated with the base of a plant, the plant enjoys a local elevation of temperature (Hoogerkamp *et al.*, 1983; Owa, *et al.* 2004).

Because Their Gut is an Excellent multiplication Factory for Microbes:

i. In a microbiological study under my supervision Olowoparija (2006) found that microbial population increases along their gut.
ii. Thus, nitrogen fixing bacteria are (10-1,000 times) more numerous in worm burrows, and in/around wormcasts than in the parent soils.
iii. Many species of earthworm feed on harmful microbes in the soil, thus reducing their population.
iv. Earthworms, in feeding, consume the spores of mychorrhizae (beneficial fungi that help the root in uptake of nutrients). These spores are deposited in the subsurface wormcasts where the roots and rootlets find them and take advantage of their help.
v. Symbiotic microbes living in the gut of earthworms assist in breaking down complex organic molecules such as cellulose and lignin. In the study under my supervision, some bacteria identified from the gut of *Libyodrilus violaceus*, an eudrilid earthworm, include *Corynebacterium* sp. *Flavobacterium* sp. *Enterobacter cloacae*, *Acinetobacter* sp. *Bacillus macerans*, *Bacillus* sp. *Proteus rennevi*, *Micrococcus kristinae*, *Proteus vulgaris*, *Erwinia salicie*, *Bacillus lichenoform*, *Bacillus laterosporus*, *Bacillus cereus*, *Micrococcus inteus* and *Alcaligans faecalis* (Olowoparija, 2006). Another microbiological work by our Earthworm Team monitored the population increase of these microbes along the alimentary system of earthworms (Owa, Osho, Aladesida, Dedeke, 2007).

Some More Ways Earthworms Improve the Soil

Soil Fertility

i. The roots of most horticultural and vegetable crops operate near the soil surface (about 15 cm deep). Minerals in this root level tend to be depleted as a result of absorption by root and incorporation into the plants and harvested organs. But earthworms, by burrowing deep into the soil, replenish the minerals by bringing nutrients from deep in the soil to the surface (Owa, Moreyibi, Dedeke & Yeye 2002).
ii. This upward carrying of minerals counteracts leaching.

iii. According to a recent study under my supervision by Kuti (2008) they concentrate nutrients in their casting; thereby rootlets in the vicinity of a cast is able to perform better at nutrient absorption. One way of concentrating nutrients is by chelating them.

iv. A nutrient such as phosphate is not necessarily absorbable in all the forms in which it is present in the soil. Nutrients that pass through the soil are often converted to the forms that are more easily absorbed by roots (Kuti, 2008).

v. Castings are richer in nutrients than the parent soils: calcium is increased by a factor of about 3, nitrogen by 5, available phosphate by 7 and available potassium by 11. Phosphorus is a limiting element for plant growth. Any process that significantly increases its availability and rate of turnover through plants and soil organic matter is very important (Reinecke *et al.*, 1992; Parkin & Berry, 1994)

vi. Nitrogen-fixing bacteria live in the gut (and castings) of earthworms, thus nitrogenase activity is higher in these places, meaning greater nitrogen fixation. A study shows that earthworms pass about 100 Kg N to the soil per hectare per year.

Soil Remediation

i. After passing through the worm gut, the soil becomes closer to neutral pH

ii. A large population of earthworms is known to suppress weed growth. This is probably because the conditions created by earthworm tunnelling negate the conditions required for weed growth.

iii. Some weed seeds consumed by earthworms are either destroyed, or their ability to germinate reduced.

iv. As earthworm gut environment stimulate microbial growth and yet weaken weed seeds, the environment encourages the microbes to feed on, and destroy the weed seeds.

v. Many toxic organic chemicals taken up by earthworms are detoxified. Examples are hexachlorocyclohexane (HCH). In this respect our Earthworm Research Team is working to collect a checklist of the earthworms of the oil spillage regions of the country with the intention to produce species that are most efficient in remediation of the affecte soils. A postgraduate student is admitted for that purpose.

Soil Water Management

i. Wormcastings intercepts the force of rain drops thereby reducing leaching and erosion of the soil. Our work shows that wormcast of the hyperiodriloid

earthworm genera are about the best suitable for this function.

ii. Earthworms in a field increases the water absorption and retention capacity of the field.

iii. An experiment showed that at 100 earthworms per square yard in a farm, the soil is able to absorb a rainfall (in the order of 2 inches) in 12 minutes, whereas the control (where earthworms are excluded) took over 12 hours to absorb that much of water. It is expected that if earthworm burrows occupy as much as 25% of the top 1 metre of the soil, the soil should be able to absorb a 9 inch rainfall.

Soil Erosion

i. Chemicals produced by earthworms make their castings to be strong and therefore able to resist soil erosion.

ii. Some earthworms such, as *Hyperiodrilus*, *Heliodrilus*, *Iridodrilus* and *Ephyriodrilus*, that produce turret type of casts, also produce them to form a carpet that resist slow erosion of the soil (Owa, Moreyibi, Dedeke & Yeye 2002).

Effects on Plant Growth and Health

Mr. Vice-Chancellor, Sir, after much exciting taxonomic work on the earthworms I felt the need to direct some energy into the applied studies, which again were equally exciting. Among our finding are the following.

1. Plant growth hormones such as auxins are produced in the earthworm castings and stimulate roots to grow faster and deeper, and the aerial organs to prosper. For example, in a puddle rice farm, stands with earthworm castings at their bases were, compared to those lacking earthworm castings, better in terms of having more tiller, more grains per stand, bigger-sized grains, longer and greener leaves (Owa, Oyenusi, Joda, Morafa, and Yeye, 2003; Owa, Moreyibi, Dedeke, Olojo, and Fashunwon, 2004)
2. Earthworm factors can increase vegetative yield of vegetable crops by as much as 70% (Owa, Moreyibi, Dedeke, Morafa, Senjobi, and Aladesida, 2007). Between 25-300% increase have also been recorded.
3. When we weed our lawn we like to have it green. Earthworms eliminate thatch by digesting the debris.
4. A recent study by one of my students (Otulana, 2008) confirms that soils rich in earthworms have less of harmful nematodes.
5. The conditions created by earthworms in the soil discourage populations of harmful soil insects, nematodes and others.
6. Earthworm products improve seed germination. Earthworm-produced composts

increase seed germination. In an experiment a water extract of wormcast not only increased the germination of the leafy vegetable jute (*Corchorus: Ewedu* in Yoruba) but made steeping (the traditional way of speeding up germination) unnecessary (Ayanlaja, Owa, Adigun, Senjobi, and Olaleye, 2001).

7. Vermicompost has been shown to improve the germinability of seeds of low viability by as much as 43%.
8. Earthworms increase the number of plant roots, root volume and root length (Owa, Moreyibi, Morafa, and Dedeke, 2004).
9. If properly managed, as earthworms stimulate rapid growth of crop plants, their resulting growth should shade out weed growth.

How Do Earthworm Activities Affect Vegetable Crops?

One of our studies was into how the presence and activities of earthworms affected the green, leafy vegetable *Amaranthus* (*efo tete* in Yoruba). Experimental plant pots were inoculated with varying numbers of earthworms and the growth parameters of the plants were recorded (Owa, Moreyibi, Dedeke, Morafa, Senjobi, and Aladesida, 2007). The following were some of the findings (Table 2):

i. Each stick of the vegetable was longer.
ii. The leaves were larger (in surface area).
iii. The leaves were greener.
iv. The mass per stick was more.
v. The root volume and number were increased.

Table 2: Relative Gain in Growth Rates of Okro (Abelmoschus Esculentus) Subjected to Different Numbers of Earthworms (Based on a Potted Experiment in Nigeria)

Parameter	0-earthworm per pot	5-earthworm per pot	10-earthworm per pot
Root volume	100%	120%	181%
Wet weight of fruit	100%	116%	107%
Dry weight of fruit	100%	146%	178%

Partitioning the Chemical and Physical Effects of Earthworms on the Growth

Performance of Vegetable Crops

We sought to know if the significant effect of earthworms on crops was due to their chemical or physical contribution to the soil. Plant pots were loaded with earthworms at about 0.4 T/ha. By restricting earthworms to one half side side of plant pots and comparing plant growth performance on both sides of the pots, and by comparing these with completely wormless pots (control), statistical analyses show that plants on the wormless sides of wormed pots performed better than those in control pots. This suggested that some earthworm products crossed the cloth septa to positively influence the growth on the wormless sides. The differences represented the effect due to chemical products of earthworms that can cross the septa.

Plants on the worm sides of pots performed better than those on the wormless sides. Their difference represented the physical effects of the earthworms. It is estimated that chemical effects of the earthworm *Libyodrilus violaceus* improves *Amaranthus* (*Efo tete*: Yoruba) by about 32% and the physical effects by about 36%. The total effect of both amounted to about 68%. The growth parameters significantly improved are: plant height, leaf length, leaf area and number of leaves, whereas stem girth and leaf width are not significantly affected. This suggests that some chemical product of the earthworms affects primary apical meristem in the cell proliferation and elongation zones. This agrees with the suggestion that earthworms produce auxin and cytokinins (Dynes, 2003). The parameters most improved by the earthworms were those that most determine the market value of *Amaranthus*.

This should therefore be a good campaign factor to encourage farmers to adopt earthworm transplantation as a partial substitute for application of inorganic fertilizers.

Implications of Apical Growth Facilitation for Tea Farming

Tea is a home and office companion in many parts of the world and is a very important food and cash crop in many high altitude east African countries such as Uganda. Many homes and individuals may not go through a day without taking tea, at least once or twice. Whatever then improves this product should be a welcome idea. Since a major effect of earthworm products is fast apical biomass growth, on a theoretical consideration, application or multiplication of earthworms on a tea farm should produce large tea yield, in high grade and with high flavour. (Our table tea is produced from the first two apical foliage leaves from branches of a tea plant, and the internode between those two leaves. The stimulant and natural flavours in tea are concentrated in that portion).

Mr. Vice-Chancellor Sir, a few years ago I received an invitation from the Below

Ground Biodiversity Project, to train fellow academic and technical staff of tertiary institutions in and around the Makerere University, Uganda, on earthworm taxonomy and identification. During one breakfast a jolly gentleman, Mr. Stephen Nagenda of Tea Estate and Dairy Farms, a fellow guest in the University Guesthouse, initiated a discussion with me which led to my visiting his tea farm on a high mountain. There he share with me his experience and desires on how to regain the title of Best Tea Farmer of the Year, a title he had earlier won when Idi Amin was the military leader. The criteria included, among other, that the tea must be rich in stimulants and flavours and must be naturally produced. According to him, the worth of naturally produced tea in the United Kingdom Market is about £17 per kg, while tea planted with application of agrochemical may be priced at about £5 per kg. What a difference!

How does one achieve commercial tea farming without applying agrochemicals (no inorganic fertilizers, no herbicides, no pesticides, etc)? One of the best answers, and which I proffered to him, was to adopt earthworm-facilitated farming, noting how earthworms can facilitate achieving that:

i. They increase plant nutrient status and therefore plant health.
ii. With that the crop have improved natural immunity against microbes. Note also how earthworms can act as a microbe sieve by suppressing the growth of harmful microbes while at the same time step up the activities of the beneficial ones.
iii. Earthworms reduce weeding in a farm. And when moa is used for weeding, the resulting grass thatch provides a soil mulch that protects the earthworms, thus further increasing their population and effects on the (tea or any) farm.
iv. Earthworms reduce the level of pest infestation on a farm. In a recent study, yet unpublished, it was observed that the quantity of earthworms applied to potted *Abelmoschus* (Okro) is inversely related to the level of insect damage to the leaf area.

Earthworms on Lowland (Ofada) Rice Farms and on Limicolous Ecology

"When you go through waters, we will be with you", earthworms tell rice! The role of earthworms in improvement of marshy farm soils caught our attention. The site of our Pre-Degree Science Building used to be a waist-deep marsh where an interdisciplinary study of lowland rice was carried out by staff of our College of Agriculture and Faculty of Science, under the chairmanship of the oryzaologist Prof. V.A. Awoderu. On a theoretical consideration I decided to study, in a blocked randomized design, the effect of the distance of earthworm casts on the growth performance of the rice. The method was simply to measure the distance between a

rice stand and the nearest earthworm casts with respect to such growth parameters of rice as height, number of tillers, leaf width, length and area; number of grains per stand, mass of 100 grains at harvest, light absorption through the leaves. The results (Owa, Oyenusi, Joda, Morafa, and Yeye, 2003; Owa, Moreyibi, Dedeke, Olojo, and Fashunwon, 2004; Table 3) showed that the presence of earthworms at the base of a rice stand had positive effect on the parameters measured, especially the number and size of the rice grains.

Table 3: Gain in Growth Parameters of Rice Stands with Casts at their Bases Relative to those Lacking Casts

Growth parameter	Percentage gain of stands with wormcasts relative to those lacking casts
Height	6%
Leaf area	29%
Weight of rice grain per stand at harvest	41%
Number of grains per stand	28%

That result stimulated a further inquiry into how earthworms produce those effects. In another study with a geophysicist Dr. Mrs. Sola Fashunwon and others, we designed a simple IC device to investigate the physical contribution of earthworms to the soil. It was found that earthworms increase soil temperature by metabolic heat production. Since earthworms live about the level of the rhizosphere (10-20 cm depth) where the roots of common vegetables also exist, the heat generated is made available to the crop roots. It was also found that the surface casts of the earthworms were cooler than the parent soil, suggesting that the casts acted as heat radiator device (heat sink). This in a limicolous environment would result in thermal gradient and consequently in a convection current. The latter results in renewal of nutrient in the rhizosphere by the convection current. Therefore when earthworms are congregated at the base of a plant, the plant enjoys more than ammoniation of the environment; the temperature of its immediate environment is raised leading to improved physiological rate; nutrients are recycled around its rhizosphere. In addition, the pH of the soil is moderated always towards neutrality.

Earthworms increase energy capture by chloroplast. An experiment was conducted involving devising a simple IC photometer to estimate light absorption through the leaves of a field crops, and in relation to juxtaposition of earthworms with plant roots. It was found that when earthworm activities are juxtaposed with plant roots the leaves are denser to light passage because of good porphyrin formation resulting from availability of nitrogen in their rhizosphere (Owa, Moreyibi, Dedeke, Olojo and Fashunwon, 2004).

Should we not know the identity of such benefactors that improve our limicolous soils? In a study by Owa and Feyisayo Olojo the identification was carried out on the limicolous locations in and around Ago-Iwoye (Owa, & Olojo, 2003). The result reveals the following (Table 4):

Table 4: Earthworms Commonly Associated with Limicolous Environments in and Around Ago-Iwoye

SN	Name of species	biomass (ton/ha)	Density (worms/ha)	Siindex	Rel freq
1	*Libyodrilus violaceus*	0.375	0.326	0.34	31.8
2	*Benhamia* sp.	0.033	0.59	0.14	30.7
3	*Eudrilus eugenia*	0.016	0.086	0	18.5
4	*Ephyriodrilus afroccidentalis*,	0.018	0.080	0	8
5	*Alma millsoni*,	0.041	0.083	0.1	10.2
	Mean values	0.14	0.319	0.17	

What are the lessons from these data? *E. Eugeniae* is a versatile worm found from the marshiest to the driest part of Nigeria. It has been found to be an important occupant of Nigeria Coastal Swamp Forest. It has also been found in the low-and short rainfall zones of far northern Nigera. This versatility facilitates its contribution to nutrient recycling and soil enrichment in all types of soil. *E. Afroccidentalis* is a solid turret-type caster which consolidates the soil into large soil aggregates that are more difficult for water or wind erosion, and therefore a good protector of the soil. *Alma millsoni* extends across all of tropical Africa. And in its tons must be contributing significantly to feeding African in via their flood plane and river basin agroeconomy.

These worms and their other limicolous peers must have been very important to the economy of such ancient countries as Egypt and other countries along the Nile that dominated world economy for centuries and millennia. Could the history of the early Man also have benefitted from them? Very likely, for the story of the creation of Man was centered around the Garden of Eden set in a flood plane of the four Rivers Havilah, Gihon, Tigris and Euphrates (Genesis 2:8-14 in the Christian Bible). How many earthworms were present in the early earth? We may not be able to tell exactly. But we can surmise that if inorganic fertilizers were yet to be discovered at that time and yet the yields supported the populations, the number of earthworms and other beneficial soil fauna must have been large.

Earthworms for Banana and Plantain Farms

Mr. Vice-Chancellor, Sir, you may not have realized that I am more than *Baba Elekolo* (father of earthworm) but also *Baba Oniyan ati Dodo* (father of pounded yam and plantain) because my wife is a food vendor. I assist her in the kitchen to clear ownerless chips. I also watch students request for plantain slices to accompany their rice. In Yoruba tradition *dodo* (fried plantain) is friend of *d:mdu* (fried yam). Our primary school song *'oni dodo oni moin moin . . .* tell how popular plantain is among children. Banana and plantain are one of the most important food and cash crops of the tropical world. In Uganda *Matoki* (plantain) commands the same aural as pounded yam has among the Yorubas. Their productivity can be significantly

enhanced by introducing earthworms. Earthworms and bananas have some things in common, including the need for similar agronomic practices which favor their lives, for example:

i. Hand weeding is mostly recommended in a banana plantation because it is less destructive to the delicate banana roots and soil. Likewise, earthworms are affected by being cut or by turning up the soil and thereby exposing them to sunshine when digging.
ii. Mulching: This helps to stabilize the soil temperature and moisture and also provides food and shelter for earthworms. For bananas, it reduces the amount of weed in a plantation by choking the established weeds and denying light to those that require it for germination. It also adds nutrients to the soil as it is decomposed by the earthworms which eat the litter and leave the nutrients in their castings for the banana to use as a natural fertilizer which is non- polluting, thereby improving soil fertility.
iii. Nematodes, which are known to be one of the very harmful pests of banana are also known to reduce in population with earthworm presence in soil (Otulana, 2008). Thus, enhancing earthworm population in soil will help control nematode presence in such soils.

How Earthworms boost Banana and Plantation Production

Among my trainees during my invitation to Uganda were those sponsored by agricultural institutes that focused on the production of plantains. On their request, we had to brainstorm on how to harness earthworms to facilitate plantain production. First I had the scientific task to correct a widespread superstition that earthworms, (mistaken for nematodes) ill-affect plantains. I explained that on the contrary, earthworms exclude nematodes from the soil and therefore must be doubly very helpful to plantain field crops.

i. Earthworms create conditions that discourage populations of pathogenic soil organisms such as insects, nematodes and others that are harmful to bananas.
ii. The tunneling activity of earthworms prevents many of the conditions that weed seeds need to germinate, thus suppressing weed growth.
iii. By passing soil and organic matter through their guts, earthworms modify the soil always towards neutrality, and thereby increase the performance of banana.
iv. Bananas have shallow roots. This, coupled with leaching and runoff of minerals, tend to deplete mineral resources around their roots. Earthworms bring up minerals from deep in the subsurface, to the root level.
v. Their burrows facilitate the blunt-headed roots of bananas penetrating the soil.

vi. Earthworm casting brings to the surface what leaching has beaten down belowground, bringing up nutrients from deep in the soil and depositing them within the banana rhizosphere (the level at which the roots operate).
vii. Worms concentrate minerals in their castings in a form that is easy for the shallow roots of bananas to absorb. The co-occurrence of both wormcasting and banana roots near the surface is advantageous to the crop.
viii. The hormones produced by some enteric microbes of earthworms and of their castings are more readily available to banana roots because of the proximity of the castings to the roots and root hairs. Thus better rooting is expected and therefore better performance of the plant.
ix. By harvesting and transporting banana fruits to the urban areas, we also transport the soil nutrients. This horizontal transportation of the nutrients must be counterbalanced by the upward transportation due to earthworm casting.
x. Bananas have high demand for Nitrogen (N), potassium (K), Phosphorus (P) Magnesium (Mg) and calcium (Ca). Earthworms are known to increase soil Ca by a factor of 3, N by a factor of 5, P by 7 and K by 11. From their calciferous glands they secrete Ca taken from deep in the soil to within the banana rhizosphere. (Barley, 1961).

All banana growers, and indeed all shallow root croppers should be encouraged to introduce, multiply and encourage earthworms in their plantations for sustainable production, food security and better income. We could spare the use of nematicides and protect public health if we practice earthworm-facilitated production of banana and plantain production.

"Earthworms, Kindly Defeacate Here!"

Not only the earthworms themselves but also their casts are useful. Two professors of this University, Ayanlaja and Owa with their other colleagues (2001) conducted the investigation mentioned above into the importance of wormcast and found that they not only increased the germination of *Corchorus* (Ewedu in Yoruba) but made steeping unnecessary(Ayanlaja, S.A., Owa, S.O., Adigun, M.O., Senjobi, B.A., and Olaleye A.O., 2001). Mr. Vice-Chancellor Sir, shall we eat shit?

Yet there is a growing advocation to prepare wormcast meal to re-inoculate the enteron of man after it has been defaunated by excessive antibiotic treatment. Topical application of wormcast is already a commonplace.

Shall we eat earthworm shit? Before we reject this with a back-snapping-of-finger allow me to share with you this story from our Prof. E. Kayode Adesogan, Professor of Organic Chemistry. On learning about my preparation to give this

lecture, he literarily hurried to provide me a copy of his own Inaugural Lecture of 1987, a must-read for all. On p. 15 (Adesogan 1987), he writes:

> "One of my former headmasters in Primary School, Mr. D. Adoun told me that ground earthworm cast with salt to taste is useful for curing chronic dysentery. His father received a dramatic cure through it; he himself used it many times. I did not believe him . . ."

At the University of California at Berkeley, he, on a Rockefeller Foundation Fellowship visit, found his host, Professor Rapoport and team, working on synthesizing the potent anti-cancer agent mitomycin C from the soil. He began to wonder if the wormcast story could be true after all. On returning to Nigeria he set a Ph.D. student Mr (now Dr) Babajide Alo to investigate the wormcast story. He continues:

> *"We have now shown that earthworm cast intact (total water extract) has antibiotic activity against organisms which cause enteric fevers, ie, dysentery-like diseases. The remedy indeed works. The most interesting one isolated was characterised by the Commonwealth Mycological Institute in Kew as Fusurium oxysporium var. schelect. From this fungus we isolated various chemical compound using two different growth media for the fungus. The most interesing of this was a new compound which we named oxysporone."*

Premium Price on Despicable Earthworms?

We should appreciate that earthworms have value like any other livestock. Therefore we should think of how to make money from earthworms and their products.

Many factors come into estimating the worth of an animal: aesthete, service done by the animal, meat value, etc. The value of an animal also fluctuate with location, culture, season, and circumstance. Yet, like all index values we often attach to an animal a value that is to summarize all parameters considered. Obviously, such a value may not be exactly repeatable under a different circumstance, yet it satisfies the mind's curiosity to represent the animal by a monetary value. These considerations are particularly true of earthworms. The following parameters may be factored into computing the monetary worth of earthworms in a locality (Owa, Dedeke, Morafa, and Yeye, 2003; Owa, Aladesida, and Dedeke, 2007).

1. In term of their contribution to soil fertility, how much of fertilizers do they save us?
2. How much garbage disposal do they save us?

3. What is the worth of their water management services: leaching minimization, water held to full capacity, contribution to erosion control?
4. What is the worth of the plant growth factors attributable to their intestinal microbes?
5. How much can we afford to pay if they were gardeners employed to keep our gardens green?
6. How much do they save us in terms of plant health?
7. What is the worth of a kilogram of earthworm meat?

Some of What We Look for in Meat

Internationally, most meats are compared to that of fish, which is the most frequent meat fed to animals in culture. The comparison usually include proximate analysis (ie, how much of the basic food types: protein, carbohydrates, lipids, vitamins, are present). Much more important is a comparison of the amino acid quality, ie, how much essential amino acids are present per gram of the meat. Essential amino acids are those that we cannot manufacture in our bodies, and must therefore be taken in our diets. A meat richer in essential amino acids is generally regarded as more superior. In a similar way, we consider the quality of the lipid content. Lipids with polyunsaturated bonds are regarded as better quality because they release more energy per gram when metabolized in the body; they combust better, leaving le residue to be deposited in the body, therefore they a less health hazards than lipi with saturated bonds. Let us apply some of these factors to earthworm meat.

How Rich in Nutrients are Earthworms?

Some analyses done by my Ph.D. student, Mr. G.A.A. Dedeke and other researchers indicate that:

i. Earthworms are between 80-85% water, and therefore about 15-20% dry matter.
ii. The dry matter consists of 60-79% protein.
iii. The quality of earthworm meat is similar to fish meal, and is potentially better than beef.
iv. The quality of earthworm lipids and oils, though variable, could be manipulated through diet and breeding conditions, to attract premium price.
   a. The lipid content of earthworms can vary between 1 and 20% of the matter.
   b. Earthworm meal contains a range of long chain fatty acids, many of wh cannot be synthesized by non-ruminants.
   c. The lipid component is similar to some fish oils which are relatively high

φ3-polyunsaturated lipids and as such are high quality products that can attract premium prices.

d. Extraction of very high value fatty acids may be possible as a substitute for fish oils in a range of products.
e. The value of these fatty acids to intensive farming, in particular the aquaculture industry, may be significant.

Who Eats Earthworms?

i. Humankind: Earthworm is consumed among a few peoples, often for medicinal purposes. For example, among a Yoruba subethnic group earthworm is steeped and eaten with new yam to treat lower backache. In another Yoruba subethnic group, earthworm soup is given to a woman who cannot push at labour, and she is expected to successfully push within a few hours. In Plateau State of Nigeria are two groups that eat earthworms, according to two former earthworm students of mine who served the NYSC year among them.
ii. Animals in nature: Many animals pursue earthworms for food, including birds, pigs, doryline ants, etc.
iii. Earthworm in Animal feeds: Earthworms are today being included in animal feedstuff either as main ration or as food supplement.

Who? Me? Eat Earthworm?

In view of all the bodily benefits mentioned above, what stops us eating earthworm? About 1987 I gave a Faculty Seminar titled "Earthworms for Dinner" in which I attempted to test the acceptability of earthworm as food among the expectedly open-minded members of this university community. Near the entrance into the venue of the seminar, two plates were placed containing fried and crumbled meat preparations (meat pastries). Attendees were expected to take a bite from each plate and announce which of the pastries was the better. Of the about 100 attendees, only two tasted either of the preparations, and those two tasted which preparation they were convinced could not have been earthworm.

This illustrates the prevailing behavioral aversion to earthworm as food. Many will not even touch a live of dead earthworm, not to talk of tasting it. Yet, there is much to speak in favour of delicacing steeped or, better still, raw but blanched earthworm. When all necessary regulatory approvals has been secured, earthworm foods can be presented in the form of pastries. It seems to me that a dephobialization process has been initiated by presentations such as Macaroni, Indomie, and Spaghetti. I am proposing that a parallel name *Ekologhetti* (or Wormeal) could be adopted

(*ekolo*: Yoruba for earthworm). After securing the approval of the food and drug authorities (NAFDAC) such earthworm products could be prepared and treated as food supplements.

An alternative is to package worm meals into medicinal capsules to be given some appealing name such as Backprod (for back prod), Nostroke (for no stroke), Recovin (for recovery), etc.

Perhaps much more likely is indirect consumption of earthworm via lower food chains. Today much effort is on to produce enough earthworm to feed animal feed mills.

Preliminary studies on Nigerian earthworms as potential food supplement for fish fingerling has been initiated by Mr Gabriel Dedeke of our Department of Plant Science and Applied Zoology and my first Ph.D student. His finding are very encouraging and shows that earthworm feed mill has a good future prospect.

A Possible International Business in Earthworms?

i. We have begun to plan how to make hard currency by trading in earthworms. A study by my Ph.D. student, Aladesida (2004) shows that the cash worth of an earthworm depended, among other factors, on the species, location with respect to limnic environment and season of the year. Prices ranging between ₦50 - ₦500 per Kg.($0.40 - $3.80 per Kg) (Owa, Aladesida, and Dedeke, 2007).
ii. This may be compared with the values of $1.00 per dozen reported in a U.S. report.
iii. A report estimates that one million earthworms in some part of the U.S. could be worth $83,000.

Obviously, a potential international trade in earthworms is feasible after passing all necessary quarantine measures.

How Much Wage Can We Pay Earthworms for Their Services?

i. It is not easy to fix the worth of the services provided in terms of producing serviceable microbes in their gut and castings. An earthworm gut is a natural bioreactor which increases the beneficial microbial density in the material that it excretes by as much as 1000 times that of the parent soil. A highly fertile soil can contain seven tonnes of microbes and up to five tonnes of earthworm per hectare.
ii. By their functions earthworms increase Ca by a factor of 3, N by 5, available Phosphate by 7, and available K by 11.
iii. One study shows that earthworm-associated microbes add about 100 Kg N per

ha per year. (Recall that nitrogen (N) is a very important component of the NPK fertilizers.).

iv. One million earthworms weigh approximately one tonne, and consume up to their body weight of soil every 24 hours. If we can feed the soil and develop even one hundred thousand earthworm per hectare, this means many tones of natural N-P-K fertilizer which contain as well tonnes of useful soil bacteria yearly.

v. Since earthworms act to pull the pH of the soil (from acidity or alkalinity, but always) towards neutrality, this becomes a costable factor, as the process saves some amount in liming and acidification. This is achieved by the buffering actions of their calciferous glands and of carbonic acid.

vi. One estimate suggests that in some countries, at one million earthworms per acre one could expect over $83,000.

vii. Millions of Dollars could be realized yearly if tonnes of vermiculture and vermicomposting products are sold to the piggery, poultry, aquaculture industries and to farmers who need earthworms in their farm.

We may also think of costing for earthworms if they were to be produced for market purposes, and costing the worth of fertilizer application that earthworms could save. For example, it has been estimated that 25 earthworm/sq. ft. of soil is equivalent to 1 tons of worm per acre, which translate into 100 tons of castings (manure) per acre. This can be further extrapolated to mean 4 lbs of nitrate nitrogen, 30 lbs of phosphorus, 72 lbs of potash, 90 lbs of magnesium and 500 lbs of calcium, which in terms of fertilizer analysis is equal to 4-68-96 plus ¾ ton of limestone for a nutrient value of $34.15/acre.

Vermiculture: Domestication of Earthworms

We all should be involved with earthworm production on a small scale for various domestic and agricultural purposes. Our Earthworm team has been conducting a series of experiments to determine customized housing, bedding, feeding regime and other environmental settings for their domestication. (Owa, Aladesida, and Dedeke, 2007). An M.Sc. student is currently experimenting on how to achieve large scale production.

Why Breed Earthworms?

Breeding earthworms is one major area of focus in the study of the benefits of earthworms to man. The need to breed earthworms arises from the following major areas of concern.

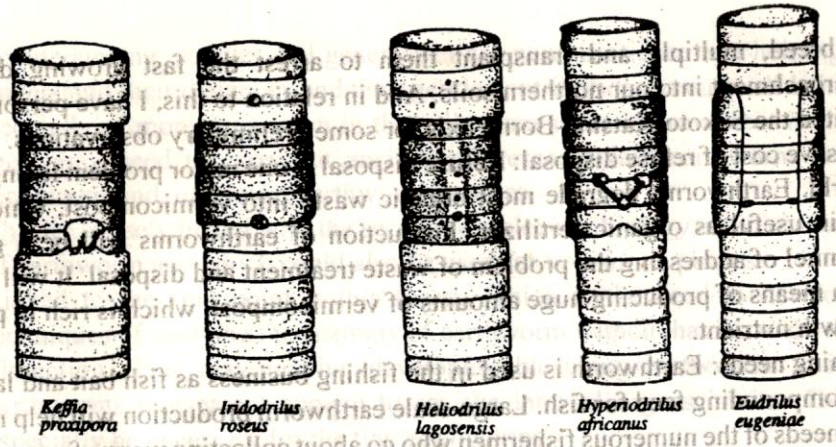

Fig. 3 External diagnostic features of some common earthworms including three hyperiodriloid species

i. For the purpose of distributing them to improve the fertility of our soils. Breeding earthworms will be a way of meeting the need of numerous farmers and gardeners who will need earthworms to help improve the soil fertility of their farmland, thus increased farm yield. It itches me to tell the following story. At the formal defence of my Ph.D. proposal at the University of Ife (now Obafemi Awolowo University) Ile-Ife, the late renown soil expert Prof. Ashaye told me how a contract was almost entered between Nigeria and a foreign country to import earthworms into Nigeria to improve our soils and facilitate reforestation of our desert encroached northern soils. The pact was almost signed when a new Minister was suddenly appointed who, though agree with the need, felt an important need to play safe; he would not want to be blamed for awarding out such a contract if a Nigerian professor could handle the project. He did not know any earthworm professor and therefore contacted Prof. Ashaye, a professor of soil. Ashaye referred the Minister to A.O. Segun, the only professor on earthworm at that time. Some how, the contract was stalled and has remained so till today. It was speculated that while the need to mass-produce earthworms remained for agricultural and soil conservational purposes were accepted as a necessity, the contract must have been broken because personal gains in foreign currencies were frustrated. Nigerian soils still cry for earthworms.

Our research team has identified the hyperiodriloid group of earthworm genera *(Heliodrilus, Hyperiodrilus,* and *Iridodrilus,* Fig. 3*)* as the best for the purpose of conservation of northern Nigerian soils. We regard it an urgent need

to breed, multiply and transplant them to arrest the fast growing desert encroachment into our northern soils. And in relation to this, I have personally visited the Sokoto-Katsina-Bornu axis for some preliminary observations.

ii. To save cost of refuse disposal: Refuse disposal is one major problem facing the world. Earthworms degrade most organic waste into vermicompost, which is again useful as organic fertilizer. Production of earthworms will be a good channel of addressing the problem of waste treatment and disposal. It will also be a means of producing huge amounts of vermicompost, which is rich in plant growth nutrient.

iii. Fishing needs: Earthworm is used in the fishing business as fish bait and lately in compounding feed for fish. Large-scale earthworm production will help meet the needs of the numerous fishermen who go about collecting worms from ponds as well as meet the needs of the fish-breeders who may need earthworms as feed for their fish.

iv. General animal feed formulation:

v. The growing discovery of the ethnomedicinal values of earthworms suggest that

Room for Scientists in the Earthworm

All can frame an economic/utilitarian question about earthworms, and think out some aspects of earthworms that need to be researched for the purpose of improving their services to humankind. Though it has been known for quite some time now that earthworm plays a great role in aiding healthy plant germination and growth, the impression and knowledge of how the earthworm is able to effect this positive impact was not as clear, as it has become now. As a result of this sudden awakening to the fact that earthworm is such a beneficial animal, which is bestowed with much grace, there seems to be a flurry of activity by researchers from various fields to dig into the yet untapped benefits of the earthworm.

Some of What We Still Need to Know about Earthworms

i. First and foremost our knowledge of the diversity of earthworm and their taxonomy needs upgrading. There seems to remain quite a number of species unknown all over the world, all with their distinct differences and adaptability. If researches in any other area of earthworm will be meaningful, it is needful to understand how to recognize the different species of earthworms on the field.

I am also happy to announce that a Ph.D. thesis is near completion under my supervision, carried out by the indefatigable Mr. Adeyinka Aladesia who has been studying the non-eudrilid earthworms of southwest Nigeria. He will soon

be announcing species and genera that are new to science and helping us to understand their dynamics and their gentle contributions to our well-being.

ii. Secondly, if more earthworm in the soil means more improvement in the soil, there is a need to carry out an in-depth research into earthworm breeding techniques and, of course, earthworm genetics

iii. Thirdly, closely linked with the second is molecular biology and biotechnology of earthworm and which could also be used for taxonomic purpose.

iv. Linked to the first point is this fourth, which is the need to develop new techniques of studying the anatomy of earthworm without having to go through dissection. This may involve developing bleaching methods to make the earthworms transparent enough to see the internal organs in-situ. This may especially be necessary for the tiny earthworms.

v. To make meaningful progress in earthworm research, there is need to conduct in-depth physiological work on the earthworm. This is in a bid to understand normal functioning in earthworms and their reactions under various environmental conditions, such as lights of different wavelength, temperature, water-logging/flooding of their soil pores.

vi. Emanating from the above is the use of earthworms as bioindicators of soil and water pollution. Our understanding of earthworm physiology will help in knowing the reaction of the various species of earthworms to various types of pollution/pollutants

vii. Since earthworms are being touted as protein supplement in animal feed formulation, there is a need to study the amino acid profile of various species of earthworms. I am pleased to announce that a Ph.D. work on the nutritional qualities of four Nigerian earthworms has been completed by a member of our earthworm team, Mr. G.A.A. Dedeke. The thesis is only awaiting external examination. This will help to determine the actual quality of their protein as compared to meat or fish, this line of research falls under biochemical studies of earthworm. The important molecules of the earthworms should be studied, including their enzyme and hormonal systems.

viii. Another area for an in-depth study is the role played by earthworm cast in soil fertility, and improvement of soil physical structure (stability), thermal insulation, convection of soil micronutrient.

From the foregoing, it is quite clear that researchers from various fields need to be involved in the study of the earthworms.

Room for Physicists in the earthworm: Some lines of earthworm researches can

benefit from the insight of Soil Physicists. For example, how wormcasting initiate thermal and nutrient convection in the soil, how earthworm create micro-environments around roots of plants and the nature of such environments. Also because most effects produced by earthworm in the soil first occur at micro-level, there is need for physicists/technologists to develop micro instruments which are sensitive enough to measure these micro-variables (Owa, Peters, Dedeke, and Aladesida, 2008)

And for Chemists and Biochemists too: Quite a number of earthworm studies already involve many biochemists; examples include the following:

a. pore-forming protein in ceolomic fluid of earthworms
b. comparative study on earthworm hemoglobins
c. Production of a collagen-like substance detected by the garter snake vomeronasal system, which substance can be used to trap the garter.
d. Low backache relieving substance in the earthworms.

Room for Economists in the earthworms: The studies on earthworm will not be complete if they cannot be converted to economic gain and policies. It is therefore necessary for economists to carry out evaluation of earthworms: their products and activities in the soil in monetary terms.

Room for Obstetricians

Very Potent Oxytocin Analogues in Earthworms can also be very effective midwives! In the 1980s it was the habit in this University to organize exhibitions preparatory to Convocation Ceremonies. In one of them (about 1987) I organized that for the Department of Biological Sciences in which I show-cased earthworms. After carefully listening to me the Late Obaruwa of Ago-Iwoye took me up on what I knew about earthworms. After my proud and hurried answer, he asked if I had learned that earthworms are used to assist parturition in women. I was blank about that aspect. To celebrate his victory over the proud lecturer he added with a tone of finality: *"Any woman administered the earthworm preparation must put to bed within two hours, "if the world does not have a negative hand on her"*. I kept that humbling lesson in my heart, though still protesting about the escapist phrase that failure can be attributed to "hand of the world". It took me about 20 years to place an undergraduate project student (in 2006) to administer a questionnaire to determine ethno-applications of the earthworms. A recurring response was its parturitive use. Fortunately, our present Department of Plant Science and Applied Zoology hosted

a conference of Herbal Practitioners of south-western Nigeria that year. The questionnaire was administered to them also, getting the same response. Our Earthworm Research Team, headed by Mr Gabriel Dedeke, administered the questionnaire to participants in a National Conference of a Church Denomination and from the few and inhibited responses the answers were the same. It became obvious it was me who did not know: their ethno-application in parturition was a widespread practice. In fact, literature show that this has been practiced in some parts of the world (eg. India, China, etc) from time immemorial. What is more, literature (Omoseebi, 2007) states that earthworms contain an oxytocin analogue which is about ten times more potent than the human oxytocin.

How is the earthworm prepared and applied to a woman in labour? From the responses to our questionnaire, the earthworm is ground and added to other additives to disguise it so that the consumer does not reject it due to psychological aversion; it is sweetened with sugar or honey. Most respondent claim the effect was immediate or nearly so. This then is good new if we could tap into it: our wives should spend less time in the labour room.

Of course this leads to more questions. Is the efficacy of oxytocin analogues from Nigerian earthworms of the same potency as that in literature? Do all species of earthworm produce the same level of efficacy? What functional group distinguishes these analogues from the human oxytocin? How does the analogue escape being digested by the intestinal enzymes? Or do the enzymes even help process them into the active form that then get absorbed? Will western trained obstetricians ever adopt to use earthworm preparations?

Room for Rheumatologists

Because of the erect posture that accumulate weight on our lower lumbar vertebrae, many suffer low-back ache. This can be debilitating when it involves a slipped disc (prolapse of an intervertebral disc). In folk medicine, earthworm meals are prepared for the sufferer. An immediate relieve is expected. Again, how does this work? Are there some component of the earthworm that strengthens the tonus of the longitudinal ligament of the vertebrae thereby preventing herniation? Or that prevents rupture of the nucleus pulpsus? Or is such component merely a strong analgesic? Or a combination of all these? Rheumatologist need to study this. Oligochaetotherapy for rheumatism could become significant in the future when we realise that according Adelowo (2005) as high as 30-38% of rural populations may suffer some form of arthritis. Thus, earthworms can become friends of the Senior Citizens who are more predisposed to rheumatism.

Earthworm in the Treatment of Stroke

Stroke has become a household terrorist whose fear is the beginning of long life. According to Hademenos (2006) Ischelmic stroke is caused by thrombosis and embolism in a carotid artery which thereby deprives the brain of nutrients and oxygen. When stroke is properly diagnosed the treatment focuses on removing the obstruction, restoring blood flow to the deprived region of the brain and preventing the development of complications. In the current treatment a drug called tissue plasminogen activator (t-PA) is administered which is a thrombolytic agent (ie, a clot buster) that breaks up blood clots and thereby restore flow through the obstructed blood vessel. But it is effective only when administered within the first three hours of a stroke, ie before the affected region of the brain is dead.

A thrombolytic agent has been identified in earthworms which could be of help to stroke patients. Obviously, it is worth investigating how to prepare this agent promptly to provide a first aid to victims of this world's third worst killer disease. Oligochaetotherapy could be very important in villages and other locations where there is little or no access to modern drugs and hospitalization. After necessary studies, can a prompt earthworm meals be offered to a new stroke patient as a first aid?

There is an urgent need to experiment on a possible synergism between this oligochaetogenic and some other herbogenic agent commonly administered in current ethnomedicare.

Geologists must hear this: Earthworms can guide in metallurgical exploration! My Ph.D. work and several other undergraduate studies indicate that the density and biomass of earthworms are positively and significantly correlated with the quantity of Fe in the soil. This, of course, should not be much of surprise because they, like us, use haemoglobin as oxygen carrier in their blood system. A regression analysis has been computed and a model suitable for predicting the economic size of Fe in the soil is being developed.

Lesson from Earthworm Taxonomy on the Nature of the Original Creation

Why did God make animal taxonomy man's earliest duty?

In Genesis 2:18-20 we read as follows:

18 ¶ Then the LORD God said, "It is not good that the man should be alone; I will make him a helper fit for him.

19 So out of the ground the LORD God formed every beast of the field and every bird of the air, and brought them to the man to see what he would call them; and whatever the man called every living creature, that was its name.

20 The man gave names to all cattle, and to the birds of the air, and to every beast of the field; but for the man there was not found a helper fit for him. (Revised Standard Version)

It is interesting to note from this passage that the first taxonomic exercise resulted from the desire of the Creator to find a companion and helper for the first Man. And that principle is still relevant till today. Animals impact on Man; the animal groups that have been most studied taxonomically are those that made the highest impact on Man. Some of them have been in the service of Man and others distracting Man.

A second point noteworthy in that passage is God leaving the naming to Man. Why didn't he do the naming Himself? I suggest that God, having completed creation and declaring them perfect, left room for unending variability among the created kinds that would become manifest with time and history, and for which Man must learn to name the new forms as they arose.

A third point that caught my attention in that passage was how many kinds of animals would have existed that Adam was able to name them? It is estimated that about one million animal species exist today, and about 10,000,000 are already extinct. (Mayr, 1971). If Adam lived 488,808,000 minutes (930 years * 365 day * 24 hours * 60 min) he would have spent an average of about fifty minutes to understand the taxonomic characters of an animal species enough to name it (and that apart from plants). That would have been a life-long duty. While it is conceivable that God could have endowed him with special power to do that duty, he would then have wasted on their taxonomy the time needed to enjoy their company and services. Much more probably, the number of original species was few enough for him to handle promptly.

It is pertinent here to note that God did not create species in today's sense of the word! What he created were kinds from which species catavolved (not evolved). We read in Genesis 1:

Verse 11: And God said, "Let the earth put forth vegetation, plants yielding seed, and fruit trees bearing fruit in which is their seed, each according to its kind, upon the earth." And it was so.

Verse 21: So God created the great sea monsters and every living creature that moves, with which the waters swarm, according to their kinds, and every winged bird according to its kind. And God saw that it was good.

Verse 22: And God blessed them, saying, "Be fruitful and multiply

and fill the waters in the seas, and let birds multiply on the earth."
23 And there was evening and there was morning, a fifth day.
24 ¶ And God said, "Let the earth bring forth living creatures according to their kinds: cattle and creeping things and beasts of the earth according to their kinds." And it was so.
25 And God made the beasts of the earth according to their kinds and the cattle according to their kinds, and everything that creeps upon the ground according to its kind. And God saw that it was good. (Revised Standard Version. Emphasis mine.).

It is noteworthy also that it was "kinds" that came to Noah for protection during the deluge. In Genesis 6: 20 we read:

Of the birds according to their kinds, and of the animals according to their kinds, of every creeping thing of the ground according to its kind, two of every sort shall come in to you, to keep them alive

According to Strong' s Hebrew dictionary, the word for "kind" carries a plural sense, a sense of sampling out of a pool. That suggests that the Creator already placed in a "kind" the power to become many. And over the history of the Earth each kind has become many.

How do earthworms exemplify this principle? In the biological species definition a species is one or more populations that are reproductively isolated, i.e. those that can freely interbreed among themselves, but not with non-members, and non-members cannot interbreed with them. By this definition, if some event took place and some members of a population lost their ability to freely interbreed, they cease to be members of the same species. In taxonomic language we say that they have speciated. Speciation is therefore a loss of the power to interbreed with members of the kind. Often it goes through an intermediate stage which we call sibling species (two or more species that look superficially identical but which have lost the power to interbreed).

Not Evolution but Catavolution: Is it a matter of semantics if we say a new species has evolved, or that the original species has dysvolved or catavolved? To some extent, the choice depends on the affective domain. The prefix *dys-* suggests ill, bad, impaired, pathological. An alternative word is catavolution (*cata* Gk: downward,

apart). I suggest that either of these words better represents what truly happened than the word evolution (Latin *e exo:* outward; *volver*: to roll out: evolution means rolling out in a gradual development). Borrowing an attitude from medical science, when a cell, tissue or organ becomes incompatible with self, we regard it as dysfunctional (bad, impaired, undesirable and pathological). When the products of a kind of animal become incompatible with the parental stock it must be catavolution or dysvolution, but not evolution.

Catavolution in Animals: We observe before our eyes the process of catavolution in dogs. Our domestic dog *Canis familiaris* today comprises about 200 varieties some of which cannot not readily interbreed. For example, the cat-sized breeds are too low in height to interbreed with the great Alsatians. Yet, they all arose from the same parental stock.

Consider the case of the four earthworm congeners (congener: species belonging to the same genus) *Keffia nigeriensis, K. variabilis, K. proxipora* and *K. penetrabilis*. The first two were described by Martha Clausen (1963). *K. nigeriensis* bears a pair of protuberances for sperm intromission. In *K. variabilis* there are no protuberances. In describing *K. proxipora* (See Fig. 3) Segun and Owa (1990) noticed that the paired protuberances were juxtaposed and will not fit into the spermathecal pores (the pores of the egg-storage bags) of *K. nigeriensis* or *K. variabilis* when mutual insemination occurs during copulation. In *K. penetrabilis* the protuberances have combined inside the earthworms to produce a unimodal external protuberance. By that structure, it too cannot interbreed with either of the other three congeners. Thus, the four phena were speciated into four belonging to the same kind. Shall we regard this as evolution or catavolution? In the sense that there has been a loss of self compatibility from the parental stock, this represents catavolution.

At genus level, consider the four earthworm genera: *Polytoreutus* Michaelsen, 1890. *Agrotoreutus* Segun, 1976, *Parapolytoreutus* Segun, 1980 and *Segunodrilus* Owa, 1995. Some of the defining characters of these genera are shown in the following Table 5

Table 5: Some of the Diagnostic Differences Between some Polytoreutoid Genera

	State in the genus:			
Character	*Polytoreutus* Michaelsen, 1890	*Agrotoreutus* Segun, 1976	*Parapolytoreutus* Segun, 1980	*Segunodrilus* Owa, 1995
Testes	Metandric	Holandric (both	metandric	Holandric

	(Posterior pair only)	and anterior and posterior pairs present		
Penial setae	Nill	2 pair	1 pair	2 pairs
Spermathecal pores w.r.t. male pores	posterior to male pore	posterior to male pore	posterior to male pore	anterior to male pore
Ventral esophageal sacs	unpaired condition	paired	paired condition	unpaired conditn.

Owa 1995 reported two West African species of *Polytoreutus* that bear one pair of penial setae. That breaks the traditional definition of the genus. Those two species *Polytoreutus peniachaetophora* and *Polytoreutus obuduensis* are intermediate between the genera *Polytoreutus* and *Parapolytoreutus*, the only difference being the paired condition of the ventral esophageal sacs in *Parapolytoreutus* and their unpaired condition in the genus *Polytoreutus*. (Fig. 4).

In another publication Owa (1998) showed that these genera and some others form a profile in which some (latent) characters are either manifest or cryptic. These types of findings are characteristic of many taxonomic work: many groups of animals form a series that differ mainly in some highly weighted diagnostic characters. A careful study of all members usually indicates that there must have been a parental stock from which all others derived. As the offsprings catavolved, some characters become lost or unexpressed. Could such non-expression be due to genes that become recessive? If affirmative, such changes are in genetic regarded as negative, in which case the resulting "new species" are catavolutionary products. They remind that the number of original kinds was far fewer than the number of species known today and that today's species have been produced by losses of some characters that were present in the parental stocks.

Evidence from Post-Mendel Observations Support Catavolution Hypothesis Since Mendel there have been careful observation of the species and the changes that take place around them. Ecophenotypism has been observed which has only created more impression that there must have been an original stock from which ecophenotypes derived genetically and adaptively.Such stock must have been the Genesis kinds. Oligochaetology is replete with examples. For example, the well established genera *Eudrilus* (Kinberg, 1866) *Eminoscolex* (Michaelsen, 1896), *Vomia* (Segun, 1976), form such a series that could be combined into a theoretical parental stock.

We also expect that the rate of speciation should accelerate because of the ever-increasing deterioration of our biosphere, due largely today to the activities of man which expose species to mutagenes. At Eden, these were not so.

The *Eudrilus-E minoscolex* Earthworm Genera Point to Catavolution

The tropical African earthworm family Eudrilidae is unique among others in the direct anatomical connection between their spermatheca and the ovary via a duct which I have named the covarian duct. A spermatheca is a little sac for storing sperm received from a patner during copulation. Own sperm is stored elsewhere in a paired sacs called seminar vesicle. The ovary is where own eggs are produced. In all

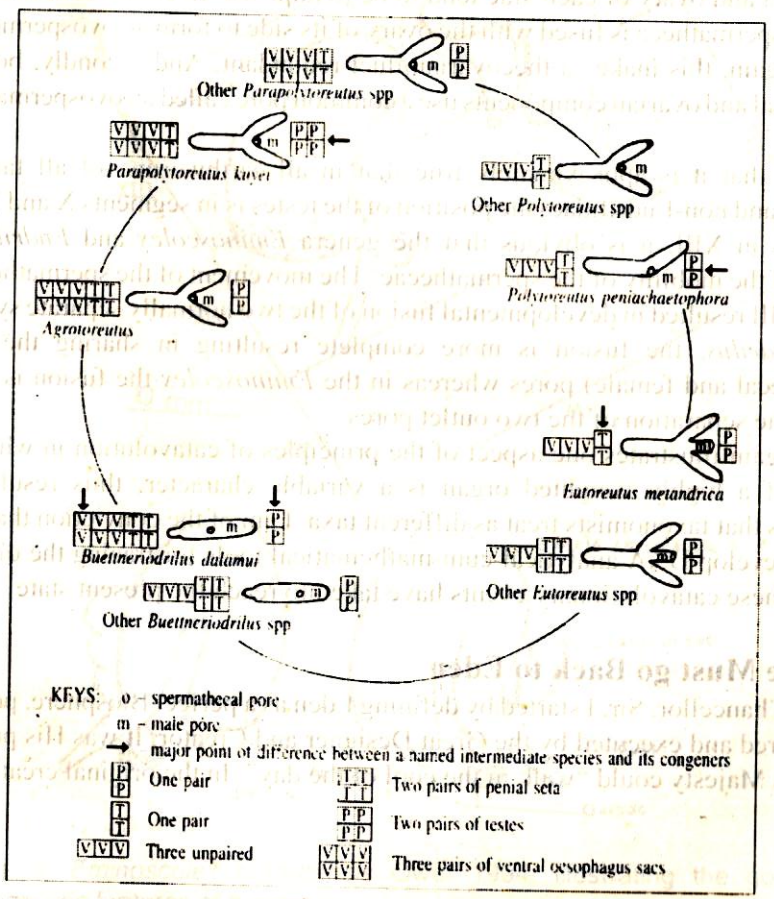

Fig. 4: Catavolutionary trend among some polytoreutoid earthworm genera

earthworms other than the Eudrilidae, the received sperm and eggs are released for fertilization outside the body (external fertilization). In a eudrilid earthworm, however, received sperm are dolled out of the spermathecae via the the covarian duct to meet the eggs released from the ovary. The two meet in the little sac called fertilization chamber. Thus, the Eudrilidae undergo internal fertilization, the only group of earthworms that do.

The genus *Eminoscolex* is, in part, diagnosed by (a) the paired condition of its spermathecal systems, (b) the distinction of the spermathecae from the ovaries and (c) the separation of the ovarian pores (female pores) from the spermathecal pores (Fig. 5). This does not necessarily imply the existence of a thecovarian duct as the spermatheca and ovary of each side tend to be juxtaposed. In contrast, in the genus *Eudrilus* a spermatheca is fused with the ovary of its side to form an ovospermatheca (Fig. 6). Again, this makes a thecovarian duct redundant. And secondly, both the spermathecal and ovarian components use a common pore called an ovospermathecal pore.

Noting that it is approximately true that in all earthworms (of all families, Eudrilidae and non-Eudrilidae) the position of the testes is in segments X and XI and the ovaries in XIII, it is obvious that the genera *Eminoscolex* and *Eudrilus* are products of the mobility of the spermathecae. The movement of the spermathecae to segment XIII resulted in developmental fusion of the two normally separate systems. In the *Eudrilus*, the fusion is more complete resulting in sharing the outlet (spermathecal and female) pores whereas in the *Eminoscolex* the fusion is partial allowing the separation of the two outlet pores.

This again illustrates one aspect of the principles of catavolution in which the position of a highly weighted organ is a variable character, thus resulting in differences that taxonomists treat as different taxa. I am of the conviction that soon, we shall develop DNA analytical-cum-mathematical tools for tracing the direction in which these catavolutionary events have taken to reach the present state.

Why We Must go Back to Eden

Mr Vice-Chancellor, Sir, I started by defining Eden as a perfect Biosphere, perfectly architectured and executed by the Great Designer and Creator. It was His pride, on which His Majesty could "walk in the cool of the day". In the original creation, the

biosphere was perfect. The ozone layer had been put in place with a water column to filter off the deleterious waves that today trouble us. That the whole world was once tropical-canopied is evidenced in the finding of forest-like fossil plants in places that are today deserts and the caps of the Earth. The sun itself was healthy and gave its

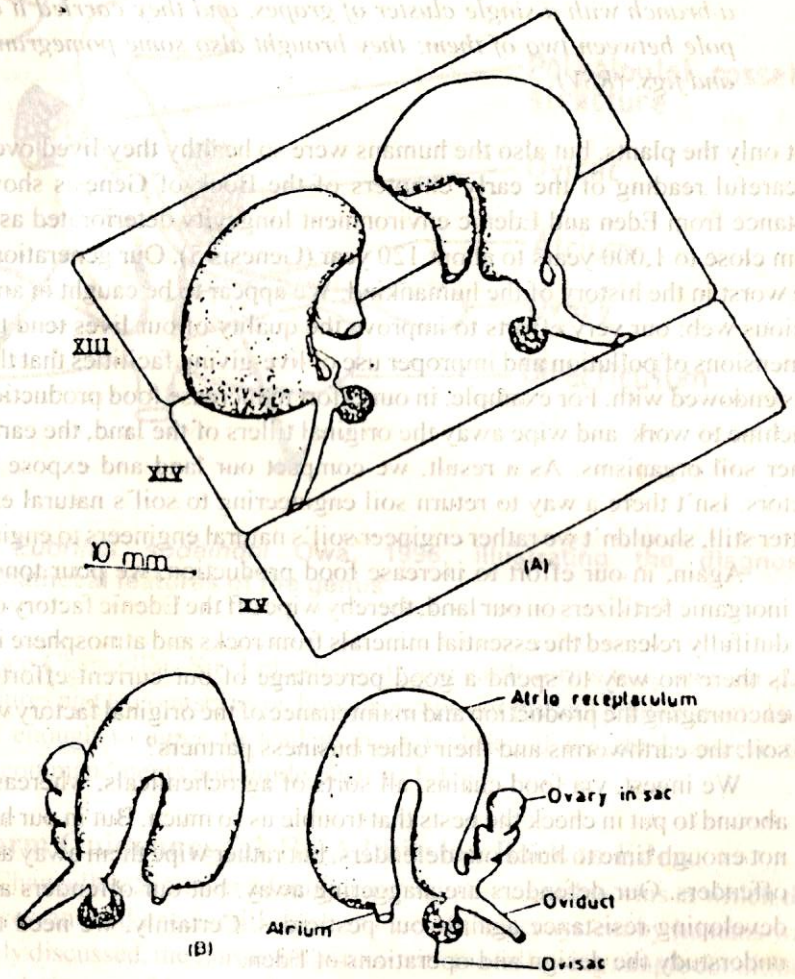

Fig. 5: *Eminoscolex buraraensis* Owa, 1994, illustrating the gonadal diagnostic features of the genus

best and the biota responded at its best resulting in high productivity as shown in fossil kind of fruits that were unbelievably large. The 'Joshua Spies' had to use a pole to carry a bunch of grapes between strong men back to their Israeli Camp. Numbers 13:23 says of the spies sent by Moses:

> *23 And they came to the Valley of Eshcol, and cut down from there a branch with a single cluster of grapes, and they carried it on a pole between two of them; they brought also some pomegranates and figs. (RSV)*

Not only the plants, but also the humans were so healthy they lived over 900 years! A careful reading of the early chapters of the Book of Genesis shows that with distance from Eden and Edenic environment longevity deteriorated asymptotically from close to 1,000 years to about 120 year (Genesis 5). Our generation is probably the worst in the history of the humankind. We appear to be caught in an inextricable vicious web: our very efforts to improve the quality of our lives tend to create new dimensions of pollution and improper use of live-giving facilities that the early earth was endowed with. For example, in our effort to increase food production we put the machine to work and wipe away the original tillers of the land, the earthworms and other soil organisms. As a result, we compact our land and expose it to erosion factors. Isn't there a way to return soil engineering to soil's natural engineers? Or better still, shouldn't we rather engineer soil's natural engineers to engineer the soil?

Again, in our effort to increase food production, we pour tons and tons of inorganic fertilizers on our land, thereby wipe off the Edenic factory operators that dutifully released the essential minerals from rocks and atmosphere into our soils. Is there no way to spend a good percentage of our current efforts and budget encouraging the production and maintenance of the original factory workers of the soil, the earthworms and their other business partners?

We ingest, via food chains, all sorts of agrochemicals, whereas earthworms abound to put in check the pests that trouble us so much. But in our haste, we have not enough time to build our defenders, but rather wipe them away along with our offenders. Our defenders are staggering away, but our offenders are adamantly developing resistance against our pesticides. Certainly, we need to go back to understudy the design and operations of Eden.

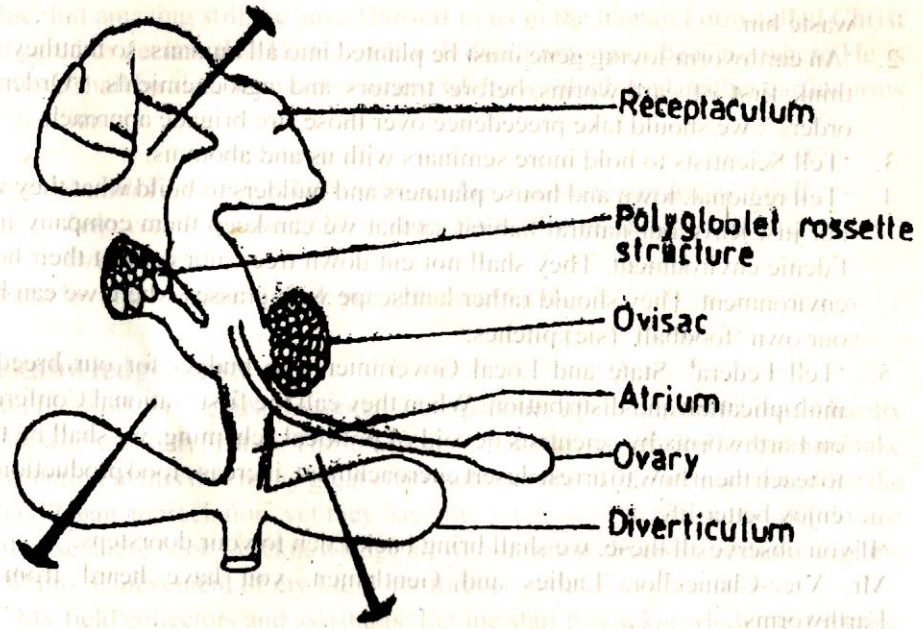

Fig. 6: *Eudrilus sodeindei* Owa, 1996, illustrating the diagnostic ovospermathecal features of the genus

Mr. Vice-Chancellor, Sir, I pleaded with the earthworms to ignore our past human failures and to counsel us on how to escape our present predicament. They were kind enough to agree to lead us back to Eden if we shall observe the following commandments and guide posts to Eden.

Earthworm Guidelines for Re-Admission Back to Eden

Mr. Vice-Chancellor, Sir, from a family meeting of the Earthworms at which the issue of incessant and unscientific disturbance of the ecosystem by humans was exhaustively discussed, the Earthworms rose with the following simple conditions for the re-admission of humans back to the Garden of Eden. I quote them as follows:

1. 'Every human must be familiar with, friendly to, and defend earthworms. We

(Earthworms) will keep their wives and family company in the kitchen, but restrict ourselves to their waste bins. We will not ask for a room other than the waste bin.

2. "An earthworm-loving gene must be planted into all humans, so thatthey will think first of earthworms before tractors and agrochemicals. "Orders is orders": we should take precedence over those fire brigade approach.
3. "Tell Scientists to hold more seminars with us and about us.
4. "Tell regional, town and house planners and builders to build what they will, but just leave our natural habitat so that we can keep them company in an Edenic environment. They shall not cut down trees, nor cement their house environment. They should rather landscape with grasses where we can have our own "foodball" (sic) pitches.
5. "Tell Federal, State and Local Governments to budget for our breeding, multiplication and distribution. When they call the first National Conference on Earthworms by scientists devoid of political scheming, we shall be there to teach them how to arrest desert encroachment, increase food production and enjoy better life.

"If you observe all these, we shall bring back Eden to your doorsteps."

Mr. Vice-Chancellor, Ladies and Gentlemen, you have heard from the Earthworms.

God, Earthworms and You

Mr. Vice-Chancellor, Sir, about 15 years ago I gave a seminar on "God, Earthworms and You" at the Annual National Conference of E C W A Church, held at Egbe. After we compared the anatomy of the earthworms with ours and studied the dutiful services earthworm gave us free of charge, we realized that the Creator must be very interested in us. He must be very wise. His original intentions in the Garden of Eden must have been wonderful. He must be very complicated, yet simply loving.

Today, some philosophize that particles and atoms are just obeying the laws of physics and thereby producing organisms (including earthworms) that diligently obey the same laws to perform their functions. However, we are left wondering why they obey the laws diligently as if under some constantly constraining principle. What will happen if their obedience to the laws of physics is reversible at intervals, or *ad libitum*, or stochastically? The Creator says, "*For I the LORD do not change, therefore you, O sons of Jacob, are not consumed.*" (Malachi 3:6, RSV)

His constant love gave us not only the quotidian earthworms of premium value, but amazing still, he gave Himself to us in the human Form called Christ and cared to declare that He Himself will dwell among us because where He is there we shall be also, in an environment where we shall need neither earthworms nor the Sun.

> *Isaiah 41:14 Fear not, you worm Jacob, you men of Israel! I will help you, says the LORD; your Redeemer is the Holy One of Israel. (RSV)*

What a loving, transcendental, yet immanent God.

Acknowledgements

I and the work I have just presented are a product of Community Love. I hardly know where to start or stop. Those whose names I fail to mention here should take consolation in this that many great contributors in the Bible are not named for the usual human appreciation, yet they have their names in the Book of Life. I must write a separate book to acknowledge all whose timely diverse injections kept me on to this achievement of my life. I am forever grateful to you all.

My field collectors and assistants: Let me start this acknowledgment section with the *Egg-or-Hen* riddle: *which comes first?* Who is the discoverer of an earthworm: the collector or the Owa who described it? Early in my earthworm career, Miss Margaret Dada (now Mrs Keshinro, sister-in-law) and Miss Tioluwalashe Owa (now Mrs. Arobadi, younger sister) were my earthworm collectors. Then came Mr Kayode Yeyeodu, whose mother partly fostered me; and also cousins Olasunkanmi Sunday and Akindele Yeye. These young men volunteered free service in all my earthworm collecting trips round the entire country. *Iridodrilus kayodei* and *Takunodrilus yeyei* were named after two of them. I did all I could to turn Mr Yeye (now named Mr. OniOko), our present Faculty Officer ,Engineering (B.Sc. Geography and Regional Planning) to pursue biogeography of Nigerian earthworms, but he would not, in spite of his having all the earthworm ball at his feet. Apart from the collection, he did the drawings and typing of most of my publications. He was a gift of God to me.

Laboratory Staff: Among the goodness and mercy that follow me were Mr. Demola Sodeinde, first Laboratory Assistant in our Department of Chemical Sciences, of the Royal Sodeinde Family of Ago-Iwoye here. He did my early driving before I became a licenced driver. In 1984 while I was in an ASUU meeting at Nsukka he collected the material that I much latter described as a new

species of *Eudrilus sodeindei*, named after him. Though he is inevitably absent from this occasion, he is represented by the ever jovial and ever young octogenarian mother and the ever-radiant Sister, Mrs Nike Tolofarin of our Deputy Vice-Chancellor's Office. Mrs Victoria Ogunbanjo and Messrs Olayiwola and Adegoke provided me contacts and materials that enabled me to get going.

Our physics Lab staff were also wonderful. Messrs Hector Otayemi, now in private electronic practice and consultant to many state governments on energy, and Sefiyu Odutola, not only assisted with designing my early simple electronic equipment, but they also personally volunteered to assist with field collections. Mr Abiodun William was always translating my lofty ideas into electronic devices that the boys constructed. When I shifted attention to ecological studies Messrs Ojo and Odejobi manufactured my soil sterilizer. Mr J.O. Aderibigbe has learned with his humours to tranquilize my fuming and barking whenever I approached him with a computer that cough twice. He has always made it possible to forge ahead.

Messrs Bayo Adeeko and Sola Coker, our former Lab Technologists during my times of field work and the current Technologists Kehinde Famuyiwa, Olumide Adesanya, Omowunmi Abimbola, know that a way to make me cry is when they fail to make available what I need to work with, and they did all within their ability to provide such materials and assistance.

Financial Assistance came from many quarters. The Evangelical Church of West Africa, (ECWA) awarded me merit scholarship all of my secondary school days. The last ones in my undergraduate days were more timely than Manner from Heaven.

The Federal Scholarship Board gave me Scholorship Awards both at Undergraduate and Masters Levels.

Cousin Olajide Ologun provided my first Titcombe College wears. When the Ordinary Level was completed and hope of H.S.C. was foreclosed, God, the Master Guide, sent a young man, one Mr. Peter Mansfield, from U.K. on Voluntary Service Overseas to Nigeria. When I failed to show up for H.S.C. Mr. Mansfield came to my home to invite me with a down-payment of my school fees for the term. I have not been able to reach him to announce that his seed has germinated into a Professor. He shares many traits with the Nobel Laureate Peter Mansfield, except for their irreconcilable age difference. On Mansfield's return to the U.K. Pa Rev. and Mama James Akintola of C.A.C. Ibadan, took over my sponsorship and fostered me with their Children Tunde, Nike, Bambo, Biodun, Seyi, Yinkus. Their love kept me on my toes. The Missionary Doctor Family

George and Esther Campion paid part of my H.S.C. fees. At two separate breaking points in my undergraduate days I received cash gifts from Mr. Ogunkolo, (now lecturer at our Department of Physiology) and from an uncle Jonah Ajayi, a lecturer at Maiduguri. They were fate-determining gifts. When as a lecturer I finally settled for earthworm research, the Elijah and Bose Abejides were there to help me acquire whatever equipment was necessary to make me progress.

Many have made academic inputs into my life. I can only mention a few that came at critical points. Teacher Ibikunle Jegede prompted my mother to send me to primary school, otherwise I may have had to sit home a little longer. All my Titcombe College Teachers (Egbe) were wonderful and each deserve a whole paragraph. Yet I must only mention representatives such as Mr. Bamidele Samuel who taught me in Form I how to handle and read books and how to make an efficient use of the library. My maths teachers happily succeeded with their objective to "force it down our throats". Mr. Finlayson taught with all vested interest while Mama Rowena Marion motivated by her generous *"102%, Lovely boy"* remarks on my little efforts. My Biology Teacher Mr Oladipo treated every class with sacred devotion and strictness. Mama Millie Mosby introduced me to reading scientific journal articles and magazine right from my secondary school. And those thing I read are still relevant to my life today. My Physics teacher, Peter Mansfield (VSO) taught me and colleagues that the life of a scientist is centered around his laboratory and he must think of instrumental solutions rather than live on conjectures.

With a letter of introduction from Rev James Akintola I arrive the University of Ibadan into the safe hand of Dr. (now Prof. Adesogan) who, by his counsel, resolved my many psychological problems related to failing to secure admission to read Medicine. He also gave us in his Organic Chemistry class a philosophical poser that has since lived with me: *Which is better, to minimize contact with chemicals so as to live long, or to enjoy the excitement of research and expect to sacrifice a few year.* I have since chosen the latter. And since he himself is now over 70 years and still looks like ready for another 70, I choose to follow his example. Dr (now Prof.) Mark Nwagwu taught me to enjoy biochemical and developmental biology research at molecular level. His exciting research lifestyle became my dream lifestyle. Prof. Ademola O. Segun's quiet research life and thoroughness provided the aural of seriousness during the time he freely gave me unlimited access to his lab for my Ph.D. research. He provided all that I needed for that research: funds, literature, attention and personal commitment and interest.

Uganda Inputs: I am also very grateful to Prof. Okwako, the Chairperson Belowground Biodiversity Research Project at the Makerere University, Uganda for searching me out to conduct the training of hers and neighbouring staff in 2004. While they claimed to have learned much from me, I guess I was the student, learning wider dimensions of soil biology. Mr Charles Nkwiine of that University has remained a brother, freely sharing scientific information with me ever since that time. I am also grateful to Mr. Stephen Nagenda of Tea Estate and Dairy Farms, Uganda, for hosting me on his Tea Farm and for challenging me to solve the practical problem of producing enough earthworms to work a farm.

I cannot find enough words to appreciate my co-researchers and co-authors. They all have sharpened my mind, taught me to think straight, and to write well. I wish I had enough space to mention them one by one. Yet I must not fail to mention Dr. Segun O.A. Morafa and Prof. Ayanlaja, both of our College of Agricultural Sciences, who taught me to think pragmatically when discussing earthworms in relation to agriculture.

My Research Committees: Prof. A.B. Ejiwumi has been an academic mentor in his simplicity of life and in organizing us into an interdisciplinary research team, which unfortunately became disbanded as a result of collegiate decentralization to distant campuses. Messrs (how I hate to still have to use that title instead of Drs) Dedeke and Aladesida have always been student that taught their professor. They have on several occasions taught me simpler designs to an intended research; they have also faithfully accepted the duty of unended criticism and editing of my manuscripts.

I must appreciate my Colleagues in the Department of Plant Science and Applied Zoology. How I wish I could dwell on the contribution of each person to my success. I never stopped asking questions and they appear to all agree to always provide any information that I needed, often treating me more than I know of myself. I appreciate you all. I will mention Dr Olowe as an example of how they donate personal research properties (his soil sterilizer) towards my research. To pinpoint a loophole in my designs I only need to chat with Dr A.D. Banjo or A.O. Lawal and my clay legs will be straight away pointed out. Our former staff Dr Olufemi Sodeinde was there providing his wildlife perspective during the planning of my Ph.D. field collections. His wildlife input is today played by Dr. Durojaiye Soewu.

Inaugural Lecture Preparation Team: A few weeks before I received the nomination to give this Inaugural Lecture, an earlier unsolicited text message reached me from Mr. G.A.A. Dedeke, suggesting three possible topics, almost like

God was using him to prompt me ready. That is just one example of the many ways God has used him to counsel me on several issues. I did not take it serious at that time. When finally I started preparing this Lecture I found myself in *Igbo Irunmole* (the Forest of a Thousand Deities: courtesy Yoruba novelist Fagunwa). The PHCN electric wires were 'wet', as usual during the raining season; the Mini Campus generator ran out of fuel; my departmental generator was down; Diesel fuel price was not touchable and not even available to power my personal home generator; and lo, even my normally-2½ hour power UPS suddenly drained flat to about 2 minutes. As usual, I 'arrested' Mr J. Aderibigbe of our Physics Laboratory for 'being behind all my woes!' He, as always predictable, disarmed me with his usual light humour and immediately settled down to solving the problems to the best of his ability. Without that this lecture will not have been possible. Other contributors to this lecture include Mr. A.O. Lawal who gave me an order to produce a laptop in less than 24 hours. I simply bowed to his superior counsel. Mr Kehinde Oduala of Kenny Bestman Computers put himself at my beck and call whenever anything was going to slow down my writing. Mr Samson of Physics Dept volunteered to handle the animation. Members of my Earthworm Research Team, Messrs Dedeke and Aladesida took on the Concept Managership and librarianship for this lecture, sourcing information and guiding in concepts.

ASUU, both national and the O.O.U. Chapter re-lighted my academic spirit. At a time, the option to sneak out of the country was given a serious thought. But as better working conditions and salary were won by national struggles, it became unnecessary to do that. Better environment also encouraged my research efforts. I am proud to be a member of such a Union of people who fight so honestly, so selflessly and with such integrity. I am also grateful that when I, along with 153 other academics, was blighted by dismissal for daring to stare the lion in the face, a sad event that would have terminated this career, the Union left none of us undelivered.

My students, past and present- It is surprising how much students can teach their teachers. My ordinary level students at the Government Secondary School, Numan, Gongola (now Adamawa) State (1979-82), during our then unending laboratory life, showed me earthworms, remembrance of which made me later during my Ph.D. studies to include that region in my earthworm itineraries. After 25 years many of that great Numan Family remain interested in my research life, as indicated today by some of them cruising the entire diagonal of this great country to personally hear my progress report at this occasion, including beloved Ms. Ibrahim Koris Damaris, Brothers Manamo Bala Yakubu and Vidiyeno

you ascended the throne of our Forefathers. May your reign witness the total transformation of Egbe and Environ into God's Jerusalem in Nigeria that it has always been called.

The Ilepa Compound Family of Oni Oko, Egbe was the place to nurture a traditionalist like me. It was where my maternal Aunts 'Mama Joko Babalola', 'Mama Toria' and maternal uncle's wife 'Mama Ebun Akure', and their more elderly children, supplied the provision to take to school. Two other Uncles' wives, Mama Lakanmi Sunday, and Mama Iyabo (Yeye Oni-Oko) took serious the duty of raising a young *buroda* Gbenga, almost like they believed that this poor boy must become someone big in the future. Cousins Dawodu, Ayo Yeye (Ise-Oluwa) and Mr. Dekunle Akure (Akunity) donated trickles of their poor incomes and housed me when I had to pursue the delayed scholarship at Lagos.

Members of my immediate family. Mr. Sunday and his wife (my elder sister) gave their best even at sacrificial level. Mr Igunnubole and his wife (my immediate sister) were very thoughtful of me and my research. They forced me to sell the 'Earthworm Beetle Car' and in its place provided another Peugeot 504 saloon car because it will suit my movement on Nigerian roads. Whatever I requested for research they sourced for in their U.K. location. My other younger sisters' (Mrs Grace Pelemo and Mrs Tolushe Arobadi) education had to be delayed till I had gone far with mine, thereby delaying their progress in life. I owe them much of appreciation for their accepting that circumstance without grudge.

Mother Still Sweet in the Grave: How far can a woman go to train the only son among five Children? Mama Martha Adeola Sakeu Owa did sell all that she had to secure my education. She rose up to the challenge of single parenting five children, four of which were academically talented. I love her for the sacrifices she made.

A Family that Competed with Earthworms: My children (Oluwalofunmilade Pwamorieno, Oluwalobukunade Pwanedo, Koledade Adegboluwaga Manamo and Ademipo Pwanobato) are all wonderful gifts of God to me. They early became friends and partners. They endured a father who fell in love with earthworms. Rather than get angry they would rather pull jokes around 'Baba Owa and his earthworms'. Many foster children who live with me have joined my biological children to assist to raise earthworm children. They provide enabling environment, prepare and tend some earthworm cultures, and ensured that the father of earthworms himself is well fed and catered for. Among them are Miss Oluwalofunmilayo Ayodele who will wait till late evening to ensure that I do not fail to eat before going to bed; Mr. Igbeayo Boluwaji, popularly called Assistant

Father of our home because of his rearguard duties, Mr. Kehinde Yeye who regularly comes to assist with unending home chore, and Mr. Emmanuel Owa whose probing questions were always mind sharpeners and whose many questions I may never attempt until he himself becomes a graduate zoologist.

My Permanent Girl Friend: Meet her in Proverbs 31. Knowing what type of life I would live here, God custom-built my wife Oluwalofunmilayo, three months after I left heaven for earth. I understand that in designing her God factored that she must be healthy, strong, endurant, sensitive to my moods, forgiving and loving. She soon learned to cope with rival-lovers, the earthworms, and soon managed to love them too. Initially frustrated to share bed with books and journal articles, she later learned to tolerate them. If only her corner of the bed can be spared. Only love can compensate her for such times she had some important matters to discuss, but had to wait till earthworms can excuse the attention of her husband. Only her could have tolerated a husband who always had a monthly salary budget for urgently required earthworm research material. She soon adopted the maxim, *if it is for research, money will come from some blue*. I am glad you are alive today (in spite of the 2000 fatal accident) to witness this happy milestone on our way to greater expectations. *"Unnumbered women have done well, but you (my only Oluwa-Oba-nikan-soso-lo-Lumilayo) are better than all of them."* (Prov. 11:29).

Surely, God's goodness and mercy have been my companions all the days of my life, and I will continue to dwell in the presence of the Lord, forever. *Oluwa-Oba-nikan-soso-lo-Gbemiga* (Only the Sovereign God exalts me: my name in full): *And what shall I say unto the Lord: all I have to say is "Thank you Lord".*

God stopped a farmer in Southern Plateau (who suspected us to be government agents to possess his fallow land) from shooting as we escaped hurriedly, always looking backward if he would release the trigger. He ensured we escaped when at Abba we were accused of coming to dig up in an area where ritual killers had recently buried a kidnaped child. He shielded us when between Ikot Abasi and the coast the Police were firing at a hit-and-run driver who drove to our front, using us to shield himself. He stopped the gun when a drunk Policeman near Ifon jumped from his *ogogoro* hideout unto the road to fire at us under the pretense that we were armed robbers trying to escape road check. When poverty forced us to approach a principal at Oturkpo to sleep in his class room, he not only disbelieved our humble request, he instead reported 'armed attack on his school premises', as a result of which a team of armed policemen tracked us down, arrested us and

took us to their station until God sent a Babel among them. I, suspecting their composition in the Police Station spoke my Yagba dialect to my 'son' Mr. Akindele Oni-Oko who had been taken into the armor room and threatened. A Yagba man among the Police soon started a protest against the Sergeant who was going to delay and torture us. The Yagba Policeman spoke so forcefully that all other policemen soon overpowered their boss and forced him to release us late that night. That God saved us a lot of accidents. Under-rating the distance between Maiduguri and Lake Chad, and because we must save the cost of being too long on field collection, we started out late on the trip to Lake Chad, and on our way returning hit a high speed breaker meant to prevent us from hitting a round-about in that dark and butterfly-clogged driving. The old Beetle Car never recovered from the impact of doing a high jump, but God ensured we landed safely. On a wooden bridge that led into Obudu region our car tyre bursted suddenly by a nail puncture. Yet our God protected us. These few testimonies showed how stubborn we were about reaching the earthworms where they were, and our God's love was to guarantee our safety and to guide us into useful collections. Indeed all we can say is, 'Thank you Lord'.

Each time I think of how I have arrived at my present humble achievement, I sing my lifelong anthem:

All the way my Saviour leads me,
What have I to ask beside
Can I doubt His tender mercy who through life has been my Guide?
Heavenly peace, divinest Comfort, here by faith in Him to dwell,
For I know whate'er befalls me, Jesus doeth all things well.

Lord, we are just about to discover Your work,
The Chromosome indicate your coded wisdom,
The particle-wave concept reminds that you are in all things taking your glory,
And the earthworms tell of Your unfailing love even to the ignorant.

I thank you all for listening.

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