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THIS IS A DUDU WORLD

Odhiambo

ICIPE

1975

THE STATUS OF INSECT SCIENCE IN THE TROPICAL WORLD:

A series of ICIPE Annual Public Lectures Delivered by the ICIPE Director

"THIS IS A DUDU WORLD"

By

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First Lecture 4th June 1975
ICIPE Research Centre NAIROBI

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THE STATUS OF INSECT SCIENCE IN THE TROPICAL WORLD

THE SERIES of ICIPE Annual Public Lectures will be devoted to the general theme of "The Status of Insect Science in the Tropical World". In it the ICIPE Director will each year examine the problems and progress of insect scientific research in all its many manifestations, but especially in the way it contributes to national development in Tropical Africa. The ICIPE is interested in investigating new frontiers of insect science, in using this knowledge to design novel methods for pest control on a long-term basis, and in building up the capabilities of the African scientific community in meeting these challenges. The inaugural lecture in this Series was delivered on Wednesday 4th June, 1975.

In this lecture Professor Thomas R. Odhiambo examines the important role the rich insect fauna of tropical Africa has played in its history, health and economic life. He contends that a more imaginative look needs to be taken of this bludgeoning biological presence. With national sensitivities raised by the prevailing environmental stance, the shortage of fertilizers, and the impending shortage of synthetic pesticides, new challenges are before mankind to discover new management practices for this crucial portion of our biological world. Professor Odhiambo sets the scene for subsequent annual lectures which will examine the new successses, the promising lines of investigations, and the emerging areas of ignorance.

Professor Thomas R. Odhiambo came to Nairobi in July 1965 after spending six years at Queens' College, Cambridge, during which he obtained his degrees of B.A., M.A. and Ph.D., the latter in insect physiology. His years in Cambridge were crowned by many scholastic adventures, and were financed by a scholarship from the Uganda Government. Previous to that, from mid-1959, Professor Odhiambo worked in Uganda as an Assistant Agricultural Officer, with special duties in Entomology.

He was born in Mombasa, started formal schooling at Kisumu and Ngiya, before going to Maseno for his secondary education. He entered the then Makerere College in 1950, and spent four years there, the last two of which he used to specialise in Entomology, Nematology, and Soil Biology. He then joined the Tea Research Institute of East Africa at Kericho, where he worked as a Technical Officer for eighteen months before joining the Uganda Ministry of Agriculture.

He joined the University of Nairobi in 1965 as a Special Lecturer in Zoology, under the Rockefeller Foundation scheme for staff training. Two years later he became Senior Lecturer, and in 1968 he was appointed to a Readership in Zoology in recognition of his research achievements. On the establishement of a new Department of Entomology in early 1970, he became its first Professor of Entomology and Head of Department. In April 1970, he also became the first Dsf the newly established Faculty of Agriculture.

Professor Odhiambo has served in many capacities in Kenya, as a Board member in many institutions, and has participated in many international forums discussing technical advances in science as well as science policy.

Professor Odhiambo is the Director of the International Centre of Insect Physiology and Ecology, which, though an independent institution, is closely associated with the University and is located on its Chiromo Campus.

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A PASSAGE in ancient Arabic literature by Al-Qualquashandi about the kings of the Mali Kingdom referred to Mari Diata II, who ruled this great West Africa kingdom in the fourteenth century. The passage, when translated, states as follows:

> *"His end was to be overtaken by the sleeping sickeness which is a disease that frequently befalls the inhabitants of those countries, and especially their chieftains. Sleep overtakes one of them in such manner that it is hardly possible to awake him. He (the King) remained in this condition during two years until he died in the year 775 A.H. (A.D. 1373-4)"*

Mari Diata II died of sleeping sickness, probably caused by the protozoal parasite, *Trypanosoma gambiense*, and transmitted by tsetse flies, biting flies of the genus *Glossiana*.

At this time, sleeping sickness was well known and prevalent in Mali and other areas of tropical Africa. The disease is acute and affects both man and his livestock. It is thought that the early colonizers of Africa, the Arabs, found it difficult to extend their sphere of influence permanently into the interior of the continent because of the difficulty of traversing the tsetse fly-infested areas. The Portuguese, who mounted large expeditions into the interior of East Africa during the sixteenth century, found their efforts repeatedly floundering when large numbers of their camels and horses were bitten by tsetse flies and fell victim to sleeping sickness. Ibadan may have in part, acquired its pre-eminence as one of the largest cities of Black Africa by the ravages the tsetse flies wrought upon the Fulani cavalry in the mid-1800's. No horses could be kept in Ibadan and Yoruba-land because of trypanosomiasis. The Fulani cavalry swept south trying to capture Yoruba-land; but their horses succumbed to the fly disease, and their drive was halted. However, the dwellers of the ravaged villages moved to Ibadan and swelled its population.

The history of sleeping sickness in Africa, and its vector, the tsetse fly, is not only of recent predominance. It goes back, with reasonable certainty, as far as our archaeological tools can take us.[1] Flies of the genus *Glossina* are presently confined to the countries of Africa. But fossil records of them have been found in the Miocene beds of North America. Protozoal flagellates of the family Trypanosomatidae are also known to be of considerable geological age, and it has been speculated that they first invaded invertebrate hosts (such as tsetse flies) in which they cause no apparent disease, before they came into contact with man and livestock. Consequently, both sleeping sicknesfk tsetse flies are of great antiquity, and must have been prevalent in the very areas where early hominids made their first man-like evolutionary experiments. Frank L. Lambrecht[1] has speculated that man may have arose first in African when, during the late Miocene or the Pliocene, certatin branches of the primate order in Africa left the forest environment and took to the savanah. He further speculated that these early ground-dwellers found 'empty' ecological richest unoccupied by the elimination of large groups of animals which succumbed to the acute form of sleeping sickness usually found in the savannah environment. Whatever substance these speculations contain, it is nonetheless clear from oral tradition and written records that tsetse-borne trypanosomiasis has long been a potent factor in the history of Africa.[2]

But so has malaria, a man killer of major proportions. Malaria has such a long hisyvand prehistory in Africa that it is not surprising that many African peoples believed that the disease was caused by the bite of the mosquito – long before Walter Ross actually did his experiments and wrote a scientific publication announcing his discovery. Tropical Africa is distinguished by other major insect pestilences - the Desert Locust, the Migratory Locust, the Red Locust, the Brown Locust, the African Armyworm, the Spotted Armyworm, termites, ticks, and nearly 4,000 other important pests of man, his crops, and his livestock. In a world where something like 10,000 species of insects are regarded as significant pests, Africa has the doubtful distinction of harbouring the largest number of them.

One may be tempted to say, as the late Robert Kennedy once said:

"Some men see things
as they are
and say, why."

I have tried to do this already; but it is rather unsatisfying and I would rather push for what Robert Kennedy had to say later:

"I dream things
that were never
and say, why not."

INSECTS AS A NATURAL RESOURCE

INSECTS are one of the most important elements of our tropical natural resource. The forests of our lowland humid tropical areas have bequethed to us a rich insect fauna almost unrivalled anywhere else. Ten million years of the Pleistocene epoch gave our savannah adequate time to evolve and flourish, and concomitant with this diversification of our grassland vegetation was a parallel rapid evolution of our insect fauna. In contrast to the temperate regions of the world, where wind pollination of plants and trees is a common phenomenon, in tropical areas many fewer species of plants are wind pollinated. The vast majority are pollinated by insects – bees, wasps, flies, beetles, butterflies, and other insect groups – and by a few animals, such as bats. So it is not surprising that Lawino, in lamenting for and singing the praises of her husband, Ocol, went into rhapsodies about flowers and insects:[3]

"The obiya *grasses are flowering*
And the pollok *blossoms*
And the wild white lilies
Are shouting silently
To the bees and butterflies!
And as the fragrance
Of the ripe wild berries
Hooks the insects and little birds,
As the fishermen hook the fish
And pull them up mercilessly.

The young men
From the surrounding villages,
And from across many streams,
They come from beyond the hills
And the wide plains
They surround you
And bite off their ears
Like jackals."

These touching words are a mere indication of the deep identification of insects with Nature, of the significant place that they occupied in the thoughts and sentiments of African peoples.

But, then, insects have always played a central role in the thoughts and pursuits of thoughtful men throughout the ages. We have, for instance, that intrepid French naturalist of the nineteenth century, Henri Fabre, spending more than 40 years studying dung beetles alone, besides more years spent on the study of wasps, bees, butterflies, and other insects. His study of the dung beetles shows both his empathy with insects as well as his understanding of their role in the environment:4

> "There is, to my knowledge, only one other example of insects preparing board and lodging for their family, as do the gatherers of honey and the buriers of well-$lled game-bags.
>
> *And, strange to say, these insects vying in maternal solicitude with the flower-despoiling tribe of Bees are none other than the Dung-beetles, the dealers in ordure, the scavengers of the cattle-fouled meadows. We must pass from the scented blossoms of our flower-beds to the Mule-dung of our high-roads to find a second instance of devoted mothers and lofty instincts. Nature abounds in these antitheses. What are our ugliness or beauty, our cleaniness or dirt to her? Out of filth, she creates the flower, from a little manure, she extracts the thrice-blessed grain of wheat.*
>
> *Notwithstanding their disgusting occupation, the Dung-beetles are of a very respectable standing. Their size – which is generally imposing – their severe and immaculately glossy attire, their portly bodies, thickset and compact, the quaint ornamentation of brow or thorax all combined make them cut an excellent figure in the collector's boxes, especially when to our home species, oftenest of an ebon black, we add a few tropical varieties, a-glitter with gleams of gold and flashes of burnished copper."*

Such an idealistic view of Nature was carried very far in the nineteenth and early part of the present century, almost verging on a new trend in philosophical thought. A prime exponent of this trend was Maurice Maeterlinck, who occupied himself with the study of social insects, especially the bees and termites, and derived from it models of social organization that became the centre of social and scientific controversy in the decade before the first World War[5].

Maeterlinck was impressed with the very complex biology of termites (the so-called white ants) and their mound architecture. His research experience made him talk of the "political, economic and social organization" of termites; he considered what he termed the "destiny" of termites as presaging the destiny of mankind, unless we took stock of the situation and changed our ways before it was too late; he averred that termites had overcome the many rigours of life and existence in this world because they possessed what is loosely termed instinct, and man had won success because of a not dissimilar faculty, although we preferred to call it intellect, for no special reason – so he said; he believed that termites are at once so remote from man and yet so "fraternally human". Indeed, he came to talk of the "termite civilization", a civilization that had been flourishing on earth 100 million years before man first appeared on earth. The language he used, and the philosophical beliefs he represented, may sometimes appear extravagant when he discusses termite civilization along the following lines:

> *"Their civilization, which is the earliest of any, is the most curious, the most complex, the most intelligent, and, in a sense, the most logical and best fitted to the difficulties of existence, which has ever appeared before our own on this globe. From several points of view this civilization, although fierce, sinister and often repulsive, is superior to that of the bee, of the ant, and even of man himself".*

From African ballads on Nature to the European poetic renderings of the doings of Nature; from philosophical mutterings on insect civilization to the dainty expressions on insect aesthetics; and so we come to the age-old hankerings after beautiful things. And what else are butterflies if they are not beautiful things, possessing a dainty grace rare in the inventory of living organisms. Because of their innocuousness and breathtaking beauty, many people, including the great Englishman, Winston Churchill, have actually gone out of their way to create a butterfly garden – to watch butterflies as they flit from one sunny flower to another sweet nectary, to observe their silent but swift courtship displays, to wonder at their sense of time and season[6]. They talk of a butterfly garden, a butterfly nursery, a butterfly sanctuary; they argue over the exchange of butterfly livestock with like husbandrymen in other countries. They tell you that if you keep one or more generations of breeding butterflies in captivity under a polythene-covered greenhouse, and tend them well, providing them with drinking water and honey water, the butterflies become so tame and domesticated that they could feed from a hand holding a pot of honey water, and, if let loose to wander in the gardens during the day, they returned to the greenhouse to roost at night.

No wonder the study of butterflies had drawn the attention of many outstanding naturalists in tropical Africa. Jackson, Van Someren, Stoneham, and many others are familiar names as experts of East African lepidopterists. Some of them have waxed eloquent making serious proposals to conserve tropical butterflies[7]. Everybody is now familiar with the national policies of Kenya and many other

African countries to conserve our national heritage of animal and plant life. The most sustained effort in this direction has been to establish national parks, which are usually located on marginal lands, on dry savannah, and whose major feature is the big game. But the rain forests in the tropics (like the Kakamega forest) are a truly amazing conservatoire of a diversified animal and plant life, containing many rare species of animals, birds, and insects – including butterflies. It seems more imaginative to direct conservation energy to conserving habitats, including some of our rain forests with its abundant life, rather than solely concentrating on the preservation of rare animals threatened by extinction. In this way, our fauna and flora will be conserved in its entirety.

This is not to say that our savannah areas are devoid of captivating butterflies and other insects. On the contrary; many species haunt the flowers and nectaries of the shrubs and weeds, and there is no sight so engrossing as a bank of weeds by the stream on a sunny day powdered by the myriads of multi-coloured butterflies, bees, flies and beetles, all eagerly and busily doing their own thing while the cicadas sing their shrill cadenzas in the trees. It is this same wonder that has drawn collectors in Europe and North America to purchasing large beetles for thier amusement, of collecting butterflies to gloat over. Taiwan earns more than U.S. $30 million a year for the export of butterflies to other countries; Sierra Leone is establishing a cottage industry out of making pictures and other adornments with the wings of butterflies. The rape of this earth's butterfly fauna is indeed going apace.

INSECTS AS A COMPETITOR

BUT insect life is not all sweet life. We do not even like some of the things they do, although we may understand it. So like Ocol, hurling verbal accusations on the village Padre, we might say with her:

"And when he shouted
The word 'graciya'
(Whatever the word meant)
Saliva squirted from his mouth
And froth flew

Like white ants from his mouth
The smelly drops
Landed on our faces

Like heavily loaded houseflies
Fresh from a fresh excreta heap."

Africa possesses something like 300,000 known species of insects and their close arthropod relatives, such as ticks and mites. Many more are still to be discovered, described, and designated – particularly the smaller beetles, flies, wasps, moths, plant bugs, spring tails, and mites. From this rich insect fauna, only something like 4,000 species – or little more than 1 % – are pestiferous to man and his agricultural produce. Even so, this small fraction looms large in the economy and public health of man; and to this extent therefore they are regarded as competitors and adversaries of man.

Man in Africa has always been interested in insects, including the pestiferous ones. And although they have worked out reasonable avoiding action for some of these pests – for instance, some of our pests of agricultural stored products, by storing them in ash and traditional granaries incorporating sophisticated microclimatic ideas – we can safely say that no long-standing traditional methods exist for the extermination or control of any of our pests.

Over the last 90 years or so, tropical Africa has seen the dawn of modern insect science and technology. Many of its vectors of human and animal diseases – trypanosomiasis, malaria, East Coast Fever, relapsing fever, yellow fever, filariasis, and many other horrendous tropical diseases – have been subjected to modern scientific study. But one must admit that successes have been limited. We have succeeded in getting relief from these diseases, by discovering curative methods for dealing with the disease in its overt state; we have also succeeded in destroying the insect pests concerned for a limited period of time using firebrigade methods, such as pesticides; but what we have not succeeded in doing is to control any specific insect pests over a long period and over a whole region. An overview of the pest situation seems to indicate that we have succeeded in controlling (but not in eliminating) only three pestiferous insects on a long-term basis. The first is the jigger, which was accidentally introduced from South America in the seventeenth century presumably by the returning slave traffic. It spread like wildfire in a population unfamiliar with this new pest, and decimated the indigenous population of West and Central Africa until, more than a century later, they came to learn how to control it – by the simple expedient of removing the larval jigger as soon as its itching presence became apparent.

The second pest in tropical Africa to have had devised an excellent long-lasing control programme is the coffee mealybug, *Planococcus Kenyae*, which, in the early history of the Kenya coffee industry East of the Rift, was a devastating pest of this important agricultural crop.

The mealybug forms thick clusters near the tips of growing points and among the green berries or flower buds, jeopardising the full development and fruiting of the plant. Chemical control can give some relief; but very good control of the pest has been achieved by the introduction of its insect parasites from Uganda in 1939.

The third pest, whose long-term control has been achieved in tropical Africa, is the cotton leafhopper, *Empoasca facialis*, which was a serious pest of cotton wherever it was grown in tropical Africa, especially under irrigation conditions, until the early 1940's. It is a tiny insect able to insinuate itself between the hairs on the young leaves of the cotton plant, from which it then proceeds to suck plant juices. The result of infestation is "hopper-burn", characterized in the early stages by the edges of the affected leaves changing colour to yellow or red in successive zones, which seems to be the result of the interruption of translocation of plant sap through the plant vehicular vessels, the phloem. These initial symptoms are succeeded by a curling of the leaves, which may eventually dry up or be shed. If the infestation occurs on young plants, their growth may be entirely arrested; if it occurs on older plants, their crop will be shed or they may be capable of producing only immature lint; in any case, losses due to leafhopper attack are usually serious in the cotton growing areas of the dry savannah. The early discovery that hairy cotton plants seem to be resistant to leaf-hopper attack was intensely exploited in breeding programmes utilising a diverse genetic source of the cotton plant; and in the 1940's it became apparent that long hairs on the leaves were directly responsible for conferring on cotton plants resistance towards leaf-hopper attack. It turned out that the resistance was due to the hairs preventing females from laying eggs on the leaf surface; the hairs did not necessarily prevent them from feeding. Breeding for this rather simple resistance factor has made an outstanding contribution in the control of the cotton leaf-hopper to the level when it can only be regarded as a very minor pest.

The control of the three pests already mentioned, over a period of approximately 150 years of pest management is a miserable return whichever way we consider the matter. At the present rate of the solution of pest problems in tropical Africa, it will take us another 200 centuries to solve the remaining major pests. Obviously, we must adopt other strategies to quicken the pace of advance in pest management practices.

And, so, to Genesis:

> *"And God said, Let the earth bring forth the living creature after his kind, cattle, and creeping thing, and beast of the earth, after his kind: and it was so.*

And God made the beast of the earth after his kind, and cattle after their kind, and everything that creepeth upon the earth after his kind; and God saw that it was good.

And God said, Let us make man in our image, after our likeness; and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over creeping thing that creepeth upon the earth....

And God blessed them, and God said unto them, Be fruitful, and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth."

How best can man have dominion over pestiferous insects without at the same time spoiling his dominion by avoiding practices that will be deleterious to its long-term ecology? This is the crux of the matter in enlightened pest management.

PESTICIDE FAMINE

IT IS calculated that 34% of the landmass of the continent of Africa is deficient in rainfall; another 7% is mountainous, and so not much use for agriculture. Even so, Africa contains more land of high carrying capacity and great biological potential than any other continent, when one considers the effective combination of adequate rainfall and effective solar radiation over most of its surface[8]. Africa is well supplied with lakes, rivers, and swamps for storing and distributing its high rainfall; indeed, Africa's inland waters total about 1.8 million square miles, or approximately 34% of the total world resources of inland waters. On the other hand, the poverty of tropical Africa is glaring. It is very largely explained by the underdeveloped state of its abundant natural potentialities. The amount of agricultural crops produced by each person per acre, for instance, is very small; this small capita production has in fact not risen in recent years.

It is recognized that agricultural practices in this continent must change – better husbandry methods, better marketing and distribution, better incentives to the farmer, better integration of modern science and technology into agronomic techniques, and better agricultural inputs.

Parallel to the recent acute oil crisis, there is also looming a fertilizer famine and a pesticide famine. In 1960's the annual world total fertilizer consumption was about 35–40 million metric tons. Of this total, Africa only consumed 1.0–1.5%, whereas Japan consumed 5.0%, North America consumed 25% and Western Europe 30%. These proportions have not changed substantially in this decade. With an expected world shortage of mineral or synthetic fertilizers in the next few years, and with little industrial capacity to produce its own fertilizer requirements, Africa is going to be hard hit by this fertilizer famine. This forecast is underlined by the recent announcement (August 1974) by the Prime Minister of Tanzania to the effect that all fertilizer imports were immediately banned and that farmers were asked to use farm manure instead.

A similar situation is likely to arise in the case of pesticide supply. Nearly all pesticide production is carried out in industrialized countries of North America, Europe and Japan – although formulation of the technical material into a commercial product is frequently done in other countries, including tropical Africa. It happens also that most of pesticide use is confined to North America, Europe and Japan. In 1970, the U.S.A. consumed 45% of all world pesticide production, Western Europe 23%, Eastern Europe 13%, and Japan 8%. The developing countries put together only consumed 7% of world pesticide production. In a scramble for pesticides for the purposes of crop protection and public health following on the oil crisis, it is likely that the pesticides manufacuturers in the industrialized nations are not likely to export much of their product to developing countries since the domestic demand itself will be at a peak.

People who are concerned about crop protection and public health – where pesticides have made a notable contribution since the discovery of DDT more than 30 years ago – will find pesticide famine an extremely urgent matter. We can expect that in tropical Africa, with its rich pestiferous fauna, pesticides will continue to be vital as a pest management tool. It is certainly a fire-brigade tool that has given excellent dividends in the control of insect disease carriers, at least on the short term.

On the long-term, pesticides have caused much anxiety, for several reasons. Although DDT, because of the simplicity of its manufacture, its wide spectrum of activity, its prolonged residual action, and its relative safety to humans and livestock, has resulted in its wide use in the control of Malaria, other insect-borne diseases, and pests of cotton, tobacco, fruit trees, and horticultural products, its abundant use and its persistance has created its own crop of problems. By 1970, 2 million metric tons of DDT had been actually applied in the field; it is estimated that up to 25% of this total still remains in circulation in the environment as DDT or as its more stable analogues[9]. A most serious aspect of this environmental polution is the almost universal distribution of DDT in both fresh and sea water, and the ability of acquatic animals to concentrate it in their fat body by eating contaminated organisms and by direct absorption. This concentration is magnified as one moves along the food-chain. For example, it has been estimated that the overall concentration of DDT from water to sea-gulls is more than a million-fold. Other insecticidal compounds, such as organo-phosphorus insecticides, carbamates, and other, have equally serious negative aspects. One of the more important of these is that insects by and large quickly develop resistance to insecticidal compounds in use; and there is no way known at present to counteract this terrible disadvantage.

It is agreed that for the foreseeable future one will have to continue to use pesticides, but it is reasonable to suggest that the use should be sanctioned only under specified conditions. Firstly, that they are safe to human beings and their livestock. This is an objective that is achievable. Secondly, that they are used only after careful study of the pest involved, so that their use is specific to the relevant stage of the specific insect species concerned, and that the techniques used are such as not to interfere seriously with other living organisms (including the parasites and predators of the pest). Thirdly, that more specific insecticidal compounds are made so that the chemical is directed towards known targets only. Finally, that the compounds, or new alternative pesticidal compounds, are made to be biogradable in time; in this way, large accumulations of pesticides in the environment are minimised.

These proposals, especially the last two, may seem starry-eyed. It takes about 10 years for the discovery of a new pharmacological agent to be developed into a commercial product, such as a drug or a pesticide. The investment in these 10 years of research and development is also enormous. It does imply that the developer and manufacturer is only going to invest such large amounts of time and money if he is certain he will be substantially rewarded at the end of the exercise.

TOWARDS A NEW ORDER

BEFORE the discovery of DDT and the subsequent avalanche of advances in the characterisation of other new pesticides since the 1940's, pest control was largely a matter of using the hammer-and-tong technique. You ate the pest (locusts and termites are dramatic examples), you shot the suspected animal reservoir of the disease from where insects distributed it (as in the case of the animal hosts of tsetse flies), or you picked and killed the offending insect (as in the case of lice and bedbugs). These techniques by and large failed to make an impression on the overall pest population except at a particular instant in time and place. The newer toll of pesticides ushered in an era of the fire-brigade approach. This phase has seen some spectacular achievements, especially in the short-term. But they also do not seem to offer a long-lasting, environmentally acceptable solution.

It looks as if we should cast our minds for a more scientific method, which recognizes that insects are not simply targets, but are biological entities with a complex ecology, behaviour, and physiology; entities that have a complex genetic potential which enable them to evolve beyond a particular situation; and entities which occupy an important place in the natural order of things.

Such an approach, a pest management approach, now seems to be emerging from the obscure horizons. It presupposes a great deal of fundamental information on the individual insect species – in as great a depth as required for any one of our domesticated animal species – if we are to suggest new avenues for controlling insect pest species within acceptable population limits. We also need to know a great deal about the underlying principles of the peculiarities of insect life for the same reasons. This is the type of strategy and perspective that the ICIPE is striving to achieve. We are gradually coming to realise that insect communication is performed overwhelmingly by means of chemical messages rather than by the use of other means of communication familiar to man – visual and auditory. These messenger chemicals, or pheromones, are employed in such a precise manner that in the termites and other social insects one can begin to believe that insects do indeed have a kind of chemical alphabet and phraseology for effective communication for food, courtship, defence, and other necessities of life. This is one example to demonstrate the promise that such a strategy portends. Other insect peculiarities are just as fascinating.

It is my firm belief that tropical Africa, with its rich and diversified insect fauna, has enormous potential for making a major world contribution in this area of human endeavour. Insect science, the study of insects in all its relations with the natural world, is still very much a young science. One can even say that the older scientists are part of the enlightened public that has witnessed its very birth. If we decide to put our minds to the task of exploring the many discoveries that still await us, we shall not only be participating in a future great science but in solving one of the most crucial problems in the tropical world.

I dreamt that I dreamt
the dreams of dreamers;
That dreams are not just
dreams,
But are the undreamt of
dreams of unlimited horizons.

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Printed by Wink Print, P.O. Box 47449, Nairobi.