Professor Thomas R. Odhiambo

INAUGURAL LECTURE

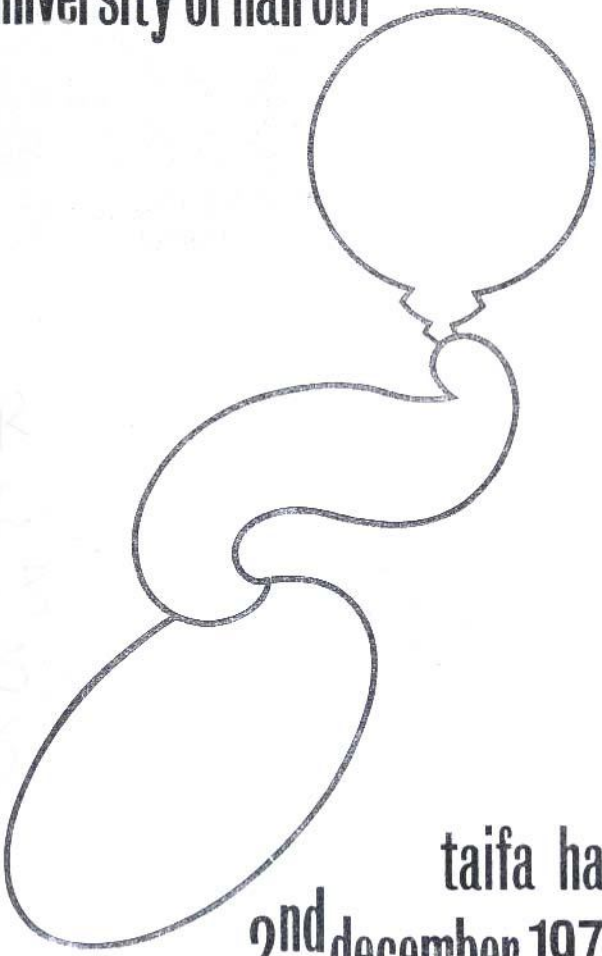
University of Nairobi

2 nd December 1975

insect production & reproduction

8th inaugural lecture

university of nairobi



taifa hall
2nd december 1975

THE INAUGURAL LECTURE SERIES were started in the days of the University of East Africa when it was the practice of the then University College Nairobi, to have its newly appointed Professors deliver their first public lecture in Nairobi. The current series under the University of Nairobi are supported by funds from the University Deans' Committee, and copies of the lectures are on sale at bookstores.

In this lecture, the Professor of Entomology, Thomas R. Odhiambo, examines the important role the rich insect fauna of tropical Africa has played in its history, health, and economic life. He illustrates his theme by recent studies in the reproductive and population biology of insects; and he contends that a more imaginative look needs to be taken of this bludgeoning biological presence in tropical Africa.

Professor Thomas R. Odhiambo came to Nairobi in July 1965 after spending six years at Queens' College, Cambridge, during which he obtained B.A., M.A and Ph.D. degrees, the latter in the field of insect physiology. His years in Cambridge were crowned by many scholastic successes, and were financed by a scholarship from the Uganda Government. Previous to that, from mid-1955 to late 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 Ng'iya, 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 at Kericho as a Technical Officer for eighteen months before joining the Uganda Ministry of Agriculture.

Thomas R. Odhiambo

He came to 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 establishment of a new Department of Entomology in early 1970, he became its first Professor and Head of Department. In April 1970, he also became the first Dean of 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 Director of the International Centre of Insect Physiology and Ecology (ICIPE) which, though an independent institution, is closely associated with the University and whose headquarters is located on the University's Chiromo Campus.

1975
A publication of the University of Nairobi
Printed by afropress ltd., P.O. Box 30502, NAIROBI, KENYA
Cover designed by Gladys Winyi

INSECT PRODUCTION AND REPRODUCTION

Nearly five thousand years ago, King Menes, the Pharaoh of Egypt, was stung by a wasp and died of his wounds shortly afterwards. One might say that, in Africa, being stung by wasps, hornets, bees, ants, assassin bugs, and a myriad other noxious insect species is not an extraordinary happening. But in *Exodus* (Chapter 23, paragraph 28) we find an extraordinary usage of hornets as a weapon of war. In it, the Children of Israel were promised:

> "I will send hornets before thee which shall drive out the Hivite, the Canaanite and the Hittite before thee."

Yet, the use of insects for military purposes may not be as strange as it appears at first sight. For instance, earlier this year, the World Health Organization (WHO) was forced to close down a mosquito control project in New Delhi, India, because of an adverse report by the Indian Parliamentary Public Accounts Committee. The Committee's report declared that the Genetic Control of Mosquitoes Research Unit was carrying on research that had "direct vital bearing on biological warfare" and that it was connected with the U.S. Army Chemical Corps. Lice have, in their own way, played a much more crucial role in wars and battles than all the great militarists put together until the discovery and utilization of DDT thirty five years ago stemmed the tide from lice-transmitted diseases. Because of the type of accountrements of the soldiers, their confined living in trenches and bivouacs, and the minimal hygiene standard soldiers under campaign conditions have had to endure, there were more deaths resulting from lousy soldiers — in its literal sense — than from actual battles.

But I am not, at the present juncture, simply concerned with the predatory wasp, the military hornet, and the sucking louse. I am more concerned with a number of broad questions of special concern to tropical Africa, all rather closely intertwined:

- * What part do insects play in tropical Nature?
- * How much concern do they cause us and how much benefit do they give us?
- * How much concern do we cause insects and how much do we benefit them?
- * What is the secret of the success of insects in the present world?
- * How much do we know or understand of the insect world?

Tropical Insect Fauna

Means (including those emanating from new scientific advances, new technological discoveries, and new management practices) to increase the availability of world food resources has become crucial. The recent World Food Conference, held in Rome in November 1974, has dramatically presented the grim situation regarding food stocks and the long-term prospects of food production. The mammoth preparations leading to the World Food Conference, and the conference deliberations themselves, have set in motion several massive global attempts to resolve this vital human problem: the Consultative Group on Food Production and Investment (CGFPI) was established a few months ago to coordinate world financial resources for a frontal attack on this problem; the International Fertilizer Development Centre (IFDC) was formed at about the same time to concentrate on the crop fertilizer problem; the United Nations University, with headquarters in Tokyo, has chosen as its initial central theme that of world food hunger; the Board of the Rockefeller Foundation has only two months ago accepted in principle the formation of a new delivery institutional system, the International Agricultural Development Service (IADS) — a new organization that will be specifically helpful in providing national agricultural institutions with the additional diagnostitc, planning, and consulting services and interim leadership they require to launch effective, efficient, and long-range food production programmes; and the new major drive by the Consultative Group on International Agricultural Research (CGIAR), which is now spending approximately $68 million a year in goal-oriented research in food production through a network of eight international research centres throughout the developing world, and which is now making a serious examination of the whole question of building up national research capacities in each of the developing countries to enable them to develop the scientific and technological capability in utilising problem-oriented research for socio-economic development in the agricultural field. One of the most serious aspects of world food production, especially in many of the developing countries, where the question has become a matter of survival, is that approximately 30% of the potential food production in the tropics is lost through the ravages of insect pests.

This loss can no longer be taken for granted. It must be drastically reduced or eliminated altogether.

The current practices in integrated pest control depend on four pillars: pesticides, biological control organisms, cultural and agronomic methods that reduce pest levels, and plant resistance. The cost of pesticides has become a crippling limiting factor in the face of the prevailing inflationary trends; moreover, the easy availability of this important agricultural input is doubtful for most of the developing countries because over 85% of world pesticide production is required for use in the industrialized countries, where more than 95% of pesticide manufacture is carried out. A premium must therefore be put on other methods of pest control and for discovering novel approaches to such pest management practices.

The ingenious use of parasites and predators to suppress insect pest populations — or "biological control" as it is called — has proved a remarkably successful and effective method for the development of environmentally safe, economic, and long-term pest control programmes. Perhaps one of the first and most spectacular successes of biological control is the control of the cottony-cushion scale, *Icerya purchasi* Maskell, that was a major pest in California in the 1880's and threatened the then young and growing citrus industry. No sprays or other chemical poisons at that time known seemed able to stem the tide of cottony-cushion scale. It was known that the original home of the scale was Australasia. An expedition to Australia in 1888 revealed that at least one predator, a ladybird beetle, was a voracious feeder on the scale. In November 1888, the first shipment of the ladybird beetle, *Rodolia cardinalis* (Mulsant), reached California, and several shipments were dispatched, and then liberated immediately on arrival on scale-infested citrus trees. Within a year, a startling and highly effective degree of control of the cottony-cushion scale was achieved throughout the citrus-growing area of the state at an estimated total cost of less than U.S. $2,000. Up to the present time, the ladybird beetle continues to maintain an effective control of the citrus scale. It is estimated that over a 35-year period (from 1923 to 1959), this one successful biological control programme has saved the Californian state agricultural industry about $110 million. The control of the coffee mealybug, *Planococcus kenyae* Le Pelley, in Kenya in the 1940's is no less spectacular; and biological control did indeed save the entire coffee enterprise in Kenya from being wiped out by the depredations of the mealybug. Chemical techniques did not make an impact on the spread of the mealybug East of the Rift Valley. However, in 1938, predacious ladybird beetles were introduced from their original home in neighbouring Uganda, and the coffee industry was saved. As a matter of record, it is estimated that biological control has been successful in controlling more than 110 insect pests throughout the world. Moreover, it has done this in spite of the fact that only about 0.3% of the funds devoted to pesticide research and use is actually employed on biological control research and application.

Viewed against this backcloth, why is it that biological control has not been taken as seriously as pesticidal control? One thoughtful answer, given by an eminent pest management authority, DOUTT[1] is the following:

> "There are two probable reasons for this. The first is that there seems to be almost a primitive gratification in taking some positive action against an organism that is viewed as an enemy or simply a nuisance. Certainly, there is a strong inclination to choose an expedient, immediate, and very visible tactic. For this reason, the use of a powerfully toxic pesticide provides enormous satisfaction because it involves physical action and the expenditure of capital that is immediately rewarded by a highly visible chemical coverage and the comfortable imagination of enormous arthropod body counts. By contrast, biological control involves a scientific and intellectual activity, instead of a physical and muscular action. The parasites and predators are frequently microscopic, and the control process proceeds in almost an invisible fashion. Biological control is not flamboyant, noisy, and commercially exploitable. It is silent, ecologically sophisticated, and economically sound . . . There is a second reason why biological control is not being as widely and intensely practised as its merits justify. Casual attempts to undertake biological control are not likely to be successful. Brief, superficial projects have led to disappointments and then to the erroneous conclusion that biological control has extremely limited application. Such unsatisfactory operations are the result of a failure to realise that a minimum organizational structure is essential to biological control."

The selection of crop varieties that are resistant to pests is a powerful tool for long-term pest management. However, the approach that the crop breeders have followed, for example in the CGIAR institutes, is a very pragmatic one — by identifying varieties that survive an insect attack under green-house or pilot-field situations, and multiplying these for further selection procedures. It has now become increasingly apparent that, in the tropics and sub-tropics, where we have a complex and rich biota, farming systems more often than not will take the pattern of minimum tillage, inter-cropping, multi-cropping, and multi-seasonal harvesting. In such a complex situation, the prospects of a breakdown of plant resistance is great due to any number of biological and agronomic factors. The pest management designer must therefore be armed with the necessary information on the basic mechanisms of resistance in individual cases, he must inventory these, and he must then feed this information into the overall breeding programme as an input for the synthesis of a new crop type with desirable characters, including that of resistance to pest attack. This kind of information is at present lacking for any crop/insect relationship.

We have now several recent examples of some of the "wonder" rice varieties that have thrown their releasers into a state of near despair because of the circumstances surrounding the loss of resistance. One example will suffice. The brown rice planthopper *Nilaparvata lugens* (Stal), has become an extremely important pest in recent years in the Philippines and S-E Asia (Sumatra, Indonesia, the Solomon Islands, and even Sri Lanka and Southern India). In some countries this pest has been a problem for some years (e.g. in the Philippines), and in many others the insect has been changing from a minor to a major pest (e.g. in Sri Lanka).

The International Rice Research Institute (IRRI) recently found that some of the rice varieties (e.g. Mudgo and ASD 7) which they had developed in the Philippines for resistance against the planthopper in this country, and which they then released for general adoption in S-E Asia, were susceptible to the same species of planthopper when grown in Sri Lanka and in Kerala State (in southern India). An initial study has shown that the brown planthopper can rapidly develop a new biotype able to attack previously resistant rice varieties, if these possess only single-gene resistance. For instance, so-called Biotype 1 is the brown planthopper indigenously found at IRRI, lives well on the susceptible rice variety TN1, but cannot develop on resistant varieties Mudgo, ASD7, and IR26 at IRRI. When, on the other hand, brown planthoppers were collected from rice fields intensively planted with resistant rice varieties and were then reared for several generations on resistant rice plants in a greenhouse, three new biotypes were found to have evolved — including one (Biotype 4) that could survive on two resistant varieties, Mudgo and ASD7. Consequently, it may be hypothesized that if only a few pest-resistant varieties of rice are intensively planted over a wide area, insect biotypes may develop, through natural selection, which are capable of attacking and, indeed, thriving on formerly resistant crop varieties. Such an eventuality will probably develop very rapidly when crop resistance is governed by a single pair of genes ("monogenetic resistance"); it may be slowed down considerably when the resistance is governed by two or more pairs of genes ("multigenic resistance"). In either case, the breakdown of pest-resistance is still a real probability.

As indicated before, part of the basis of our failure in effectively using resistance to crop pests as a long-range technique for pest management is that the techniques presently available for selecting insect-resistant plants are highly pragmatic. Experimental cultivars are grown under more or less uniform environmental conditions and inter-planted with well-known insect-susceptible cultivars, either in the field or in some type of glasshouse, screen-house, or greenhouse. In any case, the plants are exposed to intense insect populations, either found naturally occurring in the field or artificially released in the experimental arena from mass-bred insect populations; the damage to the plants are scored according to a predetermined rating, and the plants showing tolerance or resistance are thus identified, assembled, and processed for further breeding work. A first step in simplifying these selection procedures, and in making them more precise, would be to identify the sources of plant resistance to each particular pest. Besides, such definite knowledge of the sources of plant resistance — whether chemical or otherwise — would provide a tool for the monitoring of each of the steps of a plant breeding and improvement programme, ensuring that insect-resistance is retained in the course of "synthesizing" a new cultivar possessing the desirable agronomic and other characteristics that have been selected.

Earlier on, I stated that the crop losses due to insect damage are of such proportion that they can no longer be taken for granted. Yet, we find that the means we have for dealing with the problem of insect control are ineffectual, or uninformed, or simply primitive.

Uninformed Technology

We have already seen that biological control of insect pests, by turning their own parasites and predators against them, and by manipulating our detailed knowledge of the specific pest/predator relationships and the seasonal history of the ecosystem in which they operate, can be most effective and provide a long-range, ecologically acceptable, and cheap programme of pest management. The operative phrase is "detailed knowledge". And this is the rarest commodity to be found in most of our insect control craftmanship — indeed, one is tempted to conclude that insect control is still a technology with an uninformed base of knowledge.

I believe that this depth of ignorance of insect life and its interrelationships with our crops, our livestock, and ourselves, is an intellectual challenge to the young scientific community in tropical Africa. For tropical Africa, whether or not it is proved in the coming millenia to be the birth-place of the primordial insect, is certainly the Garden of Eden of the insect world. The variety to be found here — from tiny flies hardly visible to the naked eye, to large beetles that can only be caught by shooting them down with a rifle; from insects of an ephemeral adult life of only a few hours to those whose life-span can be counted in decades; and from delicate, orchid-sucking wasps to swarming, migratory insects — all these have occupied and exploited almost every habitat except the open sea. There is no question that evolutionary success of insects in tropical Africa has been little short of stupendous. The temperate regions of the world, on the other hand, are impoverished, and their inhabitants only regard insects as a curiosity for the natural history museum, with little impact on the history of the people or on their lives. The world would therefore expect us to develop a devotion for the study of these insects, to know them intimately, and to come to understand in great depth the whys and wherefores of their interaction with the human species and the human economy.

Insects are a bludgeoning presence in tropical Africa. Nobody else will develop an *Insect Science* — and its corollary, an *Insect Technology* — unless the scientific community in Africa takes it up as its Blackman's Burden.

I do not, therefore, want to agree with Ocol, who mockingly castigates his uneducated wife Lawino, the champion of African virtues and values, in this Acholi ballad of sorrowful censure:[2]

"What is Africa
To me?
Blackness.
Deep, deep fathomless
Darkness;

Africa,
Idle giant
Basking in the sun,
Sleeping, snoring,
Twitching in dreams;
Diseased with a chronic illness;
Chocking with black ignorance,
Chained to the rock
Of poverty ....

Timid,
Unadventurous,
Seared of the unbeaten track . . . ."

The unbeaten track of Insect Science and Technology is an exciting one, and some of us have a deep faith that it will lead to a new watershed of biological knowledge and development-oriented applications.

What are these straws in the wind that are beginning to stir such an excitement? The field of insect reproductive physiology is a particularly fertile one, and I shall illustrate my theme with examples of recent breakthroughs in our understanding which have been accomplished in Nairobi and elsewhere in Africa in the last two years or so — pegging my examples on a typically African insect group, the tsetse flies, which all belong to the genus *Glossina,* and which have seemingly circumvented previous efforts to eradicate them.

The International Centre of Insect Physiology and Ecology (ICIPE) initiated its research programme on tsetse biology three years ago, one component of which is the reproductive biology of tsetse flies. This research is being carried out with the express purpose of learning a great deal about the reproductive behaviour and physiology of the tsetse flies so as to open up new avenues for the control of this vector of human and cattle sleeping sickness through the exploitation of the weak links in the crucial biology of these insects — for instance, its low reproductive potential and its complex and unusual reproductive biology. In these flies, only one mature egg is ovulated at a time; it is subsequently incubated in a highly complex uterus, where the egg hatches (in 3 or 4 days time), and the larva grows and completes its full development while being sustained by the so-called milk-glands of the mother. After about ten days, the fully grown larva is deposited by the female, whereupon the larva buries itself in loose soil and debris, and pupates within a matter of hours following parturition. Within one or two hours following the previous larviposition, the next mature egg (arising from the opposite ovary) is ovulated; and the cycle of pregnancy and parturition follows. Thus, a successful parturition requires the synchronization of a number of interdependent processes: egg development and maturation, ovulation, larval development within the uterus and the synchronous modulation of the ebb-and-flow development of the milk-glands and their secretions, the mother's own feeding cycle, larviposition, and hormonal activities responsible for the coordination of these cyclical processes. The challenge facing the ICIPE is to elucidate and define the mechanisms and chemical messengers involved in this information loop, to find means for interfering with or jamming the latter, and to apply these elements to a control strategy for these pestiferous flies.

We now know that the primary event that sets off the first ovulation of the mature egg in tsetse flies is mating.[3] In the last few months, some very simple but careful experiments have shown us that the controlling factor may not be so simple.[4] If the females are interrupted during mating before semen has been passed, or if the glands that produce the various secretions are removed before mating is accomplished, ovulation will result provided mating has been sufficiently long (which is about 50-60 minutes). Thus, it is the mechanical information of mating that is passed on to the female having a mature egg which is important in initiating ovulation. However, this mechanical information is simply the primary initial factor; a neurosecretory centre in the brain (the so-called median neurosecretory cells) and a hormone from the corpus cardiacum are both involved in this information flow. Surgical removal of the median neurosecretory cells or the removal of the corpus cardiacum both lead to a failure to effect ovulation. On the other hand, a mature but virgin female injected with blood from a recently mated female will result in ovulation taking place in the virgin fly. The first ovulation is the prime time setter; and after this, the pregnancy, parturition, and ovulation cycles follow one another in a regular sequence — provided there are no abnormal occurrences.

The tsetse mother has the potential of producing ten or more progeny in her life-time. However, this is rarely realised in the laboratory. There is a most delicate mother/larval interaction[5] which can easily be upset leading to the disruption or termination of pregnancy. For instance, reproductive abnormalities, such as abortion and delay in parturition leading to the mature larva becoming a pupa while still within the uterus, frequently occur in the laboratory. From recent field observations, we now know that these abnormalities can be also frequent in field populations of tsetse flies.

The potential for tsetse control is obvious: it arises from the fact that abortion has been experimentally induced in pregnant females with applications of insect hormones, for example with topical applications of analogues of juvenile hormones or by injections of moulting hormone preparations.[6] It looks as if the dawn of family planning among insects has caught up with our ecocystem co-habitants.

The point I wish to stress here is not on the details of the discoveries but on the very fact of these discoveries themselves — accomplished on an African problem, in Africa, and in order to solve a practical economic and health problem of high priority in Africa. The second point I wish to emphasize is that, in this instance, not only are important advances being made on the purely scientific front but also that the discoveries are relevant to the national development goals. Thus, excellence and relevance can become quite intimate bed-fellows.

The Useless Insects

It is estimated that probably 3,000,000 species of insects are now known in tropical Africa. Of that number, only about 0.3% are major pests or potential pests of man, his crops, and his livestock. Yet, this small number commands the most concentrated attention of mankind. To be a "dudu" is almost synonymous with being a nasty, wicked, pestiferous being; it seems that to be a "duduman" is almost as noxious. Yet, many of these dudus are not only beneficial to man (e.g. bees, insect pollinators of horticultural crops, insect predators of other dudus), most of them could not care less about our existence one way or the other.

The Book of Proverbs (Chapter 25) states:

> "By wisdom a house is built, and by
> Understanding it is established;
> But it is by knowledge that it is filled
> With precious and pleasant riches."

A Department of Insect Science and Technology in tropical Africa must perforce focus its research attention in bringing about a thorough understanding of the biology, biophysics, biochemistry, natural products chemistry, sensory physiology, and all other scientific facets of the life and planetary existence of insects. The common view of an entomologist being a funny-looking figure with a net pursuing a beetle or a butterfly across meadows is an image that does not quite tally with the serious business of Insect Science — of pursuing insects with a purpose, of asking them questions about the secret of their success, of what makes them tick.

If we were to ask some of our African termites this question, we would probably come up with some very strange answers. Indeed, recent experiments and observations at the ICIPE and elsewhere have just done this. African termites have an elaborate social organization, consisting of several castes, each specialised for performing specific functions in the colony. Thus, soldiers are there to defend the colony against traditional invaders (such as marauding ants); the queen, and its attendant king or kings, is there to ensure a steady stream of eggs laid continuously for several years of its life to replenish the constantly changing termite community; and the workers build and repair the mound, clean it, bury the dead, tend the mushroom gardens, fetch water, forage for the food, feed the queen and king, and normally act as the general factotum of the colony. An interesting fact is that most of our termites, except for the queen and king, are blind. The social organization and coordinated activity of the colony is all very largely regulated through a system of specific odours or pheromones which constitute a chemical language which is, in many ways, just as precise as our vocal communication system.[7] For instance, during foraging, a successful termite worker returns to the mound and, while doing so, lays down an odour trail. On reaching the mound, other workers follow back his odour trail and quickly reach the original food source; on their return journey they in turn reinforce the odour trail with fresh chemical droplets; their arrival in turn recruits other workers; and so fairly soon there is a large and active toing-and-froing along the densely populated chemical highway. Within a few minutes of the exhaustion of the food resource, the odour trail evaporates and disappears since there are no more successful food-laden workers to maintain the highway with their trail-laying pheromone. There is nothing that succeeds like success; but, by the same token, there is nothing as final as failure. The two faces of the coin makes this termite chemical language as good as money.

Because of the utter poverty of our own chemical sense, it is only very recently that scientists have come to realise that social insects have a little known but powerful chemical language that may well be a factor in their great evolutionary success.

In this respect, it is intriguing to speculate whether Charles Darwin, in unravelling the very difficult concept of the co-evolution of flowering plants and their insect pollinators, may not have stumbled on yet another profound natural phenomenon. In his book on *Effects of Cross- and Self-fertilization in the Vegetable Kingdom,* published in 1875, in which he discussed his observations on cross-pollination at some length, he propounded a hypothesis of "how a flower and a bee might slowly become..... modified and adapted to each other in the most perfect manner", and indeed how over the last 80 million years or so flower-visiting insects and flowering plants may have evolved by mutual interaction, in this way achieving a functional symbiosis beneficial to both parties.[8] We are just beginning to suspect that the individual odours of the various plant species may have very specific chemical signals to their insect visitors, and vice versa, and that chemical dialogue is a crucial area which should focus our attention.

Ocol, still angry with Lawino for her African ways, hurls a utilitarian question at her;[2]

> "Do you appreciate the beauty
> Of my roses?
> Or would you rather turn
> My flower garden
> Into a maize-shamba?"

I believe we have a right to ask whether we should concentrate our attention to the tiny minoriy of 0.3% of insect species which are noxious and leave the great majority of over 99% to go their own useless way. I believe that if we did so, the world will only be the poorer: I do not want to miss the chance of knowing in detail how a chemical language works, not only because I would have a chance for patenting a novel trail-laying pheromone that might guide my customers to food or marriage or other activities, or might even lead me to design a television system which can give one not only the pictures and the sound but also the smell of the story, but I want also to enjoy the shear beauty of the chemical language itself. And I want to unravel the numerous other puzzles of insect life that plagues an inquisitive mind: How do they fight diseases? How do they know that they are hungry? How do they ensure that experiences in the larva and pupa are passed on to the adult life? Are they ever angry? What do they feel about such animals as human beings that came only recently to this world?

The sucking lice, *Pediculus humanus* Linnaeus, die within a few hours of the death of their host because they cannot live on the cold body nor can they survive in the open. The louse has become completely dependent on man, sucking his blood and completing its entire life on the human body. In many senses, it regards the human body as a complete ecosystem: the head louse is confined to the hair of the human head, the body louse ranges over his clothing and his skin, and the crab louse larks around the pubic area. They are never winged at any time in their life, nor do they jump (like fleas do); the only way in which they can move from one human being to another is by close contact between an infested body and a clean one, and by the lice crawling across to infest the adjacent human body. The three races or strains of human sucking lice are so specialized for their different ecological niches that they do not go across the perimeter of their particular habitat on the human body. This fact is dramatically demonstrated in surveys of lice resistance to DDT in a large group of Korean military personnel in 1951, where it was a routine procedure to dust each military uniform regularly with DDT before it was won. A long series of tests showed that body lice developed high resistance to DDT, whereas head lice retained their normal susceptibility.[9]

Over 250 species of other sucking lice are found living exclusively on the blood of other terrestrial mammals, with the exception of the carnivores, the dog family, and the marsupials. Just as with the human louse, they spend all their time on the skin of their hosts. A peculiar fact is that each louse species is restricted to a single host species or a few very closely related host species. Indeed, one can identify the species of a host by the kind of lice it harbours.

I would like to make a wild speculation. We have already seen that the three strains or races of human louse are specialised for specific ecological areas of the human body. I am attracted to the idea that during the evolution of the ape-man and the upright-man in Africa, the ape-man louse and upright-man louse was interacting with his host and taking a parallel evolutionary ladder. If that is so, and the present distribution of sucking lice strengthens this proposal, one way of tracing the evolution of our African lice fauna would be to follow the evolution of man; more tellingly, perhaps, is that if we could trace by immunological means the present lice fauna and by fossil records the bygone lice fauna of the suspected environments where early man lived then, we might well be able to piece together a fairly good evolutionary history of man. If this is so, one can only hope that the first man was lousy.

Problems and Prospects

Under tropical conditions, an agricultural system based on monoculture — a pure stand of a single crop — is rare and can only be grown under special and rigid conditions. The most natural agronomic system, and one most easily adopted by the peasant farmer, is likely to be that of mixed cropping. As we have already seen, the rich biota of tropical regions is most likely to conspire to make it almost impossible to adopt anything other than a mixed farming system.

Two peculiar problems arise where a mixed cropping system is practised, as has been shown by recent experience at the International Institute of Tropical Agriculture (IITA), in Ibadan, Nigeria.

Firstly, the pest problem is much less intense than is prevalent under the separate cropping of single plant species. There is not much documentation of this phenomen, nor are the factors that lead to this amelioration of the pest status known. Yet, the ecology of insect pests under varying agronomic cropping systems may well be the pivotal factor in our search for long-range, peasant-directed, environmentally-engineered, pest management programmes. Secondly, varieties of a crop that are insect-resistant while grown separately are not necessarily resistant in a mixed-cropping system. We are, at present, abysmally ignorant of the conditions that result in the breakdown of resistance. It may be that the key to this enigma is an understanding of the factors that stimulate the evolution of insect biotypes, and try to counteract this tendency under agricultural situations. It may also be that an alternative strategy might be to develop plant types with a physiology that has an in-built insurance system — producing for us the amount and quality of the particular crop we need, while, if absolutely necessary, producing additional plant material for the insect pests to feed on. If we were to succeed in doing this, the planet Earth would then have achieved a remarkable state of co-existence of the two animal groups that presently dominate the tropical world: man and insect.

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