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Man and tropical insects (**)

THE SIZE OF THE PROBLEM

A dominant feature of the tropical regions of the world, with their diversity of habitats and a rich vegetation, is the large and almost overwhelming insect kind. ODHIAMBO (1975)[1] has already neatly summarized this important ecological circumstance in the following words:

> « 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. »

This dominance is all-pervasive. For instance, in tropical Africa, there is no getting away from the overpowering presence of insects: for thousands of years, the history and development of the continent has been shaped by the environmental impact of certain insect disease-carriers — of malaria, filariasis, onchocerciasis, and trypanosomiasis. Whole villages died out without trace, and migrations of entire communities, were the result of recurring outbreaks of sleeping sickness, as so dramatically potrayed by MCKELVEY (1973)[2]. Crop production and animal husbandry has always been a hazardous occupation in Africa because of the innumerable insect pests which attack crops and the serious livestock diseases carried

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by ticks; no wonder that the African Man has tended to concentrate on getting an assured yield of a crop rather than grasping for high yields, and he has been more concerned with using his livestock primarily as a socio-cultural symbol and only secondarily as an economic resource.

Just as the nature of the physical environment in the cold temperate regions of the North might have been an important factor shaping the evolution of the European Man in the latter 5,000 years of man's development on this planet, the insect-pest-disease syndrome may have been a vital factor in the evolution of the African Man in tropical Africa, at least since his development beyond the first steps *Homo erectus* took on the chores of Lake Turkana. Indeed, tool-making, which was for a long time regarded as the hallmark for man, may have first been practised in fishing out mound-building termites from their large termitaria during their swarming — much before fire-making became a technological reality. In any case, insect hunting for food is a much easier proposition than hunting for ungulates, which requires not only stamina for outrunning your prey but also a more sophisticated wood or stone tool as an effective weapon for killing, quartering, and skinning and a coordinated team effort to outmatch a group of animals whose considerable senses of sight, sound, and smell have been developed to elude their predators. Consequently, insects were an easier target for hunting and gathering, and still remain a basic mainstay for the small, relict wandering communities of the semi-arid Rift Valley areas of Kenya (Wadorobo) and of the Kalahari Desert (the Bushmen).

The use and uselessness of insects

It is reckoned that there are probably 3,000,000 insect species now known and described from Africa. Of these, probably 3,000 species are of major importance as pests of agricultural crops and domesticated animals and as disease carriers of human and libestock tropical diseases. Probably another 6,000 species are known to occur on crops and livestock, and could turn out to be minor or major pests and disease vectors in the future — should environmental and agronomic conditions change in that time. Therefore, something in the region of only 0.3% of the tropical African insect fauna is of immediate economic and medical significance in Africa; the remaining 99.7% are of no economic or medical consequence in human terms.

Yet, the study of Insect Science is dominated by the consideration of insects as pests and disease carriers. Dethier (1976)[3] has an engaging way of recording this fact, when he wrote these words:

> « It is an interesting aside that of all the branches of zoology, entomology in the only branch concerned with the destruction of the animal that it studies. The position of entomology vis-a-vis other zoological sciences was described in an address to the Entomological Society of

America in 1967, when it was remarked that entomology had advanced a long way from "the science that treats of insects" ... to the "profession that controls insects" ... The words attributed to Archie the cockroach by Don Marquis describe the essence of contemporary entomology:

i thought of all
the massacres and slaughter
of persecuted insects
at the hands of cruel humans
and i cried
aloud to heaven
and i knelt on all six legs
and vowed a vow
of vengeance.

In all justice, it must be pointed out that of all groups of animals, insects as a whole are the most destructive to our crops, homes, livestock, belongings and persons. »

The justification for research concentration on economic or applied entomology is to be found in the last sentence of DETHIER's statement.

Yet the rich and diverse insect fauna in the tropics, offer an equally rich and diverse potential rewards for the keen student in nature. It must be so because the insect kingdom is regarded, in evolutionary terms, as perhaps the most successful group of animals — other than the higher primates. They must have invented certain biological processes and are endowed with a number of evolutionary secrets that have elevated them to such a preeminent position. The complex chemical language of social insects, which governs a great deal of their behaviour and social organization is one such area. These should be discovered and studied in detail. In the words of ODHIAMBO (1975)[4]:

« I believe we have the right to ask whether we should concentrate our attention to the tiny minority 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 pateting 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 sheer 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 CULTURAL AND INTELLECTUAL ENVIRONMENT IN AFRICA

The most intractable problem-area in tackling the insect problems in Africa — whether in terms of beneficial insects or because of the need to manage the pestiferous insect population — is the social context. Between 80 and 90% of the human population of this continent is rural. He is primarily a subsistence farmer, a resource-poor one at that. His immediate goal is to produce enough food for his family, and for this he needs to have an agronomic strategy that insures him against crop failure und unstable production; only secondarily is he concerned to produce enough of his crops to sell for other services and goods.

In order to achieve his twin-goals of (a) a stable agricultural output, and (b) a minimum of agronomic risks, he has chosen to adopt a mixed cropping system. As OKIGBO (1978)[3] has explained in some detail, this is extremely widespread in Africa's subsistence farming and we have to begin to understand its complexities and its advantages. Unfortunately for us, the entire superstructure of applied entomology at the present time is built on a system of growing and harvesting single crops. Crop protection for a monoculture system of agricultural production — which is presently the traditional system for pest control — is a very different proposition from that of a mixed cropping system. Mixed cropping entomology is messy; it is an unknown frontier, as ODHIAMBO (1979)[4] has recently discussed. Research on the status and biology of pests under mixed cropping has been grossly neglected in the past. There are many reasons for this circumstance: some of them relate to the fact that experimentation under this agronomic condition is complex, the diversity of crops within a mixed cropping unit itself is often a discouraging element to most insect scientists (who are used to an analytical approach encompassing only a few components in a simple agroecosystem), and understanding the behaviour and bionomics of insects under mixed cropping is likely to need a systems approach — which is not familiar to most insect biologists.

The rich flora of tropical Africa, and the diversity of habitats, are very much a controlling circumstance in the natural evolution of mixed cropping in tropical Africa. With this realisation, it should now be a matter of research strategy to eschew the automatic adoption of a traditional plant protection methodology for subsistence farming in the continent. As it has been stated cogently elsewhere:[4]

> « In the tropics, particularly in tropical Africa, where mixed cropping covers much the largest area under agriculture, using "monocrop entomology" to solve pest problems arising from mixed cropping practices is not only inappropriate and irrelevant, but indicates our scientific blindness to the situation so apparent in our target problem area. We simply have to direct our minds and scientific talent to long-range basic research on "mixed cropping entomology", to discover the principles governing pest biology under mixed cropping systems, to understand the plants' own system of defence under these situations, and to begin to apply this knowledge to the design of appropriate plant protection practices for this particular agroecosystem ».

Adoption of such a basic mission-oriented research will require a special intellectual environment, where fundamental research is regarded as providing a vital linkage to the eventual practical goal in those cases where science and technology are the key to their solution, as ODHIAMBO (1974)[2] has postulated.

An excellent model for this strategy of basic research and technological application can be seen in the history of the establishment of The International Centre of Insect Physiology and Ecology (ICIPE) in 1970 and its subsequent development.

THE ESTABLISHMENT OF THE ICIPE

At the time the ICIPE was being planned, between 1968 and 1970, thoughtful insect scientists and senior planners were becoming disillusioned by the fact that pesticides seemed to be the main — and, in some case, the sole — prop for pest control, while there was a gathering storm against the large-scale use of pesticides because of environmental pollution, the rise in numbers of insect and tick species which had acquired resistance to a variety of pesticides, and the killing-off of beneficial parasites and predators. This was also the time in which ideas about "third-generation" insecticides — in which the insect's own hormones and other active physiological agents were being tested as a means of inducing insect pests to commit insecticide — were then becoming fashionable. It was again the time during which suggestions regarding "integrated pest management" were commanding more serious attention. Added to the fact that it was intentionally being established in a tropical developing country, the birth of the ICIPE at this particular time was therefore a most opportune entrerprise.

The ICIPE set itself a double mission. Firstly, it set itself to undertake high quality research in several critical aspects of insect life which would lead to the design of novel methods for the control of major pests in a long-range, selective manner within an acceptable ecological framework. Secondly, it set itself the task of carrying out high-elevel technical and scientific training of young, gifted scientists and senior technicians from Africa and other developing countries in the field of insect science and related areas. It was the vision of the ICIPE founders that such research training in a development-oriented field of international concern would foster the growth of a young scientific community in Africa and other developing countries within an appropriate intellectual and cultural framework.

A principal driving force behind the genesis of the ICIPE was to bring together within a single intellectual environment a multiplicity of disciplines, many of which were not at that time traditionally associated with entomological research, in an attempt to solve major pest management problems without the already known drawbacks of classical approaches to insect control.

At the very beginning, the ICIPE had not only an educational aim, it also had a primary interest in the pursuit of fundamental research in insect biology and related disciplines, in the discovery of new knowledge that might lead to the design of novel methods of pest management, and in the encouragement and development of a young African scientific community. To many people in authority either as science policy-makers or as development experts, this approach to science-based problems in the tropical world seemed far too removed from practical realities of the human condition in the Third World. The argument was that the ICIPE (or any similar organization) should devote itself to the application of existing knowledge to the solution of pest problems afflicting tropical Africa and other LDCs in the tropics.

The ICIPE recognizes that there are important applied problems in the management of pests of food crops, the pests and vectors of livestock diseases, and the vectors of rural tropical diseases. But the ICIPE also recognizes that in several crucial cases these applied problems cannot be satisfactorily approached without further basic knowledge. Indeed, the target pest species that the ICIPE has chosen for its priority attack are all pests that have already received considerable national, regional, and international attention — tsetse flies, livestock ticks, sorghum shootfly, cereal stem-borers, African armyworm, grassland termites, and vectors of malaria, filariasis, and leishmaniasis. Many of these have been the subject of practical eradication programmes on an extensive scale over the last several decades. If there were simple, direct methods for the control of these important pests they would have been found in that time and put into operation.

The approach the ICIPE has adopted is one of open strategy. For each target insect, the ICIPE is exploring several lines of study which hold promise as novel avenues for pest management. While not eschewing short-term strategies for pest control, it has not felt it compelling to devote its best endeavours to fire-fighting efforts in short-term control of pest outbreaks. Its mandate is to find new knowledge that will lead the tropical world to long-range and environmentally-acceptable pest management techniques. On this basis, the ICIPE has chosen to concentrate its scientific resources on some of the most difficult tropical pests that encompass the following:

— Bases of Plant Resistance to Insect Attack;

— Crop Borers (cereal stem-borers and legume pod-borers);

— African Armyworm;

— Grassland Termites (in the semi-arid savannah ecosystem);

— Livestock Ticks (especially in relation to East Coast Fever, ECF);

— Tsetse (and their critical importance in the transmission of trypanosomiasis);

— Medical Vectors of Tropical Diseases (particularly in relation to malaria, *bancrofti* filariasis, and visceral leishmaniasis).

ICIPE CORE RESEARCH PROGRAMMES

Bases of Plant Resistance to Insect Attack

The overall goal of the programme is to elucidate basic factors that determine resistance of specific crops to target insect pests, and thus provide necessary information to plant breeders for use in developing pest-resistant or pest-tolerant crop varieties which also possess desirable agronomic characteristics. The use of insecticides is the most common and conventional measure of plant protection against insect pests. However, the development of resistance in insects to insecticides, the increase in the cost of inputs during the last ten years, and the public awareness of problems relating to the use of insecticides have caused increased interest in the possibility of developing alternative methods of plant protection. Among the various alternatives to insecticides, the use of insect resistant plants, in combination with good cultural practices is the most effective, convenient, economical and environmentally acceptable method of insect control. In addition, it is a method that is completely compatible with both chemical and other biological measures. The importance of the use of resistant cultivars as a method of crop protection in tropical countries has gained increasing approval. Because of economic and organization problems, host plant resistance should be considered as one of the primary lines of defence in all pest management programmes for small farmers' fields in these countries (Fig. 1 and 2).

The research goal is being accomplished through 4 types of investigation:

— Field screening of breeding material, through the development of reliable and efficient screening techniques for insect-resistant cultivars under natural and artificial infestation of maize, sorghum, millet, rice and cowpea, in close cooperation with a number of international agricultural research centres at ICIPE's Mbita Point Field Station.

For artificial infestation, the mass-rearing of insects is essential and the development of techniques for this is an important aspect of the work of the programme.

— Studies on the mechanisms of plant resistance, by investigating the detrimental effects of the resistant crops on the insect after its arrival on the plant, and on the initial stages of insect colonizations on the plant. The outcome of such studies might well lead to the identification of morphological, biophysical and biochemical factors responsible for non-acceptance in resistant plants. Should antibiosis be identified as the mechanism of resistance, investigations at the ICIPE will endeavour to identify allelochemicals acting as toxins, growth modifiers, or reproductive inhibitors.

— Genetic studies on the inheritance of resistance. An understanding of the genetic factors controlling resistance is a prerequisite for some of the breeding programmes, especially for maize, sorghum, and rice, information which is needed by the plant breeders in several collaborating institutions. Examination of the role of moderate or partial resistant cultivars of maize, sorghum, millet, rice and cowpea in integrated pest management programmes in tropical countries will be undertaken as well.

— Genetic and physiological mechanisms responsible for the breakdown of resistance barriers as a result of the formation of new insect biotypes. A first project along these lines is being understaken by the ICIPE in the Philippines, in collaboration with the International Rice Research Institute (IRRI), on the rice brown planthopper (BPH), *Nilaparvata lugens*, by studying:

· Differences in external morphology of three BPH biotypes;

· Comparative food intake and the transmission of the grassy stunt virus by the three BPH biotypes, using resistant and susceptible rice cultivars;

· The role of BPH saliva in insect nutrition, and its detrimental effect upon some physiological processes in infested plants of resistant and susceptible rice cultivars;

· Physiological, biophysical, and biochemical mechanisms of rice resistance to the three BPH biotypes;

· The genetical and physiological relationships between the BPH biotypes and the grassy stunt virus as found in resistant and susceptible rice cultivars.

The plant resistance programme is a relatively new one in the ICIPE, and has still some way to go before reaching its optimum activity level.

Crop Borers

The overall goal of the programme is to contribute to increased production of the staple cereal and legume food crops of Africa through plant protection research attuned to subsistence agriculture. The needs of subsistence farmers of the tropics have been largely ignored during the past two decades in which the international community formulated plans to address the problems of world food production. Of the various tropical countries, Africa's needs are most acute based on its record of per capita food production over the past two decades, which shows a net loss due to imbalance between population growth and gains in food production. These factors constitute a strong mandate to accept the challenge to applied ecology posed by the entomology of subsistence agriculture — starting virtually from scratch.

The food staples of Africa are not the "big two" — rice and wheat — which account for approximately half of the world's food energy. They are maize, sorghum, millet and grain legumes — grown chiefly in the traditional intercropping system, which as already referred to is poorly understood and not easily amenable to the standard production technology involving agricultural chemicals and mechanization. Based on the circumstances cited above, the following general guides apply in developing the Crop Borers Research Programme over the medium term:

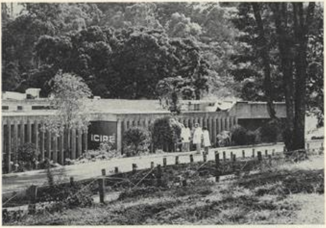

Fig. 1 — Northern Star Building of The International Centre of Insect Physiology and Ecology (ICIPE), at Chiromo Campus of the University of Nairobi.

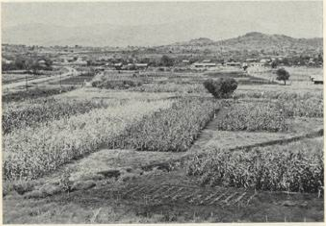

Fig. 2 — ICIPE's Mbita Point Field Station, on the shores of Lake Victoria, where pest research critical to the subsistence farmers is carried out.

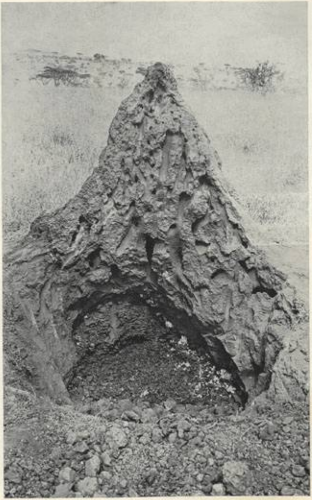

Fig. 3 — A termite mound, made by *Macrotermes* in Kajiado (Masailand), bisected to show the internal structure.

— Give the highest priority to the pests of major food crops of subsistence farmers;

— Give the highest priority to control methods which do not require high inputs of materials and technology; for instance, use of resistant varieties is taken as a basic methodology for plant protection;

— Conduct the ICIPE mission-oriented research in a region of typical subsistence farming and maintain the research on a scale consistent with prevailing farmer practice.

The programme has recently grown out of a small project on the sorghum shootfly, *Atherigona soccata* (SSF), which has been undertaken at the ICIPE for several years now. This project is concentrating on:

— *Field Surveys*: To determine seasonal development, population density, and injury levels with particular reference to variety grown and farming systems practised in the region.

— *Behaviour*: To determine the oviposition behaviour of SSF and factors influencing it, including nutrition, temperature, humidity, and photoperiod - namely:

- feeding and resting behaviour of SSF adults under field and laboratory conditions;
- mating behaviour, with particular reference to the role of pheromones;
- larval movement, feeding behaviour, survival, and rate of development.

— *Ecology*: To determine the ecological factors accounting for population fluctuations through:

- dispersal and migrations, studying these by using marking-release-recapture methods;
- population dynamics, including the influence of climate;
- effect of phenological age of sorghum cultivars on attractiveness to adults, egg distribution, and larval development;
- the role of alternate hostplants in the population dynamics of SSF and its carry-over.

— *Life Table Studies*: To determine, for each life history stage, the factors accounting for mortality, including biotic and abiotic factors.

A new project, on the cowpea pod-borer, *Maruca testulalis*, is now being undertaken and is concentrating on field surveys, ecological research, and life-table studies as a prerequisite for more detailed pest management research on this important legume pest. Similarly, as from early 1980, studies on the three very important stem-borers have been initiated — the spotted stalk-borer, *Chilo partellus* (on maize, sorghum, millet, and sugarcane), the maize stem-borer, *Busseola fusca* (on maize and sorghum), and the rice stem-borer, *Maliarpha separatella* (on rice in West and East Africa). Many of these borers occur as pest complexes in the various cereals, and their study is therefore fairly complex. In any case, stem-borers are extremely difficult problems wherever they occur in the world; and ICIPE's investigations should prove of relevant importance throughout the tropical world although the target species being investigated at present are of African origin.

African Armyworm

The African armyworm, *Spodoptera exempta*, is a serious pest of cereal crops and pastures in many parts of Africa, and especiallyy in Eastern Africa. Reliable estimates of crop losses are not available, but in plague years outbreaks are disastrous to many small farmers who are unable to cope with the rapid destruction of maize and other graminaceous crops by armyworm caterpillars. Years of heavy infestation are followed by several years when little evidence of presence of amyworm is reported, and this presents problems as farmers are caught offguard. For example, during the 1970-1971 season, dense infestations were seen on several thousand square kilometers of grassland, often in densities of 100 larvae m^{-2}. Very heavy losses were caused to cereal crops. Added to the fact that it has a wide distribution in Africa, the Yemen, Saudi Arabia, India, Burma, Indonesia, Malaysia, Australia, Hawaiian Islands, Papua, and the Philippine Islands — and to the additional fact that the African armyworm in closely related to other armyworm species (viz. the notorious fall armyworm in North and South America, *S. frugiperda*; the cotton leafworm, *S. littoralis*, in the Middle East; the lesser armyworm, *S. exigua*; and *S. litura* armyworm in the Far East) — there are few countries in the warmer parts of the world which escape significant crop losses due to these armyworm pests.

The ICIPE African Armyworm Research Programme is part of a larger coordinated thrust being developed for the control of African armyworm in Eastern Africa. The ICIPE programme is aimed at providing basic knowledge required to give a better understanding of the causes of population fluctuation and movements. Other parts of the regional programme are the responsibility of scientists of the Desert Locust Control Organisation for Eastern Africa, the Centre for Overseas Pest Research, the Kenya Agricultural Research Institute (KARI), and national crop protection services in the region. The purpose of the regional programme is to find ways of preventing outbreaks if possible; and failing this to provide ample warning and facilities with better methods of control, so that crop losses are kept to a minimum. Because armyworm moth populations are highly mobile, control has to be developed along a regional and an international basis. The ICIPE Armyworm Research Programme is, in consequence, geared to an applied goal; and its research findings are used and tried in the wider (regional) programme which has immediate and continuing responsibilities to the Ministries of Agriculture in the collaborating countries of the region. This direct link between ICIPE's basic research and its application in agriculture needs to be stressed, as it provides both a stimulus and restraint to the fields of research undertaken. The priority areas for ICIPE's research are the following:

— Investigations of the survival of armyworm during adverse seasons or periods, including the nature of aestivation-diapause in pupae;

— Studies on the behaviour of gregarious and solitary phase caterpillars in the field and laboratory, and the physiological and other differences between the phases at all stages of growth;

— Investigation of marking techniques for tracing movements of armyworm moths. Recent studies have indicated that most very long distance flight is by moths from caterpillars which were crowded during development. Consequently, future research needs to distinguish studies of the conditions associated with development of low-density populations and mechanisms leading to first major outbreaks; and studies on movement of migrant moths from previous outbreaks;

— Studies of the ecology of virus diseases which are possibly key mortality factors and which determine fluctuations in field populations, and partly explain "outbreak" years. Large field cage studies indicate that virus disease may be a key factor in determining fluctuations of armyworm populations in source areas. A study of the ecology of armyworm viruses in relation to weather and field population of armyworm is to be made. The Director of the Unit of Invertebrate Virology, in Oxford, has offered the full facilities of this unit for identification and characterisation of the viruses in *S. exempta*, and to work towards providing serological methods for determining the identities of viruses in field populations of caterpillars and pupae.

It is planned, with some confidence, that the principal part of the programme objectives should have been met within the next 5 years.

Grassland Termites

The Grassland Termites Research Programme is the oldest of the ICIPE projects, and has concentrated over the last five years on problems related to pasture production in the semi-arid savannah ecosystem. It concentrates entirely on the higher termites, which have a highly complex social system, but whose biology is little known although their economic role is obviously prominent in the tropics.

Termites are abundant and widespread in the tropics, and play an important role in their environment. We know, for example, that they constitute an essential part of the ecosystem food chain; that they play a major role in recycling cellulose in the ecosystem; and that they play an important role in soil development, and therefore have a marked effect on soil productivity. On the other hand, termites are known to attack crops, timber and buildings, and are believed to compete with livestock and game animals for forage. Consequently, it is important to assess and establish their role, especially in the tropical semi-arid savannah ecosystem (which has a large potential for animal production), with a view to: (a) the long-term control of harmful groups, or under stressful environmental conditions; and (b) the encouragement of beneficial ones.

The programme is well-established, with a solid basis for experimental and observational work. The ICIPE scientists are currently investigating, and already have obtained some information on, the competitive role of termites as compared to large mammals found in the tropical, semi-arid savannah ecosystem. There is some evidence from laboratory experiments at the ICIPE that food stimuli initiate the termite recruitment process, that the latter is mediated by trail pheromones, and that foraging effort is proportional to the quantity of food available. A method for the laboratory breeding of *Macrotermes* has been developed and the resulting incipient colonies are a source of experimental material, which is being utilized in studies on caste differentiation. A complete developmental sequence of castes in *Macrotermes* has been worked out for the first time, and a start is now being made on a study of the endocrinological basis for this process of differentiation. Chemical properties of food, particularlyy food taste, have been found to be an important component as a stimulus for recruitment of termites to food oriented trails. This finding is part of ICIPE's study of the chemical communication profile of termites, providing an approach to novel control possibilities (Fig. 3).

The concentration of the research activities is on *Macrotermes*, as a model system for the semi-arid savannah ecosystem, although some experimental work has been carried out with other grassland species to elucidate special points of interest. The major areas of research investigations are:

— Foraging Activity: Previous work on *Macrotermes michaelseni* ("closed mound" species) is serving as a model for similar assessment of foraging activity in other areas. The main focus will be on foraging activities of *M. subhyalinus* ("open mound" species), in relation to:

· daily and seasonal foraging cycles as related to environmental factors;
· determination of food preferences and consumption rates in the field.

— The Role of Termites in Soil Development: General aspects of soil ecology such as soil texture, structure, aeration, soil moisture, soil temperature, soil biology, etc., in relation to termite activities will be investigated. These data should help determine the variability of growth and species structure of vegetation:

· to study the effect of termite activity on storm run-off, infiltration, and soil loss under various environmental conditions;

· to estimate the rate of addition of soil to the surface through construction of covered runaway mounds, etc.;

· to carry out further studies on the fertility of termite mounds of various species on different parent material, as well as studies on the effect of termite mounds on vegetation;

· to explore the possibilities of determining the age of mounds by various dating techniques so as to understand the dynamics of termite colony founding, mound building and mound death;

· to estimate the mound densities in Kajiado District (the target field area) by aerial photography and remote sensing techniques (in collaboration with Kenya Rangeland Ecological Monitoring Unit, and Remote Sensing Unit in FAO, Rome), and to relate these densities to ecological conditions.

— Chemical Communication: Trail-laying behaviour and the chemical signals that mediate this behaviour are being studied intensively as forerunner for other studies in chemical communication between termites of the same colony.

— Physiology of Caste Differentiation: Studies are continuing on the following major problem-areas:

· development of laboratory techniques for the normal production of all mature castes by incipient colonies, and for their long-term maintenance;

· food (forage and fungus-comb) utilization by *Macrotermes*;

· investigation on the regulation of caste ratios in laboratory colonies: inhibitory effects by existing soldiers on the development of other soldiers; and the influence of hormones on caste differentiation, particularly of soldiers.

The programme staff have close collaboration with the Zoological Institute, University of Berne, in Switzerland (in termite physiology and behaviour studies), with Centre for Overseas Pest Research, London (on termite ecology), and with the University of Nairobi and the Kenya Ministry of Agriculture (on soil ecology).

Livestock Ticks

Throughout the tropics, but particularly in Africa, tick-borne diseases and the debility caused by tick infestation are major limiting factors on livestock production.

Some of the diseases transmitted by ticks are not amenable to prophylaxis or chemotherapy, and it is necessary to control the ticks by frequent application of acaricides to the host animals in dips or sprays. Many adverse factors are associated with this practice and include:

— Ability of ticks to develop resistance to acaricides;

— Toxicity to host animals;

— The presence of acaricide residues in animal products which are dangerous in the environment and human health.

However, it is probable that the greatest disadvantage resulting from intensive acaricidal control of ticks is that an inherently unstable situation is created which can lead to catastrophies. After a few years of efficiently applied acaricidal control, virtually the entire cattle population is completely susceptible to all of the tick-borne diseases, and naive to infestation with ticks. If, for any reason acaricidal control breaks down, as has happened on many occasions in recent years, massive tick populations will be produced and thousands of cattle will die of debility and disease.

The overall goal of the programme is:

— To carry out research on the immune response of host animals to feeding ticks;

— To produce cattle resistant to tick infestation;

— To carry out research on various aspects of tick physiology and behaviour, both avenues of which might ultimately contribute to the development of an integrated, environmentally sound methodology for the control of ticks and tick-borne diseases.

To achieve this goal, three approaches are being used concurrently: the first immunological, the second physiological, and the third ecological.

(a) *Immunological Approaches*

— It has been observed that following the exposure of animals to tick infestation, resistance is acquired and the ability of ticks to feed on such animals is greatly reduced. In Australia, this phenomenon is being used as a national policy for the control of *Boophilus microplus*.

— It has been demonstrated that mammalian antibodies ingested in the blood-meal of ticks pass unchanged through the gut wall of the tick into the haemolymph. It is possible, therefore, that if antibodies produced in mammalian hosts against various tick antigens are ingested by feeding ticks, adverse effects on the subsequent development of the ticks might result. Such antigens may include broad-spectrum endocrine regulators which may be identified in the Physiological Project.

— Finally, it is possible that these two approaches can be combined, and that individual animals can be made resistant to tick infestation as well as being immunised against target antigens from ticks.

(b) *Physiological Approaches*

The physiological project is concentrating on the elucidation of tick endocrine mechanisms involved in the processes of growth, development, and reproduction. Identification of the natural tick hormones and pheromones, and the subsequent development of synthetic analogues of comparative biological activity to the natural products, might lead to the formulation of broad-spectrum endocrine regulators which would be effective in the control of ticks, and possibly also of other external and internal arthropod parasites of domestic animals.

(c) *Ecological Approaches*

Comprehensive ecological studies on field populations of ticks are being carried out to produce basic information for population models, which will allow evaluation of the efficiency of the different control methods resulting from the above immunological and physiological studies. Based on the results achieved, the population models may well then be used for the design of sound, integrated tick control schemes.

The ICIPE has already established that cattle quickly become resistant to infestation with *R. appendiculatus* after a relatively small number of adult ticks have fed on them, and it is probable that this resistance can be enhanced by inoculation of tick antigens into host animals. It has also been established that when resistant cattle are allowed to graze in *R. appendiculatus* infested paddocks, and no other animals are available for the ticks to feed on, the tick population falls to very low levels and might even disappear. It is with excitement therefore that the ICIPE awaits further developments in this area in the next few years.

Tsetse

The ICIPE Tsetse Research Programme deals with the interrelation between these three components of the disease (vertebrate host-tsetse vector-trypanosome parasite), in order to find new and effective means to disrupt the transmission of the disease and to help in the planning of coordinated control strategies. The overall goal of the ICIPE Tsetse Research Programme can therefore be identified as follows: to contribute to the improvement of animal productivity (as well as the quality of human health) through laboratory and field investigations of tsetse vectors in order to find the means for interrupting the transmission of African trypanosomiasis. This is being accomplished by identifying parameters essential for the planning of a coordinated control of nagana and human sleeping sickness through tsetse biological control, sterile-male tsetse release, vector control by insecticidal means, and the control of the disease through the use of drugs and vaccines.

The programme involves a number of specialised disciplines, and is divided into three research projects on:

— Tsetse Reproductive Physiology
— Tsetse Ecology and Trypanosomiasis Epidemiology
— Trypanosome-Vector Physiology.

Reproductive physiology studies are carried out in males and females to investigate in detail the process of reproduction in terms of internal morphology, regulatory mechanisms and biochemistry. Some of the results will be useful in improving colony performance and ecological methods (e.g. determination of the physiological age), but some of the results might well lead to tsetse control through interruption of the highly specialised tsetse reproductive biology. The behaviour, pupal ecology, population structure and regulation of *Glossina pallidipes* in different areas of Kenya are being studied under the Tsetse Ecology Project. The studies also cover population diversity in morphological, behavioural, physiological and aspects of vectorial capacity. Trapping experiments are carried out so as to improve population sampling, and consequently make possible the collection of representative samples of the tsetse population. Infection rate in natural populations is determined in order to gain a better understanding of trypanosomiasis epidemiology in relation to fly population structure and environmental factors. The relationship between fly and trypanosome physiology is assessed during all phases of the developmental cycle of trypanosomes and in relation to the internal environment of the fly.

At the heart of the ICIPE programme is the ecological research on tsetse, especially on the important vector species *Glossina pallidipes* (as the principal target species):

— Adult behaviour: Diurnal and seasonal activity patterns are observed in relation to different components of the environment (climate, vegetation, hosts) as well as intrinsic factors of the fly (sex, age, hunger stage, pregnancy). Diurnal and nocturnal resting sites are studied during different seasons. Particulars of resting flies (sex, age, hunger stage and posture) will be registered in relation to environmental factors (location, type of plant, plant organ, climate). Studies on acoustic, olfactory and visual sensory biology are carried out and may lead to a better understanding of their relationships with their hosts; such knowledge could also be used to improve population sampling methods. Bloodmeals are collected from engorged flies to determine host preferences. Frequency of feeding are estimated by studying hunger stage in population samples using marking-release-recapture methods.

— Pupal ecology: Pupae are being collected from different types of vegetation, and particulars of pupal sites are being described (location, depth, vegetation, soil and climate); duration of pupal stage of males and females as well as time and rate of emergence, and mortality under different types of pupal sites, are being investigated. Predators and parasites of pupae are being recorded whenever observed.

— Population sampling techniques: The objective is to develop a methodology by which trap catches can be related to true population size and composition of tsetse (particularly *G. pallidipes*). The results will be directly relevant to the studies of

- Population dynamics;
- The evaluation of chemical and biological control campaigns;
- The use of traps themselves in the suppression of local populations of tsetse.

These projects are being carried out mainly at Lambwe Valley (on the shores of Lake Victoria) and at the Kenya coastal belt. Technical arrangements are being made to make the results from the coastal area and Lambwe Valley directly comparable, an objective which can only be achieved by close collaboration and exchange between the respective teams. The *results* will provide:

— A prediction of changes in population size following any control programme;

— A means of assessing the relative efficiencies of new integrated control methods;

— A better understanding of the transmission dynamics of African trypanosomiasis.

A complete epidemiological study is not intended by the ICIPE project. Rather, it is to provide the necessary information on changes in population density and infection rate that determine total challenge. Co-operation with other bodies in Kenya, especially the International Laboratory for Research on Animal Diseases (ILRAD), and the Kenya Trypanosomiasis Research Institute (KETRI), is essential to complete the epidemiological picture, and is not the task of ICIPE alone. Similarly, the major research thrust on immunology is by ILRAD, and on drugs by KETRI in Kenya (and other institutions elsewhere). The ICIPE has now probably the largest group on tsetse biology, and it expects to make a significant contribution to the control of trypanosomiasis through vector control by novel methods, and to the monitoring and surveillance of target tsetse-belt areas (Fig. 4, 5).

Medical Vectors of Tropical Diseases

The programme comprises three target species — on the vectors of malaria, *Bancrofti* filariasis, and leishmaniasis. It is a recent programme, in its revised form, which came into being in 1976, and is divided into two sections — one working on mosquito vectors of malaria and filariasis, and the other on sandflies as vectors of leishmaniasis (kala-azar). The work on mosquitoes takes place mostly at the Kenya coast, the work on sandflies is concentrated in the Machakos district of Kenya (for field work) and in Nairobi (for laboratory and experimental work). There is close collaboration with many institutions, including the Kenya Ministry of Health, WHO Special Programme for Research and Training in Tropical Diseases, Department of Parasitology of the University of Rome, the British Museum (Natural History), London School of Tropical Medicine and Hygiene, the Liverpool School of Tropical Medicine, Hadash Medical School in Israel, the Boyce Thompson Institute at the University of Cornell, and the University of Nairobi.

Malaria is a disease that has the greatest impact in rural Africa. Despite all the measures taken in the past to contain the malarial parasite and to eleminate the parasite vector, this disease remains one of the major public health problems in this continent. *Bancrofti* filariasis does not seem to have significantly decreased in Africa: this may be due to the disease not normally expressing itself in human mortalities; consequently, less attention has been paid to it than it deserves, because of its wide-spread nature and its serious disabling effects on the infected people. In rural areas of Africa, these two diseases are transmitted primarily by *Anopheles funestus*, species of the *Anopheles gambiae* complex, and *Culex pipiens quinquefasciatus* (= *Culex fatigans*). The latter species is also found in urban areas, and is at present multiplying rapidly in Africa due to the fast rate of villaginization and urbanization throughout the continent. Parallel to this circumstance is the fact that artificial water projects designed for agricultural development (e.g. reservoirs, irrigation canals, and paddy rice fields) are creating favourable breeding places for all the three mosquito vectors of filariasis (as well as bilharzia vectors) thus leading to a worsening of the epidemiological situation in the rural areas. Although, leishmaniasis is limited to some known foci, the erection of man-made water projects in the endemic kala-azar areas may cause sharp increases in sandfly populations. This situation, combined with human migration, may lead to serious epidemics affecting large numbers of the rural people. Public health authorities — in concert with agricultural development project managers — are anxious to control vector-borne diseases prevailing in large areas of Africa, and to limit the negative consequences of water management projects on rural community health.

Mosquito and sandfly vectors are not at present effectively controlled by insecticides, because of insecticides-resistance and misuse of pesticides due to lack of basic ecological information. ICIPE's ecological research is designed to lead to better and more effective insecticide application. Further to this, there is a need to improve the already existing non-chemical control methods and to promote new ones that are feasible and less expensive, to be applied by the rural community itself. However, the application of these methods requires considerable basic information on mosquito ecology, on vectorial capacities of anthropophilic species in various ecological habitats (natural as well as man-made), and on mosquito diseases, pathogens, and predators. Pathogens and parasites (fungi, bacteria, and nematodes) have been found occurring naturally in mosquitoes and sandflies. Some of these agents seem to be promising as control agents for the vector species — hence, the ICIPE has a small section dealing with insect pathology.

RESEARCH SUPPORT SERVICES

The ICIPE has 4 support research units which have variously been established from 1975 to 1978 — namely, the Chemistry and Biochemistry Research Unit (CBRU), the Histology and Fine Structure Research Unit (HFSRU), the Sensory Physiology Research Unit (SPRU), and the Bioassay Research Unit (BRU). The main objective of the 4 research units is to provide support services to the entire ICIPE core research programme. This is not intended to stultify original research, and in fact the interpretation of these support research units is manifested as the recognition of biological phenomena discovered in the core programme which depend for their action on chemical substances, cell structure and function, and sensory mechanisms, all of which need to be understood for a rational approach to acquiring critical knowledge of the biology of tropical pests and vectors of tropical diseases prior to the design of more effective pest management strategies.

The establishment of these units, together with the multidisciplinary approach the ICIPE adopted from the very beginning, has enabled the ICIPE to make advances in pest management research that would have been difficult to achieve otherwise. In addition, the availability of disciplinary expertise and advanced technology for the needed research on the spot, has enabled the ICIPE to interact and react quickly to new research challenges in the priority problem-areas (Fig. 6).

A decision has been made to establish in 1981 a support unit for biostatistics and computer service, to assist the core programmes in the design of experiments, and the analysis and interpretation of experimental and observational data. It will also be concerned with population modelling and systems analysis. It is a service sorely needed at the ICIPE.

There are 6 research and technical support services at the ICIPE establised over a period of time from 1972 (in the case of the Insect and Animal Breeding Unit) to 1979 (when Laboratory Management was formed as a distinct entity):

- Insect and Animal Breeding
- Field Stations (Mbita Point, Muhaka, and Kajiado)
- Outreach Management
- Workshops
- Laboratory Management
- Library and Documentation.

Each of these is headed by a principal staff or senior member of the technical staff. It is intended that all the support units will be headed by international professional staff by the end of the year 1982.

The ICIPE training programme

The ICIPE currently operates a number of training projects on a regular basis, with emphasis being given to selected candidates from the developing countries (although not exclusively so, especially for the postdoctoral programme):

— *Research Associateships*, for gifted young scientists from LDCs already holding appointments in their own countries. The associateships permit them to visit the ICIPE for 3-6 months each year for a period of 3-4 years to carry out collaborative research at the ICIPE on priority problem-areas.

— *Postdoctoral Research Fellowships*, for young scientists selected worldwide on a competitive basis, to work for periods of 1-3 years.

— *Graduate Research Scholars*, for project work at the ICIPE under the supervision of ICIPE staff. The trainees are enabled to complete higher degrees of their home institutions in a project relevant to the ICIPE strategy.

— *ICIPE Science Bursars Scheme*, in which every year, 8-10 high school science graduates receive a 6-month work experience in specific ICIPE research projects or research units, before they proceed to university institutions for a science career (for logistical reasons, the programme is restricted to candidates from East Africa).

— *Professional Technical and Administrative Training Programmes* for ICIPE and other staff in areas in which the ICIPE has competence.

— *Language Training*, initiated in 1978 with classes in French, and extended in 1980 to Swahili; it is intended to introduce English for the non-English speakers in 1982 (in association with a university institution).

The entire training programme of the ICIPE will be reviewed during the latter half of 1980 to give assurance that its goals and purposes are being met, both for the ICIPE's own needs as well as the needs of other institutions and nations.

The ICIPE convenes, under a regular schedule, scientific meetings and training sessions. These include:

— *Seminars* of a specialised scientific nature. In the last 7 years, the Centre in Nairobi has convened 362 formal seminars and many informal ones, on a weekly basis throughout the year. Since 1979, regular seminars are also now being convened at the field stations at Mbita Point and at the coast. Not only ICIPE staff, but scientists from many national and international institutions participate in the seminars, which coverts the whole range of ICIPE core programme and related subjects.

— *Training for Practitioners*, which includes the Group Training Course in Components Essential for Ecologically Sound Pest and Vector Management Systems, which began in July 1977 and has since met every year for about 3 weeks under the joint sponsorship of UNEP and the ICIPE. Evaluation procedures permit constant improvement of the course, which relies considerably on case-studies given mostly by external course lecturers.

It is intendede to adopt the evaluation procedures already found effective here in other training projects at the ICIPE.

— *International Study Workshops*: Small workshops of about 20 outside and 10 ICIPE participants to consider a specialised problem-area of the ICIPE core programme were initiated in 1973, and 10 such workshops have been organized since then:

· Parasite-Vector Relationships with Particular Reference to the Tsetse Fly (jointly with the Rockefeller Foundation): Bellagio, 27th June to 1st July 1973.

· African Armyworm: ICIPE Research Centre, Nairobi, 6th to 10th July 1975.

· Tsetse Ecology and Behaviour: ICIPE Research Centre, Nairobi, 28th September to 2nd October 1976.

· Physiological Significance of Tick Behaviour: ICIPE Research Centre, Nairobi, 10th to 14th October 1977.

· Science and Technology Information Transfer (jointly with SAREC, University of Nairobi, and National Council for Science and Technology, Kenya): Kenyatta Conference Centre, Nairobi, 2nd to 7th May 1978.

· Epidemiology of African Trypanosomiasis: TILLMIAP, Nairobi, 2nd to 7th April 1979.

· Appropriate Industrial Technology for the Control of Tropical Pests and Disease Vectors (jointly with UNIDO): Kenyatta Conference Centre, Nairobi, 29th July to 4th August 1979.

· The Sorghum Shootfly (Biology, Ecology, and Control of Sorghum Shootfly): ICIPE Research Centre, Nairobi, 4th to 8th May 1980.

· The Use of Naturally Occurring Plant Products in Pest and Disease Control: ICIPE Research Centre, Nairobi, 11th to 16th May 1980.

· Scientific Working Group on Cereal Stem-Borers and Legume Pod-Borers: Mbita Point Field Station and Nairobi, 1st to 5th September 1980.

A yearly event on the ICIPE calendar, is the Annual Research Conference, which is held in the first or second week of June every year and gives the ICIPE staff a chance to review their entire programme during the past year in the presence of senior scientists from the sponsors, collaborating institutions, and representatives of international organizations. Each year, two programmes are reviewed in depth, and the comments and advice so received is utilised in reviewing the ICIPE programme and budget for the ensuing period.

For the first time, in the June 1980 Annual Research Conference, the training programme will be reviewed in some depth. It is expected that a similar review of ICIPE's training activities will be undertaken every 3 years or so.

As research provides the base for training, its success means that the latter can be undertaken with confidence. It is with this blackground that the ICIPE training programmes are set. The special research facilities available provide unparalled opportunity for training in research methodology and the application of research results. In addition, the resident scientists who are experienced in diverse disciplines provide training in many areas, but in the context of clear application goals. Because of the scepticism expressed at the inception of ICIPE, by some science policy-makers and development experts on the chances of ICIPE achieving its objectives, the Centre concentrated its meagre resources in productive research to ensure that it achieved results. It therefore allocated minimal resources to the development of physical facilities including those for training. However, now that the experiment has yielded positive results and the ICIPE is confident of sustained development, and as research and training activities have expanded out of proportion with physical facilities, the ICIPE is seeking financial support to develop facilities which will ensure that it continues to meet its targets in research and training.

The ICIPE is forward looking and would not like to follow the traditional system of developing new scientific and technological knowledge without relating it to the existing socio-economic structure. Besides, the ICIPE seeks to orient its research to include the problems of rural communities who have neither the technology nor the resources for applying sophisticated and usually expensive methods of pest control to alleviate the ravages caused by insect pests and vectors to their food crops, animals, and human health. In keeping with these views, the ICIPE has established three field stations in three different ecological zones. One at the Kenya Coast with equatorial regime and with wild populations of tsetse; one at Kajiado in the semi-arid savannah grassland supporting large numbers of wild game and livestock; and another at Mbita Point on Lake Victoria in typical tropical Africa with its subsistence farming and where wild populations of tsetse occur nearby in Lambwe Valley and where a permanent resident population of African Armyworm is found. The field stations are in the same state as the Nairobi headquarters regarding physical facilities. They are either housed in temporary buildings or in limited rented accommodation. Through the generosity of three donors, an international guest centre is under construction in Nairobi. When it is completed in early 1980 it will provide the much needed training facilities. Two other donors have generously provided funds for the building programme at Mbita Point Field Station. Their grant will help the ICIPE to consolidate its research on bases of plant resistance to insect attack and on crop borers with other research programmes using the Field Station for developing pilot schemes on pest control. It will also provide facilities for research and technical training.

At the beginning, the training programmes of the ICIPE were closely linked with those of the University of Nairobi, the Kenya Polytechnic, and similar institutions in East Africa. These research training activities have been expanded and the most recent developments are:

— The ICIPE concluded an Agreement with the University of Ibadan, in Nigeria which, amongst other provisions, facilitates ICIPE programmes in Graduate Research Scholars, Postdoctoral Research Fellowships, and Research Associateships in respect of Nigeria.

— The ICIPE/UNEP Group Training Course in Components Essential for Ecologically Sound Pest and Vector Management Systems is held in Nairobi every year during July/August with professional pest management experts and entomologists from Africa, Latin America, Asia, and Middle East, and has proved to be a great success. Three of these courses have been held since 1977, and the fourth is scheduled to be held as from 30th June 1980.

— The establishment of the *African Association of Insect Scientists* during a meeting in Nairobi in December 1978. The association intends to act as a professional forum for this science in the continent. It is an independent body, with its own officers, but the ICIPE has encouraged its establishment and future development.

— The ICIPE African Committee now phased out, has recommended to the Governing Board the establishment of an International Postgraduate Studies Programme in Insect Science. This programme is widely supported by universities and research institutions in Africa. It will offer M. Sc. and Ph. D. degrees of the participating Universities in Africa. Course work will be undertaken at the ICIPE, but research may be conducted at the home institutions or at the ICIPE.

The ICIPE has held wide-ranging discussions with the WHO and its advisors in connection with its UNDP/World Bank/WHO Special Programme on Tropical Disease Research and Training (TDR), on the understanding that the ICIPE could provide vital inputs to the programme if it were to direct its attention to aspects of vector biology and epidemiology, particularly in regard to human trypanosomiasis, malaria, filariasis, and leishmaniasis. As a result, a cooperative programme with WHO-TDR was signed in May 1979, to strengthen the ICIPE in the areas of tropical disease vector research, the taxonomy of African medical vectors, and technical work in the tropical vectors field. It is hoped that by the time the contract comes to an end in mid-1981, the ICIPE would be in a position to take on major research responsibilities in the field of vectors of tropical diseases (especially in malaria, filariasis, and leishmaniasis).

Training has been stated as one mission of the ICIPE. This mission has the overall objective of building scientific and technological capabilities of the developing countries in applied insect science. Within that broad objective, specific objectives of training can be summarised as follows:

(a) To provide advanced training in research methodology and application for promising graduate and postdoctoral research fellows. This includes graduate research scholarships, postdoctoral fellowships, supervision of research projects and training in research methodology and specialized techniques.

(b) To acquaint young scientists, actively engaged in pest and vector management research or those who are starting their careers, with recent advances in pest and vector management research. The UNEP/ICIPE Group Training Course series is one of such short courses aimed at this objective.

(c) To allow young scientists who are either teaching or in research institutions to undertake advanced research in the special research environment found at the ICIPE. A successful scheme, that of *Research Associateship*, has been developed for this purpose.

(d) To improve the capability of technicians by introducing them to insect biology and the techniques used in various areas of research on insects.

(e) To develop its manpower resources through graduate or postdoctoral training; management and advanced secretarial training; technical training; study tours; study leave; and *Scientist-in-Residence scheme*.

(f) To provide an international forum for the discussion and exchange of knowledge among scientists through seminars, study workshops, symposia, and conferences on the results of the most recent research relating to insect science and technology.

(g) To improve the communication of its staff by organizing language courses.

Some of the training projects have been undertaken since 1972, but in fact training activities have become intensive since 1977, when some training funds became available on a regular basis, such as those from UNEP and UNDP. The following Table (Table 1) summarises the training output in terms of man-years.

The organizational structure of the ICIPE

Research Leadership

In the early development stages of the ICIPE, the bulk of its research staff consisted of young postdoctoral research fellows who were appointed for periods of 1 to 3 years only. There was therefore a continuing flux of staff at the ICIPE. Because of their relative inexperience in research, and because of the multi-disciplinary approach upon which the ICIPE had insisted from the very

Fig. 4 — ICIPE's Coastal Field Station on the shores of the Indian Ocean concentrates on insect vectors of tropical diseases. The fallen coconut remains are a favourite haunt of many mosquito species.

Fig. 5 — Field visit on tsetse ecology by practising entomologists attending the 1ts ICIPE/UNEP Group Training Course in Components Essential for Ecologically Sound Pest and Vector Management Systems, July 1977.

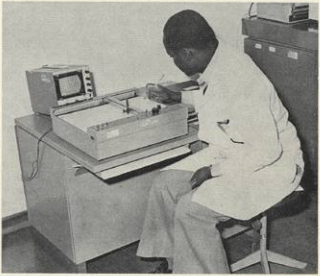

Fig. 6 — A postdoctoral research chemist at the ICIPE running the proton nuclear magnetic resonance (NMR) spectrum of an antifeedant chemical isolated from an African plant.

TABLE 1 — *Training Output (in man-years) at ICIPE Research Centre, 1972-1980.*

Programmes	YEAR 1972	1973	1974	1975	1976	1977	1978	1979	1980	Total
High School Bursars	—	—	5.50	3.50	4.00	4.50	5.00	5.00	5.00	32.50
Graduate Training:										
— ICIPE Staff at ICIPE										
M. Sc.	—	—	1.00	1.00	3.00	5.00	2.00	2.00	—	14.00
Ph. D.	—	—	—	1.00	1.00	2.00	2.00	2.00	3.00	11.00
— ICIPE Staff in other institutions										
M. Sc.	—	1.00	1.00	—	—	—	2.00	1.00	1.00	6.00
Ph. D.	—	—	—	1.00	1.00	2.00	2.00	2.00	5.00	13.00
— At ICIPE for other institutions										
M. Sc.	—	—	—	—	—	—	1.00	1.00	3.00	5.00
Ph. D.	—	—	—	—	—	1.00	2.00	2.00	2.00	7.00
Graduate Research Scholarship	—	—	—	—	—	3.00	2.00	3.00	6.00	14.00
Research Associateship	—	1.00	1.00	1.00	—	1.00	2.00	2.00	2.00	10.00
Specialized Training:										
— At ACIPE for other institutions	—	—	1.92	0.52	2.17	1.33	1.25	2.25	2.00	11.42
— ICIPE Staff in other institutions	1.08	0.50	2.65	0.96	0.83	1.75	0.58	3.33	5.00	16.68
Postdoctoral Training	—	—	—	—	—	3.00	6.00	11.00	15.00	35.00
Technical Training:										
— Basic In-House	—	—	—	3.24	3.78	2.70	3.51	—	—	13.23
Advanced In-House	—	—	—	—	—	—	2.50	—	—	2.50
— At Kenya Polytechnic	2.00	2.00	3.00	1.00	4.00	6.00	8.00	5.00	4.00	35.00
Management Training	—	—	—	—	—	2.33	2.58	3.33	4.00	12.24
Secretarial Training	—	—	—	—	—	1.25	1.00	0.75	1.58	4.58
International Group Training Course in Pest Management Systems	—	—	—	—	—	0.86	0.84	1.55	1.50	4.75
ICIPE Language Course	—	—	—	—	—	—	5.33	4.00	4.00	13.33
TOTAL	3.08	4.50	16.07	13.20	19.78	37.72	51.59	51.21	64.08	261.23

beginning, the founders of the Centre "invented" the practice of appointing senior researchers as Visiting Directors of Research (VDR). Between 16 and 22 of these VDRs were having appointments at the ICIPE in any one year; and in each year everyone of them was expected to visit the ICIPE two or three times to assess the work going on at the ICIPE, to formulate (or help to formulate) new projects, and to help the Director in other ways to get the scientific programme effectively meet its objectives. Largely because of the productive role of this VDR system, the ICIPE was able in 7 short years to get its scientific programme on a high level of excellence and achievement.

Nevertheless, for reasons of programme efficiency and to provide continuity in the scientific work, the ICIPE decided from early 1976, (a) to have more senior scientists (rather than postdoctoral research fellows) to form the bulk of its research staff, and (b) to provide longer-term employment contracts. The vigorous implementation of this policy soon made it obvious that the ICIPE must appoint resident staff as Programme Leaders, rather than to continue relying on the non-resident VDRs. Again, the application of ICIPE's research results to actual pest problems in the field — exemplified by the several collaborative agreements reached with international agricultural research centres and other applied institutions — required that the ICIPE have experienced programme leaders on a continuing basis, supervising and coordinating scientific work on the spot.

Early in 1978, the ICIPE — on the advice of the ICIPE Foundation — appointed a Visiting Group on Administration and Finance (VGAF). The Visiting Group reported in November 1978. The Governing Board made decision based on the Visiting Group report at its 35th Meeting in January 1979. Amongst these, was the decision to phase out in June 1979 the VDR system altogether, and to have senior scientists appointed as resident Programme Leaders for all the major ICIPE programmes without delay. In the course of 1979 and 1980, Programme Leaders will have been appointed in all ICIPE's 7 programmes. Similarly, the 4 research units have each now a senior or principal research scientist at its head.

A system of short-term consultancies for specific areas of concern to the ICIPE, or longer-term (up to one year) advisory appointment for extensive participation in ICIPE's work, will be continued and extended at the Centre. Financial provision for such appointments are being made in each of the programmes and units to ensure that the ICIPE can still call upon the best external advice needed to make its work more innovative and productive.

Governance and Advisory Bodies

The VGAF devoted considerable effort to an understanding of the very complex committee system that had been elaborated over the years to meet specific needs of the Centre and which now needed a critical reappraisal. For more efficient governance and management of the institute, the Visiting Group strongly recommended the simplification of the advisory committee system, and the strengthening of the Governing Board itself.

The Governing Board, at its January 1979 meeting, decided to phase out within this year the following advisory committees:

— The Research and Training Council (which consisted of the VDRs and the ICIPE Director, and which advised the Board on scientific programmes and scientific appointments).

— The Policy Advisory Committee (which was established initially as part of the UNDP/ICIPE Contract for research and training, and whose members comprised a representative of the Governing Board, the Director of the ICIPE, representatives of the UNDP, FAO, WHO, IAEA, and UNESCO, and representatives of the international agricultural research centres. Its main function was to advise the Board on the international priority and relevance of ICIPE's work).

— The African Committee (whose members included representatives of Africa's sub-regions, representatives of a number of African institutions, and the ICIPE Director. It was mainly concerned with training policy and the relevance of ICIPE's work to African problems).

The first two advisory committees held their last meetings in June 1979, and were phased out then. The African Committee held its last meeting in December 1979 and was then phased out. The only external advisory committee which is remaining is the ICIPE Foundation. Its main function is to assist the Governing Board on periodical appointment of Visiting Groups to evaluate ICIPE's scientific work and to monitor its quality and relevance to major tropical problems, and to act as a link with the international scientific community. It is headquartered in Stockholm at the Royal Swedish Academy of Sciences; and has as its members several major academies of science which have an interest in insect science and its vigorous development in the tropics.

A major internal reorganization of the ICIPE Governing Board took place recently as a follow-up of the decisions made by the Board in January 1979:

— The Board now holds one major meeting each year, in late March. The annual meeting deals with the major Board responsibilities (e.g. consideration and approval of the budget, approval of the financial report and accounts for the previous year, receiving the programme report of the previous year and consideration of the following year's programme, and deliberation on the Director's Report). It lasts approximately 6 days, including 2 days devoted to an "Open Meeting" which can be attended by representatives of donor agencies and other invitees. The first such meeting was held from 24th to 30th March 1980.

— In between meetings, the *Executive Committee* carries on the functions of the Board. The Committee takes special interest on financial matters, capital development projects, and senior appointments. The Committee consists of the Chairman and Vice-Chairman of the Board, the Director of the ICIPE, and 3 other

Board members. Its most important meeting is in September/October, when it considers budgetary and planning matters.

— The Board has established its own *Programme Committee* in place of the 3 scientific advisory committees which were phased out in 1979. It consists of 7 members of the Board, who have wide experience on scientific research and science policy. Its most important meeting is held during ICIPE's Annual Research Conference, always held during the first week of June, so that the Committee can review the progress the institute is making in its programme and so make suggestions on ICIPE's programme and budget in time for the ICIPE management to incorporate them by the end of the year for the Board's consideration at its annual meeting in the following March.

— The Board is conscious of the fact that it needs to have a regular system of membership rotation. This system was initiated in 1979. The Board has established a *Nominating Committee* of 3 Board members to have an oversight of nominations to the Board and its committees.

— The Director of the ICIPE is a member of the Board, and therefore maintains close liaison between the Board and the ICIPE Management. He is, of course, the chief executive and chief scientist of the institute.

These major organizational changes have now put the ICIPE in a strong position to reach its goals with more professional competence and with better management tools. A new Board of 16 members (including the Director) came into being in June 1979. Its geographical representation has considerably widened, and it is expected to cover the tropical regions of the world, the donor community, as well as the international scientific community.

The institute's programme activities have intensified and matured over the last eight years; but the supporting management and administrative services have not expanded correspondingly. In the next 5-year plan period, it will become essential to match the level of programme activities with the supporting administrative services — particularly as the physical facilities become available. In doing this, the ICIPE still wants to keep its planning model of keeping the administration small but efficient. In any case, there is a deliberate management policy to keep the ICIPE Administration small — and to devote most of the institutional resources to the scientific work.

The consequences of a model

We believe that the ICIPE model has created an enormous promise: that it is possible to create a vigorous intellectual environment within which serious scientific work can be undertaken — not only to push back our frontiers of ignorance but also provide the necessary scientific knowledge for technological innovations.

The ICIPE has brought a new revelation — that tropical Africa can be brought into the full scientific arena of the international community in almost one quantum jump, by assuming that the indigenous genius for scientific endeavour is there, and by then providing a catalyst (an enzyme) and the right environment to trigger off an accelerated scientific development.

This achievement, of excellence and relevance in scientific enquiry and technological application seems to require five main ingredients — if the experience of the ICIPE is anything to go by:

— FIRST, the concept of a *concentrated research centre*, with motivated young Third World scientists and first-class research facilities need to be accepted and implemented. Just prior to the planning for the creation of the ICIPE, ODHIAMBO (1967)[8] had this to say:

> « It seems to me that Africa's best long-term solution to the problems of conducting effective research is to concentrate research effort in a few very large centers. To take one example, for research in insect biology, one could imagine the establishment of a large institute in a locale where other ecological conditions are accessible. It would have a small permanent staff, but would draw a large number of postgraduate students and other researchers from many countries representing many disciplines (ecology, taxanomy, physiology, biochemistry, toxicology, and others). The institute's program would be such that it would concentrate all its resources on a few particular problems over a period, thus ensuring immediate return from the funds invested in it.... At such centers expensive equipment can be put to best advantage, and the centers offer opportunities for periodical renovation of one's scientific outlook. But above all, they are powerhouses for the initiated and for those wishing to be initiated in research ».

We believe this strategy could apply to many other areas of scientific enterprise.

— SECOND, an incentive-giving *reward system* needs to be clearly defined and imaginatively implemented, to keep motivation bubbling. Reasonable emoluments, rapid response time to expressed needs, stress on scientific productivity, and lime-lighting achievement, are some of the tools for such a reward system. Africa is conspicuous by the manner in which it neglects its scientists — and it is a problem widespread throughout the Third World.

— THIRD, a *sharp focus* needs to be turned on difficult and priority problems where science holds the key to a practical long-term solution. The insistence on a long-range solution implies that excellent science and equally good technology must go hand-in-hand.

— FOURTH, the role of *international cooperation* is clearly one of assuring the continental scientific community that it is jointly building on the store of accumulated human knowledge and giving it confidence on its vision and productivity. But an equally important task is one of information exchange and of sharing experiences, although this is being done in an atmosphere of competitive spirit.

— FIFTH, a *sense of challenge* must underlie the entire scientific enterprise. Research and Development is required urgently by the African countries, and it cannot be achieved by technical assistance: the national and regional goals can only be reached by direct involvement in scientific enquiry, discovery, innovation and industrial or agricultural development.

The ICIPE experience is therefore one of immediate concern to the major objective of integrated pest and vector management; but it carries also lessons for other scientific endeavours in Africa and other Third World countries.

Five years ago, LEWIN (1975)[*] writing in the scientific magazine *New Scientist* was most optimistic about the establishment of the ICIPE and its strategy:

> « A small but modern laboratory — known as the Northern Star Building — situated in the leafy Chiromo Campus of the University of Nairobi houses what is undoubtedly the most important enterprise in insect biology in the world today. The Nothern Star Building is the newly completed home of the International Centre of Insect Physiology and Ecology, an organization aiming to probe deeply into the basic biology of economically important tropical insect pests as a basis for more rational control. Established as an operational laboratory only within the past couple of years, ICIPE has just reached its "critical mass" of almost 30 international scientists. In spite of considerable political and financial difficulties, the research programme has already produced significant results ».

Five years later, with 42 principal staff, we can state with some confidence that the Centre has truly taken off; and we look with great expectations of major breakthroughs in the major pest problems the ICIPE has put to itself.

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