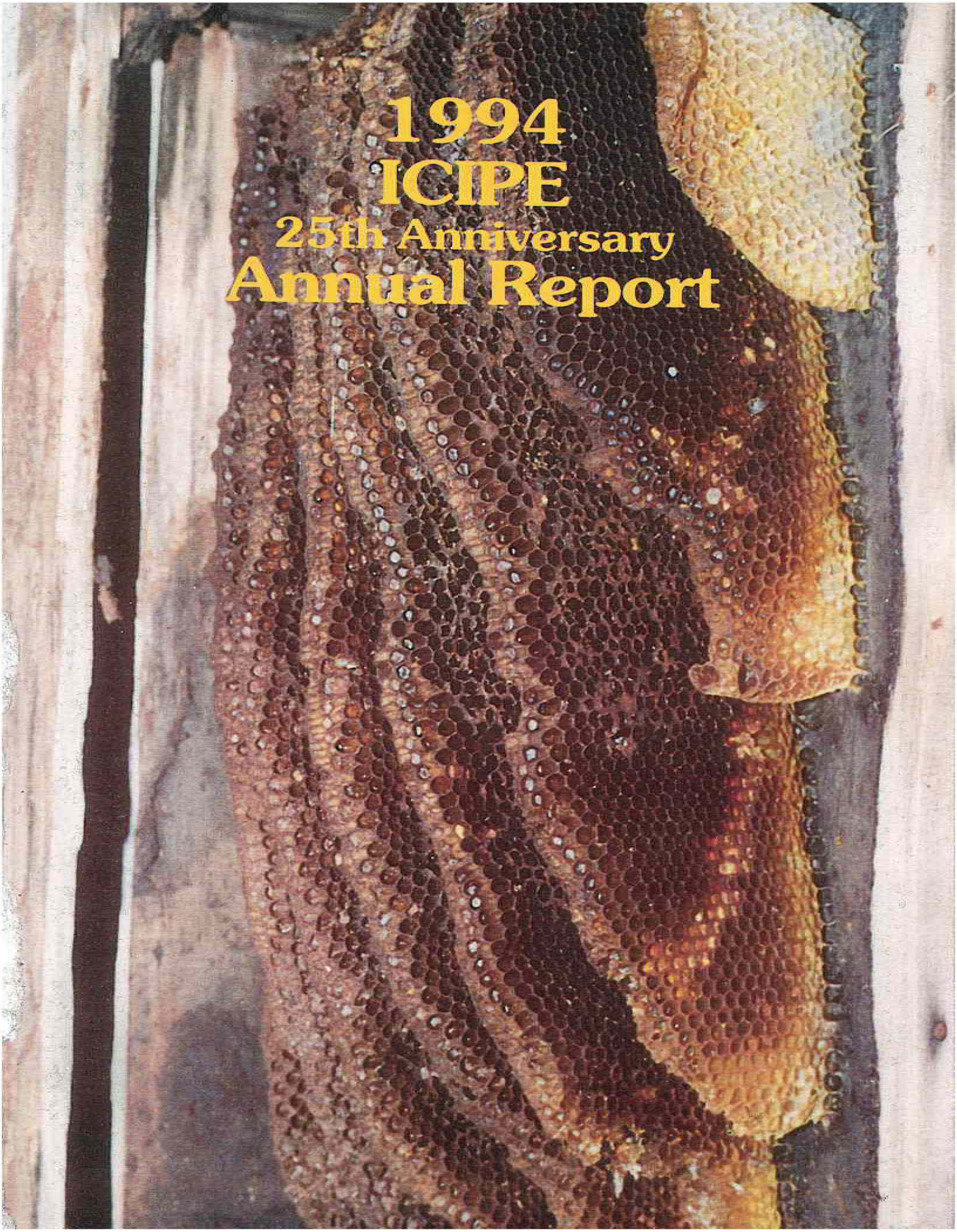

1994 Annual Report
25th Anniversary
International Centre of Insect Physiology and Ecology
icipe

1994 ICIPE

25th Anniversary Annual Report



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Dedication

Tribute to Dr William T. Mashler

This 22nd Annual Report of the ICIPE is dedicated to the memory of the late Dr William T. Mashler, Chairman of the 1994 ICIPE Governing Council. It is befitting to do so because of Dr Mashler's consistently creative ideas and belief in applying science and technology to address the issues of hunger, health and environment, issues which are at the heart of ICIPE's own mandate. Bill Mashler's contribution to funding agricultural research and development for the benefit of the underpriviledged has been recognised by the many institutions he supported in the developing countries.

Early in his career, immediately after the Second World War, Dr Mashler was associated with the international endeavour to liquidate the colonial system. When by 1962, the major task in decolonisation had been achieved, he turned his attention to assisting the newly independent countries to develop their economic and social systems. This took him to the United Nations Development Programme (UNDP), where in 1971 he was appointed Director for the newly established Division of Global and Interregional Projects, eventually rising to the rank of Senior Director.

For those who know the history of ICIPE, they will confirm that without Bill, ICIPE would not be where it is today. In 1971, he helped set up ICIPE's scientific research programme and brought to it the first major financial support base from UNDP; he subsequently persuaded other donors to provide financial support in the Centre's formative years.

Bill had a global vision. He readily acknowledged that ICIPE was a pathfinder and innovator in the area of biological control of insects, which today

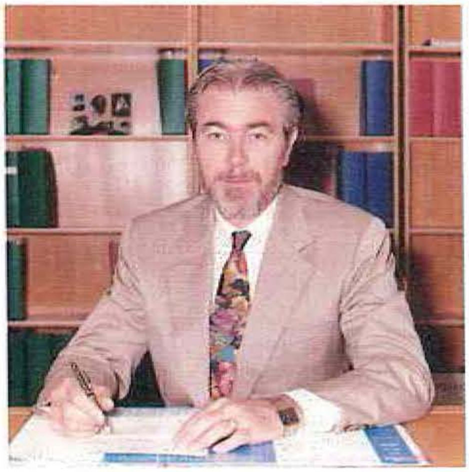
William T. Mashler

has come to be universally accepted as one of the key aspects in the concept of agricultural and environmental 'sustainability'.

As one of the intellecutal godfathers of ICIPE, Dr Mashler's concern for ICIPE's strategic planning was so intense that just two months before his death in August, 1995, he sent a message to the Governing Council urging them to ensure that in designing the scientific programme, it should be drafted in such a way as to persuade all involved of its vision and true efficacy and of its potential for collaboration with other scientific institutions. Impatient with theory, he sought always to put his ideas into practice. All this was backed by a character which upheld the virtues of integrity, trust in humanity, good humour and courtesy.

Apart from his close association with ICIPE, Bill Mashler was himself an 'institution' in the Consultative Group on International Agricultural Research (CGIAR) and its institutes. We are thankful for his life and at this time of ICIPE's 25th year, we remember all the many others who have joined him in supporting ICIPE. Bill himself singled out for mention Dr Monty Yudelman, who played a central role in ICIPE's earliest years.

Message from the Director General



Hans R. Herren

The year 1994 marked two milestones for the ICIPE, one being the 25th anniversary of its foundation and the other its complete restructuring to address the new needs of a rapidly changing world. In the past 25 years, ICIPE has successfully carried out research and capacity building in insect sciences in Africa. From a mainly basic research centre at its launching in 1970, ICIPE has been increasingly tackling arthropod-induced problems in food crops, animal husbandry and human health, driven by the mission-oriented approach of its founder, Professor Thomas R. Odhiambo.

One of the most significant recent breakthroughs relates to the uncovering of the chemical basis of locust communication and behaviour, thus paving the way to an environmentally sound and economical approach for locust control. Other major achievements include the developments of effective and environmentaly safe and insecticide-free tsetse traps, utilising cow urine as attractant; the successful establishment of natural enemies against cereal stemborers; and formulating of IPM (Integrated Pest Management) strategies for banana and cereals using agronomic practices and habitat management complemented with biological control.

Major advances have also been made in the control and management of disease vectors such as ticks, mosquitoes and sandflies. More recent projects deal with the promotion of neem and other botanicals as cost-effective and environmentally friendly alternatives to synthetic pesticides. These technologies are being applied in partnership with national institutions and rural communities for the management of crop borers and tsetse in Kenya and Zambia, and for the management of disease vectors in refugee camps in Ethiopia and northern Kenya. The most important aspect of ICIPE's activities, although not always so obvious since it is embedded within overall strategies, is the Centre's research into the basic understanding of the arthropods' biology and ecology which underpins sustainable solutions to pest problems.

The challenge, however, remains daunting. Pests still destroy an average of 40% of world food production, and this despite an ever larger amount of global pesticide use. Human and animal vector-transmitted diseases are on the rise too, despite the use of pesticides, therapeutic drugs and vaccines. Arthropods have demonstrated a relentless ability to develop resistance to almost any form of synthetic pesticide, thanks to their huge reproduction potential and due to the static nature of non-biological control agents.

With the increasing need for food over the next 25 years for a steadily growing population, and the difficulties in achieving new and substantial yield increases through breeding and agronomic practices, it is becoming even more important to reduce both pre- and post-harvest losses. While food quantity is important, quality should remain the second most important objective. In particular, the production of nutritious, pesticide residue-free food is needed so as not to endanger the health of the

Left: The health and welfare of the rural communities of the developing countries remains ICIPE's prime concern today as much as it was 25 years ago. ICIPE's programmes focus on improving food security, human and livestock health, and income-generating opportunities through research and development of management tools for arthropod pests and commercial insects. Below: Banana is one of the several major staple foods in the tropics for which ICIPE is now in closer collaboration with IITA in developing improved IPM practices for lowering pest incidence and encouraging the protective function of natural enemies already in the environment.

consumer nor the agricultural production base through indiscriminate use of chemicals.

ICIPE has recognised that many of its activities in pest control in the past were overlapping with those of the Centres of the Consultative Group on International Agricultural Research (CGIAR). Consequently, ICIPE has now re-oriented its research agenda toward areas long neglected in Africa and to a lesser degree in the tropics as a whole. For example, one new focus is on horticultural crops (vegetables, fruits and ornamentals). Because these plants are the target of so many arthropod pests, they are subject to the largest abuse of pesticides, the latter being enhanced by their high market value and the demand for 'cosmetic' produce. The pesticide abuse on vegetables in particular poses a great risk to consumer health and requires urgent attention.

The ban in the North and the progressive phasing out in the South of methylbromide used in fumigation of horticultural products is opening new opportunities for the use of biological and behavioral management tools for arthropod control. ICIPE, with its experience in relevant research areas, is well placed to tackle this challenge on a global scale. The adoption of the IPM approach in horticultural crops is expected to increase the income of the producers of 'green label products', at the same time possibly advancing the phasing-out time in the South of the ozone-depleting methylbromide.

Pests management in food crops mandated by the CGIAR remains on ICIPE's agenda only as topics for joint projects, where ICIPE will provide components for IPM based on its comparative advantage in the area of semiochemicals, behaviour, ecology, biological control, biochemistry, biotechnology and social sciences. A further activity to be revamped under a collaborative agreement with the CGIAR,

The PESTNET community-based tsetse control project in Bedessa, Wollayta Sodo, Ethiopia, is a collaborative effort of the ICIPE with the Ethiopian Science and Technology Commission and the Southern Ethiopian Peoples Government. Here, farmers learn to maintain and harvest the catch from the NGU traps. Thus far, about 980 such traps have been deployed in an area covering 200 km².

and with other international agricultural research centres (IARCs), national research centres (NRCs) and NGOs is PESTNET, a collaborative network for the implementation of pest and disease vector management strategies, now operating in ten African countries.

ICIPE is opening up to the world and to its contituency in the tropics, in particular. Developing South-South partnership, for example through PESTNET, is one of the major goals for the next five years. The Centre also has a major role to play in becoming the gateway for North-South partnership in arthropod sciences. The foundation for this has been laid by the PhD degree training programme started jointly at ICIPE in 1983, initially with a consortium of African universities, but soon to be extended beyond Africa.

Arthropods make up some 75 percent of the world's biodiversity and most of them play a key role in sustaining life on earth. Only a few, however, are pests or disease vectors, and the time has come now to seriously look at the other side of the coin, i.e. at the positive contributions of arthropods, and how to conserve them through better understanding and utilisation, key words of the United Nations Conference on Environment and Development (UNCED) 1992 Rio Conference. ICIPE is therefore investigating the usefulness of arthropods in the agro-ecosystem and their potential for income generation in Africa, in particular.

Two insects are especially important in this context: honeybees and silkworm. Both have been providing man with food, drugs and renewable fibres since early civilisation. Africa, with few exceptions, has not benefited from these ancient arts; although beekeeping is carried out, it is mostly done with inefficient and environmentally unfriendly methods. It is now time to tackle both topics and provide willing farmers and entrepreneurs with the necessary scientific basis for bee- and silkworm-based industries to take off. ICIPE is committed to developing the appropriate know-how, from insect rearing to product marketing, with selected partners. Activities such as apiculture and sericulture can become income generating options in a larger strategy for poverty alleviation, particularly for women and rural communities.

Another example of the usefulness of arthropods is demonstrated in the many highly successful biological control programmes which use one organism to control another. Within the framework of

Fifth instar larva of a wild silkmoth feeding on a host plant 'thoa' near the ICIPE Duduville campus. Wild silkmoth species are under threat in Africa because of deforestation and over-consumption as a high-protein food.

the IARCs' IPM Working Group, ICIPE has been assigned the role of lead institution in coordinating research on functional agrobiodiversity. Arthropods also play an important, but neglected, role in soil fertility maintenance and regeneration. ICIPE is proposing research in this area in collaboration with other IARCs to address the sustainability issue of production systems. Arthropods are also potentially useful tools for monitoring of overall biodiversity and as early and very sensitive indicators of changes in the environment. The latter is a promising and primordial field of research in the global undertaking on environmental protection and conservation of the natural resource base.

Consistent with its mission, ICIPE will not only develop new technologies but will also provide the enabling environment to get them off the ground. A science park is being planned, where the research outputs from ICIPE, NRCs and other IARCs will be transformed into innovative arthropod management products in partnership with the private sector. The arrangement, with its potential for income generation in an era of dwindling funding, is also designed to benefit ICIPE.

All of the above-mentioned activities require an institution with the appropriate structure and a strong set of collaborators and partners from the international, regional, national and non-governmental sectors. The restructuring exercises which the new ICIPE is still undergoing have been specifically designed to prepare the Centre for the new tasks ahead. Administration and management have been trimmed and the research and capacity building programmes reorganised and strengthened into an interactive matrix with six scientific departments and three research programmes. In this matrix, the projects are the actual working entity, with specific objectives, activities, output and lifetime.

ICIPE's plans for the future are realistic and address the real problems of the real world; and, they have been developed in consultation with the potential users. Contrary to the much-heralded opinion of many donors, the shelves of the technology stores are *not* full with products gathering dust. Even if they were, there would still be a need for research today, since the needs of tomorrow are addressed by the research of today. With its emphasis on capacity building and end-user participatory research, ICIPE is mindful that research is a means to an end, a means to improving the lives of millions of inhabitants of the tropics who suffer from food shortages, poverty and disease, all areas where well targeted and relevant research will bring the much needed relief.

I am therefore appealing to all concerned parties, the donors and their constituencies in the North, as well as the political leaders of the South, to react now with vigour and generosity and to support the activities of scientists in institutions such as ICIPE concerned with the most basic of human needs: food, health and education.

Hans Herren

(More information about ICIPE's programmes and activities can be obtained from the 1994 Annual Scientific Report.)

Integrated Pest Management at ICIPE

For the past 25 years, the International Centre of Insect Physiology and Ecology, based in Nairobi, Kenya, has been one of several organisations at the forefront of developing pest control methods known as IPM, or integrated pest management. What is IPM and is it a feasible solution to the world's pest problems?

IPM: A peaceful revolution, without bloodshed, and full of love for the environment*

The synthetic pesticide era began in the industrialised countries of the North in the 1940s, with the large-scale manufacture and use of DDT. Integrated pest management was developed during the 1940s–1960s as an alternative to the use of synthetic chemicals, when reports about their deleterious environmental and health effects became widespread.

IPM is an approach based on maintaining the natural checks and balances in nature that have been disrupted by man's activities. A key concept of IPM is that pests are 'managed', not simply wiped out from the environment. The aim is to limit pest numbers to levels where they are economically tolerable. Pesticides are used only as a last resort, and their usage, dosage and application carefully adjusted so as to produce localised and specific effects on the target pests.

Pay-offs from IPM

The Indonesian National IPM Programme was established under Presidential Instruction No. 3 of November, 1986 as a tactical measure to halt one of Asia's most serious environmental crises. The rice brown planthopper was out of control and indiscriminate and widespread use of pesticides had destroyed all beneficial predators and parasites of rice-feeding insects. Under the Decree, 57 of the most toxic insecticides were banned for use, and stipulations set that all other pesticides be used only when other methods of pest control had proven ineffective. Furthermore, the types of pesticides utilised and their application methods should take into account the maintenance of natural enemy populations.

After this offical validation of the IPM approach, further important policy changes followed, including the withdrawal of pesticide subsidies. An intensive training programme beginning in 1989 trained over 3000 pest observers and extensionists and half a million farmers.

Did this decision pay off? Six rice-growing seasons after the decree, rice yields were the highest in Indonesia's history, up 13% from 1986 levels. Pesticide use fell by 60%, saving the government US$ 120 million in pesticide subsidies per year. To quote the programme, "this is proof, that, in the world's fifth most populous nation, well considered macroeconomic adjustment can benefit farmers, consumers and the government, and drastically reduce environmental damage".

IPVM at ICIPE

The adage that "prevention is better than cure" is true for pests as well as diseases. ICIPE's approach is to concentrate on developing and improving preventive tactics that curtail pest build-up to damaging levels. Since it is not only the pests that need to be managed, but the host animals or plants and habitat as well, we now refer to our activities as "plant and animal health management". ICIPE's R&D activities are concentrated in the following areas, in order of priority: (i) biocontrol, (ii) host plant resistance, (iii) habitat management (encompassing cultural practices and agro-ecosystem management), and (iv) botanical pesticides. ICIPE is one of the very few organisations tackling the integrated control of disease vectors, and so our activities are sometimes described as IPVM (integrated pest and vector management).

By tackling the cause of the problem and not its symptoms, we seek to rely on the first three IPVM components above, limiting pesticide use to very localised or emergency situations when it is too late to apply preventive measures or when the latter are not yet available.

Does IPM pay? The answer to this question is undoubtedly 'yes', although the pay-off in terms of yield gains may take several years to become obvious. Several nations have had the foresight to adopt IPM as their national pest control strategy, and are now reaping the benefits of increased yields at a very low economic and environmental cost (see box).

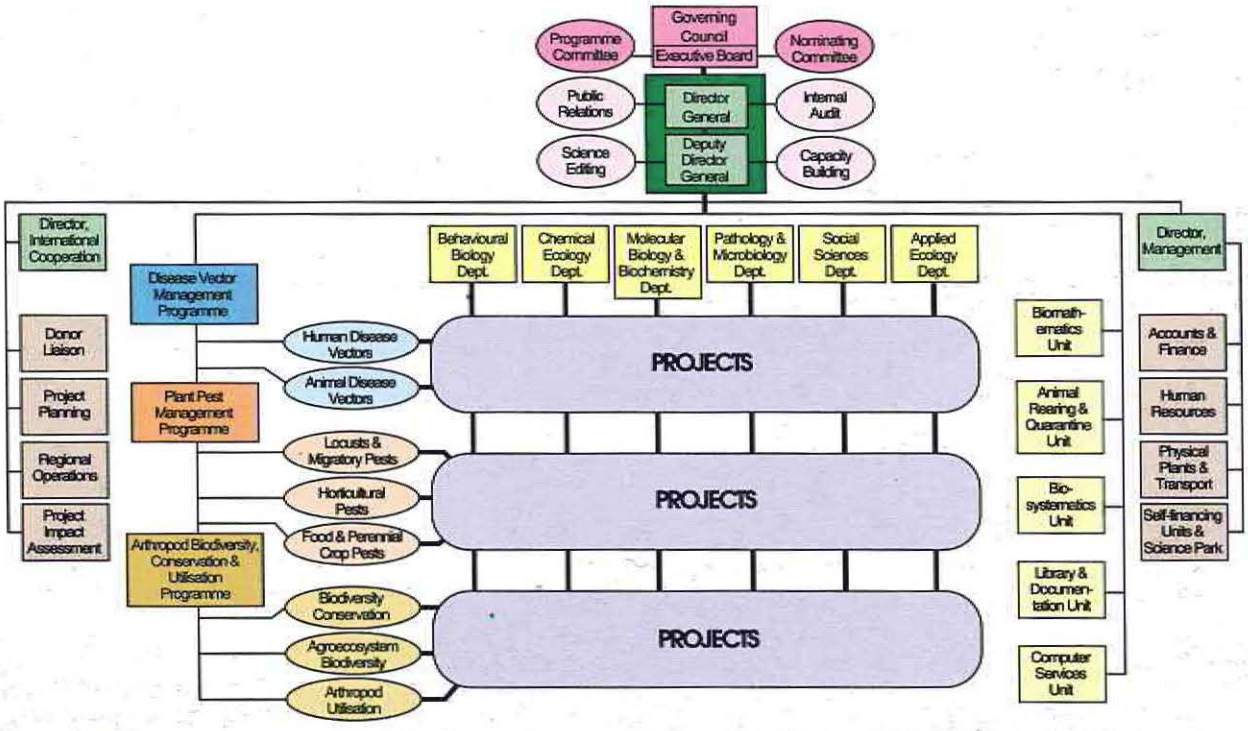
IPM is an idea whose time has come. Governments, donors and international organisations alike now recognise the

Words of novelist Mochtar Lubis about the Indonesian IPM Programme.

importance of adopting IPM for truly sustainable solutions to world hunger and environmental and animal health. A few recent landmarks in the growing movement towards IPM include:

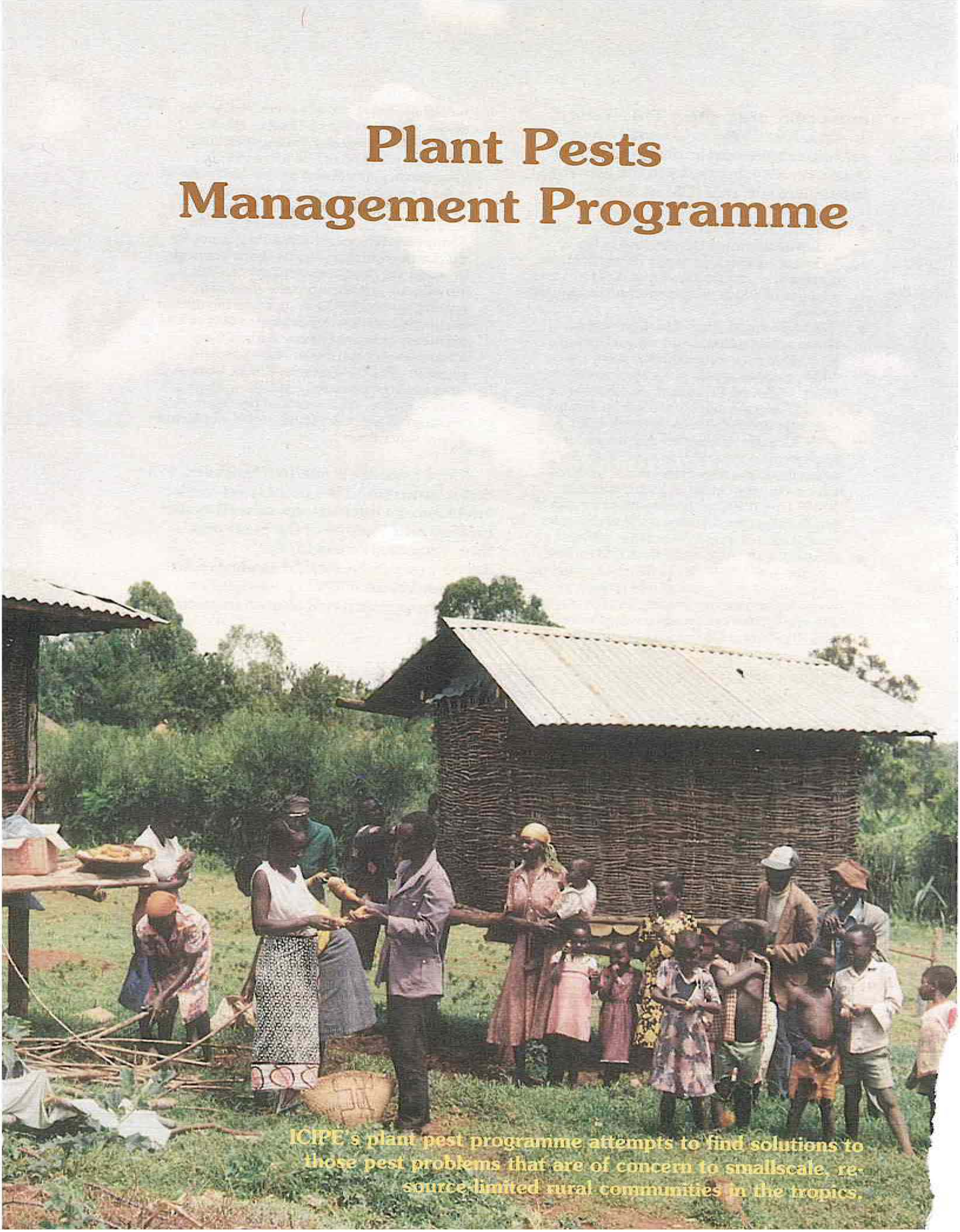
- Adoption at the 1992 United Nations Conference on Environment and Development in Rio de Janiero of Agenda 21, Chapter 14. Implicit in the concept of sustainable development is the adoption of IPM as the preferred method for pest control.
- The Mid-term Meeting of the Consultative Group of International Agricultural Research (CGIAR) in 1994, formulated the policy that "IPM principles should guide all pest control efforts within the CG system" and that IARCs should "strongly support research leading to its wider application". The inclusion of ICIPE and AVRDC in the coordination mechanism for implementing this policy was endorsed. An action group has since been formed: the Inter-Centre Working Group on IPM. Under this ICWG-IPM, ICIPE has been assigned the area of functional agrobiodiversity as a lead Centre for coordination of project formulation activities.
- Creation of an FAO/World Bank IPM Facility, together with UNDP and UNEP, to stimulate the adoption and application of IPM projects, by reviewing and seeking funding for pilot projects. The World Bank has already invested more than US$ 80 million in IPM projects or components in the last five years, and advocates IPM as "the preferred approach to pest management in World Bank agricultural lending operations".
- Increasing adoption of IPM as the official government policy of pest control. National IPM policies exist for Indonesia, Sudan, India and Cuba, among others. Regional initiatives such as the FAO Inter-Country Rice IPM Project, the Africa-Wide Biological Control Programme for the cassava mealybug, and the Asian Vegetable Research and Development Centre (AVRDC) activities are proving especially effective in controlling cross-border pests. Many countries in the tropics have now validated the utility of IPM for specific crops: rice (India, Burkina Faso, Madagascar); cotton (Sudan, China, Brazil); sugarcane (Brazil); vegetables (China, Malaysia); soybean (Argentina); and coffee (Kenya), to name but a few. What is needed now is the institutional and policy framework to implement IPM at national level.

More research is needed, however, to better understand the plant/pest-vector environment interactions, as well as the biology and ecology of the pests and their natural enemies for the development of new IPM strategies. In this endeavour, ICIPE's participatory research approach will play an important role.



ICIPE's new organisational structure is designed to ensure that the Centre's outputs in basic insect science and the resulting IPM strategies and technologies are most effectively delivered from the three programmes that define the research agenda. The six departments will provide and guarantee the requisite scientific expertise, supplemented by expert assistance from the research support units. A fourth programme on capacity building embraces all activities of the Centre.

Plant Pests Management Programme



ICIPE's plant pest programme attempts to find solutions to those pest problems that are of concern to smallscale, resource-limited rural communities in the tropics.

Within the next decade, the worldwide demand for food may be three times greater than it is today. The steady gains in global agricultural production over the past 20 years are not reflected in the Africa region, where per capita food production is falling. In this region, pervasive poverty, especially in rural areas, erodes household purchasing power. For instance, even though Ghana has made important strides in the past few years, about 40% of the population live below the poverty line. The number of African rural women living in absolute poverty has actually increased by almost 50% over the past decade. One important consequence of poverty is that families cannot afford to buy food to make up the shortfall nor to invest in agricultural inputs such as fertilizer, irrigation, mechanisation and pest control chemicals that—notwithstanding their environmental impact—might lead to greater production.

The tropical environment provides a highly favourable climate for arthropod life. As a result, insects and related arthropods such as mites are one of the key factors limiting agricultural productivity in the tropics. Insects affect food output directly by reducing the quality and quantity of the crop produce or indirectly by serving as vectors of plant diseases. Yield losses due to insect damage range from 25-40%, reaching 80% in serious infestations, and 20–40% in stored products.

For the past 25 years, ICIPE's programmes in agricultural research have been geared to boosting food production by developing biointensive pest control methods that minimise the use of expensive and hazardous synthetic chemical pesticides. Tomorrow's gains in food and fibre productivity will be the result of today's investment in agricultural research. Over the past five years, ICIPE has narrowed its crop pests research agenda down to four basic crops that are vital to the African farmer: maize, sorghum, cowpea and banana. Although the majority of research is conducted within Africa, the techniques and approaches developed can be adapted in many tropical countries.

On a pest-by-pest basis, ICIPE is tackling some of the most damaging tropical food pests: the desert locust, that can ravage vegetation across several continents; pod-borers that ruin leguminous crops such as cowpea; stemborers that wither cereals such as maize and sorghum; and the rhizome borers that undermine the banana plant. In all cases, such fundamental upstream research into insect behaviour, biology and ecology is used to provide the knowledge base for developing the pest management strategy, be it which crops to intercrop, which design of insect-attracting pheromone trap to use, which natural enemy or botanical formulation is most effective, or which insect-deterring plant characteristic is to be bred into a new variety.

The insect pest is only one small part of the farmer's total environment. An increasingly important component of ICIPE's plant pest management approach is to understand the relationship between the pest, its host plant and its environment, and how farming activities alter this natural balance. Habitat manipulation (or agro-ecosystem management) is leading to improved crop health by reducing the incidence of insect pests through novel intercropping and agroforestry systems and encouraging biodiversity of the surrounding vegetation.

Even the best pest control strategy or technology will have little impact if it is not adaptable to the local situation, or if it is not culturally acceptable and affordable to the end-user. For all these reasons, the Centre's Social Science Department is closely collaborating with biologists and agronomists in interface research to ensure that ICIPE's technologies are truly 'appropriate', and therefore become 'adoptable'. This is being accomplished by involving our clientele of farmers, extensionists and women's groups in the technology development process, from conception to application to eventual dissemination.

The following pages outline the major achievements and status of our projects on plant pests management. More details can be found in the *1994 ICIPE Annual Scientific Report*.

MAIZE AND SORGHUM

Rules of thumb: When does a dudu become a pest?

An essential concept of IPM is that control measures are not put into place against an insect (*dudu*) until it becomes a significant pest, i.e. until it begins to inflict economic damage by substantially lowering crop quality and/or yield. In a further step towards developing simple-to-follow rules of thumb for control of the spotted stemborer *Chilo partellus*, a major pest of maize and sorghum in eastern and southern Africa, experiments were conducted in two agro-ecological zones at the Kenya coast and in the Lake Victoria basin. Based on current input/output costs, a threshold of about 15 plants per 100 (or a 15% infestation level) at 2–3 weeks has been determined as the economic threshold. A simple rapid sampling technique has been devised that will allow farmers to make their own decisions about when control measures need to be implemented; the method requires periodical scouting of only a small portion of the plants in a field.

In assessing insect population patterns, traps are often used. This year, behavioural biology studies in both of the above locations showed that a new trap design can be used to catch two common species of stemborer simultaneously, *Chilo partellus* and *C. orichalcociliellus*. The trap is baited with the two major components of the moths' female sex pheromone, which have been shown to be the same for both species.

Exploiting natural pest resistance

Over the last decade, ICIPE has been collaborating with CIMMYT (maize), ICRISAT (sorghum) and IITA (cowpea), on a range of areas directed at understanding and exploiting the naturally occurring resistance/tolerance to insect pests in crop cultivars and genotypes. This year, further selection among several genotypes of sorghum which had shown combined resistance to *Chilo partellus* and the shootfly was completed, and the promising genotypes advanced for yield testing in large plots.

Adaptive testing of the pest resistant/tolerant genotypes of maize and cowpeas which have been identified or developed at ICIPE in recent years was intensified in coastal Kenya in close collaboration with NARS. Farmer-participatory on-farm trials have been conducted and the potential acceptability of a few genotypes of maize (IC92M4), IC92M5, ICZ5), sorghum (Gaddam, ICS3, Driv. 1) and cowpea (ICV2, ICV3, ICV11 and ICV12) confirmed. Most of these were also verified for their nutritional quality. The Kenyan NARS have incorporated some of the improved varieties into their national testing programmes for further evaluation and appropriate utilisation.

Habitat dynamics

Cultivated plants, particularly in monocultures, are especially susceptible to insect attack. Wild grasses can act as traps for stemborers, deflecting their activities away from the crops; the grasses can also serve as reservoirs and shelter for natural borer enemies. This project seeks to investigate the role of the wild habitat in the invasion of cereals by borers with the objective of using this ecological information in crop breeding programmes and in identifying wild grasses for use by farmers in habitat manipulation.

The studies are being conducted in three different agro-ecological zones in

Kenya. Several wild grasses have been identified as hosts of four common stemborer species. Among the six host plants tested, cultivated sorghum followed by wild sorghum was preferred for oviposition and larval development by *Chilo partellus* (Figure 1) over maize and three other wild grasses. On the other hand, the grass *Hyparrhenia rufa* was capable of deflecting the egg-laying preference of *Busseola fusca* from maize in choice tests.

Another avenue soon to be explored will be to examine the allelochemicals emanating from non-host plants that protect them from being attacked by stemborers. To this end, a surrogate stem made of rolled wax paper has been designed and evaluated. By providing the necessary physical stimuli for eliciting the egg-laying response, the device will allow the bioassay of various plant allelochemicals on the oviposition behaviour of the pests.

Managing the agro-ecosystem

Habitat management encompasses not only how the wild environment is manipulated to reduce pest numbers, but also which crops are planted together and in what manner. This year, the earlier intercropping experiments conducted by ICIPE were expanded to provide a better understanding of the ecological basis of integrated pest

Monitoring wild grasses for the presence of various life stages of stemborers. Wild or cultivated grasses, such as this H. rufa *can act as trap plants for stemborers and provide protection to the pests' natural enemies.*

***A maize field in Kenya showing severe damage by the spotted stemborer,* Chilo partellus.**

management. After testing a wide range of crop combinations, the conclusion was reached that increasing crop diversity *per se* does not necessarily lead to reduced pest numbers. Certain combinations of crops are more effective than others, however, such as the crop culture of sorghum-cowpea-cassava. Verification trials have confirmed that cassava can effectively divert the oviposition of *C. partellus,* leading to reduction in the pest severity in adjacent strips of sorghum.

The novel strip relay cropping system devised by ICIPE agro-ecologists over the past several years has now been tested on-farm at the Kenya coast and its efficiency in significantly reducing stemborer levels in sorghum as well increasing yield has been convincingly demonstrated, at the same time as improving the land use intensity and multiple cropping index.

Restoring the balance of nature through biological control

The insect world is not an exception to the axiom that "nature is red in tooth and claw". Among the hundreds of thousands of insect species, many serve as natural enemies to the unwanted species that we define as 'pests'. Exotic pests often require the importation of natural enemies from their indigenous home. Such is the case with the exotic spotted stemborer, *Chilo partellus,* accidently imported into Africa in the

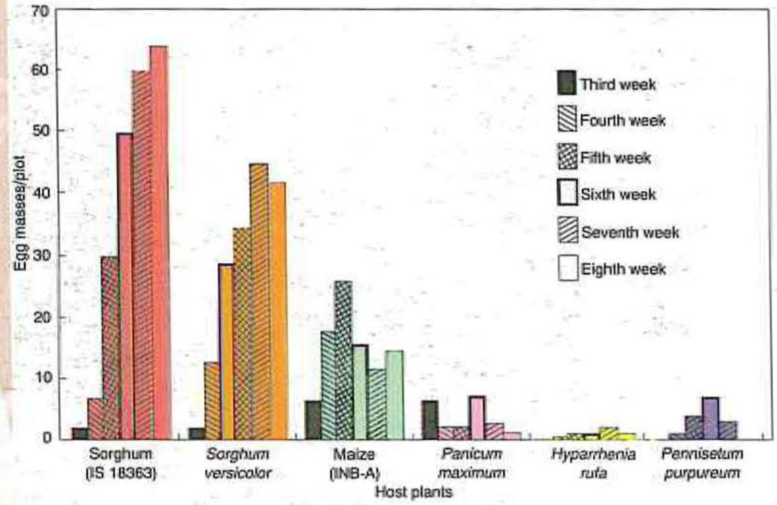


Figure 1: Distribution of Chilo partellus *eggs on host plants. In this field experiment, sorghum was the most attractive host, followed by its wild relative,* Sorghum versicolor. *The three other wild grasses were less attractive than the susceptible variety of maize used.*

1930s, and now slowly making its way across the continent. ICIPE studies have shown that this devastating pest does not succumb easily to attack by the local parasitising wasps such as *Cotesia sesamiae*, but rather is better controlled by an exotic wasp, *C. flavipes*. The *Cotesia* wasps attack the stemborer larvae in their feeding tunnels deep within the stems, and inject 30–50 eggs into the host, which hatch in about 3 days; the wasp larvae then proceed to devour the stemborer larvae from the inside out.

ICIPE imported these tiny wasp parasitoids into Kenya from Pakistan in 1991 and has since released them in large numbers at the Kenya coast, where crop losses are predominantly due to *Chilo* species. Work this year has confirmed that the exotic wasp is reproducing at a higher intrinsic rate than the indigenous wasps, and that it is maintaining itself by laying its eggs in the stemborers feeding on maize and in wild grasses at distances up to 16 km from the original 1993 release site. These recoveries, coming at 18 months (or 30 generations) after the last release, are firm evidence that *C. flavipes* has established itself in Kenya.

Biosystematic studies have shown that *C. flavipes* has a fairly high genetic diversity, which can open up opportunities for its exploitation as a control agent for stemborers in other regions of Africa and elsewhere. Several attractants for the wasp have been identified, and these may be useful in traps for monitoring the presence of the parasitoid as it expands its territory.

Additional strains of *C. flavipes* have been imported from Pakistan and India. The genetic, behavioural and life history traits of these strains are being compared. In West Africa, ICIPE's initial work with IITA indicates that *C. flavipes* can successfully parasitise the West African populations of another stemborer, *Sesamia calamistis*.

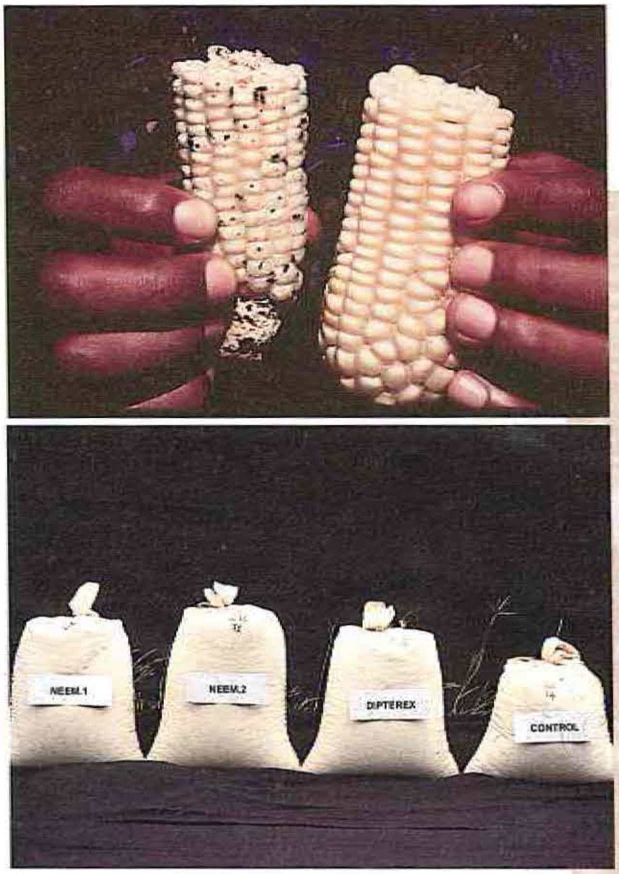
Microbial biocontrol agents

Stemborers are also under attack by another biological control agent, the entomopathogenic *Bacillus thuringiensis*, or *Bt*. A local strain of this bacterium that is specific to stemborers is being used as an aqueous spray in the coastal zone. About 100 litres of the *Bt kurstaki* (M44-2) strain have been distributed to farmers for testing as part of the ISERIPM project (see page 16). Preliminary results have validated its usefulness in controlling stemborers in maize and sorghum.

Botanicals for borers

Plant-derived substances have been used for pest control since ancient times. The neem tree, *Azadirachta indica*, possesses a potpourri of chemicals which have a selective toxicity on pests and produce a wide range of physiological and behavioural effects, such as repellence, deterrence of feeding and oviposition (egg-laying), and sterility. Amazingly, neem products have weak or negligible side effects on the pests' natural enemies and other non-target organisms such as pollinators. The multipurpose neem tree is widespread in Asia and Africa and is a renewable source of many other useful products for public health, veterinary practice and contraception, in addition to being natural pest control materials.

In 1994, the usefulness of simple neem derivatives in reducing pest infestation and enhancing crop yields and biomass was demonstrated on a variety of crops in five different agro-ecozones in Kenya and Ethiopia. When neem cake (NC) was applied at the rate of 3 g per maize plant, it produced a grain yield of 13% higher than the untreated control when applied once, and a 36% higher yield if applied twice during the growing season. The neem-treated plants were taller and remained green for longer than the controls or insecticide-treated plants. Neem seeds stored for up to two years still retained their efficacy and produced maize yields equal to that obtained with the insecticide dipterex and one-and a-half times higher than untreated controls. Neem is also being tested on other crops such as sorghum, cowpea and in agro-forestry to prevent termite and root-knot nematode attack.



Top: The maize cob on the left shows severe damage from the maize storage weevil, Sitophilus zeamais. *The cob on the right was treated with neem oil expelled from locally collected neem seed, and is completely undamaged after six months of storage.*
Bottom: Comparison of maize grain yields sampled from plots treated with 1 g of powdered neem cake per plant at various times after plant emergence. The grain yield from neem-treated plots is comparable to that from insecticide treatment at a fraction of the cost.

This year, the first phase of an awareness campaign for eastern and southern Africa has resulted in the distribution of more than 5000 neem seedlings to farmers, schools and other tree-planting groups. Training of NGO and extension personnel, as well as women's groups and educationalists is being undertaken to produce a multiplier effect through workshops and the media. Distribution systems for high grade neem seeds and seedlings are being developed and neem nurseries are being established in the region.

COWPEA AND LEGUMES

Cowpea *(Vigna unguiculata)* is one of several leguminous plants important as an intercrop with maize and sorghum in much of Africa. Several improved pest resistant/tolerant genotypes of cowpea (ICV2, ICV3, ICV11 and ICV12) developed by ICIPE are now undergoing on-farm trials with farmer participation and have met with farmer approval, as described in the adaptive research projects on page 16. The usefulness of neem in pest control was demonstrated on one of the major cowpea pests, thrips *(Megalurothrips sjostedti)*. This pest was controlled by spraying with neem seed extract (NSE) at aqueous concentrations of 5%, 10% and 20%, significantly reducing infestation levels and increasing grain yields at the cultural level. The influence of row-ratios in strip cropping as a means of controlling insect pests and increasing grain yields have been established for sorghum-cowpea cropping systems. Initial experiments with substituting beans with cowpea indicate that the former may be preferable in areas where beans are adapted.

The use of non-traditional leguminous cover crops was examined for their pest-suppressing potential with maize. At 5 weeks after emergence, silverleaf (*Desmodium* sp.), and groundnuts both gave a significantly lower stemborer incidence than in the maize monocrop. Planting maize into already established *Desmodium* cover was especially effective, lowering the percentage of borer-damaged plants by over 52% compared to other treatments.

ADAPTIVE RESEARCH ENSURES APPROPRIATE AND SUSTAINABLE TECHNOLOGIES

The Kwale-Kilifi Adaptive Research Project

Adapting the IPM technologies developed at ICIPE field stations to suit the requirements of varying agro-ecological sites and for specific target communities took place this year in two sites at the Kenya Coast. The Kwale-Kilifi Adaptive Research Project on sustainable management of insect pests is now in its third and final year. A joint effort of ICIPE and the Kenyan NARS, the project was launched in the two districts where there is considerable food insecurity due to insect-induced crop losses and the threat of tsetse. Working through the medium of PESTNET (see Outreach section of this report), ICIPE biologists have worked closely with social scientists to enhance the linkages between researchers, extensionists and farmers.

This year, the crop pest management component of the project focused on assessing the yield benefits of the ICIPE-developed pest-resistant genotypes of maize, sorghum and cowpea. The increase in yield from use of the borer-resistant maize genotypes was determined by the farmers themselves on their own farms to be in the region of 10–20%, and between 15–30% for sorghum. The grain yield advantage from the use of the promising pest-tolerant cowpea cultivars reached about 10–30% compared to the released check. Taste-testing panels rated the sorghum porridge and boiled cowpea flavours as 'acceptable'.

The newly introduced practice of early intercropping of cowpea in maize was found to be a cost-free method of reducing stalkborer damage and also helped in controlling early season weeds. The biological disadvantage of *Ootheca* leaf beetle damage to the cowpea could be minimised by increasing the area under cowpea (dilution effect) and through the use of 10% neem seed extract to control the beetles. Following these two refinements, the participating farmers were quite agreeable to adopting the new technology.

Interactive Socio-Economic Research for Biointensive Pest Management

In Phase II of the second adaptive research project on Interactive Socio-Economic Research for Biointensive Pest Management (ISERIPM), the following menu of IPM technologies undergoing adoption were tested on-farm in researcher-managed trials: (i) pest-resistant genotypes of maize and sorghum; (ii) the use of a new cropping system, strip-relay intercropping; and (iii) application of the insect pathogen, *Bt* (*Bacillus thuringiensis*).

Using the new cropping system, it was possible to obtain two crops of maize or sorghum, three of cowpea and one of cassava in the same year. The most tolerant of the sorghum cultivars was found to be Hyd-6, while for maize, it was ICZ5. The use of *Bt* gave significant reductions in insect densities.

The interactive research processes were assured by involving the social and biological scientists in the design of the research agenda, evaluation of the field trials, and in ensuring community

A simple low-cost banana pseudostem trap for weevil population monitoring and control. The traps are made by splitting the pseudostem in half lengthwise, as shown here, or by cutting in circular cross sections. Volatile compounds in the pseudostem attract the weevils to the trap, where they can be collected periodically.

participation and effective collaboration with front-line extension agents and government officials.

BANANA

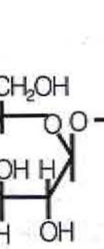
Undermining the banana borers

Bananas constitute a major source of dietary carbohydrate for over 400 million people worldwide. East Africa is a major banana growing area, but the presence of several serious pests limits production.

From the 167 cultivars in ICIPE's germplasm collection in western Kenya and Tanzania, 24 were evaluated for their resistance to the banana rhizome weevil, *Cosmopolites sordidus*, with six identified as tolerant. The cultivars which showed acceptable levels of resistance to the rhizome weevil, *C. sordidus* along with satisfactory yield potential have been re-tested and planting materials provided to farmers through the NARS in Kenya, Uganda and Tanzania. In addition, several genotypes with combined resistance / tolerance to the rhizome weevil and the banana nematode, *Pratylenchus goodei* have been identified among the major classes of highland banana germplasm. In its further research, ICIPE will seek to tie in more closely with other IARCs such as in the recently launched regional IITA initiative on IPM of bananas.

The continuous trapping of the weevil which undermines the rhizome or 'root', brought about a 50% reduction in weevil numbers, resulting in increased banana yields of 31%. There is evidence, however, that populations of the banana nematode *P. goodeyi* actually undergo an opportunistic increase as nematode populations were 13–14 percent higher in weevil-trapping plots compared to the no-trapping controls, with the consequence that yields were lower than expected. The assessment of population patterns and weevil control by such trapping seems to be accurate and realistic, using the two types of simple traps devised by ICIPE, one made of 15-cm longitudinal cross sections of the pseudostem (see photo) and a more recent version made of 5-cm circular disks.

Chemical ecology work this year has identified two compounds trapped from the volatile emissions of the pseudostem and identified by GC-EAD and GC-MS. 1,8-Cineole was found to be present in all the banana cultivars that are susceptible or tolerant to banana weevils, but was conspicuously absent in a resistant cultivar Mbu (ABB). A susceptible banana cultivar, Githumo, provided two highly feeding-stimulatory compounds, (2-hydroxymethyl)-phenyl-β-D-glucopyranoside (see figure) and glucose, which act synergistically to the banana weevil in feeding bioassays.



1, 8-Cineole

(2-Hydroxymethyl)-phenyl-β-D-glucopyranoside

The nematode nemesis

The banana nematodes pose a major constraint to production and may take years to disappear from the soil. Experiments to assess the longevity of infestation with nematodes are in progress, using fallow periods, rotation with non-host crops and use of nematode-free suckers. This year, the developmental and reproductive stages of *P. goodeyi* were studied; one female nematode can lay up to 30 eggs in 35 days in some cultivars. A new species of *Trophurus* nematode has been described, and *Rotylenchulus clavicaudatus* was recorded for the first time on banana.

Although this project was wound up in 1994, much needs to be done to create awareness of the management strategies required for this important crop. Sociological surveys have shown that only 7% of farmers' knowledge on banana cultivation derives from government extension services (compared to 50% for other crops), with 90% deriving from relatives, neighbors, etc. Only 15% of farmers were aware of the damage inflicted by weevils, and no farmer interviewed was aware of nematodes as a cause of low productivity.

LOCUSTS: PREVENTING THE PLAGUES

The desert locust, *Schistocerca gregaria* (Forskal) is a species of short-horned grasshopper in the family Acrididae. The gregarious form of this insect is one of the most studied arthropods because of its mobility across several continents and its feeding habits on a broad spectrum of crops and other vegetation. The desert locust swarms have the ability to move 150–200 km a day when migrating over an invasion territory of 29 million km^2. In the nymphal stages the hoppers march in destructive bands.

Although plagues occur only periodically, the vast numbers of insects in a swarm (up to 120 million) can potentially destroy the food supply of 10% of the worlds population. An individual locust can eat its own weight in fresh food each day. Even a small swarm of half a million locusts will consume about one tonne of food a day, enough to feed 2,500 people.

ICIPE's approach to locust control over the past few years has concentrated on developing methods for physiological, behavioural and ecological disruption of the swarming process and on methods for biological control using locust pathogens. Once again this year, chemical ecology studies of the desert locust provided several new pieces in the puzzle of locust behaviour. From previous work, it is now known that the pheromone system of the gregarious desert locust is a complex mixture of volatiles emitted by different developmental stages of the insect and their waste products. The pheromone system of mature adults was characterised by chromatographic, electroantennographic, spectroscopic and behavioural assays as a blend of four aromatic compounds. One of these compounds which disrupts aggregation in the nymphal stages is now the subject of intensive field studies.

Recent investigations of the volatiles produced by the fifth instars has revealed 18 electrophysiologically-active compounds which have been isolated and characterised as linear aliphatic compounds. These are now the subject of detailed behavioural assays. Wind-tunnel studies on the sex attraction in solitarious locusts have demonstrated that adult male solitarious desert locust are attracted to volatiles emanating from females of the same species. Out of three electrophysiologically active components isolated from female volatiles, one has been fully characterised and is currently the subject of detailed behavioural assays.

Other studies are looking at the chemicals produced by the locusts themselves or by their environment, that influence maturation, simultaneous egg-laying and mating behaviour. Some of these may find use in preventing swarm formation by causing confusion or preventing aggregation.

The egg froth of the locust egg pods has been shown by ICIPE scientists to contain a volatile pheromone that stimulates aggregation of the females and oviposition at a common site. This year, two major GC-electrophysiologically active peaks from froth volatiles were identified as acetophenone and veratrole. The amount of acetophenone and veratrole present in the volatiles trapped from the froth plug for 12 h was calculated as 64.05 and 37.02 ng, respectively.

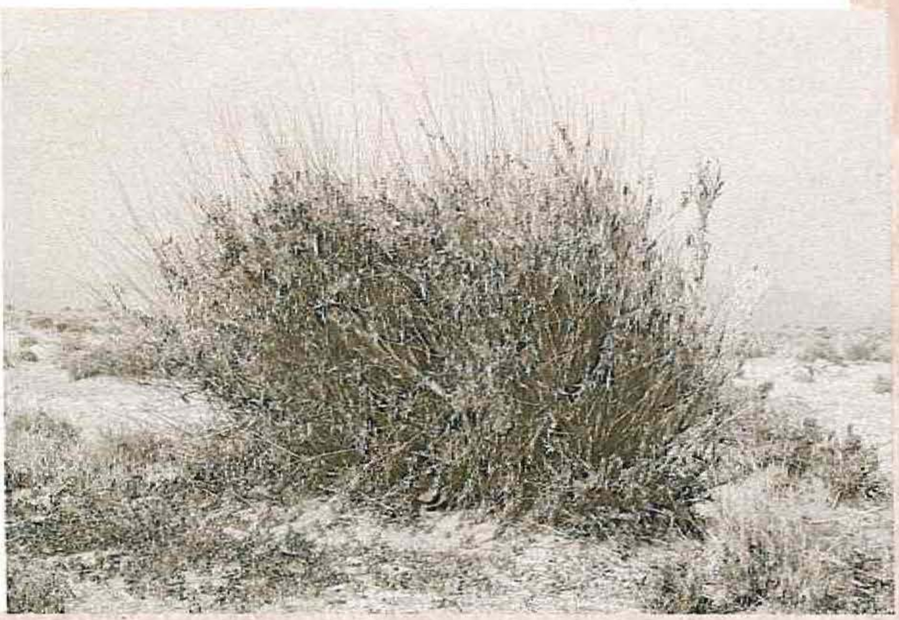
These compounds may find use in attracting the locusts to a fairly small egg-laying site where they can be controlled through localised application of pesticides or by one of the biological control agents such as those under test, as described below.

A role for protozoa in locust control?

Several biological control agents have been considered for use in regulating locust populations and preventing swarm formation. Results from ICIPE's three-year project on the use of pathogens for desert locust management came to an end in 1994, but several notable results have been obtained that now require field testing.

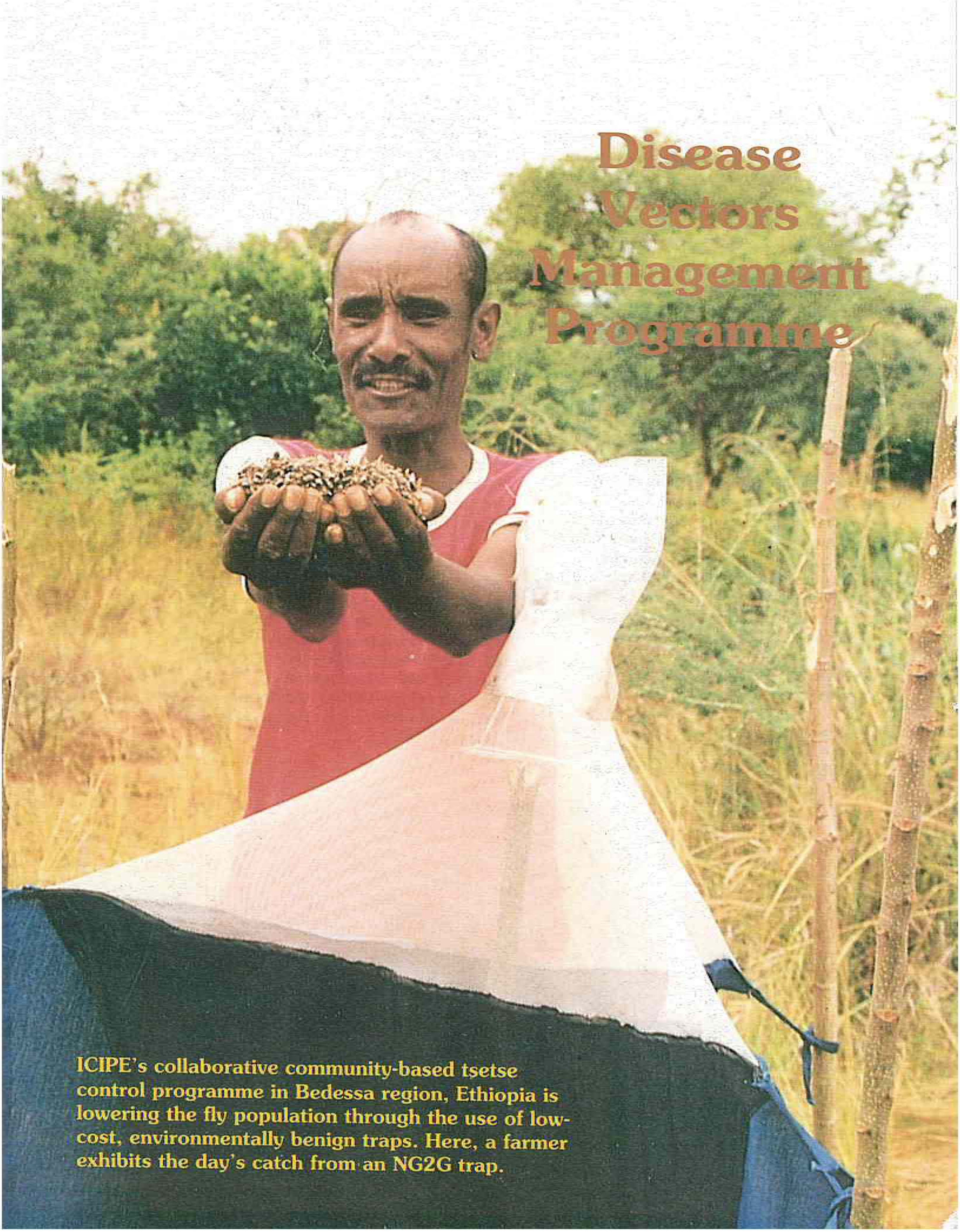
The protozoan *Malamoeba locustae* caused a gradual decline in desert locust populations, as well as lowering the fertility of females through delaying oviposition or disrupting the reproductive system. The pathogen, which is transmitted from one generation to the next through trans-ovarian infection, also causes a decrease in fecundity and longevity. The mortality life table analysis suggests that a chronic infection with the protozoan would eventually retard the locust population, even under conditions otherwise favourable for reproduction.

The efficacy of two individual pathogens, *M. locustae* and *Beauveria bassinia*, as biocontrol agents was improved by combining them. The LT_{50} values declined significantly ($P < 0.001$), showing a synergistic effect. A broad-range biocide of protozoal origin has been developed by criss-crossing it between two hosts: *L. migratoria* and *S. gregaria*.



Late instar nymphs of the desert locust* Schistocerca gregaria, *roost on* Leptadenia pyrotechnica; *others bask below the bush. This photograph was taken in a locust recession area on the Red Sea Coast of Sudan, where ICIPE has a station for field studies of this wide-ranging insect.

Disease Vectors Management Programme



ICIPE's collaborative community-based tsetse control programme in Bedessa region, Ethiopia is lowering the fly population through the use of low-cost, environmentally benign traps. Here, a farmer exhibits the day's catch from an NG2G trap.

Africa is thought to be the 'cradle of mankind', the location where our species evolved before dispersing throughout the world. It is blessed with a benign climate and fertile land, and is potentially capable of supporting large numbers of livestock. Unfortunately, these amenable conditions have also made Africa an ideal environment for harmful insects and arthropods that are the vectors of diseases afflicting man and his animals.

Two of these in particular, tsetse flies (*Glossina* species) and ticks, are responsible for enormous losses in livestock production. For example, ticks, and the many diseases they transmit (including heartwater, East Coast fever, etc.), affect about 200 million cattle in Africa and account for an overall economic loss of about US$ 3.5 billion per year. Similarly, tsetse-transmitted animal trypanosomiasis, or *nagana*, results in direct economic costs of about US$ 0.6–1.2 billion, with indirect losses of about US$ 4 billion per year. About 60–90 million cattle are at risk of trypanosomiasis, as well as tens of millions of goats, sheep, camels, horses and pigs.

Tsetse and ticks together limit or prevent livestock production in some of the best grazing lands in Africa and prevent human settlement in many productive areas. Ticks limit production throughout the continent, whereas tsetse affect an area of about 10 million km^2 south of the Sahara.

By the year 2025, Africa will need to feed an additional 800 million people. Even to maintain current levels (which are by no means acceptable), food production will have to grow at a rate of 2.75 percent per year. To improve the quality of life, a growth rate of 4 percent is required. These numbers contrast with the 1.7 percent growth rate achieved in the livestock sector from 1961 to 1988.

The impact of arthropod-borne diseases on man is staggering. For example, over 300 million people are affected annually by malaria, 80 million by lymphatic filariasis, and 18 million by onchocerciasis (river blindness). Malaria alone is the cause of an estimated 1.5-3.0 million deaths worldwide every year, with more than 90 percent in Africa alone. Even for minor diseases such as sleeping sickness (with 20,000 new cases per year), over 100 million people are at potential risk if control measures break down. With most of the continent at risk of exposure to vector-borne diseases, the scope of the problem and the associated effect on human performance and productivity as well as overall socioeconomic growth is enormous. Finally, added to these grisly statistics is the new phenomenon of the 'emerging diseases' such as the Marburg and Ebola viral diseases. The dynamics of epidemics of such diseases remains a mystery, although transmission through arthropod vectors has been considered as a possibility.

ICIPE's approach to improving the health of man and the productivity of his livestock is to focus on the disease-carrying insect and tick vectors. Research on the behaviour, biology and ecology of these pests is providing new information that is being used to develop methods of vector control that avoid the use of expensive and environmentally damaging chemical pesticides. In this respect, ICIPE is at present the only research institute in the tropics that both develops and promotes alternatives to pesticides for disease and vector control.

The task at hand, however, is not easy. Once the vectors have been reduced in numbers by even the most efficient technology, protection over vast areas must continue. Of necessity, this must occur at the community level so that control becomes a socially acceptable and sustainable process once the scientists leave. This requires education of the community and extensionists who must eventually deploy, and in some cases, construct, the control technology.

While the issue of pest resistance to biocontrol agents does not appear to be a problem, pest behaviour around a trap is more unpredictable and more subject to nature's vagaries. To overcome pest avoidance and adaptability, continuous research is needed. Other issues that need addressing are the long-term environmental impact of the control method, and how land use will be modified after successful control has been accomplished and humans and livestock re-occupy the vector-safe areas. The solutions to these and other issues can only be found by biologists and social scientists working closely together with the target communities, an approach pioneered by ICIPE.

TSETSE AND TRYPANOSOMIASIS RESEARCH

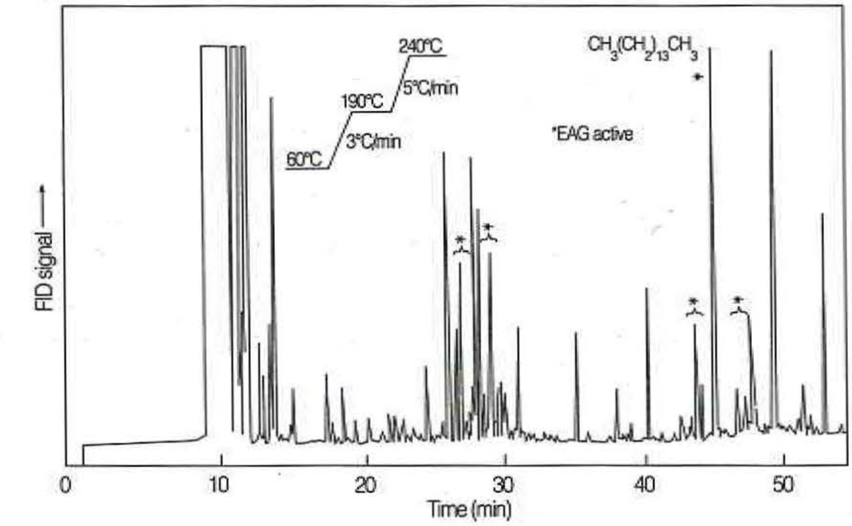
ICIPE's tsetse research in the 1980s was instrumental in the discovery of the attractiveness of phenols from bovine urine to widespread savannah species such as *Glossina pallidipes* and *G. morsitans*. These discoveries led to the adoption of attractive bait technologies for the control of tsetse in many African countries. Today, similar innovative research has continued with studies on the attractiveness or repellency to tsetse of a wide variety of wildlife and livestock hosts. These studies have been facilitated by the development of simple devices for trapping body volatiles for detailed chemical characterisation. Preferred hosts such as cattle and warthogs as well as animals very rarely fed on by tsetse, such as waterbuck, are currently being studied.

Tsetse trapping

As reported in the *1993 ICIPE Annual Report*, considerable progress has already been made in elucidating the nature of the attractiveness of reptiles to riverine tsetse. At present, there are no chemical odour baits available for this group of flies. Work at ICIPE has now demonstrated clearly for the first time that species such as *Glossina fuscipes* locate their preferred hosts (monitor lizards) through previously unknown odour cues. The chemicals responsible have been isolated and are being identified for eventual use in attractive bait technologies.

A similar integrated research approach has been used to identify the ways in which female tsetse locate sites suitable for depositing their larvae. This work has led to a breakthrough in the identification of new pheromones. The major components of the larviposition pheromones of *G. morsitans* sspp. have now been identified as *n*-pentadecane and *n*-dodecane. The compounds show great promise for the development of control methods for gravid females. These females are refractory to existing attractive devices during late pregnancy, and therefore survive in the wild to re-establish the tsetse population.

Wildlife play an important role in trypanosomiasis transmission to man and domestic animals. The monitor lizard is the preferred host of Glossina fuscipes, *an efficient transmitter of human sleeping sickness. Below: Maintenance cage for lizards, from which lizard urine can be collected for testing as an odour bait.*



Gas chromatogram of volatiles given off by larvae of Glossina morsitans morsitans. *The predominant EAG-active peak has been identified as n-pentadecane. The five EAG active compounds (starred) were found to attract gravid females to larviposition sites.*

While researching more efficient attractive bait technologies, ICIPE has continued to test and promote existing trap-based control methods for direct community use. These trials have been conducted in Kenya and Ethiopia with varying degrees of community participation. The successes and failures of tsetse control with traps have been analysed from both a social and an economic viewpoint. The lessons learned have been used to develop new socio-economic models for the implementation of community-based projects in order to ensure long-term sustainability. These models are now being implemented and monitored for impact and sustainability in on-going pilot trials in both countries.

As part of a collaborative PESTNET project between ICIPE, UNHCR and the Government of Ethiopia, ICIPE-designed NG2G traps have been deployed in the Bonga, Gambela area to analyse the high population of tsetse there. *Glossina tachinoides* appears to be the most common species, with smaller numbers of *G. fuscipes*. The most prevalent parasite was *Trypanosoma congolense* (in 15.8% of cattle), followed by *T. vivax* (4.6%) and a small proportion of *T. brucei brucei* (0.27%). The study has demonstrated that intervention is needed in this region.

A second joint project between the ICIPE and the Ethiopian Science and Technology Commission and the Southern Peoples Regional Government has been launched in Bedessa, Wollayta Sodo. In this community-based tsetse control project, about 980 NGU traps have been installed in an area covering 200 km². The trypanosome prevalence rate in this high challenge area varied between 24–31 percent, with *T. congolense* and *T. vivax* the most common parasites. As a result of the trapping operation, trypanosome prevalence has declined to about 10 percent and the fly catch per trap has declined from the initial 100 to only 2–3 flies per trap per day.

The tsetse-tryps link

In addition to adaptive research, ICIPE has made significant progress in three strategic areas that may lead to future practical applications:

- First, long-term research on the many factors controlling the refractoriness of tsetse to trypanosome infection has led to the identification of a trypsin-lectin complex that appears to control trypanosome establishment in the tsetse midgut. Full characterisation of this complex is nearly complete and may lead to novel strategies for the genetic manipulation of refractory tsetse in the wild.
- Second, experiments with biological control agents have led to the development of a simple field application technique for contaminating tsetse with a pathogenic fungus, *Metarhizium anisopliae*. The potential killing effect of

a contamination chamber attached to traps has been validated in the field and now awaits more extensive trials.

- Lastly, new trap designs have been developed for sampling biting flies such as stable flies and tabanids. These new traps represent a first step towards the development of practical techniques for suppressing biting fly populations in areas where they are involved in disease transmission, or pose a significant nuisance.

Chickens are efficient predators of ticks on domestic animals. Using a 1:1 ratio of cattle to chickens, a 7% reduction of tick load on Zebu cattle has been achieved.

TICKS RESEARCH

Ticks are undeniably the most difficult pests and vectors to control, with most farmers still relying on the often haphazard use of acaricides. Presently, most African countries cannot afford to subsidise acaricides and farmers cannot afford to purchase them without subsidisation. African countries spend about US$ 720 million per year to import acaricides, and even with these high expenditures, perhaps only 3 percent of cattle dips are functional at any given time. Clearly, affordable and sustainable alternatives to the use of acaricides are needed.

ICIPE has traditionally focused its research on tick ecology in relation to farming practices in order to develop strategies for minimising the use of acaricides. It is currently making a unique contribution to tick control research by studying diverse management options. In particular, ICIPE has led the field in promoting simple integrated strategies based on cultural practices and a sound understanding of tick biology.

Low-cost IPM for ticks

At field sites in western Kenya, ICIPE scientists have worked closely with farmers to develop low-cost methods of tick control such as hand-deticking, regulated grazing, mixed grazing, and predator facilitation (such as the use of chickens as tick predators). The adoption of these simple methods of tick control by farmers is being studied and promoted while other methods with longer-term payoffs are being researched.

Top: The parasitoid wasp, Ixodiphagus hookeri *lays its eggs in a nymph of the spotted tick,* Amblyomma variegatum. *Over 150,000 of these tiny wasps have been released in Kenya by ICIPE acarologists to test their efficiency as biocontrol agents.*
Bottom: An empty shell is all that remains of the tick after the wasp larvae have exited.

Parasites and pathogens

Particularly significant advances were made in 1994 in the field demonstration of the efficacy of biological control agents for economically important ticks. Sustained releases of the parasitoid *Ixodiphagus hookeri* which lays its eggs in *Amblyomma variegatum* were successful in reducing tick loads on cattle by about 95 percent in a trial conducted in western Kenya. This parasitoid can now be reared in large numbers in the laboratory. These encouraging results suggest that effort should be put into searching for more parasitoid-tick combinations for the development of diverse biological control strategies.

Field trials of the pathogenic fungi, *Beauveria bassiana* and *Metarhizium anisopliae*, have been successfully conducted using a variety of cheap formulations. These fungi have been demonstrated to have pronounced effects on both the fecundity and survival of ticks such as the brown ear tick, *Rhipicephalus appendiculatus* (the vector of East Coast fever, ECF) and *Amblyomma variegatum* (the vector of heartwater), both on and off the host. If economic formulations compatible with the diverse environmental conditions in Africa can be developed, pathogenic fungi could provide a useful alternative to acaricides. As ticks spend up to 95 percent of their lifetime off the host, the demonstration of the effects on ticks while on pasture is highly significant.

Botanicals for the arsenal

More weapons for potential use in the anti-tick arsenal were revealed this year through research on the anti-tick properties of plants in the families Capparidaceae and Euphorbiaceae. Extracts from a local plant, *Margaritaria discoidea* were shown to induce high mortalities in ticks in laboratory trials. Following up on previous studies, extracts from additional plants in the Capparidaceae were assessed for their repellency to *Rhipicephalus appendiculatus*. *Boscia mossambicensis* was found to be the most repellent of the four plants tested. Many chemicals responsible for tick repellency were also identified in a first step towards finding practical applications for anti-tick botanicals.

Related semiochemical research also revealed that host odours play a key role in the location of sites of attachment for *Rhipicephalus* spp. These promising results have opened up the possibility of disrupting host location behaviour with false odour cues that could be dispensed in an odour-baited tick trap, for example.

Hidden solutions

In 1994, ICIPE continued to explore promising alternatives related to vaccines against tick components using 'hidden' antigens. Good immunisation results obtained in past years with solubilised tick gut antigens from *Rhipicephalus appendiculatus* were followed up with more experiments on semi-purified material and an enriched glycoprotein fraction. Effects on ticks were found to be facilitated by low doses of ivermectin. Ivermectin appears to increase gut permeability and hence enhance the anti-tick effects of the immune molecules induced. Protocols for immunisation are now being tested with cattle in the field. Although long-term in nature, this research has good potential for practical applications if integrated with other strategies for tick control.

MEDICAL VECTORS RESEARCH

Over the past 25 years, the former Medical Vectors Research Programme has addressed some of the most important vectors of human tropical diseases: the mosquitoes that carry yellow fever, malaria and bancroftian filariasis; the sandflies that carry cutaneous and visceral leishmaniasis (kala-azar), and the tsetse carriers of human sleeping sickness. Currently, this programme is undergoing a major revamping and reorganisation.

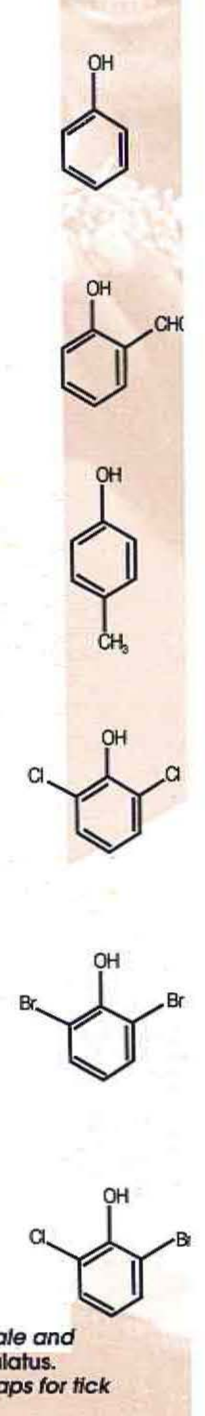


Figure 2. Compouds identified from volatiles of male and female brown ear ticks,* Rhipicephalus appendiculatus. *These substances may find use in odour-baited traps for tick control.

In the case of mosquitoes and sandflies, ICIPE's past research has focused on environment-friendly control methods which minimise insecticide use, and are adaptable to the lifestyles of rural people. Research at ICIPE resulted in the adaptation of the pyrethroid-impregnated *Mbu Cloth* for community use in the control of both vectors in rural settings where other methods are not appropriate.

The ever-increasing resistance to insecticides and therapeutic drugs has made the pursuit of radical alternative vector control technologies critical. Technology development is contingent on a thorough understanding of the bioecology, host-parasite relationship, vector competence and vector population dynamics, in addition to socio-cultural factors. ICIPE is well placed to make substantial contributions towards strategic research in these areas, and is now updating its approach in integrated malaria vector management.

Sandfly diet and vectorial capacity

Leishmaniasis is a disease caused by parasites of the genus *Leishmania*, transmitted to man by several species of phlebotomine sandflies. The phlebotomine sandfly genera, *Phlebotomas* and *Sergentomyia*, are the major vectors. Leishmaniasis is prevalent worldwide in rural as well as urban areas of temperate and tropical regions. Its newly growing importance, especially in developing countries, prompted the World Health Organisation to include it among six major tropical diseases, along with malaria, African trypanosomiasis/ Chagas disease, filariasis, schistosomiasis and leprosy.

The intensity of transmission is a function of the vectorial capacity, which is affected by, among other factors, the density and longevity of the vector. While blood is taken according to the development cycle, plant tissues are the common diet of sandflies, providing nearly half of the sugar meals of some species. These meals also contain certain carbohydrates, lectins and proteins which can compete with the *Leishmania* parasites for binding sites and thereby affect the establishment of infection. Since the life cycle of *Leishmania* takes place in the sandfly gut, the parasites are exposed to the vector gut environment and digestive enzymes and products.

In 1994, experiments were carried out to contribute more evidence on phytophagy and evaluate its effect on fecundity and longevity of Kenyan phlebotomine sandflies, with reference to *Sergentomyia ingrami* Newstead and *Phlebotomus duboscqi* Neveu-Lemaire. The first species is suspected to harbour uncharacterised *Leishmania* parasites, whereas the second is a confirmed vector of *Leishmania major*, the causative agent of cutaneous leishmaniasis in the Old World and also in the Kenyan focus in Baringo District.

Of seven wild test plants (*Azadirachta indica, Melia azadarach, Ocimum kenyense, Ocimum suave, Rumex usambarensis, Solanum incanum* and *Tagetes minuta*) offered to *S. ingrami* and *P. duboscqi*, the flies were observed to be highly selective, preferring *R. usambarensis* and *M. azadarach*. These plants elicited a feeding preference similar to sucrose, while *A. indica* and *S. incanum* were less preferred. *Ocimum kenyense, O. suave* and *T. minuta* elicited the poorest feeding response in both sandfly species, being only slightly more preferable than water.

The species of plants used as food source also affected the fecundity of the flies. In the case of *P. duboscqi*, the highest mean number of eggs per female was observed in flies maintained on *R. usambarensis* (54.05) and the lowest in those given only water (46.82). The maxima recorded were 101, 85, 127 and 85 eggs when flies were offered *R. usambarensis, S. incanum*, sucrose and water, respectively.

The maximum longevity in *S. ingrami* associated with the four diets was as follows: 28, 24, 21, and 9 days for *R. usambarensis*, sucrose, *S. incanum* and water, respectively. The maximum longevity in *P. duboscqi* was 41, 44, 27, and 17 days for *R. usambarensis*, sucrose, *S. incanum* and water, respectively. *Solanum incanum* was associated with reduced longevity in both flies. The results show that sandflies have significant preferences for particular host plants, and that these different plant tissue meals can affect the population dynamics of the flies, which in turn has implications for their capacity to act as disease vectors. Further work is needed to determine how the host plant meals might affect the *Leishmania* parasites harboured by the flies.

Biocontrol for mosquitoes

Due to the difficulty in producing an effective vaccine for malaria, the development of other disease prevention measures assumes a greater importance.

Several strains of *Bacillus thuringiensis israelensis* (*Bti*), an entomopathogenic bacteria active against mosquito larvae, have been isolated by ICIPE scientists from infected larvae from a rice irrigation scheme in Kenya. This year, the ICIPE mosquito colonies of *Aedes aegyti*, *Anopheles* spp. and *Culex* spp. were revamped to permit bioassays of *Bti* clones obtained from the Hebrew University. The projects' aim is to develop an improved larvicide by transferring genetic material coding for the toxic protein produced by *Bti* into another bacteria, *Bacillus sphaericus*, which has a longer persistence in the environment than *Bti*. The determination of the LD_{50} of the clones of the two bacilli is in progress, after which the clones will be tested in the laboratory and in the field.

ARPPIS PhD students from several African countries watch while an ICIPE ecologist, left, samples mosquito larvae from a rice irrigation cananl. Malaria and other mosquito-borne diseases are increasing in areas around dams, quarries and irrigation schemes which provide the water required for mosquito egg-laying and larval development.

Dudustop-ing filthflies

Biopesticides made from *Bt* have been successfully applied against fly larvae in Finland, Tanzania and Kenya. An ICIPE-produced strain of *Bt* named 'Dudustop' has been used to treat pit-latrines and refuse heaps in densely populated settlement areas such as slums and refugee camps.

In collaboration with UNHCR and the Government of Ethiopia, Dudustop has been applied to over 400 toilets in the Bonga Refugee Camp in southwest Ethiopia, to reduce filthflies and prevent transmission of fly-borne diseases. The number of fly larvae in the toilets reduced rapidly after 2–3 weeks of treatment with the suspension, and the effects persisted for up to 3–4 months. The *Bt* slurry used in the trials was produced in Finland. (See also under Outreach in this report).

Arthropod Biodiversity, Conservation and Utilisation Programme

Sericulture is a simple technology requiring the minimum of resources and space. ICIPE has selected this *Bombyx mori* NB18 race, shown here on the mountage, for commercial production and distribution to farmers and women's groups in Africa

The great majority of rural communities in the tropics depend on the natural resource base for their sustenance and most often for their livelihood. Insects and related arthropods (spiders, mites, ticks, etc.) are an incontestably large part of the farmers' environment. Insects are the most common and diverse form of life. While estimates vary, it is now generally thought that of possibly 12–15 million species of life on the planet earth, 5–6 million may be arthropods, of which about 1 million are already known to science.

ICIPE's research for the past 25 years has been based on developing methods for pest control that respect the integrity of the environment and of man's place in the natural world. IPM itself is a management strategy that is based on the principle of maintaining and exploiting biodiversity as a component of sustainable agriculture. ICIPE's new programme on Arthropod Biodiversity, Conservation and Utilisation will serve to focus on arthropods and their diversity as a source of environmental services: as pollinators, recyclers of soil nutrients, natural enemies of pests, indicators of pollution and environmental change, and so on.

Africa's ecosystems and their biodiversity, in particular, are important sources of new foods, pharmaceuticals, fibres and other products. The continent has 23 percent of the world's land, and almost a third of the world's tropical forest cover. Yet, this enormous potential remains largely untapped. In agriculture-based economies, there is an especially close link between economic development and the conservation and sustainable exploitation of renewable resources. In our new programme, arthropods are being viewed as a natural resource which can be managed and exploited for income generation to help alleviate rural poverty.

By virtue of its mandate and due to its strategic location in the tropics, ICIPE will seek to play a stewardship role by generating baseline information for better understanding of arthropod biodiversity and its influence on the agriculture, forestry and health sectors. This will be achieved through biological surveys and inventories that will later serve as indices for long-term monitoring of ecosystem sustainability, using arthropods as indicators. In addition to collecting data, such as on which arthropods occupy the different ecological zones, and databasing this information, ICIPE will also study the systems dynamics, and how species diversity is influenced by agriculture, forestry and other human activities. This knowledge will, in turn, help in developing management and conservation practices which will safeguard the system's integrity and which work in harmony with nature.

Chemical pesticides often have a deleterious effect on higher organisms. Oxpeckers such as these on the back of an antelope in Kruger National Park, South Africa are under threat from the acaricides used to kill ticks on domestic animals.

The Centre will also play a catalytic and capacity-building role in arthropod biodiversity by compiling, updating and maintaining data bases which can be assessed and used worldwide.

ARTHROPOD BIODIVERSITY AND CONSERVATION

Biodiversity studies are not new at ICIPE. Many of the projects described elsewhere in this Report have a biodiversity component. For instance, in our plant pests research, surveys of stemborer species, as well as studies on the genetic diversity of their natural enemies, are essential components in developing a comprehensive management strategy for these pests. Likewise, surveying and assessing the attractiveness of diverse species of wild grasses to crop pests and their natural control agents is an intrinsic component of habitat management. Our surveys of wild plant hosts for sandfly sugar meals and as forage for the desert locust are included as essential pieces in the puzzle of understanding how these insects interact with biotic factors in their environment. Genetic and species surveys are also planned for some of our 'new' target insects, i.e. the Mediterranean fruitfly and other fruitflies, honeybees and wild silkmoths.

The new programme will serve to broaden our biodiversity research perspective. This year, pilot biological surveys were initiated in two ecological zones in Kenya, one in indigenous forest and the other in the coastal agro-ecozone. This preliminary data will be included in an Africa-wide data base of species and their distribution and habitat range.

Because they play such an important role in agricultural production and health care, women will be targeted for training in biodiversity conservation and utilisation. Other groups which will play a major role in implementing this programme area are universities (both staff and students), research institutions and museums throughout Africa.

COMMERCIAL INSECTS

The prevailing poverty in Africa and in other tropical countries often compels the use of natural resources in ways that degrade and threaten the environment. Conservation *per se* is considered by some as a luxury if it competes with 'development'. ICIPE's two projects on commercial insects can provide the rationale for conserving biodiversity for practical use in income-generating activities for rural communities, particularly women, in Africa.

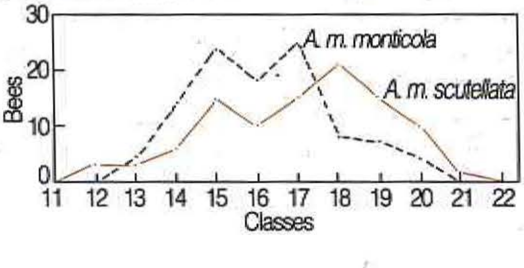
The efficient and profitable use of arthropods such as honeybees and silkmoths needs a steady flow of new research findings concerned with increasing the output, and a place where eventual problems can be addressed. ICIPE is currently in the process of setting up centres for both sericulture and apiculture which will serve Africa-wide projects and activities on these commercial insects.

Apiculture

Traditional bee-keeping (apiculture) in Africa often results in substantial losses in biodiversity. Due to lack of technical knowledge, the colonies are often destroyed during honey harvesting, and diseases and pests such as the wax moth, introduced. ICIPE's apiculture project will seek to improve both the art and science of bee-keeping. Modern techniques of honey harvesting, queen rearing, colony hygiene and colony splitting need to be incorporated into African bee-keeping practices. The science of apiculture needs to be developed through research on the notorious stinging and absconding tendencies of the African bees, backed up by studies on their behavioural biology and chemical communication in the wild.

The benefits to be accrued are many: improved foraging and pollination, leading to increased food production; and increased production of saleable high-value side products, such as honey, wax, royal jelly and other hive products,

Figure 1. Distribution curves of the cubital index of Apis mellifera sspp. from ICIPE, Kenya.



leading to micro-enterprise development in the rural areas.

As a first step in assessing honeybee diversity, preliminary studies in 1994 were undertaken to compare the cubital index of the proboscis length in two known *Apis mellifera* species in Kenya, *A. m. scutellata* and *A. m. monticola* (Figure 1). The double-peak distribution curves in both subspecies indicates that there is an intercrossing between the two strains in the stocks maintained at ICIPE. The higher second peak of *A. m. scutellata* and the lower of *A. m. monticola* is a strong indication that a higher degree of hybridisation exists in the former species. The pure races and the hybrids are being compared for honey yield, pollination capability, royal jelly production and stinging tendency. The floral calendar of different honey-producing areas of Kenya are being monitored to promote the use of Langstroth hives. Methods for improved queen rearing are being perfected for colony multiplication and for studying other behavioural traits.

Sericulture

The raising of the domesticated silkmoth, *Bombyx mori* is a new agroforestry option for Africa. Sericulture can be practiced in even the most modest circumstances to provide a high-value silk fibre with a ready world market, as well as other useful by-products such as high-protein animal feed and industrial oils.

Wild silkmoths provide the special tussah silk that must be harvested from the forests. These wild species are under threat due to the over-exploitation of the larvae as protein food (they contain up to 23% protein) and to loss of habitat.

ICIPE's proposed project on the sustainable conservation of saturniid silkmoths and commercial utilisation of selected bombyciid races will provide the scientific back-up for development of integrated land-use systems. Several previous efforts at sericulture in Africa

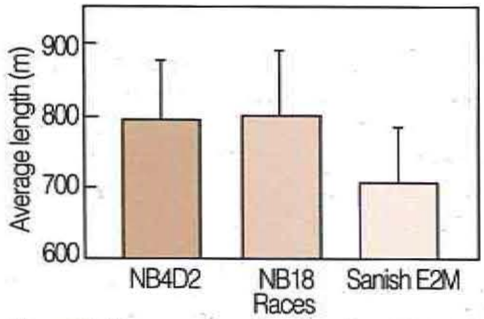


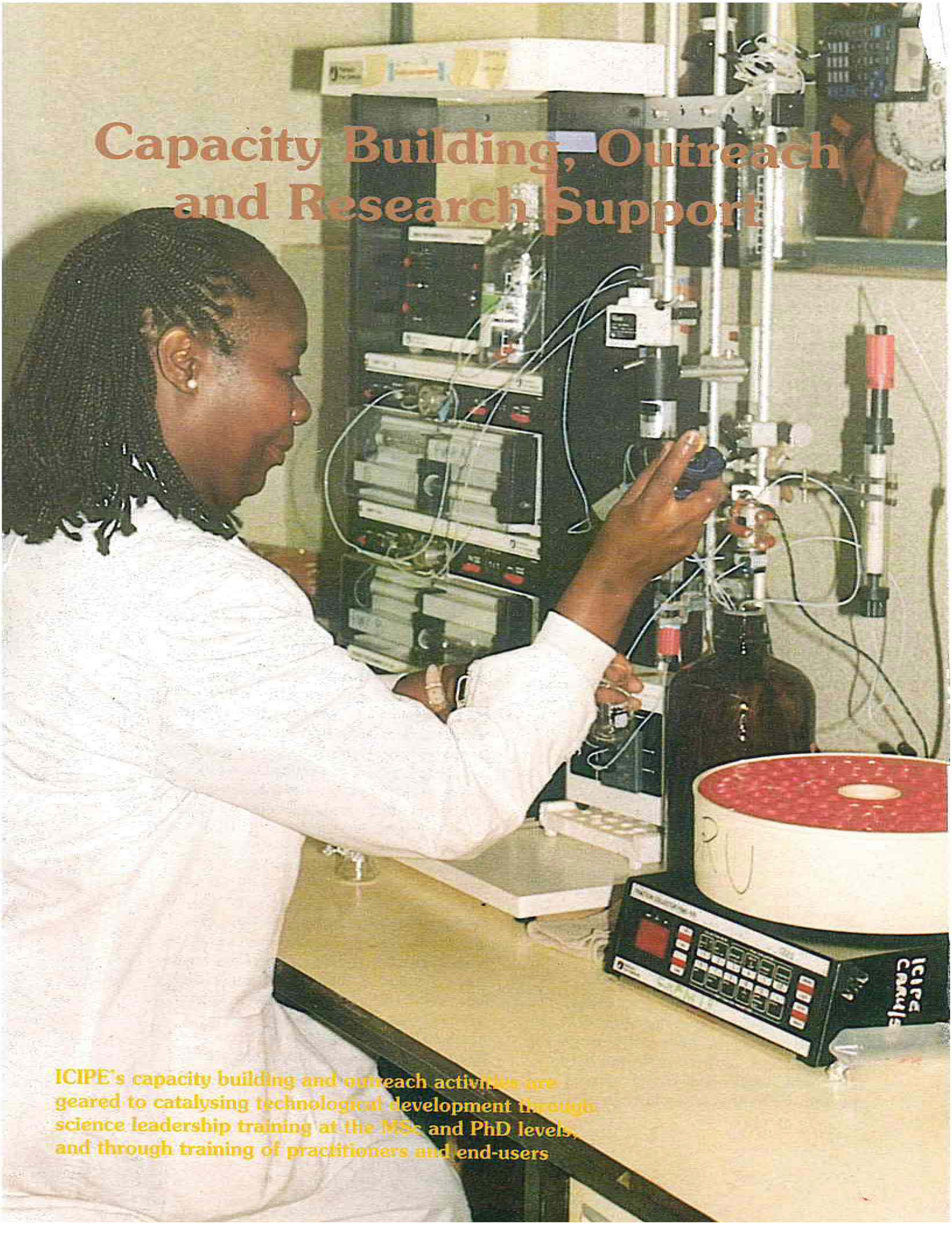
Figure 2. Average fibre length of cocoons from three races of the silkmoth,* Bombyx mori *evaluated at ICIPE.

have failed due to lack of research underpinning and understanding of the problems of disease, egg diapause, and of the grainage required for producing bivoltine hybrids.

Other than its research back-up, ICIPE will complete its preliminary market survey and will establish demonstration pilot scale processing units appropriate for smallscale industries. Audiovisual sericulture training and working modules will be developed.

In pilot studies this year, seven cultivars of the mulberry, *Morus alba* (Kanva/2; S41; S36; S54; Thailand; Embu and Thika) were screened against three races of *B. mori* (NB18; NB4D2 and Sanish) in order to select the most productive race of silkmoth for commercial exploitation. Kanva/2 ranked first among the seven mulberries, followed by Embu and S41. The parameters followed were development time of the silkworm larvae, moulting time, oviposition, occurence of disease and the silk fibre length per cocoon. These preliminary experiments were performed at 20–26°C with a relative humidity of 75–85%. The silkmoth race which performed best is NB18 and its survival rate is 95% with no incidence of disease if proper management techniques are followed. The female lays an average of 450–570 eggs and the hatching of larvae is 90 ± 5%. The length of the yarn checked with a single cocoon reeling machine is 800–870 metres per cocoon (Figure 2). This race has been selected for commercial production and distribution to farmers.

Capacity Building, Outreach and Research Support



ICIPE's capacity building and outreach activities are geared to catalysing technological development through science leadership training at the MSc and PhD levels, and through training of practitioners and end-users

Indications are that in order to make progress against poverty, improved health, effective environmental management and other positive social changes, the development agenda must be much broader than implementing sound macro-economic policies alone. It must include greater and more sustainable investment in human resources and in institutions and infrastructure development (WRI, 1995). At ICIPE, two major programme areas contribute to capacity building in insect science: the ARPPIS programme and PESTNET.

More than any other continent, Africa lags behind the rest of the world in agricultural research, personnel and expenditure. Sub-Saharan Africa (43 countries) had only 3.5 percent of the world's full time agricultural research personnel in 1985 as compared to China (26%) or the Asia-Pacific region (16%). The annual research expenditure in Africa was only 4 percent of the total of about US$ 9.2 billion (1980 PPP dollars). The 22 more developed countries accounted for 52 percent of the total (WRI, 1994). These figures point to one possible reason why Africa has trouble feeding itself and has difficulty in finding its own solutions to agricultural and public health crises. ICIPE's activities seek to redress this imbalance by providing high level training for post-graduate students and for experts and practitioners of IPVM. The Centre extends its expertise and influence to other tropical regions through the medium of PESTNET.

CAPACITY BUILDING

ARPPIS

The African Regional Postgraduate Programme in Insect Science (ARPPIS) was established in 1983 as a collaborative training programme between ICIPE and African universities, with the prime objective of helping to meet the need for insect scientists and pest management specialists in Africa. To date, 29 universities from 15 African countries are collaborating with the ICIPE in ARPPIS.

The ARPPIS PhD Programme is based at ICIPE, where students undergo three years of training and thesis research. Students are registered at participating universities which examine and award them degrees. Currently, 40 students at various stages of research work, data analysis and thesis writing are at ICIPE. Seven students from six African countries joined ARPPIS on 1 March 1994, and four scholars were awarded the PhD this year. To date, ARPPIS has produced 47 PhD graduates who are serving in various capacities, mainly in Africa. Due to the success of the programme in efficiently producing scientists of international quality, there has been a high demand for university participation in ARPPIS, with many universities using ARPPIS for their own staff development.

The ARPPIS Sub-Regional MSc Programme, established in 1991, is now operational in three sub-regional centres. Five students (all Zimbabweans) were enrolled in the MSc in Tropical Entomology (MTE) course for the 1994-1996 programme at the University of Zimbabwe's ARPPIS sub-regional centre for Southern Africa. The course commenced on 28th March 1994 in the Department of Biological Sciences.

The ARPPIS centre for western Africa MPhil Programme at the University of Ghana, Legon selected its first class in 1994 with 15 qualifying candidates (9 Ghanaians and 6 other nationals) from the region. The ARPPIS Academic Board recommended that the programme in eastern and northeastern Africa at Addis Ababa University be scheduled to start in the 1996/97 academic year in order to allow adequate time for planning.

The international group training courses for IPVM practitioners are important PESTNET outreach activities. Here, participants to the course on Management of Livestock Pests in the Developing Tropical World—Ticks and Tsetse, examine local Zebu cattle for tick infestation and disease symptoms.

Professional career development programmes

The general objective of professional development programmes at the ICIPE is to help scientists and technologists acquire specialised research skills, while the trainees themselves provide a service or make an intellectual contribution to the Centre. Fifteen (15) young PhDs from five African countries and China worked at ICIPE under the Postdoctoral Fellowship (PDF) training programme in 1994. The trainees added vigour to ICIPE's research in the fields of tsetse ecology (3), locust semiochemicals (3), tick ecology and biocontrol (4), biochemistry and molecular biology (3), biological control of stemborers (1) and biomathematics and population modeling (2). Two scientists were attached at ICIPE under the Research Associateship scheme, one from Tanzania working on the control of banana pests at Bukoba, Tanzania, and the other from the Netherlands who was attached to the ICIPE/Wageningen Agricultural University (WAU) research project on the control of stemborers.

Under the Visiting Scientist scheme, the ICIPE hosted Professor W. Ogana of the Department of Mathematics, University of Nairobi, who worked as a population modeller on a project on tsetse and ticks. Dr. William Overholt continued to serve at ICIPE as the coordinator of the ICIPE/WAU project on biological control of stemborers, and two Japanese scientists, Drs Keiji Takasu and Takahiko Hariyama, worked at ICIPE under sponsorship by the Japanese Society for the Promotion of Science.

Working in collaboration with the national universities, colleges and polytechnics, the ICIPE offered short-term field training attachments to a total of 15 trainees. In addition, pest and vector management technologists were also offered individually tailored courses in field application of pest and vector monitoring and control methods. A total of 12 ICIPE staff members were involved in officially approved staff development training this year.

Consumer-based training programmes

Four international group training courses were offered to integrated pest and vector management (IPVM) practitioners from the national research and extension services (NARES) and universities. A total of 56 scientists and technologists from 18 developing countries attended courses on the management of ticks, tsetse and stemborers of cereal crops.

Technology demonstrations and training of farmers is undertaken within countries collaborating with ICIPE and are reported below under PESTNET activities.

OUTREACH AND NETWORKING

ICIPE's major mechanism for extending its experience and expertise beyond its research facilities in Kenya is through the mechanism of PESTNET, the Pest Management Research and Development Network. PESTNET was established in

1986 as a collaborative programme between the ICIPE and national agricultural research institutions, with the objective of developing national scientific capabilities and skills in insect science. The major activities of PESTNET are: (i) interactive technology development; (ii) training, and (iii) information exchange. Although ten African countries (Rwanda, Kenya, Somalia, Sudan, Tanzania, Uganda, Zambia, Zimbabwe, Malawi and Ethiopia) have signed an agreement to cooperate with the ICIPE through PESTNET, this year activities progressed only in Kenya (crop and livestock pests), Tanzania (banana pests), Zambia (crop pests), Ethiopia (livestock pests) and the Sudan (locust), where PESTNET resident scientific teams are located. Research and development activities of PESTNET within the collaborating countries are reported under the respective research programmes.

The research and development activities under PESTNET-**Kenya** were based mainly at the Kenya coast, under the ICIPE/KARI Kwale-Kilifi Adaptive Research Project (see page 16). Training activities continued in collaboration with KARI towards extending the adoption of environment-friendly technologies by the beneficiary farmers in coastal Kenya. Field days were held at the three on-farm locations in which 20–30 farmers were each trained in the adoption of pest-resistant cultivars of maize and sorghum as well as early intercropping of cowpeas in maize. In addition, a three-stage training programme was implemented for mass deployment of tsetse traps in Shimba Hills (adjoining the Game Reserve) in Kwale District, with the following target groups being trained: district/divisional extension subject matter specialists (12); frontline extension officers from different locations (16); farmers (60).

In **Ethiopia**, the research and development activities in 1994 have

Dudustop, an ICIPE product, being diluted for application to pit latrines in Bonga Refugee Camp, Gambella, Ethiopia. Over 400 toilets in the camp were treated with the slurry, which kills filth fly larvae and reduces the spread of contagious diseases.

concentrated on research towards the management of tsetse (see page 23). In addition, the ICIPE undertook field trials and demonstrations on the control of filth flies in Bonga refugee camp, Gambella region, in partnership with a private company in Finland, the Oy G.A.C. The technology used was an ICIPE-developed biocontrol system based on *Bacillus thuringiensis* (see page 27). This year, three Ethiopian students completed their PhD training in ARPPIS.

In **Zambia**, the PESTNET Resident Team was based within the Plant Production Unit at Mt. Makulu Central Research Station. The team continued with adaptive research and locale-specific trials on the management of stemborers using various technologies developed at ICIPE, including biological control with parasitoids, resistant crop varieties, natural products, behavioural manipulation and intercropping. A national symposium on the use of plant products as pesticides was held with the aim of identifying and bringing together resource persons involved in natural plant pesticides research. Training of Zambians under ICIPE training programmes in 1994 included two PhD students, while another five students were trained through short courses at the Centre.

Research and development activities in **Sudan** are based at ICIPE's field station in the Red Sea area, and focused on developing strategies for the management of the desert locust. The activities are part of the locust semiochemicals project at ICIPE (see page 18). Eleven Sudanese are being trained in the ARPPIS programme while a total of 23 nationals participated in specialised short courses held at ICIPE headquarters; two Sudanese nationals were at the ICIPE as visiting scientists.

In **Tanzania,** R&D activities were based at Bukoba, and were focused on banana pests. The team is headed by a former ARPPIS student who received his PhD from Kenyatta University during the year. Two other Tanzanians were trained in ARPPIS during the year, while four more participated in short courses and one was a postdoctoral trainee at the ICIPE.

INFORMATION, COMMUNICATIONS AND PUBLISHING

Other important vehicles for putting forth the Centre's message and research results are through its information and publishing activities.

The Information Resource Centre (IRC) continued to grow in terms of bookstock and services in 1994. Since its commissioning four years ago, the Centre has provided the necessary backup and support to research activities at ICIPE. The following reading materials were acquired this year: 1546 books, 295 reprints, 222 subscriptions and 854 gifts, donations and exchanges. The computer database continues to serve the ICIPE fraternity and beyond. About 2,000 requests were handled by the existing IRC resources, and other queries were handled through the CGNET network or other available internet facilities. About 125 searches on CD-ROM were performed, and the database has increased as a result of the addition of 1784 records during the year.

ICIPE is the focal point of the **Pest Management Documentation and Information System (PMDISS).** ICIPE/PMDISS are linked by CGNET to all CGIAR centres through an improved electronic mail facility. Collaboration with AGRIS (Agricultural Information System) of FAO was maintained and an exchange of data on CD-ROM from the FAO was the backbone of the literature searches carried out during the year. The IRC contributed to current awareness by in-house generation of indexes and abstracts by systematic scanning of all in-coming journals for relevant articles and searching the available CD-ROM packages. This information is available to all PMDISS subscribers.

The **ICIPE Science Press** focuses on dissemination of information on integrated management of tropical insect pests and disease vectors by publishing and document processing for the Centre. This year the Press introduced two projects: The Environmental Publishing Network (ENVIRONET Links) and the University Students Attachment Programme (USAP). ENVIRONET is an initiative that can give a boost to environmental publishing, especially in Eastern Africa. USAP is a 'women's empowerment' project which takes on attachment university students for on-the-job practical experience. The Press continues with complete in-house production and distribution of the international journal, *Insect Science and its Application*, now in its 15th volume. In addition to this journal, the Press has completed several important publications in 1994, which are listed in the publications list (see page 39).

The office of the **Science Editor** is responsible for editing of manuscripts generated by ICIPE scientists destined for international journals, and for preparing the *Annual Reports*. This office has also recently assumed interim coordination for the editing of *Insect Science and its Application* until a new scientific editor can be appointed to replace the out-going editor. In 1994, preparations for the publication of two books reviewing the current status of IPM were finalised in collaboration with UNEP.

The **Public Relations** office is responsible for organising the programme for all visitors to ICIPE, and organising workshops and conferences, which this year included the 24th Annual Research Conference. In addition, the PR office organises induction of new staff and seminars. Some of the major activities this year included organisation of the very successful Third International Conference on Tropical Entomology from 30th October to 9th November. The event was attended by over 200 scientists from 35 different countries around the world.

Among the many visitors to the Centre were the women members of a credit scheme for productive activities of women in Tanzania, a UNIFEM-funded project that deals with mobilisation, training and credit delivery for women in the rural areas. The week's study tour focused on control of mosquitoes and malaria. Among the many important visitors to the Centre were Dr. Fawzi H. Al-Sultan, President of IFAD; Prof. Frederico Mayor, Director General, UNESCO; Dr. H. Hayakawa, Director, JIRCAS; Prof. C. M. Karssen, Vice-Chancellor, WAU; and Mr. Richard Jacobs, Director, DAAD Regional Office for Africa, Nairobi.

RESEARCH SUPPORT UNITS

Throughout 1994, six research support units provided specialist input into the Center's main research programme areas. The units were Biomathematics, Biotechnology, Behavioural and Chemical Ecology, Molecular Biology, Social Sciences Interface Research, and Insect and Animal Breeding. Two of the units which conduct independent research are highlighted below.

Biomathematics

The Biomathematics unit contributed towards improving the quality of research results at the Centre through various services in the area of biomathematics and GIS. Modeling activities were mainly done on tsetse, and biostatistical services were offered in the areas of design of experiments, analysis of data and interpretation of results. GIS services were in higher demand during the year, due to increasing awareness of the usefulness of GIS models. Most new projects now include some measure of GIS activities. Work continued on the compilation of the Kenya Coast database for the ISERIPM project. Collection and generation of socio-economic data took precedence, and geo-location of trial sites was accomplished during the year. In the tsetse project based in Nguruman, data collected from tsetse monitoring traps over the period May 1993–December 1994 was used to generate spatio-temporal maps. These maps show tsetse population density dynamics by species and sex per trap per season.

One important activity was the statistical study of agricultural production of smallscale farmers in sub-Saharan Africa, who provide the greater proportion of food consumed in Africa. Smallscale farmers produce at levels far below the expectations of the various packages developed by scientists. ICIPE has developed models to predict production levels, given the various factors responsible for low levels of agricultural production. A statistical examination of our model fitted to a set of survey data on this subject revealed that improving the farmers' management level can greatly enhance their productivity. Further statistical analysis of the data set showed that the various factors that constitute the farmers' management level could broadly be classified into three groups, *viz*, resources (labour and farm implements); personal characteristics (educational level and age), and external assistance (contact with extension agents/assistance), in that order of importance.

Social Sciences

The development of social science research at ICIPE is a direct response to the basic goal of the Centre to develop pest and vector management technologies appropriate for the production systems and for the economic and social circumstances of the potential users of such technologies, who are mainly smallscale agricultural producers and pastoralists. Today it is firmly established that the efficacy and sustainability of new pest and vector management technologies can be assured and its adoption and impact enhanced if socio-economic analysis is effectively integrated in the R&D process.

Two important research projects of the Centre currently under implementation in the Coast and Western Provinces of Kenya are being coordinated by the Social Sciences Unit with social scientists working hand-in-hand with biological scientists in such areas as plant pests and vectors of livestock diseases: The Interactive Socio-Economic Research for Bio-Intensive Pest Management Project (ISERIPM) and the adaptive research project on community-based management of tsetse and trypanosomiasis (ARCMTT). Among the main achievements in 1994 in the latter project are (i) the creation of an effective community organisation for tsetse control, and (ii) the wide participation of the local population in such activities as tsetse control, including trap construction and servicing; financial contributions; and monitoring impact of tsetse control in collaboration with the researchers. Most importantly, there was a validation of the benefits of interactive research involving the social and biological scientists working on the project, and in collaborative activities involving personnel of the Kenya Ministry of Agriculture, Livestock Development and Marketing (MOALDM). The key test of the success of the community-based approach will be the sustainment of trapping even after very low levels of tsetse population and trypanosomiasis incidence have been attained.

Another area benefiting from socio-economic research was the project on Interactive Development and Application of Sustainable Tsetse Management Technologies for Agropastoral Communities in Africa. This concerned the assessment of the impact of tsetse trapping in Nguruman, Kenya and investigation into problems hampering a community-based approach of tsetse control in this region. A study was conducted on the capacity of the agropastoral community in this region to adopt and manage the tsetse trapping technology. The research results indicate that tsetse trapping in Nguruman has reduced the tsetse menace in the area, and has permitted the use of larger land areas both for livestock grazing and cultivation. The importance of promoting a community-based and self-reliant approach was clearly demonstrated.

Publications by ICIPE Staff

A. Articles published in refereed journals. The list does not include manuscripts in press and those submitted during 1994.

Abegaz B., Asfaw N. and Lwande W. Chemical constituents of the essential oil of *Aframomum corrorima* from Ethiopia. *SINET: An Ethiopian Journal of Science* 17(2), 145–148. 94-1238

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Mr. E. O. Onyango, *Senior Administrative Officer/Officer-in-Charge*

ICIPE SCIENCE PRESS

Ms. A. Katama, *Manager (on secondment from Kianda Foundation)*

DUDU ENGINEERING WORKS

Duduville-Based
Mr. J. A. Mando, *Principal Controller for Technical Services*
Mr. D. Murali, *Electronics and Instrumentation Engineer*
Mr. M. S. Nakitare, *Electronics and Instrument Technologist*

SELF-FINANCING UNITS

INTERNATIONAL GUEST CENTRE SYSTEM

Duduville-Based
Mr. J. A. Achilla, *Principal Business and Catering Controller*

MPFS-Based
Mr. J. A. Kooro, *Business and Catering Controller*

MBITA POINT INTERNATIONAL SCHOOL

Mr. F. O. Omolo, *Deputy Principal*

MEDICAL AND CLINICAL SERVICES UNIT

Duduville-Based
Dr. R. W. Kimokoti, *Medical Officer*

MPFS-Based
Dr. E. C. Achieng', *Medical Officer*

DUDU TRAVEL SERVICES

Mr. F. J. Utanje, *Travel Officer*

Financial Report

Income and Expenditure Account

for the year ended 31 December 1994

		US$ 000 1994	US$ 000 1993
INCOME	Grants	9,081.6	6,206.4
	Premium on foreign exchange certificates	—	81.6
	Miscellaneous	115.5	558.6
		9,197.1	6,846.6
EXPENDITURE	Core Research	5,779.0	4,401.2
	Research Support Services	446.1	290.4
	Training and International Cooperation	1,098.7	615.4
	Information	125.7	121.3
	Management and General Operations	1,093.7	794.7
	Currency Translation Loss	299.7	—
		8,842.9	6,223.0
	Land and Buildings	159.2	6.6
	Scientific Equipment	70.7	165.4
	Office Equipment and Furniture	70.2	38.2
	Vehicles	54.9	168.8
	Generators	—	20.5
		9,197.9	6,622.5
(LOSS) SURPLUS for the year		(0.8)	224.1
Cost of Restructuring		219.5	—
TOTAL (LOSS) SURPLUS FOR THE YEAR		(220.3)	224.1

Balance Sheet

as at 31 December 1994

		US$ 000 1994	US$ 000 1993
FIXED ASSETS	Nominal value	*	*
	ICIPE Riverside House	276.9	284.6
CURRENT ASSETS :	Consumable Stores	13.4	6.1
	Grants Receivable	1,712.0	506.5
	Debtors and Prepayments	1,554.2	478.2
	Deposits — Building Maintenance Fund	215.2	184.3
	— Others	—	1,416.8
	Bank Balances and Cash	1,686.2	840.5
		5,181.0	3,432.4
CURRENT LIABILITIES	Bank Overdraft (Secured)	2,037.2	398.2
	Loan Repayable Within One Year	32.8	14.6
	Creditors and Accruals	1,912.1	1,448.9
	Unexpended Operating Grants	1,016.6	1,261.5
		4,998.7	3,123.2
NET CURRENT ASSETS		182.3	309.2
TOTAL NET ASSETS		459.2	593.8
FINANCED BY:	Reserve Funds	(59.9)	160.3
	Buildings Maintenance Fund	215.2	184.3
		155.3	344.6
	Deferred Financing	80.4	90.5
	Long Term Loan (Secured)	223.5	158.7
		459.2	593.8

** In accordance with the ICIPE Accounting Policy, all assets are written off to the Income & Expenditure account in the year of purchase. However, the Fixed Assets held by ICIPE as at 31 December, 1994, at cost, amount to US$ 6,750,680. (1993—US$ 6,435,187)*

Donors for 1994

GRANTS RECEIVED AND RECEIVABLE	(US$ 000) 1994	1993
African Development Bank (ADB)	—	326.6
African Fund for Economic and Social Development (AFESD)	241.9	122.9
Danish International Development Agency (DANIDA) — Danish Government	746.8	452.5
European Economic Union (EEU)	1,463.4	838.3
Finnish Government	120.0	19.6
Gatsby Charitable Foundation	166.6	4.5
German Academic Exchange Service (DAAD)	230.0	215.3
German Federal Ministry of Economic Cooperation	374.5	218.0
Hebrew University of Jerusalem	30.7	—
Institute of Molecular Biology and Biotechnology—Greece	—	34.6
International Bank for Reconstruction and Development (World Bank)	480.0	664.8
International Development Research Centre (IDRC)	39.9	14.4
International Fund for Agricultural Development (IFAD)	349.2	386.2
Japan Society for the Promotion of Science (JSPS)	5.7	5.4
Kenya Government	29.3	61.5
Natural Resources Institute (NRI) —UK	246.8	112.6
Netherlands Government	752.0	394.7
Norwegian Government	549.6	445.5
Overseas Development Administration (ODA)—UK	—	7.4
PEW Trust (through World Wildlife Fund)	—	3.2
Rockefeller Foundation	328.5	337.0
Swedish Agency for Research Cooperation with Developing Countries (SAREC)	697.8	712.8
Swiss Government	6.0	—
United Nations Children's Fund (UNICEF)	—	9.9
United Nations Development Programme (UNDP)	1,891.3	1,729.5
United Nations Environment Programme (UNEP)	18.1	83.7
United Nations High Commissioner for Refugees (UNHCR)	54.8	—
United States Agency for International Development (USAID)	13.8	5.7
Wellcome Trust	—	7.4
TOTAL GRANTS RECEIVED AND RECEIVABLE	8,836.7	7,214.0
Add : Unexpended Grants — brought forward	1,261.5	253.9
	10,098.2	7,467.9
Less : Unexpended Grants — carried forward	(1,016.6)	(1,261.5)
GRANTS TAKEN INTO INCOME	9,081.6	6,206.4

Abbreviations and Acronyms

AGRIS	Agricultural Information System
ARCMTT	Adaptive Research Project on Community-based Management of Tsetse and Trypanosomiasis (ICIPE project)
ARPPIS	African Regional Postgraduate Programme in Insect Science
AVRDC	Asian Vegetable Research and Development Centre
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
DAAD	German Academic Exchange Programme
ENVIRONET	Environmental Publishing Network
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic information systems
IARC	International agricultural research centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICWG-IPM	Inter-Centre Working Group on IPM
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
IPM	Integrated pest management
IPVM	Integrated pest and vector management
IRRI	International Rice Research Institute
ISERIPM	Interactive Socio-Economic Research for Biointensive Pest Management (ICIPE project)
JIRCAS	Japan International Research Centre for Agricultural Sciences
KARI	Kenya Agricultural Research Institute
MOALDM	Ministry of Agriculture, Livestock Development and Marketing
NARES	National agricultural research and extension systems
NGO	Non-governmental organisation
NRC	National research centre
PESTNET	Pest Management Research and Development Network
PMDISS	Pest Management Documentation and Information System
PPP	Portal Portal Pay
R&D	Research and development
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNHCR	United Nations High Commissioner for Refugees
UNIFEM	United Nations Development Fund for Women
WAU	Wageningen Agricultural University

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Title page photograph: A natural hive consisting of several combs of the African honeybee, *Apis mellifera scutellata*. The combs are arranged at a specific distance apart called the 'bee space'. The dark colour of the combs is due to the protein-rich propolis.

Insects are the most abundant and diverse form of animal life, with over one million known species estimated to cohabit the planet with man and other creatures. Now in its 25th year, the International Centre of Insect Physiology and Ecology (ICIPE) is redefining its mandate to research and develop environmentally benign and affordable methods for managing the myriads of insects and related arthropods that undermine food security, human and livestock health, and development in the tropical regions of the world.

A recent reorganisation of the Centre reflects ICIPE's enlarged perspective on restoring the harmony between agricultural activities, the environment and human welfare. New projects will sharpen the Centre's focus on biodiversity and arthropod and habitat conservation, issues which have always been at the core of ICIPE's *modus operandi*.

In our enlarged programme, commercial exploitation of insects such as the African honeybee, *Apis mellifera scutellata* (shown on the front cover) and the silkworm moth are being viewed as important agricultural micro-enterprises for alleviating rural poverty and increasing the participation of women in the cash economy, particularly in Africa.

This Annual Report chronicles the evolution of ICIPE's mandate in research and capacity building in insect science during 1994, the year of celebration and of taking stock of its first quarter-century.

icipe

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