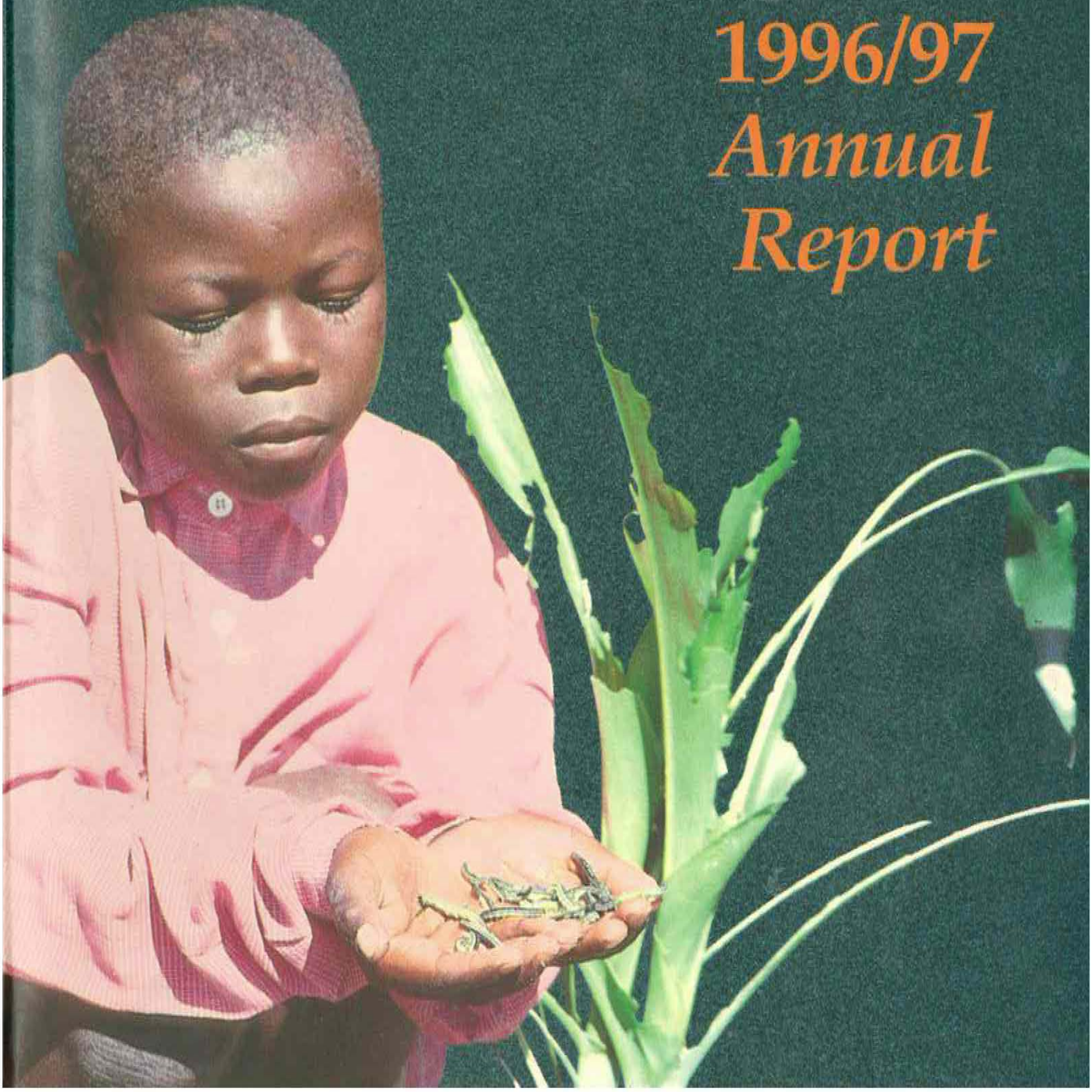
icipe Tropical Insect Science for Development

1996/97 *Annual Report*



Contents

1996/97
icipe
Annual Report

The International Centre of Insect Physiology and Ecology (ICIPE)
P.O. Box 30772, Nairobi, Kenya

1996/97 ICIPE Annual Report
ISBN: 92 9064 112 6

Published by ICIPE Science Press
P.O. Box 72913, Nairobi, Kenya

For more information about ICIPE and its activities, contact:

The Director General
The International Centre of Insect
Physiology and Ecology
P.O. Box 30772, Nairobi, Kenya
Tel: +254-2-861680–4 / 802501
Fax: +254-2-803360 / 860110
Email: icipe@cgnet.com
or
Email: icipe@users.africaonline.co.ke
Home page: http://maraboutech.com/ICIPE

Foreword

The year 1996 will become a milestone in the metamorphosis of ICIPE. After mega-restructuring in 1994/95, the Centre, together with its partners in research and development as well as its donors, has laid the foundation for its updated work agenda toward the year 2020. Two major documents have been prepared, the *Vision and Strategy toward 2020* and the *5-Year Plan*, 1996–2000. The process leading to these two documents (good consultation with partners, in-depth discussion with our Governing Council members, and approval by the 4th ICIPE Periodic External Review) has been very important and rewarding in respect of team building and gaining new insight into the problematic insect-related issues in development. It should also be noted that the *Vision and Strategy toward 2020* and the *5-Year Plan* are bound to evolve and will be updated to follow global needs as they change over time.

The Report of the 4th ICIPE Periodic External Review (IPER), submitted to the Governing Council and donors in March 1997 has confirmed the Centre's special status in the world of international research and development organisations, by concentrating not only on agriculture, but on health and the environment as well, as they are affected by arthropods. Carried out under the Chairmanship of the Director of Agriculture of the World Bank and at the request of the Sponsoring Group of ICIPE (SGI) donors, a team of eight international experts conducted the intensive three-week exercise which included every one of ICIPE's scientific departments, projects and activities. I would like to express our sincere appreciation to this dedicated group, led by Prof. William S. Bowers, and including Professors Eddy W. Cupp, Barbara Ekbom, Grace Goodell, Wen Kilama, James Nation, Mrs. Mary Okello and Dr Philip Viallate.

Upon request of the Sponsoring Group of ICIPE members, a special consultancy on the Centre's financial management was carried out by a team from GTZ and IRRI. The findings and recommendations showed that major positive changes have been implemented but that additional steps—in particular staff training and the modernisation of the standard software in use—were needed.

Following their recommendations, further reorganisation, upgrading and streamlining of the scientific and management departments has taken place, and I am pleased to announce that the Senior Management team has been strengthened by the recruitment in mid-1997 of a Deputy Director General for Research and a Director of International Cooperation and Capacity Building. We shall take the IPER team's recommendations seriously and do our best to live up to their expressions of confidence in the 'new' ICIPE. We are also counting on the donor community to support ICIPE adequately with core funds to allow a seamless and rapid implementation of the 5-Year Plan and management recommendations.

Jacob L. Ngu, *Chairman, ICIPE Governing Council*

Message from the Director General

This year's Annual Report* is—as ICIPE itself—people-centered. Since its major restructuring three years ago, ICIPE has redefined its mandate to better address the constraints to development as influenced by arthropods. The issue of sustainable development has been around for a while now, as have the issues of natural resource conservation and the link between poverty, development and the environment. At ICIPE, these concerns are not only taken seriously and discussed, they are worked on and implemented in partnership with our constituency: the local communities who stand to benefit from improvements in their environment, food security, health, and economic status.

Insects and related arthropods (ticks, mites, spiders, etc.) are central to many, if not most, of the serious problems facing humanity today. Despite the overall record use of drugs and pesticides, there are today more people suffering from curable diseases, there are greater crop losses due to arthropod pests, and there are more animals dying from insect- and tick-transmitted diseases than ever before, particularly in the developing countries. However, the ecological services rendered by arthropods outweigh by an order of magnitude their deleterious effects. These ecological services have been taken for granted until recently, when, for example, the pollinators have started to disappear, causing tremendous crop yield reductions. This is just the beginning of a chain reaction that will affect not only crops, but vegetation in general.

In another sphere, arthropods are playing a major role in the conservation and rehabilitation of our soils, again a limited resource which we can ill-afford to lose in these days of dramatic population growth and need for intensifying agricultural production. The great wealth of insect biodiversity can also provide much-needed high quality protein food and dietary supplements for assuring a balanced diet. Whereas production of conventional animal protein requires substantial amounts of feed such as cereal and legume grains—most of which could be consumed by humans—insects can thrive on alternative feedstuffs.

As you have likely read in leading news and scientific publications and heard from the media, many world food and health experts believe the answer to the food security problem is through the application of biotechnology and gene technology. I want to challenge these statements here, and refer you back to the time when synthetic pesticides arrived on the market, now some 50 years ago. Yes, there has been a tremendous increase in food production and improvement of health in many parts of the world. The biggest beneficiaries, however, are the people in the industrialised nations, where food prices have dropped tremendously, and where health care is available (albeit at a price). In the developing nations, the green revolution has in some cases averted major shortages, and has helped a few countries join the ranks of the OECD or gain the status of newly industrialised countries. However, we have also to consider the *cost* of this development, in terms of environmental degradation, increasing health care costs, widening income gap, and global climate change. All of the aforementioned problems will threaten our long-term survival unless drastic steps are undertaken to provide truly sustainable development, both in the developed and developing countries.

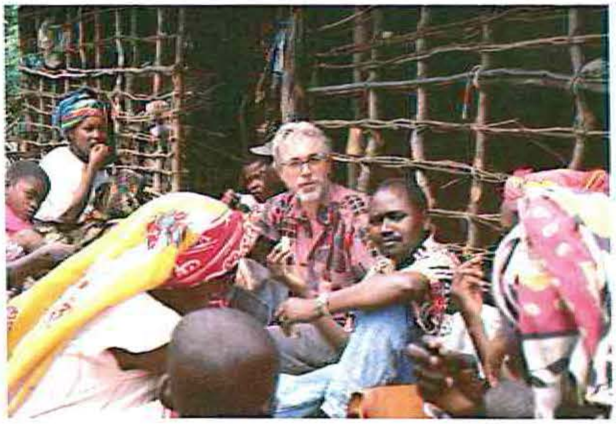
Bio- and gene technology are not the panacea for achieving true sustainability. True sustainability will come only from a deep understanding of the mechanisms underlying the functioning of ecosystems and their amazing resilience. Through genetic manipulations, we may create new crop varieties, new animal races, cure hereditary diseases—all that we *think* we need—but nothing that is absolutely essential or that we cannot derive from our existing natural resources, given that we must first understand them.

Not that gene technology will not be of use in some instances, but what we have now is a technology, with greedy investors looking for opportunities, rather than looking for real solutions to real problems. Solutions which are affordable by the needy majority, solutions which are not likely to require more sophisticated research to deal with the problems they create or are likely to create. There is a need to reiterate that it is the integration and diversity, not the segregation and uniformity, of technologies that will in the end provide the much sought-after sustainability and resilience in man-made environments such as agroecosystems.

We need to contemplate integration at the level of the community and all of its activities. For instance, nature has given us a wide choice of arthropod management products in the form of highly effective bacteria, fungi, viruses, parasitoids, predators, plant extracts, and so on. These can be produced easily and efficiently in developing countries, thereby contributing to income generation, employment, technology development and conservation of biodiversity. Such products are also ecologically sound and economically affordable. ICIPE now has such products under development and production in its TechnoPark, a joint venture between the Centre and the private sector.

It takes courage to go in another direction from that which is currently fashionable, to go in the direction which will lead to the expected results within the shortest possible time. In one approach to solving the 4-H problem—human, animal, plant and environmental health—ICIPE is now involved in helping several local communities in the design and implementation of new people-driven, integrated rural development projects, with income generation as the centrepiece. We firmly believe that sustainable development projects will succeed only when local communities are the engines and their leaders the drivers.

ICIPE's constituency includes the smallscale farmers of the tropics whose lives are intimately linked to the land and to the vagaries of nature such as environmental degradation and invasion by arthropod pests. ICIPE is now working with several communities to design and implement new people-driven, integrated rural development projects with income generation as the centrepiece.



Hans R. Herren (centre) meeting members of ICIPE's constituency at the Kenya coast.

It is our desire to make it easier for you to become more closely associated with us, whether you are a donor, a collaborator (or potential collaborator), a partner, an end-user, or simply a person interested in our insect science-based development activities. To this end we have developed a www page, which will be continuously improved and updated to provide you with the most recent information and knowledge as well as serving as a forum for dialogue. We shall be pleased to offer you the opportunity to interact with our scientists at even the very early stages of project development and execution, and we hope that you will respond to this challenge.

Looking forward to reading you on-line,

HR Herren

**This year's Report is shorter and will highlight 1996 and 1997 activities. In a world that is moving at cyberspace speed, we feel it is important to keep you updated with as little delay as possible, and given the glut of information with which our readers have to cope, we are presenting our report in as concentrated and readable format as possible.*

ICIPE news and briefs reflect growing collaboration and partnerships

The Vice President of the Republic of Kenya, Prof. George Saitoti (top photo, centre) was the special guest at the ceremony marking the end of ICIPE's first quarter-century. As the host country, Kenya has continued to cooperate with ICIPE in research and technology transfer and by donations of land, benefits and services, such as a newly tarmacked road to the Duduville headquarters. Here, Hans R. Herren (right) and Interim DDG, Ahmed Hassanali (left) demonstrate the NG2G tsetse trap.

Below: The beauty of arthropods was demonstrated at the unveiling of a metal sculpture by noted Kenyan artist, Kioko Mwitiki. ICIPE's Governing Council Chairman, Prof. Jacob Ngu is standing to the Vice President's right.

1996 was eventful in many respects for ICIPE. The Centre celebrated the end of its 25th anniversary year in September, and the launching of it's *Vision and Strategy toward 2020*. The event, coordinated by the Public Relations Office, was attended by heads of diplomatic missions and national and international organisations, donor agencies and private-sector entrepreneurs.

On 6th September, the handing over of ICIPE's tsetse trapping technology to the local community in Nguruman, Rift Valley Province took place in this semi-arid region of Kenya. The ceremony symbolises one of the final steps in the Centre's research efforts to develop tsetse control methods that are environmentally benign, affordable and sustainable by the end-users.

During the year, ICIPE also featured in a series of broadcasts for Radio France Science Corporation. The series was aired on 600 radio stations around the world. Press coverage improved, both locally and internationally, and the PR Office kept ICIPE staff and others informed of key developments and forthcoming events through the popular and

The handing over of ICIPE's tsetse trapping technology to the local community in Nguruman. The Centre will continue its partnership with the community by helping in monitoring and improving trapping efficiency. Prof. George Saitoti (right) represented the Kenya Government as the Vice President of the host country.

In the highland region of southern Ethiopia, ICIPE is working with the local people and the Ethiopian state governments of Oromia and Tigrai in an integrated development effort to introduce improved tsetse and mosquito control, income generating activities and capacity building, all in collaboration with the Ethiopian Science and Technology Commission.

monthly newsletter, 'ICIPE Update'. In addition, the Office helped organise several important workshops, seminars, exhibitions and conferences, such as the Malaria Task Force Meeting, International Workshop on the Management of Tropical Gramineous Stemborers, International Group Training Course on Basic Biology and Trapping Technologies for Mid-Level Professionals from Somalia (sponsored by the International Committee of the Red Cross) and the Neem Awareness Workshop, among others.

The Centre was host to a number of distinguished guests, including Ambassadors and Charges d'Affaires of 14 countries; the Director of the USAID-Funded IPM Collaborative Research Support Programme and other USAID officials; the Country Director of ActionAid; the UNDP Resident Representative; members of the International Committee of the Red Cross; journalists; and many scientists from national and international research institutes and universities. The headquarters at Duduville was also a popular destination for farmers, women's groups and students, who observed first-hand the research laboratories and pilot-scale apiculture and sericulture units. ICIPE staff kept abreast of the latest developments in insect science through 31 seminars by resident scientists and invited speakers.

ICIPE's relationship with its constituency, collaborators and donors was strengthened over the year through the activities of the Directorate of International Cooperation and Capacity Building (DICCB), led by its new Director, Dr Mudiumbula Futa. The Memorandum of Understanding or Agreement (MoU/A) is the main instrument that the Centre uses to define and provide the framework of cooperation with its partners. ICIPE currently has such formal agreements with 76 institutions, in addition to many informal collaborative agreements with other institutions worldwide. New agreements were signed with the following since the last Governing Council in June 1995:

• Kenya Medical Research Institute (KEMRI • The Ethiopian states of Oromia (southern region) and Tigrai, and the Ethiopian Science and Technology Commission (ESTC) • Asian Vegetable Research

Members of the Nguruman Maasai community watch the handing over ceremony. The project has resulted in a 90% reduction in tsetse over a 100 km² area, dramatically reducing the incidence of nagana (animal sleeping sickness) for this semi-pastoralist group.

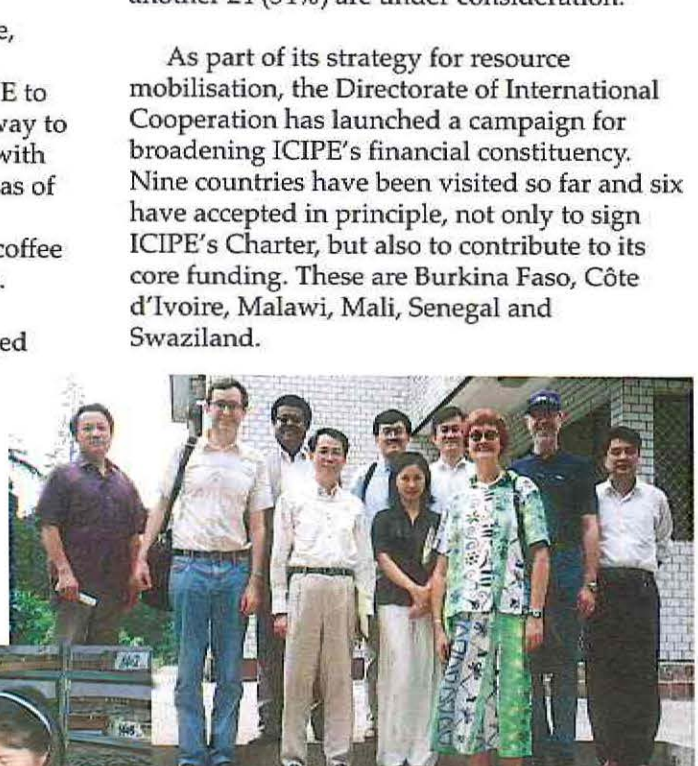
Development Council (AVRDC) • Research Corporation Technologies (USA) (on disclosure, evaluation and commercialisation of technologies) • SAROC Ltd., a Kenya-based agrochemical firm (on the processing and marketing of neem products) • Universities of Zimbabwe, Malawi, Zambia, Ghana and Assiut in Egypt • International Centre for Research in Agroforestry (ICRAF) • Chinese Academy of Agricultural Sciences (CAAS).

Also in the pipeline are MOUs with the governments of Zanzibar (Tanzania), Uganda, Ethiopia, Eritrea, Malawi, Zimbabwe, Somalia and Mozambique on control of maize stemborers. Apart from those listed above, UNESCO and FAO are processing the upgrading of their relationship with ICIPE to consultative status. Plans are also underway to initiate formal collaborative agreements with several institutions in Latin America. Areas of possible collaboration here include the improved management of fruit flies, the coffee berry borer, ticks, locusts and honey bees.

Important partnerships are being forged with other members of the global agricultural research system (GARS), including participation in several CGIAR systemwide initiatives on IPM; whitefly in vegetable-based cropping systems (led by CIAT); cereal stemborers (led by CIMMYT); legume pests (led by ICRISAT); and IPM in agroforestry systems (led by ICRAF). In the case of the CGIAR Systemwide IPM Initiative, ICIPE has been entrusted with leading the task force on functional agrobiodiversity and IPM.

To support this collaboration and research, a total of 53 proposals were submitted in 1996 to the DICCB, whose docket also includes donor liaison, project planning and preparation, and impact assessment. Of these, 15 (34%) have been approved for funding and another 24 (54%) are under consideration.

As part of its strategy for resource mobilisation, the Directorate of International Cooperation has launched a campaign for broadening ICIPE's financial constituency. Nine countries have been visited so far and six have accepted in principle, not only to sign ICIPE's Charter, but also to contribute to its core funding. These are Burkina Faso, Côte d'Ivoire, Malawi, Mali, Senegal and Swaziland.



ICIPE has much to benefit from its developing collaboration with China, as for example in the ancient art of sericulture (left). A 5-strong ICIPE delegation recently visited the Sericulture Research Institute in Jiangsu to cement the partnership with the Chinese Academy of Agricultural Sciences (CAAS). The agreement was formalised by the signing of a Memorandum of Understanding to establish scientific collaboration and training between the two organisations on apiculture, sericulture, biological control and biogas generation. Right: Prof. Yang Yansheng, Vice President of CAAS (seated left in picture), signs the MOU with Dr Herren; standing is Mr An Yongyu, China's Ambassador to Kenya (centre), flanked by his Economic and Commercial Counsellor, Mr Guanghui Zhang (left), and his Counsellor, Mr Shusheng Bao (right).

The collision theory of international development

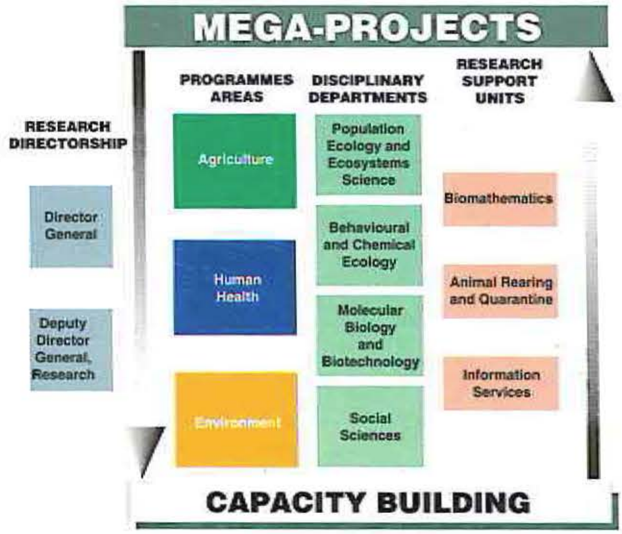
The world of scientific research and development (R&D) is becoming one interactive global web, in which, as in chemical reactions, the players (particles) bump into each other, overlap their orbits of interest, and sometimes fuse together in partnership to create a new product which is often bigger and better than its individual components.

Whether or not the new product formed will be useful depends on how it meets the needs of its intended users, how long-term or viable it is and whether the intended users have the knowledge or capacity to understand its potential and apply it for their own purposes.

Such is the case of the International Centre of Insect Physiology and Ecology. Spawned as a small organisation in 1970 to deal with immediate problems in Africa caused by insect pests, the Centre soon expanded its orbitals until it attained the status of an international organisation in 1986, after which it was able to interact with other similar organisations in areas of its mandate. Today, the structure of ICIPE comprises 360 staff originating from 19 countries, who are bonded together as a unit to develop ways and means of dealing with insects and other arthropods in all their multifarious roles.

ICIPE's orbitals are being charged up for better interaction by continuing refinements in its organisational structure (see figure). On the recommendation of the recent IPER (ICIPE Periodic External Review), the basic disciplinary departments have been reduced to only four, with three support units. These interact in almost every one of ICIPE's programme areas in the continuum that has come to be known as 'insect science'. Capacity building activities are an integral part of every project.

Interaction with other players, such as members of the global agricultural, health and



Organisation of ICIPE's research

environmental research and training system is increasing as ICIPE picks up speed and actively promotes an integrated approach to sustainable development. ICIPE now collaborates and works in partnership with other players in the web, including other IARCs, 20 advanced laboratories, UN agencies, NGOs, and over 45 universities (30 of them in Africa). The growing list of regional and global collaborative development projects in which ICIPE is a major partner is evidence of improved cooperation with like-minded organisations to produce better products.

ICIPE's social scientists continue to lend their special skills to ensure that the Centre's work is relevant to its shareholders' needs. In greater interaction at the individual level, over 6000 farmers, IPM practitioners and scientists have benefited from the Centre's educational and training opportunities.

The practical utility of some of the final products from these 'reactions' is already being demonstrated, as in the case of ICIPE's tsetse traps, use of neem preparations and *Bt*, and rapid adoption of the Centre's improved apiculture techniques, among others.

Plant Pests Management Programme

A new eco-era for agriculture...

As agriculture enters the 'eco-era', food production is expected to be both efficient and ecologically sound. Farming practices, pest management included, that endanger ecosystems are no longer acceptable. ICIPE's benign approach helps ensure plant, animal and environmental health.

A helping hand for horticulture

Horticulture is one of the fastest growing sectors of tropical agriculture. Whether grown in the home garden or by largescale producers, fruits and vegetables offer the double benefit of improving the local diet by supply of micronutrients and providing a source of cash income. ICIPE is helping farmers produce higher quality produce for the local and international markets by development of eco-friendly pest control methods.

Vegetables form a major part of the diet in many tropical developing countries, where the cost of animal protein is too high for most pockets. Although vegetables suffer damage from a large pest complex, ICIPE is one of the very few organisations addressing the needs of vegetable growers. Using the wide variety of agro-ecozones in Kenya (highland/upland/coastal; semi-arid/high potential), pilot surveys of typical farmers' pest problems in five districts have been assessed, along with the cropping practices used and the farmers' knowledge, attitudes and practices relating to pests. This information will be used in developing effective IPM strategies.

Organic vegetables for export

Export vegetables are emerging as an important source of income for a multitude of smallholder farmers in Africa. Now that basic food self-sufficiency has been assured for most developed countries, markets in the North are demanding quality food—free from persistent organic pollutants (POPs) and other toxic chemicals. Of the 13 most serious POPs, most are pesticides.

The premium price offered for export produce motivates growers to cultivate the crops throughout the year and often resort to excessive pesticide use. Although many African countries are trying to strengthen or expand this sector, the need to rationalise and minimise pesticide use is often overlooked. In attempts to remedy this shortcoming and help identify safer and more sustainable alternatives to pesticides, ICIPE is looking at the spectrum of pests and problems experienced by export vegetable growers. On-station trials in four ecozones in Kenya are being used to collect baseline data.

In East Africa, the most important export vegetables include French bean (*Phaseolus vulgaris*), snowpeas (*Pisum sativum*), okra (*Hibiscus esculentus*), egg plant (*Solanum melongena*), green peppers (*Capsicum annum*) and bitter gourd (*Momordicha charantia*).

Almost every farmer can participate in the horticulture industry. These Maasai pastoralists in the semi-arid Nguruman region of Kenya are producing top quality vegetables. About 75% of all fruits and vegetables for export are produced by smallholders, who have helped Kenya move from 7th to 4th position in the horticulture export market. ICIPE is one of the few organisations developing organic pest control methods for these important crops.

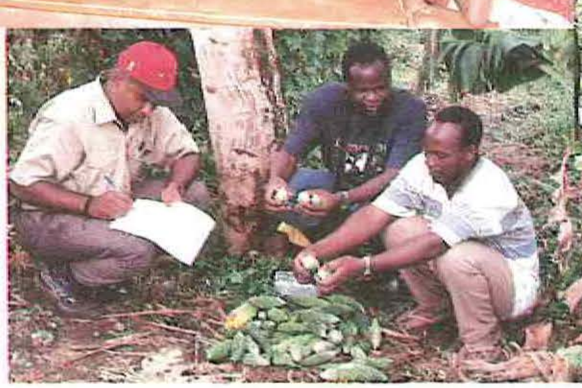
Not surprisingly, the use of neem products is gaining currency for safe pest control in these and other export crops. The effectiveness of seed treatment with neem oil, foliar spraying, and amendment of soil with neem cake powder, are being tested against the aphid *Aphis fabae* on French beans in screenhouse experiments. The best protection and aphicidal effect is obtained with foliar sprays using a solution of 2% and 3% formulated neem oil. Foliar sprays are also being tested on foliage feeders and sucking pests of French beans, snowpeas and okra, and for control of dipteran leafminers on flowers in the intensive floriculture industry in the Lake Naivasha region of Kenya, in partnership with commercial growers.

The viability of the horticultural industry in Third World countries may depend on the local acceptance of these 'soft' options for pest control, especially in light of the need for strict adoption of the maximum pesticide residue limits set by many importing countries.

Brassicas

Two of the most common insect pests on brassicas are the diamondback moth (DBM), *Plutella xylostella* and the cabbage aphid, *Brevicoryne brassicae*. In one area in Kenya, up to 100% damage by DBM in the cabbage crop was observed, even though it had been sprayed regularly. The local farmers perceived a gradual decrease in effectiveness of pesticides, indicating an apparent build-up of resistance in local populations of the moth to the synthetic pesticides (e.g. cypermethrin) applied regularly in the past. This observation underscores the need to develop a rational system of improved pest management in Africa in order to avoid a situation similar to the uncontrollable outbreaks of DBM in Asia, where the moth has become resistant to all known synthetic pesticides.

Several eco-friendly options, such as the use of neem for DBM control in cabbage are being tested at ICIPE. Screenhouse experiments indicate that seed bed treatment with neem cake powder (NCP) and foliar spraying with NCP water extract can give good control of the moth. The search for natural enemies, including *Diadegma* spp. (Hymenoptera: Ichneumonidae) is being undertaken under the project 'Functional agrobiodiversity of the diamondback moth natural enemies in eastern and southern Africa'.



Sharing problems and expertise in roundtable discussions such as these (top left) is vital if communities are to become empowered to manage their own agricultural projects. ICIPE biologists provide the advice and research back-up (left), while social scientists (above) help them to understand farmers' pest management needs, as in this okra field.

Onions

Thrips (*Thrips tabaci* Lind.) is one of the main insect pests of onion, and on-station trials at MPFS showed that it can cause yield losses of 54% (yield for full protection was 19.3 t/ha). Since onion is a long duration crop (around 5–6 months), and thrips can attack the crop at any time, studies were done to determine the phenological (growth) stage of onion in which most loss occurs. The cultivar Red Creole was treated with different protection regimes of endosulfan sprays at all crop growth stages. The onion crop produced the highest yield when protected from thrips attack during 13–21 weeks after emergence, when the yield gain reached 143%; protection was especially important during the four-week period between the 13th and 17th WAE (yield gain of 111%). This provides a basis for need-based protection decisions. Confirmatory trials are in progress to relate the seasonal thrips population changes with crop phenology effects. In situations where no alternative pest control method yet exists, the IPM philosophy recommends the judicious use of carefully selected pesticides which are applied at the most appropriate time in the growing season and in the lowest effective doses.

Tomatoes

The fruit borer, *Helicoverpa armigera* is an important pest on tomato in Kenya, causing fruit losses of up to 24% in experiments at the MPFS. Based on natural field infestation, several tomato lines were categorised for *H. armigera* damage as being highly susceptible, susceptible and moderately tolerant. Seventeen (17) lines were advanced for further evaluation; some of the promising lines include Heinz, 93KT82, Early Pearson, Sixpack, Alok, 94RT316 and Elin F1. Confirmatory studies on the reaction of these lines to *H. armigera* under enhanced pest challenge levels are in progress.

Another important tomato pest is whitefly, *Bemisia tabaci*. Originally this insect affected mainly industrial crops like tobacco and cotton, but of late it has diversified its taste and habitat to include edible vegetables, especially tomatoes, cucurbits (melons, cucumbers, etc.) and cassava. In Africa, whitefly is also a vector of several viral plant diseases. ICIPE is participating in a system-wide initiative of IARCs to study the whitefly problem, including the search for natural enemies (parasitoids) to keep this new global pest in check.

Neem products are being tested on tomatoes to control leafminers and fusarium wilt, a fungal condition caused by *Fusarium oxysporum fsc lycopersici*. Control of root knot nematodes is also being studied by soil amendments with neem cake powder.

Indigenous vegetables

Indigenous leafy vegetables are of special nutritional importance in Africa and elsewhere in the tropics, where they are eaten as accompaniment to a basic starchy dish such as cassava or maize, often in lieu of meat. Surprisingly, all of the indigenous vegetables studied by ICIPE were found to suffer substantial production loss due to attack by insect pests, ranging from 16 to 93% (see table below).

Funding: ICIPE Core Funds, USAID, DANIDA
Collaborators: AVRDC, CIAT, GTZ-IPM Horticulture Project, KARI, MOALDM and HCDA (Kenya), National Gene Bank of Kenya, University of Nairobi.

Indigenous vegetables benefit from pest protection too!

Vegetable	Main insect pest observed[1]	Yield loss due to pest damage	Yield in protected plots (kg/ha)[2]
Gynandropsis gynandra	Aphids	33%	3663
Crotalaria spp.	Leafhoppers	93%	2825
Corchorus olitorius	Flea beetles	33%	1415
Amaranthus spp.	Leafminer	16%	4152

[1]Observations in Thika, Kiambu, Nakuru, Kilifi and Kwale districts of Kenya.
[2]Vegetables protected with triazophos.

Frustrating the fruit fly

The medfly, Ceratitis capitata *is enemy Number 1 to millions of fruit growers around the world. ICIPE is helping to refine the control methods currently in use by research on this pest in its native home in Africa.*

With the continuous demand for quality fruit from the North, and the liberalisation in global trade, horticulture is one of the fastest growing agroindustries in the tropics. For instance, horticulture exports earned Kenya about US$ 175 million in 1996, making it the country's largest sources of foreign exchange. Of this amount, fruit exports accounted for only 9%, showing the vast potential for increasing this cash crop. Of the 2 million or so Kenyans engaged in various capacities in the horticultural industry, smallholders owning less than 5 ha of land produce more than three-quarters of the produce, but they are the hardest hit, suffering losses of up to 80% of their crops.

Recently, ICIPE was requested by fruit growers in Kenya, Tanzania and Sudan to provide assistance in managing fruit fly problems. Regular sampling of both cultivated and wild fruits was initiated in four locations in Kenya, to describe fruit fly species composition and pest status and to identify their environmental reservoirs. This kind of basic information is needed before effective control operations can begin.

One of the most effective methods of medfly control in current use is the sterile insect technique (SIT), where males are irradiated in the mass rearing facility and then released for non-productive matings in the wild. The study of mating behaviour therefore has very practical implications for mass rearing routines, and for methods of quality control of the flies produced and efficiency of SIT.

In the *1995 ICIPE Annual Report,* results of experiments on possible effects of routine irradiation on courtship behaviour of the mass-reared, sterilised flies used for SIT were reported. The experiment was conducted in collaboration with the Joint FAO/IAEA Laboratories in Seibersdorf, Austria. The methodology applied (quantitative ethological analysis) enabled detection of measurable, negative effects of irradiation on male courtship performance. Such effects had not been previously detected with the standard quality control methods used routinely in the mass rearing facilities. A similar experiment was conducted in collaboration with colleagues from Argentina, using mass-reared flies produced in the Mendosa facility. The experiments were carried out in the laboratory and in field cages. The results from Argentina confirmed the earlier findings about the effects of irradiation. The practical implications of the above on the efficiency of SIT operations remain to be evaluated.

Studies on the natural enemies of fruit flies is underway. The *Psyttalia* genera (Hym.: Braconidae) of wasps has been used with success in the biocontrol of these pests, but their taxonomy is poorly understood. Texas A&M University, jointly with ICIPE, will look at the wasps' biosystematics.

Donors: *ICIPE Core Funds, USDA*
Collaborators: *USDA/ARS, Honolulu, Hawaii, USA; USDA-APHIS-PPQ Methods Station, Guatemala; Univ. Exp. Station, Kauai, Hawaii, USA; Joint FAO/IAEA Laboratories, Austria; CIRAD-FLHOR, Reunion; National Museums of Kenya; KARI; ECOSUR, Chiapas, Mexico; Meteorological Department of Kenya; Regional Centre for Services in Surveying, Mapping and Remote Sensing (RCSSMRS), Nairobi; Universities of Honolulu; Texas A&M, Pennsylvania State, USA; Crete, Greece; Pavia, Italy; Hebrew Univ., Israel; Costa Rica; Buenos Aires, Argentina.*

Unwelcome traveller: The Mediterranean fruit fly has migrated from its centre of origin in Africa to become one of the most serious threats to fruit growers throughout the tropics and sub-tropics. The fly attacks fruit just before ripening, as in this photo of a female laying her eggs (ovipositing) in a ripening mango. Medfly damage runs into the billions of dollars annually. A case in point is Kenya's 90,000 tonne mango crop, of which 30–40% is lost due to infestation with medfly and other fruit flies.

IPM for banana pests

After a break of one year, ICIPE's research on alternative management strategies for banana pests (weevils and nematodes) has resumed, with the aim of increasing production of this important carbohydrate food staple and fruit.

Clean planting material is important if infestation by the banana weevil, *Cosmopolites sordidus*, is to be reduced and reflected in higher yields. The infestation dropped from about 24% in the plant crop when infested suckers were used, to about 5% when healthy suckers were used or to 6% when the infested suckers were first pared and treated with hot water (see *1994 ICIPE Annual Report*). Simple traps made from the split pseudostem were found to delay the weevil invasion by about 50% in monocrops of the susceptible Nakyetengu AAA-EA cultivar.

Studies on the behaviour of the weevil continued this year. Past research has shown that the weevil has a remarkably long lifespan and low reproductive rate. The weevils are virtually monophagus (eating only bananas), and appear to have few natural enemies. Due to a very secluded lifestyle, it is difficult to treat this pest with any control agent. In field studies, research this year confirmed the above observations, as well as the strong dependence of their migration and exploration activities on moisture (rain). Very few adults (~30 weevils per mature banana mat, or 33,000 weevils/ha) were found to be present in naturally infested plots. Design of an artificial device baited with host-plant attractants and testing of suitable pathogens which infected weevils could transfer and spread within the natural shelters where they aggregate and hide, are planned.

In order to tailor the banana weevil IPM technologies to the needs, resources and constraints of banana growers in eastern Africa, ICIPE social scientists carried out surveys among farmers in the study area. The two most important constraints reported were disease and labour. Insects themselves were rated very low due to poor understanding of weevils and nematodes, but pests and diseases as a syndrome were rated the highest, with 34% of weighted scores. The resources identified for banana production include land, labour, money and inputs (including extension services), in that order. Banana production was rated less resource-intensive than other crops by the farmers. Neem preparations are proving to be as effective as synthetic pesticides for controlling banana pests (see table below and also the report on neem on page 21).

Neem provides a gentler alternative to furadan for control of parasitic banana nematodes

Treatment	Nematode population per 100 g roots
Neem cake[1]	2000–4000
Neem seed powder[2]	0–1000
Neem seed kernel powder	1000–2000
Furadan 5G	1000–2000
Control (untreated)	8000–12,000

Values are based on three replications; each treatment had 10,000–12,000 nematodes/100 g of roots and three pairs of banana weevil adults.
[1, 2]Contains ~5500 and 4000 ppm azadirachtin, respectively.

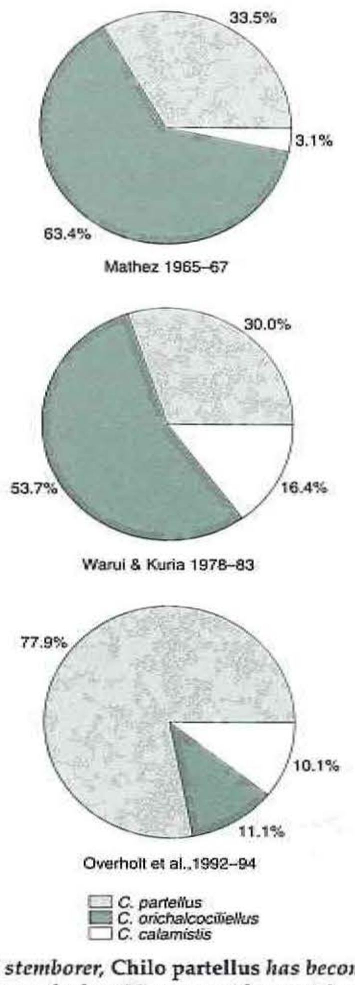
Banana IPM methodologies are passed on to farmers and officials through the many training courses offered by ICIPE. Over 40 extensionists and ministry officials from East Africa were trained this year on such techniques as preparing clean planting material by paring and treatment with hot water.

The germplasm collected between 1989–1994, consisting of 177 cultivars were transferred to the Kenya Agricultural Research Institute (KARI) as part of technology transfer to NARES in East Africa. Four cultivars (Bogoya AAA, Kampala AAA, Ngombe AAA-EA and Chundobuleku AAA-EA) have been multiplied and entered for multilocational IPM trials, and are being supplied to NARES and farmers in Kenya. Thus far over 150 farmers have benefited from the supply of 8000 clean suckers for planting.

Funding: *BMZ, ICIPE Core Funds*
Collaboration: *Institut für Pflanzenkrankheiten, University of Bonn, Germany; ARI, Maruku, Bukoba District, Commission of Research, Ministry of Agriculture, Tanzania; Ministry of Agriculture, Animal Husbandry and Fisheries, Kawanda Perennial Crops Research Institute, Kampala, Uganda; KARI, Kenya; The University of Leuven, Belgium; INIBAP, Gitega, Burundi; IITA, Uganda; and PBIP, Nigeria.*

IPM for keeping the granaries full

Basic food security remains one of the most pressing requirements for bringing about a better life for citizens of the tropical developing countries. ICIPE is conducting research on organic pest control methods such as the use of biological control (predators, parasitoids and pathogens) and natural agents like neem and semiochemicals to bring pests down to manageable levels. Other strategies include cultural methods such as intercropping and careful use of wild vegetation to deter pests.



The spotted stemborer,* Chilo partellus *has become firmly entrenched over the last 30 years as the most important maize pest in East and southern Africa, as shown in these charts of stemborer species abundance.

Biocontrol for borers

Losses in maize, sorghum and other cereals from stemborers remains one of the biggest threats to food security in eastern and southern Africa. Maize yields in Africa are less than half the world average. Especially damaging is Chilo partellus, *an intruder from Asia that was accidentally introduced into Africa in the 1930s and has now displaced indigenous pests. Because this exotic* Chilo *species had no coevolved natural enemies in its new home, it soon became infamous for causing losses of 20–80% in crops.*

An ICIPE project to control *Chilo* started in 1993, when a tiny wasp, *Cotesia flavipes* was released in Coast Province, Kenya. This natural enemy from Pakistan, the target borer's original home, has since become established near its release point with parasitism rates as high as 7% at one site. The wasp is also being recovered in northern Tanzania and in Kenya's southwest and eastern regions, although it is yet to be found in Uganda. Introduction of *C. flavipes* into two locations in Mozambique, where *C. partellus* accounts for 91% of the stemborers surveyed, was done in 1996 in collaboration with the Plant Protection Department and Eduardo Mondlane University. Further releases are planned for 1997 in Uganda, Zambia and Somalia.

Biological imperialism

Studies which attempt to identify any intrinsic differences that confer a distinct advantage of one species over another contribute to the knowledge of how indigenous species are displaced, and may be useful in understanding general declines in biodiversity in the tropics. The ecology of both the stemborers and their parasitoids were studied with this in mind.

Chilo partellus has a big appetite, as evidenced by findings that this species develops faster and consumes more maize than *Chilo orichalcociliellus*, a closely related native stemborer which occupies a similar ecological niche. However, survival of the native stemborer was higher on some native grasses, which may explain why this species has not been completely displaced by *C. partellus*. One factor in favour of *C. partellus* eventually winning out over the indigenous species is its shorter diapause (9.7 days *vs* 14.4 days for *C. orichalcociliellus*); this is likely to allow the former to colonise host plants earlier than the indigenous borer and to complete more generations in a year. Another factor is its higher survival rate from the diapausing larval stage to the pupal stage (74% *vs* 26%), as well as a shorter overall development time and a faster and greater dispersal ability.

Native predators may play an important role in suppressing stemborer populations. Studies conducted in Kenya's Coast Province revealed that ants were the most abundant predators, with numbers ranging from 0.8 to 9.4 per plant. Predator abundance and diversity increased with plant age, and was highest at the tasselling stage of maize. This period did not coincide with the presence of stemborer eggs and young larvae which are the stages most vulnerable to predation, but rather may have been in response to other potential prey such as aphids and leafhoppers. Laboratory studies identified several predators, including various ants, several spiders, cocinellid larvae and a cockroach, which would feed on stemborer eggs and larvae.

In field and laboratory competition studies between *C. flavipes* and the native *C. sesamiae*, the exotic species proved to be extrinsically and intrinsically superior when *C. partellus* was the host. Functional response studies in the field showed that *C. flavipes* attacked more *C. partellus* larvae, and produced more progeny, than the native species. When *C. partellus* was stung by both parasitoids, only *C. flavipes* emerged in the majority of cases. However, when the native stemborer, *S. calamistis* was the host, there were only minor differences in the success of the two parasitoids.

Genetic differences

Studies on the population genetics of *Cotesia* species continued in 1996. Distinct differences were observed between Indian and Pakistani populations in allozyme patterns and host suitability. DNA studies of allopatric populations are being conducted using

Stemborers are the larval stage of moths (Lepidoptera) which damage cereals, sugarcane and other grasses. Control of these pests is especially difficult because the larvae are secreted away inside the plant stems. ICIPE's biological control project seeks to use the borers' natural enemies to keep them in check. Above, **Chilo partellus**, *the spotted stemborer. Below, larvae of* **Busseola fusca** *decimate this maize stem.*

isofemale lines, with the hope of resolving evolutionary relationships in the *C. flavipes* complex, which includes *C. flavipes*, *C. sesamiae* and *C. chilonis*.

Electrophoretic examination of a polydnavirus from *C. flavipes* and two populations of *C. sesamiae* showed differences in the viral circular DNAs. These differences may help to explain why some populations of *C. sesamiae* are able to avoid the immune system of another stemborer, *Busseola fusca*, and yet *C. flavipes* is unable to successfully parasitise this pest. Only the inland population of *C. sesamiae* could develop in *B. fusca*.

In another important activity of the complementery Gatsby-funded project, the genetic variations in stemborer populations was studied among *Chilo partellus* and *Busseola fusca* by examining their isozyme variation on eight mendelian loci. Allele frequencies revealed significant geographical differences between *Busseola* populations on Lake Victoria versus those in the highlands (Trans Nzoia), but genetic differentiation in relation to host plant influence was not evident in either species, suggesting there is free movement of borer populations among the different host plants within their ecosystems.

Searching far afield

With stemborers being such pervasive and damaging insects—their seclusion deep inside the stem helps them survive pesticide spraying—searches for natural enemies continues. Over 60 species of indigenous parasitoids have been documented from East and southern Africa by ICIPE's Biosystematics Unit and thus far about seven borer species. This information will be incorporated into a database and GIS distribution map of African cereal stemborers and their natural enemies as part of the CGIAR Systemwide Initiative on IPM in collaboration with IITA, CIMMYT and others.

Classical biological control—a method in which a foreign pest such as *Chilo partellus* is controlled by the introduction of a natural enemy from its homeland—is one field in which international cooperation is vital. Information from IITA suggests that an East African population of *C. sesamiae* shipped to West Africa by ICIPE has become established in Benin. Foreign exploration in India for natural enemies of *C. flavipes* was conducted in collaboration with ICRISAT. A native African stemborer parasitoid, *Pediobius furvus*, has been supplied to Brazil for control of *Diatraea saccharalis*, an important pest of sugarcane in the neotropics.

To support this research, over 250,000 stemborers of five species were produced in the ICIPE insectaries at Duduville. Borers are also supplied to the Kenya Agricultural Research Institute (KARI) for their maize trials and to other interested parties on request.

Funding: The Netherlands Government, Rockefeller Foundation.
***Collaborators:** Wageningen Agricultural University (WAU), the Netherlands; Texas A&M University, USA; John Innis Centre, UK; IITA; ICRISAT; CIMMYT; International Institute of Entomology (IIE); University of Capetown, South Africa; National Museums of Kenya; NARES in Kenya, Zanzibar, Tanzania, Uganda, Mozambique and Zimbabwe.*

MSV research

Maize is also subject to other pests and diseases in Africa, most notably the maize streak virus (MSV), which is transmitted by leafhoppers (*Ciccadulina* spp.). In the pipeline is a collaborative project for research into the epidemiology and pathotyping of the virus and its insect vector, with the aim of developing genetic resistance in this most important of staple crops.

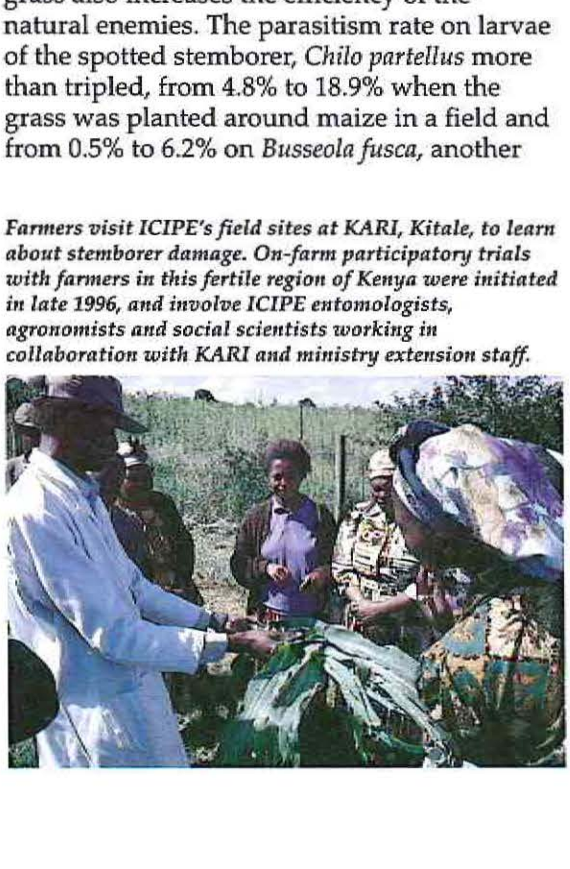
Farmers can push-pull pests from their fields

ICIPE's project on the role of wild habitat on the invasion of gramineous crops by stemborers is yielding hard data on the benefits of preserving and managing biodiversity in small- and medium-sized farms. The project is developing a novel pest management approach utilising a 'push-pull' (or stimulo-deterrent) diversionary strategy.

In this habitat management system, which involves the combined use of trap and repellent plants, insects are repelled from the main crop, and are simultaneously attracted to a discard or trap crop. The research is providing a better understanding of the relationship between habitat diversity and resilience to pest challenge, as well as ideas for habitat modification to contain this challenge.

The project has identified several plants which lower the stemborer density using the push-pull strategy, resulting in higher crop yields. Especially promising in this respect are Napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum vulgare sudanense*). These two important fodder grasses act as trap plants by 'pulling' the borers and as reservoirs for their natural enemies. Furthermore, Sudan grass also increases the efficiency of the natural enemies. The parasitism rate on larvae of the spotted stemborer, *Chilo partellus* more than tripled, from 4.8% to 18.9% when the grass was planted around maize in a field and from 0.5% to 6.2% on *Busseola fusca*, another

Farmers visit ICIPE's field sites at KARI, Kitale, to learn about stemborer damage. On-farm participatory trials with farmers in this fertile region of Kenya were initiated in late 1996, and involve ICIPE entomologists, agronomists and social scientists working in collaboration with KARI and ministry extension staff.

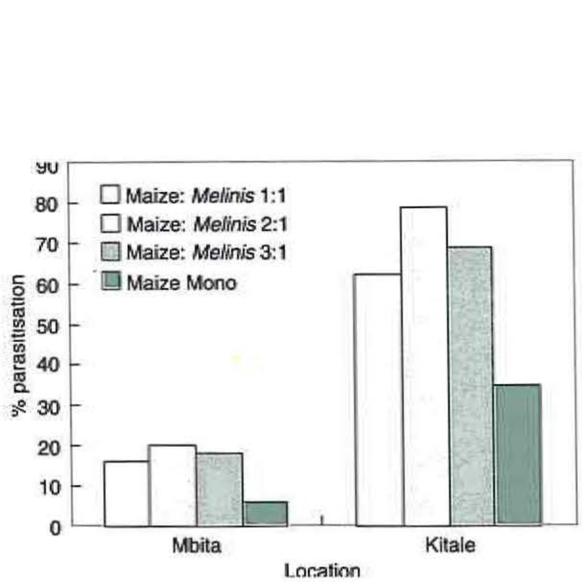


important pest. As reported last year, Napier grass has its own defense mechanism against crop borers: when the larvae enter the stem, the plant produces a gum-like substance which causes the death of the pest.

Molasses grass

The potpourri of uses of molasses grass (*Melinis minutiflora*) in habitat management are now becoming more evident. The plant releases volatiles that repel (or 'push') stemborers, but attract parasitoids. Both live whole plants of *M. minutiflora* and its volatiles were shown to attract *Cotesia sesamiae* in a Y-tube olfactometer. Intercropping with *M. minutiflora* increases parasitism, particularly by the larval parasitoid, *Cotesia sesamiae*, and the pupal parasitoid *Dentichasmis busseolae* (see figure). This study opens up the new and intriguing possibility of using intact plants with the inherent ability to release these stimuli. Such plants will have a useful role in ecologically-based crop protection strategies.

Coupled GC-EAG analysis of the volatile oils from *Melinis* shows that it contains several physiologically active compounds. Two of these (α-terpinolene and β-caryophyllene) inhibit oviposition (egg laying) in *Chilo*, even at low concentrations. In contrast, *Chilo's* host plants (maize, sorghum and Napier grass) were found to contain volatile compounds such as eugenol that attracted *Chilo* and *Busseola* and stimulated egg laying. The grass emits a chemical, (*E*)-4,8-dimethyl-1,3,7-nonatriene, which summons the borers' natural enemies. This same substance is released by whole plants as an 'SOS' when they are being damaged by pests.



Intercropping maize with **Melinis minutiflora** *increases the rate of parasitism of damaging stemborers compared to monocropping. This wild grass repels the borers, at the same time attracting their natural enemies.*

Striking down *Striga*

Research on the ecological basis of the push-pull mechanism is also being used to advantage to control another important pest, this time a parasitic weed, *Striga hermonthica*, that attacks cereal crops. In field trials at ICIPE's Mbita Point Field Station (MPFS), intercropping the maize with the fodder legume *Desmodium uncinatum* significantly reduced infestation by striga by a factor of 27 compared to the maize monocrop (striga incidence 2.7 to 0.1). Last year, we reported the beneficial effects of *Desmodium* in reducing stemborer infestation on maize. Farmer-participatory trials in Kenya's 'grain basket' (Trans Nzoia and Suba Districts) are in progress with the aim of developing a maize/napier grass/*Desmodium* intercrop that will reduce yield losses due to both stemborers and striga and at the same time improve soil fertility through its nitrogen-fixing action.

Funding: Gatsby Charitable Foundation, UK.
Collaborators: Rothamsted Experimental Station, UK; KARI, MOALDM (Kenya).

Striga *is a beautiful pink-flowered parasitic weed that saps the energy out of cereal crops, as in this heavily infested maize field (left). Intercropping with the forage legume* **Desmodium uncinatum** *suppresses the weed's germination, allowing healthy maize growth (right). In addition, farmers can reap the benefits of harvesting fodder for their livestock and of obtaining a nitrogen-enriched soil.*

Neem—a botanical of legendary powers

Natural pesticides derived from the neem tree, Azadirachta indica *A. Juss. (family Meliaceae), are gaining popularity because they are less disruptive to the environment than synthetic pesticides. The use of simple formulations or mixtures of bioactive components occurring naturally in the neem seed are an attractive option for pest management by resource-poor farmers in Asia and Africa. Though short on toxicity, neem derivatives neutralise the pests in the subtlest manner by affecting their behaviour and physiology, such as by inhibiting their desire to feed.*

In field trials against the stemborers *Busseola fusca* and *Chilo partellus*, application of neem cake reduced foliar damage and stem tunnelling at par with dipterex, resulting in an increase in grain yield corresponding to the use of this more expensive synthetic pesticide. Chemical analysis showed that even directly prepared neem cake had about 5500 ppm of azadirachtin A, thus obviating the need to reconstitute kernel and husk into cake with a standardised concentration of azadirachtin.

Neem idol: The neem tree originates from India, where it is revered due to its legendary medicinal and pest control properties. Neem derivatives affect about 450 species of insects belonging to 15 orders, as well as several species of mites and nematodes. The tree is put to so many uses in India that it is literally idolised.

Neem for banana weevils and nematodes

Neem's efficacy in controlling serious pests of banana—the nematode complex and the banana weevil, *Cosmopolites sordidus*—was tested by applying several types of formulations. Neem deterred feeding of the weevil larvae up to 60 h after treatment. When the pseudostems were treated with 1, 2 or 5% neem oil (NO), none of the larvae reached the pupal or adult stage, and those that survived were small and weak. This growth inhibition effect persisted for up to 14 days. Repellent effects were also noted. Other neem treatments using pared or unpared suckers reduced nematodes by 57 to 92%, at par with Furadan. These experiments are continuing in farmers' fields in western Kenya.

Agroforestry applications

Insects and nematodes also affect tree crops, but there is no strong tradition of pest control with chemicals on trees in smallholder agriculture. Trials conducted by ICRAF at Machakos, Kenya, and at Shinyanga and Tabora in Tanzania in 1994–1995 indicated that application of neem cake powder (NCP) could be used to control root-knot nematodes (*Meliodogyne* spp.) in sesbania. In a long-term field trial conducted at the ICRAF Field Station at Machakos, application of neem cake at 15 g per grevillea seedling reduced the tree mortality due to termite damage. After about 15 months, the untreated control showed loss of 72% of trees, compared with 60% and 52% loss with neem and carbofuran, respectively.

Nematodes are also a problem in tobacco. Field trials were conducted again at Tabora, Tanzania in the 1996 cropping season. Although application of neem did not reduce the root galling index over time, the tobacco yield increased significantly with the neem treatments.

Neem awareness

Awareness of neem is growing in the eastern and southern Africa region in large part due to ICIPE's Neem Awareness Project. Since 1994, over 30,000 seedlings and 200 kg of viable seed have been distributed among farmers, schools, churches, NGOs and other interested groups. This has stimulated the establishment of numerous private neem nurseries in Kenya and its neighbours. Commercial production of selected standardised neem-based control

Banana plants treated with neem solids at a rate of 100 g per 200 litres of soil show healthier, greener suckers (left) than untreated controls (right). Neem reduces infestation by root lesion nematodes and banana weevils.

preparations by a private Nairobi firm is another encouraging sign that demand for this ecologically safe pesticide is growing. Thus far, over 350 persons from seven East African countries have been trained in seven workshops. Another 163 persons were trained on the uses of neem in one-day seminars held during the same period. In late 1995, the project was cited as Finland's Project of the Month in *KEHITYS Newsletter* and in May 1996 it was featured for its environment impact under the *Rolex Awards*. Also in 1996, the project received wide coverage by the media in eastern Africa, featuring in two segments of the Reuters *Africa Journal* programme.

However useful this wonder tree may be, the impact of neem technology will not be felt unless neem preparations are available at an affordable price and sustainable supply to the smallholder farmer. With this in mind, pilot-scale production is underway as part of ICIPE's TechnoPark initiative *(see TechnoPark report on p. 43 and the ISERIPM report on p. 22)*.

Funding: *Government of Finland, UNEP, ICIPE Core Funds*
Collaborators: *ICRAF, KARI.*

Organic termite control

Termites are a problem when maize is grown in light soil, such as those in Shinyanga, Tanzania. Application of neem cake powder at 135 kg/ha reduced termite damage (see table) by a third in hybrid maize (Cargil) over the Furadan-treated or untreated crop. Traditional methods of termite control include removal of the queen by digging (a laborious procedure), and the use of wood ash, wild tobacco or dried chilli. More efficient is the use of synthetic pesticides, but some of the newer products are phytotoxic, as well as being more expensive than the older, now banned cyclodienes.

Trials were conducted by ICIPE during 1996 to evaluate the potential of the fungus, *Metarhizium anisopliae*, for control of damaging termites in several sites in Kenya. Two types of treatment were applied, depending on the termite species and its behaviour: dry conidia of the fungus were either blown into the vents of termite mounds using a foot pump, or mixed with soil and spread around trees. Results from farmers showed that the fungus could successfully protect trees and pastures from termite attack. In some cases application of the pathogen resulted in the destruction of the termite colony, while in others the fungus was able to give protection for up to 6–8 months, considerably longer lasting protection than the chemical pesticides the farmers had been using previously. Experiments are in progress to assess the efficacy of this fungus against damaging termites in maize cropping systems in Kenya and Uganda.

Cultures of the fungus were raised on various substrates and the conidial yield and viability determined. Rice was found to give the highest yield compared to maize and sorghum substrates. The conidial viability was about 5 months when the fungus was stored at room temperature. Rice itself, rice + vermiculite, maize + vermiculite and sorghum produced conidia with a 5-month shelf life at room temperature, which is a necessary requirement if fungal preparations are to be used on a large scale for pest control.

Funding: *ICIPE Core Funds*

Effects of application of neem cake powder (NCP) on termite damage to maize, Shinyanga, Tanzania[1]

Treatment	Termite damage (%)	Grain yield (t/ha)
Neem cake (45 kg/ha)	36.4	1.34
Neem cake (90 kg/ha)	32.2	1.56
Neem cake (135 kg/ha)	27.2	1.65
Furadan 5G	41.1	1.22
Untreated control	49.9	1.24
SED	3.5	0.15

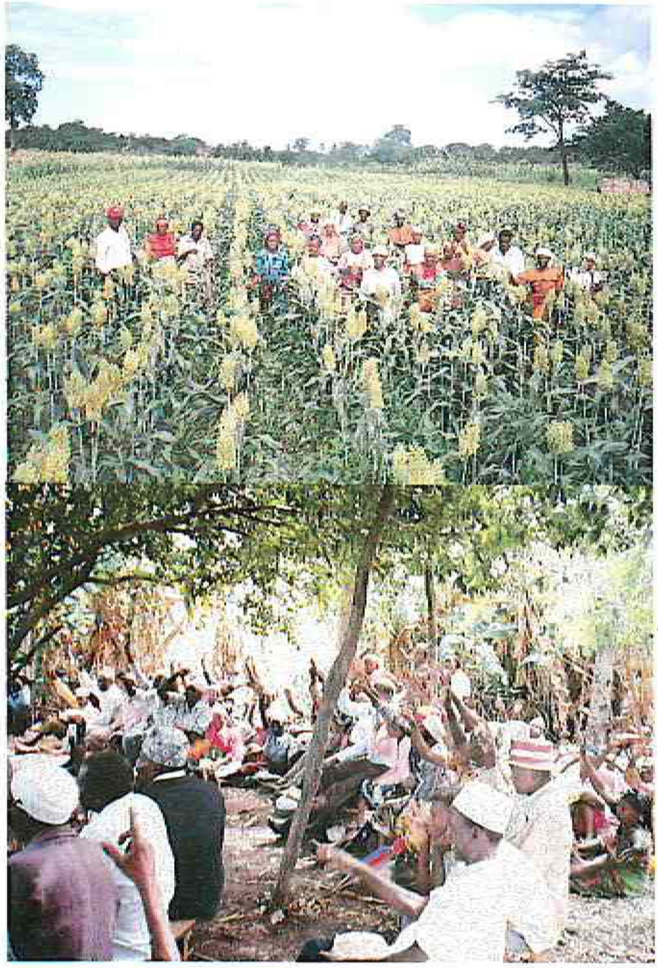
[1]Averages of 5 replications.

Six villages put IPM to the test

The last stage of this ICIPE project on 'Interactive Socio-Economic Research for Bio-Intensive Pest Management (ISERIPM)', aims to ensure the adoption and sustainability of ICIPE's IPM technologies developed by biologists and social scientists working together with NARES staff and farmers.

About 80 farmers from six villages in Kwale and Kilifi districts in coastal Kenya participated in the trials of pest resistant cultivars of maize, sorghum, cowpea and cassava, and the organic agents *Bt* and neem powder. Economic analysis of 50 of these farmer-managed technology trials was performed to establish the net benefits (NB) and the marginal rate of return (MRR)—the rate of return on the extra money invested in the new technology or practice. In the case of the maize trials, the MRR was found to be 63%, indicating a net benefit of Kshs. 0.63 for every Kshs. 1.00 invested. The profitability was greater when the farmers intercropped cassava and cowpea with their maize. The MRR for the sorghum-based trials was 29%, and again, intercropping raised the returns.

Analysis of experiments in which farmers selected their own crop combination showed that the total revenue from maize monocrop was maximised when maize was planted at 55,000 plants/ha. However, the contribution of maize to the total revenue in a maize-cassava intercrop was maximised when maize occupied 64% of the area at a plant density of 32,500/ha and cassava occupied the rest at a density of 7,200 plants/ha. The relative advantage of using IPM for maize growing was related to the general environmental quality. In the poorer environments, the local maize technology was superior to the IPM technology. However, IPM technology out-performed the farmers' practices in the better environments. Interventions that are recommended in the drier environments would be to include cassava as one of the intercrops, or to introduce sorghum where appropriate. The performance of IPM in the harsh environment is still being investigated.



Over 90% of farmers in ICIPE's adaptive IPM project at the Kenya coast feel they have benefited from their participation. Farmers from Kwale district (above) stand in a field of improved sorghum variety developed by ICIPE. Training courses and seminars were a vital ingredient, and allowed for the exchange of experiences and advice (below).

Farmers' evaluations of the IPM components

Improved varieties: In this region of the Kenya Coast, farmers expressed preference for the ICIPE-recommended maize cultivars that they assessed to be early-maturing (94%), high yielding (73%), pest resistant (15%), drought resistant (6%) and marketable (3%). Many of the farmers apparently did not readily associate the higher yields obtained with the improved pest tolerance of the recommended cultivars.

Cowpea varieties were preferred because of their high yield, early maturity and good colour. Being susceptible to pests and drought and unpalatability were factors for non-preference. High yield was the most important factor in farmers' preference of a cassava variety, followed by early maturity, palatability, and pest and drought tolerance.

Intercropping: About 40% of the farmers assessed the ICIPE-recommended strip relay intercropping pattern introduced two years ago as contributing to higher yields, and about 20% felt that this practice controlled pests. This cultural method was rated as being more labour-intensive by some farmers, and not allowing weeding by ox-plough.

***Bacillus thuringiensis* (*Bt*),** an entomopathogenic bacterium, was another IPM component tested for its adoption potential. A special strain of *Bt* active against stemborers was developed by ICIPE scientists at the Centre's Mbita Point Field Station on Lake Victoria, and evaluated in the coastal agroecology. After four years of testing, two-thirds of farmers rated the *Bt* technology as being effective and reported no problems in preparing and applying it. Although 10% said they were not able to afford this product, about 65% said that they would purchase it within a price range of about US$ 0.30 to 12.00 per season.

Neem, the natural botanical pesticide, was also tested for its ability to control pests *(see also page 20)*. It was adjudged effective in controlling maize pests by 21% of the farmers, while 60% found it useful for cowpea pests. The majority (60%) of respondents indicated they were able to prepare and apply the neem, although occasionally the disagreeable smell and difficulties such as in pounding of the neem seeds and blocking of the sprayer occurred. Farmers in this region would purchase and use neem if the cost were in the range of US$ 0.30 to 2.50 per season. About 8% of the project farmers were already growing their own neem.


SEHEMU YA KUNDE
MATARAJIO YAKE
PLOT No 1 INAMIKUNDE 2,000
PLOT No 2 INAMIKUNDE 2,000
PLOT No 3 INAMIKUNDE 1,250
PLOT No 4 INAMIKUNDE 720
TOTAL 5,970
Kwahivyo natarajia kupata
Gunia 5 ambazo ni kilo 450
Kila kilo ni Shs 20 Kwahivyo
natarajia kupata Shs 9,000

Page from a farmer's notebook in Tsuini Village on the expected output of cowpea as a result of using ICIPE's IPM technologies.

Translation: Expected output in cowpea plot:
Below are the number of plants per plot
- Plot 1 — No. of plants — 2000
- Plot 2 — No. of plants — 2000
- Plot 3 — No. of plants — 1250
- Plot 4 — No. of plants — 720
- Total — 5970
- I expect to get 5 bags of cowpea, each is 90 kg
- In total, I expect to get 450 kg
- I will sell 1 kg at Kshs. 20.00
- So, I expect to get Kshs. 9000.00

In the final analysis...

In their overall evaluation of the ISERIPM project, 90% of the farmers said they had benefited from their participation in the educational activities and practical application of improved pest control measures. Farmers' suggestions for improving the IPM technologies included continuing farmer training, provision of soft loans for purchase of ox-ploughs, and extending the activities to other farmers.

The Kenyan experience was used this year as a case study for training extension personnel from Tanzania, and is likely to serve as a model for other research projects where the technologies developed by researchers in the laboratory and on field stations can be scaled down and adapted to specific communities and agroecologies.

Donors are being sought to sponsor impact studies and a follow-up adaptive research project in other regions.

Funding: Rockefeller Foundation
Collaborators: KARI, MOALDM, Provincial administration and participating farmers, Kenya.

4000 years of locusts

No other pest has for the past four millenia caused such dramatic damage as plagues of the desert locust. In its gregarious state, the insects invade over 29 million square kilometres in 37 countries of Africa, Asia, the Middle East and southern Europe. ICIPE, together with its collaborators, is pioneering the development of a novel approach to locust control—preventing the unmanageable swarming behaviour. By manipulating the chemical communication signals between the locusts themselves and their environment, the insects might be retarded in their harmless solitarious phase or be made more susceptible to insecticides or pathogens in the initial stages of gregarisation.

Late instar nymphs of the desert locust feeding on their preferred host plant,* Heliotropium *sp. Just before the onset of the rains, desert plants emit volatile oils which stimulate the young adults to mature sexually and mate in time to lay their eggs when conditions are favourable. The plant also provides shelter and food for the newly hatched nymphs.

The control of locusts and other migrant pests such as the African armyworm has relied in the past on regional surveillance followed by the massive application of synthetic pesticides to contain impending outbreaks. As well as causing serious pollution to vast tracts of land, this expensive method is often unsuccessful.

ICIPE believes that improved future management of locusts is dependant on a better understanding of the gregarisation process. This will allow a more refined forecasting of imminent outbreaks. Control tactics such as the use of pheromones (chemicals produced by the locusts that attract them to each other and alter their behaviour, reproduction and development) can then be used to interrupt their transformation into the damaging swarms. Once they are weakened, then biological control agents such as fungi or pathogens can be employed.

Cues from desert plants

Because little is known about the solitarious phase of the desert locust, *Schistocerca gregaria* and its life system, research in 1996/97 began with studies on the host plant preferences of this phase. Of more than 30 plants that occur in the desert environment of the Red Sea area of Sudan, only four were found to be important in the insect's life cycle: *Heliotropium*, millet, *Crotalaria microphylla* and *Lannea capitata*. In the field, solitary egg pods and nymphs were always found on *Heliotropium*, which provides sites for egg laying and nymphal hiding places as well as food (see photo).There are seven *Heliotropium* species reported in the Red Sea area. Of these, *H. longiflorum*, *H. strigosum* (perennials), *H. bacciferum* and *H. pterocarpum* (annual herbs) appear to be the key species. With the advancement of the season and the drying of plants, nymphs tended to move from *Heliotropium* to millet. Contrary to previous belief, the solitary nymphs were especially efficient feeders, removing 205% of their body weight when feeding on the important pasture tree, *Acacia tortilis*, 133% on *Convovulus hystrix*, and 218% on *Heliotropium*, and spilling only half as much fodder as gregarious nymphs.

What is it in the environment that triggers off the changes from the distant (up to several hundred km apart) groups of solitary insects into the destructive masses? ICIPE's work supports the hypothesis that it is the essential oils produced by the flowers of these desert shrubs that stimulates the sexual maturation of the solitary young adults, thus beginning a chain of events that will allow them to mate, lay eggs and give rise to the 'marching bands' of hoppers feared since ancient times.

Interfering with gregarisation

Interference with the amassing of the nymphal stage was tested in the field by exposing them to the adult aggregation pheromone. This brought about confusion in the nymphs, causing the marching bands to change direction frequently, mill around in apparent disarray and eventually fragment into smaller groups and individuals, thus increasing their risk of predation.

The adult pheromone (see *1994/1995 ICIPE Annual Reports*) also increased the susceptibility of the nymphs to insecticides. After exposure to 0.01 or 0.05% of the pheromone in water, propoxur and diazinon were more effective in killing the nymphs, even when diluted 5- to 10-fold more than normally used. At a 15-fold dilution, the former insecticide proved the more effective and more persistent. Likewise, treatment of the nymphs with the adult pheromone enhanced the efficacy of two fungal pathogens that have previously been studied by ICIPE for possible use in locust control: *Metarhizium anisopliae* and *M. flavoviridae*.

These exciting results give cause for hope that semiochemicals produced by locusts themselves and by plants in their environment can be used in new tactics for environmentally friendly IPM of this very important pest.

Locust communication

Chemical ecology work this year has clarified more of the communication networking between the stages. • The nymphal (2nd–5th) pheromone system was completely characterised. It was shown to be a blend of straight-chained aldehydes and acids, and phenols. The same blend was shown to be responsible for retarding maturation in young adults. Thus, the synchrony so characteristic of gregarious locusts is determined largely by sequential effects of nymphal pheromone (retardation of early fledgers) and adult pheromone (acceleration of late fledgers). • Certain components of the aggregating pheromone cause females to lay their eggs in synchrony. Candidate compounds are now being evaluated in bioassays. • Detailed studies on the attraction of mature solitarious males have shown that the males who are producing the aggregation pheromone are more responsive to the female-produced pheromone. Identification of several candidate sex pheromone components has been done by GC-EAD, and assays of these in the wind tunnel are in progress.

Juvenile hormone mimics

The change of phase is also influenced by neuroendocrine factors produced by the insects themselves. Implantation of corpora cardiaca taken from crowded nymphs induced darkening in the integument and the compound eyes of isolated green nymphs, and more dark patterns appeared as the number of implanted corpora cardiaca increased. Likewise, the corpora cardiaca of the migratory locust, *Locusta migratoria* and the two-spotted cricket, *Gryllus bimaculatus*, were found to contain some factor(s) inducing dark colour in isolated green nymphs of *S. gregaria*. Methanol extracts of both the brains and corpora cardiaca of *S. gregaria* were effective in inducing dark colour in albino nymphs of *L. migratoria*. These results indicate that the two locusts may share a common mechanism to control the induction of dark coloration. After incubation with a proteinase at 37°C for 40 min., the methanol extract lost its activity completely, showing that this dark colour-inducing substance of *S. gregaria* is a heat-stable neuropeptide.

The application of juvenile hormone mimic (JHM) to the desert locust induced not only changes in body colour, precocious mating behaviour, inhibition of moulting and changes in haemolymph colour, but also a change in the internal reproductive organs. Spermatogenesis and / or sperm movement from the testis to the vasa deferentia was inhibited, but in females, ovarian development was promoted by JHM treatment. The nymphs took a little longer than adults to accumulate the yolk in the oocyte and no mature eggs were produced in the nymphs. These results suggest that the JHM may influence reproductive function in differing ways from the JHs or JH mimics already known.

A biological nucleation model

Some mystery still surrounds the exact nature of the gregarisation process. How do the isolated clusters of nymphs eventually give rise to the hundreds of millions of insects in a swarm? ICIPE researchers have proposed a model of gregarisation that resembles the physicochemical process of crystallisation:

(i) Solitarious adults are stimulated to mature and reproduce by volatiles from desert plants prior to rainfall.

(ii) The nymphal offspring are forced to cluster together within host/shelter plants, especially in areas where the vegetation is patchy; this is comparable to the nucleation process in crystallisation.

(iii) Gravid females lay their eggs in these same host plants, thus increasing the number of nymphs around a nucleus.

(iv) As the nymphs become more crowded, within a few days they begin releasing an aggregation pheromone. This serves to keep them together in a more organised band.

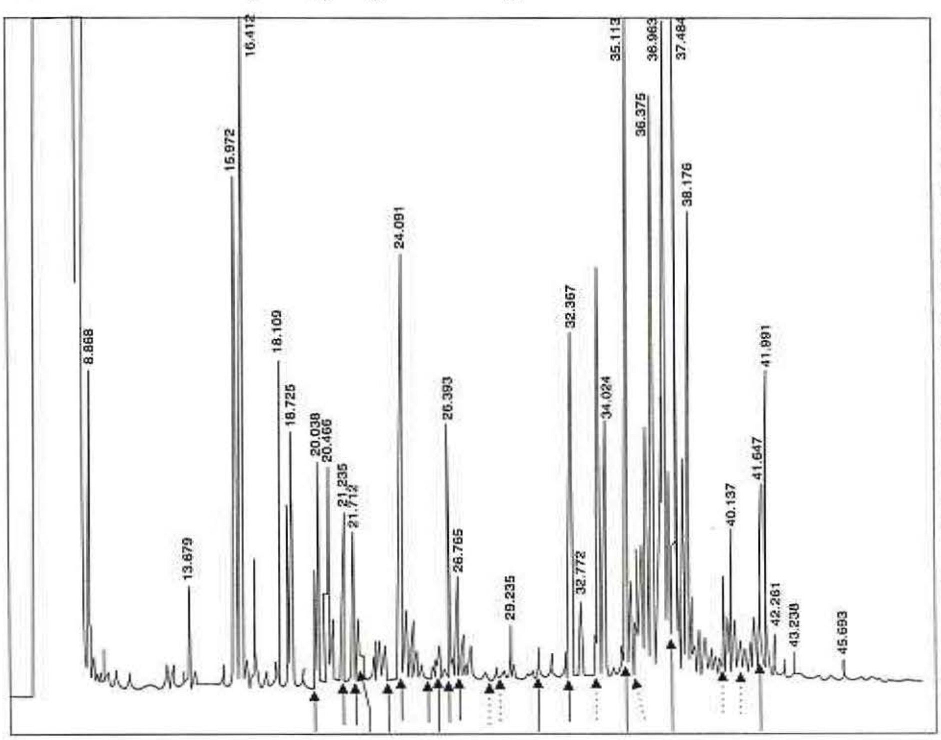
(v) The 'nuclei' of gregarising nymphs continue to grow as the nymphal pheromone serves to recruit (attract) any solitarious nymphs that fall under the influence of its alluring cloud.

(vi) The nymphal and adult aggregation pheromones respectively retard and accelerate the maturation of young adults in sequence and thus synchronise their maturation.

(vii) The complex interplay between the adults and the growing bands of nymphs serves to synchronise all the reproductive and developmental stages of the insects.

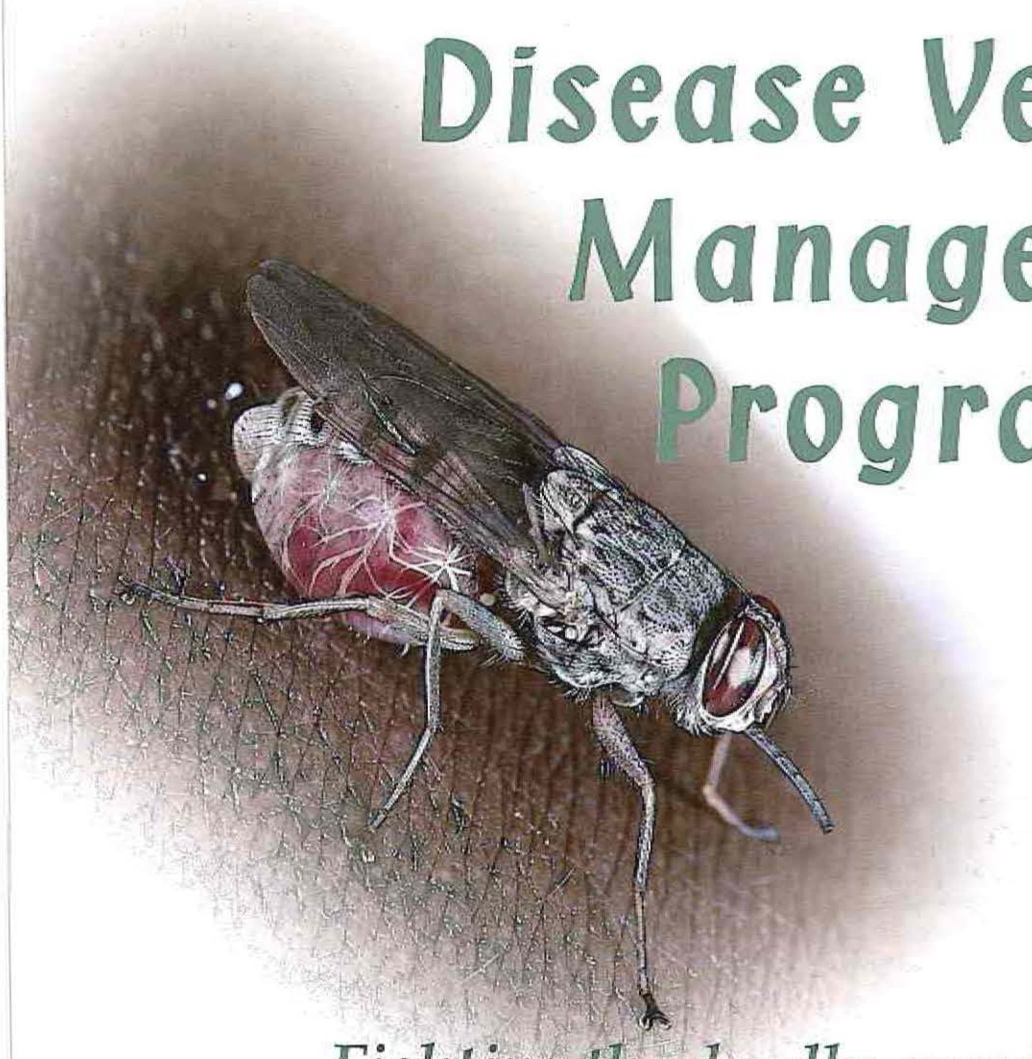
ICIPE is hoping to use the lessons learned from its research on the desert locust and extend it to two other species that have become serious problems in parts of southern Africa: the gregarious red locust, *Nomadacris septemfasciata* and the African migratory locust, *Locusta migratoria*. The African armyworm, *Spodoptera littoralis* is another gregarious pest whose control could benefit from ICIPE's approach. Thus far, 12 PhD students from locust-infested countries have been trained under this project.

Funding: *SAREC, UNDP, IFAD, AFESD*
Collaborators: *JIRCAS (JHM research).*



Chemical cues from the desert vegetation: GC-MS total ion chromatogram of **Commiphora quadricinta** *collected prior to the rains in the Red Sea coast. This desert shrub contained 22 electrophysiologically active compounds in its essential oils before the rains, and only 12 after the rainy season. Studies have shown that these compounds, mainly terpenoids and phenolics, trigger sexual maturation of the immature adults. The EAD-active components are indicated with an arrow.*

Disease Vectors Management Programme



Fighting the deadly comeback...

Arthropod vectors (ticks, flies, mosquitoes, fleas, etc.) carry some of the world's deadliest diseases. As both the vectors and the parasites they harbour become more resistant to drugs and chemicals in common use, many of these diseases are making a comeback. ICIPE is working to find more effective and sustainable methods for disease control by addressing the most vital step in the chain—the arthropods themselves.

Taming the tsetse

Animal trypanosomosis (nagana in Kiswahili) and human sleeping sickness are transmitted through the bite of the tsetse fly (Glossina *spp.). These pests, which are found only in Africa, render about 10 million km² of the continent unsuitable for agriculture and human habitation. Economic losses in livestock due to tsetse run into the staggering figure of US$ 2 billion annually. Chemical control over this vast area is too expensive for most African governments and furthermore has proven generally ineffectual.*

ICIPE is developing a community-based approach to tsetse control in three locations: the semi-arid grazing areas of the Rift Valley in Kenya; the Lambwe Valley in the Lake Victoria Basin and the highlands of Ethiopia. Basic research on tsetse behaviour, biology and ecology continues in order to find answers to the pest's canny ability to survive every kind of control measure in current use. ICIPE is looking at environmentally safe solutions to the tsetse problem such as the use of semio-chemicals to manipulate the fly's behaviour, and trapping, sometimes in combination with pathogens.

Improving life for agro-pastoralists

The welfare of agropastoralists such as the Maasai of East Africa is intimately linked to the health of their animals. And, the tsetse that infest their herds can also carry the trypanosomes responsible for human sleeping sickness. This project is serving as a model on how to transfer a technology developed in the laboratory to the people themselves.

The Olkiramatian Group Ranch in the Nguruman area spans an area of about 110 km². Since 1992, ICIPE-developed NG2G traps have been installed at 2-km intervals throughout different ecological sites (open bush, forest, swampland, escarpment) in this semi-arid region of Kenya. The simple tricolour traps are baited with cow's urine and acetone and are strategically sited to control flies in areas where cattle graze and to limit invasion of tsetse by forming an effective barrier against fly invasion from areas outside the control zone. In the final stage of this phase of the project, the management of 210 traps was handed over to the Nguruman Maasai community on 6 September 1996 (*see pages 6, 7*).

Community training and mobilisation

Prior to this important step, ICIPE social scientists had laid the groundwork by educating and training the community in basic tsetse biology and the principles of design, operation, servicing and strategic placement of the traps. Over the last year, for instance, 45 participants serviced 130 traps in a training programme organised jointly with KETRI (the Kenya Trypanosomiasis Research Institute). Earlier, a catalytic group (CG) of 25 herdsmen had been selected by the community for training, and this group is now active in training pastoralists from neighbouring areas, such as Trans Mara. ICIPE is continuing its participation in the exercise by assisting in improvement and evaluation of trapping efficiency and by developing even cheaper, more durable trap models.

To ensure the full adoption and sustainability of the tsetse trapping technology, the local Nguruman community is being encouraged to organise themselves into blocks of several villages, each for more efficient management and financing of the control operation. Thus far, the community has held 16 meetings attended by 461 residents, both men and women. Group size ranges from 15–34, with members contributing an average of Kshs 100 (about US$ 1.80) each.

The NG2G trap in place in the Nguruman woodland. Installation of the traps over a 110 km² zone has reduced the tsetse population to 90% of pre-suppression levels.

Tsetse decoys

The basic NG2G trap incorporates three colours of fabric: the blue 'apron' to attract the flies, a black target area for landing, and a white cone to lure the tsetse into the light, where they enter a plastic bag and are killed by the heat of the sun. Sewing decoys (5 per trap) made of pieces of shoelaces or brown and / or white strips of cloth appears to increase the catches of both female and male flies by 60–70%. These experiments are being repeated.

Replacing the imported white mosquito netting cone with locally purchased green plastic screening improved the catches of *Glossina pallidipes* females by 57% but had no effect on male catches. Using an off-white plastic screening purchased locally gave even better catches of both female and male flies (172% and 143%, respectively) compared to use of the standard cone. Other cheaper trap materials, including sisal, are also being tested for their efficiency and durability.

Barricade design

In most tsetse habitats, complete eradication of the widespread fly populations is either economcally impractical or precluded by the physical topography of the landscape. The development of effective barriers is essential to prevent reinvasion by tsetse flies into areas in which significant control of local populations has been achieved. The effectiveness of NG2G traps as components of a barrier system is presently being assessed in an area of high tsetse density near Shompole swamp. Odour-baited traps and repellents are being evaluated as part of a push-pull strategy for preventing tsetse immigration. A barrier of odour-baited traps was set in two concentric circles; however, the barrier appeared to not completely stop immigration of tsetse, as indicated by the capture of mature flies in a centrally located trap.

Cost-benefits of tsetse control

To assess the economic costs / benefits of community-based tsetse control schemes amongst pastoralists and agriculturalists in the Nguruman location, ICIPE is collaborating with KETRI to compile livestock productivity figures. The mean monthly milk off-take ranged from 645 to 1800 ml a day per cow. Total milk production from cows has declined over the period 1990–96, whereas goat milk production has risen from about 10% of the total milk production in 1990 to 39% in 1996. These figures can be explained in part by the frequent droughts and shortage of pasture as well as the reduction in the average herd size from 99 cattle per household in 1990 to 56 in 1996, in spite of reduction in cattle mortality.

Reduction in tsetse numbers seems to have had a definite impact on milk productivity in goats. However, in order to obtain a true picture of the uptake of the trapping technology and the low-cost benefits it brings, these activities are continuing until the end of 1997.

(See also the report on the efforts of this community to diversify into horticulture, page 12).

Funding: *European Union*
Collaborators: *Regional Tsetse and Trypanosomiasis Control Programme (RTTCP) of SADC countries, KARI, KETRI.*

Tsetse control and development in Ethiopia

In recent years, the southern region of Ethiopia has suffered drought, pestilence and other natural disasters. Trypanosomosis is rife, and the high mortality of livestock is reflected in loss of animal traction power and poor human nutrition. At the request of the community, the Southern Peoples regional government and the Ethiopian Science and Technology Commission intervened and selected ICIPE's odour-baited tsetse trapping technology for testing.

Locations with a serious tsetse problem were selected for the community-based control operations: Sodo Bedessa in North Omo zone and Cheha, Enemor and Goro Woreda along the Wabe and Gibe rivers in Gurage zone. The project was later expanded to include the Arba Minch area and Oromia and Amhara regions. *Glossina pallidipes* and other biting flies were collected monthly from the NG2G traps installed by the project from April 1995 to March 1996. The total fly catch for the period was 136 *G. pallidipes* and 24,113 biting flies. In a study done in collaboration with the Regional Veterinary Laboratory in Sodo during this period, the *G. pallidipes* population dropped from the 100 flies/trap/day originally recorded to zero. The most prevalent parasites found were *Trypanosoma congolense* (69.4%) and *T. vivax* (27.1%). Zebu cattle with trypanosome infections had very low packed cell volumes (PCV) compared to uninfected animals with PCV >25. The low PCV values were associated with 'tryps' infection.

A community-driven project

After learning the fundamentals of tsetse and trypanosome biology, the communities organised themselves for training and demonstrations, after which they were ready to begin their active participation in this community-driven project. Over 230 farmers and 45 mid- and high level government staff have been trained thus far. The importance of training cannot be underestimated, and ICIPE's scientists are playing an active role in courses on tsetse and mosquito/malaria management, for instance in the international study workshop on 'The Way Forward', held in Addis Ababa and Axum in February 1997. This course, co-sponsored by the Ethiopian government, was attended by about 100 professionals. Exchange visits between the Kenyan and Ethiopian teams are important for sharing experiences. Four senior veterinary staff from Ethiopia received intensive training in trapping technology for the control of tsetse flies at the Nguruman field station in Kenya early in the year. These trainees are now supervising rural communities in the deployment of thousands of tsetse traps in the vicinity of Sodo-Bedessa, Welkite (Gurage) and Arba Minch.

After finding the ICIPE model of the trap too expensive for the average local purse (about US$ 30), the four communities began constructing their own traps out of local materials. Thus far, 2500 NG2G traps have been made by the villagers. Three variations of the basic trap are now being tested in Sodo Bedessa and in Nechsar National Park in Arba Minch. Indications are that one version is able to increase the catch of *G. pallidipes* females by an index of increase (factor) of 2.46 and of males by 3.285, while being about five times cheaper than the standard version.

Nzi trap

Another type of trap developed at ICIPE is the Nzi trap (an *nzi* is a fly in Kiswahili) for biting flies. About 90 of these traps have been constructed by the villagers. An informal research network has been established to test the performance of this new multipurpose trap, with trials going on in Ethiopia, other African countries and elsewhere.

Tangible benefits

Assessment of the tangible impact of the trapping programme was done by ICIPE social scientists in five peasant associations in Gurage zone, each with a population of 10–15,000. After 12 months of trapping, the milk yield increased by about 15% and the herd size increased between 27–55% from the previous

Impact of the tsetse trapping programme on milk yields and herd size in southern Ethiopia (April 1995–March 1996)

Peasant association	% increase in milk yields	% increase in herd size
Anaka Dugna	13.4	27
Anka Shasara	14.6	43
Amiadamota	16.6	55
Torasadebo	15.4	48
Ellorasho	15	39

The hardworking people of Gurage were once prosperous. Tsetse and mosquitoes, in combination with a series of environmental disasters, have changed all that. Land lies fallow as vector-borne diseases sap the energy and vitality of the people and their livestock. To improve their welfare, the community has requested ICIPE to work in partnership with them in a biovillage model of holistic development.

levels. It is too early to make definitive conclusions, but one possible explanation is that the cattle which were formerly grazed in the hills to avoid the tsetse menace are now being grazed on the lush plains, resulting in improved condition of the animals. More cattle could also have been purchased as the villagers have confidence their animals will survive. Due to the very promising results obtained thus far, the Ethiopian government is supporting the project by approving a budget for production of an additional 2000 traps per year in several regions.

Funding: *EU, Ethiopian Government*
Collaborators: *ESTC, Regional Agricultural Bureaus, Ethiopia; PPI, USA.*

Environmental impact of tsetse control in the Lambwe Valley

The impact of trypanosomosis control on human welfare, land use and the natural resource base is being assessed by ICIPE and social scientists in the agricultural communities around Lambwe Valley, a region adjacent to Lake Victoria where the tsetse problem has been particularly tenacious. The sustainability of ICIPE's long-term project is being examined by looking at the management skills and income generating potential of the community organisations.

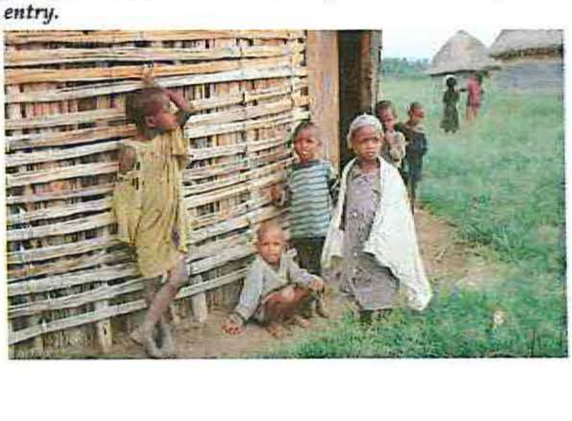
With the help of ICIPE, farmers will be growing sunflowers for sale of oil as a source of income to support the trapping activities; the oilseed cake will be used as animal feed. Women are taking a more active role in the control activities, and provided 63% of the construction labour, as well as a third of the trap placement and servicing work. Women are also becoming more involved in the management, increasing their share of the leadership by 51%. The assessment team noted that, as a result of the communities efforts, there has been a drastic reduction in the tsetse population and the incidence of bovine trypanosomosis.

As the tsetse disappear, there is fear in some quarters that once livestock move in, over-grazing, deforestation and inappropriate land use will occur. The ICIPE team are evaluating the changes in use of land and other resources by analysing aerial photos of the region and GIS digitisation over the period 1948 to 1993. Preliminary results from the period 1977–1993 show that cultivation has increased in the study area from 4% to about 37%, resulting in about 0.61 km^2 showing severe soil erosion. Limited agroforestry activities are in progress to combat erosion.

Spatial analysis of tsetse distribution in the valley was studied using LANDSAT TM satellite imagery and GIS to identify factors associated with local variations of fly density. The TM band 7, which is associated with moisture content of the soil and vegetation, was consistently highly correlated with fly density. Prediction of favourable fly habitats in inaccessible sites is possible, and these studies are continuing.

Funding: *IFAD, ODA, NRI*
Collaborators: *ILRI, ICRAF, ODG/UEA, NARES in Kenya, Zanzibar, DRSRS (Kenya), RCSSMRS.*

The traditional Ethiopian house or **tukul** *will be at the core of the emerging Biovillage Initiative in the southern region of Ethiopia. One style of round hut will be used for zero-grazing animals and the more refined version for family living (below) will be modified to limit mosquito entry.*



Uncovering the secrets of the wily tsetse

In spite of many decades of efforts to control the tsetse fly and hundreds of millions of dollars spent on the application of synthetic pesticides, the tsetse menace remains one of Africa's major development concerns. ICIPE's basic research is directed toward the better understanding of the species responsible for human sleeping sickness and animal trypanosomosis. This knowledge can then be used in the development of better methods to outwit the wily flies. Highlights of this research are below:

- *Glossina morsitans morsitans*—Field testing of the larviposition pheromone (identified as being *n*-pentadecane) of this species is being evaluated in collaboration with RTTCP. In the case of *G. morsitans centralis*, another hydrocarbon, *n*-dodecane, has been identified as the dominant electrophysiologically active component. Both these compounds have significant attraction for gravid females.

  A lectin-trypsin complex was purified from the midguts of the fly. The complex had a native apparent molecular weight of about 65 700 Da and consisted of two subunits (α, M_r~28 800 and β, M_r~35 700). The β subunit has a glycosyl residue. This molecule showed trypsin activity (specific activity of 69.3 µmoles / min / mg) and agglutinated bloodstream trypanosomes, as did the homogenates prepared from both the midgut and the peritrophic membranes. The complex was shown to induce the transformation of bloodstream trypanosomes.

- *G. swynnertoni*—This member of the *morsitans* group is found in northern Tanzania and the Mara region of Kenya and is a vector of both human and animal trypanosomosis. A new trap design (S3) has been developed which catches about a third of approaching *G. swynnertoni*, a comparable figure to the Sticky Black Target.

- *G. pallidipes*—Three of the major components of the volatiles given off by live *G. pallidipes* larvae have been identified as being C_{12}–C_{14} hydrocarbons. Larviposition sites in two tsetse areas have been baited with the natural pheromone, and pupal cases have been found at one such site. Biostatistical analysis showed that interaction effects between sites and months is of considerable importance in the interpretation of population data for both *G. pallidipes* and *G. longipennis*.

- *G. brevipalpis*—catches doubled in one trapping experiment using rhinoceros urine as bait.

- *G. fuscipes fuscipes*—No satisfactory trapping technology exists for this riverine species, a vector of human sleeping sickness epidemics. ICIPE is looking at attractants (kairomones) from the urine and whole-body volatiles of the monitor lizard *Varanus niloticus niloticus*, the preferred host. The fly prefers to land, probe and feed in the neck region, and fly density is greatest when the lizard is basking in the sun (34–45°C), which also corresponds with the highest EAG activity of the volatiles. Size is more important than shape in attracting the flies. GC-EAD analysis showed the presence of five EAG-active compounds. A blend of straight-chain C_8–C_{13} aldehydes present is especially attractive to the flies.

  The flying height of this species was estimated. About 48% of males and 35% of females were captured above 1 m. An average of 61% of males and 40% of females appeared to avoid the electric nets.

- *G. tachinoides*—Field testing of three aldehydes from monitor lizard urine was done on this riverine species in Ethiopia. These proved as attractive as the cow urine and octenol mixture used as bait at present.

- Tsetse repellents (allomones) offer another possibility of limiting transmission of trypanosomosis. One substance, a 4-substituted methoxyphenol derivative, has been shown to reduce baited trap catches in the field by 85%.

- Development of an ELISA system to identify the host species blood meals from tsetse. Reagents for about 30 hosts of tsetse have been produced.

- Tsetse supply—A total of 86,000 *G. m. morsitans* and 84,000 *G. m. centralis* were produced by the Animal Breeding and Quarantine Unit. Rearing of *G. f. fuscipes* is difficult due to its low reproductive rate, but the colony was re-established from pupae supplied by IAEA.

Organic options for tick control

Ticks carry East Coast fever, heartwater, and a plethora of other livestock diseases, causing global losses in the billions of dollars. ICIPE is looking for safe and effective alternatives to synthetic acaricides, which are too expensive for smallscale farmers and cause serious environmental pollution. Research is continuing on a range of non-acaricidal pest control options.

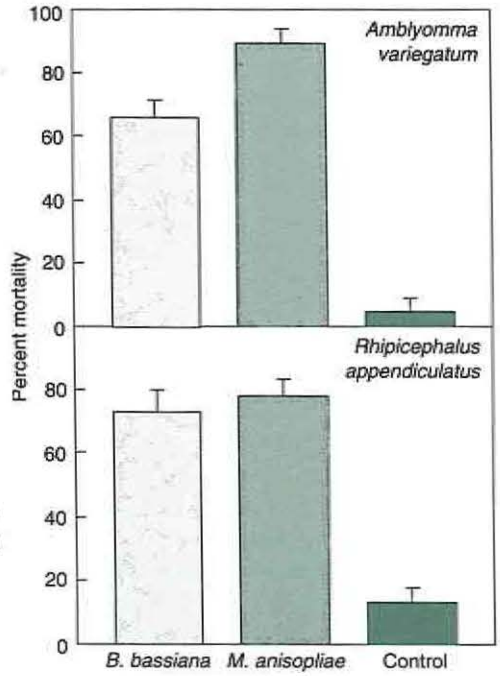
Some 80% of the estimated world cattle population of 1.28 billion cattle are at risk from ticks and tick-borne diseases. Apart from the diseases transmitted, tick infestation also causes reduction in growth rate and milk production, damage to skins and hides, prolonged calving intervals, and predisposition to other diseases.

Fungal pathogens

Beauveria bassiana and *Metarhizium anisopliae* are two fungi with specific pathogenicity toward insects. These two are now being tested by ICIPE on ticks, another class of arthropods. The fungi are applied in several formulations sprayed directly on the ticks as they feed on the host animals or onto the grass. The brown ear tick, *Rhipicephalus appendiculatus*, is the vector of the East Coast fever parasite, *Theileria parva* responsible for the death of over one million cattle in Africa annually. *Amblyomma variegatum*, the vector for heartwater, is another tick of great economic importance. Applying a peanut oil-water emulsion of the *Beauveria* conidia on ticks sealed in nylon tetrapaks and maintained in vegetation in the field resulted in adult mortalities of about 72%, while *Metarhizium* caused 80% mortalities. Ticks spend much of their time in the grass waiting for hosts to pass by.

The fungi were even more lethal to the immature stages than adults, with mortalities ranging from 80 to 96% in nymphs and 100% in the larval stages of both ticks. In other experiments with free ticks in potted grass, the two tick species were sprayed with a conidial

Mortality in two species of 'free' adult ticks sprayed with conidia of **B. bassiana** *and* **M. anisopliae** *(15% oil emulsion) in potted grass.*



suspension containing 10^9 conidia/ml in oil-water emulsion or water emulsion alone for three seconds, and the mortality recorded after 4 weeks. Mortalities ranging from 66 to 69% (*B. bassiana*) and 77 to 93% (*M. anisopliae*) were observed (see figure above).

Parasitoids

In the last two annual reports, a small parasitic wasp, *Ixodiphagus hookeri*, has been proposed as an effective natural biological control agent to control *Amblyomma variegatum*, the tick vector of cowdriosis in East, North and West Africa. The wasp lays its eggs in the tick, after which the emerging larvae consume the tick from within. Progress has been made over the past year in developing methods of obtaining the eggs from the host tick, in order to rear enough of the parasitoids for mass release. Various artificial media and artificial membranes are being tested for use in mass rearing.

Neem

Neem oil was evaluated for the control of *R. appendiculatus, A. variegatum* and *Boophilus decoloratus*. The oil was applied directly on the ticks or on the skin of the animal hosts. In rabbits, the neem oil was effective against all three tick species. It deterred larval and nymphal attachment, inhibited feeding (90–100%), reduced fecundity (30–45%) and egg hatchability (47–55%), and reduced moulting of the larvae (22–93%) and nymphs (98%). Most of the eggs were sterilised when exposed directly to various concentrations of the oil. The oil also proved repellent to all stages of the three tick species. A 25% concentration of neem oil sprayed on deticked Zebu catttle grazing on heavily tick infested natural pastures reduced infestation by tick larvae by 37–61%, nymphs 24–65% and adults 44–62% for 5 days.

Vector competency

In order to determine whether variations in ticks' ability to carry parasites is due to genetic differences, four geographically isolated *R. appendiculatus* populations in Kenya (Baragoi, Maralal, Embu and Lanet) were compared by random amplified polymorphic DNA polymerase chain reaction (RAPD-PCR). In this study, DNA samples extracted from the ticks were amplified using twenty 10-mer primers of random sequences and the products analysed by agarose gel electrophoresis. Concurrently, nymphal ticks collected from the same locations were allowed to feed on cattle that had been previously infected with two parasite strains, *Theileria parva* Marikebuni and *T. parva* Lanet. The results showed wide variations in the mean infection rates of ticks infected with the two *T. parva* strains. Resistance to infection differed according to the location, with ticks from Embu and Lanet being more susceptible than those from Baragoi and Maralal. PCR analysis showed distinct differences between the tick populations. Work is now in progress to identify specific markers to susceptibility or refractoriness to infection with *T. parva*.

Anti-tick vaccine

Following promising results of previous work on immunised cattle in the field using a glycoprotein fraction from the tick gut (*see 1995 ICIPE Annual Report*), the protective efficacy of the fraction is being evaluated on a larger scale in 40 Boran cattle. Two treatment regimes are being tested: immunisation with the glycoprotein fraction and combination of the glycoprotein fraction with sub-lethal doses of ivermectin. The effects of the fraction on tick vectorial capacity (the ability to transmit disease) will also be evaluated. Purification of the single antigens of the glycoprotein fraction using biochemical methods is in progress.

Rhipicephalus evertsi evertsi ***feeding on the perianal region of a cow in the field. Both adults and immature ticks are visible in this photo of a heavy natural infestation. Other than the obvious discomfort and loss of condition that this tick causes, it also causes paralysis, especially in lambs and calves.***

Recombinant DNA techniques are being employed to produce the antigens of interest in large quantity. As a continuation of previous work, fusion proteins have been prepared from λgt 11 recombinant lysogens in *E. coli* Y 1089. About 20 preparations of fusion proteins have been obtained and analysed by SDS-PAGE followed by immunoblotting. According to their electrophoretic patterns, the 22 preparations of fusion-proteins could be grouped into four classes. Current work is focusing on purification of the β-galactosidase fusion-proteins.

Grazing regimes

Ticks have their own internal daily rhythms, and tend to drop off cattle at certain times of the day. One simple approach to helping reduce tick infestation on animals would be to graze them at times when the ticks are less active. However, in one area of western Kenya, ICIPE social scientists have determined that this ploy will not work in areas where there is a shortage of labour. During the single cropping season, a very busy time of the year, the farmers tend to tether their animals; during the dry season, they allow them to graze all day at will because of the shortage of pasture. In both cases, the farmers cannot take advantage of the recommended grazing hours to avoid exposure to ticks. New grazing regimes are now being tested.

To support tick research, about 92,000 adult ticks and 126,000 nymphs belonging to four species (*Rhipicephalus appendiculatus, R. evertsi, R. pulchellus* and *Amblyomma variegatum*) were reared in 1996 in the Animal Breeding and Quarantine Unit.

Funding: ICIPE Core Funds, UNDP
Collaboration: KARI.

Deadly diseases make a comeback

One hundred years after the discovery by Sir Ronald Ross in 1897 in Hyderabad that mosquitoes transmit the parasite that causes malaria, the disease still claims 3 million lives a year, over a million of them children. About 40% of the world's population (about 2.5 billion people) are at risk in more than 90 countries. ICIPE is contributing to the global effort to end this and other mosquito-borne diseases by research into the behaviour and ecology of the arthropod vectors.

Malaria control still elusive

Arthropod-borne diseases such as malaria, dengue fever and yellow fever—all carried by the bite of mosquitoes—are on the increase worldwide, with major epidemics in the tropical developing countries in the past year. Yet in spite of the tens of millions of dollars invested in research and production of pharmaceuticals, WHO concludes that they have "only a limited lifespan in which they are effective". ICIPE's research will be used in integrated control tactics for these persistent pests.

As the mosquito vectors become more resistant to insecticides, at the same time they are finding new ecological niches, such as in the highland regions of Kenya. More challenging is the fact that the prevalence of the disease itself is not necessarily proportional to the percentage of a given population carrying the malaria parasite (*Plasmodium* spp.). These and other perplexing issues were discussed at a Task Force Meeting of mosquito and malaria experts from around the world in February 1996.

ICIPE is reviving its dormant medical vectors research activities, and the participants endorsed the Centre's role in malaria vector research in four general activity areas. A unanimous conclusion of the meeting was that much of the information needed for effective vector control is still incomplete. ICIPE's research orientation should be problem-solving, innovative, multidisciplinary and network-coordinated with an emphasis on scientific excellence. The four areas include:

- basic strategic research with output relevant for malaria control;
- operational research through networking with African national institutions (NARES);
- provision of services to support national and regional malaria control programmes;
- research capacity building.

Proposals are being developed that stress partnership between ICIPE, national systems and advanced laboratories. Five scientists are

A scene during an open-air performance of 'Mosquito Mask', a play performed by Moi Sindo Girls Secondary School in western Kenya. Each of the actors represents a mosquito species: yellow for Aedes, *the yellow fever vector; black for the nuisance* Culex *mosquitoes; white for the harmless* Mansonia *species. Close-up:* Anopheles, *the malaria vector, responsible for 4 million cases yearly in Kenya alone.*

research activities at three sites: at ICIPE's Mbita Point Field Station (MPFS) on Lake Victoria, in the coastal region and in Nairobi. ICIPE scientists are now working closely with scientists in KEMRI, the Division of Vector-Borne Diseases of the Kenya Ministry of Health and the panafrican MARA project to establish a foundation for mapping and analysing the ecology and behaviour of mosquito vectors and distribution of malaria prevalence in Kenya and the East African region. Studies to determine mosquito species composition and abundance and malaria transmission intensity relative to malaria prevalence have been initiated at two ecologically distinct sites at MPFS and at the coast in Malindi, Kilifi and Kwale districts.

ICIPE is looking at options for control that are more environmentally benign than the spraying of synthetic chemicals such as DDT, still used by many countries for public health applications. Options such as the use of mosquito pathogens, botanicals such as neem, use of attractants/repellents (semiochemicals), trapping, and so on. The results of ICIPE's work will be incorporated with integrated control programmes utilising insecticide-impregnated bednets, improved prophylactics and other strategies. The development of bacterial-mosquito larvicides is reported on page 49.

Neem for malaria control

Neem bark and leaf extracts have traditionally been used as malaria remedies in Asia and Africa. Recent studies conducted in India have demonstrated that neem oil is an effective mosquito repellent. As part of ICIPE's Neem Awareness project (*see page 20*), a rural community in Kenya were surveyed for their perceptions about malaria and the use of neem (*Azadirachta indica*) for its treatment. The study, conducted in collaboration with SHARE in rural communities in a malaria holo-endemic belt on Rusinga Island, surveyed 1750 households with a population of 10,855 in July 1996 to assess the malaria control knowledge, attitude and practices. Most of the respondents mentioned the use of anti-malarial drugs, while some were already aware of the use of neem for prevention and treatment of malaria. Though 98% of members of the communities knew about neem through ICIPE's Neem Project, only 36% respondents have actually used neem against malaria. Neem was taken as an infusion of the bark, leaves or roots in boiled water, inhalation of the leaf smoke, or as a concoction of neem seed powder. The mention of alternative preventive and curative strategies such as the use of neem by respondents shows that the community perceives the need for an alternative approach. Since inception of the ICIPE's Neem Project at Mbita, awareness of neem's potential has already been created and the communities have planted more than 2000 neem trees; the Rusinga United Development Group, a local women's organisation, has raised a nursery of 6000 neem seedlings.

Dramatising malaria transmission

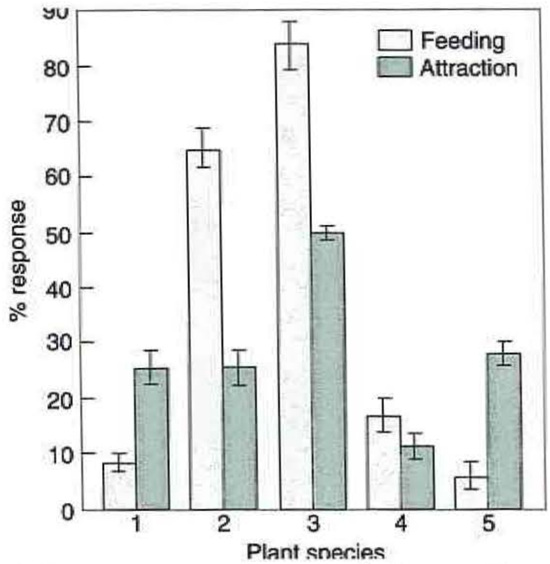
Community-based studies aimed at promoting awareness on malaria transmission were started in July 1996 by the malaria vectors project staff. The main objective of the project is to promote mosquito and malaria control activities at the household and community levels using primary and secondary schools as the entry point for awareness creation. Project activities include delivery of malaria transmission and control information; collection of ethno-botanical materials traditionally used to repel mosquitoes in houses; and dissemination of information on malaria control through drama performed by students (*see photo on page 35*).

Funding: ICIPE Core Funds with pre-project support from DANIDA, the Netherlands Government, WHO
Collaborators: KEMRI, Ministry of Health (Kenya), SHARE

Conquering kala-azar

About 12 million people are afflicted with human leishmaniasis, with 400,000 new cases annually. The visceral form (kala-azar), enters the spleen, liver and bone marrow and is usually fatal if left untreated. Recent epidemics in the Bihar region of India and in southern Sudan have left tens of thousands dead. The social cost of the disfiguring of the skin, face is beyond estimation.

The leishmaniases are a group of protozoan diseases caused by parasites of the genus *Leishmania*, transmitted to man by the bite of several species of phlebotomine sandflies. Control strategies based on chemical



Feeding and behavioural responses of the sandfly* **Phlebotomus duboscqi** *to different plant species: 1,* **Amaranthus hybridus**; *2,* **Bidens pilosa**; *3,* **Melia azedarach**; *4,* **Ocimum kenyense**; *5,* **Vigna unguiculata.**
**In wind tunnel olfactometer.*

insecticides for the sandfly vectors and chemotherapy for the parasites have proved unsuitable, due to their high cost, human toxicity and detrimental environmental effects. The life cycle of *Leishmania* takes place in the sandfly gut in an environment which includes food, digestive enzymes and their products. The competence of the fly to support the parasites may be influenced by components in its natural diet, especially sugars, for which it has a special predilection (*see 1994 ICIPE Annual Report*).

The overall goal of the ICIPE-Hebrew University of Jerusalem (HUJ) project is to identify natural sources of food for sandflies and to evaluate the effects of different diets on the vectorial potential for *Leishmania*. The attraction of sandflies to plants and their prevalence in three habitats were assessed this year.

Seventeen plants (five of which are represented in the figure) known to grow near sandfly breeding sites and human dwellings were tested for their attractancy to *Phlebotomus duboscqi*, an important vector of cutaneous leishmaniasis in the Old World in general and in Africa in particular. Three groups of plants emerged (see figure):

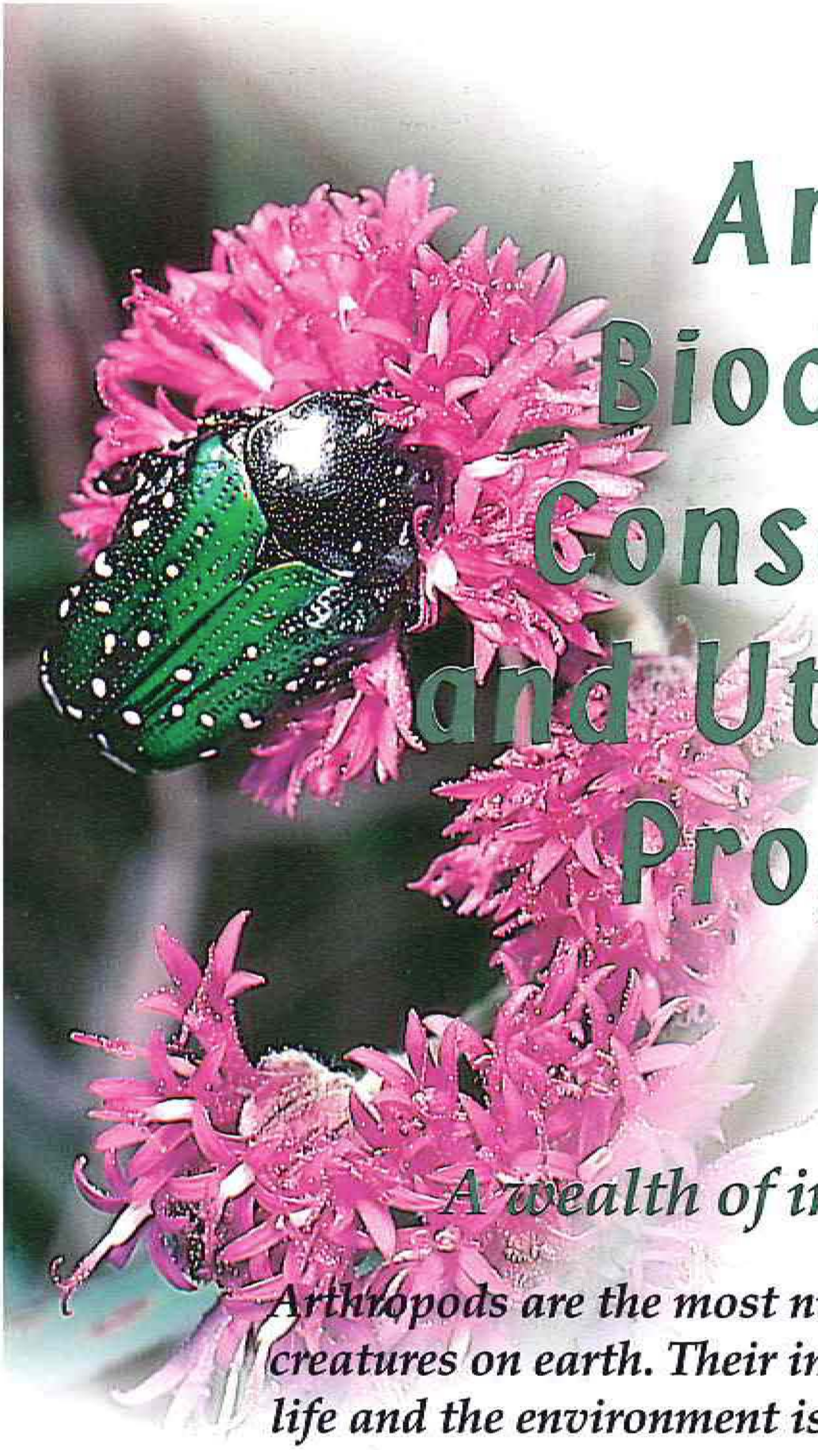
- plants with clear-cut repellency and/or antifeedant activity
- plants that attracted the fly and were used as a food source
- plants showing a more complex activity, with significant repellency but allowing a high feeding rate, or *vice versa*

Extraction and purification of the biologically active components should help clarify this picture.

The sandfly population was estimated in different kinds of sites using CDC light traps. Of the 626 sandflies trapped, more were caught near human habitations (334) than in vegetation (248) or open areas (44). Sugar meals were detected in all fly guts, with the highest percentage of sugar-fed flies being found in open areas. The relationship between sugar content of plants and the feeding response of *P. duboscqi* has been reported earlier (*see 1994 ICIPE Annual Report*), and investigations on the effect of plant feeding on the development of *Leishmania* in sandfly gut is in progress.

Funding: USAID through the Hebrew University of Jerusalem (HUJ)
Collaborators: HUJ

A big tummy could mean splenomegaly for these children from Marigat in Kenya's Baringo District, a focus of kala-azar. Enlargement of the spleen is also a symptom of persistent malaria, another common disease in this area.



Arthropod Biodiversity Conservation and Utilisation Programme

A wealth of insects...

Arthropods are the most numerous group of creatures on earth. Their impact on human life and the environment is often overlooked except when they cause problems. ICIPE's new programme area is looking at the positive side of the vast wealth of arthropod diversity, including their roles in maintaining the sustainability of the production base and as the basis for cottage industries.

Conserving Africa's insect biodiversity

Butterflies as monitors for forest health

Forest ecosystems are an essential component of the global ecology. The forest serves as a water catchment, as a sink for excessive carbon dioxide, and as a source of wealth of timber and other by-products. ICIPE is monitoring the health of the forests by using butterflies as indicator species of environmental change.

Throughout the tropics, deforestation is destroying this natural resource base, leaving only small forest fragments. A case in point is the eastern coastal forest of Africa, which once stretched thousands of miles from northern Natal to southern Somalia. In Kenya, only a few large tracts remain, such as the forests of Arabuko Sokoke (400 km^2) and the Shimba Hills (140 km^2). More common are the very small fragments like the Muhaka (1.8 km^2) and Mrima (3.5 km^2) forests. Although they are protected by the Kenya Government under the Forest Reserve Act, encroachment and over-exploitation of forest goods continues.

ICIPE researchers are surveying the species richness of butterflies in the two small forest fragments in order to provide a preliminary assessment of the effectiveness of remnant tropical forest patches to support biodiversity in general, particularly of the smaller fauna. Butterflies from each forest were collected from three sites: the forest interior, the edge and the support zone consisting of agricultural areas surrounding the forest.

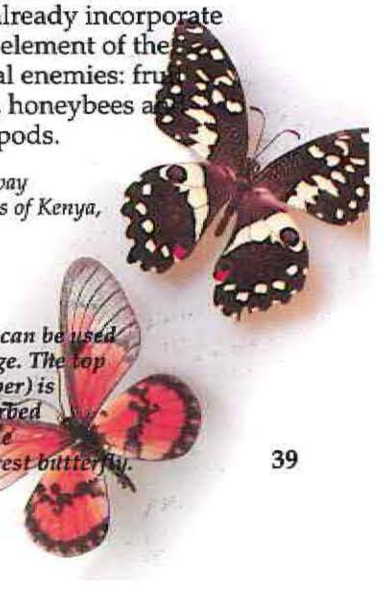
The open Muhaka fragment was characterised by a fairly even density of butterflies in all zones, with 67 species recorded in all. The interior forest had the most species (47), but 60% of these were savanna (non-forest) species, evidence of the high degree of habitat disturbance caused mainly by logging activity. In contrast to species richness, species diversity was highest at the edge. Species dominance was highest in the forest interior.

The Mrima fragment is a more closed forest, with a canopy covering the forest floor. Sixty-six species of butterflies were recorded, of which only 23 were true forest species, showing again the disturbance caused by logging, which produces the ideal open conditions for savanna butterflies (65% of the total species) to establish themselves. Compared to the larger Arabuko Sokoke forest reserve, the forest fragments of Muhaka and Mrima contained about a third as many species. However, the two patches were shown to contain several species which were not recorded even in the large forest reserves, such as *Acraea cerasa cerasa* Hewitson and *Celaenorrhinus ovalis* Evans from Muhaka and *Salamis parhassus parhassus* Drury from Mrima. No endemic species were recorded from the forest patches.

The true forest butterflies were not recorded outside the forest, i.e. in the support zone. Clearing the small forest fragments would therefore lead to local extinction of the forest butterflies. The 'bottom line' here is that as a policy measure, to preserve the diversity of the forest flora and fauna, the logged areas will have to be restored. This study is an example of how arthropods can be used as bioindicators of ecological change.

ICIPE's recommended programme direction in this important area was confirmed at a Planning Meeting of global experts and future collaborators in insect biodiversity held at the Centre in February, 1997. To support research into arthropod biodiversity, a database of African insects is to be developed. The workshop agreed on several priority areas which are inadequately covered by other entomology collections and databases. Several on-going projects at ICIPE already incorporate a biodiversity conservation element of their target insects or their natural enemies: fruit flies, stemborers, silkmoths, honeybees and graminae-associated arthropods.

Funding: The Government of Norway
Collaborators: National Museums of Kenya, Kenya Wildlife Society.



These two species of butterflies can be used to indicate environmental change. The top species (Papilio demodocus Esper) is normally associated with disturbed habitats, whereas the orange one (Acraea satis Ward) is a true forest butterfly.

Turning biodiversity into profit

Africa's wealth of insect life yields many useful products. Other than food, insects produce medicines, hormones, fibres, lac and chemicals. ICIPE's Commercial Insects project is looking at better ways of exploiting this vast natural resource through improved apiculture and sericulture and bioprospecting for new useful products.

Improved beekeeping

Apiculture is a traditional occupation in most African communities, but centuries-old practices of harvesting honey are inefficient and often cause death of the colony. ICIPE is introducing improved methods of beekeeping to farmers and women's groups supported by research back-up to solve the problems of African honeybee aggressiveness and queen rearing, and to improve production of honey and other valuable hive products.

1996 was the first official year of the ICIPE Commercial Insects Project. Research on three of the 11 sub-species or races of *Apis mellifera* found in Africa was conducted using East African races, but will soon be extended to other countries on the continent.

The population cycles of wild *A. mellifera* races in East Africa depend on both altitude and seasonal flowering. Floral calendars indicating the season of nectar flow were drawn up for various honey-producing regions in Kenya, Tanzania and Ethiopia. This information was used to establish a honeybee management plan.

Bees collect surplus nectar from a variety of plants and trees and these vegetative 'stores' in East Africa are currently being identified. For instance, in the semi-arid areas of Kenya and Tanzania, the *Acacia* genus is the predominant tree. In the high-potential western Kenya region, *Eucalyptus* predominates. In high-altitude regions such as Kinangop, Kenya, *Dombeya burgessiae* is the most common honey storage tree. Fruit-producing crops such as passion, coffee, citrus, banana, mango and avocado are widespread in East Africa and produce a large honey yield. The nectar flow period is at its peak when the large forest trees, shrubs, climbers, weeds and crops flower and the nectar-flow period is decreased when plants do not bloom simultaneously.

Swarming behaviour and queen production

Most African bees are notorious for their aggressiveness and have a tendency to leave the hive as a swarm. This is a natural process for establishing a new colony, as the swarm leaves with the old queen, leaving a new queen in the previous hive. However, it may mean that the beekeeper loses his bees! In the semi-arid Mwingi district of Kenya, honeybees swarm in response to the onset of the dry season. Reproductive swarming was observed during October and November at the beginning of the short rains and in February and March, at the beginning of the long rains. The factors initiating swarming in other areas are still under study.

A major breakthrough in beekeeping was achieved by developing and improving queen-rearing techniques. Three queen rearing methods were evaluated using the *A. m. scutellata* race and the reception of queen cells by various groups of workers was recorded in order to produce the most commercially valuable honeybee race(s). A comparative performance in egg-laying rate of queens of various African races is currently being assessed. Thus far, 17 queens have been artificially inseminated with specific drones in an attempt to select desirable behavioural traits in the offspring. This technology may resolve the behavioural defects of African honeybees (such as aggressiveness and absconding). In phase II of the project, the pure and hybrid races of the East African bees, as determined by the cubital index (*see 1995 ICIPE Annual Report*) collected from similar geographical locations will be compared on the basis of honey and bee-related products generation to determine which type is most profitable to the local apiculturist.

Bt for bee pests

The African bee industry is in an infant stage of modernisation and very little is known about bee pests and diseases. Various brood and adult diseases, as well as mite problems, which are so frequent in the other parts of the beekeeping world, have not arisen so far in the East African apicultural industry. However, the wax moth, *Galleria mellonela* is a major problem to beekeepers in Africa.

The use of the microbial pesticide *Bacillus thuringiensis* as a means to control the wax moth was evaluated. *Bt aiziwai* proved successful in completely controlling the wax moth. The bacteria exerted no detrimental effects on the honeybee brood or adult population. Tests are currently underway to check the quality of honey after eradication of the infection. On-farm trials to evaluate the efficacy of *Bt aiziwai* in local beehives and in the government apiary in Kenya are in progress.

ICIPE staff holding a queen cells frame after reception of grafted larvae in a coffee farm in Ruiru, Kenya. The large light-coloured queen cells are visible.

Better hives mean more honey

The first phase of this project involved the introduction of the innovative 10-frame Langstroth hive from America *(see photo)*. The real advantage of this hive is that honey can be cleanly harvested through centrifugation without destroying the combs, which can be reused. This saves the time and labour of bees and results in an increase in honey production which is 2–3-fold higher than that obtained in traditional African hives. The use of the Langstroth hives can multiply the volume of honey produced each season to 24–30 kg from the 5–8 kg per harvest in the logwood hive and 10–15 kg in the top bar. The cost of this hive is Ksh. 1500–1800 or US$ 27–32. When using the Langstroth hive, queen rearing is also simplified and colony multiplication becomes easier. Other hive products such as royal jelly, propolis, pollen and bee-venom can be harvested with little difficulty. Thus far, over 430 of these hives have been introduced to farmers' and women's groups in Kenya, Tanzania, Ethiopia and Uganda.

Harvesting the valuable hive products

Initial attempts were made this year to improve the techniques of extracting royal jelly and bee venom. Two different honeybee races, *A. m. scutellata* and *A. m. monticolla*, were compared on the basis of royal jelly production. Preliminary results indicate that the latter produces more royal jelly than the former. Additional experiments are underway to improve the method of royal jelly production. This will help beekeepers in Africa increase their income by augmenting the returns of bee-related products. (The price of 1 kg of royal jelly on the world market is US$ 70–100).

Bee venom is produced in the bee's venom gland and is stored in the venom sac. In humans, bee venom stimulates the heart and cortico-adrenal glands. It induces cortisone production, which makes it suitable for the treatment of rheumatic diseases, especially arthritis. A simple technique to collect bee venom was designed as part of this project using an electrically charged grid. In total, 81.2 mg of bee venom was collected from 6000 worker bees. Further research is currently underway to evaluate the abilities of *A. mellifera* races in Africa to produce bee venom, which sells at a cost of US$ 80–100 for 1 g in China.

Sericulture for Africa

Sericulture, or the rearing of silkworms, is a new occupation for most of Africa. Silk fibre can be harvested from both domesticated and wild moths, and ICIPE's new project is developing methods of sericulture appropriate for Africa which will also assist in conserving the valuable wild species of moths.

The wild silk of Africa

In the wild, the biodiversity of indigenous silkmoths and their habitats is eroding as a result of the lack of traditional knowledge on the value of the silkworm for income generation. In some communities, silkmoth larvae and pupae are harvested in bulk as a protein food source, but there are no mechanisms for the replenishment of the silkworms (the moth larvae) consumed. In Kenya and Uganda, a survey on existing wild silkmoth species identified two potential species, *Argema mimosae* and *Gonometa* sp. (from the lepidopteran families Saturniidae and Lasiocampidae, respectively) which produce a silk fibre of high quality.

The population dynamics of the *Argema* and *Gonometa* spp. are currently being studied in farmers' fields at two locations in Kenya. Overall mortality of the larval instars due to parasites, predators and other factors is high, about 84% in one field. Methods are being developed in the wild to desynchronise the parasite cycles with that of the silkworm in order to decrease silkworm mortality and silk-fibre spoilage. A bioassay is being designed to determine the optimal time for breaking pupal and egg-diapause, thereby establishing a continuous production system on the basis of host-plant availability. Another saturniid moth, *Bunea alcinoe*, whose caterpillars are consumed in many parts of Africa, has also been successfully reared in the laboratory using leaves of the host plant, *Balanites aegyptiaca*.

Wild silk production can provide a strong economic incentive for rural communities to adopt sound land management practices as an adjunct to subsistence agriculture. Sericulture thus promotes the conservation of natural ecosystems and wild silkmoth habitats in the face of a growing human population and a heightened demand for land.

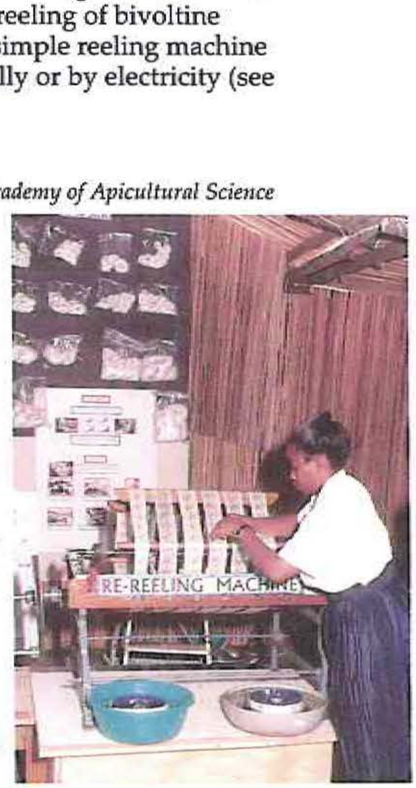
This wild silkmoth (*Gonometa *sp.) is stimulated to lay eggs on her silk cocoon soon after emergence. The cocoon is a source of the valuable tussar silk. ICIPE is training farmers on the conservation of wild moths for income generation.

Culturing of *Bombyx mori*

After a long search, a new domestic silkmoth hybrid has been developed at ICIPE that flourishes in the African environment and produces a high quality silk. The hybrid was selected by crossing a number of domestic silkmoth (*Bombyx mori*) strains and testing their vigour when grown on a variety of mulberry cultivars. The silkworm hybrid cross $NB_{18} \times NB_7$ was found to generate the highest silk yield when grown on the mulberry Kanva 2 cultivar. One kg of raw silk is obtained from approximately 5000–6000 quality cocoons. All necessary materials needed to rear domestic silkworms in the field are being constructed in ICIPE's sericulture unit using local materials and local labour. The reeling of bivoltine cocoons is done on a simple reeling machine which can run manually or by electricity (see photo).

Funding: IFAD

***Collaborators:** Chinese Academy of Apicultural Science (CAAS), China; Central Silk Board (CSB), India; New South Wales (NSW), Australia.*



A silk reeling machine, designed by an ICIPE sericulture specialist and purpose built for Africa by an Indian firm. The sericulture and apiculture cottage industries can provide the economic basis for community development, and both are particularly suited for increasing women's participation in the cash economy.

TechnoPark

A pioneer science park to produce and promote ICIPE's research products and foster low volume production of appropriate insect management technologies for use in developing countries is in the advanced planning stage, with some activities already in operation. The Centre is collaborating with national and regional R&D institutions, universities and the private sector in implementing the plans. Several of the current TechnoPark initiatives are summarised below:

Neem: ICIPE has collaborated with GTZ and SAROC Ltd. a private company, on the development of a smallscale industry based on neem-based insecticides. The goal is to produce simple, standardised neem-based pesticides, which can be purchased on the market at competitive prices. To date, about 16 tonnes of seeds have been purchased and transported to Nairobi. The azadirachtin (aza) content is being measured by high performance liquid chromatography (HPLC) in ICIPE's chemistry laboratories. Two formulations have been developed and are being tested: (i) neem cake powder, standardised at 0.5% aza by reconstituting the neem cake with neem seed shell in adequate proportion, and (ii) water-miscible oil with 0.03% aza.

To fulfill the requirements of the Pest Control Products Board (PCPB) of Kenya, field and laboratory trials were started in order to test the effectiveness of the formulated products. The frequency of application and effective concentrations which are economically competitive with available pesticides for control of key pests in important horticultural crops is also being determined. *(For testing of neem preparations on insect pests, see the research reports, for example on page 20).*

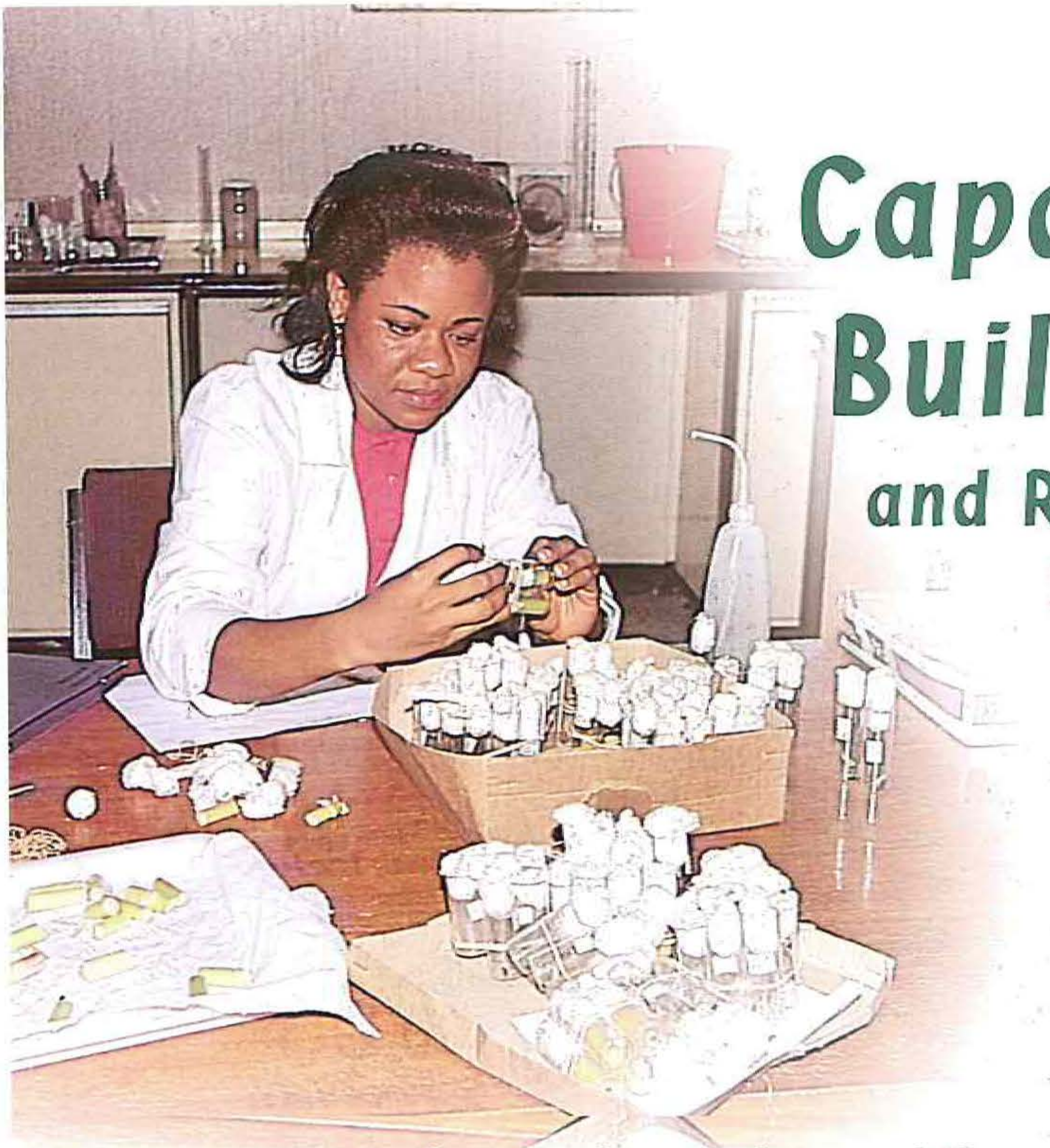
***Bt*-based control agents:** ICIPE is currently developing a number of *Bacillus thuringiensis (Bt)*-based biopesticides for use against mosquitoes, stemborers and wax moth. The production of DUDUSTOP^R, a *Bt* formulation used to control filthflies, continues to be done in a small laboratory fermenter (15-litre) and available shaker incubators. ICIPE has provided about 350 litres to relief organisations. A private company, Oy GAC Ab from Finland, has produced 500 litres and this has been distributed to UNHCR by ICIPE as per the current agreement. SAROC K. Ltd. is currently upscaling the production capacity of the pesticide and has fabricated a 1000-litre fermenter. ICIPE will provide the inoculum to the plant. It is hoped that SAROC will eventually take over the local production of the material when the plant is ready.

The biotechnology laboratory has also produced more than 125 litres of *Bt kurstaki* for control of *Chilo partellus*. Meanwhile, further studies on other indigenous *Bt* isolates against selected tropical insect pests are being carried out. From these studies, three selected isolates (ISO1, ISO2 and ISO3) have proved adequately toxic to three species of stemborers.

Four *Bt* isolates (*Bt aizawai*, M44-2, 50 and ICIPE-T) from the ICIPE microbial bank have been screened against the greater wax moth which attacks honeybee colonies. The *Bt aizawai* was found to be the most active and results so far indicate that a concentration of between 3–5% of the fermentation broth gives between 80–100% protection after 5–7 days, particularly in the case of 2nd instar moth larvae. Mass multiplication of the bacteria for large-scale field testing is in progress.

The final report on efforts to develop more persistent cloned materials of *Bacillus sphaericus* with improved mosquito larvicidal activity by transferring material coding for one or more of the several *Bacillus thuringiensis israelensis (Bti)* strains has been submitted. The nine clones were more toxic to *Aedes aegypti* with an LD_{50} range of 0.36–1.01 µg/ml as compared to the original *Bsp* with an LD_{50} of 46.18 µg/ml. The *Bti* still remains the most toxic with an LD_{50} of 0.017 µg/ml. The toxicity of the nine clones of *B. sphaericus* and *B. thuringiensis* to both *Culex quinqifasciatus* and *Anopheles gambiae* was comparable with an LD_{50} range of 0.0010–0.009 µg/ml. Although these Israeli-produced clones are active against the three mosquito species, they seem to deteriorate on storage. Further investigation is needed before eventual mass production can be implemented.

Funding: *USAID, ICIPE Core Funds*
Collaborators: *Hebrew University of Jerusalem, SAROC K. Ltd., Oy GAC Ab, Finland, GTZ*



Capacity Building
and Research Support

A continent in waiting...

ICIPE's extensive education and training activities are geared to all its stakeholders, from the farmer level up to PhD scientists and beyond. All of the 80 or so graduates of ICIPE's postgraduate programme in insect science have remained in Africa. Empowering people to solve their own problems is half the development battle.

Building capacity for development

Human resources development is one of the cornerstones of ICIPE's mandate. Individual and institutional capacity in the multi-disciplinary field of insect science spans each and every one of the Centre's programme activities, and this feat is achieved in partnership with universities, advanced research laboratories and national institutions throughout the world, but especially in Africa.

Capacity building is one of the most active programmes of ICIPE, through which substantial achievements have been made in the past two decades. The programme aims to enhance the capabilities of developing countries in the tropics and subtropics, particularly in Africa, for research and training in insect science to promote the development and utilisation of sustainable arthropod management technologies. Apart from providing a mechanism by which ICIPE disseminates its research findings to the consumers, the programme makes a major contribution to ICIPE's research through the activities of postgraduate students and postdoctoral scientists training at the Centre. In financial terms, the programme constitutes more than 30% of ICIPE's annual budget. The thrust of ICIPE's capacity building strategy is directed toward three major areas of activity:

- training of African nationals for leadership in insect science and to enhance interactive technology generation and adaptation;
- enhancement of national capacities for technology diffusion, adoption and utilisation, and
- facilitation of dissemination and exchange of information.

The ARPPIS (African Regional Postgraduate Programme in Insect Science) PhD programme is based at ICIPE, where students undergo three years of research training. The ICIPE provides a thesis project, research facilities and supervision, and a training fellowship to support students' maintenance, university fees and research costs, totalling US$ 30,000 per student per year. The students are registered at any of the 30 African participating universities which examine the students and award them degrees. Each PhD class is composed of an average of seven students. The programme has, at any one time, between 20 and 40 students at various stages of their thesis work at ICIPE. To date, a total of 126 scholars have been enrolled in the programme from 25 African countries.

ARPPIS celebrated its 13th anniversary in style in 1996, with 12 graduates of the programme being awarded their PhD degrees from various participating universities during the year. This brings the number of ARPPIS-trained doctoral scientists to 82. Research training progressed well for continuing students of the 1993, 1994 and 1995 classes, while three new students joined in 1996. Training at masters level continued in the ARPPIS MPhil programme hosted by the University of Ghana, with the first intake of students proceeding to the second year, while the third intake for the ARPPIS MSc course scheduled at the University of Zimbabwe was postponed due to lack of enough sponsored candidates. The MSc Programme for Eastern Africa, hosted by Addis Ababa University, is to be launched in September 1997. The success of the ARPPIS programme has stimulated university interest, whereby 18 universities have renewed their collaboration with ICIPE under new agreements. ICIPE is proud of the fact that after graduation, all former ARPPIS scholars stay in Africa to work towards solving the continent's insect-related problems. Most graduates are employed in national research systems, universities or in science-based international organisations (see table).

The Dissertation Research Internship Programme (DRIP), which supplements the

Careers and placement of ARPPIS PhD graduates of classes as at 31 December 1996

Employing organisation/ Level of responsibility	PhD graduates	Awaiting award of PhD
National research systems:		
- Directors/Project leaders	11	0
- Research officers	30	11
Universities in Africa:		
- Heads of departments	4	0
- Snr lecturers/lecturers	21	5
International organisations based in Africa:		
- Scientists and postdocs.	15	0
Commercial business firms:		
- Technical managers	1	0
Total scientists released to date (= 98)	82	16

Note: The total excludes losses during training: deceased, 3; discontinued, 7.

ARPPIS programme by providing training opportunities to students recruited worldwide, also saw marked activity with nine new postgraduate students from Somalia, Kenya, China, Britain and Germany registered during the year.

Professional career development programmes

Three schemes were implemented to enable individual scientists to advance their careers through training. These included: the **postdoctoral fellowship programme**, which this year enabled four young scientists from Kenya, Ethiopia and Cameroon to serve at ICIPE; the **research associateship scheme**, through which two scientists from Sudan from national research and training institutions gained experience through research in chemical ecology; and the **visiting scientist scheme**, which facilitated the participation in 1996 of two scientists from Japan and one scientist from the Czech Republic to conduct research at ICIPE.

Non-degree training for technology adoption

In order to ensure that the Centre's technologies reach its end-users, ICIPE conducts training programmes for IPM practitioners and other interested groups. To date, ICIPE has trained a total of 831 insect pest management practitioners and over 3000 farmers in various aspects of insect science. Examples of some such courses offered in 1996 include the following:

- eight specialised group courses for the training of insect pest management practitioners, including one held in Niger in the French language in which 173 people were trained;
- several farmers' awareness courses in which 535 farmers from Kenya and Ethiopia participated;
- practical training for 57 young technologists to receive hands-on training in laboratory techniques and practice through in-service attachment.

ARPPIS enrols students from 25 African countries (1983–1996 classes)

Country	No. students
Benin	1
Burkina Faso	1
Cameroon	1
Chad	2
Egypt	3
Ethiopia	7
Ghana	3
Kenya	39
Malagasy	1
Malawi	2
Mali	1
Mozambique	1
Namibia	1
Nigeria	13
Rwanda	2
Senegal	1
Sierra Leone	3
Somalia	2
South Africa	1
Sudan	14
Tanzania	7
Uganda	10
Zambia	5
Zaire	4
Zimbabwe	1
Total	126

Funding: *DAAD (major sponsor), IFAD, GTZ, Rockefeller Foundation, through ICIPE projects*
Collaboration: *ICRAF; Universities of Nairobi, Kenya; Nnamdi Azikiwe Univ., Nigeria; Enugu State Univ. of Science and Technology, Nigeria; Alemaya Univ. of Agriculture, Sudan; University of Gezion, Sudan; Cape Coast, Ghana; Pretoria, South Africa; Malawi; Ogun State Univ., Nigeria; Moi University, Kenya; Zambia; Khartoum, Sudan; Ibadan, Nigeria; Zimbabwe; Kenyatta Univ., Kenya; Rivers State Univ of Science and Technology, Nigeria; Assiut Univ., Egypt; Maiduguri, Nigeria; Ahmadu Bello Univ., Nigeria.*

Research Support Units*

ICIPE's support units provide specialist services to the Centre's research activities, and help to collect and disseminate information among the scientists and ICIPE's stakeholders.

A mini-project on developing an IPM Information Network for Africa was initiated by the **Computer Unit** (CU) in 1996. Three East African countries (Ethiopia, Kenya and Uganda) will particpate in the first phase of the project, after which the network will be extended to other countries of the former PESTNET (Pest Management and Information Network) in the East and southern Africa region. Eventually the IPM Information Network will be continent-wide. A dial-up e-mail/Internet connectivity has been established through a local Internet service provider for most of the Centre's computers with fax/modem. Personnel training on Internet e-mail and Internet browsing is also being conducted.

The **Animal Rearing and Quarantine Unit (ARQU)** began the provision of quarantine facilities for research activities in 1996. Built and equipped under the Wageningen Agricultural University/ICIPE collaborative project on the biological control of cereal stemborers, the unit will facilitate the importation of research insects and other arthropods, control entry of arthropods and potential plant and animal pathogenic microorganisms, and maintain cultures of imported arthropods and microorganisms under restricted conditions so as to exclude the possibility of escape of any onoxious insects. It will also determine the health status of all arthropods imported through ICIPE, and will multiply arthropods under quarantine for supply to users. (*See research reports for ARQU's supply of arthropods to the projects*).

The **Information Resources Centre (IRC)** provides and makes available useful information in recorded format to ICIPE staff and other users. The IRC houses over 190 journals relevant to insect science, as well as over 3000 monographs, theses and reports, and about 11,000 books. The IRC produces the Pest Management Documentation and Information Systems and Service (PMDISS) bibliography as a means of maintaining a pest management database in the East and southern Africa region. A large chunk of this information with a specific bias on African livestock diseases has been used to publish a CD-ROM disk by ILRI-Ethiopia. Data from the PMDISS database was also given to UNECA/PADIS, and again was used to prepare an African Pest Information database on CD-ROM for use in the sub-region. The existing collaborative efforts between ICIPE and FAO continues, with ICIPE contributing relevant data to the AGRIS Information Service on a regular basis.

The newly created **Information Services unit** amalgates the former editing and publishing functions of ICIPE with the Information Resources Centre (IRC) for more efficient publication, documentation and dissemination of the Centre's research results and development activities. **ICIPE Science Press** is the publishing arm of ICIPE, and provides a service to the Centre by producing and printing much of the stationery, conference proceedings and other documents. ISP also co-publishes tertiary-level or scholarly works for external clients, such as the 13-volume series for the United Nations Institute for Natural Resources in Africa, and the new journal *Horizon—Developing an Architectural Tradition for Africa* for a Kenyan university (JKUCAT). The Press underwent an external review during the year by a publishing consultant, and her recommendations for improving on cost effectiveness and efficiency are now being implemented. The ICIPE-sponsored journal, ***Insect Science and its Application*** is completeing its 16th volume, and Volume 17 (1997) is in press. The journal benefited from the afore-mentioned consultant's input, and is attempting to improve on its editorial content, presentation and timeliness. Regional offices in South America and Asia will soon be established so as to make the journal more pan-tropical in content and appeal.

(**The activities of the Biomathematics and Biosystematics units have been included in the research reports*).

1996/97 ICIPE publications

A. Refereed papers

(Includes notifications up to September 1997. Does not include articles in press or those submitted)

Annan I. B., Saxena K. N., Schaefers G. A. and Tingey W. M. (1994) Effects of infestation by cowpea aphid (Homoptera: Aphididae) on different growth stages of resistant and susceptible cowpea cultivars. *Insect Science and its Application* 15, 401–410. 94-1370

Assad Y. O. H., Torto B., Hassanali A., Njagi P. G. N., Bashir N. H. H. and Mahamat H. (1997) Seasonal variation in the essential oil composition of *Commiphora quadricincta* and its effect on the maturation of immature adults of the desert locust, *Schistocerca gregaria*. *Phytochemistry* 44, 833–841. 97-1350

Assad Y. O. H., Hassanali A., Torto B., Mahamat H., Bashir N. H. H. and El Bashir S. (1997) Effects of fifth-instar volatiles on sexual maturation of adult desert locust *Schistocerca gregaria*. *Journal of Chemical Ecology* 23, 1373–1388. 97-1365

Bekele A. J., Obeng-Ofori D. and Hassanali A. (1996) Evaluation of *Ocimum suave* (Willd.) as a source of repellents, toxicants and protectants in storage against three stored product insect pests. *International Journal of Pest Management* 42, 139–142. 96-1305

Bekele A. J., Obeng-Ofori D. and Hassanali A. (1997) Evaluation of *Ocimum kenyense* (Ayobangira) as source of repellents, toxicants and protectants in storage against three major stored product insect pests. *Journal of Applied Entomology* 121, 169–173. 97-1352

Binta M. G., Mushi E. Z. and Rurangirwa F. R. (1996) Effect of anti-thymocyte serum on acquisition of resistance to infestation by *Rhipicephalus appendiculatus* larvae in rabbits. *Onderstepoort Journal of Veterinary Research* 63, 213–216. 96-1325

Chitere P. and Kiros F. G. (1996) Farmers' participation in the adaptation of IPM technologies in sub-Saharan Africa: Experiences from Kenya. *The African Crop Science Journal* 4, 115–126.

Dakouo D., Nacro S., Post R., Traore Y., Nokoe S. and Munyinyi D. M. (1995) Evaluating an insect pest management system in an irrigated rice environment. *Insect Science and its Application* 16, 93–101. 95-1368

Darlington J. P. E. C. (1994) Mound structure and nest population of the termite, *Pseudacanthotermes spiniger* (Sjostedt) in Kenya. *Insect Science and its Application* 15, 445–452. 94-1371

Deng A. L., Torto B., Hassanali A. and Ali E. E. (1996) Effects of shifting to crowded or solitary conditions on pheromone release and morphometrics of the desert locust, *Schistocerca gregaria* (Forskål) (Orthoptera: Acrididae). *Journal of Insect Physiology* 42, 771–776. 96-1324

Denlinger D. L. and Zdarek J. (1997) A hormone from the uterus of the tsetse fly, *Glossina morsitans*, stimulates parturition and abortion. *Journal of Insect Physiology* 43, 135–142. 97-1339

Dossa S. C., Kaaya G. P., Essuman S., Odulaja A. and Assoku R. G. K. (1996) Acquisition of resistance to the tick *Amblyomma variegatum* in Boran cattle, *Bos indicus* and the effects of *Trypanosoma congolense* and *Babesia bigemina* on host resistance. *Veterinary Parasitology* 62, 317–330. 96-1290

Duale A. H., Nwilene F. E. and Okwakpam B. A. (1997) Suitability of pupae of the stem borer *Chilo partellus* (Swinhoe) (Lep.: Pyralidae) of various ages for parasitism by *Pediobus furvus* (Gahan) (Hym.: Eulophidae). *Journal of Applied Entomology* 121, 147–150. 97-1360

Duale A. H. and Seshu Reddy K. V. (1995) Survival and development of *Chilo partellus* (Swinhoe) on sorghum cultivars. *Insect Science and its Application* 16, 13–16. 95-1354

Hanson B. S., Ochieng S. A., Grosmaitre X., Anton S. and Njagi P. G. N. (1996) Physiological responses and central nervous projections of antennal olfactory receptor neurons in the adult desert locust, *Schistocerca gregaria* (Orthoptera: Acrididae). *Journal of Comparative Physiology, A* 179, 157–167.

Jura W. G. Z. O. and Otieno L. H. (1994) Infectivity and virulence of *Trypanosoma brucei* metacyclics from *Glossina morsitans morsitans* salivary glands infected with tsetse DNA virus. *Insect Science and its Application* 15, 551–556. 94-1318

Kaaya G. P., Mwangi E. N. and Ouna E. (1996) Prospects for biological control of livestock ticks, *Rhipicephalus appendiculatus* and *Amblyomma variegatum*, with entomogenous fungi *Beauveria bassiana* and *Metarhizium anisopliae*. *Journal of Invertebrate Pathology* 67, 15–20. 96-1291

Khan Z. R., Abenes M. L. P. and Fernandez N. J. (1996) Suitability of graminaceous weed species as host plants for rice leaffolders, *Cnaphalocrocis medinalis* and *Marasmia patnalis*. *Crop Protection* 15, 121–127. 96-1299

Khan Z. R., Ampong-Nyarko K., Chiliswa P., Hassanali A., Kimani S., Lwande W., Overholt W. A., Pickett J. A., Smart L. E., Wadhams L. J. and Woodcock C. M. (1997) Intercropping increases parasitism of pests. *Nature* 388, 631–632. 97-1363

Kimani-Njogu S. W., Overholt W. A., Woolley J. and Walker A. (1997) Biosystematics of the *Cotesia flavipes* species complex (Hymenoptera: Braconidae): Morphometrics of selected allopatric populations. *Bulletin of Entomological Research* 87, 61–66. 97-1346

Kitron U., Otieno L. H., Hungerford L. L., Odulaja A., Brigham W. U., Okello O. O., Joselyn M., Mohamed-Ahmed M. M. and Cook E. (1996) Spatial analysis of the distribution of tsetse flies in the Lambwe Valley, Kenya, using Landsat TM satellite imagery and GIS. *Journal of Animal Ecology* 65, 371–380. 96-1308

Madubunyi L. C., Hassanali A., Ouma W., Nyarango D. and Kabii J. (1996) Chemoecological role of mammalian urine in host location by tsetse, *Glossina* spp. (Diptera: Glossinidae). *Journal of Chemical Ecology* 22, 1187–1199. 96-1297

Mahamat H., Hassanali A. and Ferenz H.-J. (1997) Vitellogenin titres in normal and accelerated maturition of gregarious-phase *Schistocerca gregaria*. *Comparative Biochemistry and Physiology* 116B, 447–451. 97-1340

Maniania N. K. (1994) A laboratory technique for infecting adult tsetse with a fungal pathogen. *Insect Science and its Application* 15, 421–426. 94-1316

Massamba N. N. and Mutinga M. J. (1994) Heterogeneity in the *Leishmania donovani* complex (Protozoa: Kinetoplastidae). *Insect Science and its Application* 15, 541–550. 94-1317

Mbapila J. C. and Overholt W. A. (1997) Oviposition, development and searching behaviour of *Cotesia flavipes* Cameron and *Cotesia sesamiae* (Cameron) (Hymenoptera: Braconidae) in relation to aestivating and non-aestivating *Chilo* spp. (Lepidoptera: Pyralidae) larvae in maize. *African Entomology* 5, 35–39. 97-1356

Mihok S. and Clausen P. H. (1996) Feeding habits of *Stomoxys* spp. stable flies in a Kenyan forest. *Medical and Veterinary Entomology* 10, 392–394. 96-1358

Mihok S., Maramba O., Munyoki E. and Saleh K. (1996) Phenology of Stomoxyinae in a Kenyan forest. *Medical and Veterinary Entomology* 10, 305–316. 96-1322

Mihok S., Moloo S. K., Oden'y J. O., Brett R. A., Rakwar J. G., Munyoki E., Kiilu J. and Kyorku C. A. (1996) Attractiveness of black rhinoceros (*Diceros bicornis*) to tsetse flies (*Glossina* spp.) (Diptera: Glossinidae) and other biting flies. *Bulletin of Entomological Research* 86, 33–41. 96-1279

Minja E. M. and Ampofo J. K. (1995) Effect of sorghum and cowpea intercropping pattern on the spotted stemborer, *Chilo partellus* (Swinhoe) larval establishment in southwestern Kenya. *Insect Science and its Application* 16, 217–222. 95-1367

Mohamed-Ahmed M. M. and Odulaja A. (1997) Diel activity patterns and host preferences of *Glossina fuscipes fuscipes* (Diptera: Glossinidae) along the shores of Lake Victoria, Kenya. *Bulletin of Entomological Research* 87, 179–186. 97-1341

Muhigwa Bahananga J.-B., Diamani B. and Kabungo K. (1996) Physico-chemical preferences of the zooplankton and notes on the predominance of a carnivorous copepod in Lake Tanganyika. *African Journal of Ecology: (E.A. Wildlife Society)* 34, 86–89. 96-1301

Mwangi E. N. and Kaaya G. P. (1997) Prospects of using parasitoids for tick management in Africa. *International Journal of Acarology* 23, 1–5.

Mwangi E. N., Hassan S. M., Kaaya G. P. and Essuman S. (1997) The impact of *Ixodiphagus hookeri*, a tick parasitoid of *Amblyomma variegatum* (Acari: Ixodidae) in a field trial in Kenya. *Experimental and Applied Acarology* 21, 117–126.

Ndiege I. O., Budenberg W. J., Otieno D. O. and Hassanali A. (1996) 1,8-cineole: An attractant for the banana weevil, *Cosmopolites sordidus*. *Phytochemistry* 42, 369–371. 96-1307

Ngi-Song A. J., Overholt W. A., Njagi P. G. N., Dicke M., Ayertey J. N. and Lwande W. (1996) Volatile infochemicals used in host and host habitat location by *Cotesia flavipes* Cameron and *Cotesia sesamiae* (Cameron) (Hymenoptera: Braconidae), larval parasitoids of stemborers on graminae. *Journal of Chemical Ecology* 22, 307–324. 96-1285

Nguu E. K., Osir E. O., Imbuga M. O. and Olembo N. K. (1996) The effect of host blood in the *in vitro* transformation of bloodstream trypanosomes by tsetse midgut homogenates. *Medical and Veterinary Entomology* 10, 317–322. 96-1323

Njagi P. G. N., Torto B., Obeng-Ofori D. and Hassanali A. (1996) Phase-independent responses to phase-specific aggregation pheromone in adult desert locusts, *Schistocerca gregaria* (Orthoptera: Acrididae). *Physiological Entomology* 21, 131–137. 96-1302

Nyindo M., Essuman S., Chesang' R. and Muteria P. (1996) Immunity induced by vaccination with *Rhipicephalus appendiculatus* salivary gland antigens does not augment immunity acquired naturally by exposing rabbits to adult ticks. *Journal of Medical Entomology* 33, 559–565. 96-1303

Obeng-Ofori D., Reichmuth Ch., Bekele J. and Hassanali A. (1997) Biological activity of 1, 8-cineole, a major component of essential oil of *Ocimum kenyense* (Ayobangira) against stored product beetles. *Journal of Applied Entomology* 121, 237–243. 97-1366

Odulaja A. and Abu-Zinid I. M. (1996) The relative efficiencies of Latin square and randomized complete block designs for insect trapping experiments: An investigation using field data on tsetse flies. *Ecological Entomology* 21, 101–105. 96-1309

Odulaja A. and Kiros F. G. (1996) Modelling agricultural production of small-scale farmers in sub-Saharan Africa: A case study in western Kenya. *American Journal of Agricultural Economics* 14, 85–91. 96-1320

Odulaja A. and Mohamed-Ahmed M. M. (1997) Estimation of the efficiency of the biconical trap for *Glossina fuscipes fuscipes* Newstead along the Lake Victoria shore, Kenya. *Entomologia Experimentalis et Applicata* 82, 19–24. 97-1345

Oghiakhe S. (1995) Progress and future prospects in utilisation of host plant resistance in the control of insect pests of cowpea, *Vigna unguiculata* in Africa. *Insect Science and its Application* 16, 123–143. 95-1349

Ogoyi D. O., Osir E. O. and Olembo N. K. (1996) Effect of phase status on responses to AKH I in the desert locust, *Schistocerca gregaria gregaria*. *Archives of Insect Biochemistry and Physiology* 32, 173–185. 96-1304

Okech S. H. O. and Overholt W. A. (1996) Comparative biology of *Cotesia chilonis* (Hymenoptera: Braconidae) on selected African gramineous stemborers. *Biocontrol Science and Technology* 6, 595–602. 96-1326

Omolo E. O., James M. D., Osir E. O. and Thomson J. A. (1997) Cloning and expression of a *Bacillus thuringiensis* (L1-2) gene encoding a crystal protein active against *Glossina morsitans morsitans* and *Chilo partellus*. *Current Microbiology* 34, 118–121. 97-1344

Omwega C. O. and Overholt W. A. (1996) Genetic changes occurring during laboratory rearing of *Cotesia flavipes* Cameron (Hymenoptera: Braconidae), an imported parasitoid for the control of gramineous stem borers in Africa. *African Entomology* 4, 231–237. 96-1321

Omwega C. O., Overholt W. A., Mbapila J. C. and Kimani-Njogu S. W. (1997) Establishment and dispersal of *Cotesia flavipes* (Cameron) (Hymenoptera: Braconidae), an exotic endoparasitoid of *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) in northern Tanzania. *African Entomology* 5, 71–75. 97-1355

Potting R. P. J., Overholt W. A., Danso F. O. and Takasu K. (1997) Foraging behaviour and life history of the stemborer parasitoid, *Cotesia flavipes*. *Journal of Insect Behaviour* 10, 13–29.

Rai M. M., Hassanali A., Saini R. K., Odongo H. and Kahoro H. (1997) Identification of components of the oviposition aggregation pheromone of the gregarious desert locust, *Schistocerca gregaria* (Forskal). *Journal of Insect Physiology* 43, 83–87. 97-1353

Saini R. K., Hassanali A., Andoke J., Ahuya P. and Ouma W. P. (1996) Identification of the major components of larviposition pheromone from larvae of tsetse flies *Glossina morsitans morsitans* Westwood and *Glossina morsitans centralis* Machado. *Journal of Chemical Ecology* 22, 1211–1220. 96-1306

Saini R. K., Rai M. M., Hassanali A., Wawiye J. and Odongo H. (1995) Semiochemicals from froth of egg pods attract ovipositing females *Schistocerca gregaria*. *Journal of Insect Physiology* 41, 711–716.

Saxena R. C. and Kidiavai E. L. (1997) Neem seed extract spray applications as low-cost inputs for management of the flower thrips in the cowpea crop. *Phytoparasitica* 25, 99–110. 97-1348

Solomon G. and Kaaya G. P. (1996) Comparison of resistance in three breeds of cattle against African ixodid ticks. *Experimental and Applied Acarology* 20, 223–230. 96-1298

Takasu K. and Overholt W. A. (1996) Oviposition behaviour of *Cotesia flavipes* and *Goniozus indicus*, larval parasitoids of the lepidopteran stemborer, *Chilo partellus*. *Japan Journal of Applied Entomology and Zoology* 40, 308–310.

Tawfik A. I., Mat'hova A., Sehnal F. and Ismail S. H. (1996) Haemolymph ecdysteroids in the solitary and gregarious larvae of *Schistocerca gregaria*. *Archives of Insect Biochemistry and Physiology* 31, 427–438. 96-1311

Tawfik A. I., Vedrova A., Li W., Sehnal F. and Obeng-Ofori D. (1997) Haemolymph ecdysteroids and the prothoracic glands in the solitary and gregarious adults of *Schistocerca gregaria*. *Journal of Insect Physiology* 43, 485–493. 97-1347

Torto B., Hassanali A., Nyandat E. and Bentley M. D. (1996) A limonoid from *Turraea floribunda*. *Phytochemistry* 42, 1235–1237. 96-1314

Torto B., Njagi P. G. N., Hassanali A. and Amiani H. (1996) Aggregation pheromone system of nymphal gregarious desert locust, *Schistocerca gregaria* (Forskal). *Journal of Chemical Ecology* 22, 2273–2281. 96-1327

Zdarek J. and Denlinger D. L. (1997) Species variation in the response of tsetse flies (*Glossina* spp., Diptera: Glossinidae) to parturition hormone. *European Journal of Entomology* 94, 381–383. 97-1362

B. Other publications

(Includes review articles, papers in published conference proceedings, books, chapters in books, articles in newsletters, electronic-journal articles and theses)

Herren H. R., Overholt W. A. and Lwande W. (1996) Pest management for ornamental horticulture. *Horticultural Trade Journal* 4, 23–24. 96-1364

Kiarie M. and Saxena R. C. (1996) Exploratory evaluation of neem extract sprays on maize for control of stalk borers in coastal Kenya, pp. 571–573. In *Neem and Environment*, Vol. 1 (Edited by R. P. Singh, M. S. Chari, A. K. Raheja and W. Kraus). Proceedings of the World Neem Conference, India, 1993. Oxford & IBH, New Delhi.

Khan Z. R. (1997) A review of entomological techniques and methods used to determine mechanisms and bases of stem borer resistance in maize, pp. 62–67. In *Insect Resistant Maize: Recent Advances and Utilisation* (Edited by J. A. Mihm). Proceedings of an International Symposium held at the International Maize and Wheat Improvement Centre (CIMMYT), 27 November–3 December 1994 at CIMMYT, Mexico, D.F.

Kiros F. G. (1996) The silent violence of insect pests and disease vectors in sub-Saharan Africa: Facing up to the challenge. *Bulletin of African Insect Science*, Vol. 16, pp. 1–3.

Nabasirye M. (1996) Statistical inference on pest resistant indexes. PhD (Biometrics), Makerere University, Kampala, Uganda, Awarded 18 September 1996.

Ngi-Song A. J. and Overholt W. A. (1997) Host selection by *Cotesia flavipes* and *Cotesia sesamiae* (Hymenoptera: Braconidae): An example of a tritrophic relationship in a grass-stem borer parasitoid system, pp. 173–181. In *Integrating Biological Control and Host Plant Resistance*, Proceedings of a CTA/IAR/IIBC Seminar, Addis Ababa, Ethiopia. 9–14 October 1995. CTA Publication.

Odindo M. O., Nour A. M., Ajala S. O., Kiros F. G., Chitere P. O., Ampong-Nyarko K., Mohamed Ali M. A. and Ngalo Z. O. (1997) Integration of *Bacillus thuringiensis* with elite sorghum and maize genotypes to enhance productivity of small-scale farms in the coastal region of Kenya. In *Integrating Biological Control and Host Plant Resistance*. Proceedings of a CTA/IAR/IIBC Seminar, Addis Ababa, Ethiopia. 9–14 October 1995. CTA Publication. ISBN 92 9081 1625.

Osir E. O. and Gould F. (1994) The future role of biotechnology in integrated pest management. *Insect Science and its Application* 15, 621–631. 94-1329

Overholt W. A., Ngi-Song A. J., Omwega C. O., Kimani-Njogu S. W., Mbapila J., Sallam M. N. and Ofomata V. (1996) An ecological approach to biological control of gramineous stemborers in Africa: The introduction and establishment of *Cotesia flavipes* Cameron (Hymenoptera: Braconidae). In E. B. Radcliffe and W. D. Hutchison (eds), *Ted Radcliffe's Gopher State IPM Site*, URL:http://www.ent.agri.umn.edu/academics/classes/ipm/ipmsite.htm.Univ. of Minnesota, St. Paul, MN.

Raguraman S., Jayaraj S. and Saxena R. C. (1996) Effect of neem extracts on brown planthopper, *Nilaparvata lugens* and its symbionts, pp. 375–380. In *Neem and Environment*, Vol. 1 (Edited by R. P. Singh, M. S. Chari, A. K. Raheja and W. Kraus). Proceedings of the World Neem Conference, India, 1993. Oxford & IBH, New Delhi.

Saxena R. C. (1996) Sustainable development—Beyond 2000. *Global Neem Update* 1(2), 3–5, and 11–12.

Ssennyonga J. W. (1996) Community-based tsetse control, pp. 99–107. In *Partnerships for Sustainable Agriculture* (Edited by L. A. Thrupp). World Resources Institute, Washington DC.

Ssennyonga J. W., Goodell G., Lako G. T. and Tedla S. (1994) Social and economic aspects of integrated pest management in the tropics. *Insect Science and its Application* 15, 633–648. 94-1330

Van Emden H. F. and Dabrowski Z. T. (1994) Biodiversity and habitat modification in pest management. *Insect Science and its Application* 15, 605–620. 94-1338

Van Lenteren J. C. and Overholt W. A. (1994) Ecology and integrated pest management. *Insect Science and its Application* 15, 557–582. 94-1331

Reprints of articles with a call number at the end of the citation can be ordered from the Documentalist, ICIPE.

C. ICIPE publications

- *Vision and Strategic Framework towards 2020*. ISBN 92 9064 111 8. 74 pp. September 1997.
- *1995 ICIPE Annual Report*. ISBN 92 9064 098 7. 72 pp. October 1996.
- *Directory of Neem Workers in Eastern and Southern Africa*. Edited by R. C. Saxena. ICIPE Science Press, Nairobi. ISBN 92 9064 107 X. 30 pp. April 1997.
- *ICIPE 5-Year Plan: Research and Capacity Building Plan for the Period 1996–2000* (temporary cover). ISBN 92 9064 104 5. 132 pp. December 1996.
- *Improved Insect Pest Management for Maize, Sorghum and Cowpea Production in Coastal Kenya: Technology Handbook for Extensionists*. Compiled by S. Sithanantham, G. M. Kamau, E. Wekesa and K. Mwangi. ICIPE Science Press, Nairobi for the Kenya Agricultural Research Institute. ISBN 92 9064 106 1. 12 pp. December 1996.

ICIPE Governing Council, 1996/97

Professor Jacob Lifangi Ngu, Chairman*
Head, Immunology-Biotechnology Laboratories
WHO Collaborating Centre for Research and Training in Immunology (Cameroon)

Professor Lindsay Norman Innes, Chairman≠
Agricultural Research Consultant and formerly Deputy Director, Scottish Crop Protection Institute (UK)

Dr John William Meagher
Vice Chairman, and Chairman, Nominating Committee*
Formerly Chairman, Centro Internacional de la Papa (CIP) (Australia)

Professor C. J. Chetsanga, Vice Chairman≠
Director General,
Scientific and Industrial Research and Development Centre (SIRDC) (Zimbabwe)

Professor Peter Esbjerg, Chairman, Programme Committee*
Royal Veterinary and Agricultural University (Denmark)

Dr Barbara Ekbom, Chairperson, Programme Committee≠
Swedish University of Agricultural Sciences (Sweden)

Dr Deborah Merrill-Sands, Vice Chair, Programme Committee≠
Visiting Fellow
Simmons Institute for Leadership and Change, Simmons College
(USA)

Dr B. Kipkorir, Chairman, Audit Committee≠
Formerly Kenya's Ambassador to the USA (Kenya)

Dr Dely P. Gapasin, Chairperson, Nominating Committee≠
Agriculturist
The World Bank (Philippines)

Professor Hans Wilps, Member, Programme Committee≠
Gesellshaft für Technische Zusammenarbeit (GTZ) (Federal Republic of Germany)

Professor Constantina Safilios-Rothschild**
Professor of Sociology (Greece)

Professor Michael Ashburner*
University of Cambridge (UK)

Professor Shellameah O. Keya**
Executive Secretary
Technical Advisory Committee (TAC) of FAO (Kenya)

Professor Shozo Takahashi*
Formerly of Kyoto University (Japan)

Professor Jose Ribiero**
The University of Arizona (USA)

Dr Moise Mensah*
Formerly of IFAD, Economic Planning (Benin)

Dr Hans Rudolf Herren
Director General, ICIPE
(Switzerland)

* *Retired/resigned May 1997*
** *Retired March 1996*
≠ *Effective May 1997*

1996/97 Professional Staff≠

Management and General Operations

Office of the Director General

Dr Hans R. Herren, *Director General*
Prof. Ahmed Hassanali, *Interim Deputy Director General**
Dr Akke J. van der Zijpp, *Deputy Director General, Research***
Ms Remedios Dela Paz Ortega, *Public Relations Officer*
Ms Dinah W. Njoroge, *Internal Auditor*
Mr Julius K. Kamau, *Assistant Internal Auditor*
Ms Shamim A. Hashmy, *Executive Assistant**
Ms Susan M. Kagondu, *Executive Assistant*
Ms Agripina N. Ramoya, *Executive Assistant*

Management and Finance

Mr Vinod Tandon, *Director, Management*
Mr Kurt B. Iten, *General Manager, Guest Centre System***
Mr Khrisnahsamy Appadu, *Head of Financial Accounting***
Mr Alfred Lustenberger, *Head of Physical Plants and Transport***
Mr Fraser J. Utanje, *Travel Manager*
Mr A. Razaq S. Abdalla, *Workshop Manager**
Mr William P. Habaradas, *Fleet Manager***
Mr Anthony O. Alexis, *Personnel Officer (Admin.)**
Ms Veronique Tournier, *Personnel Officer (Recruitment)**
Mr Patrick N. Ndiangui, *Project Accountant*
Mr Dominic F. Sifuna, *Project Accountant*
Ms Serah N. Mungai, *Project Accountant*
Mr Gitonga J. Rugendo, *Treasury Accountant*
Mr Peter D. K. Ndirangu, *Procurement Supervisor*
Mr Vincent M. Kamanyi, *Assistant Accountant**

International Cooperation and Capacity Building

Dr Mudiumbula T. Futa, *Director, International Cooperation and Capacity Building***
Dr Vitalis O. Musewe, *Head, Capacity Building*
Mr Jason R. Kapkirwok, *Projects Administrator*
Mrs Lucy W. Gacheru, *Projects Assistant*

Core Research Departments

Population Ecology and Ecosystems Science Department

Dr Johann Baumgärtner, *Head (and Mega-Project Leader, Horticultural Crops/Fruit Fly Initiative***)
Dr William A. Overholt, *Principal Scientist (and Mega-Project Leader, Food and Perennial Crops***)
Dr Steven Mihok, *Senior Scientist (and acting Programme Leader, Disease Vectors Management Programme**)
Dr Srinivasan Sithanantham, *Senior Scientist (and acting Programme Leader, Plant Pests Management Programme**)
Dr K. V. Seshu-Reddy, *Senior Scientist*
Dr Suresh K. Raina, *Senior Scientist (and Mega-Project Leader, Commercial Insects***)
Dr Magzoub O. Bashir, *Senior Scientist*
Dr Kwesi Ampong-Nyarko, *Scientist (and Ag. Head**)
Dr Tracy Johnson, *Visiting Scientist**
Prof. John Beier, *Consultant Scientist (and Mega-Project Leader, Mosquitoes***)
Dr John Githure, *Consultant Scientist*
Dr Lucie Rogo, *Consultant Scientist (and Mega-Project Leader, Biodiversity***)
Dr Cliff M. Mutero, *Consultant Scientist*
Dr Charles M. Mbogo, *Consultant Scientist*
Dr Robert S. Copeland, *Scientist*
Dr Mohamed M. Mohamed-Ahmed, *Scientist*
Dr Esther Mwangi, *Scientist*
Dr Charles O. Omwega, *Scientist*
Dr Getachew Tikubet, *Scientist*
Dr M. Ali Bob, *Associate Scientist*
Dr Adele J. Ngi-Song, *Postdoctoral Fellow*
Dr Vishnu V. Adolkar, *Postdoctoral Fellow*
Dr Ballo Shifaw, *Postdoctoral Fellow*
Mr Paul N. Ndegwa, *Postdoctoral Fellow*
Dr Shawgi M. Hassan, *Senior Research Assistant*
Mr Lucas Ngode, *Senior Research Assistant*

Behavioural Biology and Chemical Ecology Department

Prof. Ahmed Hassanali, *Principal Scientist, Head (and Mega-Project Leader, Locusts and Migrant Pests***)
Dr Rajinder K. Saini, *Senior Scientist and Mega-Project Leader, Tsetse*** *(Ag. Head, Behavioural Biology Department**)
Dr Zeyaur R. Khan, *Senior Scientist*
Dr Slawomir A. Lux, *Senior Scientist*
Dr Wilber Lwande, *Scientist (and Ag. Head**)
Dr Baldwyn Torto, *Scientist*
Dr Hassane Mahamat, *Scientist*

Dr Peter G. N. Njagi, *Scientist*
Dr Muhinda Mugunga, *Visiting Scholar**
Dr Melaku Girma, *Postdoctoral Fellow*
Mr Andrew Mbiru, *Senior Research Assistant*
Ms Florence N. Munyiri, *Senior Research Assistant*
Mr Onesmus K. Wanyama, *Senior Research Assistant*

Molecular Biology and Biotechnology Department

Dr Ellie O. Osir, *Senior Scientist, Head*
Dr Godwin P. Kaaya, *Senior Scientist (and Mega-Project Leader, Ticks**)*
Dr Moses Makayoto, *Consultant Scientist*
Dr Suliman Essuman, *Scientist*
Dr Ne Ngangu Massamba, *Scientist*
Dr Nguya K. Maniania, *Scientist (and Ag. Head, Pathology and Microbiology Department*)*
Dr Guiyun Yan, *Scientist*
Ms Matilda A. Okech, *Senior Research Assistant*

Social Sciences Department

Prof. Fassil G. Kiros, *Senior Scientist, Head (and Mega-Project Leader, Social Sciences**)*
Dr R. C. Saxena, *Principal Scientist*
Dr Joseph W. Ssennyonga, *Senior Scientist*
Dr George T. Lako, *Scientist*
Dr Joseph M. Maitima, *Postdoctoral Fellow*
Ms Rosemary A. Emongor, *Senior Research Assistant*
Mr Philip E. Ragama, *Senior Research Assistant*

Research Support Units and Services

Biomathematics Unit

Dr Adedapo Odulaja, *Scientist, Head*
Mr Christopher N. Olando, *Senior Research Assistant*

Animal Rearing and Quarantine Unit

Dr Maurice O. Odindo, *Senior Scientist, Head*
Mr Francis O. Onyango, *Senior Research Assistant*

Biosystematics Unit

Dr Susan W. Kimani-Njogu, *Postdoctoral Fellow*

Computer Unit

Dr Yunlong Xia, *Scientist, Head*
Mr Darisi Murali, *Senior EDP Specialist*

Information Services

Dr Annalee Ngeny-Mengech, *Head of Information Services** (Head of Science Editing*)*
Ms Daisy W. Ouya, *Science Editor,* ***Insect Science and its Application***

ARPPIS PhD Scholars

Mr Godwin M. Zimba, *Outgoing 1994 Class#*
Ms Zipporah Njagu, *Outgoing 1994 Class#*
Mr Fanuel A. Demas, *Outgoing 1994 Class*
Ms Vivian C. Ofomata, *Outgoing 1994 Class#*
Mr Mohamed N. Sallam, *Outgoing 1994 Class#*
Mr Jean-Berkmans B. Muhigwa, *Outgoing 1994 Class#*
Ms Syprine Akinyi, *Outgoing 1994 Class#*
Ms Rosabella Orangi, *Year 3*
Ms Mary Anne Groepe, *Year 3*
Mr Jenard Patrick Mbugi, *Year 3*
Mr Atem Garang Malual, *Year 3*
Mr Sunday Ekesi, *Year 3*
Ms Esther N. Kioko, *Year 2*
Ms Josephine M. Songa, *Year 2*
Ms Shi Wei, *Year 2*
Mr Linus M. Gitonga, *Year 2*
Ms Eunice A. Misiani, *Year 2*
Mr Nicholas K. Gikonyo, *Year 2*
Ms Deolinda S. Pacho, *Year 2*
Mr Sileshi W. Gudeta, *Year 1*
Mr Vincent O. Oduol, *Year 1*
Mr Abera T. Haile, *Year 1*

Out-Stations

Mbita Point Field Station

Dr K. V. Seshu-Reddy, *Head of Station*

Port-Sudan Field Station

Dr Magzoub O. Bashir, *Senior Scientist*

Ethiopia Country Office

Dr Getachew Tikubet, *Country Coordinator*
Mr Ato Befekadu Ameya, *Protocol Officer*

≠As of 31 December, 1996. Staff leaving or joining in 1997 are shown with asterisks.
*Until mid-1997
**From mid-1997.
#On extension until December 1997.

Financial Statement

Income and expenditure account for the year ended 31st December 1996

	US$ 000	
	1996	1995
Income		
Grants	9,864.5	8,629.6
Currency translation gains	208.5	502.2
Miscellaneous	241.1	99.6
	10,314.1	9,231.4
Expenditure		
Core Research	4,724.2	5,969.9
Research Support Services	484.2	534.7
Training and International Cooperation	1,049.7	908.5
Information	145.0	135.9
Management and General Operations	2,403.0	1,281.6
	8,806.1	8,830.6
Land and Buildings	158.4	41.7
Scientific Equipment	506.1	30.1
Office Equipment and Furniture	415.8	130.2
Vehicles	428.8	32.7
	10,315.2	9,065.3
(Loss) Surplus for the year	(1.1)	166.1
Cost of Restructuring	-	(166.1)
Total (deficit) surplus for the year	(1.1)	-

Balance sheet as at 31 December 1996

	US$ 000	
	1996	1995
Fixed Assets		
Nominal value	*	*
ICIPE Riverside House	260.2	269.2
Current Assets		
Consumable Stores	31.8	30.4
Grants Receivable	1,565.3	2,321.5
Debtors and Pre-Payments	851.3	1,187.1
Deposits—Buildings Maintenance Fund	127.4	239.3
Bank Balances and Cash	2,192.5	1,850.6
	4,768.3	5,628.9
Current Liabilities		
Bank Overdraft (secured)	112.7	1,453.4
Loan (repayable within one year)	81.0	91.0
Creditors and Accruals	1,933.9	1,814.5
Unexpended Operating Grants	2,804.1	2,198.6
	4,931.7	5,557.5
Net Current Assets	(163.4)	71.4
Total Net Assets	96.8	340.6
Financed by:		
Reserve Funds (deficits)	(146.2)	(59.9)
Buildings Maintenance Fund	127.4	239.3
	(18.8)	179.4
Deferred Financing	60.4	70.4
Long-Term Loan (secured)	55.2	90.8
	96.8	340.6

*In accordance with ICIPE accounting policy, all fixed assets are written off to the Income and Expenditure Account in the year of purchase. However, the fixed assets held by ICIPE as at 31st December 1996 at cost amount to US$ 8,386,066 (1995—6,941,020).

1996 Donors

Grants received and receivable	US$ 000	
	1996	1995
Arab Fund for Economic and Social Development (AFESD)	**200.0**	430.0
Australian Centre of International Agricultural Research (ACIAR)	**55.8**	–
Austrian Government	**500.0**	–
Danish International Development Agency (DANIDA), Danish Government	**786.6**	1,062.6
European Union, European Development Fund (EDF)	**2,484.6**	1,540.5
Finnish Government	**150.0**	439.6
Gatsby Charitable Foundation	**349.7**	178.6
German Academic Exchange Service (DAAD)	**245.0**	202.5
German Federal Ministry of Economic Cooperation	**240.6**	–
Hebrew University of Jerusalem	**31.0**	42.4
International Bank for Reconstruction and Development (World Bank)	**200.0**	200.0
International Development Research Centre (IDRC)	**5.4**	18.1
International Fund for Agricultural Development (IFAD)	**1,429.6**	650.0
International Institute of Tropical Agriculture (IITA)	**16.0**	–
Japan International Research Centre for Agricultural Sciences (JIRCAS)	**27.5**	21.6
Japan Society for the Promotion of Science (JSPS)	**6.0**	6.0
Kenya Government	**115.9**	118.1
Natural Resources Institute (NRI), UK	**37.0**	114.5
Netherlands Government, Directorate of NGO, International Education and Research Programme	**1,229.1**	1,214.1
Norwegian Government	**309.1**	481.1
OPEC Fund for International Development	**40.0**	–
Rockefeller Foundation	**528.1**	434.3
Swedish Agency for Research Cooperation with Developing Countries (SAREC)	**1,200.1**	624.9
Swiss Government	**2,075.0**	1,100.0
Toyota Foundation	**18.4**	–
United Nations Development Programme (UNDP)	**249.7**	907.3
United Nations Environment Programme (UNEP)	**1.0**	11.0
United States Agency for International Development (USAID)	**249.6**	7.6
University of East Anglia, UK	**5.6**	–
University of Hawaii, USA	**5.0**	–
World Resources Institute (WRI), USA	**–**	6.8
Total Grants Received and Receivable	**12,791.4**	9,811.6
Add: Unexpended Grants—brought forward	**2,198.6**	1,016.6
	14,990.0	10,828.2
Less: Unexpended Grants—carried forward	**(2,804.1)**	(2,198.6)
	12,185.9	8,629.6
Less: Grants for 1995 paid in 1996	**2,321.4**	–
Grants taken into income	**9,864.5**	8,629.6

Abbreviations and Acronyms

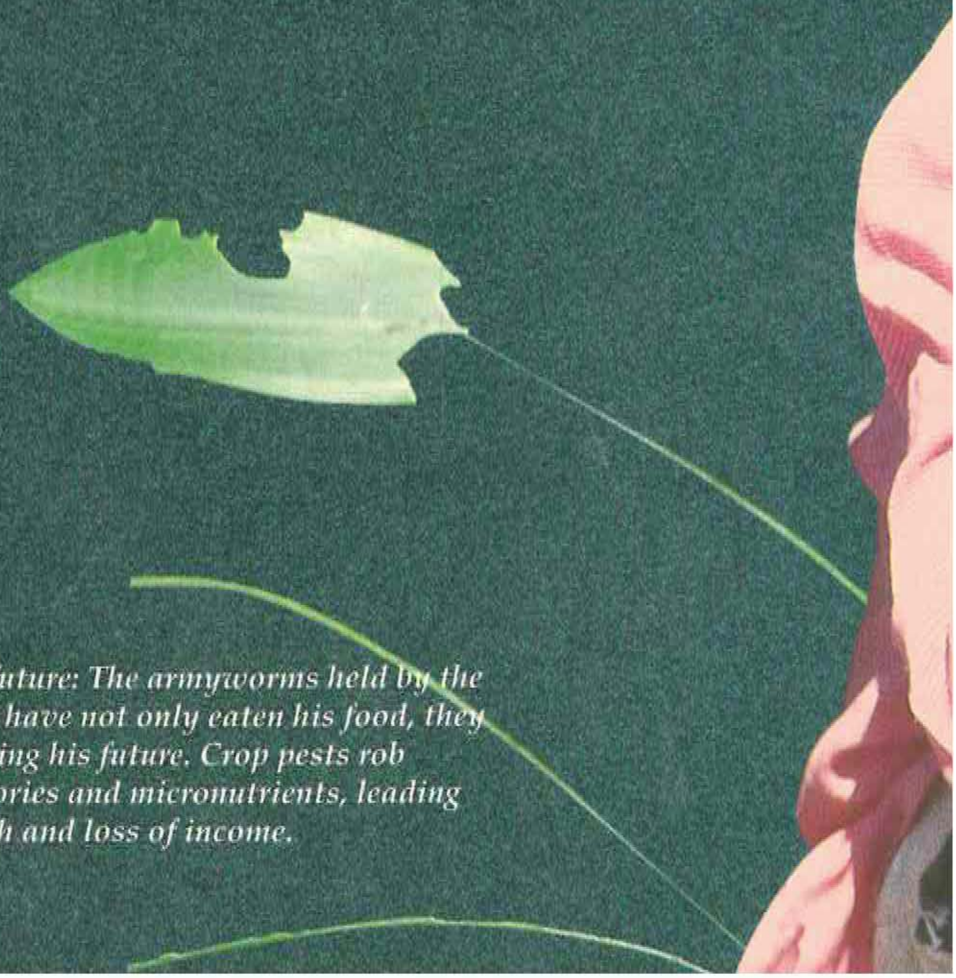
AGRIS	Agricultural Information Service (FAO)
AVRDC	Asian Vegetable Research and Development Centre (Taipei, Taiwan, China)
BMZ	Bundesministerium fur Wirtschaftliche und Entwicklung Zusammenarbeit (Bonn, Federal Republic of Germany)
Bt	*Bacillus thuringiensis*
CAAS	Chinese Academy of Agricultural Sciences
CGIAR	Consultative Group on International Agricultural Research (Washington DC, USA)
CIAT	Centro Internacional de Agricultura Tropical (Colombia)
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico DF, Mexico)
CIRAD/FLHOR	Centre de cooperation internationale en recherche agronomique pour le développement—Département des productions fruitères et horticoles (Réunion)
CSB	Central Silk Board (India)
DANIDA	Danish International Development Agency (Copenhagen, Denmark)
DBM	diamondback moth
DRSRS	Department of Resource Survey and Remote Sensing (Kenya)
ECOSUR	El Colegio de la Frontera Sur (Tapachula, Mexico)
ESTC	Ethiopian Science and Technology Commission
FAO	Food and Agriculture Organisation of the United Nations (Rome, Italy)
GARS	global agricultural research system
GIS	geographic information systems
GTZ	Gesellschaft für Technische Zusammenarbeit (Eschborn, Germany)
HCDA	Horticultural Crops Development Authority
HUJ	Hebrew University of Jerusalem
IAEA	International Atomic Energy Agency (Vienna, Austria)
IARCs	international agricultural research centres
ICRAF	International Centre for Research in Agroforestry (Nairobi, Kenya)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (Hyderabad, India)
IFAD	International Fund for Agricultural Development (Rome, Italy)
IIE	International Institute of Entomology (UK)
IITA	International Institute of Tropical Agriculture (Ibadan, Nigeria and Cotonou, Benin)
ILRI	International Livestock Research Institute (Nairobi, Kenya and Addis Ababa, Ethiopia)
INIBAP	International Network for the Improvement of Banana and Plantain
IPER	ICIPE Periodic External Review
IPM	integrated pest management
IRRI	International Rice Research Institute (Los Baños, Philippines)
ISERIPM	Interactive Socioeconomic Research for Bio-Intensive Pest Management (ICIPE project)
JHM	juvenile hormone mimic
JIRCAS	Japan International Research Centre for Agricultural Sciences
JKUCAT	Jomo Kenyatta University College of Agriculture and Technology (Kenya)
KARI	Kenya Agricultural Research Institute
KEMRI	Kenya Medical Research Institute
KETRI	Kenya Trypanosomiasis Research Institute
MOALDM	Ministry of Agriculture, Livestock Development and Marketing (Kenya)
MPFS	Mbita Point Field Station (ICIPE)
MSV	maize streak virus
NARES	national agricultural research and extension systems
NGOs	nongovernmental organisations
NRI	Natural Resources Institute
NSW	New South Wales (Australia)
PPI	Permaculture and Parasitology Institute (Ethiopia)
R&D	research and development
RCSSMRS	Regional Centre for Services in Surveying, Mapping and Remote Sensing (Nairobi, Kenya)
RTTCP	Regional Tsetse and Trypanosomiasis Control Programme (Zimbabwe)
SADC	Southern Africa Development Community (Gaborone, Botswana)
SAREC	Swedish Agency for Research Cooperation with Developing Countries (Stockholm, Sweden)
SGI	Sponsoring Group of the ICIPE
SIT	sterile insect technique
UNDP	United Nations Development Programme (USA)
UNECA/PADIS	United Nations Economic Commission for Africa/Pan African Development Information System (Addis Ababa)
UNEP	United Nations Environment Programme (Nairobi, Kenya)
UNESCO	United Nations Educational Scientific and Cultural Organisation
UNHCR	United Nations High Commissioner for Refugees
USAID	United States Agency for International Development (Washington DC, USA)
USDA/ARS	United States Department of Agriculture/ Agricultural Research Service (Honolulu, Hawaii, USA)
WAU	Wageningen Agricultural University (The Netherlands)
WHO	World Health Organisation

Photo credits: Cover photo by R. C. Saxena, ICIPE; photos on p. 17 by courtesy of A. Polaszek (top) and R. Kfir (bottom). Insect close-ups on chapter pages by R. Copeland, ICIPE. Other photos by ICIPE staff: H. R. Herren, Getachew Tikubet, S. Sithanantham, K. V. Seshu-Reddy, P. Lisamulla, Z. R. Khan, R. C, Saxena, Fassil G. Kiros, S. El Bashir, R. K. Saini, G. P. Kaaya, C. Mutero, M. Mugunga, S. Raina and Filmart Studio, Nairobi for ICIPE.

Compiled and edited by A. Ngeny-Mengech; **Layout and design:** Irene Ogendo; **Editorial assistance:** Dolorosa Osogo

(New) Home page No.: http://www.maraboutech.com/icipe

The International Centre of Insect
Physiology and Ecology (ICIPE)
P.O. Box 30772, Nairobi, Kenya
ISBN: 92 9064 112 6



Stealing his future: The armyworms held by the African child have not only eaten his food, they are jeopardising his future. Crop pests rob people of calories and micronutrients, leading to poor health and loss of income.