Draft

THE INTERNATIONAL CENTRE OF
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ICIPE'S LONG-TERM VISION AND STRATEGY

TOWARD 2020

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BOX 1: WHY ICIPE?

- The tropical African environment provides an ideal abode for a rich variety of arthropod life. This has had a **profound influence on economic and social life** in tropical Africa, unfortunately, mostly negative. Thus, for centuries, the tsetse fly has dictated the pattern of agropastoral land-use in vast areas of the continent. Malaria vectors are responsible for the highest cases of mortality and morbidity recorded anywhere else in the world. Locust swarms appear at a frequency and severity not seen elsewhere in the world. Insect pests alone contribute anywhere between 30-80% yield losses in Africa's food and cash crops. The rich beneficial arthropod resources of the continent are also among the most under-utilised or under threat.

- Problems associated with arthropod pests and disease vectors on one hand, and opportunities in arthropod conservation and utilisation on the other, cut across the **key sectors of health, agriculture and the environment.** ICIPE's focus on arthropod science and its application makes it **unique among international research centres** which address problems associated with the production of specific commodities in the agricultural sector.

- Moreover, ICIPE is the only Centre in Africa with the **highest concentration of arthropod science specialists** and is the ideal place for the incubation of scientific capacity and leadership in arthropod related problems and opportunities in the continent and other tropical areas.

- **In the foreseeable future, these countries will continue to rely on ICIPE for research leadership and capacity building in arthropod science, pest and vector management, conservation and sustainable exploitation of arthropod resources.**

- Now, 25 years after its modest beginnings, ICIPE is invigorating its mandate to serve as a force in a global effort to alleviate world poverty and to ensure food security and good health for peoples of Africa and other tropical countries through better management of both harmful and useful arthropods. ICIPE must be capacitated to function optimally to fulfil this mission.

BOX 2. INSECTS AND THE MOSAIC OF LIFE

- There are about 10^6 (1 million) described species of insects. Estimates of total number of insect and other arthropod species range from 10^7 to $8x10^7$. Thus only a fraction (1-10%) of arthropods have been described to date.
- The total number of all vertebrates (mammals, birds, fish, etc) is estimated at about $3x10^4$. Thus, of over a million animal species described, more than 90% are arthropods.
- Arthropods represent the most diverse group of all species. They have been on earth for more than 200 million years, adapting to life in most diverse habitats, from hot springs to the icy wastes of Antarctica.
- Less than 1% of arthropods are harmful to man.
- The majority are indirectly important to humans and the environment in the following ways:
  - as links in food webs and thus the functioning of ecosystems
  - as predators and parasitoids of insects and thus control populations of pests and potential pests
  - as pollinators and thus sustaining both agricultural crops and wild plants
  - as agents of decomposition and recycling of organic matter and thus contributing to soil quality and fertility.
- Some are directly useful to humans
  - as food e.g. termites, locusts, wild silkworms, etc.
  - economically e.g. silkmoths, bees and lac insects
  - as potential sources of pharmacologically active compounds e.g. venoms of different insects, antibiotics, etc.

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CHAPTER I

PRIORITIES AND SCOPE: THE NEW PERSPECTIVE

During the past 25 years, insects as pests or disease vectors have comprised the dominant theme of ICIPE's research agenda and related training and collaborative activities. Several interwoven considerations have combined to reinforce this theme. First, insects represent an important limiting factor in the production of food crops and livestock in Africa and other tropical countries; second, they transmit some of the most debilitating diseases that afflict human beings such as malaria; third, folllowing Rachel Carson's "The Silent Spring" in 1962, there has been a growing concern the world over about the indiscriminate use of synthetic pesticides. The need for alternatives that are selective, non-polluting, to which the target species do not develop resistance, and that are affordable by resource-limited rural communities, became an important imperative for ICIPE's research focus. Attention was given to a few selected pest problems that were important to the small-scale, resource-poor farmer and to rural life in general, and that were pervasive from a broad regional perspective. Thus, ICIPE's core research targets comprised medical vectors (mosquitoes and sandflies), vectors of cattle diseases (tsetse and ticks) and crop pests (with a special focus on stem borers of maize and sorghum and the rhizome borer of banana).

In developing a fresh perspective for the next 25 years, ICIPE has had a hard look at its constituency, current global and regional concerns, and the role the Centre could and should play within the framework of the international and national research systems. Here we highlight some of the challenges and considerations that have shaped our new vision and strategy.

Environmental concerns. Environmental concerns have intensified in the last 25 years as evidence of increasing pollution and habitat destruction continued to mount. And yet, crops, livestock and human beings must be protected from pests and disease vectors. Within ICIPE's constituency, two examples illustrate the variegated nature of the dilemma. First, there has been a significant growth of horticultural industry (based on vegetables, fruits and flowers) in the last two decades for both domestic and export markets. This has been accompanied by the intensive

use of synthetic pesticides to protect the crops. However, with the need and growth in demand for residue-free products, both from the local and export markets, this fledgling industry is now threatened. Second, organochlorines were used in the past to control persistent or periodic pests such as mosquitoes and locusts. Concern for their effects, particularly on fragile ecosystems, has led to their banning without there being any viable alternative. Plainly, ICIPE must continue to be a focus of research on and development of alternative approaches to arthropod pest control. This *Vision and Strategy* stresses innovative research on biological control and integrated management of pests and disease vectors based on a sound understanding of their behaviour and ecology.

Arthropod biodiversity. Few environmental concerns are now more universally acknowledged than those relating to the rapid global erosion of biological diversity. Indeed, in the multitude of vital issues brought up during the Rio Earth Summit of 1992, none drew greater attention than the urgent need to protect species and conserve ecosystems. Insects and other arthropods, which account for more than 70% of animal life, occupy a unique and dominant part of the mosaic of living things. Many are critical to the integrity of different habitats in ways that are little understood. Some are useful as sources of protein food, some for fibre, some in pollination, and some in recycling of organic matter and thus contributing to soil fertility. A number have provided agents that may impact human health. Others play important roles in controlling pests or potential pests. ICIPE is in a unique position to play a stewardship role in research and training in arthropod diversity and on the effects of habitat changes on this diversity as a basis of conservation and a more rational and sustainable utilisation of natural resources.

The problem of underdevelopment and poverty. The vicious cycle of underdevelopment and poverty represents one of the greatest challenges of our time. Indeed, improved management of the environment and biodiversity is intimately interlocked with the general improvement of the quality of life for rural and marginalised urban communities. ICIPE can make a significant contribution to poverty alleviation and to overall socio-economic development of these communities in a number of ways. First, by broadening the scope of its pest management studies to include high-value, nutrient-rich horticultural crops, it can impact not only food security among these communities but also improve their health and income. Second, a diversification of income-generating opportunities can be achieved if ICIPE uses its expertise in insect science

to provide backstopping scientific, technical and training facilities to promote small-scale enterprises on commercial insects, e.g. silkmoths and honeybees. Third, human performance and productivity in large stretches of Africa is hampered by vector-borne diseases such as malaria and leishmania. About 75% of the sub-Saharan African population lives in areas with recurrent incidences of malaria, and about 80% of all malaria cases, exceeding 300 million worldwide, and over 90% of malaria-related deaths occur in this region. Vector control is widely seen as an effective way of managing vector-borne diseases. ICIPE can make a major contribution by developing new methods and integrating available methods of control.

Gender issues. The "feminisation" of poverty in most parts of Africa and other tropical countries is central to its understanding and its alleviation. A dominant proportion of smallholders and horticultural crop producers are women who primarly stand to benefit from any ICIPE initiatives in the development of pest management packages for these crops. Likewise, women are expected to be the main beneficiaries of ICIPE's programmes on commercial insects, particularly those relating to silkworm moths. In this regard, ICIPE is cognizant of the need to ensure that training and backstopping are targeted to the actual producers and that it is these that are actually involved in mutually beneficial activities such as networking and cooperative marketing of products.

Rationalising ICIPE's R&D role. How does ICIPE reconcile the breadth of its new vision demanded of it by the specific conditions in its constituency and by global concerns at large with its institutional capacity? It does so through an approach to increased efficiency and productivity, in part based on a new relationship with its partners, old and new. Thus, in relation to the CGIAR centres the key words are complementarity and collaboration. A group of these centres have the mandate to develop comprehensive integrated pest management (IPM) systems for cereal and grain legume crops. ICIPE will henceforth not involve itself in IPM work of insect pests of these crops, but focus in vital augmentative components where it has unique or specialised expertise such as ecology, behaviour, biocontrol, botanical control, chemical ecology, agrobiodiversity and socio-economic research, in close partnership with the CG centres. Migrant insect pests like locusts and the African armyworm represent special opportunities for the Centre. Alternative preventive approaches to the control of these pests are contingent on basic understanding of the bioecology and chemoecology of primary outbreaks which ICIPE is well

placed to address.

In the livestock area, a clear delineation of ICIPE's role has already evolved. The Centre will continue to focus its attention on vector management whilst its major international partner in this area, the International Livestock Research Institute (ILRI) addresses livestock diseases and livestock management as a whole. A similar partnership in the control of insect pests of agroforestry systems is in the offing with the International Centre for Research in Agroforestry (ICRAF).

As indicated above, pests of horticultural crops are protected largely by synthetic pesticides and ICIPE must play a dominant role in the development of IPM approaches to these pests. However, in this as in other ICIPE newer initiatives in biodiversity and commercial insects, the Centre will work closely with national organisations and institutes individually or in networks, as appropriate. In the specific case of arthropod biodiversity, ICIPE will mobilise 3-4 key universities in different parts of Africa into a team that will ensure concurrent, long-term studies in different ecosystems. In all cases, special attention will be given to early participation of major implementing organisations, international such as FAO and WHO, regional such as the Desert Locust Control Organisation (DLCO) and Centre International de Recherche et de Devélopement sur l'élevage en Zone Sub-Humide (CIRDES), and non-governmental organizations (NGOs). In addition, ICIPE is opening its doors to interested partners in specialised institutes elsewhere and cultivate special links with advanced laboratories to promote a wider circle of involvement in its areas of research. In a nutshell then, ICIPE can respond to the new challenges highlighted above through creative forms of partnership and synergistic ways of task-sharing.

Rationalising ICIPE's capacity building role. Capacity development has always been seen as one of ICIPE's vital contributions in its constituency. Training has been conducted at all levels targeted for diverse needs ranging from provision for postdoctoral experience, graduate training for M.Sc. and Ph.D. degrees, to on-site training of practitioners in specific technologies. The African Regional Postgraduate Programme in Insect Science (ARPPIS), a graduate training in collaboration with a network of African universities has been the Centre's premium innovation in capacity building. Its popularity may be gauged from the fact that there are now 29 universities in ARPPIS and several new ones are likely to join soon. However, several

improvements are now clearly due in the scope and management of the programme. First, the inclusion of universities from other tropical regions with similar insect problems and opportunities of the African region would benefit these parts of ICIPE's constituency. Second, facilitating entry to students from universities around the world with requisite sponsorship is expected to attract young men and women with diverse interests in tropical arthropods. This would substantially enrich the programme through pan-global interaction and the range of scientific questions that may be addressed within the framework of the Centre's mandate. Lastly, this new vision for ICIPE's capacity building role implies a restructuring of the programme management which the Centre has initiated.

ICIPE's constituency: signs for optimism. The last 25 years were a period of relative gloom in ICIPE's primary constituency in Africa. Many countries in the region registered negative growth rates. However, there are clear signs that the next 25 years will be different. Political and socio-economic reforms, on the one hand, and rapid globalisation of the world economy, on the other, are expected to have an increasingly positive impact on African and other third world economies. Significantly, the World Bank projects economic growth for sub-Saharan Africa at 3.8% a year from 1995-2004 compared to an average of 1.9% in the previous decade. Apart from gradual improvement in the general infrastructure and services, this is expected to result in improved material capacities of national research and extension systems. Thus, ICIPE can be expected to operate under a more favourable climate in the region and make greater impact in its areas of operation.

BOX 3. STRATEGIC CONCERNS, ICIPE'S ROLE, AND PROSPECTS

- ICIPE will respond strategically to six vital global and regional concerns - food security, human health, biodiversity, poverty, gender issues and institutional capacity - in its constituency. Specifically, it will, in partnership with other international and national institutions,
  - continue to be a focus of research on and development of environment-friendly approaches to the management of arthropods injurious to crops, animals and humans;
  - play a stewardship role in the conservation and sustainable utilisation of arthropod diversity in Africa;
  - contribute to poverty alleviation and to improvement of the quality of life by broadening the scope of its pest management studies to include high-value, nutrient-rich horticultural crops, and promoting science-led exploitation of commercial insects;
  - contribute to reversing the process of "feminisation" of poverty by targeting women in its training, backstopping and networking activities in income- generation projects mentioned above;
  - strengthen and enrich its capacity building activities, particularly the graduate programme which will be extended to other tropical countries.
- A rationalisation of ICIPE's collaborative role already underway with emphasis in creative partnership and synergistic task-sharing with its collaborators in national and international systems, as well as with advanced laboratories elsewhere, will ensure that the Centre plays these roles optimally and productively.
- Improving conditions in ICIPE's constituency are expected to provide an improved climate for ICIPE's R&D and training activities, to facilitate a smoother collaboration with national systems and a wide-ranging impact.

CHAPTER II

R&D AND CAPACITY BUILDING PROGRAMMES

ICIPE's strategy will be implemented through three research programmes and a capacity building programme. The research programmes which encompass the Centre's new research foci comprise:

- **Disease Vectors Management Programme (DVMP),**
- **Plant Pests Management Programme (PPMP), and**
- **Arthropod Diversity, Conservation and Utilisation Programme (ADCUP).**

These programmes define and delineate areas of research undertaken at ICIPE. DVMP addresses both human and livestock disease vectors. PPMP is concerned with a range of plant- feeding insects: specialist pests of staple crops (cereals, legumes, bananas, etc), pests of horticultural crops (vegetables, fruits, flowers), and generalist pests that attack wide range of crops, shrubs and trees. ADCUP represents ICIPE's new initiative and responds to global concerns on eroding biological diversity and its sustainable use. In addition, the Capacity Building Programme coordinates all training activities undertaken in the research programmes and disciplinary departments (see Chapter III) at the Centre. Each programme's mission, priorities and strategy are outlined below.

A. DISEASE VECTORS MANAGEMENT PROGRAMME

Overview of the Problem

The tropical world as a whole, and Africa in particular, provides ideal environments for a series of blood-feeding insects and other arthropods that transmit debilitating or fatal diseases in human and livestock (Box 4). The direct impact of arthropod-borne diseases

BOX 4.	IMPORTANT ARTHROPOD VECTORS AND PRINCIPAL DISEASES THEY TRANSMIT
Arthropods	Diseases
Mosquitoes	malaria, filariasis, yellow fever, dengue fever (human)
Sandflies	leishmaniasis (human)
Black flies	onchocerciasis (human)
Fleas	plague (human)
Tsetse flies	trypanosomiasis (human, livestock)
Ticks	theileriosis, anaplasmosis, babesiosis, cowdriosis, etc (livestock)
	borelliosis, haemorhaegic fever, relapsing fever, baseiosis, etc. (human)

on man is staggering. For example, annually over 300 million people are affected by malaria, 80 million by lymphatic filariasis, and 18 million by onchocerciasis (river blindness). Malaria alone is the cause of an estimated 1.5-3 million deaths worldwide every year, with more than 90% in Africa alone. Appropriately, the US National Institute of Health has described malaria as "the microscopic killer that remains the closest single target for scientists interested in helping Africa". Even for "minor" diseases such as sleeping sickness (20,000 new cases per year), over a 100 million people are at potential risk if control measures break down. Indeed, 1995 data on ongoing sleeping sickness in Zaire suggest as many as 300,000 new cases of the sickness in this country alone. A variety of interacting factors - environmental degradation, climate change, evolutionary forces, deprivation, social strife and dislocation - often lead to the resurgence of vector-borne diseases in unprecedented numbers. Recent examples of unusual outbreaks include epidemics of leishmaniasis in the Sudan, human sleeping sickness in Zaire, and yellow fever in Kenya. With most of the continent at risk of exposure to vector-borne diseases, the scope of the

problem and associated effect on human performance and productivity as well as overall socioeconomic growth, is enormous. Finally, added to these grisly statistics is the new phenomenon of "emerging diseases" such as the Marburg and Ebola viral diseases. The dynamics of epidemics of such diseases remain a mystery. However, transmission through arthropods, has been considered a possibility.

Indirect effects of vector-borne diseases on man through his livestock are just as pervasive. For example, the many diseases transmitted by ticks to livestock account for global losses in production of about US$ 7 billion, half of which occur in Africa. Direct losses in livestock production due to tsetse flies and animal trypanosomiasis are estimated to be in the region of US$ 0.6-1.2 billion each year, with indirect effects estimated at about US$ 4 billion (FAO). Together, tsetse flies and ticks severely limit livestock production (and human habitation) in some of the best grazing lands in Africa. Tsetse-infested areas occupy 36 countries in sub-Saharan Africa, about one third of the continent, or 10 million Km^2. About 60- 90 million cattle are at risk in addition to millions of goats, sheep, camels, horses and pigs.

Accomplishments and Status

During the last 25 years, ICIPE made notable progress in the development of control strategies for a number of disease vectors.

In the control of tsetse flies, ICIPE has made excellent progress in the development of control strategies for savannah species through major advances in attractive bait technology. ICIPE's research in the 1980s was instrumental in the unexpected discovery of the attractiveness of bovine urine phenols to widespread species such as *Glossina pallidipes* and *Glossina morsitans*. In particular, ICIPE's research has demonstrated that given efficient traps, the biological attributes of tsetse render them ideal for control by mass trapping. In addition, the bait technology has been adapted to simple trapping systems appropriate for community implementation. Indeed, ICIPE researchers have already demonstrated a community-based approach of tsetse control in parts of Lambwe Valley, Western Kenya, which has resulted in the successful suppression of tsetse and trypanosomiasis to very low levels. This approach is

currently being adapted to the socio-economic conditions of the semi-pastoralist communities of Nguruman. ICIPE has been the only institute both developing and promoting simple alternatives that do not use chemical insecticides. However, much remains to be done. Efficient baits and traps need to be developed for a broader profile of tsetse such as forest and riverine species. Once a tsetse population has been brought down, continued protection of the area in an optimal way represents another research problem. The issues of sustainable deployment of bait technology such as land use following successful control, as well as long term environmental impact are already being addressed as integral parts of the community based tsetse control strategy.

In the case of mosquitoes and sandflies, ICIPE's research has also focused on environment-friendly control methods which minimise insecticide use, and are adaptable to the lifestyles of rural people. Ecological and epidemiological research at ICIPE resulted in the adaptation of pyrethroid-impregnated "Mbu" cloth for community use in the control of both vectors in rural settings where other methods were not appropriate. Pilot trials with Mbu cloth in East Africa have shown some promise, but insecticide treated targets must remain a temporary solution. Ever-increasing resistance to insecticides and therapeutic drugs has made the pursuit of radical, alternative, but sustainable, technologies critical. However, this is contingent on a thorough understanding of the ecology, eco-epidemiology, population genetics, vector competence and vector population dynamics in addition to environmental and socio-cultural factors. ICIPE is well placed to contribute substantially towards strategic research questions in these areas with the goal of developing an integrated approach to vector and malaria control.

In the case of ticks, ICIPE has focussed its research for many years on tick ecology in relation to traditional farming practices in order to develop simple management strategies for minimising the use of acaricides. This approach has indicated possible alternatives to the use of acaricides, but has not yet resulted in new practical methods. Ticks are undeniably among the most difficult pests and vectors to control. Significant progress in the development of new control techniques will require a combination of basic and applied research on methods that can further exploit weak links in tick biology, particularly off the host, where they spend most of

their life. ICIPE is currently making a unique contribution to tick research by studying novel approaches based on predators, parasitoids, fungi and anti-tick grasses. Similar innovative research activities are ongoing in anti-tick natural products, and in behavioural and semiochemical research. Lastly, ICIPE is exploring promising immunological approaches targetted against specific physiological processes in the tick and in its vectorial competence.

Programme mission

The overall mission of the Programme is to improve human and animal health in the tropics through the development, integration, and promotion of appropriate technologies for sustainable disease vector management. The primary focus will be on disease vectors of livestock and human of importance in Africa: tsetse flies, ticks, and mosquitoes.

A.1 TSETSE SUB-PROGRAMME

Goal

The Sub-programme's major goal is to enhance the management of human and animal trypanosomiasis through research and development of integrated vector control approaches based on tsetse behaviour, population ecology, and tsetse-trypanosome and tsetse-host relationships.

Priorities and Justification

The FAO/WHO/OAU "Global programme to clarify and solve the problem of African animal trypanosomiasis", is currently being reformulated in recognition of the fact that trypanosomiasis persists as the most important livestock disease in sub-Saharan Africa. Human trypanosomiasis is also a priority research target for OAU and WHO because of recurring epidemics. Accordingly, ICIPE will continue to accord a high priority to its research on vector control based on attractive bait technology which has shown a lot of promise to date. Studies on concurrent suppression of important tsetse species through integrated deployment of baits and traps will be emphasised. In addition, the Sub-programme will undertake strategic research in a number of areas such as the biochemical basis of refractoriness or susceptibility to trypanosomes in tsetse flies, and the semiochemical basis of refractoriness of some wild tsetse

BOX 5 TSETSE AND THE AFRICAN TRYPANOSOMIASIS: OVERVIEW

- About half of Africa comprising 36 sub-Saharan countries and representing 10.4 million km^3 (greater than the land mass of USA) is infested with *Glossina* (tsetse flies).
- About 50 million people and 60 million heads of cattle (in addition to camels, horses, goats, sheep, etc) are at risk from trypanosomiasis transmitted by species of *Glossina*.
- Direct losses in livestock production due to animal trypanosomiasis are estimated at US$ 0.6-1.2 billion annually, with indirect losses estimated at about US$4.0 billion.
- There are about 30 species or sub-species of tsetse. The major vectors of human sleeping sickness are *G. fuscipes, G. palpalis* and *G. tachnoides* (the palpalis group). About 23 species are associated with the transmission of animal sleeping sickness.
- Tsetse-born diseases can, in principle, be controlled with anti-typanosome agents (drugs, vaccines), vector control, and use of trypanotolerant breeds of livestock. No significant drug development has taken place in recent years and vaccine development against the diseases has been frustrated by antigenic variation in trypanosomes.
- Vector control which interrupts disease transmission is accepted as the most effective way of controlling tsetse-borne diseases. Past methods included destruction of vegetation where flies occur, that of their wild hosts, and application of synthetic insecticides.
- Tsetse flies continue to thrive despite enormous and continual effort to control them with above methods.
- Mass trapping based on bait technology develop at ICIPE has shown a great deal of promise and constitutes a major thrust of the Centre's R&D in tsetse control.

hosts, which may lead to new tactics in managing the vector or the disease.

The question of land-use resulting from possibilities of livestock expansion is also a priority. The Sub-programme will link in regional initiatives in East and West Africa to develop land-use planning models that would promote sustainable use of land for crop production, grazing and exploitation of forest resources.

Objectives

The objectives of the Sub-programme are:

1. To improve attractive bait technologies for the management of all savannah group tsetse, particularly for those species found in Eastern Africa.

2. To develop new attractive bait technologies for the management of the *Fusca* group such as *Glossina brevipalpis* and *Glossina longipennis*, and riverine species of tsetse such as *Glossina fuscipes*, *Glossina palpalis* and *Glossina tachinoides*.

3. To undertake tsetse migration studies to guide the development of tactics for strategic deployment of traps that protect cleared areas in a sustainable manner.

4. To undertake multispecies suppression studies through integrated deployment of baits and traps.

5. To develop new attractive bait technologies for the management of biting flies (tabanids, stable flies) in areas where mechanical transmission of *Trypanosoma evansi* is economically important, and in areas where flies of all kinds cause problems for human health.

6. To develop novel methods of disease control through strategic research in vector-

parasite interaction and epidemiology.

7. To refine and adapt existing socio-economic models for the integration of tsetse control into extension packages that can be used by rural communities of differing social structures and animal husbandry practices.

8. To develop land-use planning models for the implementation of integrated tsetse management packages that take into account the socio-economic and environmental impacts of increasing livestock populations.

Strategy

To address these objectives, the Sub-programme will strengthen its research in fly quantitative ecology and behaviour, with a focus on population and community ecology, and host-seeking and larviposition behaviour. Population studies will include migration patterns of tsetse in relation to flora and fauna dynamics with a specific view to identify sources of immigrants in areas being cleared and population profiles in cleared areas. Semiochemical research will be expanded, particular attention being paid to the screening of preferred and non-preferred hosts for useful semiochemicals (kairomones and allomones), e.g. reptiles as preferred hosts for riverine tsetse, camels as preferred hosts for biting flies, water bucks as unpreferred hosts for savanna tsetse. Biocontrol research will explore the usefulness of combining biological control agents with attractive devices. Field studies will be broadened to include Eastern, Central and Western Africa in collaboration with appropriate national or regional institutions. Socio-economic research will form an integral part of pilot tsetse management trials in different agro-ecosystems with differing community organisations and animal husbandry practices, all in partnership with national institutions and extensionists. A close partnership consortium will be formed with UN agencies (UNEP and FAO), international centres (ILRI) and regional or national institutes to develop land-use planning models and to undertake environmental impact studies. Lastly, wherever appropriate (e.g. studies on the molecular basis for tsetse refractoriness to trypanosomes), a similar partnership will be developed with laboratories in the North to achieve target objectives.

A.2 TICKS SUB-PROGRAMME

Goal

The Sub-programme's major goal is to improve livestock health and hence productivity by developing tick management technologies based on a detailed understanding of the ecology, population dynamics, behaviour, vector-host and vector-parasite relationships of economically important species of ticks.

Priorities and Justification

Ticks are now controlled largely through the use of acaricides with all their attendant problems - environmental pollution, contamination of meat and milk, and resistance development in the vectors. In Africa, high costs of acaricides have resulted in frequent interruption in their use and breakdown of associated infrastructures. Research priorities in Africa have varied because of the many species of ticks involved and different disease agents they transmit. In East Africa where *Rhipicephalus appendiculatus* is a vector of *Theileria*, ILRAD (now part of ILRI) has concentrated on developing a vaccine for East Coast Fever. In Southern Africa, researchers have focussed their efforts on *Cowdria* transmitted largely by *Amblyomma hebraeum*. In contrast, ICIPE has concentrated its efforts on ticks themselves in the hope of addressing the pests and the diseases they transmit together. In the short term, significant impact on tick management can be achieved through simple tactics based on cultural practices and a sound understanding of tick ecology. ICIPE has been a leader in this field, working closely with farmers to develop low-cost methods such as handpicking, regulated grazing, mixed grazing, and the use of predators such as chickens. Continued improvement of these methods and their promotion will be given a high priority in the Sub-programme. In addition, there are some minimally-researched areas that should lead to practical applications in the mid-term, such as biological control with fungi, parasitoids or anti-tick botanicals which the Sub-programme will also accord a high priority. In the medium to long term, quantitative improvement in the effectiveness and efficiency of tick control can only emerge from strategic research in carefully selected areas. Some priority will thus be given to tick chemical ecology which could not only provide more effective semiochemical-based tools for tick sampling off-the-host (important in

BOX 6. PROBLEMS RELATING TO LIVESTOCK TICKS: SOME FACTS

- About 80% of world cattle population of 1.2 billion are estimated to be at risk from ticks and tick-borne diseases.

- Apart from diseases transmitted (see Box 3), tick infestation also cause reduction in growth rate of livestock, reduction in milk production, damage to skins and hides, prolonged calving intervals, and predisposition to other diseases.

- Global production losses from ticks and tick-borne diseases are estimated at US$ 7 billion.

- In Africa, 90% of about 200 million cattle are infested with ticks, 70% by multiple species. Half of global production losses from ticks and tick-borne diseases occur in Africa.

- Over 1.1 million cattle die annually from East Coast Fever alone, a disease transmitted by the brown ear tick *Rhipicephalus appendiculatus.*

- Africa spends about US$ 720 million annually on imported acaricides for use mainly in cattle dips.

- However, synthetic acaricides have proven unsustainable and unsatisfactory: high costs, poor maintenance of dips, small proportion of farmers and herdsmen served, resistance development in ticks, contamination of meat and milk, etc.

- Alternative integrated control of ticks must be affordable to resource-limited farmers and herdsmen who raise over 90% of the cattle population in Africa.

population dynamic studies and in the development of basic population models) but also a means of manipulating tick behaviour as a control tactic and as a way of enhancing the effects of biopesticides on-host or off-host. Similar research directed toward immunological disruption of specific tick physiological processes and parasitic development in ticks may provide novel approaches to tick and tick-borne disease control.

Underlying all these studies, is the need for gathering requisite data for population modelling which can evaluate all control tactics and guide the development of integrated tick management systems.

Objectives

The objectives of the Sub-programme are:

1. To undertake detailed ecological studies of tick populations using improved sampling tools and to develop population models for different species for use in the evaluation of different tick control regimens.

2. To develop and test biological control strategies for *Rhipicephalus appendiculatus*, *Amblyomma spp.* and *Boophilus spp.* using tick parasitoids and entomogenous fungi.

3. To test and promote the use of anti-tick botanicals and anti-tick grasses as methods of tick management.

4. To test and promote social and economic models for the integration of cultural and scientific management practices into tick control at the farmer level.

5. To develop the use of tick semiochemicals in the development of sampling tools off-host, and in manipulating tick behaviour as a control tactic.

6. To develop immunological methods for disrupting specific physiological processes in ticks and for interrupting parasite transmission in ticks.

Strategy

High priority will be given to tick ecological studies and, in particular, to tick survival and development in different habitats in relation to meteorological, host and vegetation factors. This will provide a basis for tick population and GIS-based spatial distribution models which will guide the evaluation of all tick control tactics and the development of integrated tick management regimens. The Sub-programme has developed a collaborative project with CSIRO of Australia and KARI of Kenya to infuse Australia's modelling experience in tick population dynamics and management into ICIPE led studies in Africa.

Research on the parasitoid (*Ixodiphagus hookeri*) of *Amblyomma variegatum* will be expanded to other tick species (*Rhipicephalus, Boophilus*) particularly among wild bovids where parasitoids may have survived unexposed to acaricides. Mass production and field testing of the existing parasitoid of *Amblyomma* will also be initiated to assess the impact of parasitoid releases on tick populations in pilot trials. Work on the fungi, *Beauveria bassiana* and *Metarhizium anisopliae*, will focus on the development of economical formulations and mass production techniques that maintain suitability for field application. Trials will also be conducted to assess impact of these fungi on non-target organisms. Ethnobotanical information available from national institutions and universities will guide the search for anti-tick botanicals. Anti-tick pasture plants will be evaluated for both their efficacy for controlling ticks and their nutritional appropriateness for livestock. Ecological and socio-economic research at ICIPE will be intensified to evaluate evolving tick management system based initially on cultural tactics and then incorporating biocontrol approaches. ICIPE will join hands with ILRI and NARS to evaluate combined management of ticks and tick-borne diseases under different animal husbandry practices. These are expected to provide models for large-scale adaptive trials in various African countries. Chemical ecological research will explore the use of identified semiochemicals (pheromone, kairomones and allomones) in behavioural push-pull, repellent and confusion tactics

on-host, and in combination with biopesticides off-host. Immunological studies will target key proteins involved in the maturation of parasites within the tick. Research will initially focus on *R. appendiculatus* and will be undertaken in partnership with a number of laboratories in the North (Neuchatel, National Environment Research Council, UK) and South (South African Agricultural Research Council).

A.3 MALARIA VECTORS SUB-PROGRAMME

Goal

The Sub-programme's main goal is to contribute to the improvement of human health in Africa and other tropical countries through the development and promotion of integrated strategies for the control of malaria vectors in close association with disease management approaches.

Priorities and Justification

Of mosquito-borne diseases -- malaria, filariasis, dengue, yellow fever and Japanese encephalitis -- malaria is by far the most important in terms of the number of individuals it affects and the mortality it causes. It affects nearly half the world population (2.2 billion people) in some 90 countries, with 300-500 million estimated clinical cases each year, 1.5 - 3.0 million deaths, 90% of which occur in tropical Africa. The worsening malaria situation in the world led the WHO to declare malaria control a global priority. However, incidences of other diseases have also been on the increase in some areas. Vector control is acknowledged as an essential part of control programmes of these diseases to which ICIPE can make vital contributions.

In February 1996, ICIPE together with WHO and the Netherlands government sponsored a Task Force Meeting of mosquito and malaria experts from Africa, USA, Europe and Asia to review the status of malaria vector research and to identify critical gaps which ICIPE could address. A unanimous conclusion of the meeting was that much of the information needed for effective vector control focussed on disease control is incomplete, and, in some important aspects, lacking. Surprisingly little is known about the relation between inter and intra-specific

diversity among mosquito species, their vectorial dynamics, and underlying population genetics, nor between disease incidence and population dynamics of critical mosquito populations in different environments. A recurring paradox in Africa is apparent lack of direct relation between transmission pressure and malaria disease. Little is known about larval population ecology and physiology, and particularly the relation between environment, competitive population dynamics of different sibling species (e.g. of *Anopheles gambiae*) and vectorial fitness of adults. As a result, no meaningful ecosystem based quantitative models can be formulated to guide proactive vector control strategies. Moreover, some of the key behaviours of malaria vectors, such as host location and oviposition, and their mediating cues, have not been investigated in any detail. The discovery of semiochemical cues from such research could provide powerful tools for behavioural manipulation of critical vectors. The meeting resolved unanimously that ICIPE should become involved in strategic research and capacity building in these areas in partnership with other institutions elsewhere, citing ICIPE's location and experience in vector research as its unique advantages in this regard.

Objectives

The objectives of the sub-programme are:

1. To develop a programme of strategic research on malaria vector ecology and population dynamics focussed on important eco-epidemiological settings and embracing both the adult and larval stages.

2. To undertake pertinent vector population genetics studies in collaboration with groups in Eastern Africa, Southern Africa, West Africa (including ORSTOM), Europe and America, to backstop ecological and eco-epidemiological studies and to provide the theoretical underpining for disease dynamics in different areas.

3. To set up a mosquito identification facility at the Centre (based on molecular techniques) with a back up reference collection to service ICIPE's own research as well as that of national institutions in the continent.

4. To develop models from data derived from ecological, epidemiological and population genetics studies in different endemic malaria zones for prognosis and for testing new control approaches.

5. To undertake pertinent behavioural studies on epidemiologically important arthropophilic vector populations relating to host location, oviposition, and mating and to identify the mediating semiochemicals.

6. To exploit behavioural knowledge to develop new sampling tools and control methods and tactics that integrate identified semiochemicals with other control agents (botanicals, entomopathogens, IGRs etc) for the suppression of epidemiologically important vectors.

7. To identify socio-cultural and socio-economic factors influencing patterns of human habitation and behaviour associated with malaria transmission and prevalence.

8. To develop technology packages for malaria control guided by social science research which integrates the needs and resources of rural African communities with practical techniques targeted against important vector populations.

Strategy

The Task Force meeting held at ICIPE in February 1996 stressed the primacy of epidemiological considerations in the prioritisation of mosquito ecological research. Accordingly, in the near term the goal of the Sub-programme will be to seek to elucidate the environmental basis of both transmission pressure and disease incidence in different eco-epidemiological settings. Responsible vectors will be identified with the help of molecular techniques. Population dynamics studies will focus on epidemiologically important vector species at larval and adult stages and these studies will seek to clarify the relation between larval population ecology and physiology and adult vectorial fitness. Population genetics studies will be

undertaken to elucidate the underlying basis of temporal and spatial patterns of disease dynamics in different environments. The longer term goal of this highly focussed approach to vector ecology is to construct an ecosystem based vector population - epidemiology model that can guide future research in the development of new strategies for vector and disease control as well as actual interventions. In time, the model would be refined to assist in forecasting disease patterns.

Concurrently, as recommended by the Task Force, the Sub-programme will initiate an in-depth study on the behavioural and chemical ecology of significant anthropophilic vectors with the objective of identifying semiochemicals that mediate important behavioural elements such as host location, oviposition and mating. With respect to interspecific signals, the role of both kairomones and allomones will be studied. The research on host location will embrace human and mammalian alternative hosts, as well as plant nectar sources. Identified semiochemicals will be used to develop efficient sampling tools and control tactics targeted for specific behaviours in conjunction with other control agents such as IGRs, botanicals and entomopathogens.

On both fronts, the Sub-programme will establish close collaborative links with the national research and control programmes in Africa and research groups in the North and Asia as well as with the international organisations (see illustration).

In the meantime, the Social Sciences Department will undertake research to identify socio-cultural and socio-economic factors influencing patterns of habitation associated with malaria transmission and prevalence. These insights as well as the assessment of indigenous perceptions and knowledge as well as institutional and economic capacities of different rural communities will constitute substantive inputs into the design of effective and sustainable methods of malaria control.

Overall Global Goal
Sustainable, integrated malaria management

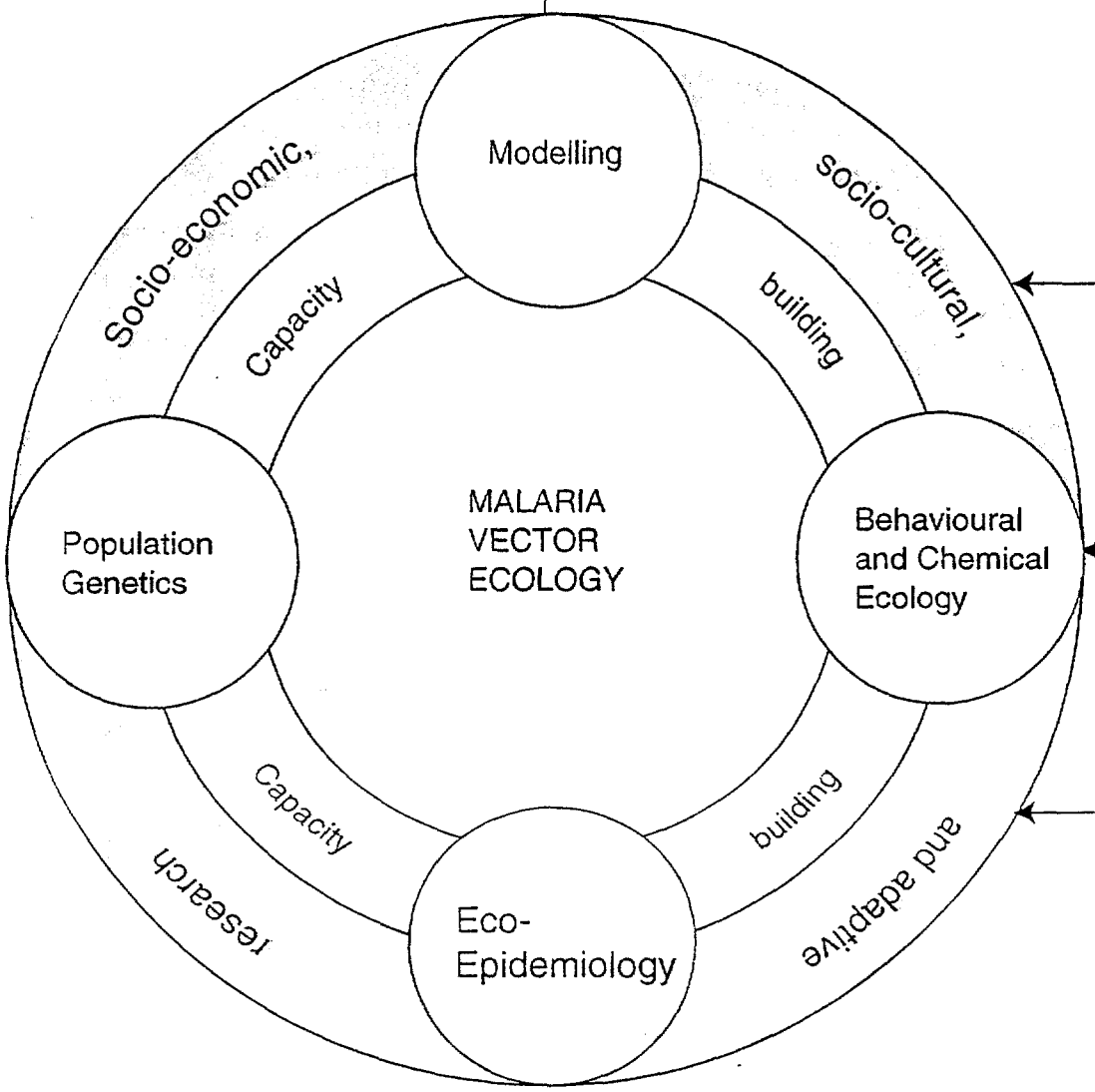
Specific Programme Goal
Improved malaria vector management strategy

Programme Outputs

- Vector population-epidemiology model for prognosis and evaluation of new interventions
- New vector-specific monitoring tools and tactics for control
- Major malaria eco-epidemiological zones stratified
- Improved capacity (human resource, research, technology delivery) in national systems
- Clarified socio-economic and socio-cultural issues

Other Vector/Disease Control Methods from other Research Groups

- Malaria vaccines
- New drugs
- Insecticide impregnated nets, garments, curtains etc.
- Repellent formulations
- Larval control



Collaborators

- National R&D Systems in Africa
- WHO/PEEM IIM
- Laboratories in the North and South (ICITR India, South African IMR, Orstrom, Wageningen, Tulane, Georgia, Aberdeen, London, Howard, etc.)

B. PLANT PESTS MANAGEMENT PROGRAMME

Overview of the Problem

The tropical environment provides a highly favourable climate for a wide variety of herbivorous insects many of which are serious pests of food crops (cereals, legumes, tubers), horticultural crops (vegetables, fruits, flowers), plantation crops (coffee, tea, sugarcane, cocoa) and multipurpose shrubs and trees. Insects involved vary in taxonomic type (Coleoptera, Diptera, Hemiptera, Homoptera, Lepidoptera, Orthoptera, etc), host plant selectivity (specialists to generalists), feeding and egg-laying habits, persistence, seasonality of outbreaks, and migratory aptitude. Damage by insect pests on crops may be by direct reduction of the quality and/or quantity of the produce, or indirect by acting as vectors of important plant diseases. Average yield losses in fields due to insects range from 25-40%, and may run up to 80% in some situations. Some insects also destroy crop produce during storage and cause substantial additional post-harvest losses (20-40%). Collectively, insect pests not only affect the nutrition, income and welfare of multitudes of individual families, but also bear upon the collective food security of communities. In the case of migrant pests such as locusts and the African armyworm, which are generalist feeders (polyphagous), their explosive appearance periodically may wipe out a variety of crops in large areas.

Control of plant pests in the tropics is largely reactive to problem situations. Satisfactory IPM approaches have yet to take root. This means that no satisfactory early warning systems against impending outbreaks exist. The result is either crop losses or excessive reliance on synthetic insecticides in cases of heavy or serious outbreaks. Hitherto improved pest management technologies are often inappropriate to the social and economic circumstances of resource-limited farmers. Where they may be technically appropriate, technology transfer processes are often insensitive to the dominance of women in crop production and to their gender-specific needs and constraints.

Accomplishments and Status

ICIPE has been in the forefront of research on environment-friendly strategies for plant pest management for about two decades. The major components researched include host plant resistance, biological control, manipulation of cultural practices, pheromone based monitoring and the use of botanicals. The main insects researched are the stalk borers of cereals (maize and sorghum), the legume pod borer (*Maruca testulalis*), sucking pests (aphids, thrips) on legumes (especially cowpea), and the banana rhizome borer (banana weevil). Host plant resistance research has provided some understanding of the mechanisms and the genetics of resistance, as well as leading to the development of new genotypes which combine insect resistance with acceptable agronomic/yield attributes. Some of the improved maize and sorghum genotypes have been chosen by the NARS for testing and on-farm evaluations, pending their release. An ICIPE-IRRI collaborative project on the biology of major rice pests was also successfully completed, with several original contributions both basic and applied. A comprehensive classical biological control initiative under ICIPE-Wageningen Agricultural University (WAU) collaboration is emerging as an ecologically sustainable model involving the introduction and establishment of a larval parasitoid (*Cotesia flavipes*) from Pakistan against the stalk borer *Chilo partellus* in East Africa. A combination of cultural practices was shown to be effective in reducing banana infestations by the weevil and in increasing banana yields. Significant progress has also been made in the isolation of a range of local strains of insect pathogens including those of *Bacillus thuringiensis* and, in some cases, significant progress was made toward their practical utilisation. Applied ecologists at the Centre have provided useful insights into tritrophic interactions (host-insect-enemy) in tropical agroecosystems and developed several options of cultural practice manipulations that can minimize the build up and/or activity of insect pests and associated yield losses. One such innovation involves the "strip relay" intercropping system which combines the merits of polyculture and intensive land use. Significant strides have also been made in the identification of key pheromone systems of the desert locust and in field application of stalkborer pheromones for pest monitoring. Neem and other indigenous botanicals have been shown to be practicable and sustainable means of natural crop protection and a neem awareness popularisation project was launched recently. Three adaptive research projects with the participation of farmers,

undertaken jointly with social scientists and NARS, have provided insightful experience and have led to the development of methodological approaches useful in social science-biology interface research.

Programme Mission

The overall mission of the Plant Pest Management Programme is to help increase the productivity of tropical agricultural crops important as sources of food, fodder, fuelwood and income to the resource-limited farmers by contributing to the development of sustainable management technologies for key insect pests of these crops. Three categories of plant pests will be addressed, each representing a Sub-programme of the Plant Pest Management Programme: horticultural insect pests, food and perennial crop pests, and locusts and other migratory pests.

B.1 HORTICULTURAL PESTS SUB-PROGRAMME

Goal

The Sub-programme's major goal is to enhance the quality and production of vegetable, fruit and other horticultural crops and thereby improve the diet and income of the farmers and expand income generating opportunities in rural areas through the development and promotion of appropriate and environment-friendly pest management technologies.

Priorities and Justification

Vegetables and fruits are an important part of the diet and source of essential nutrients for rural and urban communities in the Tropics. The last couple of decades have also seen a rapid growth of the horticultural industry comprising vegetables, fruits and flowers for both domestic and export markets. These crops have generally low pest resistance and are very vulnerable to attack by insect pests which considerably affects the yield, the quality and the resultant value of the produce. Among the more commonly grown vegetables, brassicas are often severely damaged by defoliators (especially the diamond back moth) and aphids. Tomatoes are prone to substantial losses from fruit borers (especially *Helicoverpa armigera*), aphids, whiteflies, leafminers and mites. Thrips constitute a major constraint to the production of onions and garlic. Several insect groups such as whiteflies, leafhoppers, aphids, mites and defoliating

BOX 7. YIELD LOSSES* IN MAJOR CROPS DUE TO INSECT PESTS

CROP	PEST	LOSSES		
		% Range	% Ave.	US$ equiv.x10[6]
Horticultural Crops				
Cabagge[a]	Diamond-back Moth	35-70	40	16.7
Egg plant[a]	Fruit borer	10-60	20	33.5
Okra	Pest complex	10-40	20	
Onion[a]	Thrips	5-75	30	166
Tomato[a]	Fruit borer	10-45	25	363
Food Crops				
Maize	Stem borers	15-70	25	1260
	Soil pests	3-30	10	
Sorghum	Stem borers	13-88	26	350
	Midge	5-99	15	
	Shootfly	8-25	15	
Bean	Bean fly	20-30	20	271
Cowpea	Pest complex	30-94	35	244
Groundnut	Pest complex	5-30	15	208
Banana	Weevil borer	10-52	30	64
Cassava	Mealy bug	20-60	38	200
	Green mite	20-45	30	
Sweet Potato[a]	Weevil	20-50	27	218
Plantation Crops				
Cashew	Bugs	5-50	15	
Cocoa	Bugs	10-20	15	454
Coconut	Pest complex	5-20	10	
Coffee	Pest complex	8-21	10	191
Sugar cane	Pest complex	10-46	25	1265
Storage Pests				
Cowpea	Beetles	10-30	15	
Maize	Larger Grain borer	9-45	30	1500
Maize	Grain weevil	10-20	15	
Sorghum	Grain weevil	10-30	20	269

***For Africa per annum; estimates based on 1990 FAO prices or 1995 Kenya prices (a)**

beetles have been implicated in yield reduction of indigenous vegetables in Africa. Some sucking pests are destructive even in low numbers because of their vectorial role in spreading viral diseases. Among fruit crops, fruitflies (led by *Ceratitis capitata*) and the mango weevil are highly destructive in several parts of Africa.

Priorities and Justification

Vegetables and fruits are an important part of the diet and source of essential nutrients for rural and urban communities in the Tropics. The last couple of decades have also seen a rapid growth of the horticultural industry comprising vegetables, fruits and flowers for both domestic and export markets. These crops have generally low pest resistance and are very vulnerable to attack by insect pests which considerably affects the yield, the quality and the resultant value of the produce. Among the more commonly grown vegetables, brassicas are often severely damaged by defoliators (especially the diamond back moth) and aphids. Tomatoes are prone to substantial losses from fruit borers (especially *Helicoverpa armigera*), aphids, whiteflies, leafminers and mites. Thrips constitute a major constraint to the production of onions and garlic. Several insect groups such as whiteflies, leafhoppers, aphids, mites and defoliating beetles have been implicated in yield reduction of indigenous vegetables in Africa. Some sucking pests are destructive even in low numbers because of their vectorial role in spreading viral diseases. Among fruit crops, fruitflies (led by *Ceratitis capitata*) and the mango weevil are highly destructive in several parts of Africa.

Women are the major producers of vegetables and fruits for the domestic urban markets, but have no means of protecting their crops by affordable and safe pest management technologies. Several indigenous or traditional vegetables such as kale (a brassica), species belonging to Capparidaceae family (e.g. *Gynandropsis gynandra*), *Amaranthus* spp. ("terere", "mchicha") and *Solanum spp.* ("osuga") are also infested by a range of insect pests. Such vegetables form substantial part of the diet of subsistence farmers and low-income groups, but little research has been undertaken to determine crop losses due to insect infestations, and no measures are taken to control the insects. On the other hand, the demand for blemish-free

produce by the export market has meant intensive protection of crops by synthetic insecticides. Local and international concern for environmental pollution and the growing demand for residue-free products, particularly by the export market, is now threatening this fledgling industry.

Currently, no major institute in Africa is addressing these problems, although the Taiwan-based Asian Vegetable Research Development Centre (AVRDC) is promoting improved varieties of vegetables in several African countries. Thus, the Sub-programme sees a major challenge in this sector. On the basis of the pest problems as well as potential social, economic, and environmental benefits, priority will be accorded to developing IPM tactics for pests of a number of common and indigenous vegetables (including brassicas, *Amaranthus* spp., onion, tomato, egg plant and okra) followed by those of fruit crops (mainly mango) and tree crops (especially coconut and cashewnut), and lastly those of ornamental crops.

Objectives

The objectives of the Sub-programme are:

1. To assess the production, consumption and marketing levels of indigenous and common vegetables and fruits, and to identify crops that are important from social and economic standpoint.

2. To assess the pest status and extent of losses caused by commonly occurring insect pests on tropical horticultural crops.

3. To enhance the understanding of the biology, ecology, reservoir sources, and population dynamics of the insects infesting common crops.

4. To develop IPM components based on botanicals, biological control, and behavioural manipulation for the management of major pests of selected crops.

5. To test and identify habitat management tactics that can minimize pest severity as

well as yield losses in the target crops.

6. To integrate the various pest management tactics into IPM packages and undertake social science led research to evaluate these in collaboration with NARS, and with farmers participation.

Strategy

In view of the diversity of pests involved as well as the differing status of current knowledge about these pests and associated availability of effective control methods, several approaches will be pursued in parallel. In the case of common vegetables such as brassicas, onions, solanaceous and malvaceous vegetables, a lot of information and varietal improvements are already available elsewhere relating to the key pests of these crops. In the short term, the Sub-programme will work closely with AVRDC and its outreach activities in Africa and build on available varietal resistance/tolerance a number of tactics based on cultural practices and botanicals to achieve some measure of pest reduction. In the meantime, longer-term studies will be initiated on the dynamics of pest diversity and populations of natural enemies on different crop and farming systems in different habitats to identify agroecological attributes conducive or otherwise to pest complex buildup, and to lay down the groundwork for more rational intervention approaches that integrate in-depth knowledge of the pests with host plant varietal features, biocontrol, botanicals, cultural practices and appropriate habitat management tactics. In the specific case of whiteflies, the CGIAR inter-center IPM programme has designated CIAT as the lead centre to formulate a multi-centre proposal on IPM of these pests and vectors in the tropics. The Sub-programme will join this effort and make specific contributions in the Centre's disciplinary areas including research leading to biological control, and the development of molecular probes for intraspecific diversity studies, and monitoring techniques based on semiochemicals.

In the case of indigenous vegetables, the Sub-programme will first assess their relative importance in the diets of farmers and low-income groups in close collaboration with NARS, survey insects that feed on the plants and assess their pest status and, accordingly, develop a

programme of research embracing components highlighted above for common vegetables.

Although much is known elsewhere about insect pests of fruit crops such as citrus, gauava, mango and tree crops like coconut, very little has been documented about the distribution of these pests in tropical Africa and the nature and extent of damage they cause. The Sub-programme will first seek to fill this gap, undertake strategic research where appropriate (e.g. in the case of fruit flies) to understand pest dynamics, host range and preference, intra-specific variability etc., develop effective monitoring and pre-warning systems for important pests, and develop bait- trapping approaches for their control.

Despite its lower priority, floriculture is a high-input commercial activity and currently relies heavily on synthetic insecticides and is a cause of major environmental concern. The Sub-programme will assess the environmental impact of insecticide use and seek commercial growers' support for the development of IPM approaches based on biological and botanical control.

B.2 FOOD AND PERENNIAL CROP PESTS SUB-PROGRAMME

Goal

The Sub-programme's major goal is to contribute to the development and application of sustainable insect pest management on major staple food crops in close partnership with the CGIAR centres and NARS. It will work toward specific IPM components that complement those being developed by the CGIAR centres and that represent ICIPE's special disciplinary strengths and experience.

Priorities and Justification

Food security in Africa and other tropical countries is continuing to be affected by several major specialist and generalist feeders. The specialist include stalkborers (*Chilo, Sesamia, Busseola*) on maize and sorghum, rhizome weevil (*Cosmopolites sordidus*) on bananas, sucking insects (aphids, thrips and leafhoppers), flower/pod damaging insects (*Maruca testulalis*, pod sucking bugs), and other specialist feeders that affect grain legume crops. Conservatively, these

BOX 8. POSSIBLE ECONOMIC BENEFITS ACCRUING FROM CONTROL OF STEMBORERS ON MAIZE IN EASTERN AND CENTRAL AFRICA

Country	Maize area* (ha.10^3)	Yield* MT/ha)	Total production (MT.10^3)	Loss to stemborers# (MT.10^3)	Equivalent Persons Fed+
Kenya	1428	1.7	2428	428-1619	2,378,000
Tanzania	1796	1.3	2335	412-1557	2,289,000
Uganda	421	1.4	589	104-393	578,000
Malawi	1365	0.9	1228	217-819	1,205,000
Zambia	681	1.3	885	157-590	872,000
Zimbabwe	1044	1.2	1253	221-835	1,228,000
Mozambique	952	0.3	285	50-190	278,000
Total/ Average	**1787**	**1.16**	**9003**	**1589-6003**	**8,828,000**

* Production figures based on 1992 FAO statistics

\# Yield losses due to stemborers estimated at 15-40%

\+ Persons that may be fed assuming a 15% yield increase (per capita consumption of maize estimated at 180kg/year)

insects have been estimated to cause an average of 15-40% of preharvest yield losses in many countries. It has been estimated that a 15% yield increase of maize in 7 countries of eastern and central Africa could feed over 8 million additional persons annually in the region (see Box 8).

The generalist pests in order of priority include *Heliothis (Helicoverpa armigera)*, storage pests (beetles, bruchids and moths), and thrips. *H. armigera* is a widespread generalist feeder that is a significant yield reducer of a wide-range of crops including maize, sorghum, pigeonpea, chickenpea, groundnut, tomatoe, sunflower and cotton. Storage pests are the major reducer of grain yields after harvest (10-45%). Thrips represent significant pests of legumes particularly cowpea, bean and groundnut.

ICIPE's research priorities on these pests are dictated by two factors:

- Its multi-disciplinary expertise in such areas as ecology, behaviour, chemical ecology, agrobiodiversity and biocontrol could help fill the gaps in IPM work undertaken by CG Centres. In particular, ICIPE can undertake strategic research where appropriate on population ecology of the pests in different agroecological systems and habitats, environmental reservoirs of the pests, mechanisms of host-plant resistance/susceptability as well as behavioural and chemical ecology, and lay down the groundwork for the development of new or improved intervention strategies. For storage pests, ICIPE can make immediate impact in a number of areas such as the use of botanicals, crop sanitation tactics, and semiochemicals-based pest detection and monitoring techniques.

- Its proximity to key pest populations such as *Chilo partellus* and related species and institutional experience built todate on the biology and control of such pests. ICIPE's on-going project with Wageningen Agricultural University (WAU) on the introduction of a natural enemy of *C. partellus* (i.e. *Cotesia flavipes*) obtained from its aboriginal source is an example.

[illegible] agroforestry, which is a major farming system catering for food, fuelwood, traditional medicines, fodder, shade, building materials, and additional income needs of subsistence farmers, is also being threatened by several insect pests. These include the psyllid (*Heteropsylla cubana*) on leucaena, the termites (specially *Microtermes* and *Odontotermes*) affecting tree establishment, and also emerging pests like leaf beetle (*Mesoplatys*) on sesbania, stemborers on grevillea, and scale insects on calliandra, *Albizia* and *Senna* spp. One or more of these pests affect self-propagation of trees by destroying flowers, seedling survival, or general health of mature trees leading to fungal and viral infections and eventual destruction of trees. In view of the importance of agroforestry for diverse needs, including conservation and productivity improvement of indigenous fruit and multipurpose trees, development of strategies for the management of these pests has been given priority and ICIPE is working with ICRAF to initiate short and long term research on the pests.

Objectives

The objectives of the Sub-programme are:

1. To improve trapping and monitoring techniques for major insect pests of food crops.

2. To undertake spatio-temporal population dynamics studies of major pre-harvest specialist and generalist feeders.

3. To undertake research on the biology, dynamics and pest status of insects affecting agroforestry and plantation crops.

4. To develop biological and botanical control strategies for sustainable management of target insect pests on food and perennial crops.

5. To identify appropriate habitat management tactics for the control of key insect pests in model crop systems.

6. To develop components for the control of storage pests based on pheromone monitoring, improved crop sanitation, and the use of repellent botanicals.

7. To evaluate social and economic sustainability and potential environmental impact of pest management technologies developed in tropical farming systems.

8. To collaborate and network with the IARCs and NARs in research, capacity building and technology dissemination for pest management in target crop systems.

Strategy

The Sub-programme will be proactive in identifying research niches in CGIAR-mandated crops where ICIPE can make a significant difference. However, ICIPE's proposals and work plans will be developed in close consultation with the relevant IAR centres and executed in an interactive manner. The direction of development work will, likewise, be planned in close partnership with these Centres and in the context of evolving IPM systems. The Sub-programme, will focus on strategic research that is directed, in the first place, toward a better understanding of the pest ecology, behaviour, and dynamics, and which would in turn form a basis for improved monitoring technologies, behavioural manipulation and control approaches. Stress will be placed on the development of effective prewarning systems and on control based on novel habitat management tactics, biocontrol and botanicals.

Research on agroforestry pests in Africa will be developed and conducted in close partnership with ICRAF. Research will initially focus on the assessment of relative pest status of different insects across major agroecological systems and seasonal population patterns, and on the role of off-season reservoir hosts. Stress will then be placed on (a) the development of reliable ecological monitoring techniques that could form a basis for prognosis of impending outbreaks, (b) intra-species diversity within tree species to identify resistant or tolerant varieties, and (c) identification of biocontrol agents and botanicals for possible use in strategic control or plant protection approaches. In the specific case of soil pests, cultural control practices will be

integrated with soil fertility enhancement tactics to minimise damage by these pests.

Research on plantation crops shall be undertaken largely in response to special problems and specific needs of NARS. However, the Sub-programme's basic strategy essentially will be the same as for agroforestry pests.

B.3 LOCUSTS AND MIGRANT PESTS SUB-PROGRAMME

Goal

The major goal of the Sub-programme is to contribute to improved and environment-friendly management of migrant polyphagous insect pests through a better basic understanding of the population ecology of the insects including the underlying mechanisms of pest outbreaks.

Priorities and Justification

Migrant pests such as locusts, the African armyworm, and armoured crickets have been a major concern in Africa. Crop losses caused by such pests can hardly be expressed in kind. Explosive outbreaks of these pests can wipe out food harvests in large areas often with heartbreaking efficiency. The control of these pests in recent years has relied largely on surveillance on a regional basis and on the use of synthetic pesticides to contain upsurges and plagues. Concern for large-scale application of insecticides, particularly in fragile ecosystems where outbreaks of these pests often occur, have led to the search for alternative control agents such as biopesticides and selective insecticides. However, in the long term, a more radical solution to the migrant pest problems based on a preventive approach can only come from a better understanding of the biological mechanisms underlying the development of outbreaks in primary recession areas. Accordingly, the Sub- programme will give priority to such studies. High priority will initially be accorded to the desert locust and the African armyworm.

In the case of the desert locust, the Sub-programme can build on its accomplishments to date on the identification of the semiochemicals of this insect in its solitarious and gregarious phases. The principal uses of these semiochemicals are:

- As sensitive indicators of phase change, for elucidating ecological factors responsible for gregarisation.

- As agents for disrupting gregarisation (already demonstrated in the field) or for direct control in conjuction with biocontrol agents.

- As monitoring agents for solitarious insects expected to be particularly useful in the early stages of population build up.

ICIPE's experience with acridid chemical ecology gives it a comparative advantage in this area with respect to grasshoppers which also are a major threat to agricultural production and food self-sufficiency in parts of Sahelian and Sub-Saharan Africa. ICIPE will join hands with other institutes (such as IITA) working on the development of new control tactics based on the use of biocontrol microbial agents and behavioural manipulation.

Objectives

The objectives of the Sub-programme are:

1. To undertake basic research on the behaviour and communication systems of migrant pests, phase dynamics and mechanisms underlying outbreaks.

2. To develop population dynamics models and, where applicable, gregarisation models for key species which can be used to guide and evaluate intervention tactics.

3. To contribute toward prognosis of outbreaks of migrant pests by integrating pheromone monitoring with satellite and remote-sensing techniques, GIS and modelling.

4. For species exhibiting phase change, to develop appropriate pheromone

components for inhibiting or reversing gregarisation.

5. To contribute toward the development of novel control approaches for both migrant and non-migrant generalist pests based on the use of biopesticides and behavioural manipulation with semiochemicals.

6. To assess socio-economic and environmental impact of promising management tactics and to contribute to the development of land-use planning models conducive to these tactics.

Strategy

For migratory pests, the desert locust will be treated as a model in a multifaceted study to determine if a preventive intervention in the early stages of locust gregarisation is feasible. The study will seek, in the first place, to elucidate habitat attributes conducive to gregarisation (monitored sensitively by pheromone release). This will be linked to remote sensing, GIS, and modeling techniques in collaboration with appropriate institutes (FAO, NRI, CIRAD), to develop improved forecasting of impending outbreaks and to identify breeding/gregarisation areas critical to the evolution of outbreaks. In parallel, the potential of some of the pheromones of the desert locust (adult pheromone as a disruptant of nymphal aggregation, oviposition aggregating pheromone etc) in the manipulation of the behaviour and/or physiology of the insect in the early stages of gregarisation will be studied. In particular, the combined use of pheromones and pathogens will be explored.

In the case of the African armyworm, very little is known about the environmental and intraspecific signals associated with the transformation of the solitarious insects to the migratory gregarious phase. The Sub-programme will first seek to identify these as a basis for research on the dynamics of transformation of the insect leading to primary outbreaks. In the meantime, the Sub-programme proposes to work closely with the EA-DLCO in such areas of the current control methodologies where it could effect improvements (more efficient use of pheromone monitoring, modelling of migratory trends during outbreaks, replacement of insecticides with

biocontrol agents).

On grasshoppers, the Sub-programme is developing joint research with IITA to explore novel behavioural manipulations of the pests based on the use of appropriate semiochemicals to enhance their contact with entomopathogens. The variagated grasshopper, *Zonocerus variegatus*, will be used as a model. Both intraspecific and interspecific semiochemicals will be identified for the purpose.

C. ARTHROPOD DIVERSITY CONSERVATION AND UTILISATION PROGRAMME

Overview of the Problem

Few environmental concerns are now more universally acknowledged than the accelerating losses in biodiversity all over the world. It has been estimated that approximately 17,000 species of plants and animals disappear from the earth every year. The major cause of this is destruction of habitats resulting from man's overexploitation of native ecosystems. In Africa too, the main vegetation types and associated habitats are changing, often drastically. These habitats support diverse species of flora and fauna, including insects and other arthropods which, in terms of biomass and diversity, represent a much larger group than all of the other animal groups combined (see Box 1). Arthropods play an important and often critical role in the functioning of ecosystems. Many act as links in the food web of local ecosystems. Many are predators and parasitoids and thus suppress populations of other insects including pests or potential pests. Pollination by insects is essential to many agricultural crops, and also to the reproduction of wild plants. Arthropods are also involved in the decomposition and recycling of organic matter on and within the soil and thus contribute to the maintenance of soil quality and fertility. Some (honeybees, silkmoths, lac insects, etc) are important economically, while others (termites, locusts, silkworms, etc) are an important part of the diet of local communities. It is estimated that less than 1% of 5-10 million species of insects can be considered pests. Although the threat to plants, game and birds has received a lot of attention in Africa and elsewhere, arthropods have received very little attention.

There is an intimate link between conservation of biodiversity and habitats, on one hand, and sustainable exploitation of renewable resources for economic development, on the other. The immense richness of tropical biodiversity remains to be tapped for new foods, natural pest control agents, pharmaceuticals, fibres, genetic resources and others. By virtue of its mandate and its location, ICIPE can play a catalytic role in Africa in arthropod conservation effort within the framework of a broader regional or national land use and biodiversity conservation policy. Specific areas of ICIPE's potential contributions are:

(a) Documentation of selected arthropod species and their ecological niches in key native ecosystem types with viable populations of native species in natural relative abundance that would ensure normal ecological and evolutionary processes to continue; and selection of key indicator species important for monitoring habitat change.

(b) Undertake research on interspecific diversity in agroecosystems and, specifically, elucidate the factors underlying the relation between predators and parasitoids, on one hand, and pests and potential pests on the other. This would provide a basis for habitat management tactics in the control of pest populations and may lead to the discovery of potent natural enemies of pests.

(c) In specific cases undertake research on intraspecific diversity in selected agroecosystems. Intraspecific diversity may represent a challenge in pest and vector management (because of the existence of different subpopulations resulting from genetic selection in response to different environments), or an opportunity in the case of widely distributed pests whose native populations exist in study areas (where potential may exist for discovering potent natural enemies and semiochemicals for the control of the pests).

(d) Initiate collaborative research with national institutions on sustainable exploitation of threatened arthropods (e.g. wild silkmoth) and in bioprospecting for useful

bioactive components and entomopathogens among wild arthropod populations.

Accomplishments and Status

Although the new Programme's functional life began toward the last quarter of 1994, a number of ICIPE's ongoing research projects on cereal crop pests initiated earlier have been undertaken from the standpoint of agrobiodiversity. These include the (a) ICIPE-WAU project on the establishment of the parasitoid *Cotesia flavipes* in different habitats in Eastern Africa infested with *Chilo partellus*, which addresses both interspecific diversity of the parasitoid and interspecific diversity comprising related local species of the parasitoid and the pest; (b) Gatsby Charitable Foundation-funded project on the role of wild habitats in the infestation of cereal crop farms, which is being undertaken in different ecological zones in East Africa, and includes examination of relative colonisation of different wild hosts by stem borers, intraspecific genetic variations within these pests, and documentation of their enemies. The latter project is executed in close collaboration with IITA which covers the central West African region. These studies are beginning to lay down the groundwork for better understanding of the relation between habitat diversity and habitat resilience to pest challenge, as well as the scope for habitat modification to contain this challenge.

Among the accomplishments to date of the Programme include the launching of projects on sericulture and apiculture, initiation of a database on arthropod diversity projects in Africa, conducting a pilot survey to estimate abundance of several arthropod groups in Kenya, and preparation of medium term programmes of research in such areas as conservation biodiversity in selected native ecosystem types, interspecific and intraspecific diversity of fruitflies (important pests of both exotic and indigenous fruits), and African honeybees and wild silkmoths.

Programme Mission

The overall mission of the Programme is to initiate and catalyse a process of conservation and sustainable utilisation of arthropod diversity in Africa within a broader framework of regional land use and biodiversity conservation policies and programmes. This responds to Agenda 21 of the Rio Earth Summit and the Convention on Biological Diversity.

The Programme's foci (which also make up its Sub-programmes) will be on conservation biodiversity in native ecosystems, agroecosystem biodiversity for self-regulatory pest control and sustainable agriculture, and science-led development of small-scale industries based on commercial insects.

C.1 BIODIVERSITY CONSERVATION SUB-PROGRAMME

Goal

The Sub-programme's primary goal is to help set up a sound Africa-wide network of research and monitoring effort that would form the basis for an informed, long-term conservation of arthropod biodiversity in natural ecosystems within a broader policy and management framework of land use and conservation at community, national and regional levels.

Priorities and Justification

Among the anthropogenic factors that are responsible for habitat destruction and erosion of biodiversity include lack of information on and appreciation of species diversity, the ways different species interact and ecological niches they occupy, and how man's manifold interventions affect species richness, adaptations, survival and overall habitat integrity. This is clearly a gigantic task and the Sub-programme's prime priority is, therefore, to initiate studies to fill this knowledge gap in the area of arthropods in collaboration with appropriate institutions in Africa. Concurrent studies would need to be **initiated** in several key native ecosystems on the following fronts:

(a) Decription of arthropod species richness, abundance and distribution in key ecosystem types. This is expected to provide a basis for identifying species that may be specifically threatened and to assist policy makers to select habitats and define conservation needs for planning.

(b) Identification of arthropod communities that can serve as effective indicators of environmental health and habitat change, and initiation of monitoring in key

habitats and ecosystems. This will serve to detect and measure transformations as a result of environmental changes and/or human interventions, to assess accomplishments of conservation management goals, and to direct appropriate changes in environmental management policy.

(c) Description of ecological niches of selected arthropod groups in selected habitats and elucidation of species interactions and community patterns in relation to resource structures and environment. This will serve as long-term ecological basis for understanding habitat dynamics and direction of regional and national policy and management response.

Objectives

The objectives of the Sub-programme are:

1. To set up a network of institutions comprising ICIPE and African universities representing important ecosystem types to undertake long-term research in arthropod biodiversity and arthropod-based monitoring of habitats.

2. To initiate investigations on arthropod species richness, abundance, and distribution in selected native ecosystem types.

3. To identify arthropod assemblages that can serve as indicators of ecosystem and environmental health and habitat change.

4. To initiate studies of ecological niches, interactions between different species and arthropod community patterns in relation to resource configuration and environment.

5. To initiate long-term monitoring of selected arthropod groups in selected habitats and the establishment of associated database.

6. Within the research network referred to in 1, to develop socio-economic models for arthropod biodiversity conservation and utilisation at regional and community levels.

Strategy

A pilot project has been launched with the objective of generating information on the status of arthropod research in Africa and elsewhere, locating potentially important ecosystem types where useful research could be conducted, undertaking pilot studies in two areas, and identifying potential partners for the proposed network. This pre-project phase is considered important for ensuring that the Sub-programme launches itself on a strong foundation that is based on a judicious choice of habitats and research partners.

Important strategic elements of the proposed network's research and information dissemination activities that have been identified include:

- Selection of arthropod species in different habitats as targets for diversity research and the development of inventories, databases as well as reference collections for retrospective studies.

- A complementary biosystematics capability within the network to augment those of national institutions in the region, which can provide speedy and reliable assistance in the identification of collections.

- Selection of indicator arthropods for different ecosystem types,launching long-term quantitative monitoring of these species, and documenting all relevant anthropogenic disturbance factors on and around different habitats.

- Development of relevant ecological research projects (to address objective 4) appropriate for postdoctoral researchers, MSc and Ph.D projects which can be undertaken within the networking institutions.

- Development of links with other institutions elsewhere undertaking research in biodiversity for exchange of information and experience, and for collaborative work.

C.2 AGROECOSYSTEM BIODIVERSITY SUB-PROGRAMME

Goal

The Sub-programme's primary goal is to understand arthropod biodiversity in different agroecosystems and socio-economic milieu and to evaluate and promote its practical implications in pest and disease vector management and sustainable agriculture.

Priorities and Justification

Multiple-use agroecosystems present their own sets of biodiversity issues, challenges and opportunities. A priority question is the impact of land use patterns on interspecific and intraspectific biodiversity and the relation of this to pest and vector problems. Ecological studies relating to such questions in different environments especially ones being newly exploited or undergoing changes in land use (such as irrigation, monoculture, agroforestry or vector-suppression projects), are expected to provide useful insights, and to impact environmental planning.

There are also a number of related important research questions. IPM interventions may occur in areas ranging from large commercial farms of monoculture to mixed-crop, small-holder farms in a mosaic of natural habitats. Can farming practices be manipulated to promote pest regulating processes? Will these facilitate control of target pests in consonance with other IPM components, or will biodiversity lead to new pest problems? At ICIPE, experience in this is already coming from Gatsby-funded research on the role of wild habitats on pest intensity in cereal crop farms and in the ICIPE-WAU project on the introduction of exotic *Cotesia flavipes* cultures. These and other similar studies are expected to provide useful models for this kind of research.

The Sub-programme has also accorded a high priority to the search for and identification

of beneficial insects (predators and parasitoids) in ecosystems native to key pests and disease vectors like stem borers, fruitflies, ticks etc. Focussed studies on selected taxonomic groups could lead to breakthroughs in biological control with regional and even global impact.

IPM intervention problems and failures may occasionally be related to genetic selection of insect subpopulations resulting from adaptations to specific situations. The Sub-programme recognises that research in intraspecific diversity on widely distributed pests such as the Mediterranean fruit fly would be of value. Evidence suggests that the fly may have originated from Eastern Africa which may thus be a centre of genetic diversity of the insect as well as those of its enemies.

Lastly, agricultural activities by and large lead to erosion of biodiversity. Amelioration of this is possible through environment-friendly pest management tactics already researched. The Sub-programme sees it desirable to undertake adaptive research to facilitate the adoption of such tactics among farmers.

Objectives

The objectives of the Sub-programme are:

1. To study the impact of IPM interventions and land use patterns on biodiversity in relation to pest problems and to develop appropriate models as part of pest and/or vector population suppression programmes.

2. To study the impact, positive or negative, of habitat biodiversity on the performance of IPM interventions and to identify habitat management tactics that promote natural pest regulating processes and augment IPM interventions.

3. To undertake wide geographic surveys for natural enemies of ICIPE's target plant pests and disease vectors and to explore their potential in classical biological control.

4. To undertake research on intraspecific diversity of selected pests of wide geographic distribution and to initiate genetic, behavioural and semiochemical characterisation of the subpopulations.

5. To undertake social science led adaptive research on available IPM tactics, including habitat management and practices, with ameliorative effects on eroded biodiversity.

Strategy

The Sub-programme will work closely with Conservation Biodiversity Sub-programme and those of Disease Vector Management and Plant Pest Management Programmes to develop projects and work plans that integrate biodiversity issues with pest and vector management goals. In addition, strong links with regional and international institutions will be forged and where appropriate, multi-institution programmes developed.

Given the broad scope of its mandate, the Sub-programme's strategy would be to focus initially on a few projects, some already ongoing, that would evolve into models responding to specific biodiversity issues relating to agroecosystems. Thus, on the question of land use, the Gatsby-funded project and tick and tsetse suppression projects could provide useful models in agricultural and livestock sectors. Irrigation schemes where land use pattern needs to address the problem of disease vectors as well as plant pest problems can provide another model. The Gatsby-funded project together with ICIPE-WAU project are expected to form a basis for habitat management tactics that promote the benefits of biodiversity.

On the search for enemies of ICIPE's target pests, the Sub-programme has selected fruitflies as a first focus of its studies because of their wide distribution and economic importance locally and globally. However, with the discovery of a parasitoid of the tick *Amblyomma variegatum* in areas with no previous history of acaricide use, effort will also be put in the search for parasitoids of other tick species among wild bovid populations.

The Mediterranean fruit fly and the banana weevil have been selected for studies on intraspecies diversity. The Sub-programme is collaborating with the IAEA and institutes in the Mediterranean and South America on the fruitfly and is developing a project with IITA on the weevil.

ICIPE has already developed methodological approaches in social science-biology interface research and a lot of experience has been gained from several adaptive projects with the participation of farmers and NARs. The Sub-programme will continue to develop such projects led by the Social Science Department to promote already researched technologies.

C.3 COMMERCIAL ARTHROPODS SUB-PROGRAMME

Goal

The Sub-programme's major goal is to provide the research underpinning that integrates the development of arthropod-based rural microenterprises with arthropod conservation aims, and thus to contribute to the improvement of the quality of rural life and environment in Africa.

Priorities and Justification

The Sub-programme has given top priority to R&D work leading to modernisation of apiculture technology in Africa and to the establishment of sericulture. Traditional bee-keeping in Africa is afflicted with a series of problems, including low productivity, losses of colonies during honey collection, stinging and absconding behaviour of the local strains of *Apis melliphera*, pests and diseases. Introduction of movable-frame (Langstroth) hives, queen rearing and selection in colony multiplication techniques, could considerably improve and modernise apiculture technology and productivity in the continent. Moreover, studies in the behavioural biology and associated signals of wild populations could throw some light on their behaviours. Similarly, bee pathology and pest research could lead to general improvement of bee health and performance. The Sub-programme also sees an opportunity in promoting the exploitation of beehive products other than honey and beeswax, such as royal jelly, propolis and bee venom.

With respect to silkworm industry, although there have been several attempts to establish sericulture based on domesticated silkmoths in different parts of Africa, they were not successful because of lack of research backup on the site in such areas as disease problems, grainage for bivoltive hybrids, and egg diapause. Currently, the demand for silk in the world outstrips supply, but a thorough local and international market research for silk and socioeconomic study of silk industry in the African context is important to guide its development. ICIPE could become a Centre for research and training not only on domesticated silkmoths and thus promote this industry in Africa, but also on wild silkmoths which are being threatened by overconsumption locally for food and by clearing of forests.

Another area where the Sub-programme sees a window of opportunity is in bioprospecting for pharmaceutically active compounds and entomopathogens associated with arthropods in the wild. Chemical prospecting from arthropods is a relatively new idea but existing evidence suggests that because of the importance of interspecific interactions mediated by chemical signals in arthropods, there has been continual evolution of secondary compounds, and the possibility of discovering useful pharmaceutically active lead compounds from this source is high. Likewise, entomopathogens may be discovered from the wild that are particularly potent or that are highly specific for some pests.

Objectives

The objectives of the Sub-programme are:

1. To contribute toward the transformation of African apiculture industry by identifying and eliminating existing constraints and shortcomings, both technical and socio-economic.

2. To study the swarming, absconding, and aggressive behaviour of local populations located at different altitudes, and to develop better strains from reared cultures.

3. To study the foraging behaviour of African honeybee strains and mediating

signals, and to exploit appropriate strains as pollinators of cultivated crops.

4. To conduct ecological surveys and determine distribution patterns of wild silkmoths, to develop species risk indices for different silkmoth communities, and to define their conservation needs.

5. To screen different strains of host plants and to identify the ones appropriate for the development of sericulture.

6. To research and solve disease and grainage problems in wild and domesticated silkmoth populations and to facilitate the development of sericulture for fibre and food.

7. To explore the use of marginal and waste lands for growing silkmoth host plants of different species for the silkmoth industry and thus to contribute toward the improvement of the environment.

8. To promote market research on silk and silk products and to undertake pertinent socioeconomic research to evaluate the development of a domestic market for these products.

9. To join international efforts in bioprospecting for pharmaceuticals and entomopathogens associated with arthropods in the wild for the benefit of local communities and conservation research and management.

Strategy

The major shortcomings in beekeeping in Africa comprising total dependance on the wild strains of bees and problems relating to attack by pests and diseases will be given special attention. Queen rearing by artificial insemination and colony splitting methods will be developed using Langstroth hives. This will help in genetic selection of desired tracts. At the same time,

bee pathology research to address chackbrood and other brood diseases will be developed. [illegible] moths and the hive beetles are also a problem and techniques to deal with these will be explored. Queen rearing and genetic selection will also allow the development of strains for value added beehive products and for pollination. It may also form a basis for selection of strains with more desired behavioural characteristics.

Work on domesticated silkmoths will follow a similar strategy. The major constraints faced in past attempts to set up sericulture in Africa (disease, inappropriate techniques for producing bivoltine hybrids, and egg diapause) will be addressed. For wild silkmoths, special attention would need to be given to ecological surveys to assess conservation needs and to identify threatened strains.

For the dissemination of improved technologies, pilot units will be established for demonstration and training. The Sub-programme will work closely with existing NGOs and national networks to ensure rapid spread of techniques.

On bioprospecting for useful chemicals from arthropods, ICIPE proposes to join one of several international initiatives currently being conceived in the genre of INBIO-Merck agreement linking Costa Rica's Instituto Nacional da Biodiversidad with the multinational company Merck. In the African region, a proposal to set up a similar plant natural product network has been taken up by International Organisation for Chemical Sciences in Development (IOCD). The Sub-programme is exploring a special niche for itself in this network in the arthropod area. For microbes an in-house proposal for screening for useful strains is being developed.

D. CAPACITY BUILDING PROGRAMME

Overview of the Problem

The relative failure of projects in the developing countries, and particularly in Africa, is high. Projects fail, or are not optimally successful, for a variety of reasons, but no single reason is more prevalent than the lack of critical mass of national institutional capacity to undertake

relevant research and development work and to transmit technologies to the end users. Sustainable capacity development is made up of at least two critical elements: progress in indigenous capability at all levels, and institutional capacity in optimal utilization of that capability. Specifically, it implies not only human resource development for a spectrum of relevant functions including scientific, technical, operational, and management, but also overall institutional development for productive use and expansion of that resource pool. Thus, capacity development is necessarily a partnership between national policy and decision makers, on the one hand, and multilateral agencies and institutions, on the other, with the former assuming increasingly greater responsibility in the development process. In the area of its mandate, ICIPE has always seen contribution to capacity development as a vital part of its functions and has accorded a high priority to it.

Accomplishments and Status

Since its inception in 1970, ICIPE has successfully mounted a number of training and educational programmes including:

(i) graduate training at MSc and Ph.D levels;

(ii) exposure of practitioners to new ideas and techniques in IPM in the form of lectures, laboratory and field courses;

(iii) professional development schemes for postdoctoral scientists, visiting scientists, and research associates from national R&D systems;

(iv) on-site, interactive training of extensionists, technicians and end-users in specific research techniques or pest control technologies; and

(vi) interactive technology development and adaptation with national staff and farmers or herdsmen at country and sub-regional levels.

From the period 1983-1995, ICIPE enrolled a total of 125 candidates on the Ph.D course of the now well-established African Regional Postgraduate Programme in Insect Science (ARPPIS) which is undertaken in collaboration with African Universities; about two-thirds of these have completed their Ph.D work and are now working in different institutions in Africa

BOX 9. ICIPE CAPACITY BUILDING OUTPUT

Training of Scientists and IPM Practitioners: 1977 - 1995

A. *ARPPIS Graduates and their Career Placement*

Level of Responsibility	PhD Graduates	Awaiting PhD Award
1. **National Research systems**		
. Directors/Team Leader	5	2
. Senior Research Officers	4	1
. Scientists	22	11
2. **Universities in Africa**		
. Heads of Departments	2	-
. Senior Lecturers/Lecturers	18	10
3. **International Organization:**		
. Scientists and Postdoctoral	5	1
. Scientific Officers	-	1
4. **Private Business Firms:**		
. Technical Managers	-	2
Total Scientists Trained	57	28

5. **Natural losses (2 deceased; 5 withdrawn)**

B. *Training of IPM practitioners*

	International Courses	National Courses
. Number of Courses	39(99 wks)	9(46 wks)
. Trainees: Africans	605	133
Others	53	-

(see Box 9). In addition, up to 10 students from universities outside Africa undertook their Ph.D work at ICIPE under joint ICIPE-university supervision.

In response to manpower needs at medium level, particularly for field entomologists, ARPPIS has mounted a sub-regional MSc programme hosted by three African Universities. The course for Southern Africa at the University of Zimbabwe was launched in 1992. The other two at the University of Ghana (Lagon) and Addis Ababa are due to be launched in 1995/96.

During the period 1982-95, over 800 practitioners from different tropical countries attended group training courses in IPM, while several thousands have been trained through attachment to ICIPE's work on crop pests, tsetse, ticks and medical vectors.

In addition,ICIPE brought into its professional training schemes over 80 young scientists as postdoctoral fellows or visiting scientists from different parts of the World, or as research associates from African national R&D systems.

Recent assessment of ICIPE's training schemes suggests that although the Centre is making a significant impact in capacity development at higher echelons of the national systems, more thought needs to be given at the lower level and particularly in the development of training packages for extensionists and end-users to facilitate quicker and more effective technology transfer and greater impact of developed technologies.

Programme Mission

The mission of the Programme is two-fold:

- to impact human and animal health, food security, and arthropod conservation and commercialisation programmes through appropriate links and training packages; and

- to contribute toward capacity development and institutional viability of national R&D systems through the training of high level manpower in arthropod science, pest management and conservation.

Priorities and Justification

As indicated in the mission statement above, the Programme will give priority to training at two levels: technology delivery process and high level human resource development. ICIPE's technologies will be developed largely through on-site, interactive research to ensure direct links with the end-users and guided by relevant social science interface to ensure relevance, sustainability and feed-back. However, the Centre would not have the capacity to train significant numbers of end-users themselves, nor does it see this as desirable. Wider and rapid dissemination of technologies is only possible through the training of extension staff in the national systems who can in turn train the end-users. Accordingly, appropriate training packages will be developed to capacitate this category of staff in the national systems.

High level manpower training at MSc, Ph.D and postdoctoral level is also considered important for the growth of the national R&D systems, which must eventually develop independent capacity to identify problems, to prioritize them, and to undertake the necessary R&D work to address them. As a Centre of excellence in insect science specialised in tropical problems and opportunities, ICIPE has a unique role to play in this area of capacity development. The Centre will, therefore, strengthen its activities in this area, streamline ARPPIS administration and management, and open its membership to other tropical countries such as latin America, the Caribbean and the Far East islands.

The ARPPIS sub-regional MSc programme based on three African Universities is also considered a useful collaborative model in the evolution of specialised regional research and training centres in Africa. ICIPE will continue to play its part in helping the establishment of the programme through an improved fund-raising strategy and management backstopping.

Objectives

The specific objectives of the Programme are:

1. To develop and undertake a series of pedagogically sound training packages for extensionists from the national systems in IPM technologies, and in arthropod conservation and utilisation.

2. To provide research training at masters and doctoral levels to young graduates from tropical developing countries in arthropod science relevant to pest and vector management, and arthropod conservation.

3. To promote the growth of diverse and vibrant postgraduate research at ICIPE by attracting students from universities outside ICIPE's target areas.

4. To provide opportunities to new doctoral graduands and young visiting scientists to contribute to ICIPE's R&D work and to gain further experience in arthropod research and management in a multidisciplinary setting.

5. To undertake careful periodic assessment of the impact of the different training schemes, and to review and modify their contents and methodologies for greater effectiveness.

Strategy

The Programme will work closely with ICIPE's research programmes to identify pest and vector management tactics and tools that have gone through the validation stage and socio-economic evaluation, and develop training packages targeted for extensionists in the national R&D institutions and NGOs or self-help cooperatives and networks. Careful thought will be given to the preparation of these packages to ensure that the trainees have a good understanding of the scientific basis of the technologies and are able themselves to effectively train the end-users in their utilisation. A variety of educational techniques will be used including audiovisual, permanent demonstrations in the field or at ICIPE stations, interactive practical work, illustrated

brochures in local languages, etc. Moreover, the Programme will undertake periodic assessment of the impact of these training packages through ICIPE's Social Science Department, review their contents and methodologies, and modify them as necessary.

Likewise, the Programme will work closely with ICIPE's research programmes and departments to identify viable projects for masters and doctoral research in areas where ICIPE is actively involved. Students will be admitted competitively from all over Africa and other interested tropical countries. ICIPE will continue to articulate the importance of graduate training in arthropod science, and seek training scholarships for the students and support for the activity, both within Africa and abroad. Currently, graduate training is managed by ICIPE in partnership with a network of about 30 African universities where students register for their degrees. The Programme has initiated a review of this structure in consultation with its ARPPIS member universities with the purpose of developing a leaner but more effective way of managing the activity. Moreover, the Programme will develop links with universities outside the ARPPIS network, both in the North and South, and explore possibilities of students from there to do their research on tropical arthropods and undertake their work at ICIPE headquarters or on one of its field stations under joint ICIPE-university supervision. This is expected to substantively enrich graduate research at the Centre in terms of the diversity of problems addressed and the ensuing interaction between students from different academic and cultural backgrounds.

In view of the importance of the sub-regional MSc programme as a collaborative model for regional centres of excellence in Africa in different study areas, ICIPE will play a more active role in nurturing the programme until it becomes well established and self-sustaining. In particular, ICIPE will assume greater responsibility in promoting the venture and fund-raising for student scholarships and will work closely with the host institutions to ensure that each develops into an effective sub-regional centre.

Postdoctoral fellows recruited internationally, visiting scientists, and research associates from national R&D systems have always been an important part of ICIPE's human resource. ICIPE's research grant proposals have normally provided for appointments of postdoctoral

work for the specified periods of different projects. Postdoctoral fellows are expected to constitute the largest component of scientific staff at ICIPE, with a high turn-over maintained to enable the beneficiaries to return to their homes and to ensure a continued flow of new ideas into the Centre from the world over. Visiting scientists come on special exchange arrangements with a number of organisations such as the Third World Academy (TWAS), the Royal Society (UK), and the Association of African Universities (AAU). The Programme sees a special value in such schemes and will continue to support them.

CHAPTER III
IMPLEMENTATION STRATEGY

Four categories of output are expected from ICIPE's programmes outlined in Chapter II:

- Affordable, widely adoptable and environmentally sound strategies and technologies (tactics, approaches and systems) that are effective in and contribute towards the management of both injurious and beneficial arthropods.

- Products, tools and devices that are important components of pest management strategies or technologies for commercial use of arthropods, and that need systems of production and marketing in the form of appropriately sized commercial enterprises.

- Scientific output, as reflected in the peer-reviewed research papers published in international journals, new insights in arthropod science presented in conference papers or published reviews, and corresponding new, cutting edge areas of research and development opened up in arthropod science.

- Motivated young women and men who have received different levels of training at ICIPE and who will form the mainstay of the national systems in ICIPE's

constituency.

What is ICIPE's strategy in ensuring that these outputs are effectively delivered from its programmes?

New Organizational Structure

A dynamic process of restructuring began at ICIPE in late 1994, and will continue into the future in response to experience and needs. The guiding principle behind the process is to make the Centre better able to serve the needs for research and development in insect science in the tropical areas of the world. The central theme of research at ICIPE is to increase the understanding of the ecology of arthropods, and use this knowledge to improve their management and conservation to the benefit of humans and the environment. The new structure is designed to be highly integrated, flexible, and conducive to collaboration both within the Centre, and with national, regional, and international research and development organizations.

As explained in Chapter II, the foundation of ICIPE's new structure is the three research programmes and the capacity building programme. These programmes will be implemented through a matrix with the research programmes occupying one dimension, discipline-based scientific departments the other, and capacity building programme embracing both the programmes and the departments. Whereas the programmes define and set the research agenda for the Centre, the requisite scientific expertise is drawn from six departments: Ecology and Biodiversity, Behavioural Biology, Chemical Ecology, Molecular Biology and Biochemistry, Pathology and Microbiology, and Social Sciences. Scientists in these departments are involved in research in one or more of the programmes, depending on the need. The breadth of biological disciplines covered by the departments, from the molecular level to the ecosystem, will allow ICIPE to conduct research and training on arthropods, as reflected in the agenda of its programmes, in a holistic way unique in the tropics. The Social Science Department will play a key role in most R&D processes beginning from the stage of research design to the final evolution of technological impact (see Box 10).

BOX 10. SOCIAL SCIENCES RESEARCH: MAIN FUNCTIONS

- Study the production systems, socio-economic profiles, resource endowments and constraints, indigenous knowledge base, and technological needs of ICIPE's clientele.

- Collaborate with other ICIPE departments to develop interdisciplinary and participative research methodologies.

- Promote participation of the Centre's research clientele and collaborators in its R&D processes.

- Develop socio-economic indicators for technology adoption and impact assessment.

- Monitor the adoption process of new technologies and assess their economic viability and social compatibility.

- Evaluate the socio-economic and (in collaboration with others) the environmental impact of new technologies.

- Develop a socio-economic data-base on different aspects of pest and vector management.

- Undertake capacity-building activities and share knowhow and experience in Social Sciences research with other institutes in Africa.

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which ICIPE seeks to develop. This concept primarily signifies the social and economic features of new technologies. In order to be sustainable and effective, a new technology must fit into and operate within prevailing socio-cultural and economic structures and environment. Hence, the client's needs, preferences, priorities and circumstances need to be taken into account from the outset. The role of the social scientists at ICIPE is to undertake research which probes the suitability and acceptability of technologies by the potential users who are mostly characterised by limited resources and poverty. Thus, ICIPE takes the work of the social scientists as an essential component for the successful development and dissemination of appropriate technologies among rural and urban communities.

Social science research has thus been given a special status in the new matrix structure of ICIPE and constitutes one of the six disciplinary departments (page 61). Its major tasks comprise:

Elucidating the social and economic context of research. The Social Science Department (SSD) will continue to play a strategic role by helping bring into focus the social and economic priorities and technological needs of the Centre's research clientele, highlighting the forces of change which have an influence on these priorities and needs, and pin-pointing the critical social and economic research problems. Social and economic considerations will be taken into account right from the conceptual stage of applied research projects, and relevant objectives and work plans in this regard incorporated into the formulation of projects.

Charting methodological pathways. The Social Science Department will continue to advocate and promote research approaches which can ensure the development of appropriate technologies and facilitate their adoption and sustainability. These approaches include,

- The adoption of a *"participatory"* mode of research in which the potential users of new technologies (resource-limited women and man) can take part at different stages in the technology design and evaluation process;

- The adoption of a "*demand-pull*" rather than a "*supply-push*" approach to research which places priorities and needs of the clientele at the centre of the research priority and focus;

- The promotion of an "*iterative*" research process involving basic research, technology design, testing and impact assessment in which social scientists play an active role;

- The development and application of "*interdisciplinary*" research methodologies based on holistic view of research problems; and

- The identification and evaluation of pertinent "*indigenous*" technical knowledge to build upon or to integrate, whatever appropriate, in the design of new technologies.

Provision of assistance in social science research. The emergence of a multidisciplinary social science team at ICIPE and the institutionalisation of experience and knowhow in research at the interface between biology and social science represent a rare development in the region. There is a clear need for ICIPE to share its methodologies and insights with other institutions in the region involved in applied agrobiological and related research. This, the Centre will undertake through different forms of collaboration.

In the medium and long term, the role of Social Science Research at ICIPE is likely to shift from the confines of individual projects to studies on the effects of adoption of combinations of pest and vector management technologies and income-generating ventures on different social groups and on the way environment (and biodiversity) is managed. Thus, social science research will continue to play a vital role in the development of research methodologies in monitoring long-term impact on communities and in identifying new problems and challenges that will

inevitably emerge in a dynamic human situation (see Chapter V).

Collaboration and Networking

ICIPE is cognizant of the fact that science has become one large interactive web of global enterprise. Science has not only become multidisciplinary and interdisciplinary in character but also a highly cooperative effort that cuts across geographical and institutional borders. The electronic information revolution is expected to catalyse and push these trends even further. Given its intergovernmental status, the location of its laboratories and field-stations amid the needy areas in Africa and the tropics, its expertise in social science interface research, and its networking experience, ICIPE is in a unique position to serve as a focal point for arthropod related research and capacity development in its constituency. In this regard, ICIPE's policy is to take stock of its comparative advantages and purposefully cultivate and nurture its collaborative network in a way that would enhance its output and its effectiveness in realising its strategic goals. Principal forms of collaboration with the Centre's partners are outlined below.

International Agricultural Research Centres (IARCs). ICIPE shares common goals with most of IARCs, both CG-associated and unassociated. These include those involved in research in food crops (IRRI, IITA, CIMMYT, ICRISAT, ICARDA, WARDA, IPGRI, CIAT and CIP), horticulture (AVRDC), livestock (ILRI), and agroforestry (ICRAF). With respect to major food crops, as outlined in Chapter I, ICIPE is winding up its research activities relating to IPM development which is being addressed comprehensively by the different CG Centres. Instead, it will concentrate on strategic research in poorly understood facets of pest biology and ecology in close collaboration with the appropriate Centres. ICIPE's disciplinary strengths in different areas of arthropod science are important in this regard. The goal of such research would be to build the groundwork for the development of essential components for insect pest management, or novel tactics that could qualitatively transform the effectiveness of IPM systems. On the other hand, pests of horticultural crops are not addressed by any major institute in Africa. ICIPE can play a major role in this area and intends to work with AVRDC with headquarters in Taiwan on integrated management of vegetable pests, and also address pests of fruits and

ornamental plants. These crops are currently subjected to instensive insecticide treatment. In the case of livestock, a clear delineation of responsibilities has already developed between ICIPE and ILRI, the former addressing the livestock disease vectors and the latter livestock diseases and livestock management as a whole. The two Centres have resolved to work very closely together in the development of integrated systems for the management of vectors and diseases of livestock. Similar forms of partnership with other Centres such as ICRAF are developing, with ICIPE focussing on research and the development of IPM for insect pests in agroforestry systems.

Regional and national R&D systems, and universities. ICIPE sees its collaboration with regional and national R&D and extension systems, including universities, as critical to appropriate technology development and its sustainable delivery to its clientele as well as in capacity building. Several major forms of collaboration have been developing and will be carefully nurtured in the future:

- *University-ICIPE linkages.* Apart from the ARPPIS network (see below under *Networking)*, ICIPE will cultivate special links with selected departments in African Universities to promote collaborative research and training. National Universities are a key to long-term sustainable capacity building in Africa at different levels. Such a partnership will enrich both the ICIPE and the collaborating universities with respect to the scope of research in arthropods the partners can undertake as well as extending the pool of young women and men who can be trained. In the specific case of arthropod biodiversity, continued long-term research can be sustained only through the involvement of local institutions such as universities located near important ecosystems involving 4-6 key universities to launch the arthropod biodiversity project.

- *One-to-one linkage with national R&D institutes* . This involves collaboration with an appropriate national institution to design and evaluate one or more pest management technologies with the active participation of farmers. The experiment has been very successful in understanding the socioeconomic dynamics of adoption of tsetse and crop

pest management systems and will be developed further. In particular, to effect broader impact and wider dissemination of research results, the Centre will link with Regional organisations such as SADEC, ASARECA, CORAT, DLCO, and others, whenever appropriate.

- *Outreach.* A resident ICIPE scientist is placed in a country to coordinate a number of ICIPE's activities ranging from basic research to close collaboration with a consortium of host institutes. ICIPE's arrangement with Ethiopia represents such a collaborative model. ICIPE needs access to Ethiopia's native habitats for its work on biodiversity and to species of tsetse populations which do not occur in Kenya, while Ethiopia needs ICIPE's assistance in the control of disease vectors of livestock and human. The scope of the collaboration can be expanded to include other activities. ICIPE's access to palpalis group of tsetse in the near future may be similarly facilitated in a West African country.

- *Centres-national institutes consortium.* Rationalisation of ICIPE's role within the international research systems has meant that the Centre will increasingly join hands with other international Centres to work with national systems on relevant areas. Thus, in the area of ticks and tick-borne diseases, it is working closely with ILRI to forge links with relevant national institutes. Similar links are developing in the area of major crops.

- *Key ecological sites.* Certain kinds of upstream and downstream research require ICIPE to place resident teams at sites most pertinent to its objectives. Thus ecological studies relating to locust gregarisation are carried out in the Sudan Red Sea area. The national locust control network there provides the ICIPE team with information on locust densities and movement as well as logistical support. Similar arrangements will be worked out in ICIPE's proposed study in the primary outbreak areas of the African armyworm in Central Tanzania and in other areas for different locust and grasshopper species.

- *Networking*. ICIPE's most successful networks are the African Regional Postgraduate Programme in Insect Science (ARPPIS) and Pest Management Research and Development Network (PESTNET). The first links about 30 African universities in postgraduate training in insect science and the second serves to promote exchange of information and experience in pest management between national programmes and ICIPE. Both networks will be consolidated and reorganised for better efficiency, with ARPPIS management trimmed for greater efficiency but extended to other tropical countries, and PESTNET broadened to include regional organisations and IARCs. ICIPE also sees networking as an effective mechanism for promoting knowhow in commercial arthropod activities.

Advanced laboratories. ICIPE sees a special opportunity in advancing the frontiers of tropical arthropod science through collaboration with advanced laboratories in the North and South specialised in specific disciplines, and in the development of new concepts and methodologies in arthropod management. Several forms of links will be cultivated including direct research collaboration on specific projects, exchange of visits of varying duration, joint supervision of students, exchange of information, and provision of laboratory space and field facilities. Toward the year 2000 and beyond, it is envisaged that ICIPE becomes a global hub of ideas and activities in tropical arthropod science with the participation of a vibrant network of individual scientists, students and institutions around the world.

Towards ICIPE Science Park

Following the brilliant success of the Silicon Valley in California, "*Science Parks*" have been widely adopted in the industrialised world as a mechanism of promoting synergy between upstream research and industry-based development efforts with the objective of commercialising promising ideas and inventions. The concept pre-supposes the existence of a strong industrial base, high output of ideas and inventions, and commercial companies that can provide production and marketing expertise. From an African perspective, it is clear that lack of knowhow and mechanisms for evaluating and translating promising laboratory results into marketable products constitute major handicaps in the commercialisation of research innovations in Africa. The idea of a *Science Park* has been under discussion within ICIPE for a number of years now, spurred

by the desire to see that some of its products for the management of pests reach the market place and begin to make impact in pest control within its clientele.

The *raison d'être* for such a park includes:

- The virtual absence of interest in commercialising low volume products such as biopesticides, semiochemicals, and natural products that are specific for tropical pests;

- An opportunity exists for the development of processes for the production of refined value-added products from ICIPE's new programmes in commercial insects, such as insect venoms and brood (royal jelly);

- The possibility of nurturing small start-up companies by providing them with an environment, facilities and provision for scientific advice on the manufacture and commercialisation of arthropod control agents and arthropod related products arising from ICIPE's own R&D activities or from those of other research institutes in the region;

- The need for the Centre to establish an institutional framework which would enable it to scale up the production and evaluation of products that have more widespread commercial potential and that could be licenced to interested enterprises anywhere in the world;

- The need for the Centre to diversify its funding; the Park could generate significant amount of income in the longer term.

Thus the motive for an ICIPE Science Park is compelling. The need is there, and it will give ICIPE an opportunity to contribute towards industrial development in the region and, where appropriate, to earn royalties which could be ploughed back into its R&D work. The Centre recognises that the specificities of its environment are different from those where *Science Parks* have thrived and, accordingly, its *Science Park* will be radically different and will need to be nurtured thoughtfully.

Information and Communication

Information retrieval and generation and its exchange and dissemination are an integral part of the research and development process. As a centre of excellence with a network of partners and collaborators, and as it consolidates its position at the cutting edge of insect science and its application globally, efficient and state-of-the-art information management and communication system will be vital to ICIPE's functions in the next 25 years.

In the short to medium term, ICIPE expects to continue to rely on its library subscriptions as a primary access to relevant scientific literature. The library now subscribes for about 150 journals which include most of the important journals in entomology, acarology, parasitology, ecology, biodiversity, microbiology, insect behaviour, biocontrol, modeling, chemical ecology, insect physiology, biochemistry, molecular biology, social science, etc. Several CD-ROM versions of these journals have now become available and the ICIPE library is experimenting with some of these to determine their relative advantage and cost-effectiveness. With the setting up of a local network within ICIPE, direct access to library-based CD-ROM versions of journals is expected to become more popular.

In the longer term, however, with the growth of electronic publishing and the possibility of on-line searching and browsing of the full-text contents of journals, ICIPE's library, as others elsewhere, is expected to change radically and to become substantially computerised, particularly with respect to periodicals. The traditional library will be reduced to stocks of textbooks, monographs, reviews and similar literature.

ICIPE's own research results, reports, brochures, educational materials for training etc. are currently disseminated wholly by printed materials. Scientific papers are published in peer-reviewed international journals. The rest are published largely in-house by ICIPE's Science Press (ISP), a self-financing research and training support unit that also undertakes publication of non-ICIPE materials on a commercial basis. The work of the Press and the way ICIPE scientists disseminate their research results are also expected to be swept up in the wave of new digital publishing technology. In particular, ICIPE will have a WWW site, accessible through

the internet where project information, data bases and research results will be made available to users worldwide.

Research Sites

Strategic location of R&D sites is critical to ICIPE's work in different groups of arthropods in different habitats and agroecological zones. At its headquarters in Kenya, in addition to its laboratory and administration complex near Nairobi, ICIPE currently has a number of field stations that cater for different activities:

- **Mbita Point Field Station (MPFS)** situated on a 50-acre site in a remote rural community on the shores of Lake Victoria, representing an agroecological zone typical of parts of eastern and central Africa. The station is located adjoining tick-infested livestock populations and tsetse habitat that harbours vectors of mainly livestock trypanosomiasis, but also those of human. In addition, it is a malaria endemic area and has been selected as a primary base for ICIPE's research on malaria vector.

- **Muhaka Field Station** (320-acre) near the coast which represents a zone typical of coastal eastern Africa stretching from Somalia, across Tanzania, to Mozambique. A unique undisturbed tropical forest of over 200 acres is available within the station for biodiversity and other faunistic studies. The station is a focal point of research on stem borers (WAU-ICIPE, Gatsby-funded project), pests of horticultural crops, and different species of ticks and tsetse.

- **Nguruman Escarpment** near lake Magadi which represents a unique habitat for tsetse vectors of animal trypanosomiasis (*G. pallidipes* and *G. longipennis*) and inhabited by pastoralist communities. The area is currently undergoing changes in land use including the introduction of horticultural crops.

- **Marigat Field Site** located in the semi-arid Baringo district (near lake Baringo),

temporarily closed, but a useful location for research on vectors of leishmania and malaria.

Outside Kenya, ICIPE has two important research locations in the field:

- **Port Sudan** on the Red Sea coast which is located in the midst or near all the three seasonal breeding areas of the solitarious desert locust; and

- **Addis Ababa** in Ethiopia, which represents an ICIPE outreach base for its work on tsetse, plant pests, disease vectors etc. but also provides access to important disease vectors especially tsetse populations not found in Kenya (*G.m. sub-morsitans* and *G. tachinoides*).

Location of future research sites will be carefully guided by several criteria including the need to undertake outreach adaptive research in key agroecological zones, primary outbreak source or endemicity of important target pests or disease vectors, and promixity to native ecosystems identified as important for arthropod biodiversity research. Such multipurpose-based selection would optimise the use of field stations. To minimise costs, the Centre will seek to share existing facilities with other international or national organisations. One such station is planned for Cote d'Ivoire in West Africa which is expected to become ICIPE's base for its research on the vectors of human trypanosomiasis, arthropod biodiversity and outreach activities in the area.

A Culture of Excellence

ICIPE's new management is cognizant of the fact that the Centre's vitality depends not only on its mission statement, strategy, structure and facility - the "hardware" of the Centre - but also on an environment conducive to creativity, innovation and excellence which would ensure the realisation of its mission and goals. The Centre's environment depends on the collective skills, motivation and values of its staff - the Centre's "software" - which the management is committed to nurture. Indeed, the management sees the building of such an

environment as an integral part of its new strategy and it proposes to do so within the following framework:

- A flexible matrix structure already described that houses a series of inter-disciplinary and inter-programme projects that promote team-work and cooperation between participants to realise common objectives.

- Decentralised management of research based on a 3-tier leadership of programme leaders, departmental heads and project coordinators, designed to promote the sharing of responsibilities, interactive development of projects and problem analysis from different perspectives.

- Openness in research undertakings within the Centre and with outside collaborators to promote free exchange of ideas and results, as well as high standards of scientific integrity and accountability.

- A compensation system that is competitive, and that recognizes creativity and innovativeness in research, as well as accomplishments in problem solving, technology generation and capacity development.

- A participatory management style in all aspects of the Centre's functions including staff recruitment, welfare and performance evaluation, project prioritisation and planning, resource allocation and sharing, job assignments, etc., to ensure adequate consultation at all levels and open communication in all directions.

Within this framework, those in the leadership positions will be expected to set the pace and example, to establish informal and cordial interpersonal relationships between all levels, to share credit fairly, and to inspire others to excel.

CHAPTER IV

RESOURCE NEEDS AND MANAGEMENT

In the preceding chapters we outlined ICIPE's programmes designed to contribute toward increased food production, improved public health, alleviation of poverty and gender imbalances, small-scale industrial development, protection of the environment, conservation of biodiversity, and capacity development in its constituency. These represent an ambitious set of goals. But, the needs are there and, with its new implementation strategy outlined in Chapter III, ICIPE can deliver if capacitated optimally. In this Chapter, we outline the Centre's resource needs and plans for their effective use and efficient management.

Funding Profile

The funding profile must enable the Centre to undertake strategic planning over a reasonable time scale. It must be flexible to allow resources to be allocated in a way that would ensure that new knowledge can be generated to sustain its applied and adaptive research. It must be stable over a reasonable time to attract talent, to minimise large turnovers of senior staff, and to ensure institutionalisation of expertise, experience, and a culture of excellence. **Stability, flexibility and continuity can only be built from unrestricted core funding which can support a critical mass of core activities in the science departments and support units to service programme goals.** Recent trends in ICIPE's funding with substantial reduction in absolute levels as well as in the proportion of core funds have seriously eroded the Centre's capacity to rebuild itself into a viable Centre of Excellence.

During the rebuilding phase, it is envisaged that the Centre would need to maintain a total of 33 international professional staff, 4 in the directorate and the rest distributed between the science departments, and support units. Support for a core staff comprising the Head and a minimum of two senior staff is planned for each science department except the larger Applied Ecology which will have additional core staff. Attached to each core staff position will be one postdoctoral position which will ensure continual influx of new ideas and techniques from other laboratories. Based on an improved renumeration structure and comparable cost elements used

by CGIAR centres, the average unit cost of a senior scientist has been compiled (Box 4).

If the unit cost for a scientific position is US$270,000, the 33 core positions will cost US$8.91 million. It is hoped that ICIPE's sponsoring group, the SGI, will recognise the importance for the Centre to rebuild itself and will respond appropriately to this need.

In the meantime ICIPE is pursuing several areas for long-term sustainable sources of funding:

- A concept of buying "shares" of the Centre was proposed in the SPAAR meeting in South Africa in March 1995. ICIPE's clients would purchase these "shares" in return for research results and technologies provided, and training undertaken at different levels, by the Centre. This novel idea was received with interest by national and regional bodies and by donors, and was considered worthy of further attention.

- Annual subventions may be provided to the Centre by the client countries in addition to grants from traditional funding agencies from the North. The idea has been proposed to African Heads of States. Thus, if 30 such countries contributed $150,000 yearly, half of ICIPE's core funding needs would be met.

- The ICIPE *Science Park* (Chapter III) once established could open a significant source of revenue for the Centre. ICIPE would provide its intellectual property and knowhow in return for shares in revenues generated by companies that initially grow on the *Park*.

- Of ICIPE's self-financing units the ICIPE Science Press (ISP) has the potential of generating large surpluses if configured to undertake substantial revenue generating activities. This the Centre is exploring. If investment funds are forthcoming, ICIPE's housing scheme ("ICIPE Village") and a conference facility

BOX 11. UNIT COST OF ONE IPS PER YEAR (IN US$)

1.	Emoluments	65,000
2.	Home passage	10,000
3.	Transportation	10,000
4.	Field Expenses & Vehicle running costs	20,000
5.	PDF/Scientific Officer	45,000
6.	*ARPPIS Student	
7.	Research Assistant	10,000
8.	Support Staff (3)	15,000
9.	Equipment	20,000
10.	Maintenance of Equipment	2,000
11.	Research Supplies and Services	12,000
12.	International Travel	6,000
13.	Literature Acquisition, Publication and Reports	5,000
14.	Sundries	5,000
15.	#Institutional Services (20%)	45,000
	TOTAL	270,000

** To be funded separately*

 # Institutional Services does not include 5% for Bridging and Maintenance Funds

at its headquarter linked to the guesthouse could similarly generate additional revenue. Plans for these projects have already been initiated.

To complement core programme research and development activities, the Centre will continue to seek funds from traditional sources to service its special projects and capacity development activities. In addition, ICIPE is urging its clients in the national systems to access funds for collaborative activities with the Centre from multilateral sources such as the Agricultural Fund of the World Bank, UNDP Capacity-21, UNDP-IPF country programmes, and Global Environment Fund (World Bank, UNDP, UNEP).

Criteria for Resource Allocation

The current (1995-1996) level of core funds provide very little flexibility to base resource allocation on a rational set of criteria. The Centre operates largely opportunistically - do what is funded. In the foregoing section, a case has been made to the donor community for a radical change toward a critical minimum of stable core funding if the Centre is to rebuild itself into an effective and vibrant Centre.

It is envisaged that core funds would in the first place be distributed about equally between the three research programmes. However, within each programme, resources would be allocated on the basis of (a) potential impact of a project in solving a given constraint in food production, rural health, or arthropod related commercial ventures; (b) potential for a scientific breakthrough or important insights in a given area which could open up a new way of managing a pest or vector problem, or enhancing environmental integrity; (c) performance of a given project and the likelihood of a rapid conclusion of specific objectives with additional resource; and (d) human or material resource constraints in a project, allocation of which could speed its progress. In this regard, all programme projects would be reviewed annually, constraints identified, and resources reallocated accordingly.

In the case of special projects, the Centre will continue to seek funds whenever

opportunity arises for R&D activities that would augment its core activities. It is envisaged that some of the basic, exploratory research in arthropod science would be funded this way. However, special adaptive research at the national level may also be funded through specific funding.

Resource distribution between ICIPE's research and capacity development, on the one hand, and support functions and services, on the other, will follow guidelines already well established in the Centre. 75% of resources are allocated to the former, 10% to direct research support and information services, and 15% to indirect institutional services including financial management and administration. Institutional service costs are controlled centrally since these are designed to benefit the whole Centre on an equitable basis. The first level of indirect research and training cost allocation comprises field facilities, maintenance services, etc. The second level relate to institutional support comprising governance, directorate, human resource management, administrative services, public relations, utilities, etc.

Physical Facilities and Equipment

In Chapter III, the location of ICIPE's R&D sites was given. Of these, the laboratories in Nairobi and MPFS are currently adequate. The MPFS infrastructure is being refurbished and nominal funds exist in a deposit account for emergency repair and maintenance of the Nairobi facility. However, funds for routine and preventive maintenance would have to be set aside from ICIPE's different core and project sources. Of the smaller field stations, the facility at Nguruman Escarpment is being rehabilitated, the Marigat field site already has experimental huts for mosquito work, but the Muhaka station needs to be developed. Outside Kenya, ICIPE has rented facilitiees in Port Sudan and Addis Ababa. Elsewhere in the future, the Centre is likely to seek to share facilities with other institutes or hire appropriate facilities at nominal rates.

ICIPE's financial state in the last couple of years (1992-5) has badly affected the implementation of its policy for periodic equipment and vehicle replacement. However, a recent substantial grant from a donor will ease the situation somewhat and help the Centre improve its communication facility with its field stations. With anticipated improvement in its funding

effective and current in its capability.

Human Resource Management

ICIPE has undertaken a major audit of its human resource profile and needs in order to develop a policy framework for attracting and retaining talent, nurturing a multi-skilled workforce capable of operating flexibly and responding to changing demands on the Centre, defining precisely its qualitative and quantative needs, and providing a standardised grading system for different job categories in the institute. Henceforth, human resource development will be based on the following principles:

- A policy of blending longer and shorter term scientific staff will be instituted, the former to allow the growth of a coherent team of senior researchers and the building of knowledge and experience at institutional level, the latter to promote the inflow of new ideas, techniques and knowhow from other laboratories.

- The goal to build a cadre of 33 core staff will be pursued, as explained earlier, to fill key leadership and scientific positions in its programmes, departments, support units and the directorate. This core staff will be augmented by (a) short-term postdoctoral fellows, (b) project staff recruited to work for specific durations in special projects, and (c) visiting scientists from national and international institutions.

- The Centre is an equal opportunity employer. Staff will be recruited competitively, and the best and the most productive will be given preference. Special executive search will be used to augment international advertisements to fill key leadership positions.

- The non-scientific professional, technical and support staff category will be kept trim and keen and will be well equipped to maximise their efficiency. The Centre will ensure that there is an in-house capacity among the professional and technical staff to maintain all specialised equipment where this is cost-effective.

- Although human resource planning will embrace all aspects of the institute, special emphasis will be given to strengthening research departments and units, and in particular, the Ecology and Biodiversity Department which constitutes the core discipline of arthropod science.

- The possibility of integrating research support activities of higher cadre technical staff with graduate training goals will be examined, and, where appropriate, preference will be given to graduate students to undertake these activities as part of their higher degree work.

- As outlined in Chapter III, ICIPE is committed to creating an environment that will motivate all employees to grow and excel, where talent and productivity are rewarded fairly. This will be done through a comprehensive set of job descriptions, employee participation on decision making, management accountabilities and job objectives, management training when needed, performance evaluation against well-defined measures and standards, and a common reward criteria.

CHAPTER V
MONITORING AND IMPACT ASSESSMENT

Need, Scope and Objective

ICIPE's institutional performance will be judged by not only its outputs but also the longer term impact of these on its client groups and the environment. The Centre is cognizant of the need to evaluate these and to develop appropriate methodologies and mechanisms for the purpose. The Centre's outputs represent incremental and collective performance at different levels of the institute - programme, department, project and individual. These are readily defined as follows (see Chapter III):

- Technologies for the management of injurious and beneficial arthropods;
- Products, tools and devices as components of these technologies;

- Scientific output in the form of papers, reviews and intellectual property, and
- Trainees at different levels.

Impact, on the other hand, remains to be defined in the context of ICIPE's goals to contribute to poverty alleviation, environmental health, capacity development etc in its constituency. Since many partners are involved in these processes, in addition to socio-political and economic factors, measuring ICIPE's impact is likely to be a much more difficult task. Underlying monitoring, evaluation, and impact assessment is an important objective: to identify gaps or weaknesses in R&D implementation and technology transfer processes and, accordingly, to develop ways of rectifying these.

Monitoring Outputs

A system of monitoring performance and output has been operational at ICIPE at different levels:

- **The individual staff.** All researchers (and support staff) are reviewed annually and their performance evaluated on the basis of agreed work plans and targets.

- **The Annual Research Conference.** This is largely an in-house mechanism of monitoring and appraising progress in different programmes. It is undertaken with Programme Committee members of the Govening Council and the Centre's collaborators and have taken the form of oral and poster presentations.

- **Project reviews.** Many Projects are reviewed annually or periodically by external teams appointed by specific donors.

- **Institutional reviews.** Starting from 1983, the SGI instituted the "ICIPE Periodic External Review (IPER)" system which undertakes review of the scientific programmes, administrative and financial management of the Centre.

Since projects are the actual working units of the Centre, a great deal of attention will henceforth be given to ensuring that inputs, work schedules and outputs at the project level are proceeding according to defined objectives and plans. Within projects, performance by individual researchers will be assessed by the 3-tier leadership (programme leaders, departmental heads and project coordinators) of ICIPE's new matrix structure. This will ensure greater accountability by the researcher as well as fairness in performance appraisal.

Impact Assessement

To date, no work has been undertaken to assess the impact of the Centre's R&D and capacity building activities. However, this is envisaged to be an important task of the Centre's Social Science Department (see Chapter IV). The Department's functions will now include the development or adaptations of appropriate methodologies and indicators for monitoring impact on the Centre's target clientele. Impact assessment needs to be undertaken at several different levels:

(a) intra-household level, on individual women and men;

(b) household level comprising different types of legal and *de facto* male- and female-headed households; and

(c) collective level representing women groups, cooperatives, marketing networks, national R&D institutes, communal environmental management initiatives, etc.

Accordingly, specific indicators that would need to be developed would include (a) individual income levels, their nutritional and health status, skills and knowhow, relative social status in the family and community, membership in collective organisations etc.; and (b) evidence of collective development as reflected in institutional capacity, environmental condition, growth of arthropod-based industries, emergence of cooperatives and marketing networks etc.

CONCLUSIONS

In the preceeding chapters, we have described ICIPE's vision of its future. We identified the vital regional and global concerns that we wish to address, and the client groups that we would wish to benefit from our activities. We outlined the elements of the strategies we intend to follow to realise our vision. ICIPE has an important mission to perform. It needs the means to perform this mission. We hope that it will be provided with this means.

BOX 12. ICIPE'S MANDATE

The mandate of the ICIPE is: (i) research in integrated control methodologies for crop and livestock insect pests and for insect vectors of tropical diseases crucial to rural health; and also the management of beneficial insects; and (ii) the strengthening of the scientific and technological capacities of the developing countries in insect science and its application through training and collaborative work.

PRINCIPAL OBJECTIVES

(a) Undertake fundamental research on selected pests in order to provide information on their identity, abundance, distribution, ecology, behaviour, physiology, pathology, genetics, and the application of this knowledge to the problems of integrated pest and vector management systems to improve the quality of life at farm and family level as well as their application to the management of beneficial insects;

(b) Establish research cooperation with key international research centres and advanced laboratories throughout the world, and with national programmes in Africa, to facilitate research on the testing and demonstration of pest control strategies;

(c) Provide advanced training in research methods for doctoral candidates and postdoctoral fellows, as well as young practitioners in insect science and technology;

(d) Provide an international forum for the accumulation, discussion and dissemination of scientific knowledge through seminars, symposia, conferences, training workshops and the establishment of document production, handling and storage facilities;

(e) Promote the growth of the scientific community in the tropics and especially Africa, both by its activities and its special relationships with universities, research institutions, specialized agencies, and Academies of Science.