THE INTERNATIONAL CENTRE OF INSECT PHYSIOLOGY AND ECOLOGY AS AN INTEGRAL PART OF THE AGRICULTURAL CENTRES NETWORK

SUPPORTING PAPER TO THE APPLICATION

Nairobi, Kenya. 17th December, 1974.
FOREWORD

At its 22nd Meeting held on 6th September 1974, the Governing Board of the International Centre of Insect Physiology and Ecology (ICIPE) endorsed the action already taken by the United Nations Development Programme (UNDP) through its Director for the Division for Global and Interregional Projects, Mr William T. Mashler. On 5th August 1974, the latter sponsored the proposal that the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) consider the urgent need to admit the ICIPE into the network of the international agricultural research centres that operates under the umbrella of the CGIAR. In response to the favourable reply that the TAC would consider the ICIPE at its February 1975 meeting in Rome, the ICIPE Governing Board is now presenting a detailed application to the CGIAR for acceptance of the ICIPE within the network of international agricultural centres and for the funding of its core programmes and activities from January 1976.

Five factors are vitally important in considering the ICIPE application:

1. Means (including new science, new technology, and new management practices) to increase the world food availability has become crucial. The recent World Food Conference, held in Rome in November 1974, has dramatically presented the grim situation regarding food stocks and the long-term prospects of food production. For many of the less developed countries (LDCs) this has become a matter of survival. It is reckoned that approximately 30% of the potential food production in the tropics is lost through pests; this loss can no longer be taken for granted, and must be eliminated.

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

3. The selection of crop varieties that are resistant to pests and diseases has very largely depended on a pragmatic approach. It has now become increasingly apparent that, in the tropics and subtropics, where we have a complex and rich biota, farming systems

............../ (ii)
more often than not will take the pattern of limited cultivation, inter-cropping, multi-cropping and multi-seasonal harvesting. In such a complex situation, the prospects of breakdown of plant resistance due to any number of biological and agronomic processes is great. We must therefore be armed with the necessary information on the basic mechanisms of resistance in individual cases as a necessary architectural inventory for the plant breeder.

4. Apart from its major role of acting as a fountain of ideas for the development of practical and long-term control of selected major pests of the tropical environment, the ICIPE has also a major commitment to building up intellectual capital in insect science in the LDCs - and in this way foster the growth of a development-conscious scientific community in the LDCs. The ICIPE is eminently placed to act in this capacity: a climate has already been built up wherein a diversity of scientific talent from both the developing and developed countries can pursue advanced targeted research under the guidance of eminent scientists from many disciplines.

5. During this establishment phase of the ICIPE, the more substantial of the 20 or so donors of the Centre are part of the same group of donors that are supporting the international network of agricultural research centres through the CGIAR - for instance, the UNDP, the Swedish International Development Authority (SIDA), the Swiss Technical Cooperation, the Rockefeller Foundation, the Ministry of Overseas Development of the United Kingdom (ODM), the Danida International Aid Authority (DANIDA), the Norwegian International Aid Authority (NORAD), and the U.S. Agency for International Development (USAID). It would be apparent therefore that, for managerial reasons, it would be more efficient to consider the long-term and continuing support of the ICIPE alongside that of the rest of the international centres network.

The ICIPE has a short history. It was legally incorporated under Kenya law in April 1970. It started its research activities at the end of 1971 in a small way. In these three short years it has established strong multi-disciplinary programmes of research of high quality under difficult conditions. It has proved the efficacy of this model of concentrated research in LDC environment. We are confident that the ICIPE programmes will yield novel and vital information that will be important in the design of pest management practices of direct significance to crop and livestock production. We are also conscious of the fact that the ICIPE will complement much of the work of all the CGIAR network of institutes. Consequently, we are encouraged to believe that the CGIAR will consider the ICIPE application with the greatest sympathy.
The ICIPE programmes, their expected development over the next five years or so, the necessary budgetary and capital requirements, are explained in the following pages.

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Governing Board

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Department of Zoology, Oxford
ENGLAND

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Minister for Planning and Economic Development,
TANZANIA

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Research Associate, American Academy of Arts and Sciences, Boston
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Professor of Chemistry, University of Columbia, New York
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Director, Centre National de Recherches Agronomiques,
Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières, Bambey
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Max-Planck-Institut für Verhaltensphysiologie
Seewiesen
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University of California, Berkeley
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Directors of Research

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Insect Sensory Physiology and Behaviour

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Professor A. R. Möller (1973) Sweden
Professor J. W. S. Fringle (1970) England
Professor Dietrich Schneider (1970) W. Germany

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Professor Jerrold Meinwald (1970) U.S.A.
Professor K. Nakanishi (1970) U.S.A./Japan
Professor D. S. Smith (1970) U.S.A.

Insect Hormones

Professor Martin Löscher (1970) Switzerland
Professor Thomas R. Odhiambo (1970) Kenya
Professor H. A. Röller (1970) U.S.A.
Professor J. de Wilde (1970) Netherlands

Policy Advisory Committee (UNDP/ICIPE Committee)

United Nations Development Programme
Mr William T. Mashler
Dr A. Davidson

International Centre of Insect Physiology and Ecology

Chairman, Governing Board (Chairman, 1973 - )
Director, ICIPE
All Directors of Research
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Dr John L. Nickel

Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT)  
Dr Keith W. Finlay

Centro Internacional de la Papa (CIP)  
Dr Richard L. Sawyer

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)  
Dr J. S. Kanwar

International Institute of Tropical Agriculture (IITA)  
Dr Dennis J. Greenland

International Laboratory for Research on Animal Diseases (ILRAD)  
Dr James B. Henson

International Rice Research Institute (IRRI)  
Dr N. C. Brady

Food and Agriculture Organization (FAO)  
Dr William R. Furtick  
Dr P. Finelle

International Atomic Energy Agency (IAEA)  
Dr D. A. Lindquist

World Health Organization (WHO)  
Dr J. Hamon

International Committee

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Professor Jan de Wilde (Chairman, 1974 – )  
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Danish Academy of Sciences  
Professor Overgaard Nielsen

The East African Academy  
Professor R. J. Okembo

The Israel Academy of Sciences and Humanities  
Professor E. D. Bergmann

Japan Science Council  
Professor H. Chino

Max Planck Society  
Professor Dietrich Schneider  
Dr. Friedrich Schneider
National Academy of Sciences (U.S.A.)
   Professor Carl Djerassi

American Academy of Arts and Sciences
   Professor Roger Revelle
   Professor Carroll L. Wilson

Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM)
   Professor J. Bergerard

Centre National de la Recherche Scientifique
   Dr. S. Fuzeau-Braesch
   Professor J. Labeyrie

Norwegian Academy of Sciences
   Professor A. Semb Johansson
      (Vice-Chairman, 1974 -)

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      (Chairman, 1970 - 71)

Royal Swedish Academy of Engineering Sciences
   Mr. Lennart Baverud

Royal Swedish Academy of Sciences
   Professor Carl G. Bernard (Chairman, 1971 - 72)
   Professor Erick Dahl

Swiss Society of Natural Sciences
   Dr. Fritz Schneider

Observers:

   (1) Academy of Finland
       Professor H.G. Gyllenberg

   (2) Hungarian Academy of Sciences
       Dr. T. Jermey

Professor Thomas R. Odhiambo (ex - officio)

African Committee

Professor T. Ajibola Taylor (1973)
   (Chairman, 1974 -)
   Faculty of Agriculture, University of Ibadan, Nigeria.

Dr. I.K.A. Amuh (1974)
   Director, Cocoa Research Institute, Tafo,
   GHANA
Professor Mahmoud Hafez (1974)
Faculty of Agriculture, University of Cairo
EGYPT

Professor Aklilu Lemma (1970)
Vice-President, Haile Selassie I
University; Chairman, Institute of Pathobiology,
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ETHIOPIA

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TANZANIA

Dr D. S. Nkunika (1972)
Secretary General, National Council for Scientific
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Chairman, Department of Botany, University of Nairobi
KENYA

Dr D. P. S. Wasawo (1970)
Division of Natural Resources,
U.N. Economic Commission for Africa, Addis Ababa
ETHIOPIA

(Three vacancies being filled in March 1975)

Professor Thomas R. Odhiambo (ex-officio)

Mr J. M. Ojal (ex-officio), Secretary

ADMINISTRATION

Director

Deputy Director (Science)

Deputy Director (Special Duties)

Financial Manager

Controller for Technical Services

Librarian

Head, ICIPE Coastal Research Station

Professor Thomas R. Odhiambo

Dr J. Strangways-Dixon

Mr Joel M. Ojal

Mr J. II. Jivanjee

Mr A. Mando

Mr D. R. Kigera

Dr L. P. Lounibos
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<tr>
<th>Abbreviation</th>
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<tbody>
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<td>AAASA</td>
<td>Association for the Advancement of Agricultural Sciences in Africa</td>
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<tr>
<td>CGIAR</td>
<td>Consultative Group on International Agricultural Research</td>
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<tr>
<td>CIAT</td>
<td>Centro Internacional de Agricultura Tropical</td>
</tr>
<tr>
<td>CIMMYT</td>
<td>Centro Internacional de Mejoramiento de Maiz y Trigo</td>
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<tr>
<td>CIP</td>
<td>Centro Internacional de Papa</td>
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<tr>
<td>CNRS</td>
<td>Centre National de la Recherche Scientifique</td>
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<tr>
<td>CRU</td>
<td>Chemistry Research Unit (ICIPE)</td>
</tr>
<tr>
<td>DANIDA</td>
<td>Danish Agency for International Development</td>
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<tr>
<td>EAAFRO</td>
<td>East African Agriculture and Forestry Research Organization</td>
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<td>EATRO</td>
<td>East African Trypanosomiasis Research Organization</td>
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<td>EAVRO</td>
<td>East African Veterinary Research Organization</td>
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<td>ECF</td>
<td>East Coast Fever</td>
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<td>ERU</td>
<td>Electrophysiology Research Unit (ICIPE)</td>
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<td>FAO</td>
<td>Food and Agriculture Organization of the U.N.</td>
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<td>FSRU</td>
<td>Fine Structure Research Unit (ICIPE)</td>
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<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
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<td>IITA</td>
<td>International Institute of Tropical Agriculture</td>
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<tr>
<td>ILPAD</td>
<td>International Laboratory for Research on Animal Diseases</td>
</tr>
<tr>
<td>IRRI</td>
<td>International Rice Research Institute</td>
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<td>JH</td>
<td>Juvenile Hormone</td>
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<td>LDC</td>
<td>Less Developed Country</td>
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<td>NORAD</td>
<td>Norwegian Agency for International Development</td>
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<tr>
<td>NUFFIC</td>
<td>Netherlands Foundation for Fundamental Research</td>
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<tr>
<td>ODA</td>
<td>Overseas Development Administration (U.K.)</td>
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<td>ODM</td>
<td>Ministry for Overseas Development (U.K.)</td>
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<td>ORSTOM</td>
<td>Office de la Recherche Scientifique et Technique Outre-Mer</td>
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<td>TAC</td>
<td>Technical Advisory Committee of the CGIAR</td>
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<td>TPRI</td>
<td>Tropical Pesticides Research Institute</td>
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<tr>
<td>SIDA</td>
<td>Swedish International Development Agency</td>
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<td>UNDP</td>
<td>United Nations Development Programme</td>
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<td>UNEP</td>
<td>United Nations Environmental Programme</td>
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<td>USAID</td>
<td>United States Agency for International Development</td>
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<td>WHO</td>
<td>World Health Organization of the U.N.</td>
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I. BACKGROUND AND ORIGINS OF THE ICIPE

In December 1968, three senior scientists and two science administrators met with Professor Thomas R. Odhiambo of the University of Nairobi at the offices of the American Academy of Arts and Sciences, in Boston, U.S.A., to consider whether or not an international research centre for tropical insect science should be established and, if so, where. The meeting was the result of an article in Science which had appeared a year before and which had advocated the establishment of a few concentrated research centres in the LDCs as a means of building up intellectual capital in these countries as well as solving their long-term science-based problems. The article led to correspondence between Professor Odhiambo, in Nairobi, and Professor Carl Djerassi, in Stanford University, U.S.A., who had suggested to the 1967 Pugwash Conference a model for postgraduate training in a specialist field in the LDCs based on his experiences in building up chemical schools in Mexico and Brazil by using young American postdoctoral scientists.

The Boston meeting recommended the establishment of such a centre in Kenya, and called for a planning conference as soon as possible to work out a detailed programme. The planning conference was convened in Nairobi in October 1969; and brought together over 60 distinguished scientists, science administrators, and public officials from Africa, Europe, North America and Australasia, for a week of intensive discussions and field visits. The conference endorsed the idea of establishing the ICIPE in Nairobi, and laid down a number of guidelines for a planning committee to whom the detailed planning and execution of the policy decisions were left.

The planning committee met for the final time in January 1970 at Wageningen, in the Netherlands. The detailed design of the ICIPE, its legal status, its organizational arrangements, and a schedule for effecting its establishment was agreed upon. In April 1970, the ICIPE was registered under Kenya law as a company limited by guarantee and having no share capital (see Appendix I).

Parallel with these efforts, negotiations were initiated with the authorities of the Kenya Government and the University of Nairobi; the first because of the need to obtain certain privileges to facilitate the work of the Centre (including the provision of land, exemption from income tax and customs duties, and the provision of work permits for international staff); the second to enable the Centre to have a close working relationship in the sphere of advanced training, in which field the ICIPE was committed from the very beginning. Agreement with the two authorities was reached by the end of 1970 (see Appendices 2 and 3). Similar efforts were started with the East African Community authorities; and, in spite of the serious internal problems that were
then racking this semi-federal set-up, an understanding regarding collaborative efforts between the ICIPJ and the applied research institutes of the Community was reached by mid-1971. A practical demonstration of this understanding is exemplified by the Memorandum reached with the East African Veterinary Research Organization (EAVRO) earlier this year in respect of tick research (see Appendix 4). The rapid manner in which these various understandings were reached in East Africa testified to the major concern these countries felt regarding pest problems and the appropriate high-level training.

Several national forums for the discussion and development planning of the ICIPJ were crucial in its early establishment: an ICIPJ "Development Office" in Boston was important in finding "seed" money for a start-up of the Centre; a similar Development Office in Wageningen found the original funds to erect the first two buildings - both of a temporary nature - to enable the ICIPJ to embark on its research activities in late 1971; a small planning group in Nairobi undertook much of the detailed planning, early negotiations, and ad-hoc administrative arrangements to enable the ICIPJ to become a living entity right from the time of its legal registration; and the British ICIPJ Committee did much to clarify the relationship between the ICIPJ and the applied research establishments in Africa and other LDCs. Since then, national ICIPJ Committees have also been established in the U.S.A., the Netherlands, Sweden, Denmark, Norway, Israel, Switzerland, West Germany, Japan, and France. These committees discuss ICIPJ activities, disseminate information on the progress the ICIPJ is making, and help in raising financial support.

At the time the ICIPJ was being planned, thoughtful insect scientists and other senior planners and scientists were becoming disillusioned by the fact that pesticides seemed to be the main - and in some cases, the sole - prop for pest control. Ideas about "third-generation" pesticides - in which insects' own hormones and other physiological agents were a prominent feature - were then becoming fashionable; and suggestions regarding "integrated pest control" were then commanding more serious attention. It was also during this time that the LDCs were beginning to pay particular attention to building up their own research and technological capabilities in science-based national programmes. The birth of the ICIPJ at this particular time was therefore a most opportune event.

It set itself a double mission. Firstly, it set itself to undertake high quality research in all critical aspects of insect life that would lead to the isolation of new agents and the design of novel methods that would control pests in a highly selective manner, which would not lead to long-term environmental pollution, and which would not result in the development of resistance in the pest species. Secondly, it set itself the task of carrying out high-level technical and scientific training of young scientists from Africa in the field of insect science and related areas, with the specific intention of fostering the growth of an African scientific community.
The design of the ICIPE was equally novel: a number of leading scientists in insect science, with active laboratories in their home countries, were given three-year honorary appointments (as "Directors of Research") to guide the research programmes of the ICIPE: the major academies of science were invited to sponsor the ICIPE and to appoint representatives to an advisory International Committee, whose major concern is to maintain the quality of ICIPE research and to ensure that the ICIPE staff are in constant touch with the international scientific community: and an African Committee to assist in the development of the training programme and to judge the relevance of ICIPE's work to the critical pest problems of Africa.

To these original objectives, there was added in May 1974 a third. At the meeting in that year of the Policy Advisory Committee, the Directors of Research at the ICIPE became aware (many of them for the first time) of the opportunities that exist for assisting the global agricultural institutes with some of their entomological problems. This additional role has been accepted by the Governing Board, and one new core research programme has since been started as the direct result of a suggestion made at a meeting of the Policy Advisory Committee. Within the limits set by its facilities, the ICIPE is ready to consider special projects for the international research institutes and to help mobilize international intellectual resources to the long-term solution of tropical pest problems.
II. OBJECTIVES: PRESENT AND PROPOSED

The mandate of the ICIE is to promote and carry on research into insect biology, including fundamental questions in insect ecology, genetics, physiology, endocrinology, biophysics, biochemistry, organic chemistry, and other related disciplines, which will lead to the design of effective long-term pest management programmes having minimal side-effects; to provide advanced training to young African scientists and technologists, and thus assist in the fostering of a development-conscious African scientific community; and to foster international collaboration in these fields.

While the mandate is broad, the focus is on more limited objectives for each succeeding phase of the ICIE development. Basically, there are four objectives in the present ICIE's programmes:

1. To discover new knowledge which would lead to the long-term control of the principal vectors (tick and tsetse-fly) of the two leading African livestock diseases, African animal trypanosomiasis and East Coast Fever (ECF).

2. To discover, through multi-disciplinary research new knowledge which would assist in the long-term control of three "international" pests of major importance to agricultural production - African Armyworm (a migratory pest that attacks graminaceous crops and pastures), the Sorgum Shootfly (the major insect pest of sorghum wherever it is grown in the world), and the higher termites (which attack pastures and forest products).

3. To test intensively a model for the control of a tropical pest through genetic manipulation (the model being used is *Aedes aegypti*, the Yellow Fever vector).

4. The training of young African post-doctoral scientists and senior technical staff through participation in ICIE programmes.

Because of its preponderant aim in increasing world food production, the ICIE's goals are necessarily closely complementary to those of the existing international agricultural research centres. The ICIE, through its own staff and its research contacts, seeks to unravel the basic ecological and physiological processes that underly long-term and environmentally-acceptable pest management techniques. The ICIE also closely collaborates with the applied research institutes in Africa and other LDCs, which have not the resources needed to find lasting solutions to the problems of tropical pests.
In the last three years, the ICIPE has succeeded in establishing a
potent and high-calibre multi-disciplinary team in laboratory-oriented
insect science, and it has already made significant achievements in
fundamental insect science (see Chapter IV). The next phase, which
will begin in 1975, is for the ICIPE to put special effort into building
up similar appeal and make similar notable advances in field-oriented
research (particularly in insect ecology). This type of research is
expensive, and the ICIPE is only now ready to embark on this phase,
which has an important synergistic relationship with laboratory studies.
The third phase, and one which is crucial to the whole ICIPE thrust,
is to gather together this fundamental information on individual insect
species’ ecology and physiology and select those items likely to make an
impact in pest management. During this phase, which will probably start in
1978 for three target species - tsetse flies, ticks, and armyworm - intimate
relationships with the applied research institutes and the international
agricultural research centres will be essential.

Although we have termed these ICIPE research strategies as phases,
they can only be regarded as such in describing the historical development
of the ICIPE. Ideally, if the ICIPE had started as a fully endowed
establishment, the three phases would not be distinct and there would have
been, instead, a continuum of strategies. Indeed, this is the state of
affairs that the ICIPE plans to reach by the beginning of 1978, when all
three strategies for research - laboratory-oriented research (in insect
natural products chemistry, biochemistry, biophysics, functional fine
structure, endocrinology, physiology, etc.), field-oriented fundamental
research (in insect ecology, population genetics, micro-climate,
agricultural meteorology, insect pathology, etc.), and inputs for pest
management (pilot testing of novel control techniques, short forecasting
system, etc.) - will constantly interact with each other and feed-back
information for new areas of research and development.

By 1981, the ICIPE should have made major advances in some of its
studies on target insects - especially on tsetse flies and ticks - to
permit a major review of its programmes and re-ordering of priorities
by introducing new important agricultural pests of other food crops for
investigation.

It is not thought that the ICIPE itself will ever become a pest control
institute. But it is the purpose of the ICIPE to yield special inputs for
overall pest management programmes of the chief tropical and sub-
tropical pests. In doing this, it also plans to stimulate the build up of
the capabilities of the LDCs in research and development in the field
of insect science and technology.

Finally, it has been suggested to the ICIPE that greater consideration
might be given to the insects' contribution to (as opposed to the
destruction of) world food production. For instance, the bees' role in
pollination and therefore in increasing crops, and also their role in honey
production - the importance of which is becoming increasingly apparent
as sugar prices escalate. Whilst apiculture is highly sophisticated in
developed countries, the European-bees do not survive in Africa.
Therefore this field of research is still in its infancy and requires
urgent attention.
III. PRESENT STATUS AND ORGANIZATION

1. Management

The highest policy and management body of the ICIPE is the Company itself (see Appendix I), presently consisting of about 140 members from Africa, Asia, Australia, Europe, North America, the U.S.S.R., and the Far East. It has no share capital; but every year the members hold an Annual General Meeting to receive the annual accounts, the budget for the following year, to review research progress, and to elect members of the Governing Board, to which the Annual General Meeting devolves its powers of managing the Centre.

The Governing Board presently consists of 10 members, although it has powers to become larger (with a membership of up to 30). One-third of the Board membership retires every year, so that a Governor normally serves for a period of three years. The members are selected from among Company members, whose number can be increased by a resolution of the Board. The composition of the Board has always been international in character and has included senior science administrators, senior researchers, and men of public affairs. The Board at present meets twice a year, of which one is always in Nairobi.

Priorities for research at the ICIPE are discussed at an Annual Research Conference in Nairobi, attended by all Directors of Research and scientific staff; recommendations from this meeting are made to the Governing Board, which meets immediately afterwards. The Board also receives advice from three advisory bodies, the African Committee, the International Committee, and the Policy Advisory Committee, which meet annually.

The African Committee contains institutional members from the U.N. Economic Commission for Africa, the East African Community research organizations, the University of Nairobi, and eight regional representatives from the four geographical areas of Africa. The members are senior persons with expertise in research policy or technical science and advice on the relevance of the ICIPE research programmes and activities to major African pest problems.

The International Committee consists of representatives from the East African Academy and of Academies of Science of the larger countries of the world, who provide for the expenses of their representatives. It assists in fund raising and advises on the appointment of Directors and Research: it also exercises a watching brief on the quality of research at the ICIPE by detailed consideration of the Annual Report and by appointing from time to time members of a Visiting Group of experts to assess the development of the Centre.
The Policy Advisory Committee consists of representatives from UNDP, FAO, IAEA, WHO and the international agricultural centres. It meets with the Directors of Research of the ICIDE to discuss the relation of their programmes of research to on-going research and technical needs of the various organizations.

This pattern of advisory bodies has hitherto worked well and they have given valuable advice in the development of the Centre. In 1975, all three advisory bodies will meet during the same period in Nairobi and it is possible that this will lead to some measure of reorganization.

2. Administration

The research centre is led by the Director, who is also Professor of Entomology in the University of Nairobi and at present holds a part-time appointment with the ICIDE. It is possible that he may become a full-time Director and provision is made for this in the budget.

The Director is assisted by a Deputy Director (Science), a Deputy Director (Special Duties) with particular responsibility for public relations, a Financial Manager, and senior officers in the administration.

On the technical side, the ICIDE has for more than a year had an experienced technologist and engineer as Controller for Technical Services. Under him are the research support sections for insectary, workshops, photography and laboratory management, each with a vigorous training programme. The newest of the ICIDE support services are those pertaining to Library and Documentation. At first, it was thought that library resources in and around Nairobi would be adequate for the research needs of the ICIDE. Experience has shown that the Centre must build up a technical reference library in the field of insect science in order to keep in touch with advances made elsewhere. The library is now taking shape with the help of grants from Switzerland, the Netherlands, and the United Kingdom and an experienced scientific librarian has been recruited to guide this development. The Documentation Section has only just been formed and requires further staff and facilities before it can provide the service needed both within the Centre and to organizations in Africa and elsewhere.

3. Institutional Relationships

The closest institutional relationships that have been worked out to facilitate the work of the ICIDE are the following:
1. That with the Kenya Government (see Appendix 2), the provisions of the joint Agreement permit the ICPE to request land for its laboratories, field stations, and ecological programmes. It also enables the ICPE to enjoy certain privileges.

2. That with the University of Nairobi (see Appendix 3), the provisions of the joint Agreement enable the two institutions to reciprocate and complement each other in specific areas of research, training, and the sharing of facilities.

3. That with certain of the East African Community applied research establishments have already worked out close collaborative arrangements with EAVRO (on tsetse and ICP research); the East African Trypanosomiasis Research Organization (EATRO), at Tororo, Uganda (on tsetse and trypanosomiasis research); the Tropical Pests and Diseases Research Institute (TPI) at Arusha, Tanzania (on insecticides chemistry and tsetse ecology); and the East African Agriculture and Forestry Organization (EAGRO) at Nairobi (on armyworm research).

The ICPE has recently initiated discussions with the Kenya Government to enable the two bodies to review some of the provisions of the Agreement. In particular, provisions relating to the income structure of ICPE's international staff would need to be reviewed to fall in line with those of the other CGIAR institutes.

Efforts are also being initiated to discuss and conclude enabling collaborative agreements with other high-quality research establishments elsewhere in Africa (e.g., in Zambia, Nigeria, and Senegal) and other LDCs (e.g., in India, Malaysia and Brazil).

A specially important linkage is that already forged between the ICPE Research Centre in Nairobi with the laboratories of the Directorates of Research living abroad. Such close connections make ICPE the hub of an invisible network of insect research establishments which, together, constitute a formidable apparatus for the advancement of our multi-variate knowledge of insect biology.

An equally important linkage is that which is beginning to be forged between the ICPE and the CGIAR network of international agricultural research. These linkages are already particularly strong with IITA (on crop ontogeny, in general), with ICRISAT (who proposed to the ICPE that the latter launch a special research programme on the
Sorghum Shootfly), and ILRAD (whose complementary work on trypanosomiasis and ECP will be especially intimate, ILRAD working on immunological aspects while the ICIPE is devoting its efforts to the vector problems). Equally important linkages and steadily becoming evident with the other international agricultural institutes, as the needs of both parties and the special knowledge they can bring to bear to solve the pest and food production problems become clearer.

4. Recruitment and Training

Recruitment of the principal scientific and administrative staff is on an international basis. International advertising of openings is part of the recruitment process, and interview and selection is done carefully and thoroughly.

In the very beginning, some of the funding was tied to particular country recruitment. With the signing of funding agreements with the UNDP and SIDA in 1972, who supply over 75% of the ICIPE funding at present, these tied recruitment programmes are becoming gradually phased out and being entirely replaced by the recruitment of the best staff from anywhere. The ICIPE plans to continue with this recruitment strategy.

Training is an important activity of the ICIPE (see Chapters II and IX). Most of this is currently being carried out while the trainee is actually working on an ICIPE research programme—whether in ICIPE's own installations in Africa or elsewhere in the laboratories of the relevant Directors of Research. As will be described in the next section, ICIPE's physical facilities (and funding also) have been limited over the first years of its establishment. In spite of these limitations, the ICIPE has a considerable record of successful advanced training of young Africans as follows:

- Experimental Officers ............. 8 (ICIPE's own staff)
- Senior Technical Staff ............ 6 (ICIPE's own staff)
- Visiting Senior Technicians ........ 2
- Visiting Postdoctoral Scientists .... 2
- High-school graduates, going on to University science courses .. 9.

The provision of adequate physical facilities, organizing manpower, and the necessary funds is high on the list of requirements for the next phase of the development of the ICIPE.

The basic formula for the recruitment of the principal scientific staff was that the staff should be young postdoctoral scientists holding short contracts at the ICIPE of a maximum of 3 - 4 years. This early design
decision has enabled the ICIPE to capitalise on the pioneering spirit, the youthful enthusiasm, and the imaginative faculties of those young people at a critical embryonic stage of the ICIPE. At present, all ICIPE principal scientific staff are working under these short-term contract arrangements. Although this recruitment strategy has served the ICIPE well so far, there is no doubt there are several serious disadvantages. The first is that it does not lead to the continuity of a line of research - even though a replacement scientist may be instructed to continue a fertile line of research, simply because no two scientists think alike. The second is that there is not enough experienced and senior scientific talent actually resident in Nairobi to guide the work of the rest of the programme team: the Directors of Research are physically too far away to maintain continuous and close contact although they endeavour to visit the Centre two or three times a year. The third is that ecological studies frequently demand longer than 4 years to lead to any worthwhile results. And, finally, the research units need scientists who have got long and expensive training, and who therefore cannot be replaced so frequently.

These are serious shortcomings of the earlier recruitment programme: and the Board has recently agreed to modify this strategy so as to retain the most vital elements of the earlier recruitment model (enthusiasm and imaginativeness), the positive elements of a lengthened contractual arrangement (continuity of profitable lines of investigation), and the appointment of a few senior scientists (to coordinate the multi-disciplinary studies focussed on each particular target insect).

When the present contracts of the principal scientific staff end variously in 1975 and 1976, their replacement staff will be appointed under three major categories:

1. As "Postdoctoral Fellows": newly graduated postdoctoral scientists embarking freshly on research studies at the ICIPE. Their contracts will be restricted to periods of 2 - 3 years.

2. As "Assistant Scientists": young postdoctoral scientists who have already completed at least 3 - 5 years on their own; they may, indeed, be selected from among the more successful performers from the first category above. They will be offered longer-term contracts of 4-5 years, which are renewable if they continue to satisfy the ICIPE. The more senior of these scientists would be eventually elevated to an "Associate Scientist " status.

3. As "Research Scientists": these would be senior scientists, established internationally in their own specialties, and who will assist the relevant Directors of Research in coordinating the work of the various programmes (especially at the target-species level).
The Experimental Officers - contrary to what obtains in the case of the principal scientific staff - have always been recruited among qualified scientists from African countries only. This policy will probably continue. This staff category is meant to attract those candidates who have an innate capacity for high-level technical work, while retaining some potential in scientific research. They are therefore an extremely important support staff for the principal scientific staff. They also provide critical leadership in maintaining the research units and the support services, where an advanced level of technical-cum-scientific knowledge is essential. It is for this reason that the training programme for ICIPE's Experimental Officer cadre has always been so extensive from the very beginning.

An equally important concern is devoted to the training of the technical staff for the various support services - laboratory management, photographic service, mechanical and electronic workshops, insect and animal breeding service, amongst others - as well as providing trained technical personnel for the research programmes themselves.

5. Physical Facilities and Equipment

The ICIPE started its research activities in late 1971 with a temporary building of 175 sq. m to house all its programmes. In May 1972, a similar building was completed, and was largely devoted to research space. At the end of this year, the ICIPE will have completed its third (but first permanent) building. Throughout this early phase, the practical outlook of the ICIPE has been to initiate work and get on with the job, and to put up buildings around people and get the appropriate experimental equipment into their hands. This policy has paid handsomely, for the ICIPE Research Centre is a nerve centre of activity and research studies always get promptly underway within weeks of the necessary grants being made available.

Nevertheless, there are apparently some critical needs in terms of research space and scientific equipment, which will be described in more detail in subsequent pages (Chapter XIII).

At the present time, the ICIPE has the following accommodation:

1. A temporary building ("Harambee Building") of about 175 sq. m, a gift of the Universities of Amsterdam and Wageningen. Completed and occupied in May 1971 on the Chiromo Campus, a 6-acre area on a long-term lease at a peppercorn rent from the University of Nairobi. It adjoins the main Science Centre of the University. The building houses most of the insectary facilities, a termite laboratory, a small workshop area, and the office for the Controller for Technical Services.

2. A second temporary building ("Mwangaza Building") of about 175 sq. m, on the Chiromo Campus also. The gift of the
3. A series of concrete blocks, on which temporary superstructures for experimental and observational purposes have been erected. These were eventually completed in November 1974, and provide space - including greenhouse space - of about 225 sq. m, for studies on African armyworm, termites, and ticks, and also provide space for several climatic chambers.

4. A third (and permanent) building ("The Northern Star Building"), a gift of NORAD, SIDA, and the Royal Swedish Academy of Sciences. It is already partially occupied, although it will not be fully completed until the end of 1974. When completed, it will house the Fine Structure Research Unit (FSRU), the Chemistry Research Unit (CRU), a training laboratory, a cold room, a room for large climatic chambers, a darkroom, a small combined library/seminar room, a chemical and general store, an enlarged workshop, and the administration (previously housed in rented accommodation 6 km away). The total area involved is 960 sq. m, and the building integrates well with the other structures on the Chirono Campus.

5. The ICIPE Coastal Research Station, at Mombasa, is quartered in a large rented house on the Nyali Beach on a short, renewable annual lease.

6. The ICIPE Kibos Field Station is presently accommodated in a house loaned to and renovated by the ICIPE. It is here that the programme on the Sorghum Shootfly is based.

With a research staff of 35 in Chirono (23 principal scientific staff and 12 Experimental Officers), added to the technical, support, and administrative staff, the Chirono accommodation is marginally adequate. Some activities have taken place in space loaned by the University on a temporary basis, and in rented accommodation elsewhere (for administration and storage). Furthermore, the building regulations of the City of Nairobi require that the temporary buildings initially erected by the ICIPE, and which were instrumental in enabling the ICIPE to embark on its programmes so quickly, be demolished and be replaced by new permanent structures acceptable to the planning authorities. Finally, further experience has shown the need for adequate accommodation for programmes, services and activities that were not at first entered for: for instance, a proper reference library, adequate seminar and conference rooms, training laboratory and
lecturing accommodation, laboratory and office space for visiting research associates (including Directors of Research), well planned workshop facilities (for woodwork, metal work, and electronics), facilities for basic vehicle maintenance, hostel accommodation for trainees and short-term visiting scientists, room for technical and support services, well designed insect and animal breeding units, and similar requirements. Consequently, the ICIPE urgently needs new and expanded accommodation.

Part of this accommodation will be erected in the Langata Campus, a 10-acre site newly leased from the Kenya Government on a long-term basis (on a no-rent basis), only 8 km from Chiromo. It is located in a forest area, well suited for insect and animal breeding. It will accommodate the bulk of the mass-rearing facilities, leaving Chiromo to house only experimental material. Langata will also contain hostel accommodation and some technical training facilities. The two campuses in Nairobi will be administered as a single unit.

A third site, also about 10 acres, has also been recently acquired from the local government authority at Kajindo, near the Kenya/Tanzania border, 75 km from Nairobi. It is a dry savannah area, well suited to field studies of foraging (or harvester) termites, which will be initiated on this site early in 1975, and for other ecological studies (such as those on ticks). Plans for erecting a first temporary building are already underway. Eventually, more permanent buildings for laboratory accommodation and staff houses for the station staff (scientific, support, and administrative) will be erected.

Similar plans are being completed for a field station at Kibos, 340 km. from Nairobi, near Lake Victoria (for field work, especially on the Sorghum Shootfly, armyworm and tsetse flies). A third field station at the Kenya Coast, probably at Mtwapa (near Mombasa), to replace the presently rented accommodation, may be required to continue the mosquito studies as well as form a field base for studies on the drywood termites, ticks, and the Sorghum Shootfly under humid tropical conditions.

It is proposed that these two or three field stations will form an essential network of facilities for field ecological studies now being expanded and any subsequent pest management input studies which may be added to the programme.

The larger equipment at the ICIPE, which has in many cases enabled its staff to make rapid advances in this early phase, include the following items:

(a) A gas chromatograph linked to a mass spectrometer
(b) High-pressure liquid chromatograph equipment
(c) Two complete electrophysiological units for taste reception and olfactory reception investigations
(d) Climatically controlled incubators in separate, small units
(e) A high-resolution transmission electron microscope, and a scanning electron microscope
(f) Pour mobile laboratory units, towed by one-ton front-wheel vehicles.
IV. RESEARCH ACHIEVEMENTS

In reading this Chapter, it should be borne in mind that it was decided, as a matter of policy, that the ICPE should try to start research work quickly, with a minimum budget and facilities, in order to demonstrate the efficacy of its structural model. The Centre has been in existence for less than three years, and many of the programmes are even younger than this. The first permanent laboratory building has only just been completed; and the work described has been done under simple and often disturbed conditions.

The achievements can be highlighted as follows:

1. Tick sperm undergo a complicated morphogenesis in the male until they reach an "invaginated state" at which point further morphogenesis ceases. The sperm are then transferred to the female's uterus during mating. There they evaginate and acquire the capacity for motility; and they then move to the female's spermatheca where they are stored. The factors that are responsible for the further development of the sperm in the uterus have been discovered to originate from the male tick's accessory reproductive glands, and are restricted to 3 of the 8 lobes of these glands. The active principle is proteinaceous, and is being analysed in detail.

2. Adult ticks usually aggregate at selected feeding sites. It has now been demonstrated that, among the soft ticks, virgin females of Ornithodoros moubata (a vector of swine fever and human relapsing fever) produce a powerful "aggregation (or assembly) pheromone" at the feeding site which attracts males; that males produce a weaker aggregating factor; that nymphs do not produce such a pheromone; and that other species of soft ticks tested (e.g. Argas persicus, O. tholozani, and A. brunetti) produce a similar aggregating pheromone, which has a heterologous effect on the other soft tick species. The pheromone can be extracted in saline, and is undergoing chemical analysis at the ICPE. Behaviour experiments show that this pheromone, in addition to acting as an assembly factor, also acts as a calling signal for males for the purpose of mating; the male sense organs responsible for sensing this pheromone seems to reside in the first segment of the palps, while the first pair of tarsi (holding the so-called Haller's organ) act as a reinforcement to the palpal receptors.

3. The sex pheromone of the hard tick, Rhipicephalus appendiculatus (the major vector of L.C.F.) has been biologically isolated, and chemically characterized. The pheromone attracts adult male ticks to females;
its peak production being found in virgin females that have been attached to a feeding site for 3 - 6 days (where male ticks, which have fed for at least 3 days, cluster). The pheromone itself is a mixture of phenol and para-cresol.

4. The dynamics of the pregnancy cycle in the tsetse fly has been worked out in detail, and this has been correlated with the secretion cycle of the milk-glands which provide nutrients for the growth and full development of the uterine larva.

5. The course of abortion has now been studied, its frequency under laboratory conditions investigated, experimental abortion tested (using, e.g. hormone analogues); and some of the causes of such abnormality enumerated. Wild populations are now being studied in so far as abortion is concerned.

6. The functional morphology of the tsetse salivary gland is now known in some detail. It has special structures in its musculature and innervation, including neuro-endocrine relations, which permit it to act as an efficient and controlled syringe for passing out saliva. A specific site for the lodgement of trypanosomes during their developmental sojourn in the salivary glands has also been identified.

7. A technique for collecting tsetse saliva, using a stretched bat wing, has now been developed. This technique will allow the detailed biochemical and immuno-chemical analysis of tsetse saliva for factors that regulate trypanosome development (within the salivary glands) to the stage when they become infective to vertebrate hosts.

8. The ICIPE has shown that the potential transmission of trypanosomiasis is greatest following infection of the tsetse with its first meal (approximately only 0.01% of infected flies transmit infection) and that the locus of the trypanosome’s greatest mortality lies in the middle region of the tsetse midgut. The hostile biochemical factors of this region are now being investigated.

9. Mating is essential for ovulation to take place in the tsetse fly. Ovulation then triggers off the orchestrated sequence of ovulation, intra-uterine larval development, and larviposition.
10. Earlier studies on the African armyworm had suggested that migration of adult moths was the major factor in the development of outbreaks. Field studies during 1974 indicated that, although migration was certainly occurring on a large scale, certain outbreaks could be better explained by the build-up of a resident population. Marked differences in flight behaviour were noted under different conditions. Laboratory studies have confirmed and analysed the strong preference of the caterpillars of this species for graminaceous plants, and have proved that the moths have the capacity for extended migratory flights and that pheromone-mediated mating occurs only after a period during which migration could take place.

11. A detailed study of chemical communication in termites (behaviour, source of pheromone, chemical characterization of the active principle, biology of the glands concerned, sensory receptors for the pheromone, etc.) has begun at the CIPE with a study of the harvester termites, Hodoterms and Trinervitermes. A detailed study of the behaviour relationships has been completed.

12. Some termites which can forage outside galleries for a brief period, e.g. Hodotermes mossambicus, can orientate with sun and moon, in addition and alternative to orientation by pheromones. They have, furthermore, a homing instinct.

13. Recent work by the CIPE, in collaboration with the termite research group at Berne, has shown that juvenile hormone (JH) is important as a regulatory factor for caste differentiation in termites (into soldiers, workers, nymphs, reproductives, etc.). The team has now shown that queens secrete enormous quantities of JH to the environment, largely packaged into eggs. How this leads to the control of caste differentiation, and the mechanism of hyper-production of the JH, are now being studied intensively.

14. Only termite workers lay foraging trails, using an ephemeral trail-laying pheromone produced from the sternal glands. Soldiers have these glands, but produce no pheromone.

15. Trinervitermes female alates have a pheromone produced by the sternal gland 1,200 times more active than in the worker. Male alates have also hypertrophied gland activity. This pheromone permits the alates, after swarming, to pair and move off in tandem to select prospective nesting sites. This pheromone is vital in attracting the two sexes at short range (2 cm or less); but the alates use a second pheromone, produced by the tergal glands, for attraction at long range (over 2 cm).

16. Success (in small petri dishes, etc.) has been achieved in producing a number of castes in artificial termite nests in the laboratory. These are important for the experimental study of
caste differentiation (Odontotermes, Trinervitermes, Hodotermes, and Macrotermes). In some cases, even incipient fungus gardens have developed in these artificial situations.

17. A very detailed study of the life table base-line data of the whole range of phenotypes of A. aegypti along the Kenya Coast, from fully wild to fully domestic populations of this mosquito, have been gathered, along with behaviour of the adult mosquitoes, their biting preferentia, their genotypic relationships, their oviposition preferentia, their seasonal abundance, and their dispersal and migration among clusters of villages (some ecologically isolated). All this information is essential for a major study of alternative genetic engineering experiments: the initial model being tried is that of suppressing this mosquitoes population by introducing a chromosomal homozygous translocation.

The three research units (for chemistry, electrophysiology, and fine structure) are supportive in function and are beginning to make a major impact on the multi-disciplinary research programmes of the Centre. A list of publications stemming from ICIPE research is contained in Appendix 8.
V. PEST MANAGEMENT - AN INPUTS PROGRAMME

Pest management research is an important bridge to the application of new knowledge in actual control programmes in the field. It requires a synthesis of information on the target insect pest and the associated insect fauna (some of whom might be parasites, predators, and even pests), the host plant itself, the rest of the associated biota, the microclimate and environment, agronomic practices that prevail, and the relationship with the rest of the ecosystem - all within a historical framework. Consequently, pest management studies are a complex matter and involve a great deal of population model building, modulation of these models as a result of new information, and the fact that the efficacy of the model depends on its forecasting ability and accuracy. Any and all of these studies require a firm foundation knowledge of ecology.

Ecological studies at the ICIPE have therefore two main justifications: firstly, ecological findings are essential in spot-lighting priority areas for future research - particularly with regard to the physiological field, and secondly, such knowledge provides the main basis for pest management research. In the present phase of ICIPE research programmes, the preponderant emphasis is on the first need - hence the emphasis on studies of behavioural ecology, ecological genetics, and physiological ecology. Later, with attention orientating increasingly towards pest management research on one or two pest species, attention will swing to population ecology and related aspects more closely concerned with actual population regulation of those particular pest species.

The target pest species that the ICIPE has chosen for its first attack - tsetse flies, ECF ticks, African Armyworm, Sorghum Shootfly, and foraging termites - are all pests that have already received considerable national, regional and international attention. Many have been the subject of practical, so-called eradication programmes on an extensive scale over the last 70 years. If there were simple, direct methods for the control of these pests they would have been found in that time and put into operation. This important fact has persuaded the ICIPE to approach these major pest problems with a more open strategy. Thus, the ICIPE will, in each case, explore several lines of study which hold promise as novel avenues for pest control, and which possibly together with already-tried methods may be fashioned into a pest management programme.

It is not the intention of the ICIPE to become a pest control agency. Pest management studies will require collaborative research with the appropriate applied research institutes and operative divisions of governments. This is an important component of ICIPE's philosophy of work.
VI  COMPONENTS OF THE CORE RESEARCH PROGRAMMES

Five core programmes will receive the chief attention of the ICIPE during the six-year plan period (1976-1981), continuing the process already established in the first four-year phase of ICIPE research activities (1972-1975):

1. Programmes Concerned with Tsetse Biology
2. Tick Vectors of Tropical Livestock Diseases
3. Sorghum Shootfly
4. African Armyworm

All these programmes are already yielding important new results (Chapter IV); and, in each case, those lines that have proved profitable will be continued, as well as opening a considerable ecological front - a theme already discussed previously (see Chapter V). The role of the two or three field stations will therefore be complemented to the laboratory-based investigations.

In the following pages, a brief description of each programme will be provided. In each case, it is planned that optimum research staff will be attained between 1978 and 1980. These manpower figures are given, as reference material.

1. Programmes Concerned with Tsetse Biology

The projects that are being pursued under this programme are those that have shown to have the most promise as possible sources of new ideas for the control of tsetse vectors of livestock trypanosomiasis:

(a) Development and reproductive physiology
(b) Factors controlling infectivity of trypanosomes
(c) Breeding of Glossina pallidipes.

This is presently one of the largest and best established programme of the Centre. It will have, by 1979, a staff of 9 principal staff and 6 experimental officers.

It is hoped that in early 1979, the tsetse biology programme would have advanced to the stage at which research findings can begin to be put into a pest management programme. At this stage, it is planned to have a number of experienced staff - three (mainly in the fields of ecology, epidemiology, and parasitology) - to join efforts with relevant applied research institutes in a cooperative (or outreach) programme to put these ideas into a field test. In 1981, a thorough review of the programme as a whole will show in what directions this research effort should move.
A. Development and Reproductive Physiology

4 Principal Scientific Staff: to be reached in 1979

1 Postdoctoral Fellow
2 Asst. /Assoc. Scientists
1 Research Scientist

2 Experimental Officers
6 Technical Staff

Synopsis of the Problem

The chief focus of the programme is the elucidation of the complex nature of the unusual reproductive biology of the tsetse flies - peculiarities that may open this pest to attack by agents aimed exclusively at these species. In these flies, only one egg is ovulated at a time; it is subsequently incubated in the "uterus", where the larva hatches, grows, and completes its full development while being fed by the "milk glands". After about two weeks, the fully grown larva is deposited by the female, whereupon the larva buries itself in the loose soil and pupates within a matter of hours. Within 1-2 hours after the previous larviposition, the next fully developed egg (arising from the opposite ovary) is ovulated; and the cycle of pregnancy ensues. Thus, a successful pregnancy requires the synchronization of a number of interdependent processes - oocyte development, ovulation, uterine pregnancy and milk-gland modulation and secretion process, the mother's own feeding cycle, larviposition, and hormonal activities responsible for these reproductive processes. The challenge is to elucidate and define the mechanisms and substances involved in this information loop, to find means for interfering with the latter, and to apply these elements in the control of the pestiferous tsetse fly species (especially G. morsitans and G. pallidipes, both important as vectors of livestock trypanosomiasis).

A second focus is the study of events that take place at the time of mating - namely, sperm activation, spermatophore formation and sperm transfer, sperm storage and viability within the female, and the eventual sperm penetration of the ovum. These events maybe of particular relevance for the ultimate population control of insect pests.

Progress to Date

The programme team has now elucidated in detail the dynamics of the whole 9-day pregnancy cycle - taking the second ovulation cycle as a starting base-line. The investigations have also provided information on the mechanism of milk-gland secretory discharge; far from adopting
an apocrine secretion process, a novel type of exocrine discharge has now been unravelled in which secretion is stored in an extracellular reservoir and released into the glandular lumen through a dense cuticular sieve-like pore. Parallel with the pregnancy cycle is a coincident modulated "ebb" and "flow" development of the milk glands.

This first phase of the work has shown a most delicate mother/larval interaction. It is a prelude to research on possible disruption of the pregnancy cycle as a mechanism for control. For instance, reproductive abnormalities, such as abortion and in utero pupation, frequently occur in both field and laboratory populations of tsetse flies. The potential for control arises from the fact that abortion has been experimentally induced in pregnant females with topical applications of juvenile hormone analogues and injections of ecdysone preparations. These abnormalities need intensive investigation.

It is now known that initiation of sperm motility (in tsetse and other insects) is triggered off by several simple biochemical mechanisms (e.g. change in pH of the bathing fluid); but that continued motility needs the provision of substrates, of which mature sperm have little or none. It is now important to know the external sources of these substrates within the insect’s genital tract.

It has been shown that the accessory glands do not merely provide structural materials for the formation of the spermatophores, in which sperm are normally transferred to the female. Indeed, in the tsetse fly, where work at the ICIPE has established that mating is essential for the initiation of the whole reproductive cycle, some evidence seems to point to the possibility that the initiating factor may well reside in the secretions of the male accessory reproductive glands.

Future Plans and Prospects

The major thrust of the immediate future is to identify the "pacemaker" of the entire reproductive cycle of the tsetse fly and to focus attention on the phenomenon of abortion and related reproductive abnormalities. Over the next 6 years, therefore, a number of major questions on this intricate tsetse female reproductive biology will be asked:

(a) What is the chemical nature of the active principle (in the secretion of the male accessory reproductive glands or other reproductive tissues) that sets off the very first ovulation process? What is the nature of the pacemaker mechanism that then maintains the subsequent cycles of pregnancy, parturition, and the subsequent events? How is the process of larviposition initiated and completed, and the larva take an active part in this?

(b) What factors lead to abortion?
(c) In what way is intra-uterine larval growth and development geared to lactation? Which are crucial factors in information exchange between mother and larva?

(d) Which are the critical stimuli that correlate intra-uterine larval feeding to lactation, and vice versa? How is lactation geared to the mother's food intake?

Advances in solving these questions will lead to further studies on the nature of and relations between the neuro-endocrine systems of the intra-uterine larva and the mother; investigations on the synthesis of the milk-gland secretion and yolk proteins; and the biochemical nature of the regulatory mechanisms of the whole female reproductive cycle.

Staff and Budget

Of the 4 principal scientific staff, 2 are already in position: one is a physiologist working on the female reproductive biology, the other is an endocrinologist studying these processes in the larva and mother. In 1978, a third scientist will be needed to concentrate on a deeper analysis of the problems of the male sperm biology, and include also the investigation of mating behaviour of tsetse flies. The fourth scientist, a physiological biochemist, will be required in 1979 to take up the biochemical aspects of the investigations once the on-going research has pointed out the more crucial biochemical problems.

The principal scientific staff will be supported and complemented by 2 experimental officers, both already recruited: one is concentrating on histological and fine structural investigation that are an essential feature of the research programme; and the other is a physiologist/biochemist, who is continuing the work on male accessory reproductive glands, and who will eventually work closely with the male reproductive physiologist and the physiological biochemist when they are eventually appointed in 1978 and 1979 respectively.

B. Factors Controlling Infectivity of Trypanosomes

4 Principal Scientific Staff: to be reached in 1978

0 Postdoctoral Fellow
3 Asst. /Assoc. Scientists
1 Research Scientist

3 Experimental Officers

6 Technical Staff (plus 4 for tissue culture)
Synopsis of the Problem

As a basis for the preparation of a practical vaccine against livestock trypanosomiasis, we need to know a great deal about how to block antigenic variation in the brucei - subgroup of trypanosomes (the so-called polymorphic trypanosomes), where this latter phenomenon is a dominant feature of immunogenetical development of these parasites. Furthermore, information on the vectorial capacity of tsetse flies might provide insights into new approaches to altering the genetic make-up of tsetse populations in such a way that they become refractory to trypanosome infection (as is being attempted in the case of malaria mosquitoes).

It has been known for some time that, even among the most susceptible populations of tsetse flies, only a very small proportion (approximately 0.01%) remain infected with brucei-group trypanosomes when they feed on infected animals. Within a few hours of reaching the tsetse (24-48 hours), the trypanosomes lose their ability to infect other vertebrate animals; and they undertake a complicated route through the alimentary canal until they eventually reach the salivary glands, where the trypanosomes somehow re-acquire their ability to infect suitable vertebrates.

The manner in which the trypanosomes first lose their infectivity (in the gut) and subsequently re-acquire it (in the salivary glands) are obscure; many critical details of the course of the immunochemical development of the trypanosomes need to be gathered; and the factors that control the vectorial capacity of the tsetse need to be thoroughly investigated.

It is suspected that a similar relationship exists between the tick vector, R. appendiculatus, and the protozoal agent of ECF. A further complication is that once a tick population is infected, it becomes permanently so. Investigations of these immunobiological and eco-genetical studies need to be carried out, parallel to any direct studies on the vertebrate aspects of ECF.

In all these investigations, close collaborative work has developed between the ICPE and the leading research institutions for these protozoal diseases of livestock, e.g. EATRO in Uganda, ILRAD in Kenya, and EAVRO in Kenya, as well as with FAO and WHO.

Progress to Date

The salivary gland physiology programme has only been underway for two years, and has concentrated effort on the tsetse/trypanosome relationship for the time being.

In that time, considerable base-line data has been gathered that has sharply defined the next stages of research. It is now established that most of infectivity is lost within 48 hours of an infected blood-meal being taken by
a teneral fly that this rate of loss is higher the more frequently the fly has fed (whether on "clean" meals or not); and that this loss is associated, at least partly, with the mass mortality of the trypanosomes when they reach the middle section of the mid-gut. It has also been established that the alimentary canal/proventriculus/salivary gland is not the only route of trypanosome migration in the tsetse, and that a proportion of the parasites are frequently to be found in the haemocoelic cavity where they have acquired a fairly advanced stage in their development. This is an important finding, as it may give a simpler route to the developmental history of the parasites. Finally, a detailed histological, cytochemical, and ultrastructural study of the salivary glands has been made; and recent results have shown that the middle region of these glands is the site for the final developmental phase of the polymorphic trypanosomes. The manner in which saliva is secreted is being studied in great detail.

Future Plans and Prospects

The major thrust of the programme is to undertake a thorough re-examination of the developmental life-cycle of the polymorphic trypanosomes - in the gut, haemocoelic, and salivary glands - to relate these cycles with the physiological and biochemical events in the fly, and to correlate these with the immunological loss of infectivity and its eventual re-acquisition. A chief question in regard to the latter is whether the antigens acquired by the trypanosomes while residing in the insect salivary glands are immunochromically the same antigens that the parasites previously acquired in the vertebrate host and lost in the first few hours of its sojourn in the insect. The answer to this question will form an important corner-stone to the whole problem of producing a practical vaccine against trypanosomiasis.

While ILRAD and EATRO are concentrating on immunological studies - of the parasite in the vertebrate host, the ICIPE is undertaking complementary studies on the parasite during its insect phase. In this respect, the ICIPE will be establishing a laboratory for the culture of tsetse salivary glands and other tsetse tissue for the study of the infective development of the trypanosomes. ILRAD will share this facility.

An equally important effort will be devoted, as from 1976, on investigating the nature of and the factors that regulate vectorial capacity in the tsetse fly. These capacities are linked with endogenous factors of the tsetse fly itself (e.g., species, sex, age, physiological condition, and host preferences), the trypanosome itself (e.g., the infective capacity of the trypanosome, the various strains and developmental forms, and the dosage), and ecological factors (micro-climate, presence of appropriate host, etc.). Much of this work will require a great deal of field work including new methods for sampling. For instance, how best can we sample the epidemiologically significant tsetse population as opposed to the whole tsetse population? With the discovery of haemocoelic infection of tsetse flies, there is need for a re-evaluation of techniques for trypanosome sampling of tsetse flies, which is vital for a meaningful survey of the
problem of vectorial capacity. Finally, the genetic basis of vectorial capacity in tsetse flies is not known at all.

When these investigations have made a significant headway, probably by the end of 1979, preliminary studies will be initiated on similar problems regarding tick/ECF relationships.

Staff and Budget

One principal scientific staff is already working as parasitologist/immunologist; a second staff member has been identified, and will be starting to work at the Centre in February 1975 as a biochemist. The first task of the latter will be to analyse biochemically the salivary gland secretions, and to identify the possible substances that control trypanosome development and the re-emergence of infectivity in these parasites. The second task will be to follow the biochemical products of digestion throughout the feeding cycle, and to identify the active principles internal to trypanosome viability within the mid-gut. Later on the biochemist will work more closely with the immunologist.

The third position, to be filled in 1978, is that of an immunochemist, who will build up his work on the foundation already laid by the parasitologist and biochemist. He will be assisted, in this highly technical work, by an experimental officer specialising in immunobiology. The tissue culture facility will be critical to the work of these two scientists. The first experimental officer, already in position, is assisting with parasitological research already underway.

A great deal of the studies in this programme depends on histological, fine-structural, and autoradiographic techniques. A graduate technician in the programme team is undergoing intensive training on these techniques with our JSRU, who are also intimately involved with this research programme.

When field research begins in earnest in 1977 the proposed Field Station at Kibos will form an important centre for investigations on tsetse behaviour and vectorial capacity. In this latter regard, a fourth member of the principal staff will be appointed in 1977.

The programme is presently well catered for in terms of parasitological equipment. It needs new equipment relevant for radionuclide, biochemical, immunochemical, and ecological field work.

C. Breeding Biology of Glossina pallidipes

1 Principal Scientific Staff: to be reached in 1976

0 Postdoctoral Fellow
The project concentrates on G. pallidipes, which, although extremely important as a vector of livestock trypanosomiasis in eastern Africa, has only attracted relatively meagre attention from ecologists, geneticists and physiologists. The distribution of this fly raises a number of questions, whose solution may well have definite implications for the control strategy of this pest. Furthermore, the development of techniques for establishing self-sustaining colonies of this species in the laboratory, or under semi-natural experimental condition, is crucial to rapid research on this pest.

So far, entomologists have only succeeded in maintaining this tsetse species, either in the laboratory (being fed on laboratory animals or on cattle or on various preparations of vertebrate blood) or in field cages (and fed on tethered animals). Continuous breeding of the fly has so far defied all efforts.

It is this major problem, of devising new methods for the rearing and breeding of G. pallidipes under both laboratory and semi-natural cage conditions in the field, that the project team is investigating. The production of competitive flies is important for many lines of research— for instance, for the two projects on tsetse already discussed in subsections A and B above— and for any future projects on tsetse, for example, on possible genetic control techniques. Such studies require a knowledge of reproductive barriers, amongst others. In this case, therefore, the determination of hybrid sterility, genetic incompatibility, and hybrid breakdown can only be assessed on the basis of careful assessment of fertility, fecundity, and other measures of reproductive potential. Thus, a reproducible rearing technique is essential.

Progress to Date

Preliminary studies in this project started only in June 1974 based on the base-line data that are being gathered in connection with the project on Population Diversity of Tsetse Flies (Chapter VII, Section 3, b). This latter project, field information on biting pattern, host range preference, breeding sites, and resting sites—amongst other lines of enquiry—is being put together as a basis for subsequent ecological studies. Preliminary attempts on breeding are also being based on earlier experiences at EATRO and University of Nairobi, where G. pallidipes...
colonies have been maintained successfully for some time.

These preliminary attempts, based on material collected from a major G. pallidipes habitat, the Lambwe Valley on Lake Victoria shores, are too early yet to give firm indications of success. But at least three generations have been kept successively, although followed at each step by high mortality. A significant success so far has been the design of a device for the successful transportation of the adult flies from the field, 350 km away, to Nairobi. Such an operation is normally accompanied by a very high mortality, of up to 95%.

Future Plans and Prospects

The preliminary studies underway at the moment consist largely in ensuring that field-collected flies, (i) reach the laboratory in a satisfactory biological state; (ii) that they feed successfully on a laboratory animal (e.g. rabbit, for ease of handling); (iii) that they behave and mate normally; (iv) that they produce large and viable pupae which have a high emergence rate; and (v) that the first generation flies resulting from this first step in the naturalisation process of G. pallidipes to laboratory rearing conditions are also equally successful in feeding, mating and reproducing. This is a major initial barrier which we hope to overcome within the next year or so.

From 1976 onwards, it is hoped to concentrate on two further steps: (a) the establishment of a self-sustaining colony of G. pallidipes which does not need to be replenished with new flies or pupae collected from the field; and (b) the establishment of a resident tsetse colony in a large field cage in one of the traditional tsetse habitats, using one of the naturally favoured hosts, cattle.

Staff and Budget

One principal scientist, an entomologist trained in comparative insect pathology, will be recruited to take charge of this breeding programme. He will be assisted by a technically highly-trained experimental officer who is familiar with the mass breeding of tsetse flies and other blood-sucking arthropods.

For some time now, it has become evident that the great mortality of insects at the onset of laboratory-naturalization process may be due not only to "stress" but also to pathological conditions that become aggravated under these artificial conditions. The services of a competent general insect pathologist will therefore be needed. His services are also essential in monitoring, on a regular basis, the pathological condition - if any - of other insects that the ICPE maintains under continuous breeding. This is
an innovation which we feel will pay handsome dividends, by ensuring that insecticidal material for laboratory experiments are of a high health standard and should therefore be expected to have a normal physiological condition.

New insectary requirements are expected to emerge from these studies; and the necessary budgetary provisions have been estimated in an approximate way.

2. **Tick Vectors of Tropical Livestock Diseases**

   4 Principal Scientific Staff, to be reached in 1979
   - 1 Postdoctoral Fellow
   - 2 Asst./Assoc. Scientists
   - 1 Research Scientist

   2 Experimental Officers

   4 Technical Staff

**Synopsis of the Problem**

The main thrust of the tick programme has been to deflect attention from reliance on acaricides to which they are now signs of world-wide resistance, for the control of these vectors of numerous rickettsial and spirochetal diseases of livestock, and to devote more attention to those aspects of tick biology that might lead to the design of non-conventional control methods. Among these are a thorough understanding of the population ecology of the tick and a detailed knowledge of tick sexual behaviour, feeding behaviour, and developmental processes. In these respects, the field ecology and the laboratory biology of the tick are closely integrated in the programme.

The major effort is concentrated on *Rhipicephalus appendiculatus*, the brown ear-tick, which is the main vector of *East Coast Fever* - which ranks with trypanosomiasis as the two major health hazards to livestock production in the greater part of Africa.

**Progress to Date**

In 1973, it was shown by the programme staff that adult females of *R. appendiculatus* that had been feeding for several days secreted a volatile substance that induced engorged males to move towards them and mate. Chemical studies have now shown that the active principle is a mixture of pheromone and para-tertol. Further recent work has shown that many other substituted pheromone compounds are active similarly, some of which are much less volatile than the natural pheromone - a significant finding for
selecting suitable candidate controlling agents. Finally, several other species of hard ticks have been studied, some of which secrete similar active substances.

When this research aspect is completed it might well lead towards new methods of selective reduction of these tick vectors, by the use of, for instance, pheromones for leading ticks to insecticidal baits.

On the ecological front, a long-term study on the changes in numbers of an experimental population of *R. appendiculatus* has been in progress for a year. Large numbers of juvenile ticks were placed on cattle that had been inoculated with ECF (*T. parva*, Muguga strain). The ticks engorged, detached and moulted, and the cattle died. When susceptible cattle were subsequently introduced, they picked up many ticks, became infected and died. The tick population became established in the field, and so did the disease. This field is now also being used as a "challenge" for cattle immunised against ECF at EAVRO, and the ICPE continues to follow the changes in numbers of the ticks. A control field, with no seeded ticks, and cattle introduced only at intervals, is also being studied.

Analysis of the tick population in the experimental field has shown that the tick population increased during the year, and the numbers attached to the cattle fluctuated during the year: the reasons for the fluctuations are being studied. The study site is highly favourable for survival and reproduction of ticks, both because of the high density of cattle that have been maintained in the field and because of the climate of the area. Comparative studies in other contrasting areas and with differing stocking rates are currently being planned.

**Future Plans and Prospects**

The three lines of investigation already started will be continued:

1. The physiology of pheromone production and a detailed study of the associated tick behaviour.

2. The hormonal factors responsible for tick development, and how analogues might unbalance the normal sequence.

3. Field ecology of tick populations, and the latter's relationship with the epidemiology of ECF, both in paddocks and free grazing land. These studies will be extended to the habitats of reservoir animals, e.g. buffalo.

Close collaborative relationships, already established with EAVRO for studies on *R. appendiculatus*, will continue. A similar relationship will be worked out when ICPE launch their programme on ECF immunology.
Staff and Budgets

Two principal scientific staff are already at work; a physiologist (joined the ICPE early in 1973) who is continuing the project on biology and tick behaviour and an ecologist (joined the ICPE in October 1974) who is participating together with the present experimental officer (in ecology) in carrying out the ecological studies on R. appendiculatus.

The second experimental officer (in physiology) is already laying down background information on tick development. It is hoped that by the beginning of 1978, a solid foundation would have been laid for a detailed experimental attack of tick developmental endocrinology by a senior researcher, a physiological biochemist with a strong endocrinological training.

The fourth principal scientist will be recruited in 1979, to concentrate particularly on a thorough study of the population dynamics of R. appendiculatus in the field, as a prelude to any subsequent pest management studies.

A considerable proportion of the tick programme is devoted to field studies, requiring remote-sensing equipment, four-wheel drive vehicles, enclosed experimental plots, and a steady supply of cattle. These are all expensive items.

3. **Sorghum Shootfly**

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<thead>
<tr>
<th>Principal Scientific Staff to be reached in 1979</th>
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<tr>
<td>0 Postdoctoral Fellow</td>
</tr>
<tr>
<td>2 Asst./Assoc. Scientists</td>
</tr>
<tr>
<td>1 Research Scientist</td>
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<tr>
<td>2 Experimental Officers</td>
</tr>
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<td>4 Technical Staff</td>
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**Synopsis of the Problem**

Sorghum thrives in a variety of climates and will grow in areas unsuitable for other crops. This makes it of particular value to the drier parts and drought-prone regions of the tropical and sub-tropical areas of the world.

Although sorghum is an ancient crop in Africa and Asia, much has still to be learnt about its pests, the most important of which is the Sorghum Shootfly, Antherigona varia soecata Rondani. This lack of knowledge may be partly due to the fact that the local cultivars in these regions are somehow tolerant to shootfly attack, and therefore the seriousness of the pest was not fully realised. Quite recently, however, some new high-yielding cultivars (e.g. "serena" developed in Serere, Uganda) have been introduced throughout East Africa and they have been found to be highly prone to shootfly attack, considerably reducing the grain yield.
Because of the international importance of the Sorghum Shootfly, and as a result of the recommendations made by the UNDP/ICIPE Policy Advisory Committee at its April 1974 meeting (a recommendation prompted by a suggestion from ICRISAT), the ICIPE Board took a decision in September 1974 to launch a new programme on the Sorghum Shootfly immediately.

It appears that the main damage to the sorghum arises from the habit of the shootfly larvae to penetrate the growing point, thus causing "dead hearts" in the young shoots. Although the plants react by producing tillers, which in turn may also be killed by larvae, the number of grain-producing panicles are reduced. Much of the base-line data on this fly is not known, thus limiting choices on control techniques.

**Progress to Date**

The only member of the programme team so far in post is an experimental officer, trained in insect eco-physiological problems, who has initiated basic studies on the life history of the shootfly, seasonal distribution, host specificity, and possible diapause. Field work, and much of the developmental studies, are based in loaned accommodation at Kilos, an important area for sorghum production. Since the available literature suggests that the shootfly undergoes homodynamic development (with alternate hosts in some regions) and heterodynamic development (with adult diapause in other locations), some attention is being devoted to life-cycle studies in relation to the host plant, environmental temperature, and relative humidity.

Taxonomic material of the shootfly from various localities is also being collected, since it is known that the genus Antherigona contains many species, several of which attack sorghum. The identity of the target species must be clearly known soon.

**Future Plans and Prospects**

It is hoped that, fairly soon, it will be possible to devise a laboratory procedure for the continuous rearing of the shootfly. Such a colony will be needed for experimental studies.

At the present time, it is not absolutely clear which major line the investigations will take. However, three principal aspects seem to be candidate foci for detailed research, once the base-line data have been gathered in the next year or so:

1. Detailed investigation of the development of the larva, the chief pest stage. The manner in which the host physiology, host specificity, and the micro-environment control larval development will be a major part of these studies.

2. The study of the control of reproduction of the fly and its reproductive potential in the
field. Such studies will naturally lead to the consideration of seasonality of shootfly occurrence and outbreaks.

3. Investigation of the responses of larvae to plant hosts (for feeding and of adults (for oviposition), and the sensory mechanisms (including the active principles involved) underlying these behaviour patterns. These aspects are key to the problem of host specificity; they may also lead to the chemical (or other) sources of plant resistance to this pest.

The latter direction may, ultimately, be one of the most profitable ones in regard to shootfly control, as the identification of sources of plant resistance may enable plant breeders to build these into new high-yielding sorghum varieties. Close cooperation will be maintained with ICRISAT throughout this programme.

Staff and Budget

An immediate senior appointment is needed to spearhead the work on larval development and the necessary field work. Provision is therefore made for the appointment of an eco-physiologist at the beginning of 1976. The experimental officer, already in position, will closely support his work.

The second senior scientist, to concentrate on behavioural and concurrent sensory-physiological studies in host selection, will be appointed in 1978. He will be supported by a second experimental officer. The two will build on the base already provided by the two research staff members of the team working on shootfly development.

The third principal scientist will be appointed in 1979, to investigate in a detailed manner the possible sources (including chemical ones) of sorghum resistance to shootfly larvae. He will work closely with the project team on chemical sources of plant resistance (Chapter VII, Section 1).

The establishment of the Kibos Field Station is essential for the consolidation of this programme. It will form the principal base for the field work, supplemented by samplings from other ecological zones in eastern Africa. This extensive programme requires mobility; and the necessary provision for field vehicles and a mobile laboratory have been made.

4. African Armyworm

3. Principal Scientific Staff: to be reached in 1977.

0. Postdoctoral Fellow
2. Asst. / Assoc. Scientists
1. Research Scientist

2. Experimental Officers
5. Technical Staff
Synopsis of the Problem

The African Armyworm, Spodoptera exempta, has long been known as a major pest in eastern Africa. During its migratory flights, it ranges from South Africa to northern Ethiopia, and even, in some years, into the Yemen. It has also been recorded from other parts of Africa, from Europe, and across Asia and the Pacific to Hawaii. Its widespread geographical distribution, the sporadic nature of its outbreaks in time and space (but with a distinct south-to-north trend following the tropical rain fronts), its existence in two forms (gregarious and solitary) all led to early theories of its migration. However, the occurrence of small numbers of adults in light traps throughout the year in many parts of its range supported the alternative hypothesis of outbreaks arising from resident populations of the solitary form when favourable environmental conditions prevailed. The operation by EAAFRO at Muguga, of a network of light traps throughout eastern Africa, supported with results analysed in conjunction with meteorological data by Rainey and Betts of the Centre for Overseas Pest Research (COPR), virtually confirm the migration theory although the role of resident populations still needs clarification.

Research on this species at the ICIPE started in 1973 with the dual objective of obtaining further information which would assist and improve the accuracy of the warning service operated by EAAFRO, and of elucidating in more detail the behaviour of this insect to identify features of its life history which might be susceptible to forms of control other than chemical spraying. Consequently, research is planned on the following aspects:

1. **The reasons for selectivity during larval feeding**
2. **The nature and role of female and male pheromones**
3. **Genetic polymorphism and the occurrence of migratory and non-migratory races**
4. **Improved methods for detecting outbreaks**
5. **Improved methods of determining the migratory range**
6. **Moth behaviour during migratory flights**

Assistance will also be given to other research organizations carrying out surveys of economic damage and in research on the use of viral pathogens.

Progress to Date

The two-year period since this programme started has yielded some important results on which further work is being built:

1. **The female moth is unselctive with regard to the species of plant on which she oviposits.**
Future Plans and Prospects

Experience indicates the need to diversify the types of investigation carried out on the African Armyworm in order to determine the importance of migration and to maximise the likelihood of discoveries which will be of use in control programmes. During 1977-81, the following investigations will be pursued:

1. Intensified search for methods of reducing the acceptability of graminaceous plants to the larva. A promising line for research is the use of extraneous deterrent sprays.

2. Chemical characterization of the female pheromone(s) and the determination of the role, if any, of male pheromones in assembly and mating.

3. Investigation of the genetics of S. exempta to determine the extent of structural and behavioural polymorphism in the resident and migratory populations.

4. Extended study of outbreaks, to elucidate the relative importance of resident and migratory populations and the influence of environmental conditions on migratory behaviour.
5. investigation of methods other than adult trapping for the early
detection of larval outbreaks. Aerial infra-red photography is
a possibility.

6. Large-scale field experiments to determine the best method of
precisely correlating two successive outbreaks due to migration.

7. Field observations using mobile radar to discover whether the
adult moth orients during migratory flights, since such a capability
would double the migratory range. If orientation is proved,
behavioral and electrophysiological experiments will be carried
out in the laboratory to determine the physiological mechanism used.

The armyworm programme requires a great deal of international
cooperation, e.g. with EAAFRO (in East Africa), Kenya Ministry of
Agriculture, COPR, the Unit of Invertebrate Virology at Oxford, the
Ecological Physics Group at the University of Loughborough, and
vectorial agricultural offices in the countries of eastern Africa.

Staff and Budget

The three principal scientific staff include an ecologist/ethologist
(already in post), a population geneticist (in post since November 1974),
and a field ecologist (to be recruited in 1977). Of the two experimental
officers needed, one is being recruited now, and will devote his attention
to field work; while the second, to be recruited in 1976, will continue the
research on the caterpillar host-plant relationship (in collaboration with
the ERU) when the present postdoctoral fellow completes his contract
in 1975.

The programme needs proper laboratory accommodation (in Building IV),
as well as a fully-equipped experimental insectary having full climate
control and proofed against microbial infection. Much of the behaviour
work is carried out in insect-proof cages, of which several will be needed.

Pheromonal studies require considerable insect material at specified
developmental stages. It will be necessary, therefore, to build up a large
stock culture of armyworm for these investigations.

Some of the projects listed under 'Future Plans and Prospects' require
expensive equipment. Item 5 will need the use of an aircraft equipped for
aerial photography in the infra-red, and item 6 the use of a mobile radar
installation. Furthermore, great emphasis is being placed on field studies
in the future programme; consequently, increase of field equipment has
been budgeted for,
5. Biology of Foraging Termites

6. Principal Scientific Staff: to be reached in 1976

1. Postdoctoral Fellow
4. Asst./Assoc. Scientists
1. Research Scientist

2. Experimental Officers

2. Technical Staff

Synopsis of the Problem

The programme is divided into two functional aspects:

A. The Termite Physiology Research Project
B. The Termite Ecology Research Project.

These aspects will be described separately in appropriate sections, but these integrate closely into one whole. Up to now, only the first project has got off the ground; the second project will start in January 1975 at the conclusion of an intensive training programme of research staff in London and Nigeria.

The original proposals for research at the ICIPE outlined the importance of termites in the African economy arising from their abundance and their ability to eat all kinds of cellulose-containing plant materials. Not only do they damage buildings, but also trees and crops, as well as competing with cattle and game for pasture grasses.

The existing methods of control have serious shortcomings from their adverse environmental and public health side-effects. The development of new, safer methods of control demands much greater knowledge of the physiology and ecology of these insects. The objectives of the research already underway at the ICIPE are to find weak points in the behaviour and life cycles of the termites that will allow us to repel their attacks or reduce their numbers without damage to the environment or to other species.

The entire programme is focussed on the foraging termites, which feed on pasture grasses and cereal crops, and are of immense economic importance in the tropics.

A. Physiology. The ultimate aim of this project is to develop new control methods with minimal adverse environmental side-effects. This objective can, however, only be reached if the physiology of development, reproduction and behaviour is thoroughly understood - areas that are so far badly neglected.
In research on the so-called higher termites, the predominant termite fauna in tropical and subtropical Africa. It is our firm belief that a profound knowledge of these functions will reveal new possibilities for termite control: and, since they all seem to be regulated by chemical substances (e.g. pheromones and hormones), it is a tempting idea to use the insect’s own regulatory substances (or their chemical analogues) for control measures (e.g. using pheromones as a lure or as a confusing agent). But knowledge of the chemical structure of these active substances is not enough; it is also necessary to know in great detail how, and where, and at what time they act upon the insects.

B. Ecology. Termite damage in Africa falls into three categories:

(a) Damage to buildings by dry-wood and subterranean termites. This is the most noticeable damage in everyday life, and is more important in the humid coastal zones, with rainfall over 150 cm.

(b) Damage to agricultural crops and forestry plantations. This is characteristic of the savannah zones, with rainfall of 50-150 cm.

(c) Competitors with cattle and game for pasture grass. Widespread in pastoral regions with rainfall of up to 50 cm.

Our main interest is on the last two categories.

These termites belong to three main groups of widely differing biology. *Hodotermes mossambicus* is a true harvester of arid zones, and is notorious for damage to pastures in marginal conditions throughout East and Central Africa. *Trinervitermes bettonianus* also feeds on grasses in the open; and, although not a pest, it is of conservation interest, being an important consumer in the steppe conditions of the Serengeti. *Macrotermes subhyalinus* is a mainly grass-feeding species common throughout equatorial Africa and a pest of grain crops. These three species, together with *Odontotermes* (a litter-, timber- and grass-feeding group) are the basis of the behavioural and physiological research presently underway at the ICIPE.

Because workers elsewhere have been working on *Hodotermes* for some years (mainly in South Africa), and because a similar group is working on *Trinervitermes* in Nigeria at Mokwa (Nigeria), it was decided that the ecological work at the ICIPE be initiated on *M. subhyalinus* first. At a later date, these studies would be extended to other important foraging species (as noted above).

It is already known that the patterns of activity in many termite colonies, and the proportionate numbers of the various castes, show considerable seasonal variation. There is also probably a feedback effect from the nutritional status of the colony to the levels of pheromones circulating or secreted. Thus, the behavioural and physiological studies can only attain their full value in the wider context of understanding the whole seasonal cycle and environmental significance of the termites concerned. The obvious need for
a parallel research effort to study the ecology of those same termite species resulted in the proposals that will begin to be operative in 1975, when the ecology project is launched.

**Progress to Date**

The three-year physiology research project has made some notable advances:

1. Work on caste differentiation is now moving quickly ahead because of recent success in establishing laboratory cultures of several species of the higher termites, and for maintaining larger groups of certain species for prolonged periods. By these means, it has been demonstrated that in the higher termites - just as in the lower ones - juvenile hormone (JH) plays a crucial part in caste determination. JH is found in high concentration in the haemolymph of queens and workers, and it is transmitted to the eggs in variable amounts. The JH-producing glands, the corpora allata, are largest in presoldiers and in queens - which indicates their importance in the development of soldiers as well as in producing gonatrophically active JH in the queen. In contrast to other insects, the termite queen does not synthesize yolk proteins in the fat body, but in the ovary itself; and the respiratory metabolism of ovary homogenates is significantly stimulated by JH and ecdysone. Preliminary results suggest seasonal variation in the JH content of eggs, and in the queen haemolymph - changes which are correlated with the variations in the content of the JH-binding protein.

2. Initial focus on the analysis of the basic mechanisms of communication which enable mass-feeding in grass-eating termites (Trinervitermes and Hodotermes) demonstrated that the mass-recruitment to a food source involves the production and laying down of a pheromone along a trail. In one species (Hodotermes) an optical light-compass orientation was discovered to be brought into operation (to replace olfactory orientation) when a suitable light source (sun or moon) was available. In at least one termite species, the trail pheromone is produced in extremely high amounts by the dealated reproductive when it is used as a sex pheromone and is involved in sexual attraction and courtship behaviour. Chemical characterization of the active principle is now being attempted by the CRU.

**Future Plans and Prospects**

**A. Physiology**. Future studies on caste differentiation will be built on the foundations already laid down: a careful observation on the development of castes in incipient colonies under laboratory conditions, and observation
on the results of the proportionate removal or addition of various castes; observation of the effect of JH, other hormones, or other extracts on caste determination; a detailed study of the endocrine glands, especially the corpora allata, in the queen and other castes, and the determination of JH titre in various castes and in eggs during seasonal cycles in order to correlate these with caste development; and the effect of preliminary small-scale applications of JH analogues in the field. A new study will be the identification of the termite JH, and the examination of the possibility that various castes have a variant of this active natural product.

Much more detailed investigations will be carried out in respect of the reproductive physiology of the termite queen. For instance, a study of the protein metabolism of the queen in relation to the enormous egg production, the influence of hormones on the synthesis of vitellogenins and JH - binding protein, the respiratory metabolism of the queen's tissues and any seasonal changes, and the possible functions of the so-called 'royal fat body' (which has recently been demonstrated to show an extremely high respiratory rate), will be mounted.

Up to now, the trail pheromones are the only known pheromones that influence termite behaviour. The emphasis of our behaviour studies therefore will continue to rely on trail pheromones as model substances for these inter-related studies, and as candidate substances for use in termite control. The detailed functional morphology of the trail pheromone gland (the so-called sternal glands) will be completed, and the physiology of trail pheromone production, storage and release, and the regulatory mechanisms responsible for production (which is suspected to be, in part, endocrine) will be thoroughly investigated. Another front for research will be the physiology of the trail pheromone perception, which will be done collaboratively with the ERU.

An analysis of building behaviour, and its coordination, seems to indicate that it is only possible on the basis of communication by olfactory or tactile stimuli. Preliminary observations indicate that trail pheromones may be significantly involved in this coordinated activity; but it is probable that air currents, dryness of the air, and other yet unknown factors may be the primary stimuli. It is planned to go further with these investigations, as they are basic to an understanding of some of the ecological problems under study.

B. Ecology. The chief focus will initially, be on M. subhyalinus. This study will concentrate on base-line studies on the annual cycles of the termite, by investigating three inter-related fields:

(a) The state of the termite colony by sampling mounds on a monthly basis: to determine the state of brood-eggs, larvae and nymphs; the state of worker/soldier ratio; the state of fungus gardens; and the microclimate of the mounds,
(b) Colony development: by determining the fertility of fungal combs; polyethism by behavioural changes due to advancing age; the recolonisation of apparently dead mounds; and the state of brood development.

(c) Foraging and food consumption: by enumerating foraging-holes and finding out their permanence, if any; by determining timing, extent, and quantity of material foraged; by studying the establishment of foraging territory; by determining caste composition of foraging parties; and by observing food preferenda (including cattle dung).

It is expected that, by 1978, these studies on *Macrotermes* would have progressed far enough to permit parallel studies on another foraging species, *H. mossambicus*. It is possible that *Hodotermes* may in fact be a competitor of *Macrotermes* in certain situations.

A special feature of this programme is the close working relationship between the ICIPE staff and the termite groups at the COPR station in Nigeria and the termite team at the Department of Zoophysiology in the University of Berne.

Staff and Budget

The six principal scientific staff in this programme include the following specialists (with the dates of their recruitment): physiologist (1972), physiologist/ethologist (1974), biochemist (1973), developmental biologist and endocrinologist (1976), ecologist (1974), and population ecologist (1975). This group will work very much as an inter-disciplinary team, although the field work will be largely centred around Kajado (and possibly Mtwapa). These studies are extensive, and will require considerable resources (as indicated in the budget).

Two experimental officers are needed: the first (an endocrinologist) is already in position since 1973; the second (an ecologist) will be recruited in 1977.

Culture rooms, with controlled environmental facilities, will need to be expanded in Nairobi to meet the enlarged needs of the programme. Other needs, especially for biochemical and field radioisotope tracer techniques, are included in the budget.
VII. COMPONENTS OF SPECIAL PROJECTS

The Governing Board considers that a total scientific staff complement of 50 (principal scientists and experimental officers) is just about the optimum size of an institute such as the ICIPE. The Board is anxious to maintain the high quality of its research work, and conserve the present character of the institution, which has many attractive and stimulating features. These considerations lead us to permit only a very limited number of special (or contractual) programmes that the ICIPE can reasonably accommodate and participate in. In accepting these programmes, the ICIPE will need to assure itself that the projects are closely related to the on-going work at the ICIPE, that they meet the long-term objectives of the Centre, and that they carry the full budgetary weight of the Centre's services and needs.

Precise figures cannot be given at present for the full complement of the scientific staff of such contractual programmes. Something like 20 would seem to be the upper limit. (To this number should be added the 10 visiting scientists, research associates, and postgraduates students discussed in Chapter IX, Section 1).

Three of the programmes discussed in this Chapter are, in effect, cooperative research programmes with research institutions in Africa and elsewhere. These projects are excluded from the core programmes because it is felt that the investigations are, relatively speaking, long-term studies with less likelihood of providing practical results in the foreseeable future than are the core programmes. They are nevertheless closely related to the main focus of ICIPE's immediate mandate in that they either give special impetus to the on-going core programmes in the information that they will yield or are, in themselves, of considerable potential importance.

The three cooperative research projects are:

1. Chemical sources of plant resistance to insect attack (collaborative programme with several international agricultural centres).

2. Grassland termites in a tropical savannah ecosystem (a programme to be started in mid-1975 and supported by funds being negotiated with the United Nations Development Programme, UNEP).

3. Ecological studies of *Aedes aegypti* in East Africa preliminary to genetic control (supported by USAID).

A second category of projects are those concerned with elucidating the basic mechanisms underlying some of the scientific and technological problems we are concerned with in considering the five target insects in the core programmes. Such analysis requires
fundamental research, and may need many years in which to unravel the natural phenomena involved. Although these projects may well yield important findings which could eventually form the basis for core programmes, our current understanding is not such as to lead us to expect rapid results. On the other hand, these studies could well provide significant inputs for current core programmes. It is for this reason that such programmes have been entitled "Exploratory Projects".

Funding for Exploratory Projects is not being sought from the CGIAR. Required funds will probably come from academies of science, the International Foundation for Science, national science foundations, other private foundations and similar sources. It will be noted here that cooperative programmes will also not be funded from the CGIAR.

All these programmes are briefly described in the following pages.

1. Chemical Sources of Plant Resistance to Insect Attack

   1 Principal Scientific Staff: to be reached in 1977
   0 Postdoctoral Fellow
   1 Asst./Assoc. Scientist
   0 Research Scientist

   1 Experimental Officer

   3 Technical Staff

Synopsis of the Problem

One of the principal means for mitigating losses suffered by crops through insect pests is to breed plant strains that are resistant to these pests (and which, at the same time, possess the desired crop properties). The means to do this is still largely an art, as far as it applies to the major food crops. Discussions have recently been initiated with several of the international agricultural research centres for ICIPE to investigate the chemical sources of plant resistance to insect attack. Such information should form an essential source of ideas for plant breeders in deciding on the plant characteristics to breed for. The first such project will be on cowpeas, starting probably from 1977.

Grain legume entomology at the International Institute of Tropical Agriculture (IITA), in Nigeria, is at present concentrated on cowpeas for which IITA has an international responsibility. It is basically involved in applied research and directly oriented towards increased cowpea production. Major efforts are therefore spent in extensive
field trials and greenhouse screening for insect resistance. The entomology project at IITA does not carry out any basic research, because of limited trained personnel, limited facilities, and priorities established at the institute. The ICIPE, on the other hand, has excellent facilities in its CRU, as well as being geographically, well located near IITA, and cowpea pests at the IITA are also present in East Africa. Consequently, cooperative research projects can be established profitably and an essential feedback mechanism between the basic and applied activities maintained continuously.

The first project will be on possible chemicals responsible for resistance to leafhoppers and thrips in the cowpea crop. The recently released IITA cultivar, TVU 1190 (or VITA 9), has a remarkably wide range of resistance to leafhoppers (Empoasca fascialis), thrips (Sericothrips occipitalis), the moth Maruca testulalis, aphids, soil borne larvae (e.g. Ootheca), and root-knot nematodes. This cultivar is therefore an excellent variety for studies on insect resistance mechanisms, when compared with the national cowpea varieties which have previously been released because of their high yield potential but which are highly susceptible to these pests (e.g. PRIMA). If these varieties are not protected by a heavy insecticide umbrella, the plants die off before they reach the flowering stage. Local varieties grown by peasant farmers, on the other hand, are relatively resistant to these pests but have low yield potential (of about 450 kg/ha). At IITA, excellent work has been conducted in developing cowpea varieties resistant to these pests and having, at the same time, a considerable yield potential - such as VITA 9. With no insecticide protection during the pre-flowering stage, and with such protection only in the post-flowering phase, VITA 9 can produce over 1200 kg/ha, whereas PRIMA will not produce any crop. This type of treatment has demonstrated that VITA 9 is resistant to leafhoppers and thrips, whose major attack is during the pre-flowering stage.

There are now plans at IITA for a study of the Inheritance of resistance to these insects in cowpeas. Inputs pinpointing the chemical sources of such resistance would be a significant contribution to this genetic programme. Legumes are known to have a pronounced phenol defence mechanism to insect attack, and it is possible that phenols, or their precursors, may be a factor in cowpea resistance to attack by leafhoppers and thrips. The ICIPE will investigate this and other chemical avenues.

The second cowpea project will be concerned with resistance to the pod-borer, Maruca testulalis, which is found practically all over the tropical world. It is a pest of legumes, and is one the principal pests of cowpeas, feeding on flowers and newly developed cowpea pods. In this way, it causes an almost 100% damage. Recent observations at IITA have shown that Maruca attacks the flowers and newly developed pods of all varieties of cowpeas so far tested without a significant difference, but that damage to flowering pods shows some varietal differences. The resistance mechanism seems to be complicated, as the varieties which are resistant at the earlier pod development stage were susceptible at the later pod development stage, and vice versa.
It would be important to establish the causes, including chemical ones, for pod-borer resistance at the various pod development stages.

The third cowpea project is concerned with another pod-borer, Laspeyresia pychura, one of the major pod-borer pests of cowpea in Africa. The caterpillars develop inside the pods and damage the seeds nearing maturity. Resistance to this pod-borer has been so far found only in two cowpea varieties. It has been noticed by IITA Scientists that the moth has a very specific laying behaviour: it lays its eggs only around the calyx of the pod. It is possible that resistance is associated with this selective laying behaviour, and it is proposed to study the pheromonal factors that might be responsible for this specific site selection.

Projects on other crops are now being considered.

Progress to Date

Negotiations with IITA regarding the cowpea project have been commenced recently, and will be continued with the possibility of finalising the project before the end of 1975.

Future Plans and Prospects

Discussions on other crops will commence in 1975 with the relevant institutes, mainly CIMMYT, IRRI, and CIAT, on maize, rice, and cassava respectively. Studies on possible sorghum resistance to the Sorghum Shootfly have already been discussed as part of the Sorghum Shootfly programme (Chapter VI, Section 3).

This will be a continuing programme, as part of an overall pest management strategy.

Staff and Budget

Only a small additional staff has been budgeted for, as they will work effectively within the existing CRU.

2. Grassland Termites in a Tropical Savannah Ecosystem

Principal Scientific Staff: to be reached in 1978

2 Postdoctoral Fellows
5 Asst./Assoc. Scientists
3 Research Scientists
1 Senior Research Scientist

3 Experimental Officers

9 Technical Staff
Synopsis of the Problem

The ICIPE core programme on foraging termites is focussed on those aspects of termites that might eventually lead to long-term, ecologically acceptable control methods (Chapter VI, Section 5). However, our knowledge of termites is woefully small, and is largely confined to the research efforts of scattered research groups in Australia, South Africa, England, and Switzerland. Indeed, we need to know a great deal more about the natural history and ecology of termites in order to assess more accurately their place in the biotic economy, and their economic role in human welfare - both deleterious and beneficial. The present project is designed to do just that.

The present project is limited to the grassland termites, partly because this consideration will enable us to discuss the termite in relation to one of the most important ecosystems for crop agriculture - namely, savannah - and partly because the ICIPE is already concentrating on the foraging termites, which are the preponderant termite element in the savannah, and there will thus be close collaboration between the two programmes.

The present programme will endeavour to investigate all aspects of grassland termite ecology and bionomics with the eventual purpose of determining their value in the savannah ecosystem. It will, in this respect, therefore examine a number of questions:

1. The role of termites in improving soil structure and agricultural fertility.
2. The role of grassland termites as a source of food for birds, wild animals, and human beings.
3. The contribution of termites, through their intestinal micro-organisms, to the breakdown of cellulose products, and therefore their recycling.

The programme is overwhelmingly an ecological one, with inputs from several disciplines to this central theme.

Progress to Date

The programme is still on the discussion stage with UNEP, the principal promoters of the programme. It is expected that the discussions will be finalized in early 1975, and for funding to be available from mid-1975.

Future Plans and Prospects

The studies on grassland termites will eventually lead to a detailed study of the population dynamics and bionomics of individual species over a considerable period of time in order to arrive at a meaningful population model, bionomic assessment, and role in the entire savannah ecosystem. There is no doubt that the programme must be seen over a horizon of ten years or more.
Insights from this work will directly assist our core programme on foraging termites, but it will do more than that by indicating to us some criteria for judging when these termites are really a pest and when they are a boon.

Staff and Budget

The staff complement includes researchers in ecology per se and other disciplines which will contribute directly to the overall objectives. Of the II proposed principal staff, 8 will be located in the field (at Kajiado, and possibly Mombasa if this station is established) and only 3 in Nairobi. They are:

1. Population ecologist (Kajiado, 1975)

2. Ecologist, to study the annual cycles in the mound and foraging area (Kajiado, 1977)

3. Ecologist, to study competition between termites and ungulates for grass and other resources (Kajiado, 1978)

4. Plant ecologist, to study the relationship between termites and the plant kingdom (Kajiado, 1977)

5. Physical biologist, to study the micro-climate requirements within termite nests and galleries, and the critical architectural features of termite mounds (Kajiado, 1977)

6. Ecologist, to study the biomics of foraging and wood-eating termites, both in the dry savannah area and the humid coastal area (Kajiado or possibly Mombasa, 1978)

7. Developmental ecologist, to study colony development concurrent mound development, and factors regulating these phenomena in both savannah and humid coastal areas (Kajiado or possibly Mombasa, 1978)

8. Ecologist, to study the biomics of termites, their role as source of food for vertebrates and man, and their position in the food chain (Kajiado or possibly Mombasa, 1978)

9. Soil chemist, to study the contribution of termites to soil structure, chemical composition, soil development and conservation (Nairobi, 1978)

10. Microbiologist, to study the micro-organisms associated with grassland termites (both in the gut and externally), in terms of soil development and as food producers for other animals and plants (Nairobi, 1978)

11. Physiologist/Ethologist, to study the foraging activity of termites and carry out a combined investigation of the natural history and physiological analysis of caste determination in the nest (Nairobi, 1976).
It is important to have the senior member of this team (the Population Ecologist) appointed soon after the research contract is agreed upon, probably in mid-1975. The whole team will probably not be assembled until 1978. At that time, the termite ecology in the core programme will cease to operate as an independent unit and be merged with this larger research effort.

The principal scientists will be supported by three experimental officers: two ecologists based at Kajiado (and possibly also in Mombasa) and a computer programmer based at Nairobi.

The team will need to have full field facilities available at Kajiado and Mombasa. It is projected that these stations, to be supported largely by funds contributed by this programme, will be fully operational by the beginning of 1977. In the interim, the staff will operate from rented or temporary accommodation at those field sites.

3. Ecological studies of *Aedes aegypti* in East Africa
   Preliminary to Genetic Control

3 Principal Scientific Staff: reached in 1974
3 Postdoctoral Fellows
0 Asst./Assoc. Scientist
0 Research Scientist

0 Experimental Officer
3 Technical Staff

Synopsis of the Problem

The project has been in existence for nearly three years now, and will be coming to the end of the first four-year phase in June 1975. The contractual support is from USAID entirely.

The Yellow Fever Mosquito, *Aedes aegypti*, is one of the half dozen most important insects affecting mankind. Although the species originated in Africa, it has spread with man (via shipping) to almost all of the tropical and sub-tropical world: it transmits many viruses, including yellow fever, dengue, Asian haemorrhagic fever, and Chikungunya. As demonstrated by the present contract, it may play a significant role in the epidemiology of filariasis (elephantiasis).

In East Africa, *A. aegypti* is widespread and abundant; at present, even minimal control is not feasible in most areas. To compound the problem, there is evidence to two populations within the species. One occurs in villages, breeding in domestic water containers and throw-away containers such as tin cans and rubber tyres. The other is feral, breeding in tree-holes and forest situations that are far from human habitation. The relative importance of these two forms to disease transmission and control and the genetic relationships between them have never been established.
Control of *A. aegypti* is expensive and technically difficult. Larvae breed in containers that are inaccessible to conventional mosquito control techniques, such as drainage and larviciding. Human activities such as urbanization and water storage, added to poor sanitation, have increased the threat of this mosquito. Vast eradication campaigns directed against this species have failed dismally, in large part because control weapons are inadequate.

In recent years, entomologists have been searching for alternative, non-chemical control methods which might avoid the twin hazards of insecticide resistance and environmental pollution. Among the most promising biological approaches is genetic control, which involves turning a species against itself. While the best-known method is the "sterile-male technique" where released radiation-sterilized males compete for wild females, there are many other methods of genetic manipulation which could achieve a similar end. For *A. aegypti*, chromosome translocations, sex ratio distortion, genes for sterility, and other genetic devices have shown marked promise in the laboratory. However, field research and trials are required to allow proper evaluation of these newer methods. This is the main objective of this project.

The long-term goal of this project is to discover whether genetic control of *A. aegypti* is feasible under East African conditions. As originally proposed to the USAID in 1971, this goal would require five years of research and a total budget of about $1,000,000. Subsequently, the period was extended and the level of effort per year reduced. The first three years (1971-74) of the contract were allocated to background biological research, a fact reflected in the title, "Ecological Studies Preliminary to Genetic Control". Specific research objectives for the first three years were as follows:

1. Develop a study area where the population of *A. aegypti* is thoroughly and intensively known and then:
   a. discover the absolute number of mosquitoes in the area and determine population fluctuation on a daily, seasonal and annual basis.
   b. develop predictive life tables on a specific population, using data on fecundity, mortality, growth rate and ecological parameters.

2. Establish 10-20 replicate villages (ecological islands) which can be used for later releases; and monitor each population for at least one year.

3. Determine the genetic and ecological relationships between indoorbreeding and feral populations of *A. aegypti*.

4. Develop chromosome translocations and other genetic mechanisms potentially useful for genetic control.

5. Develop facilities for mass-production of mosquitoes.

6. Make preliminary field releases of laboratory-reared mosquitoes to develop technical methods.

7. Conduct subsidiary socioeconomic research on related mosquito disease vectors.
As recognised at the initiation of this Contract, the funding and the three-year period have proved inadequate to develop a final answer to the question, "Is genetic control of A. aegypti feasible?" However, marked progress has been made in developing a base-line for a sound approach to this question. From mid-1974, the second phase of this project should commence, involving the use of released chromosome translocation homozygotes to replace the natural population in experimental villages. It is hoped that, in the three years, efforts will be devoted to the population suppression by released translocations.

A similar project, run by the WHO in New Delhi (India), closely exchanges information with the ICIPE project.

Progress to Date

At the Rabai study site, which is representative for a large part of the Kenya Coast, A. aegypti exploits two fundamentally different habitats - the peridomestic and forest habitat where the mosquito is dependent on rainfall and the domestic habitat where it is independent of rainfall thanks to man's habits of water storage. The two habitats are occupied by two genetically different forms. The type form of A. aegypti occurs regularly in domestic habitats, occasionally in peridomestic, and very rarely in forest habitats. The forest form (sub-species formosus) is found in woodland and peridomestic, but never in domestic habitats. Probably due to a scarcity of large larval habitats like tyres, rain-water drums, and other such containers, the type form of A. aegypti is considerably less successful than formosus in the peridomestic environment. Most of the larval habitats dry out fast and put the type form with its slower development at some disadvantage except during the peak rainy season. Although the two forms mingle during the rainy season in peridomestic habitats the separation is maintained by behavioural differences such as host preference, preference for oviposition site, preference for hunting site, and infraspecific mating preference. Hybrids do occur, however, which seem to occur only during the rains and mostly in peridomestic habitats.

The two forms differ clearly in their population dynamics. The population density of formosus is low through most of the year but shows a steep increase of about 10-fold, three to six weeks after the first heavy rains. Thereafter the population decreases again even if the rains continue. All attempts at trapping adult A. aegypti ssp. formosus in peridomestic and forest habitats in sufficient numbers for mark-release-recapture experiments have failed so far. No population estimates, or estimates of life expectancy or dispersal have therefore been made.

The population density of the domestic form is almost stable throughout the year if the Rabai area is considered as a whole. On the village and house level, however, the populations fluctuate with time mainly in response to domestic water consumption and the sporadic cleaning of water containers. Basic differences in population density also exist between villages and seem to be caused by differences in location, personality and quality of water sources, and so on. The only significant increase and decrease in the domestic form of about 2-fold coincides with the main rainy season.
Mark-release-recapture experiments with individually marked, field caught mosquitoes established a life expectancy of 4.75 days for marked females and 1.13 days for marked males. If the marked individuals survived the first 24 hours after marking, life expectancy increased to 8.08 days for females and 2.17 days for males. Marking seemed to increase mortality at least for the first day after marking. Alternative marking methods were explored but proved to be less efficient. It is assumed that the life expectancy of newly emerged, unmarked females is somewhat higher than 8 days.

Domestic A. aegypti type form moves regularly between houses of a village and frequently also between villages. Dispersal distances of up to 150 metres against the predominant wind direction have been observed. The proportions of immigrants and emigrants vary with the villages, and with time, between more than 50% and less than 10% of the resident population. Dispersal seems not to be restricted to just one period of adult life. Mating in particular, which occurs in the first 48 to 120 hours of adult life, does not affect dispersal. In view of the low numbers of adults present in a village it was assumed that domestic mosquito populations are very vulnerable. It was therefore attempted to eradicate a domestic population from a medium size village by systematic cleaning of water pots together with indoor spraying with pyrethrum against the adults. While the adult population dropped immediately in response to the spraying and the removal of larvae and pupae, it proved to be extremely difficult to get rid of the large store of eggs. After the control measures were stopped, the population returned to precontrol level within five weeks.

At present there are 46 translocations maintained at Mombasa: 37 were induced in indoor strains, 7 in outdoor strains, and 2 in a peridomestic strain. Of the 46 translocations, 19 involve linkage groups one and two, 17 involve linkage groups two and three, and 10 involve linkage groups one and three. Of the 46 translocations, 39 have been tested for homozygosity. Of these only one has given homozygotes in the genetic tests. Further testing will be conducted to verify homozygosity for the translocations, before the strain can be used for releases.

Until recently all mosquitoes irradiated for isolation of translocations have been from strains of wild populations and have given a very low return for homozygotes. Recently, a highly-inbred strain has been irradiated and this strain may be more easily capable of furnishing homozygotes, as it is already conditioned to a high degree of isosenicity and presumably the recessive lethal mutants have been selected out. It may be that the presence of recessive lethals in translocation heterozygotes is what determines the inviability of translocation homozygotes.

Although in the Rabai villages the domestic populations of A. aegypti are neither isolated from each other nor from peridomestic ssp. formosus experiments at displacement through genetically altered stock seems nevertheless promising for the following reasons:

1. The domestic populations of single villages are in general fairly small, less than 1,000 even in large villages. Nuptiality rates are usually less than 100 per day.
2. Provided a vigorous translocation stock with the right behaviour pattern can be produced, even modest daily releases should thus suffice to affect the indigenous mosquito population of a village.

3. A large number of similar villages is available. Various release strategies and translocations can be tested simultaneously and in replicates.

4. Since the village populations respond rapidly to house spraying with pyrethrum, or the cleaning of the household water containers, releases can as an alternative be integrated with conventional control methods to assure the introduction of translocations. Translocation populations thus established can be monitored over a period of time and the effects of interbreeding with wild type immigrants assessed.

In summary, the scarcity of large peridomestic larval habitats and a short rainy season prevent the type form of *A. aegypti* to establish a strong continuous peridomestic population. However, the water storage habits of the Rabai people offer suitable larval habitats inside houses and this leads to small, vulnerable, more or less separate village populations of this species. These populations constitute ideal experimental units to test the idea of genetic control propagated first by Serebrowsky (1940) and later by Curtis (1968).

**Future Plans and Prospects**

Discussions are going on with the USAID for the continuation of this project. If successful, further testing will be conducted along now established lines using homozygous translocations.

**Staff and Budget**

Similar staff will be maintained for this project, which already has most of the equipment needed. The technical staff is now well trained and experienced in breeding, releases, and field recording.

4. **Exploratory Projects**

It is hoped that these projects will give some fundamental information which might later be starting points from subsequent research effort in the core programmes. They will be funded from sources supporting fundamental research, such as foundations and academies of science.

(a) **Pheromonal and Reproductive Biology of the Soft Tick, *Ornithodoros moubata***

1. Principal scientific staff to be recruited in 1978

   1. Postdoctoral Fellow
   0. Asst. /Assoc. Scientist
   0. Research Scientist
Synopsis of the Problem

An important aspect of tick biology is the part that pheromones play in their assembly on suitable hosts for feeding and how they identify their reproductive mates. The core programme on the ECF vector is concerned with these aspects, among others (Chapter VI, Section 2). However, soft ticks are extremely good experimental material, as they are simple to handle and their soft integument permits surgical procedures that are difficult to perform on the hard ticks. The present programme is therefore concentrated on Ornithodoros moubata, on which the ICIPE has already considerable experience (see the Annual Reports for 1973 and 1974).

Progress to Date

It has been shown at the ICIPE that adults of both sexes secrete a water soluble material that induces the opposite sex to cease moving when they come close. This "assembly pheromone" is also active in other argasid (or soft) ticks. The ICIPE is now investigating the chemical nature of this pheromone.

Some preliminary studies have indicated that the application of exogenous analogues of ecdysone on adult O. moubata at the time of feeding leads to "super-moulting" into another adult (although larger in size). These studies are being continued.

Future Plans and Prospects

The two lines of investigation—on assembly pheromone, together with a detailed study of the associated behaviour, and that on hormonal control on development—will be pursued. There is an obvious linkage between this project and the one on the ECF vector.

Staff and Budget

Funds are now being sought for this project, and it is hoped to re-start it in 1978.

(b) Population Diversity of Tsetse Flies

2 Principal scientific staff to be reached in 1978

1 Postdoctoral Fellow
1 Asst. /Assoc. Scientist
0 Research Scientist
0 Experimental Officer
4 Technical Staff

Synopsis of the Problem

...
The distribution of this fly poses a number of questions, which may have
definite implications for the control strategy of this pest.

This species inhabits several areas in East Africa exhibiting widely divergent
ecological conditions. For instance, the species is found in the wet areas of
Nyanza Province of Kenya and northern Tanzania near Mount Meru, and at
the same time also inhabits the very dry areas of Lake Magadi. Diversity in
G. pallidipes has also been observed with respect to biting pattern, host
reference, and breeding sites. Whether the apparent diversity of this species
in phenotypically or genotypically determined is still a matter of conjecture.
It is possible that, in addition to geographical barriers, other isolation
mechanisms (e.g. ecological and behavioural barriers) are also operative.
The main concentration of the programme therefore is to elucidate these
eco-population problems as a preliminary step in the possible control of this
pest species by genetic techniques. For instance, genetic incompatibilities
may be a useful method for tsetse control. Indeed, releases of alien types
was already seriously considered by Vanderplank (1947) for the closely related
tesetse species, G. morsitans and G. swynnertoni. Regrettably, these
studies stopped before yielding critical information.

Progress to Date

Actual studies in this programme only started in East Africa in February 1974,
by the selection of field sites for long-term base-line studies. The two
ecologically contrasting habitats that have been initially selected are:
(i) west of Magadi, near the Nguruman Escarpment (very dry savannah), and
(ii) the Coastal strip of Kenya (lowland, equatorial, humid savannah with
scattered woodland). Information is being gathered about breeding sites,
resting places, diurnal activity, and host preferendia. These field studies
may also promote the information necessary for the laboratory breeding of
this species, which so far no one has succeeded in breeding continuously
(see chapter VI, section I, c). If rearing is successful, then it will be
possible to carry out a great deal of genetic studies and to quantify the
fertility and fecundity of various populations before and after the introduction
of alien elements.

It is expected that these initial studies (which will be extended to field studies
centred at Kibos), which will go on till about 1976, will lead to a basic
understanding of the adaptive flexibility and types of isolation mechanisms
operating in G. pallidipes.

Future Plans and Prospects

The first goal of the research programme, beginning from 1977, is to discover
whether reproductive barriers exist between the various populations of
G. pallidipes. Such information is vital, especially with respect to genetic
control possibilities. The determination of hybrid sterility, non-viability, and
hybrid breakdown must be assessed, and can only be so measured if reliable
quantification of fertility, fecundity, and related phenomena, is possible -
which points to the crucial importance of devising a successful laboratory
breeding technique for G. pallidipes.
The second goal is to reach a full understanding of the genetic variation of enzymes from various pallidipes strains or populations. Using horizontal starch gel electrophoresis techniques, and focussing attention on iso-enzyme polymorphism with respect to leucine-amino-peptidases (LAP), recent preliminary experiments have already demonstrated that we can distinguish strains of G. morsitans from Tanzania (at Tanga) and Rhodesia. These zymogram techniques will be applied to G. pallidipes, as a complementary tool for the ecological studies already underway, to (i) distinguish the various strains of this species in East Africa; (ii) to give data on the amount of genetic variability in pallidipes populations; and (iii) to provide information on the extent of genetic affinities between populations from different regions and habitats. It is expected, from theoretical considerations, that the interpopulation variation in G. pallidipes is great, whereas it is more restricted in intra-population situations.

These studies will lay the foundation for the third phase of the work, which will deal with the release of flies originating from alien habitats into the Magadi site. Zymogram techniques (among others) will be employed to provide information on the adaptive potentials of the released material to their new environment, and also to gauge the amount of migration going on.

Staff and Budget

Of the 2 principal scientific staff, one, an ecological geneticist, is already working in the field, accumulating data on breeding sites, resting places, activity cycles, and related base-line data on G. pallidipes in its various selected habitats. It is essential to devote concentrated effort on the laboratory breeding of this species, as a basis for laboratory investigations on this tsetse fly as well as the subsequent genetical studies. This aspect is already discussed in the breeding programme for this species (Chapter VI, Section I, c.). The second senior member of the team will be recruited in 1978, and will be concerned with detailed population studies of G. pallidipes, and thus bring together the ecological and genetic studies.

An experimental Officer is already undergoing training in electrophoresis and other pertinent analytical techniques, and will give assistance to this programme; he will take his part in the team towards the end of 1975, although he is being trained mainly for the core programme for tsetse reproduction (Chapter VI, Section I, a).

Much of the time of this research team will be spent in the field, centering their field work from the permanent field stations at Kibos (and possibly at Mombasa later), and using mobile laboratories for extended visits to Magadi, northern Tanzania, and other areas in East Africa.

(c) Acoustic Component of Insect Communication

2 Principal scientific staff: to be reached in 1978
1 Postdoctoral Fellow
1 Asst./Assoc. Scientist
0 Research Scientist
Synopsis of the Problem

That many insect species produce various types of sound, that many insect species possess auditory receptors, and that sound may thus play an important role in the behaviour of these insects has been known for several decades. Nevertheless, sound production and reception - as a means of insect communication - has been studied far less than the case is regarding chemical communication, which has drawn major attention in recent years. Technical difficulties and the lack of people with sufficient interdisciplinary knowledge in the acoustic biology field have made progress in the latter slow. The ICPE is making strenuous efforts to overcome these problems, and has embarked on the acoustic biology of tsetse flies as from April 1974.

Earlier efforts by several workers (e.g. Dean et al., 1969; Turner, 1971) were devoted to demonstrating that tsetse flies might be able to communicate by means of a pheromone. These efforts have so far failed. Yet, it remains difficult to explain the field behaviour of tsetse flies without assuming some form of communication between the individual flies: tsetse flies are usually scattered throughout an area, yet they may congregate at certain times (for instance, for feeding or mating); also, despite their being very selective about the host on which they feed, and in spite of the necessity to feed at least every 3-4 days, they can manage to survive in a situation where there is a very low density of suitable hosts. Consequently, they must have - on an individual basis - the means to find a suitable host and, having found one, to communicate this information to other flies.

For over 50 years now (Carpenter, 1924), it has been known that tsetse flies produce sounds. However, so far, no experimental evidence is available to demonstrate that sound is utilized by these flies for communication.

Previous studies on tsetse sound production have been concerned with the frequency range that is audible to man. In the present studies being carried out by the ICPE, investigations have been extended to the ultrasonic range. This modification has yielded important new results. These studies could well be crucial in designing new control techniques for tsetse flies.

Progress to Date

All the basic studies have been carried out on G. morsitans. It has now been established that the sound made by adult tsetse flies has an ultrasonic component, that sound spectrogram analysis clearly distinguishes the ultrasound associated with feeding from that connected with mating and that the sound produced by the female fly differs from that produced by the male when ultrasonic range is analysed. Indeed, it appears that the high-frequency components in these sounds yield much more information than the low-frequency ones.
From these first results, it looks as if sound may constitute an important mechanism for tsetse communication.

Future Plans and Prospects

An important circumstance for initial success of this programme is that the recording of sounds, the relevant behavioural studies, and the subsequent field work are all based in Nairobi. Initially at least, all the analytical work is carried out in the laboratories of the Division of Physiological Acoustics in the Department of Physiology II at the Karolinska Institutet, Stockholm, where much of the analytical and statistical techniques in the field of insect acoustics have been developed. By 1977, however, the training in Stockholm of the staff for this analytical work will have been completed and the necessary equipment will be installed in Nairobi - thus allowing all the work on insect acoustics to be centred in Nairobi.

The first goal is to elucidate the code used by tsetse flies in their acoustic communication. This demands the recording of sound using highly sensitive equipment, the careful use of various analytical tools (e.g. "voice-print" sonagraph, hybrid audiospectrum analyser, oscilloscopes, and statistical signal analysis techniques), and a detailed study of relevant behaviour patterns. It will also require the study of the hearing ability of the flies, the mechanism for doing so, and the electrophysiological information so obtained by the fly. At a later date, it is planned to carry out field studies of the acoustic biology of G. morsitans (and other important tsetse species); and then find out, by the artificial generation of synthetic tsetse sounds, the behavioural responses of the wild population.

When significant progress has been made on tsetse acoustic problems, probably by 1978, a project will be launched on termite acoustics. Sounds produced by termites are complex; but it is not known in sufficient detail what role in communication they may play and how they do so. Other eminent candidate insects for acoustic studies are the African armyworm and the mosquitoes.

Staff and Budget

Training of the senior staff will occupy major attention in 1975 and 1976. Thus, whereas the first principal scientific staff - an entomologist with training in ethology - will be recruited early in 1975 and start his investigations on tsetse acoustic behaviour in Nairobi immediately, the experimental officer (who has a physics background) will embark on an intensive one-year training in Stockholm on recording and analytical techniques at about the same time. The second scientist will undertake a similar training programme from 1977, and join Nairobi later as the acoustics physiologist.

The equipment to be used in Nairobi is being gradually gathered together according to rigorous specifications. In the new building being planned (Building IV), a special acoustics laboratory will be designed for this long-term project.
VIII. RESEARCH SUPPORT SERVICES

Several support services have been found essential for the normal functioning of the ICIPE as a research institution: a library, a workshop complex, technical services, and a communication and information service. All these services need to be managed by highly qualified professional persons, and supported by a trained and experienced staff. These services have been set up at the Centre only where experience has proved that these services were not available elsewhere in Nairobi or, if available, not at the level of efficiency demanded by our research activities.

Eight services are described in the following pages which form essential facilities for all the research undertaken by the ICIPE. The first three years of ICIPE's research activities have proved their importance; and it is planned to upgrade the quality of their work by careful additional recruitment, better equipment and, in some cases, by providing them with more adequate accommodation.

1. Chemistry Research Unit

4 Principal Scientific Staff: to be reached in 1977

0 Postdoctoral Fellow
2 Asst. /Assoc. Scientists
1 Research Scientist
1 Senior Research Scientist

1 Experimental Officer

4 Technical Staff

Service Goal

The chief mandate of the CRU is to collaborate with the biologically-oriented research groups at the ICIPE in solving chemical problems that are important for the solution of the overall insect problem. In this way, the CRU brings to bear advances in physico-chemical methods, isolation techniques, purification methods, techniques for chemical structural elucidation, and biosynthetic studies to characterize the natural regulators of insect life. Thus, in the first three years of its existence, the CRU has focussed its attention on characterizing the insect hormones (and their mimics), pheromones, and growth regulators that seemed to the ICIPE biologists to be critical in their own investigations.
A second objective is to give service to other programmes - e.g., contractual programmes at the ICIPE, and collaborative projects with other institutes with direct significance to ICIPE work - where chemical expertise is essential.

Some of the time of the CRU team is devoted to some long-term projects, which are not immediately linked to the core programmes, but which seem to be important as inputs for pest management programmes. This forms the third objective.

Progress to Date

The first two years were mainly spent in setting up the basic instrumentation for the unit and in carrying out some exploratory studies. Since mid-1974, with the purchase and installation of more sophisticated equipment (e.g., gas chromatograph-mass spectrometer), the CRU is now in a much better situation to carry out isolation and structural studies at a more refined level.

The first three most significant advances have been:

(a) The full characterization of the female sex pheromone of the ECF vector, R. appendiculatus, this year. The pheromone is actually a mixture of phenol and para-cresol. Females of R. pulchellus were also found to produce the same pheromonal phenols, although in a different ratio.

(b) The elucidation of the complex structure of azadirachtin, which is a potent insect anti-feedant isolated in large quantities from the plant, Melia azedarach and the Indian neem tree, Azadirachta indica. The complex structure of this antifeedant (C35 H44 O16) was elucidated by using a C-13 nmr technique, which had not been used before, in one of the Research Director's laboratory.

(c) The determination of the defensive secretion emitted by soldiers of the termite, Odontotermes badius. The secretion consists of a mixture of benzoquinone and protein in an aqueous solution.

Future Plans and Prospects

The first three areas which will be developed over the next five years or so are concerned with the target insects - termites, R. appendiculatus ticks, and the African armyworm. The fourth is concerned with insect regulators from plant sources (using the African flora as its main source material): this is the CRU's own project. A cooperative programme is that on the investigation of chemical sources of plant resistance, already described in Chapter VII, Section 1.
1. **Termites**, the oldest social insects, rely heavily on chemical communication for the organization of their societies. Chemical investigations in the future, based on preliminary chemical work already done, and with an active feedback with the termite research group throughout, will concentrate on the characterization of trail pheromones and to a lesser extent on alarm substances, which are often closely linked to defensive secretions.

The trail pheromone of *H. mossambicus* and of *Schedorhinotermes* to some extent, are now well characterized from a biological and behavioural point of view. Chemical studies on these pheromones have recently been initiated. At a subsequent time, the trail pheromone of *Trinervitermes bettonianus*, a grass-feeder, will be studied intensively. Preliminary tests have shown the trail pheromone to be an extremely labile substance; it is important therefore to gain considerable additional experience before tackling this problem successfully.

Alarm and defensive secretions of nasute termites, especially *T. bettonianus*, will be examined and characterized. Interesting caste differences have recently been demonstrated in the compounds emitted by the "small" and "large" soldier castes of this species. Apart from the characterization of these compounds, it would be worthwhile to find out the generality and significance of these chemical caste differences.

2. **Tick Vectors of ECF.** Following on the successful elucidation of the female sex pheromone of *R. appendiculatus*, and the indications that *R. pulchellus* may have a different pheromonal composition, further comparative studies on the composition of sex pheromones from a variety of hard tick species related to the ECF vector will be pursued. Biosynthetic investigations will also be initiated aimed at uncovering the metabolic origin of the sex pheromone of *R. appendiculatus*.

Important for pest management studies is the structural specificity of tick pheromonal receptors. Our current studies seem to demonstrate that *R. appendiculatus* males are attracted to a surprisingly wide range of phenolic substances. This non-specificity is at variance with the situation that generally obtains for insect sex pheromones.

3. **African Armyworm.** Preliminary studies of the chemistry of the female sex pheromone of the armyworm have been going on already, and the chemical identification should be completed by the end of 1975. The male sex pheromone, presumably produced by the well-developed hair-pencils of these moths is a more challenging task; initial extractions of these organs have yielded no demonstrable active substance. However, detailed studies of the mating behaviour of this species is soon to be completed by the African Armyworm group (see Chapter V, Section 4). These
Insect Regulators from Plant Sources. In recent years, there has been a renewed interest in insect regulators from plant sources because, unlike synthetic regulators, the natural principles are usually devoid of halogen and phosphorus and are also more readily biodegradable. A search will be continued more extensively therefore on African flora for new regulators which may be useful in pest management.

Staff and Budget

There are presently two principal scientists in the CRU. The programme that the unit has to deal with, however, is enormous: the requirements are also diverse, including chemical problems needing expertise in protein chemistry, natural products chemistry, the chemistry of pheromones and attractants, and the chemistry of hormones. There is need therefore for two more principal scientists: one in 1976, and the other in 1977. An experimental officer, to be appointed in 1978, will bring the scientific complement to full strength, and enable the unit to give a wide range of services to the other programmes.

The decision in 1973 to start equipping the CRU with relevant equipment, however, sophisticated - rather than relying on analytical (or other chemical) studies requiring sophisticated equipment which are available in overseas laboratories - has already paid handsome dividends. Most of the progress the unit has accomplished in the last 12 months is due solely to this decision. This policy will be continued.

Immediate requirements for the unit are a chemical ionization unit to be attached to the present gas chromatograph-mass spectrometer, a digital readout polarimeter, and a second high-pressure liquid chromatograph.
2. **Electrophysiology Research Unit**

3. Principal Scientific Staff: reached in 1974

- 0 Postdoctoral Fellow
- 2 Asst./Assoc. Scientists
- 1 Research Scientist

1. Experimental Officer

3. Technical Staff

**Service Goal**

Since chemical communication is highly important in the target insects selected by the Centre, the analysis of the structure and function of chemoreceptors - whether for olfaction or taste - remains one of the most urgent tasks of the ERU in the near future. Furthermore, in combination with clear-cut behavioural tests, electrophysiological bioassays can greatly help to a more rapid identification of biologically active substances employed in sexual displays, food-plant selection, host detection, and host finding. Finally, there are other sensory systems present and operating in the target insects which can be analysed profitably; for instance, the visual system in the orienting tsetse fly and in the armyworm moth, and the auditory system in both insects. Thus, the ERU must always remain highly flexible, so that it can adjust to new experimental demands.

It is a fortunate circumstance that electrophysiological techniques can be employed rather simply in insects, down to the cellular level. Indeed, insects can be considered ideal model systems for this method of experimental approach in neurobiology and behavioural sciences. The main sensory equipment of insects is often extremely accessible, their central nervous system is arranged in such a way that the integrating and coordinating mechanisms are in more or less separate regions, their neuromuscular systems allow the registration of electrical activity and the generation of motor patterns even in unrestrained and freely moving animals, and they are known to organize their behaviour in a rather stereotyped fashion quite often; these characteristics enable us to obtain a great deal of information from electrophysiological experiments.

Just as in the case of the CRU, the ERU works in close concert with the other programmes to solve the problems of direct importance to the subsequent management of the target insect pests. The mandate of the ERU can be summarized as follows:

1. The employment of electrophysiological techniques in unravelling the basic processes underlying the sensory and behavioural physiology of the target insects.
2. The provision of fast and quantitative methods for the bioassay of active insect substances, e.g. sex pheromones, insect repellents, trail pheromones, sexual aphrodisiacs, and alarm substances. These are particularly valuable methods for chemical analytical work.

3. The provision of supportive information which, combined with results from the FSRU and behaviour studies, give a clearer picture of the structural and functional properties of sensory receptors.

Progress to Date

The unit has become operational only since the beginning of 1974. It has now three electrophysiological set-ups, each consisting of the basic instruments for stimulating and recording sensory, muscular, and central nervous systems. The unit is already probably the best equipped laboratory in Africa for electrophysiological research.

It is recognized in the ERU that without a detailed knowledge of the behaviour of the insect being studied, and without a thorough knowledge of the structure of the sensory and nervous elements involved, a purely electrophysiologically oriented approach is unsatisfactory and sterile. Consequently, the ERU works closely with FSRU and also with the biologists working on the behaviour of the target insects.

This strategy has yielded some significant results already:

1. Food-plant selection in armyworm caterpillars: Using single-cell recording techniques on taste cells, it has now been shown that certain receptors respond selectively to feeding stimuli released by the graminaceous host plants; and that the styloconic sensilla located on the maxillae and the coeloconic sensilla located within the epipharyngeal region of the mouthparts seem to be the most promising candidates for food-plant recognition and selection.

2. Female sex pheromone in the tick: Present experiments seem to indicate that basiconic sensilla found on the palps of ticks may be the main mechanism for the recognition of the female sex pheromone.

Future Plans and Prospects

With the accumulation of more detailed information on the behaviour of target insects, and the recent commissioning of the electron microscopes of the FSRU, a vigorous collaborative programme for the near future has emerged.

1. Completion of the detailed analysis of the structure and function of the taste receptors responsible for
the highly restricted host-plant selection in armyworm caterpillars.

2. Initiation of a detailed study of the receptors responsible for the trail-laying behaviour in foraging termites.

3. Completion of the detailed analysis of the structure and function of the receptors that respond to the female sex pheromone in ticks. Present experimental evidence indicate that at least two systems of receptors are important for the response of the male to this pheromone.

4. Host finding in tsetse flies. It is not yet clear how tsetse species are able to discriminate so well among available host animals. Early work suggested that there might be chemicals emanating from suitable hosts that directionally attract hungry flies. This might well be tested in the case of G. pallidipes (see Chapter VI, section 1, c).

The unit will continue to render bioassay service to the CRU.

Staff and Budget

The unit has already its full principal scientific staff. However, if the future research plans have to be implemented fully, the unit requires to recruit an experimental officer by 1977 to take charge of bioassay procedures, and two senior technicians (with sufficient training in electrophysiology or biophysics) who are able to handle competently electronic apparatus.

Equipment for simultaneous activities by 3 research staff have already been commissioned. But with the increased number of staff, and the need for more refined methods, oblige us to obtain additional equipment. Furthermore, the future progress and success of the ERU depends to a very large extent on the functioning of a well organized workshop within the Centre (see Chapter VIII, Section 7).
3. **Fine Structure Research Unit**

2 Principal Scientific Staff: to be reached in 1977.

0 Postdoctoral Fellow
1 Asst./Assoc. Scientist
1 Research Scientist

2 Experimental Officers

5 Technical Staff

**Service Goal**

The FSRU is a research resource vital to the entire ICIPE programme and is concerned with the structure of cells and their products. The electron microscope, both in transmission and scanning modes, is now an established research tool in all major biological research institutes, since significant answers to physiological, and ultimately to ecological, problems can now be sought at the level of subcellular function. The FSRU laboratory is staffed by experienced personnel who conduct studies on fine structure relevant to the ICIPE objectives and who will, at the same time, provide the necessary instrumentation and expertise to investigators in other areas for whom electron microscopic information is an important complement to other studies. The unit established at the Centre is of high quality; it should play an important part not only in the research efforts of the ICIPE but also, through collaborative work, in the research activities in other institutions in Africa.

The overall nature and objectives of the FSRU programme are to provide information on structural correlates with cellular physiology and chemistry, at a resolution approaching the molecular level, as a necessary extension of observations conducted with the light microscope.

The objectives of the FSRU programme interrelate closely to all the other ICIPE programmes: e.g.

1. Work on insect behaviour requires information on sensory receptors, provided by both transmission and scanning electron microscopy.

2. Many basic questions concerning insect function and development ultimately involve details of endocrine activity, requiring study at the fine-structural level.

3. Details of secretion of many products in the insect body (e.g. "milk" and the peritrophic membrane in the tsetse fly) are most productively observed in the electron microscope, while light microscopic studies retain a valuable complementary role in cytochemical work.
4. Modulations in the structure of protozoan parasites (e.g., Trypanosoma) correlated with infectivity are fully evident only at the fine structural level.

5. Techniques for studying sequential events in the living cell by use of radioisotopes, originally designed for light microscopic studies, have been adapted for use at the enhanced level of resolution provided by the transmission electron microscope.

In short, the FSRU is equipped to provide information on cellular structure at a level without which all morphological results of ICIPE research would be considered inadequate by the international scientific community.

Progress to Date

The two large electron microscopes, transmission and scanning, were installed and commissioned in June and October 1974, respectively. The staff are all highly trained, and the unit is now fully functional with its laboratory complex. Before this was achieved, the staff worked with instruments in Nairobi (of lower resolution) and Miami (which has excellent facilities). With this arrangement, the unit has been able to accomplish some significant results over the last 18 months: e.g.

1. The milk glands of tsetse have been studied in detail at both light- and electron-microscopical level to follow the changes that take place during the secretion and release of the nutritive milk, and a novel means for the release of the latter has been uncovered. A detailed study of the striking changes in cell form and intracellular organization accompanying the pregnancy cycle (work being done in collaboration with the Miami team) is near completion.

2. In collaboration with EATRO, Tororo, studies are being made on the fine structure of blood-stream infective trypanosomes. Earlier last year, isolates of T. brucei free from cellular and plasma blood components, were studied in Miami by both scanning and transmission electron microscopy, and by freeze-fracture replication. New information has been obtained on the membranes of the trypanosome; later work will focus on the fine-structural localization of the external antigens.

3. A very detailed histological, histochemical and fine-structural study of the tsetse salivary gland has been completed, as a baseline for future studies on functional control of the secretion process and as an environment for trypanosome development.

4. A study of the chemoreceptors of the adult tsetse flies has been started.
Future Plans and Prospects

It is anticipated that the FSRU will play an increasingly important role in the overall ICIPE programme. Since this laboratory provides, in part, a service resource for the other programmes, the development of the unit is closely connected with the progress of other species-oriented and system-oriented projects. Thus, it is planned to have carry out important new or continued collaborative studies in the following areas:

1. A detailed study of the tsetse uterine and ovarial system in conjunction with the tsetse reproductive physiology programme.

2. An investigation of the modulation of the tsetse salivary glands during feeding cycles, and the cytological interrelationships of trypanosome infection of the glands.

3. An investigation of the developmental cycle of T. brucei throughout its sojourn in the tsetse (crop, midgut, hindgut, haemocoele, and salivary glands), and the identification of any characteristic antigens and their modulation during this sojourn.

4. Chemoreceptors important for pheromone attraction in male ticks.

5. A correlated study of the morphology, function, and activity of the neuro-endocrine system during a tsetse pregnancy cycle.

6. A detailed investigation of the fine structure and cytochemistry of the whole alimentary canal, the changes that occur during successive feeding cycles, the structure and function of the peritrophic membrane, and an understanding of this environment for trypanosome development.

7. The fine-structural differences and functioning of the corpora allata of the various castes of termites, with special reference to the hyperactivity found in queens.

8. A detailed study of the chemoreceptors responsible for chemical communication in termites.

In addition, it is expected that calls for assistance with research requiring fine structural data will increasingly be made on the FSRU from outside the ICIPE, and that collaboration will be extended whenever possible.

Staff and Budget

A principal scientist and two experimental officers have already been appointed. However, it is clear that there is a great volume of work for the unit; moreover, it will strengthen the range of expertise available at the unit if a senior scientist with both fine structural and cytochemical expertise could be recruited. It is planned to do this in 1977.
The present major instrumentation (Philips EM 201, and JEOL scanning electron microscope) will be adequate up to 1981. But ancillary equipment is urgently needed, especially two Huxley-LKB ultramicrotomes (we have presently two very old models donated to the unit last year), a critical-point drying apparatus, diamond knives for high-quality sectioning of cuticle-associated tissue, and equipment for fluorescence microscopy.

4. Insect and Animal Breeding Unit

1 Experimental Officer

16 Technical Staff

Service Goal

The major mandate of the Insect and Animal Breeding Unit is to maintain a large self-reproducing colony of each of the target insect species for experimental purposes and of other insect species needed for bioassays and similar work. For blood-sucking arthropods, this requires that the unit also maintains colonies of appropriate host animals. For plant-feeding insects, it may well require the provision of standardised plant material. In any case, the standard required in the maintenance, breeding and record-keeping for each of the insect colonies is very high to ensure uniformity of stock origin and quality.

The unit does not concern itself with the maintenance of insects when they are actually being used in an experimental protocol.

The existence of an efficient insectary is a prerequisite for a considerable proportion of the research work of the Centre.

Progress to Date

A small insectary was one of the very first programmes that were established at the very beginning of the Centre’s existence. Success in this direction has enabled the Centre to make substantial progress in most of the research programmes at the Centre (see Chapter IV). Of particular significance has been success in the following:

1. Successful establishment of a colony of G. morsitans. The colony
has, for the last year, supplied all experimental needs of the Centre. Indeed, the Centre is now supplying two research institutions in Zambia and Nigeria with pupal material for starting their own colonies too. (It should be noted that the staff initiating these two colonies have had training at the ICIPE insectary.)

2. Successful establishment of a colony of G. austeni. This colony is kept at a low level as comparative experimental material, but not as part of a major programme since it is not of direct pest importance.

3. We have now worked out a detailed system of the colonization and maintenance of the soft tick O. moubata, based on investigations at the Centre on host preference, breeding biology, etc. (Our work on the ECF vector, R. appendiculatus, relies on supplies from EAVRO, which has maintained a successful colony for many years, and with whom we have a collaborative programme.)

4. The colonization of the cereal stem-borer, Chilo zonellus, using an artificial medium.

5. The production of several insect species used for bioassay or occasional experimental work, especially the wax-moth (Galleria mellonella), and two locust species (Schistocerca gregaria and Locusta migratoria migratorioides).

6. Several strains of Aedes aegypti mosquitoes are maintained at the ICIPE Coastal Station, in Mombasa, for genetic studies.

Future Plans and Prospects

It is planned to add to the insect colonies at the ICIPE the Sorghum Shootfly, the African Armyworm, and G. pallidipes, based on the breeding experiment that are currently underway. The first species is little known, and requires a great deal of basic knowledge of its life history and food preferences before a successful insectary protocol can be worked out. The second species also requires additional information, but the main problems are concerned with bacterial and viral infections. The third species is a major theme of the core programme (see Chapter VI, Section 1, c). In any case, it is thought that by 1977, many of the problems may have been overcome and reasonable breeding of the three species would then follow.

At the moment, supplies of R. appendiculatus for our research is obtained from EAVRO. On the long-term, however, because of the expected vast increase of demand for tick material, the ICIPE will have to maintain its own breeding colony for mass production.

Staff and Budget

The problem of accommodation for insect colonies and laboratory animals
is most acute. The present accommodation at Chiromo is cramped, inadequately designed for animal breeding, and is in temporary buildings which we are obliged by the City planning authorities to pull down soon. It is for this reason, mainly, that the ICIPE has acquired land at the Langata site in a forest zone outside the business area of the city. The 10 - acre site will be planned for the mass-breeding of insects and laboratory animals. It is estimated that planning will begin early in 1975, and that actual building of insect and animal houses will commence in 1976. By the end of 1977, it is hoped that all mass-breeding facilities will be concentrated at Langata, leaving only small holdings at Chiromo for immediate experimental purposes.

This unit requires some greenhouses and mesh-houses for growing plants under more or less restricted conditions (for pests and diseases) for use in the insectary. These facilities will be built also at Langata.

Many of the insectary staff have undergone intensive training, and they will go on to train additional staff that will be needed for the intensive programme of breeding. The unit will be assisted greatly by the insect pathologist in the C. pallidipes breeding programme, who will undertake regular monitoring of the health of the insects. We have a similar arrangement, in regard to animal health, with the Veterinary School of the University of Nairobi. Personnel in this unit must be extremely dependable since insects must be cared for seven days of the week, and the ability to follow precise rearing instructions is an absolute requirement. In addition, the unit must be so organized that it can produce supplies on order and to a uniform quality standard.

5. Field Stations

2 Administrative Officers/Book-keepers
2 Clerk/Typists
0 Technical Staff

Service Coal

Ecological work at the ICIPE is the main anchor of much of the other multidisciplinary research on the target insects. Although the ICIPE has already a number of mobile laboratories for some of its field work, the longer term field ecological investigations does require more or less permanent residence in the field or close to the field operations. Another important consideration is the selection of appropriate sites which will give our core programmes a variety of ecological conditions for the
detailed investigations that are required for a balanced pest management programme.

Following these ideas, the Board has now agreed to the establishment of two field stations:

1. Kajiado Field Station, at Kajiado, 75 km from Nairobi, located within a large area of dry savannah grading into almost the semi-arid zone. Negotiations for the acquisition for a 10-acre site to house the field buildings and accommodation have just been completed and the land has been demarcated. The station will be the main site for research on foraging termites and ECF vector, R. appendiculatus; but it will also be used for observations on shootfly and armyworm.

2. Kibos Field Station, near Kisumu, on Lake Victoria, 340 km from Nairobi. Negotiations are going on with the Kenya Ministry of Agriculture for adequate land for field station buildings, staff accommodation, and field plots. Kibos will be the main focus of shootfly field work, but it will also be used for ecological work on armyworm and G. pallidipes.

It is vital that these field stations be fully operational by the end of 1976 so as to permit the most intensive ecological work planned for the subsequent period (see Chapter V).

Groundwork negotiations for a third, coastal, field station are underway prior to official consideration by the Governing Board. The expected site for the ICIPE Coastal Field Station may well be at Mtwapa, some 20 km from Mombasa town on the northern coast, and in close proximity to the main coastal research station of the Kenya Ministry of Agriculture. The station will be mainly for studies on tsetse flies; but it will also be important for work on armyworm, shootfly, termites, and mosquitoes. The station is located within a lowland humid tropical area.

Progress to Date

At present, the field station at the Kenya coast has been operating for the last three years in rented accommodation at Mombasa. This is in a residential suburb and it will not be a suitable site for long-term programme of field work and for the several target species of insects. However, it has proved a crucial facility for the mosquito eco-genetical studies (see Chapter VI, Section 3).

Research work has not yet commenced at the Kajiado site, but Sorghum Shootfly preliminary field studies are being carried out from borrowed accommodation at Kibos, a major centre of sorghum production in Kenya. It is a particularly good area for this type of work; and it is planned to have a full-fledged field station for this and other target insects in the next two years.
Our experience so far demonstrates the vital importance of the proposed field stations for the ICIPE programmes.

Staff and Budget

Estimates have been made, for each of the field stations, for a laboratory and office building, storage space for field equipment and other items, utilities (such as a water tank and standby power plant), living quarters for station staff, and guest accommodation for visiting scientists. It is intended that most of the basic ecological work be undertaken at the stations, leaving analytical studies to be completed at the main ICIPE Research Centre in Nairobi.

The small core staff suggested for the stations will ensure the basic technical needs, and security and janitorial services. The small administrative staff will work in close concert with the Centre in Nairobi, and is needed to relieve the scientific staff of administrative routine.

6. Laboratory Management

The Controller for Technical Services supervises a number of auxiliary services for the research programmes: supervision of technical staff, selection and elaboration of training programmes for technical staff (including on-the-job training), the organization of safety measures for the whole Centre, maintenance of the physical facilities of the Centre, maintenance and servicing of equipment, routine servicing of vehicles, and the overall supervision of all technical services (workshops, photographic service, and the insect and animal breeding service). This section will also run a small transport unit.

7. Workshops

The ICIPE vitally needs to maintain a first-class electronic workshop for servicing the many electronic equipment at the Centre and to assist in the design and fabrication of new equipment, which is a constant need for electrophysiological and other research going on at the Centre. The latter
also needs mechanical and wood-workshops. All these facilities already exist at the ICIPE, although in a miniature form only. During 1975, with the completion of slight modifications to the recently completed permanent building, some additional space will be available in the ground floor where some of the urgently needed facilities of the workshop complex will be housed. With the equipment already installed and others on order, the ICIPE workshops should be able to undertake basic workshop services for the ICIPE activities quickly and efficiently. It is clear, however, that wider facilities, including glass-blowing facilities, will be needed beyond 1976.

The workshops will also be running a small facility for the routine servicing of vehicles.

8. Statistical Service

The ICIPE depends at present on outside consultants for statistical and computer assistance in working up research data needing this type of treatment. The accounts of the Centre are at present not done by computer, although this question is likely to reviewed in the near future.

Recent experience has shown that there is increasing demand for the ICIPE to acquire its own adequate statistical service. Indeed, with the increasing tempo of ecological work in the next two years, it is virtually certain that the need will become a very real one. The ICIPE is therefore planning to examine this question thoroughly in 1978, and take appropriate action on the recommendations.
IX. TRAINING AND LIAISON

The first task of the ICIPE is to fulfill its research objectives, and to ensure that its present research programmes are fully operational and are beginning to yield important results. The initial phase of the ICIPE has demonstrated its research capability; and it is now appropriate for the ICIPE to put considerable effort into its training and liaison objectives. Five main principals should be considered in this respect:

(a) The ICIPE needs to strengthen its training programmes on a continuing basis for its own staff, particularly in the area of technical training. Technical training is such an essential service for quality research, especially in the LDCs, that it is regarded as a vital investment in the ICIPE.

(b) The ICIPE needs to expand its postdoctoral training programme for young African Scientists and to launch a similar programme for selected postgraduate students. The latter should be associated with African university institutions.

(c) It is essential that the ICIPE cooperate with other research institutes and arrange joint use of facilities. To achieve the stated objectives of helping to develop practical solutions for the control of pests, the integration of the ICIPE research programmes with ongoing activities in applied research institutes whenever possible is of top priority.

(d) Several pest control projects are underway in various research centres in eastern Africa and elsewhere, which might possibly benefit from collaboration with the ICIPE. It is important to maintain strong liaison with such centres or programmes for the mutual benefit of all.

(e) Collaboration with the CGIAR institutes will receive special attention: the institutes are interested in particular pest problems interfering with optimum food production, and the ICIPE could assist in selected areas in helping to solve these problems.

The effective communication of ideas to further ongoing research, to stimulate new fields of endeavour, and to avoid duplication can be tackled not only by exchanges of publications and liaison visits but also by conferences, seminars, and study workshops. The ICIPE is in a unique position to convene and administer such meetings, both by itself and in conjunction with other bodies in Africa (e.g., the University of Nairobi, the Nigerian Agricultural Research Council, the Zambian National Council for Science and Technology, and the AAASA).
In the same way, the potential of the ICIPE for specialized training is considerable; but experience has shown that the introduction and administration of a training programme is demanding and may even impede the effective growth of the research programme in the early stages of an enterprise such as the ICIPE. Consequently, it has been necessary for the ICIPE to plan a phased development of this programme. Thus, the initial programme was a modest one (see Chapter IV). The next step is for the ICIPE to include a larger programme of postdoctoral and technical training, and to initiate a small postgraduate programme. In anticipation of this, the ICIPE recently appointed a Deputy Director for Science responsible for research collaboration, as well as guiding the multidisciplinary research programmes of the ICIPE.

1. Research Training

Postdoctoral training is an important ingredient for a vigorous scientific community. This ingredient is almost absent in the African scene. The ICIPE has started in a small way by granting postdoctoral fellowships to two young African scientists, who have been enabled to spend considerable time at the Centre working as "Research Associates" on ICIPE core programmes. Their contribution to ICIPE programmes has been significant, while their experience at the ICIPE has stimulated them in mounting similar research projects at their home institutions on their return. The multiplying effect of this approach is one of the most exciting aspects of this fellowship programme.

It is intended to intensify this Research Associateship programme and to make provisions for up to 6 fellowships in any year from 1977. For each appointment, the grantee (who still maintains his substantive appointment) will be able to spend six months at the Centre in the first year, and three months each for the following two years. In this way, the grantee will maintain organic collaborative contacts with the ICIPE for a period of three years. In time, these alumni will form a development-oriented invisible college of immense benefit to pest research in Africa.

The second project for research training is the present scheme under which Research Fellows are appointed soon after completing their doctoral work. These young scientists, recruited from any part of the world (including Africa), are able to devote 2-3 years of their postdoctoral period to intensive research at the ICIPE. They are regarded as part and parcel of the principal scientific staff at the Centre, and have proved to be the main source of the vigour and imaginative inventiveness of the ICIPE up to now. The policy of recruiting such staff will continue as an integral part of recruitment strategy of the ICIPE.

A third project is the possibility of making facilities available at the Centre for postgraduate training of young scientists from the LDCs. The ICIPE plans to have the physical facilities to enable them to do so. A special
requirement is that the students should engage on studies in the areas
ICIPIZ is concentrating its efforts; in this way the students will add to the
sum-total of ICIPE knowledge, as well as ensure the ability of the ICIPE
scientists to supervise their work. Arrangements for registration of
these students with the University of Nairobi forms parts of the joint
agreement ( Appendix 3 ); and the ICIPE intends to conclude similar
agreements with other universities.

The first such student, sponsored by EATRO, will join the ICIPE in
early 1975. Several ICIPE staff are already registered with the University
of Nairobi.

It is planned that the total number of all these visiting scientists (Research
Associates, Postgraduate Students, and Visiting Scientists independently
financed but working on ICIPE projects) will be about 10 in any one year.

2. Professional Training

The ICIPE puts very high premium on the training of their technical
staff - particularly those engaged in research programmes, workshops,
and the insect and animal breeding unit. Such training is partly under-
taken on the job at the Centre, as well as at the Kenya Polytechnic, in
Nairobi, which caters for a wide range of technical and practical training.
Where necessary, this training has been topped up by training in institutions
abroad. In this latter connection, our technical staff have had advanced
training at the U. S. Department of Agriculture research institutions
(insectary training), International Atomic Energy Agency (IAEA) in Vienna
(tsetse breeding), Universities of Cambridge and Manchester (radioisotope
techniques), Universities of Cambridge and Miami (electron microscopy),
University of Berne (termite research techniques), Karolinska Institute in
Stockholm (acoustic research techniques), and the International Institute of
Tropical Agriculture in Ibadan (for greenhouse techniques and the breeding
of phytophagous insects).

Such training will continue, as new projects come into being, as new
staff are engaged, and as it becomes necessary to update the knowledge
of experienced staff.

The African Committee has especially urged the ICIPE to mount specialized
courses from time to time for the training of senior technicians from other
countries in Africa. Tsetse breeding at the ICIPE is a notable success
story, and already two trainees (from Zambia and Nigeria) have undergone
training at the ICIPE in the last 18 months. There are proposals to
intensify this programme for several institutions that need this assistance.
Similar proposals are in being for specialized training in scientific photo-
graphy, electrophysiological methods, fine-structural techniques, and in
the maintenance of electronic equipment. In the next three years, ICIPE
facilities will be built up to cater for the training of small groups of
senior technicians.
Although it is not strictly research or professional training, the ICIPE has found from two years of experience, when it has awarded six-month bursaries for high-school science graduates (eight in all, on selective basis), that this type of exposure has been a tremendous stimulus to the students going on to university courses. A high proportion of these have taken on science, and are likely to go on to entomological research. The ICIPE plans to maintain this programme on a competitive basis, as before.

3. Conferences, Seminars, and Workshops

The most important conferences of the ICIPE has become the Annual Research Conference, at which the whole ICIPE scientific community, members of the Board, and members of the advisory committee have multidisciplinary discussions, review the research progress of the year coming to close, and establish new lines of concentrated research. These conferences have proved seminal, and will be retained as an institutional mechanism for monitoring ICIPE research activities.

As the ICIPE has established its research programmes, they have become able to contribute significantly to conferences dealing with relevant aspects of the ICIPE concerns. In the last two years, the ICIPE has been a major participant of the Bellagio Conference on "Parasite-Vector Relationships with Particular Reference to the Tsetse-fly" (June 1972), the biennial conference of the Specialist Entomological and Insecticide Committee (September 1972), conference on "The Host Plant in Relation to Insect Behaviour and Reproduction" at Tihany, Hungary (June 1974), conference on "Sterility Principles for Insect Control" at Innsbruck, Austria (July 1974), the Seventh International Symposium on Comparative Endocrinology at Tsavo National Park, Kenya (July 1974), the Annual Livestock Conference at Dar-es-Salaam, Tanzania (December 1974), and the FAO/WHO Joint Meeting of Investigators on the Immunology of East Coast Fever at EAVRO, Muguga Kenya (December 1974). These conferences are important vehicles for an exchange of ideas, and for sharpening the focus of ICIPE programmes.

Weekly seminars on specialized topics have been a feature of ICIPE scientific life from the very beginning. Scientists from Nairobi and its environs are invited to these seminars, and they have become an essential means for constantly reviewing the work of this multidisciplinary institute.

Together with the AAASA, the ICIPE has planned a series of annual specialized workshops on the general theme of "Progress in Insect Control in Africa". The first will be convened in Nairobi in September 1975. About 10 fundamentally-oriented scientists will meet with a similar number of field-oriented workers to examine in depth the progress in any particular line of pest problems. In the next few years, it is hoped that we will, in this way, critically review the progress that is being made - in research and pest control - of tsetse flies, ECF ticks, the sorghum shootfly, and termite termites, among others. The critical reviews, and the detailed discussions that will be going on among this expert conference participants, will be summarized and published for a wider public.
In the case of the African Armyworm programme, which was planned from the start to be a cooperative project with the EAAFRO and the Centre for Overseas Pest Research in London, the most immediate need was for a "Study Workshop" to review progress and apportion future priorities. The first of them will be held in January 1975 in Nairobi, attended by 20-30 scientists and agricultural officers from 10 countries affected by this and closely related pests.

4. Liaison with Other Institutes

The ICIPE has, already, developed an extensive network of liaison with various research institutes - both in Africa and abroad. These linkages can broadly be categorized as follows:

1. Liaison with the home laboratories of the ICIPE Directors of Research.

2. Liaison with research institutes abroad that are able to give specialized assistance in techniques, for instance, that are not available in the ICIPE or in the laboratories of the Directors of Research.

3. Liaison with applied research institutes in Africa and elsewhere for collaborative work on ICIPE target insects. The agreement with EAVRO for tick research is the most formal arrangement so far concluded (see Appendix 4). But ICIPE already enjoys close working relations with the following institutions:

- EATRO, Tororo, Uganda
- Makerere University, Kampala, Uganda
- East African Virus Research Institute, Entebbe, Uganda
- Medical Research Centre, Nairobi, Kenya
- Ministry of Agriculture, Kenya
- Ministry of Tourism and Wildlife, Kenya
- EAAFRO, Muguga, Kenya
- University of Nairobi, Kenya
- National Museums of Kenya
- Coffee Research Foundation, Ruiru, Kenya
- University of Dar-es-Salaam, Tanzania
- Tropical Pesticides Research Institute, Arusha, Tanzania
- East African Institute for Malaria and Vector-borne Diseases, Amani, Tanzania
- National Council for Scientific Research, Lusaka, Zambia
- University of Ibadan, Nigeria
- Institute of Pathobiology, Addis Ababa, Ethiopia
- Tsetse Research Laboratory, University of Bristol, England
- Centre for Overseas Pest Research, London, England
- WHO Aedes Research Unit in West Africa
- WHO Aedes Research Unit in New Delhi, India
4. Liaison with the international agricultural research centres involved in food production problems. Especially close relations have already been established with IITA, CIMMYT, ICRISAT and ILRAD. These links will be intensified as the ICIPE programmes become more established, and they will be widened to include many other institutions concerned with the priority objectives of the ICIPE.
X. LIBRARY AND DOCUMENTATION

Thanks to the generosity of the Netherlands Government, the Swiss Academy of Natural Sciences, the British Council, and the ODM over the last 18 months, the ICIPE has now accumulated 400 volumes on insect science and is subscribing to 52 periodicals relevant to ICIPE programmes. The Library has only been established recently because of the acute lack of books and journals in the Nairobi area dealing with insect science. The ICIPE Reference Library was therefore established early in 1974 to close this gap. However, we are continuing with our present reciprocal arrangements with the University of Nairobi, the Medical Research Centre in Nairobi, and the EAAFRO-EAVRO Library at Muguga. The ICIPE has recently engaged a professional librarian, who is planning a more expanded library and documentation service.

There are tentative plans for the ICIPE to document the scientific literature on those target insects on which the ICIPE is working, similar to the ODA-supported documentation now being undertaken by the University of Salford (England) for trypanosomiasis. There are presently no such periodic documentation for armyworm, shootfly, termites, and ECF tick. Such a service will be an invaluable tool for all research workers in these fields. It is not proposed that this documentation programme be started before 1979, when new library accommodation will have become available and when the library acquisition will have been greatly expanded as a base for such an initiative.
XI. COMMUNICATION AND INFORMATION

The Communication and Information service has been established to sub-serve the following functions:

1. To develop regular communication channels which will keep the relevant institutes and programmes in close touch with the work at the ICIPE. These channels include the production of the Annual Report, the first of which was published for the ICIPE work up to July 1973, publication of a regular newsletter, the issue of other information documents as occasion demands, and visits.

2. To provide an editorial service for all ICIPE staff.

3. To provide artistic and graphic expert assistance for all activities of the Centre.

4. To supervise all printing and production of ICIPE materials, and consider providing these facilities within the ICIPE if this step leads to more efficiency and lower costs.

5. To provide an information service for all visitors to the Centre.

Experience over the last two years has abundantly shown the importance of this facility. Therefore, adequate provision has been made in the budget for an experienced Communications Officer having a strong background in science, who will be supported by a small staff of editor, translator (especially English/French/German), publications officer, photographer, graphic, artist, and printer. Printing by the litho-offset method is both cheap and convenient, while retaining a high standard of presentation. We estimate that capital expenditures in printing will be recovered within 2 - 3 years from savings from the high cost of commercial printing, apart from convenience and control aspects.

This development, including the capital funds required, will be phased over a period of time (three years). But the Communications Officer will be needed in early 1976.
XII. MANAGEMENT AND ADMINISTRATION

The chief mandate of the ICIPE is research; the arrangements that have been developed for the management and administration of the ICIPE are those that are thought best suited to support this mandate and to guarantee its success.

1. Organization and Management

The highest policy and management body of the ICIPE is the Governing Board, which is formally appointed by the Annual General Meeting of members of the ICIPE company (Appendix 1). The statutes allow a membership of 20, but the present Board has a membership of 10 for reasons of economic stringency. Governors normally serve for a period of three years, and they are broadly selected on the basis of their leadership and expertise in scientific research, science policy management, financial management, and on a broad geographical base (including three members from Africa). The Board is aware that its composition must be wider, and include leaders in agriculture and world economy.

In order to carry out its responsibilities, the Board is required by ICIPE statutes to meet at least once a year, although in fact it has been meeting more often than that during this early formative stage. It also appoints special committees from time to time to undertake special tasks; and since September 1974 it has a small Executive Committee to take care of much of the detailed business of the Board between meetings.

The Board has three advisory and consultative committees to assist it in reaching decisions on ICIPE business:

1. African Committee;
2. International Committee; and

They have already been described previously (Chapter IV, Section 2). There is some overlap in the work of these committees, which were set up because of the needs felt at the time. As it happens, the three committees will be having joint sessions during the annual meetings of the ICIPE in June 1975; and it is possible that a new rearrangement may well emerge.

2. Administration

The Administration of the Centre includes the Director (who is responsible to the Board for the management of the Centre and is also the chief scientist), assisted by the Deputy Director for Science (who is responsible for coordinating the research programmes, and provides
overall guidance for the research facilities and support services). There are also three senior management staff: the Administrative Manager (responsible for administrative routine, personnel matters, secretarial service, and general services), the Financial Manager (in charge of the finance department), and a senior staff officer (responsible for public relations work, liaison in Africa, and similar matters).

The senior staff are supported by one administrative assistant, 2 bookkeepers, and 6 secretarial staff at present. It is planned to increase this number to 3, 4 and 7, respectively, by 1978. In summary, it can be stated that the administrative staff is small.
The application to the CGIAR is based on the case that has been made in the earlier chapters. The actual budgetary proposals are founded on two principles:

1. That funds under the CGIAR umbrella should only be sought for the core research programmes, capital development, and the means to provide supporting services, facilities, and administration.

2. That the special projects should be funded from special funds negotiated by the ICIPE with various donors (including the national academies, national science foundations, the International Foundation for Science, private foundations, universities, and other agencies).

In terms of research institutes, the ICIPE is a medium-sized operation, with a total projected scientific manpower (including those under contractual programmes, and those working as longer-term visiting scientists) of about 60 principal scientists and 30 experimental officers. In terms of insect research institutes in particular, it will be one of the largest, and planned to have excellent chances of making important breakthroughs that will be critical to pest management programmes.

The budgetary estimates have been worked out in such a way that the request for 1976 will (a) give the ICIPE bridging finance to strengthen some of the bases of the core research programmes, but (b) mainly it will provide the necessary finance to permit detailed planning for capital development and make a start on actual building operations. The estimate for the period 1977 - 1981 give a picture of gradually phased growth of the physical facilities of the ICIPE and the period during which all the core programmes reach their optimal operational level.

Tables 1 - 4 give details of the budgetary estimates that will be directed to the CGIAR, while Table 5 gives a summary of these proposals. Tables 6, 7, and 8 analyse the budgets and projections by programme and activity, by man-years and organizational unit and by object of expenditure.

Details of the budgetary estimates for special projects are not given; but a summary of present proposals are summarized in Appendix 11.
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Pans 20, (2) 229-233.

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J. Insect. Physiol. 20, 1015-1026

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WANYONYI, Kizito (1974)
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Some endocrinological aspects of pupal diapause in cyclorrhaphous Diptera.
Int. Congr. on Diptera, Brno, Czechoslovakia.
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## Table 2

### Research Support - Budget 1977 and Projections 1978 to 1981

( in thousands of US Dollars )

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### Projections

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1978: 522.2
1979: 504.0
1980: 516.9
1981: 558.8
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**Projections**

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  - 24
  - 630.4
  - 2
  - 233.9
  - 26
  - 1073.3
- **1979**
  - 163.9
  - 25
  - 711.6
  - 2
  - 295.9
  - 27
  - 1714.4
- **1980**
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  - 25
  - 742.7
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  - 27
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- **1981**
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### SUMMARY OF EXPENDITURE BUDGETS 1977 AND PROJECTIONS 1978 to 1981

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NOTES ON 1977 EXPENDITURE BUDGETS AND 1978-81 PROJECTIONS

1. Ancillary and Daily-Rated Staff

This staff, whereas large in number, represents a proportionally smaller cost, and has been excluded from the staff numbers so as not to distort the figures. The rate for Daily-Rated Staff is laid down by Government Order and is expected to rise to about K. Shs 15/- per day by 1st January 1977. In 1977 the number of Ancillary and Daily-Rated Staff would be 94.

2. Salary Scale

The Scales are worked out to include basic salary, subsidized housing or housing allowance in lieu, 20% gratuity or retirement benefit scheme, a small travel allowance for annual leave taken in Kenya, medical insurance, workmen compensation insurance, and/or personal accident insurance, and in the case of staff expected to be recruited internationally the cost of passages from/to home.

A 10% increase per year is built in the Scales.

3. Consultations

A consultation is expected to cost US $ 3,430 and would include the consultants' travel, hotel accommodation, and a small supplement for incidental expenses.

No emoluments to the consultant for his time is included.

In the Administration budget, consultations are provided for to enable a review of the accounting systems and establish a case for and feasibility of the computerization of the accounting and budgetary programmes.

4. Travel

The Travel Budget is comparatively large and is based on the travel costs of

(a) Ten Governors and 2 Advisors to at least two Board meetings per year.
(b) 17 Directors of Research to the ICPE Research Centre for supervisory scientific visits for 1 - 3 times a year depending on the circumstances of individual programmes.
(c) Each principal scientist to a Conference/Seminar/Study Workshop at least once in eighteen months.
(d) African Committee meetings
(e) Five members of the International Committee who might not be able to meet the costs of attendance at the annual committee meetings.
(f) Ten members of the Policy Advisory Committee to attend their annual meeting.
(g) The Executive Committee which is expected to consider ICIPE policy and management matters in between Board meetings.
(i) The Director and the Deputy Directors' travel to various international centres, meetings, and conferences.

5. Equipment

In the core Programmes and Support Services "equipment" is comprised of vehicles and scientific equipment. In the Library/Communication Services it consists of library shelving, printing machine, collator, binder, etc.

The ICIPE provides office furniture and equipment as a central service. The budget for these requirements are therefore included in the equipment budget of Management and Administration.

Computer cost has not been budgetted for at this stage.

6. Provision for Price Change

The provision is calculated on a 15% flat rate per year on costs other than personnel. Personnel costs have a 10% annual increase already built into the salary scales.

7. Proportionate Division of Costs

The percentages are shown on Table 5, and are repeated here

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<td>By Object of Expenditure</td>
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As a percentage, the Management and Administration Budget looks very high. But it should be noted that this budget includes the following items:

(a) Office Furniture/Equipment for all programmes and services (The purely Management and Administration portion = US $25,500)
(b) Computer consultancy (US $10,290)
(c) Travel and meeting costs of the Governing Board and Committees. These could have been allocated alternatively to the Conferences vote (US $159,000).

If these costs are excluded from the Management and Administration budget, the balance would represent 17.5% of the total.

The travel budget also appears high as a percentage and can be explained at (4) above.
| TABLE 6 |

**SUMMARY OF BUDGETS AND PROJECTIONS BY PROGRAMME AND ACTIVITY 1976 - 1981**

| US $ Thousands |

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**NOTES TO: CAPITAL DEVELOPMENT BUDGET**

**Buildings and Development at Chiromo**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Laboratories to replace two temporary buildings at present occupied as Laboratories</td>
<td>1000</td>
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<tr>
<td>Training - Laboratory</td>
<td>150</td>
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<tr>
<td>Rooms to accommodate small discussion groups</td>
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<tr>
<td>Library to accommodate up to 50 readers at a time, 4 staff, shelving area for 30000 volumes and storage</td>
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<tr>
<td>Seminar/Conference Room to accommodate 150 participants, projection room and translation booth</td>
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<tr>
<td>Workshops - Metal Workshop, Carpentry, and Electronic Workshop</td>
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<tr>
<td>Stores - Chemicals, Laboratory Supplies, Equipment, Workshop Consumables, and other Consumables</td>
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<tr>
<td>Experimental Breeding - to replace present insectary in temporary building which now needs to be demolished</td>
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<td>Printing - Machine Room, Photography room, Storage room, Offices for Communications Officer, Information Officer, Printer and Scientific typing pool (4 Secretaries)</td>
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<tr>
<td>Finance &amp; Accounts - Offices to enable Finance Division to be moved from present accommodation to release space for Fine Structure Laboratories - Finance Managers Office, Accountants Office, Account Office, Registry, and Secretary's Office</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>4370</td>
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<tr>
<td><strong>Add: 60% for Circulating area, Services, Corridors, Staircases etc.</strong></td>
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<tr>
<td><strong>TOTAL Sq. meters (Say 7000)</strong></td>
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</table>
Cost @ K£150 per sq. m. (inclusive of Fees and fixed fixtures) 3,000,000

Master Planning and Landscaping of Chiromo site 15,000

Water Tank: 6 days Water Supply to overcome shortages and pressure fluctuations 90,000

Standby Generator to meet emergency power requirements during interruptions of power supply 45,000

Telephone PABX 10,000

Total Chiromo 3,160,000

Buildings and Development - Langata

Kenya Government has allocated to ICIPE 10 acres of land on the verge of Nairobi in the Langata Forest Area. It is proposed to site on this land the Insect and Animal Breeding Unit and to provide training accommodation and staff housing for technical staff.

Master planning 30,000
Site preparation and fencing 36,000
Insectary (including pathology rooms) 180,000
Large Animals - Stables, etc. 45,000
Small Animals Breeding Unit 15,000
Training Laboratory (including Common Room, Seminar Room and Canteen) 50,000
Hostel for Trainees 180,000
20-Seater Commuter Bus (Langata/Chiromo) 15,000
Water tower and borehole 90,000
Standby Generator 45,000
Housing for Technical/Ancillary Staff 210,000

TOTAL US $ 886,000
Field Stations

**Kajiado**

Space required for 10 Scientists, 3 Exp. Officers, 6 Technicians, 1 Admin. Staff, 1 Clerk/typist, and one visitor.

Land at Kajiado has been allocated to ICIPE by the Kenya Government

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (US $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fencing and Site Preparation</td>
<td>25,000</td>
</tr>
<tr>
<td>Laboratory, Office and Storage 800 sq. m. @ K£100</td>
<td>229,000</td>
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<tr>
<td>Two generators to provide 24-hour electric supply</td>
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<tr>
<td>Water tank and Borehole</td>
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<tr>
<td>Radio - telephone</td>
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<tr>
<td>Housing - 14 Senior @ K£5000</td>
<td>7 Junior @ K£3500</td>
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<tr>
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<td>270,000</td>
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<tr>
<td><strong>TOTAL US $</strong></td>
<td><strong>709,000</strong></td>
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</table>

**Kibos**

Land needs to be obtained, and it is hoped to acquire this free from the Kenya Government.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (US $)</th>
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</thead>
<tbody>
<tr>
<td>Site Preparation and fencing</td>
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<tr>
<td>Laboratory Office and Storage 150 sq. m. @ K£100</td>
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<td>Standby generator (small)</td>
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<td>Water tank &amp; piping</td>
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<tr>
<td>Radio-telephone</td>
<td>10,000</td>
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<tr>
<td>Staff Housing 2 Senior @ K£5000</td>
<td>2 Junior @ K£3500</td>
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<tr>
<td></td>
<td>49,000</td>
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<tr>
<td></td>
<td>150,000</td>
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</table>
Clerk of Works

A professional Clerk of Works is required to supervise the building and development plans 3 years @ 20,000 US $

60,000

Riverside Drive House

This property has been purchased to provide offices and accommodation for Visiting Scientists and Directors of Research

52,000

Rotating Loan Fund

ICPE does not provide vehicles to the Scientists. On appointment, Scientists and Senior Administrators need loans to enable them to purchase vehicles for social and other activities.

A Rotating Loan Fund needs to be set up to provide this facility:

40,000
### Summary of Sources of Funds for ICIPE Activities, 1970 - 1976

**Grants**

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<th>7.7-7.73</th>
<th>7.7-7.74</th>
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<th>1.7-7.75</th>
<th>1.7-7.76</th>
<th>1.7-7.76</th>
<th>Pledges</th>
<th>Total</th>
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**Total Expenditure**

- **12226**
- **104724**
- **216964**
- **415385**
- **1153791**
- **1904060**
- **1519355**
- **193574**
- **551202**
- **3163711**
- **504501**

**Surplus/(Deficit) - Year**

- **488**
- **6537**
- **113514**
- **350915**
- **22236**
- **178588**
- **160602**
- **169285**
- **3059415**
- **1225**

**Cumulative**

- **7025**
- **106489**
- **487414**
- **518676**
- **504501**
- **504501**
- **504501**
- **504501**
### Summary of CIPE Budgets for the Period 1970 - 1976

#### EXPENDITURE

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<td>1.7.71 to 30.6.72</td>
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<td><strong>Library Equipment &amp; Books</strong></td>
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<td><strong>Price Changes</strong></td>
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<td><strong>Provision for Price Changes</strong></td>
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<td><strong>TOTAL EXPENDITURE $</strong></td>
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## SPECIAL PROJECTS ESTIMATES

(US $ Thousands)

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<tr>
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<td>ManYears</td>
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<td>ManYears</td>
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<td>2. Grassland Termites in Tropical Savannah</td>
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<th>Personnel Costs</th>
<th>Consultations</th>
<th>Travel</th>
<th>Supplies &amp; Expenses</th>
<th>Equipment</th>
<th>Vehicles</th>
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(1) and (3) Donors to be identified
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