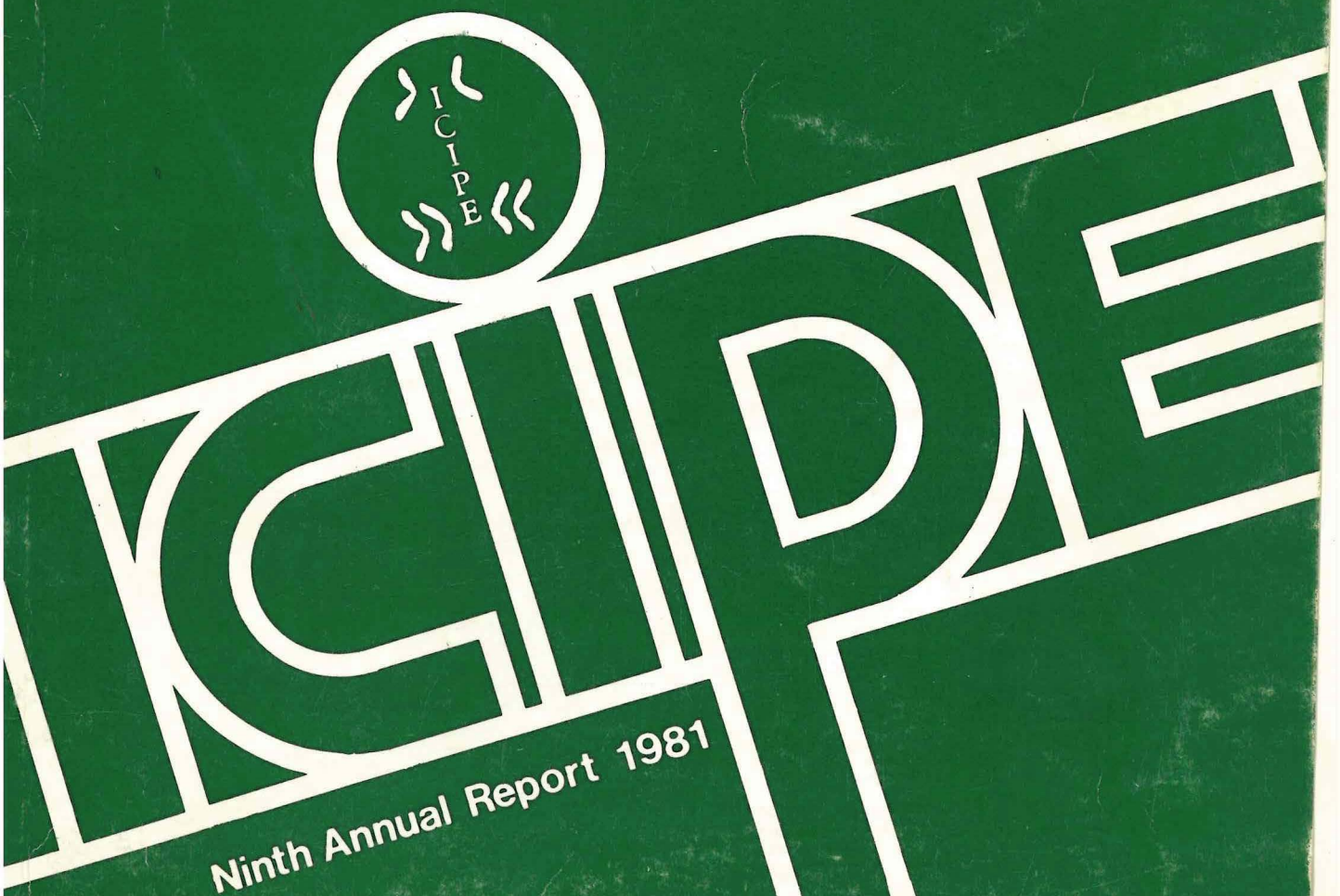
THE INTERNATIONAL CENTRE OF INSECT PHYSIOLOGY AND ECOLOGY



Ninth Annual Report 1981

MANAGER'S SAMPLE COPY

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THE INTERNATIONAL CENTRE OF INSECT PHYSIOLOGY AND ECOLOGY

NINTH ANNUAL REPORT 1981

Nairobi, October 1982

ICIPE GOVERNING BOARD, MARCH 1981

1982 RETIREMENT CLASS (April 1982)

Professor R. Galun	1979	(C, I)
Professor M. Kassas	1979	(C, I)
Professor K. Prewitt	1979	(C, I)
Professor A. Semb-Johansson	1979	(F, I)
Dr. F. J. Wang'ati	1979	(K, I)

1973 RETIREMENT CLASS (April 1983)

Professor H. Brooks	1977	(F, II)
Professor Guy Camus	1977	(C, II)
Mr. Peter Nderu	1977	(K, II)
Dr. T. K. Arap Siongok	1977	(K, II)
Dr. O. M. Solandt	1977	(C, II)

1984 RETIREMENT CLASS (April 1984)

Professor L. K. H. Goma	1981	(C, I)
Dr. Peter T. Haskell	1981	(F, I)
Professor John H. Law	1981	(F, I)
Mr. R. B. Stedman	1978	(C, II)

1985 RETIREMENT CLASS (April 1985)

Professor Dr. Heinrich C. Weltzien	1982	(C, I)

Notes:
- I First 3-year tenure
- II Second (and final) 3-year tenure
- C ICIPE company nominee
- F ICIPE foundation nominee
- K Host country nominee

STAFF LIST

SCIENTIFIC AND TECHNICAL STAFF RESEARCH PROGRAMMES

BASES OF PLANT RESISTANCE TO INSECT ATTACK

Dr. Z. T. Dabrowski, Programme Leader
Dr. R. C. Saxena, Senior Research Scientist
Dr. R. S. Ochieng', Research Scientist
Mr. G. T. Masina, Graduate Research Scholar
Dr. C. McFoy, Postdoctoral Research Fellow
Mr. E. O. Nyangiri, Senior Technician
Mr. S. H. Okech, Senior Technician
Mr. F. O. Onyango, Technician
Miss A. Ragot, Technical Assistant
Mr. E. L. Kidiavai, Junior Technician
Mr. E. O. Omolo, Agronomist
Mr. M. D. O. Bungu, Junior Technician
Mr. E. O. Arigi, Technician
Mr. P. E. W. Njoroge, Junior Technician

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Dr. K. V. Seshu Reddy, Senior Research Scientist
Dr. G. C. Unnithan, Research Scientist
Mr. A. G. L. Delobel, Research Scientist
Mr. K. Ogwaro, Research Scientist
Mr. J. B. Okeyo-Owuor, Associate Scientific Officer
Mr. J. J. Njokah, Associate Scientific Officer
Mr. J. C. Olela, Principal Technician
Mr. K. E. Kidega, Senior Technician
Mr. S. M. Othieno, Technician
Mr. G. O. Amala, Technical Assistant
Mr. C. O. Jacomito-Simbi, Technician
Mr. Philomen O. Agwaro, Junior Technician
Mr. J. G. Kibuka, Technical Assistant
Mr. M. Lubega, Technician
Mr. D. B. Mathenge, Technician
Dr. B. Amoako-Atta, Research Associate
Dr. A. K. Raina, Research Scientist
Dr. Dang Thahn Ho, Postdoctoral Research Fellow
Dr. J. B. Suh, Postdoctoral Research Fellow
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Mr. P. O. Ollimo, Technician
Mr. M. O. Arwa, Technical Assistant
Mr. P. W. Agina, Technical Assistant

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Dr. L. H. Otieno, Senior Research Scientist
Dr. M. F. B. Chaudhury, Senior Research Scientist
Dr. M.B.A. Nyindo, Senior Research Scientist
Dr. T. K. Golder, Research Scientist
Dr. F. Snow, Senior Research Scientist
Dr. D. A. Turner, Senior Research Scientist
Dr. (Mrs). M. S. Ramasamy, Research Scientist
Philip Onyango, Senior Technician
Mrs. M. Owaga, Scientific Officer
Mr. T. S. Dhadialla, Scientific Officer
Mr. Erasmus I. Onweluzo, Graduate Research Scholar
Mr. J. Kawooya, Postgraduate Trainee
Miss N. F. Darji, Research Assistant
Mrs. R. W. Kunyiha, Research Assistant
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Miss R. Chesang, Junior Technician
Mr. D. Uvyu, Junior Technician
Mr. D. K. Mungai, Technical Assistant/ Driver
Mr. R. Mutuaruhiu, Junior Technician
Mr. J. Likhanga, Junior Technician
Mr. J. M. Muchiri, Technical Assistant/ Driver
Mr. J. A. Makau, Technical Assistant
Dr. G. P. Kaaya, Research Scientist
Mr. J. K. Kiilu, Technical Assistant
Mr. P. O. Agutu, Senior Technician
Mr. J. Apale, Technician
Mr. F. Mkunza, Junior Technician
Mr. James A. Atema, Junior Technician

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Dr. J. P. Darlington, Research Scientist
Dr. G. W. Oloo, Research Scientist
Dr. B. M. Okot-Kotber, Research Scientist
Dr. T. O. Oloya, Postdoctoral Research Fellow
Dr. D. A. Ruyooka, Research Scientist
Dr. Robert Sieber, Research Scientist
Dr. T. Abe, Research Associate
Mr. G. N. H. Nyamasyo, Graduate Research Scholar
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Mrs. N. M. Baraza, Technician
Mr. M. O. Kotengo, Junior Technician
Mr. P. O. Amoke, Technical Assistant
Mr. E. Nyandat, Junior Technician
Mr. P. Muteria, Technical Assistant
Miss G. M. Wanjiru, Technical Assistant

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Mr. J. G. Yarro, Graduate Research Scholar

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Mr. D. Punyua, Scientific Officer
Dr. (Miss) G. M. Binta, Associate Scientific Officer
Mr. J. Kilori, Technician
Mr. A. Mongi, Postgraduate Trainee
Mr. A. Chiera, Research Assistant
Mr. J. Ojowa, Junior Technician
Mr. G. T. Thuo, Technical Assistant
Mr. J. Mugane, Technical Assistant
Mr. G. M. Hindi, Subordinate Assistant
Mr. K. C. Wainaina, Subordinate Assistant
Mr. A. Bwire, Technician

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Dr. W. A. Otieno, Research Scientist
Dr. F. W. Mosha, Research Scientist
Dr. M. J. Mutinga, Senior Research Scientist
Dr. J. B. Kaddu, Research Scientist
Dr. Maurice Odindo, Postdoctoral Research Fellow
Mrs. Lucy M. Rogo, Graduate Research Scholar
Miss D. Sabwa, Graduate Research Scholar
Miss Lucy Irungu, Graduate Research Scholar
Mr. P. Mwamisi, Junior Technician
Mr. S. Muti, Junior Technician
Mr. E. Mkuzi, Technical Assistant
Mr. J. Mwandandu, Technical Assistant
Mr. J. A. Otieno, Junior Technician
Mr. M. C. Ngumah, Junior Technician
Mr. R. C. Odhiambo, Junior Technician
Mr. M. P. Nyamori, Senior Technician
Mr. D. M. Omogo, Technical Assistant
Mr. F. M. Kyai, Technical Assistant
Mr. C. M. Mutero, Postgraduate Research Scholar
Mr. P. Amuttala, Technical Assistant/Driver
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SCIENTIFIC AND TECHNICAL STAFF RESEARCH UNITS

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Mr. E. W. Osir, Graduate Research Scholar
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Mr. P. Lisamulla, Principal Technician
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Dr. (Mrs) R. S. Awiti, Postdoctoral Research Fellow

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Mr. B. O. S. Ogal, Technical Assistant
Mr. R. Okello, Technical Assistant
Mr. G. M. Ng'ang'a, Technical Assistant

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Mrs. S. W. Mwanycky, Associate Editor

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Miss M. Wafula, Secretary
Mrs. M. Olutatwa, Secretary
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Mr. D. Odhiambo Aoko, Messenger
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Mr. S. K. Langat, Driver

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Mr. W. O. Ogallo, Planning Officer
Mr. V. S. Mutisya, Internal Auditor

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Mr. C. M. Oloo, Supplies Assistant
Mrs. L. Kimani, Accounts Assistant
Mr. F. Otieno, Messenger

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Mrs. T. Lohay, Secretary
Mrs. M. Antao, Secretary
Mrs. G. Wasike, Secretary
Mrs. R. Okoth, Assistant Secretary
Miss R. Vugaba, Secretary
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Mr. R. Nyaridi, Messenger
Mr. L. Kisutia, Cleaner
Miss S. Christopher, Cleaner/Tea Maker
Mr. C. Otieno, Messenger
Miss E. Afandi, Assistant Secretary

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Mr. S. Akhaya, Assistant Janitor
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Mr. L. Okong'o, Watchman
Mr. W. W. Achiroma, Watchman
Mr. E. K. Shilengo, Watchman
Mr. A. M. Ouma, Watchman
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Mr. J. Elegwa, Gardening Assistant
Mr. A. M. Bubusi, Cleaner
Mr. D. Chege, Cleaner
Mr. E. Asami, Cleaner
Mr. J. A. Onyango, Watchman
Mr. Z. O. Nyandere, Watchman
Mr. D. O. Singa, Watchman
Mr. A. O. Ogaja, Watchman
Mr. J. K. Opere, Watchman
Mr. M. M. Ogolla, Watchman
Mr. A. N. Makori, Watchman
Mr. J. D. Nyawalo, Watchman
Mr. R. K. Milgo, Watchman
Mr. A. Muyanda, Watchman
Mr. C. O. Okello, Gardener

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Mr. S. Karanja, Senior Technician
Mr. J. M. Maina, Technician
Mr. J. N. Mtei, Technician
Mr. H. Gichinga, Technician
Mr. J. N. Musisi, Maintenance Engineer

Mr. J. O. Onyango, Plumber/Mason
Mr. B. Omulo, Junior Technician
Mr. K. Kibe, Technical Assistant
Mr. J. Omondi, Technical Assistant
Mr. P. Oluya, Junior Technician/Glass Blower
Mr. E. N. Nyoike, Junior Technician/ Glass Blower
Mr. S. O. Obiero, Technician

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Mr. G. M. Kinyanjui, Driver
Mr. E. W. Muchiri, Technical Assistant Driver
Mr. F. Ombija, Senior Mechanic
Mr. F. O. Hamala, Mechanic/Driver
Mr. B. Oyondi, Driver
Mr. J. K. Maina, Technical Assistant/ Driver
Mr. R. B. Gathu, Technical Assistant/ Driver
Mr. P. Mahogo, Senior Driver
Miss E. N. Mwangi, Driver
Mr. J. G. Mahinda, Driver
Mr. A. Orina, Mechanic/Driver

LABORATORY MANAGEMENT

Mr. E. E. Muro, Engineer & Controller for Laboratory Services

FIELD STATIONS

MBITA POINT FIELD STATION

Mr. J. F. Omange, Senior Administrative Officer
Mr. B. S. K. Masyanga, Farm Controller
Mr. F. K. Ongola, Assistant Accountant
Mr. J. O. Angado, Maintenance Engineer
Mrs. M. N. Okach, Assistant Secretary
Mr. H. Purcell, Project Manager
Mr. E. Sonye, Watchman
Mr. S. O. Aol, Watchman
Mr. D. Oyoto, Watchman
Mr. G. N. Harshe, Site Engineer II
Mr. R. C. Joshi. Site Engineer I
Mr. J. O. Ohato, Mechanic/Driver
Mr. P. Mbuya, Driver
Mr. B. Mogendi, Watchman
Mr. J. N. Asanyo, Mechanic/Driver
Mr. P. O. Ouma, Farm Assistant
Mr. N. M. Sangura, Farm Assistant
Mr. P. O. Auta, Farm Assistant
Mr. J. Sagini, Farm Assistant
Mr. Wolukau, Technician

MBITA POINT INTERNATIONAL SCHOOL

Mrs. P. A. Ogada, Principal
Mr. F. O. Omolo, Teacher
Mrs. C. O. Ndiege, Teacher
Mrs. S. A. Omune, Cleaner

KAJIADO FIELD STATION

Mr. J. M. Ole Kobaai, Watchman

COASTAL FIELD STATION – MOMBASA

Mr. M. M. Moinde, Senior Administrative Officer
Mrs. C. Rarieya, Assistant Secretary
Mr. P. O. Ngugi, Senior Accounts Clerk
Mr. J. B. Kariuki, Mechanical/Driver
Mr. S. Abdalla, Watchman
Mr. S. Wanjohi, Cleaner
Mr. L. O. Odongo, Technical Assistant/ Driver
Mr. S. M. Kibati, Security Assistant
Mr. E. M. Sowah, Driver

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Mr. J. E. Mwangi, Head Cook
Mr. A. I. Okapesi, Assistant Head Cook
Mrs. J. A. Musiga, Housekeeper
Mr. P. H. Opondo, Kitchen Assistant
Mr. B. O. Randiga, Assistant Launder
Mr. A. M. Mutwoli, Room Steward
Miss S. M. Kagondu, Secretary
Mrs. E. Kwach, Telephonist/Receptionist
Mr. C. B. Oyieyo, Room Steward
Mr. A. Lweya, Cook

Mr. H. M. Kibisu, Assistant Launder
Mr. G. Gichuru, Kitchen Assistant
Mr. A. E. Mulae, Room Steward
Mr. Omutimu, Room Steward

SENIOR MANAGEMENT STAFF

Professor Thomas R. Odhiambo, Director

Mr. J. M. Ojal, Manager for Communication Systems
Professor A. S. Tahori, Deputy Director (Research)
Mr. L. Z. Mosha, Financial Manager

CONTENTS

SCIENTIFIC DEVELOPMENT: THE TRIAL OF THE ICIPE COMMUNITY

Last year, in commenting on the Centre's Scientific Development: Planning for the Future, I was able to confidently state that, ". . . our preeminent goal in the first decade of ICIPE's existence has now been accomplished — that of establishing a critical mass of talented, highly motivated, interacting scientific community at the ICIPE all cooperatively targeted on a few, carefully selected pest management goals, collaborating productively with the wider scientific and practitioner community in Africa and other tropical regions, and concentrating on the major pest problems of its constituency. The next phase for us now seems to be one of giving this ICIPE scientific community the means to accomplish its mandate on a continuing and rationalised basis." These sentiments could not have experienced a more searching test than what the Centre went through in the year 1981.

Stemming from the worldwide economic recession, the ICIPE experienced the most acute financial situation that it has ever undergone in its eleven years of existence. This situation tested the institute as a whole to the very core. It is a testament to the resilience of the entire ICIPE community that, in spite of the very reduced circumstances, the scientific work and its quality continued unabated. The pioneering spirit is virile, the staff morale is high, the Governing Board has exhibited an exceptional concern and responsibility, and the ICIPE donors have shown a tenacious faith in the ICIPE.

The traditional donors of the ICIPE have, since November 1980, established an informal platform, a sort of consortium, which enables them to review ICIPE's performance and progress, and the support it needs to accomplish its tasks, in a more regular manner than was possible to do before. This group — the sponsoring group for the ICIPE (SGI) — presently consists of the United Nations Development Programme (UNDP), the Food and Agriculture Organization of the United Nations (FAO), the International Fund for International Development (IFAD), the World Bank, The OPEC Fund for International Development, the U. S. Agency for International Development (USAID), and the International Aid Agencies of Australia, Sweden, Norway, Denmark, the Netherlands, France, Switzerland, the Federal Republic of Germany, the United Kingdom, and Belgium, as well as the host country — Kenya. The SGI met formally in Paris (May 1981) and Washington, D. C. (November 1981) at which time it set in motion a detailed examination of the programme and needs of the ICIPE over the medium-term perspective. This would form a basis of a continuing scheme for the support of the Centre.

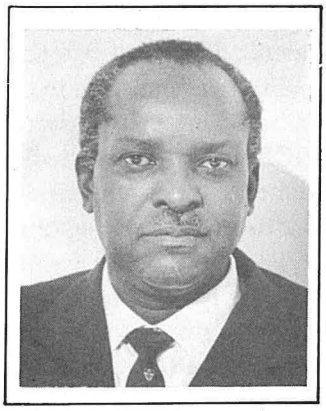
One important point that has emerged from a reappraisal of the ICIPE programme during the year 1981 is that the most crucial target of its research effort is the satisfaction of the resource-poor farmer in Africa and other tropical regions in his pest management needs. We are therefore reassessing all of our research activities to ensure that their goals will correspond closely with these needs, and that research training we are undertaking for Africa are such that it will strengthen the national programmes in this critical area.

Thomas R. Odhiambo
Director, ICIPE

14th August 1982

PROFILES

J. M. OJAL

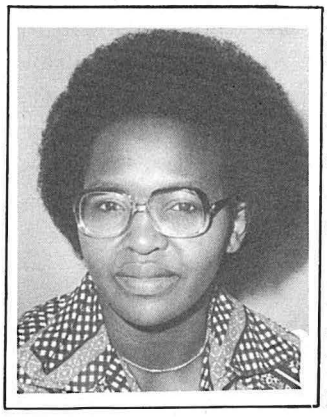


Mr. Ojal, Manager for Communication Systems, heads all the communication activities of the Centre that include Training, Library and Documentation, Communication and Information, Public Relations and Visitor Service. Mr. Ojal is by training a geologist, a botanist and a geographer and has had a distinguished public service career in Kenya, notably as a science teacher in a number of the reputable schools in the country.

Mr. Ojal has been associated with the ICIPE since 1970 when he was a member of the ICIPE Company and Governing Board. He was then the Permanent Secretary in the Ministry of Natural Resources.

In March 1972, Mr. Ojal joined the staff of the ICIPE as the Centre's Chief Administrative Officer. His position was later changed to that of Deputy Director (Administration). When the position of Administrative Manager, Deputy Director (Research) and Financial Manager were established, Mr. Ojal became the Manager for Communication Systems.

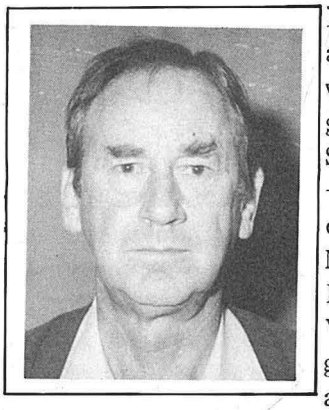
E. D. KOKWARO



Dr (Mrs) Kokwaro heads the Histology and Fine Structure Research Unit at the ICIPE. She was educated at the University of Nairobi where she obtained her Ph.D. in Entomology; the topic for her thesis being "Oocyte Development in the Fleshfly, *Sarcophaga tibialis*". She later received advanced training in Fine Structure and Cytochemistry at the Karolinska Institute in Stockholm, Sweden and at the Institut de Biologie Moleculaire in Paris.

Dr. Kokwaro is also involved in the teaching of insect developmental biology, histological techniques and electron microscopy. She is a member of a number of scientific societies including membership to the African Association of Insect Scientists.

M. P. CUNNINGHAM



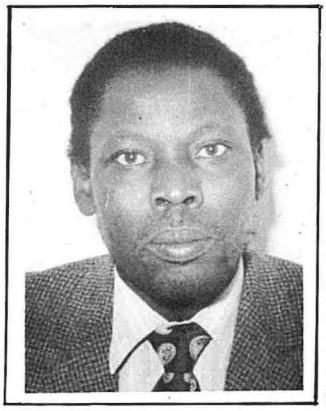
Dr. Cunningham attended the University of Glasgow Veterinary School from 1947 — 1952, where he qualified as a Member of the Royal College of Veterinary Surgeons. His first appointment was with the University of Glasgow Veterinary School where he taught and conducted research on Bovine paratuberculosis and Canine leptospirosis. He also participated in the development of a vaccine for cattle against *Dictyocaulus viviparus*.

From 1958 to 1967 he worked for the East African Trypanosomiasis Research Organization at Tororo, Uganda. Some notable contributions resulting from his work at EATRO include establishment of a trypanosome bank, and the development of techniques for the diagnosis of the disease in animals.

As a Project Manager of the FAO/UNDP project on Tick Control in Kenya, he participated in the development of methods for immunization of cattle against ECF and identification of an ECF curative drug. He joined the ICIPE in 1977 as the

Programme Leader of the Livestock Ticks Research Programme

G. W. OLOO



Dr. Oloo, Programme Co-ordinator, Insect Pathology and Pest Management Programme (IPPM), obtained his first degree from the Department of Entomology and Environmental Sciences, Rutgers — The State University of New Jersey, USA in 1968. On his return, he served in the Entomology Section of the Ministry of Agriculture, Kenya. He carried out applied research on sugar cane pests for a period of six years leading to his Ph.D. degree in 1973. He joined the Grassland Termite Research Programme at the ICIPE in 1974, where he worked on the role of chemical communication in the coordination of foraging behaviour. He has recently been appointed the programme coordinator of the newly established IPPM Programme.

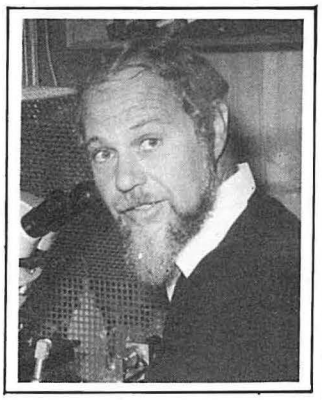
R. S. PATHAK

Dr. Pathak, Acting Programme Leader of the Crop Borers Research Programme joined the ICIPE in 1980. He obtained his Ph.D. degree in Genetics from the Punjab Agricultural University in 1968. He then joined the Hryana where he later headed the Cotton Breeding Section and taught in the Department of Plant Breeding.

From 1972 to 1980, Dr. Pathak worked in the Faculty of Agriculture, University of Nairobi. He is credited with starting the first Postgraduate Programme in Plant Breeding there.

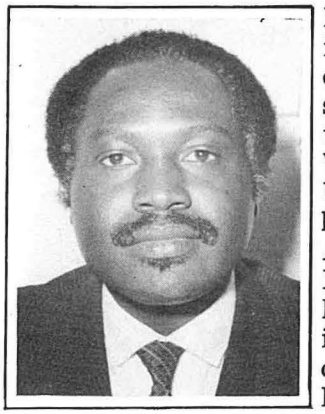
At the ICIPE Dr. Pathak is spearheading research on genetics of host plant resistance to insect pests in cowpea, sorghum, maize and rice.

C. J. DEN OTTER



Dr. Den Otter was born in Holland and received his M.Sc. (cum laude) in 1960 from the State University at Leiden, Holland and his Ph.D. in 1971 from the State University at Groningen, Holland. From 1960 to 1966, Dr. Den Otter taught Animal Physiology at the Leiden State University and built up and directed the Sensory Physiology Research Unit. In 1966 he was appointed the Head of the Sensory Physiology Research Group at the Department of Zoology, State University at Groningen. In 1974 he spent a sabbatical year at the Max Planck-Institute fur Verhaltensphysiologie at Seewiesen (Federal Republic of Germany) at the Laboratory of Professor Dietrich Schneidier. In January 1981, he was granted special leave to join the ICIPE as Head of the Sensory Physiology Research Unit.

L. O. ABE



Dr. Abe was born in Uganda. He received his university education in the USA at Washington State University where he obtained B.Sc. Agriculture, B.Sc. Entomology and M.Sc. Agronomy in 1971. He completed his Ph.D. studies at

TRAINING AT THE ICIPE

INTRODUCTION

Training continued along the same lines as in 1980. However, there were several new developments within the year which will now bring new dimensions into the ICIPE's approach to meet its goals of building capacity for mission-oriented research into pest management.

One of the major tasks of 1981 was continuation of review of the training programmes, which had been started in 1980. Part of this review resulted in the rationalized programmes which are reported below.

TRAINING PROGRAMMES

STAFF DEVELOPMENT TRAINING

As part of its strategy to strengthen its capacity, the ICIPE has evolved several approaches to meet its institutional goals.

Research Training. Several members of the scientific staff were involved in research training at the ICIPE or overseas. At least fifteen such staff undertook training at institutions in Canada, Australia, the Philippines, Sweden, Italy, the United Kingdom, Japan, the United States of America and the ICIPE itself.

Technical Training. As has been in the past, the ICIPE continued to support members of its technical staff in courses to upgrade their skills. This was done mainly at the Kenya Polytechnic. One staff, however, undertook a course at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Hyderabad, India.

Management Training. As a means of sharpening managerial skills, the ICIPE Management Staff also continued to receive advanced training in research management.

Training in Communication Skills. The secretarial staff continued to train in advanced secretarial courses at secretarial colleges in Nairobi.

PEST MANAGEMENT RESEARCH TRAINING

Postdoctoral Research Fellowships. At least 5 postdoctoral fellows were supported in 1981 in the following programmes: Crop-Borers Research, Bases of Plant Resistance to Insect Attack, Grassland Termite Research, Histology and Fine Structure Research.

The International Postgraduate Studies in Insect Science. As a means of rationalizing the ICIPE's input in high-level postgraduate training in pest management, the planning workshop convened in Bellagio, Italy, recommended the establishment of the African Regional Postgraduate Programme in Insect Science, (ARPPIS). The ARPPIS is intended to be collaborative with African universities. The ICIPE is to act as the managing agency and to offer coursework and research, while the universities are to award the degrees. The programme is expected to start in January 1983. The first intake is to consist of up to ten postgraduate trainees from the participating universities.

Under the ARPPIS, trainees are expected to undertake research in such areas as; ecology of arthropods of economic importance in agriculture and rural health, insect endocrinology, developmental and pheromonal biology, parasitology, insect pathology, bases of plant resistance to insect attack, insect behaviour, morphology and anatomy, biochemistry and natural products chemistry, toxicology, insect nutrition and mass-rearing, development of specialized bioassay techniques etc.

The programme will consider and admit postgraduate students with M.Sc. or graduates with good first degrees in biological sciences, entomology, biochemistry, agriculture, forestry, medicine or veterinary science.

Professor Mutamad Ahmed Amin, Professor of Medicine, University of Khartoum and Director, Regional Ministry of Health and Social Welfare, Sudan signs the agreement for the establishment of the African Regional Postgraduate Programme in Insect Science (ARPPIS), reached at Bellagio, Italy. Witnessing are Professor Anthony Youdeowei (left), Professor Thomas R. Odhiambo (right) and Dr. Rodney C. Hills, who served as chairman of the Conference.

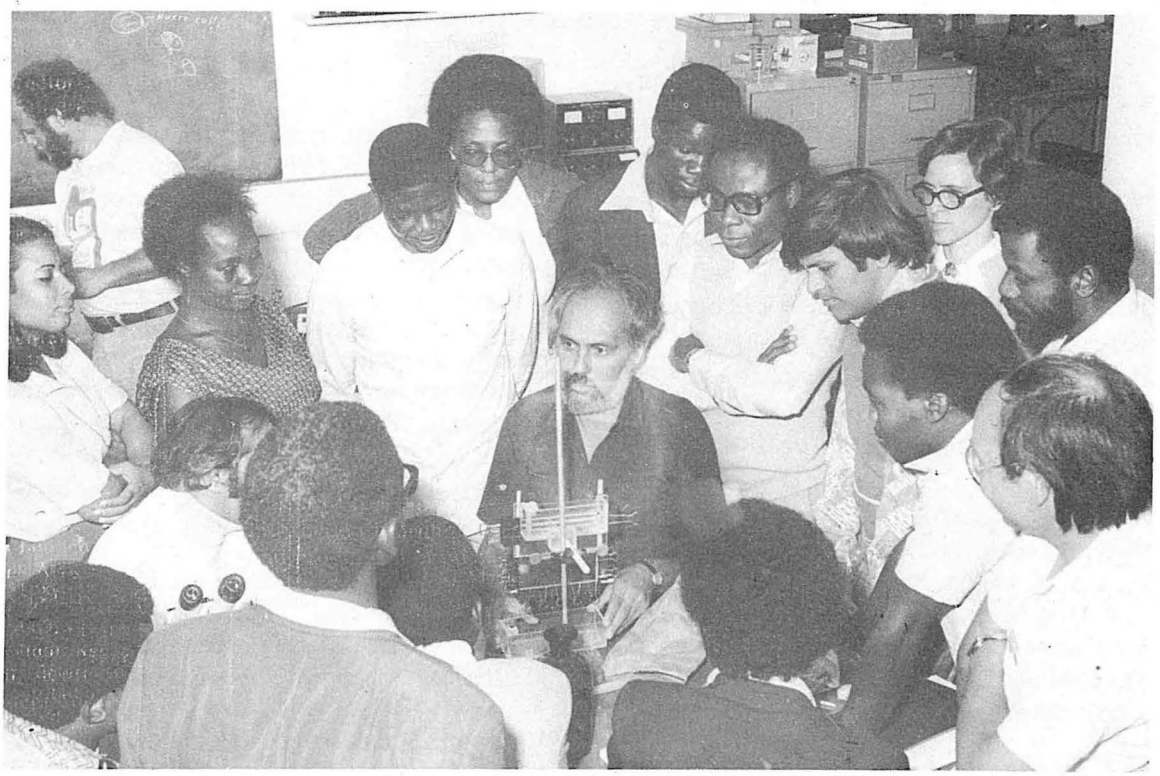
TRAINING FOR PRACTITIONERS

The International Group Training Course on Components Essential for Ecologically Sound Pest and Vector Management Systems. The fifth course in this programme was held from 19 July to 7 August 1981. The United Nations Environment Programme, (UNEP) has continued to co-sponsor this course. This year the course attracted 32 participants from 18 countries: Brazil, Colombia, Ethiopia, Nigeria, the Philippines, Saudi Arabia, Senegal, Somalia, Sudan, Tanzania, Uganda, United Arab Emirates, Zambia and Zimbabwe. Since 1977, when the course was first held, 132 trainees have participated in this course.

The International Group Training Course on Insect Growth, Development and Behaviour. The first course, in the series under the theme Insect Growth, Development and Behaviour, was held at the ICIPE from 10 to 21 August 1981. The purpose of the course is to provide an opportunity for young scientists who have already completed their academic training, and are at the beginning of their career in research or teaching, to learn new research techniques and advances in the area of insect physiology and developmental systems and behaviour. The first course, which concentrated on insect physiology and developmental systems was divided into lectures, practicals, tutorials and seminars.

A total of 17 trainees from 13 countries participated. The countries represented were: Ghana, Nigeria, Kuwait, Ethiopia, Mauritius, Malawi, Poland, India, Sierra Leone, Kenya, Uganda, Egypt and Vietnam. The course was co-sponsored by the International Cell Research Organization (ICRO), UNESCO, the International Society for Developmental Biologists (ISDB) and the ICIPE.

Participants at the ICIPE/UNEP Group Training Course look into the problems of pest management in sugar cane plantation in Nyanza, Kenya.



Practical demonstrations of laboratory techniques being conducted by Professor F. C. Kafatos (centre, seated) of the Harvard Biological Laboratories, U.S.A.

INTERNATIONAL STUDY WORKSHOPS

The planning conference on the African Regional Postgraduate Programme in Insect Science (ARPPIS) held at the Rockefeller Foundation Conference and Study Centre, Villa Serbelloni, Bellagio, Italy, from 7 to 11 September 1981, was the major event in this category. This was a historic conference and should form a very important milestone in the training programme. In all, 23 participants from the following institutions attended the conference: the ICIPE, the University of Khartoum, the University of Ife, West African Rice Development Association (WARDA) University of Montreal, University of Ibadan, University of Malawi, Australia Development Assistance Bureau (ADAB), University of Ghana, University of Dar-es-Salaam, the Rockefeller Foundation, the United Nations Economic Commission for Africa (ECA), the Institut Senegalais de Recherches Agricoles (ISRA), the Danish International Development Agency (DANIDA), Makerere University and the United Nations Educational Scientific and Cultural Organization (UNESCO).

COMMUNICATION

The Communication Department continued to provide editorial, print, photographic and graphic art support for research, training and administrative activities of the ICIPE. These services culminated in a grand poster display of ICIPE activities during the laying of the foundation stone of the ICIPE's Mbita Point Research Station by His Excellency the President of Kenya, Hon. Daniel Arap Moi in April 1980.

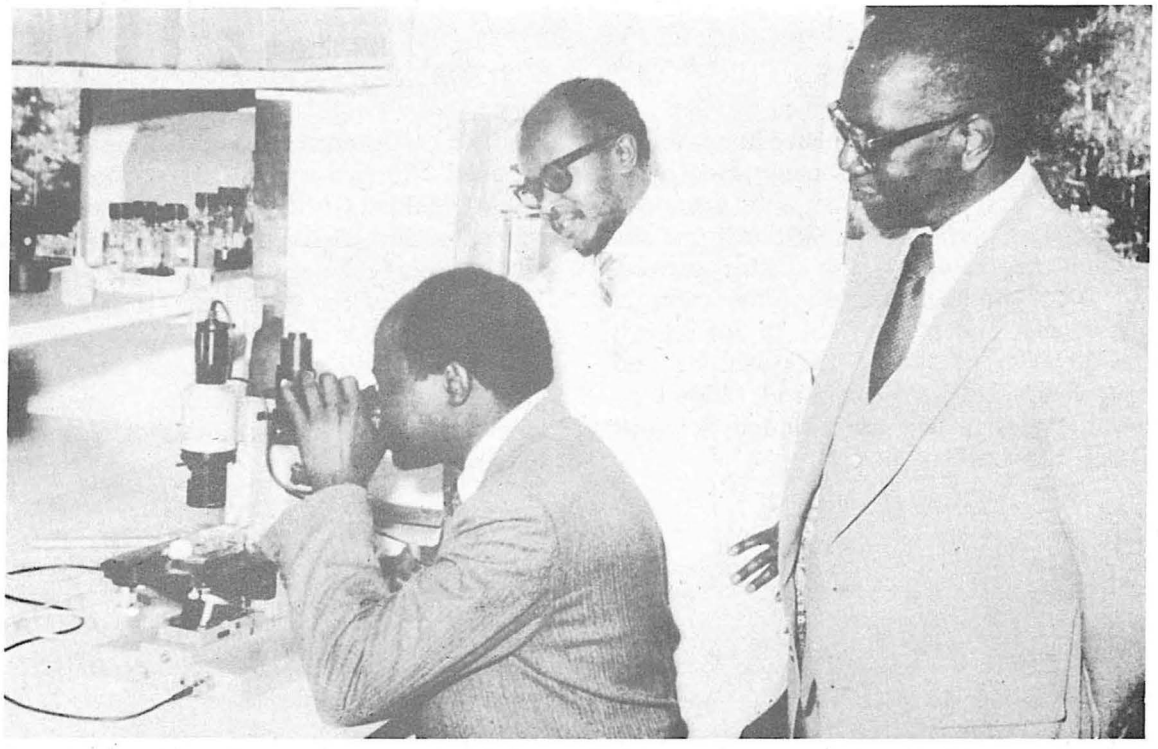
SEMINARS, CONFERENCES AND STUDY WORKSHOPS

Seminars, conferences and study workshops are regarded as ICIPE's main thrust for disseminating research information, discussing new scientific advances, reviewing current research and planning future projects.

In 1981, a total of 41 institute-level seminars were presented at the headquarters in Nairobi, at Mbita Point Field Station and at Muhaka Field Station. Over one third of these were presented by visiting scientists. Programme-level seminars or internal discussions continued to take place throughout the year in all ICIPE research programmes and units.

At the 11th Annual Research Conference, the Tsetse and Grassland Termite Research Programmes were reviewed in depth.

His excellency the President of Kenya, Hon. Daniel Arap Moi signing the visitors book at the end of his tour of the ICIPE farm complex. Standing in the extreme left is Professor Thomas R. Odhiambo, Director of the ICIPE and at the centre is Hon. Alphonce Okuku, M.P. for Mbita.



The Vice President of Kenya, Hon. Mwai Kibaki seen looking at *Trypanosoma brucei,* the micro-organisms that cause Nagana in cattle under the microscope. Standing behind him, to his left is Professor Thomas R. Odhiambo, Director of the ICIPE and Dr. M. B. Nyindo (in white coat), a senior research scientist in the Tsetse Research Programme.

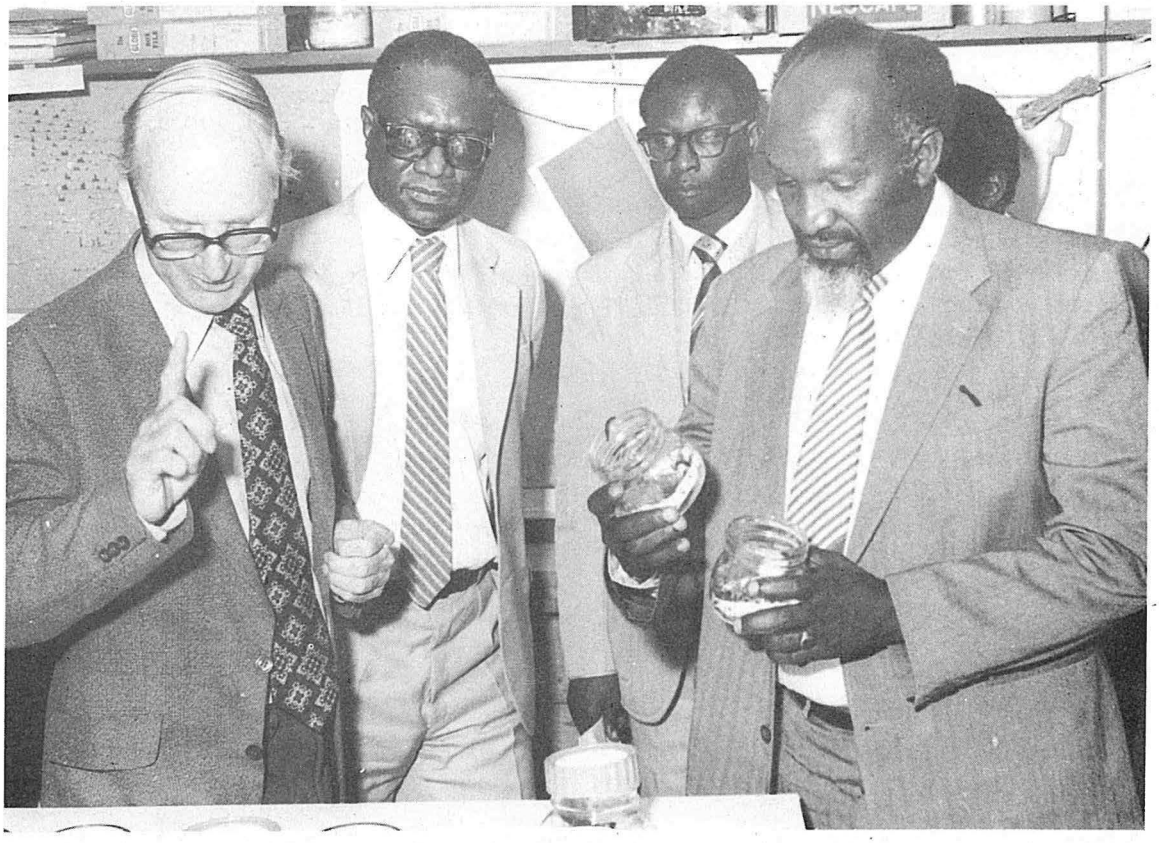
Dr. A. Hassanali (Bioassay Unit) is seen showing Dr. Bradford Morse, Administrator, UNDP, a synthetic sample of tsetse *(G. pallidipes)* sex pheromone synthesized at the ICIPE.

AUDIO VISUAL SERVICES

The ICIPE aims to improve her communication and outreach services by incorporating the use of relevant and advanced audio-visual material particularly in the training programmes, for visitor service, and for exhibition and demonstration in laboratories and in the field. In this regard, the department started the planning and production of synchronized slide/tape presentations which are planned to cover all ICIPE research projects.

VISITORS SERVICE

The Communication Department received 800 visitors in 1981 at the ICIPE. These included His Excellency the President of Kenya Hon. Daniel Arap Moi who visited Mbita Point Research Station in April 1981, the Vice President Hon. Mwai Kibaki in August 1981, several cabinet ministers, senior government officials, international and national research scientists, ICIPE donors, and college and school parties.



Hon. G. K. M'Mbijjiwe, Kenya Minister for Agriculture seen holding jars containing armyworm larvae and pupae while he listens to Dr. D. J. Rose explaining the work going on in the African Armyworm Research Laboratory. In the centre is Professor Thomas R. Odhiambo, Director of the ICIPE and Dr. F. J. Wangati from the Ministry of Agriculture.

LIBRARY AND DOCUMENTATION SERVICE

STAFF CHANGES

Mr. D. R. Kigera, who was the Librarian, left ICIPE in the middle of 1981. A Chief Librarian — Mr. William E. Umbima — was appointed in November. Before joining the ICIPE, Mr. Umbima worked with the University of Nairobi.

ACQUISITIONS

As usual off-prints on entomology and related fields dominated library acquisitions. Many of these originated from the ICIPE sponsored journal, *Insect Science and its Application*, while others came from renowned scientific journals all over the world. A supplementary stock of off-prints emanated from photocopies largely through the British Library. In all, about 207 off-prints were received. There has been a great demand for these not just from the ICIPE scientists but also from scientists in other parts of the world. Multiple copies of some of the papers are available for exchange purposes.

The ever rising cost of books has meant a reduction in the number the library can afford to purchase. Only very essential textbooks were acquired, making a total of 101 new monographs for the year.

The same strain was experienced in the area of periodical subscriptions forcing the ICIPE holdings to be restricted to leading entomological and a few scientific journals of the world. These include major abstracting and indexing services in the same fields. The Swiss Academy of Sciences must be singled out for its generosity. Its support has enabled the ICIPE to maintain subscriptions to about 125 journals.

VISITS

Mr. R. Labelle, Project Advisor (Information and Documentation), International Council for Research in Agroforestry (ICRAF), visited the ICIPE Library/Documentation Centre in an advisory capacity for one day. Valuable discussions centering on the proposed Pest Management Documentation Project at the ICIPE were held between him and senior ICIPE staff. Similar discussions were held with UNESCO through correspondence. Mr. G.A.R. Davis of the British Council also visited the Centre and discussed with ICIPE officials the possibility of British Council book aid for the new library to be established at Mbita Point Field Station.

MBITA POINT FIELD STATION LIBRARY

The new building at Mbita Point Field Station has provision for a library. A librarian has been appointed for May 1982. It is hoped that the new library will begin functioning fully towards the end of 1982. A grant of £1,200 for books from the British Council is a great boost for the Mbita library. The books have already been ordered and should begin arriving soon.

CO-OPERATION WITH OTHER ORGANIZATIONS

Arrangements for exchange of publications with organizations such as IRRI and ICRISAT are working quite well. Similarly, inter-library loan arrangements especially with the Kenya Agricultural Research Institute (KARI) and the University of Nairobi, have been a great help to the ICIPE.

FUTURE PLANS

The ICIPE has plans for a Pest Management Documentation Service whose aims are:

1. To enhance and facilitate its research on crop pests and medical vectors of tropical diseases by providing an efficient and effective documentation service to its scientists.

2. To serve as a nucleus for a network of information on insect science research. This will enable the

ICIPE to play its role in increasing the capabilities of developing nations to tackle development oriented research objectives in the field of insect pests.

3. To supplement its own resources by having easy access to international information banks in the relevant field, in an effort to devise alternative pest management systems that may be adopted for pest control in the tropics.

Eventually, the results should contribute to finding a solution to real and urgent human needs such as food and health.

A modest start has already been made by compiling lists of documents and collecting basic literature. Detailed subject lists, indexes, information packages and subject files are envisaged. The project will go into full swing as soon as necessary help is received from donors.

PROGRAMME ON BASES OF PLANT RESISTANCE TO INSECT ATTACK

INTRODUCTION

Plant resistance to insect attack governed by major or vertical genes is generally believed to be of a high level but short-lived because with a single gene conditioning resistance, only a single gene controlling nutrition or behaviour in the insect is required to overcome the resistance. Plant resistance governed by polygenic or horizontal resistance is considered more stable and longer-lasting than vertical resistance. The latter type of resistance is biotype nonspecific and there is no gene-for-gene relationship , so there is very little danger that biotypes will develop. Horizontal resistance is generally of low level and involves a number of mechanisms. It is difficult to develop methods which are sufficiently sensitive to separate lines possessing small differences of resistance.

Both types of biological systems are included in our studies on plant resistance. Rice resistance to the brown plant-hopper, *Nilaparvata lugens* and cowpea resistance to the aphid, *Aphis craccivora* represent the biotype-specific resistance, and maize and sorghum resistance to *Chilo partellus* and cowpea resistance to *Maruca testulalis* represent the moderate multifactorial resistance.

In 1981, research on plant resistance concentrated on the following aspects:

- Confirmation and expression of resistance to stem-borers in maize lines originated from CIMMYT and Kenya National Programme.
- Effect of maize and sorghum resistant lines on behaviour, development and survival of the spotted stalk-borer, *Chilo partellus.*
- New methodology of cowpea screening for resistance to the legume pod-borer, *Maruca testulalis*, under artificial infestation.
- Effect of resistant cowpea lines originated from IITA on *Maruca testulalis* and the cowpea aphid, *Aphis craccivora* behaviour and development.
- Biochemical, physiological and genetic relationships between resistant rice cultivars, released by IRRI, and *Nilaparvata lugens* biotypes; and
- Experimental bases of mass rearing of *Maruca testulalis*, *Chilo partellus*, *Eldana saccharina*, *Busseola fusca* and *Atherigona soccata* on artificial diets.

The joint project between the FAO/UNDP Kenya Sorghum and Millet Development Programme and the ICIPE was initiated to screen large germplasm collection by the Kenya Programme for resistance to stem-borers using the methodology developed by the ICIPE. Experiments were conducted in the Mbita Point Field Station, to identify mechanisms of resistance in selected advanced lines. The joint project with Ahero Irrigation Research Station on Screening rice for resistance against *Maliarpha separatella* was continued.

A project on maize resistance to stem-borers and on the effect of cultivars on economic injury level was initiated at the Coast National Agricultural Research Station, Mtwapa, in collaboration with the resident scientists. The stem-borer species composition in Mtwapa differ from that of Mbita. Besides *C. partellus*, two other species of stem-borers, *C. orichalcociliella* and *Sesamia calamistis*, are present at the coast.

SCREENING MAIZE FOR STEM-BORER RESISTANCE

It is assumed that maize germplasm contain many genes for resistance to insects and by gradual accumulation of the favourable genes in selected populations, the maize crop would be able to resist or tolerate pest hazards much better. New resistant varieties would benefit farmers, particularly the small-scale farmers in the developing countries.

The objectives of screening is to test and confirm the reported resistance of lines from other International Research Centres to the East African stem-borer complex under Kenyan conditions. On a limited scale, local cultivars are also screened under field conditions to select and develop lines that are resistant to the stem-borer complex. Screening for *C. partellus* resistance is carried out at Mbita Division and screening for *Busseola fusca* resistance will be done in the Kisii highlands, at the Nyanza Agricultural Research Station.

In Mbita, screening was carried out at the Mbita Station and in farmers' fields. Percentage damage was determined based on leaf and plant damage scale. Based on data collected at the first screening, the first ten and the last ten, in order of magnitude of resistance, were selected for testing and confirmation during the following season.

A total of 460 maize lines from CIMMYT, Mexico, reported to be resistant to the most widely spread borers affecting maize in the western hemisphere *(Ostrinia; Diatrae)* were planted under natural conditions at Mbita Point. Most of the maize lines showed good adaptability and high yield potential under dry conditions in western Kenya. Twelve lines showing resistance to *Chilo* and good agronomic performance were selected and were planted for studies on mechanisms of resistance.

BEHAVIOUR AND SURVIVAL OF *CHILO PARTELLUS* ON RESISTANT MAIZE LINES

Fifteen maize lines, identified previously as showing the lowest leaf and overall plant damage under natural field infestation were repeatedly planted in April and September 1981 at the Mbita Point Field Station. The highest number of egg masses were always found on foliage of susceptible Inbred A line, used as the control in both experiments. The lowest number of eggs were laid on the CIMMYT lines 324, 125, 34 and Inbred D. The number of holes and tunnels in stems was always higher on the susceptible Inbred A. More significant differences were found when the frequency distribution of stem tunnelling (in % of plant height) by stem-borer larvae on Inbred A and D were compared.

Chilo larvae completely destroyed 60—70% of the susceptible Inbred A at stages 4—6, whereas only 0—4% of the moderately resistant CIMMYT lines and Inbred D and G were destroyed by *Chilo*. Highest number of larvae and longest tunnels were observed on the susceptible Inbred A followed by lines Mz5, CIMMYT 33, 34 and 71. The lowest number of larvae and shortest tunnels were found in lines 125 and 324. Most of the larvae concentrated their feeding on the top 20 cm portion of the stem of the susceptible Inbred A line, whereas they were uniformly distributed on stems of Inbred D and G. The extent of tunnelling on Inbred A was twice as long as on plants of Inbred D or G (Fig. 1). Those two factors—the longer tunnels and their concentration on the young growing portions of stems—were responsible for destruction of susceptible plants by *Chilo* larvae.

Studies on maize resistance to *C. partellus* suggest that there are at least five levels of relationships affecting plant colonization, larval survival and damage level:

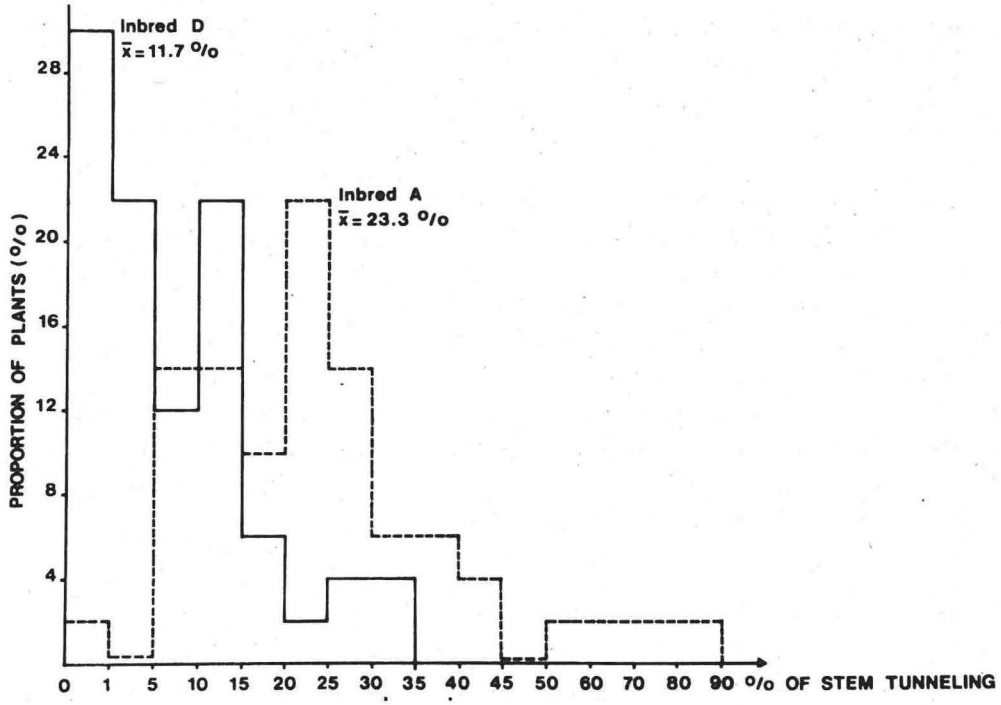


Figure 1. Frequency distribution of stem tunnelling (in % of plant height) by stem-borers larvae in two maize inbred lines. Mbita Point Field Station, 1981.

1. Non-acceptance for oviposition: Inbred D and G and CIMMYT lines 125, 33, and 178. Preference for the Inbred A.

2. Feeding of young larval instars on young leaves or leaf sheaths: reduced on CIMMYT lines 324, 125 and 33.

3. Concentration of feeding of young larval instars on the upper growing part of the plant: extensive on the highly susceptible Inbred A and reduced on all resistant lines tested.

4. Penetration of young larval instars into stem: reduced on CIMMYT lines 34 and 125 and Inbred G.

5. Feeding of older larval instars in stem: reduced on CIMMYT lines 324, 104, 125, 181, 28 and Inbred D.

Extensive larval feeding on the whorl and upper part of the stem of susceptible Inbred A and low damage on the resistant lines may suggest that the plant resistance may result from the plant failing to provide positive gustatory stimuli required by *Chilo* larvae or by the possession of characteristics (biophysical factors, dense trichmoes or biochemical) having adverse effects on feeding activities. The chemicals acting as feeding suppressants or deterrents may also affect the larval survival (physiological inhibitors).

BEHAVIOUR AND DEVELOPMENT OF *CHILO PARTELLUS* ON SORGHUM CULTIVARS

Several field, screenhouse and laboratory experiments were conducted in 1981 to investigate the effect of resistant sorghum cultivars on the behaviour, development, survival and fecundity of the spotted stalkborer, *C. partellus.*

NON-ACCEPTANCE FOR OVIPOSITION

Experiments were conducted to determine whether the host plant variety is oviposited on by chance or there are

factors involved in orientation and oviposition; whether oviposition preference exists for any particular variety; and if this is related to the age of the plant.

Most of the eggs were laid on the middle leaves. About 60% of the eggs were laid on the upper side, mostly on the midrib, and 40% on the lower side except on IS 17739 and IS 18361 where the above ratio was reversed. It was observed that oviposition preference of *Chilo* females to sorghum cultivars is determined by several factors modified by the age of the plant. Some of these factors interact or even negate each other.

IS 18363 was consistently the most preferred cultivar for *Chilo* oviposition and thus possibly releasing positive chemical or physical stimuli for the females (Fig. 2). IS 18479, IS 1082 and Serena are the least preferred. IS 18479 may not be preferred because of its short height, among other things. IS 1082 is one of the least preferred from 42 days onwards. It needs to be established as to what changes take place at this stage. IS 4660 seems to contain either a repellent or some undesirable physical characteristics affecting *Chilo* oviposition. At the early stages IS 17739 is also nonaccepted and the reason for this needs to be established.

MIGRATION AND ESTABLISHMENT OF FIRST LARVAL INSTARS ON SORGHUM CULTIVARS

Experiments were conducted in the screen-house, at Mbita Point Field Station, using 22 cultivars to monitor migration and mortality of *Chilo* larvae and their damage on the plants.

IS 1044, IS 18489 and IS 18349 had the highest migration, low mortality and low

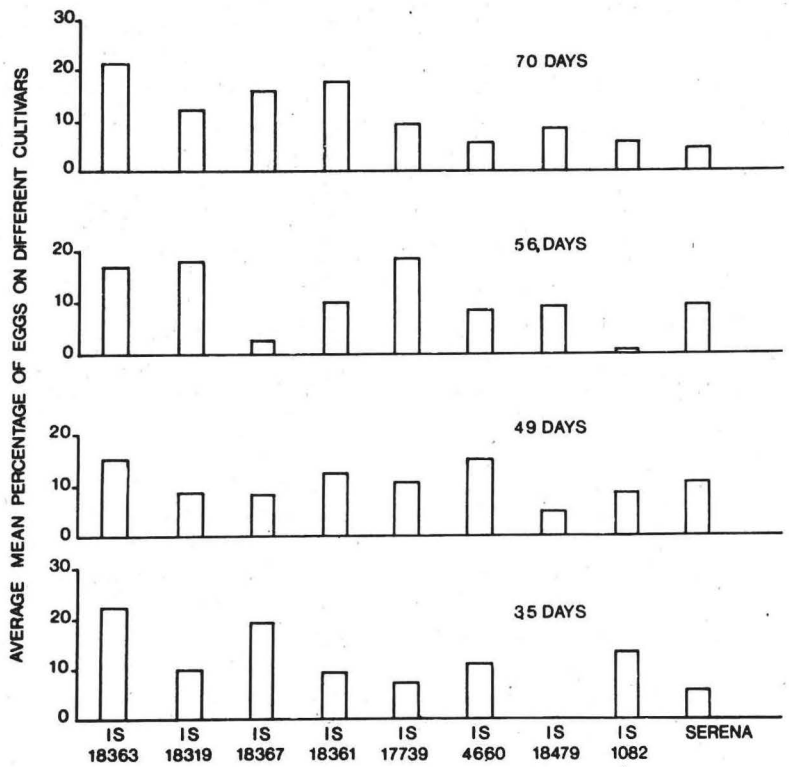


Figure 2. Effect of cultivar and age of sorghum on the relative oviposition preference of *Chilo* females under screenhouse conditions.

plant damage. This leads to the suspicion that these cultivars have some deterrents or suppressants affecting feeding of the first instars. In IS 1151, IS 4660 and IS 18479, there was little migration. The leaves were extensively damaged but a large number of larvae died. From this, it is inferred that some factor(s) (chemical or physical) cause high mortality but these factors were not deterrents. In IS 1082, IS 2205 and IS 18367 there was high migration, and high mortality but they still showed extensive leaf damage. The differences observed in migration of larvae from various cultivars indicate the presence of some chemical or biophysical factors restricting initiation of feeding by first instars.

STEM DAMAGE BY LARVAE

Stem damage caused by *C. partellus* larvae on selected cultivars were assessed under field conditions. Samples taken 28 days after planting revealed *C. partellus* to be the predominant stem-borer species (74.7%). There were also *S. calamistis* (14.6%) *B. fusca* (6.6%) and *E. saccharina* (4.2%). The stem damage caused therefore was due to all the four species.

The least tunnelled cultivars were: IS 18489, Serena, IS 2122 and IS 1151. However, IS 2122 had the highest incidence of lodging, suggesting that this cultivar's tensile strength causing tolerance is not very high. The plant may also contain some chemicals restricting larval tunnelling. The cultivars with the least number of plants killed were IS 1151, IS 18349, IS 2122 and IS 2205.

EFFECT OF SORGHUM CULTIVAR ON LARVAL SURVIVAL, PUPATION AND FECUNDITY

Preliminary studies have shown that pupal weight was lowest when larvae were reared on IS 2123, Serena, and IS 2205. Adult emergence was lowest for larvae reared on IS 18489 and IS 1082. Moths from larvae reared on IS 4660, E303 and IS 1082 were the least fecund.

SCREENING THE COWPEA PLANT FOR RESISTANCE TO *MARUCA TESTULALIS*

Some preliminary screen-house and field experiments were conducted to determine the optimal number of insects for artificial infestation that will allow differentiation among susceptible and resistant lines, the most suitable developmental stage of *Maruca* for artificial infestation in a mass-screening programme, and effect of plant growing stage on the expression of resistance. The TVu 946 line was included in our experiments as resistant, Ife Brown as moderately resistant and Vita I as the susceptible cultivar. The suitability of using young plants or seedlings as the cheapest and the most rapid method in screening of cowpea for *Maruca* resistance was also verified.

By using 10 eggs per plant in pre-flowering stage and 20 eggs per plant in flowering stage, it was possible to differentiate between the resistant and susceptible lines. Higher larval population used for artificial infestation did not improve the screening results. Plant growing stage has modified the expression of cowpea resistance to *Maruca* larvae. Five to seven shoot stage (not younger) was found to be the most suitable for screening for resistance in the pre-flowering period.

EFFECT OF RESISTANT COWPEA LINES ON THE LEGUME POD-BORER *MARUCA TESTULALIS*

Our screenhouse and field experiments on cowpea resistance to the legume pod-borer showed that the resistance in some cowpea lines of IITA origin is expressed in the pre-flowering and flowering stage. At present we may only identify three levels of *Maruca* — cowpea relationships expressed in the resistance:

(1) Vita I plants showed a significantly higher number of eggs per plant, followed by Ife Brown and TVu 946.

Table 1. Longevity, fecundity, oviposition, and hatching of eggs of Biotype 1 brown plant-hopper females on susceptible and resistant rice varieties IRRI, 1980–81 [1]

Variety [2]		Longevity [3] days	Fecundity [3] (No. of eggs/ Female)	Oviposition [4] (No. of eggs/ 5 Females/18h	Egg hatch (%) [5]
TNL	(S)	10.6 a	444.2 a	112 a	88.0 a
Mudgo	(R)	3.8 b	89.9 b	111 a	69.3 bc
ASD7	(R)	4.0 b	124.5 b	111 a	82.7 ab
Rathu Heenati	(R)	4.0 b	105.7 b	112 a	65.3 c
Babawee	(R)	4.7 b	113.9 b	120 a	69.0 bc
Ptb 33	(R)	3.8 b	88.3 b	101 a	69.3 bc
ARC 6650	(R)	4.8 b	100.2 b	95 a	68.0 bc

[1]In a column means followed by a common letter are not significantly different at the 5% level by DMRT.
2 = susceptible check; R = resistant
[3]Average of 10 replications
[4]Average of 5 replications
[5]Average of 6 replications

but its genetic composition has not been studied. TNI served as the standard susceptible check variety.

The study was divided into two major phases. Phase I involved the study of the biology of the BPH on the test varieties. The experiments conducted included settling response of adults, nymphal development, female longevity and fecundity, oviposition and egg hatch (Table 1). Also the quantity of food ingested and the metabolic utilization of ingested food from the test varieties by adult females was determined.

BPH adults preferred to settle on the susceptible variety (TNI) over the resistant varieties after 6 hr of introduction into the test cage. Mortality of the nymphs was very high on resistant varieties and the nymphal growth index was correspondingly very low. All the resistant varieties had a lower amino acid composition than that in the susceptible TNI variety.

Plant allelochemics were obtained by steam distillation of leaf sheaths followed by diethyl ether extraction. Bioassays of allelochemics included orientation, settling and feeding response of adults, toxicity to both nymphs and adults, and phagostimulation or inhibition when added to 10% sucrose solution when offered to the BPH. Effect of extracts on egg hatch was also examined.

The insects were significantly more attracted to the rice plant odours than to the blank source in an olfactometer. However, they were unable to differentiate between odours of resistant and susceptible varieties. Significantly, more insects settled and fed on TNI plants treated with TNI extract and control plants than on plants treated with extracts from resistant varieties. Allelochemics from resistant varieties were more toxic to both nymphs and adults of the BPH than allelochemics from TNI (Table 2). Toxicity of the allelochemics from resistant varieties when applied topically to adults, increased with plant age up 60 days after seeding and then decreased from 100 days after seeding

Table 2. Toxicity of steam distillate extracts of susceptible land resistant rice varieties to 1st instar Biotype 1 brown plant-hopper IRRI, 1981. (Extracts were sprayed on the susceptible rice plant tillers).

Variety 1		Mortality (%)[2]			
		Dose (µg Extract/30-day-old plant)			
		0.01	0.1	0.5	1
TN1	(S)	2.5 ab	5.0 bc	0.0 d	40.2 b
Mudgo	(R)	0.0 b	7.5 abc	10.0 cd	70.2 a
ASD 7	(R)	13.1 a	10.6 abc	15.8 bc	61.1 a
Rathu Heenati	(R)	5.0 ab	13.4 ab	20.8 abc	73.3 a
Babawee	(R)	5.0 ab	2.5 c	24.3 ab	71.1 a
Ptb 33	(R)	7.5 ab	18.1 a	32.1 a	70.1 a
ARC 6650	(R)	7.5 ab	16.2 a	34.6 a	51.5 a

[1]S = susceptible; R = resistant

2 Average of 4 replications. In a column, means followed by a common letter are not significantly different at the 5% level by DMRT. Extract sprayed on the susceptible rice plant tillers.

Table 3. Phagostimulation by steam distillate extracts of susceptible and resistant rice varieties IRRI, 1981

Variety [1]		Quantity of sucrose solution [2] ingested (µg)[1] [1]
TNI	(S)	12.037 a
Mudgo	(R)	4.550 bcd
ASD 7	(R)	12.502 a
Rathu Heenati	(R)	2.350 cd
Babawee	(R)	6.532 bc
Ptb 33	(R)	0.657 d
ARC 6650	(R)	7.927 b
Sucrose (control)		6.312 bc

[1]S = susceptible; R = resistant.

0.1 µg of extract per parafilm sachet was incorporated with 10% sucrose solution offered to 20 newly-emerged females.

[2]Average of 4 replications. Means followed by a common letter are not significantly different at the 5% level by DMRT.

which suggests that the level of resistance changes with plant age. TNI allelochemics stimulated more feeding on 10% sucrose solution than that of the resistant varieties (Table 3). Egg hatch was not affected by these allelochemics.

Although the allelochemics evaluated in the present study are not likely to be found in the phloem which is the feeding site of the BPH, their odoriferous and volatile nature makes them have a strong influence on the internal and external chemical

environment of the rice plant. These allelochemics are therefore of ecological significance in the BPH resistance in rice plants. Gas chromatograms showed distinct qualitative and quantitative differences among the steam distillate volatiles. These 'fingerprints' of the steam distillate volatiles illustrate basic chemotaxonomic differences between the BPH-susceptible and resistant rice varieties.

CYTOGENETIC VARIATIONS IN THE BROWN PLANT-HOPPER BIOTYPES 1 AND 2

Chromosome number, morphology and behaviour have often been relied upon as complementary taxonomic indicators in a number of species complexes. The sex chromosomes are especially useful in cytotaxonomy because they may show from marked to subtle differences within a genus, or a species. In 1981, cytological investigations of the meiotic chromosomes of the brown planthopper Biotype 1 and 2 populations, maintained as stock cultures at IRRI for several years, revealed that the first meiotic division was reductional and the second division equational for all the components of the species' genome. The male diploid number was 2n = 30, consisting of 14 bivalent autosomal pairs and XY sex chromosomes. Thus, *Nilaparvata lugens* has an XY sex - determining mechanism, the males being heterogametic (14II +XY) or producing two types of secondary spermatocytes and the females homogametic (14II + XX) or producing only one type of secondary oocytes.

The sex chromosome is more isolated from outosomes in biotype 2 than in biotype 1. Also, the extent of chromosome clustering was detected to be higher in the former than in the latter. The occurrence of chromosomal aberrations as 'loose pairings' of paired homologous bivalents as well as fragmentations or chromosomal deletions were found to be more frequent among biotype 1 than among biotype 2 chromosomes. Further cytogenetic studies are in progress.

EXPERIMENTAL BASES OF INSECT MASS REARING

In view of the importance of insect rearing at the ICIPE, an experimental unit has been set up to develop mass-rearing methods for insect pests of tropical Africa. The target species include the sorghum shootfly *(Atherigona soccata)* and several lepidopterous crop-borers: *Chilo partellus, Busseola fusca, Maruca testulalis, Maliarpha separatella, Eldana saccharina* and *Sesamia calamistis.*

THE SORGHUM SHOOTFLY, ATHERIGONA SOCCATA

Over 35 artificial diets were formulated and evaluated in the laboratory. Several diets based on casein, yeast and shredded Kleenex® tissue paper were found satisfactory. The rearing was done in 75 x 25 mm glass vials at 27°C. On the best diet, the larval period was 13—15 days and adults emerged in 21—25 days. Larval survival was 64%. To date 3 generations have been completed. Fecundity study is continuing; indications are that egg production is comparable to that of wild flies. The work will continue until a practical rearing method is developed.

THE SPOTTED STALK-BORER, CHILO PARTELLUS

The larvae were reared at 20°, 25°, and 30°C on two diets: a wheat germ diet without plant powder and the same diet with plant powder added. Both diets were found equally satisfactory. The average time taken from egg to adult was 36 days at 30°C, 48 days at 25°C, and 68 days (estimated) at 20°C. On the whole rearing performance was better at 25°C.

At present the culture is in its second generation and in excellent health. In

2—3 months, we expect phase 3, that is management of the colony and supply of insects for experimentation.

LEGUME POD-BORER, MARUCA TESTULALIS

Several diets were evaluated including the previous diets with cowpea flower powder added and already in use at the ICIPE. An improved diet without cowpea flowers was formulated. The life cycle data on this diet at 25°C are: larval period 10—12 days, pupal period 6 days. Adult recovery from neonate larvae was 60%. The adults have not reproduced in the laboratory due to lack of suitable oviposition substrate. This will be investigated and given priority. A protozoan disease of *Maruca* was discovered; it is now under investigation.

THE MAIZE-BORER, *BUSSEOLA FUSCA*

This species has a longer life cycle than the two species described earlier. The insect has developed on Pritam Singh's artificial diet and larvae have pupated starting from day 35; some larvae have entered diapause. It is expected that normal adults will emerge in due course.

CROP-BORERS RESEARCH PROGRAMME

INTRODUCTION

The Crop-Borers Research Programme was established in late 1979, its main objective being to develop environmentally safe and economically feasible integrated pest management practices for crop-borers of major food crops in Africa. The target crop-borer species under active investigation are: sorghum shootfly, *Atherigona soccata;* maize and sorghum stem-borer, *Chilo partellus;* rice stem-borer, *Maliarpha separatella;* and cowpea pod-borer, *Maruca testulalis.* In addition, information on the importance of other stem-borers such as *Busseola fusca, Sesamia calamistis* and *Eldana saccharina* of maize and sorghum, and aphids and thrips of cowpea is being collected.

To formulate effective intergrated pest management practices, investigations cover the following areas:

1. Biological and ecological studies on the target pests.
2. Physiology and behaviour of the target pests.
3. Biological control agents.
4. Crop loss assessment for sorghum, maize, rice and cowpea in respect to economic thresholds of the target pests.
5. Intercropping in terms of pest management.
6. Screening for resistance and tolerance, confirmation of pre-selected materials from international agricultural research centres and national programmes under the Mbita Point Field Station conditions and other representative ecological conditions.
7. Genetics of resistance and tolerance.

Apart from laboratory studies on the sorghum shootfly, crop-borers research is carried out at the Mbita Point Field Station (MPFS) and at nearby farmers' fields were the crops and their pests occur in their natural habitat. Existence of a high pest population at MPFS facilitates screening of cultivars under natural infestation.

The Crop-Borers Research Programme witnessed a great expansion in its scientific manpower and research activities during this period, reflected by a number of findings. Sorghum shootfly population level depends on rainfall, availability of host plants, rate of parasitism and predation and availability of food to adult. Honeydew produced by cereal aphids and cowpea aphids is an efficient food source for shootfly adults and may influence the shootfly population in the field. *Chilo* is the most abundant borer (over 90%) infesting sorghum and maize, particularly in the warmer and low altitude areas of Kenya. In the cooler and high altitude areas, however, *Busseola* is found to be the most important. Preliminary studies on the rice stem-borers have indicated that *Maliarpha* is the most abundant. However, *Diopsis* and *Sesamia* caused a high incidence of 'dead hearts' at vegetative stage and 'white heads' at reproductive or ripening stages, respectively. Studies on cowpea pod-borer, have shown that under both pure and mixed crops, *Maruca* is the most abundant accounting for more than 90% of the total borer population. Studies on the development of cowpea plants and damage/injury levels or threshold of *Maruca* infestation have been initiated. Intercropping experiments to determine the importance of pests within a mixed ecosystem of maize, sorghum and cowpea are being conducted. Studies have been initiated on the genetics of host plant resistance and tolerance to target insect pests.

The Crop-Borers Research Programme collaborates with CIMMYT, ICRISAT, IITA, IRRI and WARDA, and National Research Programmes of Kenya.

SORGHUM SHOOTFLY

POULATION DYNAMICS

Atherigona soccata population levels are closely linked with the availability of sorghum stems (wild and cultivated), of a suitable stage. Field experiments using susceptible sorghum hybrid (CSH-1) at MPFS have shown that *A. soccata* females lay more eggs on young sorghum seedlings, measuring 4 to 8 cm in height, than on plants of any other size and newly hatched larvae survive only in shoots measuring less than 24 cm in height. Survival of the first instar larva depends on the size of the host plant, resistance to penetration of the leaf sheaths and the distance between infestation site and growing point. Sorghum plant density affects oviposition by *A. soccata.* Low density plots with stouter plants bearing broader and greener leaves received over 3 times more eggs than plants in higher density plots. Larval mortality resulting from competition increased from high to low plant densities. These results support the farming practice of using higher seeding rates and subsequent thinning of infested plants.

Heavy rainfall after dry months was found to be detrimental to shootfly adult population. It took 3 months for shootfly population levels to become re-established after the rainy season. However, water plays a central and preponderant role in increasing shootfly population. It promotes the growth of wild and cultivated sorghums and has a direct effect on survival of every stage of the pest, except for the second and third instars, which are completely protected inside the plant tissues. Sufficient air humidity is required by the egg to complete its development and for hatching, dew is necessary for the progression of the newly hatched larva from egg site to the point where it enters the stem. Mortality increased rapidly with decreasing humidity (from 100%), especially at temperatures below 12°C and above 32.5°C. No development occurred at humidities lower than 67%.

The local farming practice, which allows cattle to graze on sorghum stubbles after harvest certainly helps reduce larval populations during the dry season. Aphid honeydew is a major source of food for shootfly adults. Flies fed on honeydew of cowpea aphids and cereal aphids had very high fecundity. The part played by aphid population fluctuations may be of considerable significance in understanding shootfly population fluctuations.

Among the major parasites and predators of the sorghum shootfly, the following have been identified: *Tetrastichus nyemitawus* — a larval parasite; *Trichogramma kalkae* Sch. & Feij. — an egg parasite, and *Scymnus trepidulus* Weise — an egg predator.

MAIZE AND SORGHUM STEM-BORERS

STEM-BORERS COMPLEX

Previous studies on stem-borers complex have shown that *Chilo partellus* contributed to over 90% of all the borer species infesting the lowland maize and sorghum. Recent studies on the incidence of stem-borers complex on sorghum variety Serena at MPFS have confirmed that although all the four stem-borer species, viz: *Chilo, Eldana, Busseola* and *Sesamia* were found damaging, *C. partellus* was the predominant species (87 to 99%) followed by *Eldana* (9—32%). It was found that *Chilo* larvae infested the crop at 3 weeks from emergence and continued infesting till harvest. The incidence of *Busseola* and *Sesamia* was very low. At the Nyanza Agricultural Research Station, Kisii, which is at an altitude of 1806 m above sea level, *Busseola* was found to be the major stem-borer species.

During the long rainy season of 1981 in farmers' fields at Ruri, *Chilo* damage started when the crop was 3 weeks old. No other stem-borers were seen up to the tenth week. *Chilo* infestation was observed up to the sixth week and the maximum was 8%. *Sesamia* attack was started at the eleventh week and continued till harvest, with a maximum of 5% infestation.

SURVEY OF STEM-BORERS OF SORGHUM AND MAIZE IN KENYA

A field survey on the distribution of stem-borers of sorghum and maize was conducted in Nyanza, Western, Rift Valley, Central, Eastern and Coast Provinces of Kenya. *Chilo partellus* was found to be the major stem-borer species on both sorghum and maize. In coastal areas, however, two species of *Chilo*, viz: *C. orichalcociliellus* and *C. partellus* were present. *Busseola fusca* was the second most important stem-borer. It appears that the distribution of stem-borer species is influenced by altitude, rainfall and temperature. In the warmer and lower altitude areas, particularly in the lake basin and coastal areas, *Chilo* is the most important stem-borer. It was recovered from 21 to 1,670 m. *Busseola fusca* was found to be the dominant stem-borer species in cooler and higher altitude areas, above 1,140 m. The presence of *E. saccharina* on sorghum and maize in the sugar belt of Western and Nyanza Provinces and *S. calamistis* in many areas of Kenya except in higher altitudes were noted.

PEST CARRYOVER STUDIES

In order to study the carryover of stem-borer species, Serena sorghum stalks with their stubbles were stocked after harvest in February 1981. Monthly sampling of 100 stalks was carried out for seven months for the presence of larvae and pupae. Initially, a very high proportion of stalks contained larvae and pupae of *C. partellus* followed by *Eldana*, *Busseola* and *Sesamia*. The presence of *Chilo* and *Sesamia* larvae was observed up to 180 days in the dry stalks and that of *Eldana* and *Busseola* larvae up to 90 days after stocking.

LIGHT TRAP STUDIES

At MPFS a pressure lantern was operated partially for 19 nights before the break of long rains. All the four stem-borer species, viz: *C. partellus*, *E. saccharina*, *B. fusca* and *S. calamistis* were attracted to light and the catches were 109, 15, 7 and 5 respectively, thus confirming that *Chilo* population was the highest.

SCREENING FOR CONFIRMATION OF RESISTANCE

One hundred and forty selected sorghum lines which had already been screened for resistance to stem-borers at ICRISAT, India, were tested at MPFS to confirm resistance to *Chilo*. Preliminary observations showed that some lines possess a fair degree of resistance.

PHYSIOLOGY OF AESTIVATION-DIAPAUSE IN CHILO PARTELLUS

Physiological aspects of aestivation-diapause in the pyralid borer, *C. partellus* were investigated with the main objective of finding out endocrinological relationships involved in aestivation-diapause. Effects of 20-hydroxyecdysone on last instar *Chilo* larvae were investigated by injecting larvae with 4µg of the hormone. It was observed that the number of diapausing larvae increased as the dry season started.

RICE STEM-BORER

STEM-BORER COMPLEX AND DISTRIBUTION

In Kenya rice is grown under lowland irrigated (LLI), upland rainfed (URF) and swamp flooded (SF) conditions.

In western Kenya, at Ahero Irrigation Scheme and at MPFS where rice is grown under LLI conditions four species of stem-borers attack rice. These are: *Maliarpha separatella* Rg., *Sesamia* sp., *Chilo* sp. and *Diopsis thoracica*. Although *M. separatella* was the most abundant of all, it was the least responsible for causing 'dead-hearts' or 'white-heads'. *Diopsis* caused the highest incidence of 'dead hearts' at vegetative stage. *Sesamia* occurred at reproductive stage and caused the highest number of 'white heads'. *Chilo* occurred only rarely and caused the least damage.

In the Central Province, at Mwea Tebere Irrigation Scheme *Maliarpha* was also the

most abundant stem-borer on rice. But the 'dead-hearts' were caused by *Sesamia.*

In the Coast Province where rice is believed to have been introduced earlier than in the rest of Kenya, the distribution of the borer species differred. In Mazeras, under UF conditions *Chilo* and *Sesamia* were as abundant as *Maliarpha.* While in Ramisi, under SF conditions, only *Maliarpha* was recorded.

REPRODUCTION, DEVELOPMENT AND POPULATION DYNAMICS OF MALIARPHA SEPARATELLA

Maliarpha adult emergence occurs after sunset at about 1900 hours. Adults were capable of mating a few hours after emergence. Light trap and field data revealed that the sex ratio is close to 1:1. Mean longevity of males and females were 3 and 4 days, respectively. Mean preoviposition period was 2 days. Females produced on an average 2 egg-masses, each with 50 eggs. Incubation period was 8 days, and 81% of the eggs hatched. Oviposition, under field conditions, started at the vegetative stage and lasted throughout the growth stage of the rice crop, but egg-masses were most abundant at the late vegetative stage.

Under field conditions, and depending on varietal resistance, larval period ranged from 30 — 50 days. Soon after hatching the larva moves towards the leaf sheath, penetrates the stem and moves downwards into the hollow internode. Larvae survive only if the stem has been differentiated with internal hollow. Older larvae and pupae were found at the lower internodes, at ripening stage. Larvae are gregarious; they can survive in stems previously infested with other species of stem-borers. Pupal period was about 14 days.

In both long and short rainy seasons, oviposition started before tillering stage and reached the peak at the vegetative stage, from 45 — 60 days after transplanting (45—60 DT). Larval and pupal population reached the peak at 75 DT (flowering stage) and at 90 DT, respectively. This suggests that *Maliarpha* would complete only one generation on short duration rice varieties. Tiller damage was correlated with larval population. Per cent 'dead-hearts' was very low although a maximum of 70% of the tillers were infested in IR 579—48—1 and in the local variety Sindano. The economic importance of this pest is questionable because the damage appears to reduce only the vigour of the plants without causing 'dead-hearts' or 'white-heads'. However, combined infestation with Sesamia caused high incidence of 'white-heads'.

EFFECT OF NITROGEN FERTILIZER ON RICE STEM-BORER INFESTATION

Preliminary studies using the local rice variety Sindano revealed that 'dead-heart' incidence was maximum (9.4%) at tillering and flowering stages at 60 kg N/ha nitrogen and this was significantly higher than that of crops without N fertilizer (0.9%). Further, the effect of nitrogen fertilizer was not only on increase in total incidence of damage but also in the distribution pattern of the stem-borer species.

COWPEA POD-BORER, *MARUCA TESTULALIS* GEYER

POPULATION STUDIES UNDER PURE AND MIXED CROP SITUATION

It was observed that on cowpea (local

variety — Nyar milambo) under both pure and mixed crop, *M. testulalis* was the most abundant borer accounting for more than 90% of the total borer population at all sampling stages. Among other borers, the Lycaenid butterflies, especially *Euchrysops* sp. and *Lampides* sp. were most prominent at MPFS and in the farmers' fields. These studies revealed that the population of *M. testulalis* is lower in pure than in mixed crop and that the mixed crop ecosystem might be favourable for pest survival.

STUDIES ON PEST-HOST RELATIONS AND YIELD LOSS ASSESSMENT

Work was initiated at MPFS to study the development of cowpea plants and determine damage/injury levels or thresholds of *M. testulalis* infestation on cowpea. The purpose was to understand the partitioning process in cowpea, that is, how it channels its energy in coping with the consistently changing biotic and abiotic relationships in the agro-ecosystem, as a basis for establishing damage thresholds or indices for managing the pest complex of the crop.

Phenological studies showed that pods matured at an average of 30 days in field plants; only 29 to 30% of flower buds resulted in mature pods, i.e. up to 70% of flowers and pods arising from buds are 'wasted'.

Results of this preliminary trial on field infestation and yield loss assessment suggested that:

1. The number of pods and pod weight per plant, pod dimensions, number of seeds per pod and shelling per cent were comparable among treatments.

2. Pod deformation caused by sap sucking insects and/or plants stress was much higher when related to numbers of pods (50—60%) but was considerably lower (less than 20% compared to 35% in infested and non-infested plants, respectively) in relation to pod weight.

3. An assessment of pods sampled showed that only 6 to 7% seed damage resulted from infestations of 4 and 5 *M. testulalis* larvae, respectively per plant.

GENETICS OF HOST-PLANT RESISTANCE TO INSECT PESTS

It is envisaged to work out the genetics of host-plant resistance to sorghum shootfly, *A. soccata* in sorghum; to stem-borer, *C. partellus* in sorghum and in maize; to rice stem-borer, *M. separatella* in rice; and in cowpeas to pod-borer, *M. testulalis* and aphids. During the long rainy season at MPFS, efforts were made to screen some cowpea cultivars for resistance to aphids and *Maruca*, and some sorghum cultivars to sorghum shootfly and stem-borers. The susceptible and resistant cultivars identified will be used in crosses for genetic studies.

THE SORGHUM SHOOTFLY

On the basis of 'dead heart' counts on the main stem and tillers, some resistant cultivars identified were: IS 2146, IS 5613, IS 1044, IS 4660, IS 18361, IS 18363 and IS 18427. The most susceptible were Serena, IS 1522, CSH-1, IS 8595.

STEM-BORER, C. PARTELLUS

The same set of 25 sorghum cultivars were also evaluated for stem-borer resistance. Based on the tunnel length, the cultivars such as IS 5613, IS 1044, and IS 18489 were found resistant to *Chilo* damage. The cultivar IS 8595 was found to be the most susceptible followed by IS 1522 and local variety Serena.

APHIDS

A severe natural infestation of aphids during long rainy season at MPFS made it possible to screen a total of 275 cowpea cultivars. Among the local cultivars Emma-60 was found to be resistant to aphids. Other local cultivars such as Katuli-107, Katuli-108, Machakos-66 and Machakos-68 when attacked, showed total damage. Some of the IITA cultivars, namely Tvx

66–2H, Tvx 337–3F, Tvx 33–iJ and Tvx 2394–02F were found resistant though late in maturity. It was encouraging to note that some F_4 progenies of the cross ivolving Emma-60 with IITA cultivars were found resistant to aphids and appear promising for grain yield/and/early maturity. Among others, Tvx 1999–01F was identified as highly susceptible to aphid attack.

POD-BORER

Maruca infestation was also very severe during the long rainy season of 1981. The pod infestation ranged from 25 to 100% under natural field conditions. The IITA cultivar Tvu 946 appears promising as it showed the lowest pod infestation of 25%. Tvu 946 being the earliest in flowering and maturity, may have escaped the pod-borer attack and hence needs confirmation of resistance. The local high yielding cultivar Katuli-108 and Emma-60 appear to possess some tolerance. Most of the selected IITA cultivars were found to be highly susceptible to pod-borer attack. It may be encouraging to note that some F4 progenies involving Emma-60, Tvu 1509 and other cultivars appear promising for resistance to *Maruca* attack and show high yield potential and earliness.

INTERCROPPING EXPERIMENTS

PEST COMPLEX WITH ECOSYSTEM OF MAIZE, SORGHUM AND COWPEA

The main objectives of this experiment are:

(1) to standardize sampling procedure in intercropping experiments;

(2) to assess pest complex within a mixed ecosystem of maize, sorghum and cowpea; and

(3) to test the influence of the spatial pattern of different plant species on the pest abundance within the intercropping system.

The experimental material included the early maturing cultivars of maize (Katumani), sorghum (Serena) and local cowpea (ex-Luanda). They were planted in monocrop, dicrop and tricrop combinations. Target insect pest species monitored were categorized into three: specialized feeders, *M. testulalis* and *A. soccata;* relative specialist feeders, *B. fusca, C. partellus, S. calamistis* and *E. saccharina;* and general feeders, *Spodoptera littoralis, Heliothis armigera* and *Aphis* sp.

AFRICAN ARMYWORM RESEARCH PROGRAMME

Research on the African Armyworm has remained at low ebb during the year with no new investigations started. The remaining two scientists were winding up their work, prior to the expiry of their contracts at the end of the year. Although the study of techniques for determining the physiological age of armyworm moths was not completed, it has provided the basis for estimating the age of female moths obtained in the moth trap network, widespread in many African countries. With further refinement this method is being used to provide consistent results for moths up to 48 h old. It gives an indication of the distance of moths from the source based on various assumptions derived from other studies of moth flight. The most useful parameter is the width of the developing ova in the proximal follicles of the ovarioles.

Cynodon dactylon grass is superior to all other host plants for *Spodoptera exempta*. It is the preferred grass in choice experiments in the laboratory and in mixed pastures in the field. Star grass is the natural habitat for low-density populations of armyworm caterpillars, and the parts of grasses with high nitrogen levels are preferred. This may have some importance in understanding the common occurrence of outbreaks of caterpillars on new flush of grasses with high nitrogen content; and it also raises speculation about the consequences of applying nitrogenous fertilizers to cereal crops.

Field surveys by scientists in collaborating institutes and organizations, (COPR, KARI and DLCO-EA) have shown that armyworm moths and caterpillars are present during the off-season in Kenya, particularly in the *C. dactylon* pastures in the uplands where grasses are green throughout the year. Population studies are therefore necessary to measure their abundance and distribution and to assess their significance.

LIVESTOCK TICKS RESEARCH PROGRAMME

INTRODUCTION

Ticks are found in all areas of Africa which are suitable for livestock including approximately 10 million km^2 presently infested with tsetse, and livestock production is seriously affected because of disease transmission and debility caused by tick infestation.

The most important diseases transmitted to cattle by ticks are theileriosis, anaplasmosis, babesiosis and ricketsiosis all of which occur throughout the continent. Theileriosis caused by *Theileria annulata* occurs in North Africa and extends into Sudan. Theileriosis caused by *T. parva* and *T. lawrencei* occurs in East, Central and parts of Southern Africa. Drugs and methods of vaccination have been available for sometime for the control of anaplasmosis, babesiosis and ricketsiosis. Work was carried out by the UNDP/FAO Regional Project (Research on tick-borne diseases and tick control) RAF/67/077 from 1967 to 1977 at Muguga in Kenya, and since then continued at the Veterinary Research Department of the Kenya Agricultural Research Institute (KARI) and at ILRAD Nairobi. As a result curative drugs and experimental vaccine against East Coast Fever (ECF) have been produced. Successful field trials with the experimental vaccine have been carried out in Kenya and Tanzania, and plans are in hand to carry out extensive trials in western Kenya and in coastal province. In addition, a DANIDA/FAO project has been established in Malawi which is expected to produce ECF vaccine for Malawi and neighbouring countries. A successful field trial has recently been carried out by the staff of the Veterinary Research Department, Muguga, in western Kenya using two curative drugs against ECF.

The traditional method for controlling ticks and the diseases they transmit is the close interval application of acaricides in dips or sprays to livestock. To control ECF, two weekly applications are necessary. This procedure has many disadvantages: the high cost of installing, maintaining and staffing dips and spraying races, the high cost of acaricides, the development by the ticks of resistance to acaricides, high levels of acaricide residues in beef and dairy produce. But perhaps the greatest disadvantage of using acaricides for the control of ticks is the fact that an inherently unstable situation results where regularly dipped cattle are completely susceptible to disease and naive to tick infestation. If for any reason acaricide application fails, catastrophies can occur. This happened recently in Zimbabwe on a very large scale when acaricide control broke down as a result of hostilities, and more than 1 million cattle died of tick-borne diseases and debility caused by massive tick infestation.

At a recent conference on theileriosis at ILRAD in Nairobi, attended by delegates from many countries in Africa and elsewhere, concern was noted regarding the present situation of using acaricides to control ticks and great support was given for the development of biological methods to control ticks, to be used in conjunction with curative drugs and vaccines against the tick-borne diseases. It was considered that such an integrated approach would create a stable situation which would obviate most of the disadvantages associated with the use of acaricides.

What are the prospects? As stated above, curative drugs and vaccines are now or shortly will be available for the control of the diseases of cattle transmitted by ticks. In addition, it has been known for many years that cattle can be made resistant to ticks, and the technique is now being used in Australia to control *Boophilus microplus*, the vector of babesiosis.

Bovine resistance to tick infestation was reported in the early part of this century and it was found that cattle in Queensland, Australia developed resistance to *B. microplus* following infestation. However, it is only within the last 10 years that this finding has been applied in the field, necessitated by the widespread development of resitance to acaricides by *B. microplus* and made possible by the availability of curative drugs and a vaccine for the control of babesiosis. Over the years, a great deal of work has been carried out on this subject but very little in Africa.

CATTLE RESISTANCE TO TICKS

Investigations were started at the ICIPE in an attempt to produce resistance in cattle to ticks. All of the work so far has been done on *R. appendiculatus* because of its importance as a vector of *T. parva* and because of its widespread distribution in East, Central and Southern Africa.

Following the Australian work, it was quickly found that cattle become resistant to *R. appendiculatus* when approximately 500 adult ticks are allowed to feed on them. Resistance also develops when cattle are exposed to ticks in paddocks. Resistance has been produced in *Bos taurus* as well as in *B. indicus* cattle, and is long lasting — at least 2 years.

Resistance appears to be stimulated in cattle in response to antigens inoculated in the saliva of the feeding tick. When ticks feed on a resistant animal, they excrete antigens in the saliva. These antigens stimulate an immediate type hypersensitivity reaction, and marked swelling occurs at the site of attachment of the tick, within 20 min of attachment. This reaction interferes with the ability of the tick to feed properly. The effect is most marked against larvae, less against nymphs and least against adult ticks. In highly resistant cattle, very few larvae, less than 25% of nymphs and less than 50% of adult ticks are able to complete feeding, and the engorged weight is also reduced. The smaller ticks which are produced after moulting have a reduced survival potential when exposed to temperature and humidity stress and the females produce smaller egg batches.

Two experiments have been carried out which demonstrate that resistant cattle can control field populations of *R. appendiculatus:*

(1) Individual tick-naive cattle were exposed in each of five paddocks infested with ticks. Initially, the tick populations in each paddock increased and reached a peak after 9 months, when hundreds of adult ticks were seen on the cattle. Thereafter, the ticks decreased in number and after 2 years had almost disappeared. On removal from the paddocks the cattle were found to be highly resistant.

(2) In the second experiment, a pair of resistant cattle were exposed in a paddock infested with larval ticks, and pairs of tick-naive cattle were exposed successively in a similar paddock. Thousands of adult ticks were produced in the tick-naive cattle paddock and very few adults in the tick-resistant cattle paddock.

Another important finding is that tick-resistant cattle infected with ECF, greatly affect the infection rates in larvae or nymphae which feed on them, resulting in reduced transmission of the disease. It is probable that resistance to ticks in cattle will enhance the efficacy of vaccination against ECF by reducing challenge.

Another approach to produce resistance in cattle depends on the observation that bovine gamma globulins ingested by

ticks pass unchanged from the tick blood meal into the haemolymph. When target antigens from the ticks are inoculated into rabbits or cattle, antibodies are produced against the target antigens. When ticks are fed on these animals, a high tick mortality results and the reduced numbers of female ticks which do engorge, either do not lay eggs or produce eggs which have markedly reduced viability.

Finally, it has been established that cattle quickly become resistant to infestation with *R. appendiculatus* after a relatively small number of adult ticks have fed on them and it is probable that this resistance can be enhanced by inoculation of target antigens from ticks into host cattle. Furthermore, it has been demonstrated that when resistant cattle are allowed to graze in *R. appendiculatus* infested paddocks, and no other host animals are available for the ticks to feed on, the tick population falls to very low levels and might even disappear. As a result of these findings, the ICIPE group has been invited to cooperate with colleagues from the Kenya Agricultural Research Institute (KARI), and from ILRAD to carry out trials using tick resistant cattle, vaccinated against East Coast Fever and exposed to challenge in enzootic areas in Western and Coastal Province in Kenya.

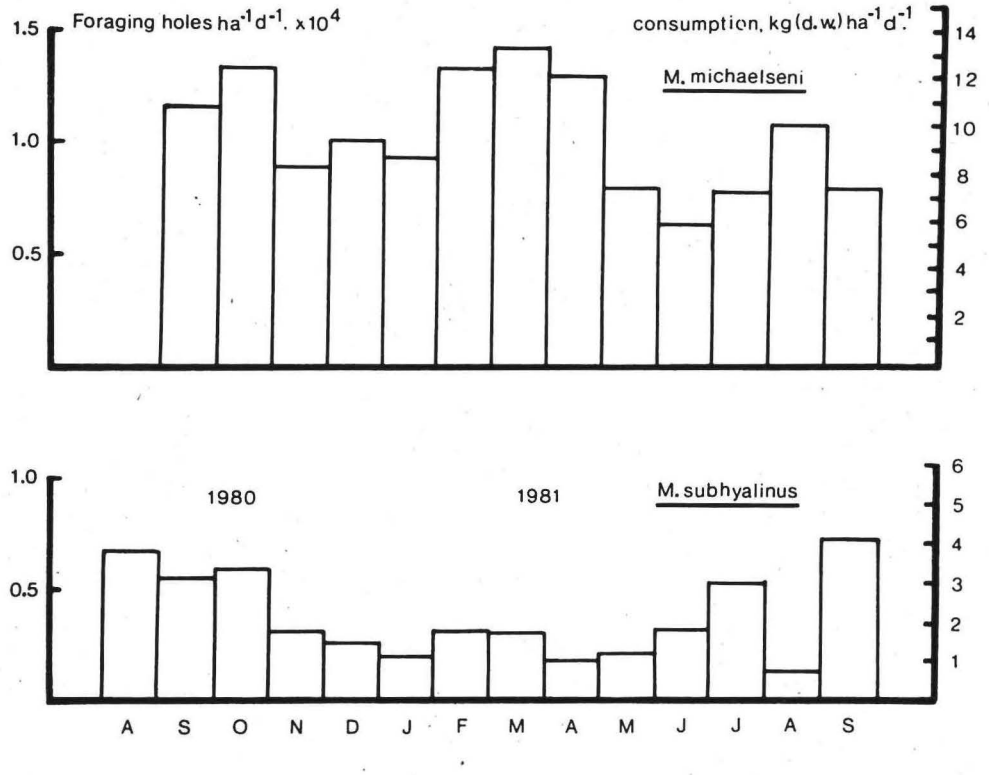


Fig. 1. Comparison of foraging activity and offtake by two species of *Macrotermes* in Kajiado District.

TSETSE RESEARCH PROGRAMME

INTRODUCTION

During 1981 the Tsetse Research Programme pursued its activity through its three projects: Ecology, Reproductive Physiology and Trypanosome-Vector Physiology.

Studies of the ecology of *Glossina pallidipes* on the South Kenya Coast have continued. Analysis of the bulk of data collected for several years is underway in order to elucidate mechanisms of population fluctuations in relation to density-dependent and density-independent factors. The studies undertaken in the Lambwe Valley in 1980 and 1981 were interrupted due to tsetse control measures applied to stop an outbreak of sleeping sickness. However, in collaboration with the authorities, an entomological evaluation of the effectiveness of spray operation was made on a monthly basis. Trapping trials have continued, using cylindrical revolving screens as attachment to the biconical trap to improve trap performance.

In the Reproductive Physiology Project, experiments have been pursued to investigate the role of juvenile hormone (JH III) in the control of egg maturation, and the effect of precocene on corpus allatum. Studies have been undertaken on the effect of feeding males and females on rabbits immunized against various reproductive tissues from males. In addition, preliminary observations have been made on immunomechanisms in tsetse.

In the Trypanosome-Vector Physiology Project, experiments have been carried out in order to determine the part played by temperature and the number of *Trypanosoma (Trypanozoon) brucei brucei* in the vectorial capacity of *G. morsitans morsitans*, and the effect of proteolytic enzyme on the survival of trypanosomes ingested by young tsetse. Studies on the sensitivity of trypanosome-infected *G. m. morsitans* to toxic substances have been extended to include female flies and natural pyrethrin.

After 4 years of successful *in vitro* cultivation of *T. brucei* studies now concentrate on the metabolism of this microorganism. Epidemiological surveys have been carried out in the Lambwe Valley after the recent outbreak of sleeping sickness, while on the South Coast, patterns of trypanosome infections in *G. pallidipes* have been assessed in various habitats with different host availabilities.

TSETSE ECOLOGY

TSETSE ECOLOGY ON THE KENYA COAST

Studies of the ecology and behaviour of *G. pallidipes* on the south Kenya coast have continued. Emphasis has been placed on the investigation of the population dynamics of this tsetse through a comparison of the characteristics of population at different localities and detailed monitoring of selected populations. Many aspects of this work are a continuation of preliminary investigations in the ICIPE and this study has now entered a phase of consolidation and analysis of field data.

The investigations have been aimed at understanding the processes involved in the natural regulation of the numbers of tsetse at different localities on the south Kenya coast. This will show why population densities differ at different localities and what factors govern the fluctuations of these populations. Mortality factors act at all stages of the tsetse life cycle, but the studies to date have only considered what is happening to adult tsetse and in particular to mature females since these are the productive members of the population.

The sampling project was based on the use of biconical traps, which capture *G. pallidipes* in large numbers. Continuous, monthly (4 days in 28 days) observations were completed for 33 months at Muhaka and 21 in Shimba Hills. Occasional or shorter series of observations were also made at Diani, Mwalewa and Ukunda.

When the relative density, survival rates and month to month fluctuation in relative density of the different tsetse populations are considered, a number of points suggested in previous reports have become clear with the accumulation of more data. Fluctuation in numbers of males and females roughly parallel each other. Minor differences may be due to the shorter life-span of males. Population changes at different localities are not synchronized, despite the fact that the study sites are very close with marginal climatic differences between them. Each population has its own characteristic equilibrium level although there may be considerable fluctuations about this mean population density. This suggests that factors determining the equilibrium level of each population may be operating at other stages of the life cycle of this tsetse. Although mean population densities differ significantly between sites, mean survival rates are virtually the same. There is a relationship between population changes and the survival of adult female *G. pallidipes* at Muhaka, but this relationship is less clear at other localities.

Mortality of tsetse is affected by abiotic and biotic factors. The abiotic or climatic factors mainly act independently to density. Their effect is often termed Density-Independent Mortality (DIM). As noted in previous reports, there is a relationship, at Muhaka, between rainfall and change in population density. Rainfall between 50 and 200 mm, for 28 days, creates optimum conditions and the population almost invariably increases. With more or less precipitation, numbers generally decline, with higher adult mortality. Although the main climatic effect is almost certainly saturation deficit rather than rainfall, these observations do indicate that climatic factors, acting as DIM can contribute to the fluctuation in apparent density of tsetse at the study sites.

The biotic factors — predation parasitism and competition, act with increasing severity as population density increases and their effectiveness is described as DensityDependent Mortality (DDM). There is a relationship between change in density and apparent density of the *G. pallidipes* population at Muhaka. This indicates the density relatedness of some of the components involved in the regulation of adult tsetse population on the Kenya coast. The relationship between apparent density and survival of a population shows that survival rates are optimal about the mean population level (Fig. 1). Lower survival rates at higher densities indicate DDM factors coming into play. However, they appear to come into operation at a different density at each locality, suggesting that these processes are different, or at least operate in a different way at each site.

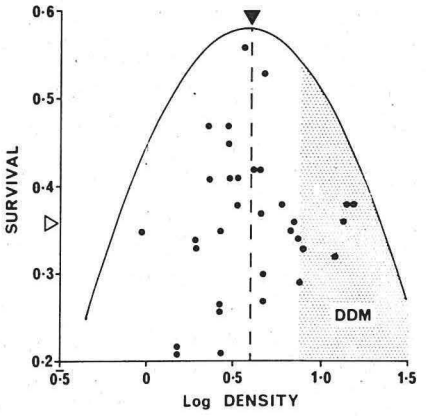


Fig. 1. Relationship between log apparent density and survival of female *G. pallidipes* at Muhaka. Lower survival rates at the higher densities indicate the influence of density dependent mortality (DDM) factors.

Although the fluctuation in numbers of adult tsetse can, to a large extent, be explained on the basis of the results outlined above, they cannot account for differences in population density of *G. pallidipes* at different sites. If young adult tsetse are considered, two categories can be recognized in females before their first ovulation: Oa teneral and Ob non-teneral. These tsetse are poorly represented in biconical trap catches and the numbers in these two categories do not reflect their true relative numbers. Nevertheless, the difference between the two age groups, if sampling biases are the same, will give an

indication of the relative survival from Oa to Ob at different localities. There is a clear inverse relationship between the proportion of Oa females in the catches and apparent density. Highest mortality rates are observed in the lowest density population. Newly emerged tsetse have limited food reserves and are very susceptible to stress. Host animals seem less abundant in areas with low tsetse densities and this factor, resulting in a greater delay between emergence and finding a first blood-meal, may be critical for the survival of newly emerged flies. This is the first indication of a factor which could explain differences in population size between different localities.

A number of mark-release-recapture trials have been carried out on the *G. pallidipes* population at Diani. This semi-isolated tsetse population is associated with 10 ha forest relic. Although wild pigs and small antelopes are still present, a single small herd of cattle is occasionally grazed around the forest edge. The results of the mark-release-recapture experiments are providing data on tsetse population size in relation to apparent density assessed from the catch per trap per day and true sex ratios which seem similar to those observed in the trap catches. An attempt has been made to integrate these ecological techniques with the epidemiological work to estimate the number of trypanosome-infected bites received by the cattle grazing around this forest. It was estimated that each cow received from *G. pallidipes* one infective innoculum of *T. congolense* every 5.8 days during the first experiment and 4.1 days in the second.

THE ECOLOGY OF G. PALLIDIPES AUST. IN THE LAMBWE VALLEY, SOUTH NYANZA

The planned long term study of the ecology and behaviour of *G. pallidipes* in the Lambwe Valley, started in August 1979, was terminated prematurely in February 1981. The Kenya Government authorities, in response to a serious epidemic outbreak of Rhodensian sleeping sickness in the valley during 1980, undertook measures aimed at eradicating the vector from the valley and its environs. Operations were based on sequential aerial applications of endosulfan aerosal, backed by ground spraying of residual dieldrin and bush clearance in areas of difficult terrain. While eradication was not in the end achieved, the population was reduced by over 99.5% which effectively precluded further studies of an ecological nature. The data obtained to date, relating to population dynamics, feeding behaviour and mark-release-recapture studies, are now in the process of being analysed.

In collaboration with the authorities, an entomological evaluation of the effectiveness of spraying operations was made. This was done by monthly sampling, using biconical traps, in three localities characterizing the principal habitat types of *G. pallidipes* in the Lambwe Valley: thicket, acacia woodland and coniferous plantation. On the basis of the standard evaluation technique of ovarian age-grading of female flies caught, in relation to the timing of spray applications, it was found that some adults were unaffected by spraying in all three localities. The measures were particularly ineffective in the coniferous plantation. This was because of the technical problems associated with aerial spraying in the hilly terrain on which they plantation is located and the difficulty of achieving adequate spraying droplet penetration beneath the canopy of the conifers.

Post-spray monitoring to date (September, 1981), indicates that the population is recovering, albeit slowly at present. In the possible absence of future anti-tsetse measures, monthly sampling will continue in order to assess the rate of recovery and to predict duration to full re-establishment.

In view of the unlikely recovery of the population in the short term and the unpredictable epidemiological situation in the Lambwe Valley which may necessitate further tsetse control measures, it has been decided to transfer the operations of the Lambwe Valley Tsetse Ecological Research Team to the Nkruman *G. pallidipes* fly belt near Lake Magadi in the Rift Valley Province. Steps are underway to establish the necessary basic support facilities there.

Our field and laboratory investigations, in collaboration with the Insect Pathology Unit and the Fine Structure Unit, on the phenomenon of cuticular lesions on *Glossina* species have been concluded. Lesions present on the ventral abdominal integument are common among tsetse in Kenya. They occur in all species *(G. pallidipes, G. swynnertoni, G. austeni, G. fuscipes, G. brevipalpis* and *G. longipennis)*, and in all populations of species sampled from areas widely apart. While considerable variation exists in number and size of lesions, four or five basic forms are distingished: small pits; raised, irregular shaped scabs or warts; tumour-like eruptions of soft cuticle with a hard black melanotic core; a round shallow disc and flat plate-like forms; and necrotic tracks or striations, running anterior-prosteriorly. Between species, the occurrence of lesions ranged widely from 3 to 72%. Monthly monitoring of *G. pallidipes* populations in the Lambwe Valley over twelve months indicated that sex, seasonal and locality differences in incidence of lesions were related to the population age structure, being more common in older flies. Microbiological and histopathological studies have failed to implicate bacterial, fungal or viral microorganisms in lesion formation nor was there any evidence of transmissibility when purified suspensions of macerated cuticular lesions were applied by various pathways to labortory-reared, newly emerged *G. morsitans.* Lesion formation and subsequent melanization apparently result from integumental injury caused by non-infectious agents in the natural environment. Instances of penetration of the integument by foreign bodies have been observed in wild flies, and most forms of lesion can be induced by artificial wounding in the laboratory.

REVOLVING TRAPS FOR G. PALLIDIPES

A revolving screen around the base of the biconical trap has been developed and used for sampling *G. pallidipes*, and a range of speeds, namely 15 revolutions per minute (rpm) 20 rpm, 35 rpm, and 40 rpm have been used. A similar trap with screens revolving at 20 rpm showed promise in capturing tsetse of age grades that were closest to theoretical lifetable structures, although the total yields of the trap were less than those of the ordinary stationary trap. These observations are based on one study area only — Nkruman escarpment in the Rift Valley.

When the flat revolving screens were replaced with cylindrical ones and tested, stationary devices, with flat or cylindrical attachments, gave higher catches than any other. The stationary flat screen yielded even higher numbers than the ordinary standard biconical trap. The total yields decreased with the speed of revolutions and 75 rpm gave the lowest numbers. However, the 20 rpm performed better than the 15 rpm trap.

The age structure of females from all stationary traps was similar with a large number of old flies. High speeds of revolution, e.g. 40 rpm and 75 rpm, considerably improved catches of very young flies, but not those of older females. The optimum for getting a lifetable-like curve of age grades was still 20 rpm of flat screens, and 35 rpm of cylindrical screen. Flies caught by traps with cylindrical screens at speeds (40 rpm, 75 rpm and stationary) are not significantly different in age structure from those by traps with flat screens at the same speeds.

The highest number of females carrying fully developed larvae with black breathing lobes were captured by stationary traps of both flat and cylindrical screens. The proprotion of females with empty uteri due to both abortions and after larviposition was rather high in fast moving screens.

There was no significant difference in fat reserves between the individuals captured in revolving flat screens and revolving cylindrical screens. However, flies from stationary traps had lower fat reserves (not significant) than those from revolving traps.

REPRODUCTIVE PHYSIOLOGY

CONTROL OF EGG MATURATION IN G. M. MORSITANS

The corpus allatum (CA) produces the juvenile hormone (JH) in insects. In the adult state of most insects, JH is the gonadotropin that stimulates oocyte maturation, particularly the vitellogenesis. In some insects, the egg development neurosecretory hormone (EDNH) stored in the neurohemal organ, corpus cardiacum (CC), acts as a gonadotropin. Available evidence of the role of JH and neurohormones in the egg maturation process of *Glossina* is rather scanty and confusing. Allatectomized females produce at least some progeny before they stop giving birth. Ablation of median neurosecretory cells of the brain has little effect on the rate of egg maturation in *G. austeni.* Additionally, in the maturing oocyte of *G. austeni*, spaces between the cells of the follicular epithelium do not appear during the vitellogenesis. In most insects studied, the appearance of vitellogenetic protein, is regulated by JH. Thus it appears that, unlike in most other insects studied, the vitellogenesis is independent of JH in *Glossina.* What then is the role of JH in the egg maturation process of *Glossina?* And how do the brain neurohormones influence the development of tsetse egg?

Results of our experiments showed that the females allatectomized 12 h after emergence developed mature follicles in all four ovarioles in about 37 days. About 40% of females which were allatectomized 6 h after emergence failed to develop mature follicles in at least two ovarioles (third and fourth) of most of the insects. These eggs did not develop past previtellogenic stage. In contrast, flies that had their CA-CC complex removed 12 h after emergence failed to mature the third and fourth eggs. They completed the previtellogenic stage but did not undergo yolk incorporation. Females allatectomized at 1 h after emergence and subsequently treated with JH III developed the third and fourth eggs in about 30 — 70% cases, respectively. In contrast, JH III treatment of flies lacking the CA-CC complex did not produce any more eggs than the control insects.

It is therefore clear that JH is not required for vitelogenesis in *G. m. morsitans* but is perhaps an important factor in previtellogenic development of the oocyte. The JH probably activates a particuar stage during previtellogenesis and once the follicle is activated and allowed to pass the JH dependent stage, the vitellogenesis proceeds. A neurosecretory factor from the neurohemal organ of tsetse (comparable to EDNH) probably induces the final stage of previtellogenesis to undergo vitellogenesis.

PRECOCENE-INDUCED STERILITY IN F_1 GENERATION OF G. M. MORSITANS

Precocene treatment of female *G. m. morsitans* does not disrupt its reproductive cycle but some F_1 females produced are sterile and their ovaries contain only germaria (ICIPE Annual Report, 1980). Further studies on the effects of precocene on female tsetse suggest that the 'critical' time for precocene action appears to be related to each ovulation and precocene could have its effect on the recently fertilized egg which could ultimately give rise to an adult female. Furthermore, each application of precocene, made either at the time of ovulation of the first egg or subsequently after each larviposition, holds good for one reproductive cycle only. The occurrence of retardations/abnormalities in ovarian development among F_1 females, in addition to the total absence of oocytes in vitellaria has enabled the characterization of stages in development of ovarina follicles in *G. m. morsitans.*

It was reported earlier that JH III reduced the incidence of sterility in F_1 females. However, in the later investigation, initial sterility of females was not established and it is possible that these females already had oocytes in their ovaries at the time JH III was applied. Similar experiments were repeated with juvenile hormone analogues after sterility of the

females was established. Topical application of ZR 512 and ZR 515 did not promote follicle development even 37—39 days after adult emergence. However, these compounds appeared to influence the development of the milk gland in sterile females.

Although precocene did not induce degeneration of corpus allatum of treated 'mothers', the corpus allatum of her sterile offspring appeared relatively inactive and degenerate. Toluidene blue stained semi-thin sections and electron micrographs suggest that the gland had undergone some degree of degeneration and that they were not active at the time of fixation.

STUDIES ON MALE G. M. MORSITANS

Antibodies were raised in rabbits against some components of the reproductive organs and fat body of male *G. m. morsitans* to study the effects of ingested antibodies on the development of abnormalities/lesions in tsetse fed on immunized rabbits. Larviposition was normal and there was no significant mortality among male or female parents. Pupal development, spermatogenesis, accessory gland development and inseminating ability of F_1 generation from parents fed on immunized rabbits were similar to those of controls.

Pharmacological studies on the mechanisms involved in the release of accessory gland material during copulation are being continued.

DEVELOPMENT OF TSETSE BIOCONTROL METHOD

Groups of 50 female teneral *G. morsitans* were maintained for two successive generations (F_O and F_1) on rabbits immunized with homogenates of whole crude tsetse (WCT), engorged tsetse guts (ETG), gravid tsetse uteri (GTU) or on untreated control rabbits. It was confirmed both by immunodiffusion and by immunoelectrophoresis that these tsetse-derived antigens provoked a strong antibody response in the inoculated rabbits. No mortality occurred in the flies maintained on the immunized rabbits but a decrease in fecundity and in mean pupal weights, and a slight increase in pupal mortality were observed. In the two fly generations (F_O and F_1), a total fecundity decrease of approximately 31%, 36% and 47% were observed in the CWT, ETC and GTU groups respectively when compared with the controls. The overall decreases in the mean pupal weights in F_O and F_1 generations were approximately 12%, 9% and 12% for CWT, ETG and GTU groups respectively. No pupal mortality occurred in the pupae of F_O flies, but in the F_1 generation alone, a pupal mortality of approximately 7, 18, and 8% were observed in the CWT, ETG, and GTU groups respectively.

These observations strongly suggest that this immunological technique, if improved, e.g. by using purified insect antigens may prove to be useful for tsetse control. This view is strengthened by the fact that different fly generations feeding on the same immunized animals are affected. These observations suggest that if the animals preferred by the flies as the source of blood meal within an isolated tsetse infested area are immunized, the fly population will presumably decrease progressively. Lastly, it should be born in mind that these data were obtained from a laboratry colony under ideal conditions and that in the field where adverse conditions exist, it is likely that pathological effects on both flies and pupae will be even greater.

TRYPANOSOME-VECTOR PHYSIOLOGY

TEMPERATURE EFFECT ON THE VECTORIAL CAPACITY OF G. M. MORSITANS

A variety of factors have been suggested to account for the variable trypanosome infection rates observed in the tsetse following engorgement on *T. brucei* infected animal. In this exercise the intention was to see if there was a difference in the infection rates between flies fed directly on the bellies (the number of trypanosomes circulating in the veins per unit time may not be uniform or constant) of infected

rats and those fed through silicone membrane on the same population of trypanosomes suspended uniformly in defibrinated rat blood.

It was interesting to note that among the control group of membrane fed flies, the number of infected flies remained remarkably constant (12%) regardless of the height of parasitaemias. On the other hand, flies cooled 6 h after engorgement showed a steady increase (from 6.5 to 21%) in infection rates. No consistent results were obtained with flies cooled immediately after engorgement, although the highest infection rates (31.5%) were observed among this group. Flies fed on the bellies of infected rats gave variable results.

ESTIMATION OF THE LEAST NUMBER OF T. BRUCEI INFECTIVE TO G. M. MORSITANS

The observation that *in vitro* feeding gave more consistent results than the *in vivo* method, made it important to see if it was possible to determine the least number of trypanosomes that would initiate an infection in a tsetse. The number of flies which showed salivary gland (mature) infection did not differ substantially whether the source was 3.3×10^{1} or 3.3×10^{5} organisms/ml. Nevertheless, there was a significantly higher incidence of immature (gut) infections when the source was 3.3×10^{5} organisms/ml.

RELATIONS BETWEEN PROTEOLYTIC ENZYME ACTIVITIES AND THE SURVIVAL OF T. BRUCEI BY YOUNG G. M. MORSITANS

It has been demonstrated that ingested bloodstream form of *T. brucei* influenced the activity of proteolytic enzyme (trysin) in young female *G. m. morsitans.* The decrease in enzymic activity is thought to be caused by the presence of trypanosomes. It is postulated that the enzymes are being utilized in the lysis of trypanosomes. In order to examine this possibility, young *G. m. morsitans* have been exposed to rats infected with *T. brucei* at various parasitaemic levels and enzyme activities of trypsin and aminopeptidase monitored over a 4 h period after trypanosome ingestion.

No significant differences were observed in aminopeptidase activities between control and flies which ingested trypanosomes, nor was there a difference between day 3 and 5 infections. Trypsin activities were constantly higher in control flies than in flies which fed on trypanosome infected blood. The differences were however not statistically significant.

Flies fed on rising parasitaemias (day 3 infections) destroyed almost all ingested trypanosomes within 24 h. On the other hand, flies fed at peak parasitaemias (day 5 infections) destroyed the ingested trypanosomes gradually. The surviving trypanosomes after 24 h of ingestion, were virtually all stumpy in shape. The sharp decrease in the number of slender trypanosomes in both cases indicated that these organisms were more susceptible to the lethal factor in the tsetse midgut.

OXIDATIVE METABOLISM OF METACYCLIC TRYPANOSOMES CULTURED IN VITRO

In the infected mammalian host, *T. brucei* utilizes glucose in the plasma and in about 2 h the parasites can consume glucose equal to their own dry weight. The end product of glucose metabolism is pyruvate. In this way bloodstream forms lack the cytochrome system. Hence in terms of energy conservation they are poor doers, indeed, since only 2 ATP are formed from one molecule of glucose compared to 38 from eukaryotic cells.

The metacyclic trypanosomes we have grown *in vitro* for about 4 years now also utilize glucose to pyruvate (Fig. 2) but also

yield glycerol (ratio of 3:1). The latter product is toxic to bloodstream forms of *T. brucei.* The studies indicate that the infective trypanosomes grown from the vector have a peculiar glucose utilization pathway which would be of interest in the study of mechanism of energy production in *T. brucei* of tsetse origin and bloodsteam forms.

POSSIBLE EXISTENCE OF SEXUAL FORMS OF T. BRUCEI

The possible existence of sexual forms of *T. brucei* and other pathogenic trypanosomes has been in the minds of many investigators for a long time. However, at no time has karyogamy (meiosis) been demonstrated. It has not been possible either to transfer the phenomenon of drug resistance of one strain of the parasite to another showing no resistance.

In our laboratory we have grown *T. brucei* as midgut and metacyclic forms and in both types of parasites a phenomenon was observed that suggested possible existence of sexual forms at light and electron microscopic observations. Two parasites were seen to come into apposition at their posterior ends (Fig. 3). In many cases one of the parasites was smaller or slender than its partner and displayed vigorous twitching movements at the region of the kinetoplast or flagellar pocket of the bigger parasite. Parasites were also seen to lie parallel to each other. Electron microscopic studies showed that the points of contact of the two parasites were either the kinetoplast, flagellar pocket or nucleus. Two of these sites (kinetoplast and nucleus) contain genetic material.

The classic definition of sex requires that a new individual arise by union of two sex cells or gametes. The formation of new individuals was not demontrated in this study

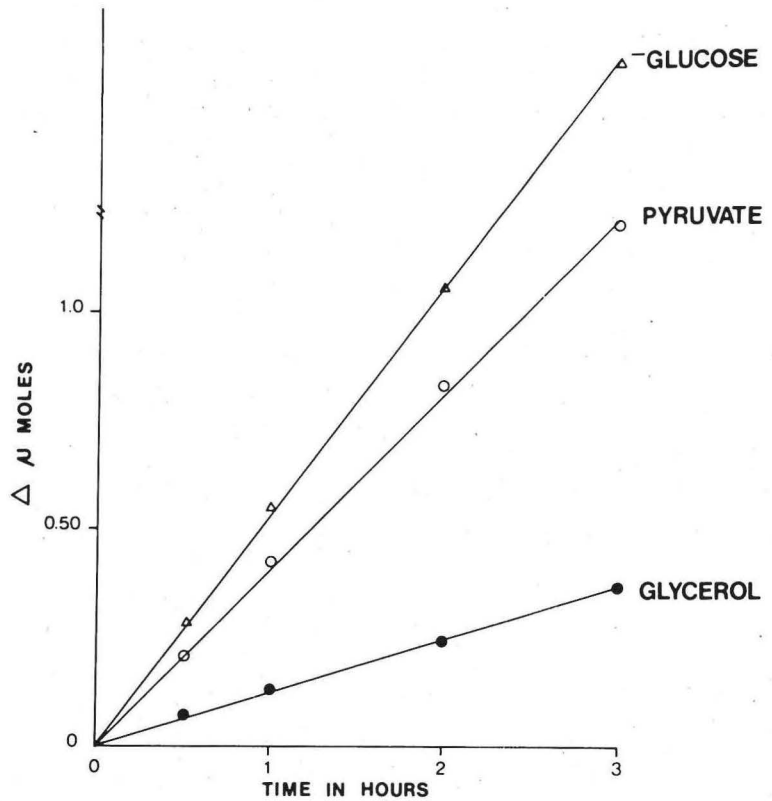


Figure 2. Utilization of glucose and production of pyruvate and glycerol by metacyclic *T. brucei* propagated *in vitro.*

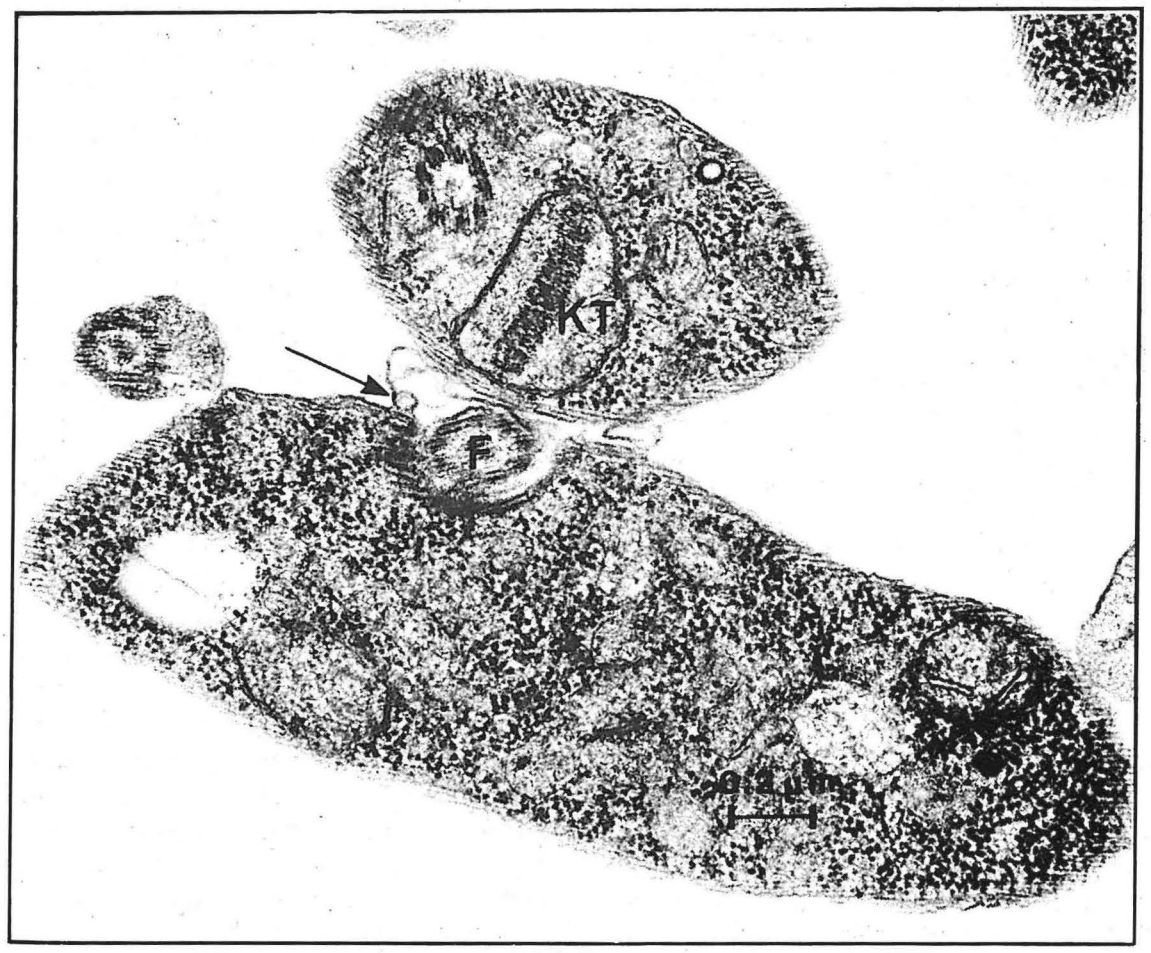


Figure 3. Possible sexual forms of *T. brucei* in culture. Areas of contact were kinetoplast (KT) and flagellum (F). Arrow indicates reflected membrane.

SENSITIVITY OF TRYPANOSOME-INFECTED G. M. MORSITANS TO TOXIC SUBSTANCES, ENDOSULFAN AND PYRETHRINS

We have reported previously (ICIPE Annual Report, 1980) that preliminary results suggested that trypanosome infected male *G. m. morsitans* Westwood were more sensitive to endosulfan than non-infected flies. We have extended our studies to include female flies and another toxic substance, natural pyrethrin. *G. m. morsitans* reared in our insectary were used.

Infected flies of both sexes showed statistically significant increase in sensitivity to both toxic substances. For endosulfan, there was 48% mortality in non-infected males (28 dead out of 58) compared to 90% (18 dead out of 20) for the infected male flies. For the pregnant flies, non-infected flies showed 31% (8 dead out of 26) as compared to 68% (13 dead out of 19) in the infected group. For the pyrethrin extract, there was 14% mortality in the non-infected males (14 dead out of 101) compared to 50% (13 dead out of 26) in the infected flies. In the pregnant female group the mortality was 40% (70 dead out of 175) in the non-infected flies and 59% (17 dead out of 29) in the infected group.

These results support our hypothesis that *G. m. morsitans* with mature salivary gland infections of *T. b. brucei* are not as healthy as non-infected flies. This contention will have to be tested further using other parameters of stress. Nevertheless, the data from this study indicate that

T. b. brucei harms the fly. This view has not been widely held in the past. Several studies have provided data which suggest that trypanosome infections are harmless to the tsetse and may perhaps increase the fly's longevity.

We are continuing to explore changes in physiology and behaviour of infected flies in the hope that this information will provide new insights for trypanosomiasis control.

EPIDEMIOLOGICAL STUDIES

EPIDEMIOLOGY OF HUMAN SLEEPING SICKNESS IN LAMBWE VALLEY, WESTERN KENYA

Lambwe Valley is one of the few areas in Kenya where human sleeping sickness is known to occur from time to time, occasionally reaching epidemic proportions. In June 1980, such an epidemic occurred. This outbreak was described by the local inhabitants as being much more severe than those of the recent past and even children were affected. The involvement of children suggested that the disease is not contracted in the game reserve area only, but active transmission was occurring close to, or in the villages.

Three surveys have been carried out in the Riamakanga area of Wiga, to examine the role of *G. pallidipes* in the transmission of this disease. One survey was carried out during the outbreak of the disease and the other at the beginning of endosulfan spraying operations. The last survey was carried out 6 months after endosulfan spraying. The isolated *T. brucei* sub-group organisms were characterized using isoenzymes and the Blood Incubation Infectivity Tests (BIIT).

During the first survey, four stocks identical to stocks isolated from man in the 1980 outbreak were isolated. During the second survey, one *T. brucei* isolate gave similar enzyme patterns to *T. rhodesiense* isolated from a patient in this area. It was interesting to note that a stock with similar enzyme pattern combination has been found in patients in Zimbabwe. All these stocks are probably man-infective.

PATTERNS OF TRYPANOSOME INFECTION IN G. PALLIDIPES ON THE KENYA COAST

Populations of *G. pallidipes* have been monitored for trypanosome infection rates, factors affecting infection rate and trypanosome species, at five selected localities. These areas were chosen on the basis of habitat with wild hosts. Diani and Ukunda are semi-rural areas with mainly domestic stock and few wild animals. Muhaka is an intermediate situation having both wild and domestic animals. Using biconical traps, *G. pallidipes* has been sampled quarterly, that is during the long rains (May), intermediate rains (August), short rains (November) and the dry season (February). The parasites have been identified through their location in the fly and the age of the female tsetse has been determined using ovarian age-grading techniques.

The trypanosome species observed in order of their abundance are: *Trypanosoma congolense* group, *T. vivax* and *T. brucei*. *T. brucei* is rare, but has been identified in all the study areas except Muhaka. The Blood Incubation Infectivity Test (BIIT) has been carried on some isolates of *T. brucei*. No human strain has been identified on the coast. *T. simiae* has, however, been identified from Muhaka. Since *T. congolense* and *T. simiae* inhabit the same location in tsetse, all infections of gut and proboscis have been included together as *T. congolense*. *Trypanosoma congolense* appears to be stable in the study localities with *T. vivax* accounting for most of the fluctuations.

Although *G. pallidipes* was feeding more on bovids than suids in Shimba Hills, Diani and Ukunda, a lower infection rate was noted at the former. This could be related to the presence of wild hosts

which have lived with the trypanosomes for a long time and may have evolved some immunity to infection. *Glossina pallidipes* in Mwalewa and Muhaka appear to be feeding more on suids.

Highest infection rates were generally observed during the dry season and lowest during the long rains. Trypanosome infection rates increased with the age of the tsetse up to around 70 days beyond which they tended to decline. This suggests that older flies may lose their infection or disappear from the population due to higher mortality.

A detailed study is being made of the situation at Diani. A semi-isolated population of *G. pallidipes* is associated with a small area of forest. Tsetse are feeding both on a small herd of cattle grazed around the forest and on wild pigs using the forest as a refuge. Epidemiological and ecological techniques have been used together to estimate the intervals between infective bites received by each cow per day from *G. pallidipes*. The infection rate in animals has also been determined. Although the cattle are under regular chemoprophylaxis, an infection rate of more than 30% was observed in these animals. Infection rate in wild pigs has been reported to be lower.

Tsetse take more than 50% of their meals from bovids, mainly cattle as the other bovids in these areas come out only at night. Since *G. pallidipes* feed every 3 to 4 days, the observed infection rate of 5% in *G. pallidipes* suggests a considerable barrier to trypanosome infection from the mammalian host to tsetse. Studies are continuing at this locality in an attempt to develop an epidemiological model for this situation.

MEDICAL VECTORS RESEARCH PROGRAMME

INTRODUCTION

The Medical Vectors Research Programme, composed of the mosquito, leishmaniasis and insect pathology research projects has maintained its aim of searching for alternative methods of insect control without using insecticides.

With regard to mosquitoes, carriers of malaria and filarial worms, investigations have been undertaken in the areas of taxonomy, ecology and natural enemies (predators and competitors).

In the taxonomic investigations of the mosquito *Anopheles gambiae* it has been demonstrated that preimaginal (immature) stages, like adults, can be identified using electrophoresis techniques.

Laboratory observations have indicated that a better understanding of the role of salinity in breeding sites could be employed in the control of mosquitoes. In this regard it appears that partial control of the mosquito *Culex quinquefasciatus* could be achieved through an increase in the salinity of its breeding sites. Application of such a control measure is feasible especially along the Kenya Coast where salt is commonly introduced into pit latrines in the belief that salt lowers the water level in latrines. Furthermore, investigations have shown that of the 5 species of mosquitoes which can develop at various ranges of salinity, *Culex sitiens* has the widest range. It has been observed that in the laboratory, female mosquitoes of the fresh water *Anopheles gambiae* complex prefer to oviposit on dark targets, but the preference is overriden by the pale turbid water from natural breeding sites — suggesting that there is a chemical factor involved in the choice of ovipostion site. The prolonged durations of egg viability shows that the ecology of the egg is an important factor in the population dynamics of anopheline preimaginal stages.

Research on the epidemiology of visceral leishmaniasis (kala-azar), transmitted by sandflies, has covered three components namely, the vector, the parasite and the animal reservoir. The investigations have led to two major findings which include the occurrence of leishmanial parasites in the excretory structure, called the malpighian tubules, of two species of sandflies, and the uptake of culture forms (promastigotes) of lizard leishmania by mouse macrophage. While the former finding may lead to the development of a technique for identification of parasites during field work, the latter suggests a possible relationship between lizard and mammalian leishmaniae.

Studies on insect pathogens involved looking at two possible ways of controlling mosquitoes and tsetse flies. These include the possible use of pathogens (fungi and microscoporidia) of mosquito larvae and virus-like particles which infect salivary glands of tsetse flies.

Observations have shown that the fungus *Coelomomyces indicus* can infect freshwater species of the *A. gambiae* complex. These mosquito species together with *Anopheles merus* and *C. sitiens* are susceptible to microsporidia but with low incidence influenced by rainfall and salinity.

Investigations have shown that the incidence of excessive growth (hypertrophy) in salivary glands of the wild tsetse flies, *Glossina pallidipes* is highly variable throughout the year while seasonal variation is slight. The causative virus is infective to *G. pallidipes* through the haemocoel and the mouth parts.

MOSQUITOES

IDENTIFICATION OF SPECIES OF THE ANOPHELES GAMBIAE COMPLEX BY USE OF ELECTROPHORESIS

Electrophoresis of soluble enzyme protein structural products on starch gel is an important tool for identifying morphologically similar species. The advantages of this method are that the genetic appearance of an individual can be scored at a number of loci simultaneously and relative electrophoretic mobilities (electromorphs) usually show simple mendalian inheritance without dominance. More than one member of the *A. gambiae* complex are known to occur in the coastal region, therefore, it became necessary to distinguish the freshwater and saltwater breeding members of the *A. gambiae* complex.

A standard method described in part by both Smithies and Barlow and Ridgeway was used. After electrophoresis the gel was sliced into two equal parts which were used to detect the activity of two enzymes, namely, Octanol dehydrogenase (ODH) and Superoxide dimutase (SOD). In the study using mosquitoes from Jimbo location along the Kenya Coast, it was found that the *A. merus* mosquitoes from salt waters had slower SOD white bands than *Anopheles gambiae sensu lato* from fresh waters. It was established, also, that detection of SOD was a sufficient tool to distinguish fresh water from salt water breeders. This system is valuable in that it makes it possible to identify both the preimaginal and adult (male and female) stages.

ROLE OF SALINITY

Laboratory observations on fresh-water species of the A. gambiae complex, Anopheles funestus and Culex quinquefasciatus. Salinity as a limiting factor in the breeding of these species has not been well documented but is known to have detrimental effects at high concentrations.

Newly hatched larvae of these species were reared up to the adult stage in serial dilutions of 0, 10, 30 and 40% sea water in distilled water. The medium lethal concentrations (LC_{50}) of sea water was also estimated, but for newly hatched larvae only, in the same manner as for larvicides.

Of the various concentrations tested, significant differences in larval survival rate were observed between 0 and 5% for both *A. funestus* and fresh water *A. gambiae* s.l. Significant differences were unnoticed at concentration below 10 and 20% for *A. funestus* and *C. quinquefaciatus*, respectively and between 5 and 10% for *A. gambiae* s.l. Maximum salinities supporting full development for the larvae were 30—40% sea water for *C. quinquefasciatus* and 20—30% sea water for both *A. funestus* and *A. gambiae* s.l. The period to full development of *A. gambiae* s. l. and *A. funestus* was the same in all the different solutions of sea water used, while the average period for *C. quinquefasciatus* was 9 days in all dilutions within the range 0—20% sea water and 12 days at 30% sea water.

LC_{50} of sea water for *C. quinquefasciatus*, *A. funestus* and *A. gambiae* s. l. was 60.3%, 20.3% and 50.5% respectively.

Field observations were undertaken to find out whether there was a mosquito faunal succession and potential dynamics related to salinity variation in a brackish breeding site in Jimbo, a coastal village at the Kenya-Tanzania border. Sampling at 2 week intervals began in October 1980 and ended in October 1981. The immature stages sampled were reared to adulthood for confirmation of identification.

Five different mosquito species were collected during the course of the present work: *Aedes albocephalus*, *A. gambiae* s. l., *C. sitiens*, *Culex thelassius* and *Culex tritaeniornynchus*. *Culex sitiens* occurred

when departing from the breeding site but there is no proof that they had actually developed in the site. Detergent introduction was stopped on 20 January 1981. *Culex cinereus* numbers then increased steadily until the end of our observations in early March.

Thus, it appears that detergents have a detrimental effect on *C. cinereus* and they can prevent this mosquito developing in breeding sites. It also appears that *C. quinquefasciatus* was unable to recolonize the breeding site after *C. cinereus* had been eliminated. In order to explain this, we conducted two series of observations, one on *C. quinquefasciatus* females departing from the breeding site during the period of detergent introduction, the other on the susceptibility of *C. quinquefasciatus* preimaginal stages to domestic detergents. The susceptibility of the two species' preimaginal stages to domestic detergents was compared by rearing batches of 20 first instar larvae in water taken from the lower breeding site at different times through December 1980 and January 1981, i.e. after *C. cinereus* had been eliminated from the site. The effect of detergents was assessed by the pupal productivity. In the controls, pupal productivity was high for both *C. quinquefasciatus* and *C. cinereus*, 94.4% and 81.3%, respectively. In water containing detergent, none of the *C. cinereus* larvae could be reared as far as the pupal stage and only 11.3% of *C. quinquefasciatus* larvae yielded pupae, of which 56% died so that the final pupal productivity was 5%. Thus, even if *C. quinquefaciatus* is less susceptible to domestic detergents than *C. cinereus*, its pupal productivity may be seriously affected as in the present situation.

VISCERAL LEISHMANIASIS

VECTOR STUDIES

Preimaginal stages. The search for breeding sites of various species of sandflies continued at Kibauni, Machakos District (Fig. 1). Several termite hills were opened and soils from them examined for presence of sandfly immature stages. So far no recovery has been made and studies are continuing.

Taxonomical investigations on larval stages of *Sergentomyia* and *Phlebotomus* genera are being carried out, and the preliminary results indicate that there are differences in the sculpture of the eggs among the species examined so far. The apparent differences in egg sculpture may be a valuable tool in the differentiation of sandflies of the *Synphlebotomus* complex. In addition, the chaetotaxy of immature stages is in progress and possible differences among laboratory-reared larvae of 5 species is being investigated.

Laboratory colony. Anthropophilic sandflies which transmit visceral leishmania are abundant in their natural habitat only during the dry season. For research to continue it is necessary to have a laboratory colony of sandflies. Consequently, in collaboration with the Walter Reed Army Research Institute, a laboratory colony of sandflies has been established. With sandflies in the second (F_2) generation to date, the colony contains 200, 230 and 300 *Phlebotomus martini*, *Sergentomyia africanus* and *S. antennatus*, respectively; and a few *S. bedfordi*. The valuable acquisition of the sandfly colony, achieved through experimentation on larval diet and feeding procedures, will make it possible to carry out experimental work on vectorial capacity and taxonomy of Kenyan sandflies.

Pilot studies were undertaken to find out factors which influence the abundance of sandflies inside termitaria. In this regard termitaria which were known to harbour sandflies were watered artificially for 3 months during the dry season. The results showed that there was an increase in the number of sandflies captured from the

watered termitaria, but it was not clear whether or not the increase was due to emergence of the flies which were resting inside the termitaria.

PARASITE STUDIES

Parasite isolation. Dissections of various species of sandflies continued at Kalawa (Machakos focus). In addition, because of the Kala-azar outbreak at Masinga and Kitui (see Fig. 1), comparative studies were carried out in these areas to assess the vector potential. These flies were caught from houses and termite hills and dissected in physiological saline.

In the Machakos focus, promastigotes were encountered in the three species: *Sergentomyia garnhami, S. bedfordi* and *S. schwetzi. Sergentomyia bedfordi* and *S. schwetzi* are mainly reptilian feeders in rock crevices, and since *Leishmania* parasites have been isolated from lizards, it would appear that the parasites are of reptilian origin but determination of the type is pending.

In the Kitui focus more positive species were encountered including *S. garnhami, S. clydei, S. ingrami, S. graingeri, S. schwetzi, S. kirki* and *S. bedfordi.* Blood meals, which have yet to be analysed, have been collected from these areas to assess the hosts the flies prefer to feed on.

VECTOR-PARASITE RELATIONSHIPS

Investigations are being carried out on naturally infected sandflies not only to isolate parasites in search of vectors of human leishmaniasis but also to bring out information regarding the infection rate of leishmanial parasites in sandflies; and the effect (if any) of the parasites on the vector.

Sandflies were captured from their natural resting sites in termitaria at Tseikuru (Kitui District), Msinga (Machakos District) and Marigat (Baringo District). They were processed in the same way as for parasite isolation. From the results obtained, leishmania infections were found in four species of sandflies in three sublocations (Muuna, Nziitu and Ngiluni) of Tseikuru. These species of sandflies included. *S. garnhami, S. kirki, S. graingeri* and *S. schwetzi.* At Masinga, leishmanial infections were found in three species of sandflies namely, *S. garnhami, S. bedfordi* and *S. antennatus.* At Marigat only *S. antennatus* was found. Parasites were found in the abdominal midgut, the hindgut and malpigian tubels. Only *S. garnhami* and *S. antennatus* had parasites in the malpighian tubules. The infection in the malpighian tubules of *S. garnhami* was such that there were parasites both free in the lumen and in close contact with the 'basement mebrane'. Cultures of parasites isolated from the malpighian tubules became positive so that the isolate was stabilized and incorporated in the ICIPE Leishmania cryobank.

Uptake of promastigotes of a lizard Leishmania sp. and L. donovani by mice peritoneal macrophages. Inbred Balb/c mice strain of 7-8 weeks old were injected intraperitoneally with a known quantity of *in vitro* promastigotes of human leishmania *(L. donovani)* and a lizard *Leishmania* species. The peritoneal macrophages of the mice were harvested at different time points after infection and the percentage of infected macrophages was determined after adhering the macrophages onto coverslips and staining with Giemsa. Results showed that when promastigotes were injected intraperitoneally into mice, the rate of infection of macrophages for the lizard *Leishmania* and *L. donovani* (human strain) were not markedly different.

Lizard *Leishmania* sp. assumed rounded or oval shapes similar to amastigotes of *L. donovani* and other mammalian *Leishmania.* After 24 h, intact lizard *Leishmania* parasites could not be seen in the infected macrophage granules and clusters which appeared to be disintegrated parasites were

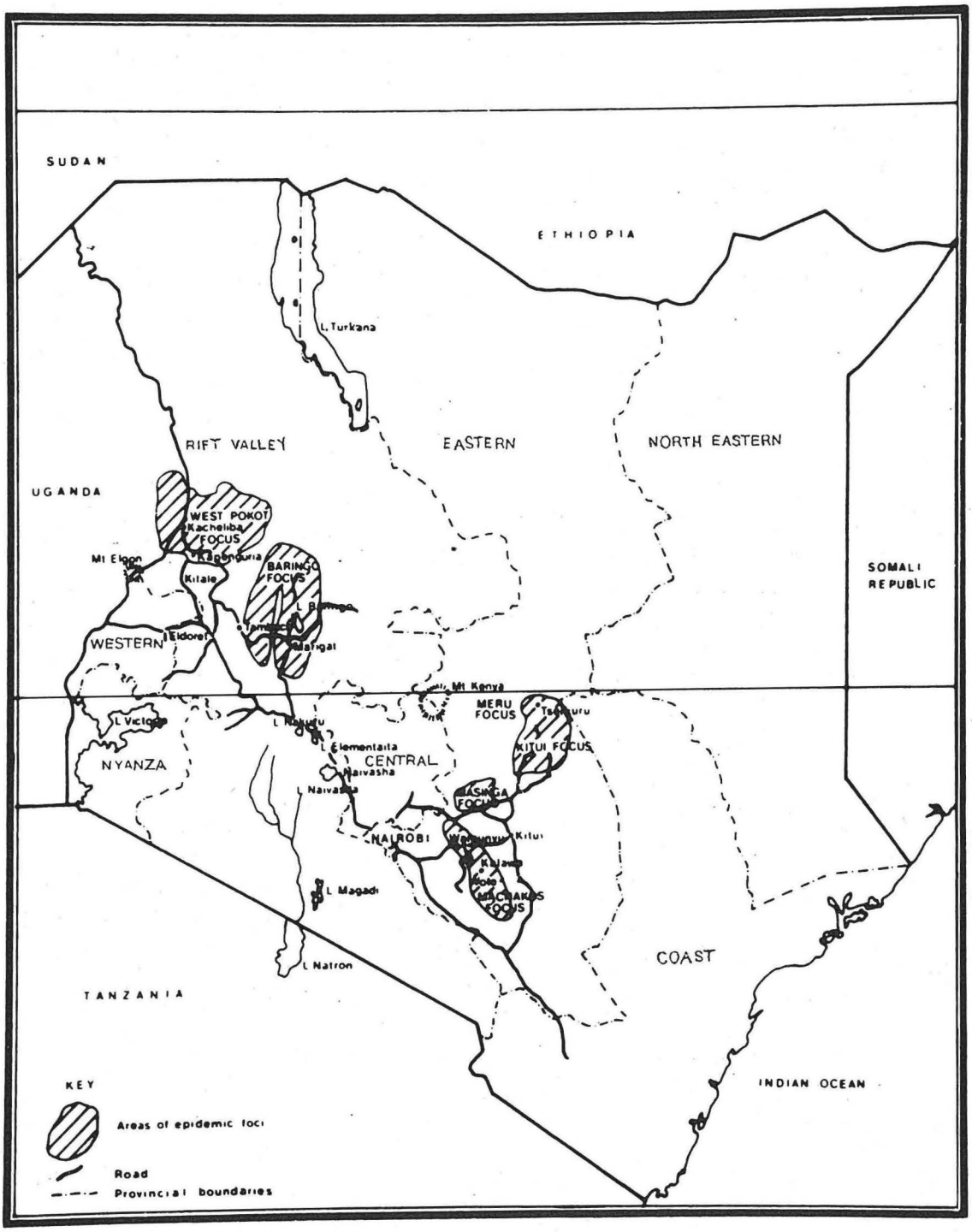


Figure 1. Epidemic foci of visceral leishmaniasis in Kenya.

numerous. *Leishmania donovani* amastigotes were, however, clearly visible at this time.

These results suggest that amastigotes of this lizard *Leishmania* could be encountered in warm blooded mammals in nature. This could also explain partly why transient infections have been reported after some human volunteers and other lower warm-blooded mammals were inoculated with promastigotes of reptilian origin. The transformation of this lizard *Leishmania* sp. into amastigote forms, in mice macrophages which normally support growth of *L. donovani*, is suggestive of some relationship between lizard and true mammalian *Leishmania*. More studies are being conducted to determine the role of reptiles in *Leishmania* epidemiology in Kenya.

Leishmania cryobank. Well-controlled investigations regarding vectorial capability and vector-parasite relationships of various species of sandflies require not only a supply of laboratory-bred sandflies but also a reliable source of known physiological types of leishmania parasites. It was because of this that a system called the 'Leishmania Cryobank' was organized and established in 1979—1980 to make it possible to cryopreserve parasites which are isolated during field work. Between January and October 1981 a total of 23 isolates were made. Stabilates of the isolates were made and incorporated in the Leishmania cryobank.

Serological investigation on Leishmania isolates from Kenya. Leishmania, like other protozoan parasites, consist of a complex series of antingens. Some are species-specific, others are genus-specific and some are shared with related genera. Coss-reacting titres in antigenic analyses are generally lower than homologous titres. Particularly where speciation is actively going on, antigenic differences among emerging strains are to be expected. Studies on antigenic relationships of *Leishmania* are important for strain differentiation and for the development of immunodiagnostic reagents with high specificity.

Human and lizard *Leishmania* strains stabilated as ICIPE 126 and 140 respectively were used as antigen. Large numbers of promastigotes were grown in Dulbecco's Modified Eagle's Medium (DMEM) supplemented with 20% foetal calf serum (FCS). Excreted Factor (EF) of the two species was partially purified from the infected medium. Antisera were raised in rabbits using promastigotes grown in blood-agar (NNN) culture medium.

Using counter immunoelectrophoretic and double diffusion techniques the antigenic differences and/or similarities between the isolates were studied. Preliminary results showed that antiserum to the human isolate does not recognize any antigens or EF of the lizard leishmania. Immunoelectrophoretic studies employing homologous antisera to human and lizard leishmania isolates indicated a number of antigens peculiar to each isolate.

An attempt to develop an immunofluorescence assay for canine antibodies to Leishmania. Isolation of *L. donovani sensu stricto* from dogs in Kenya has raised the question as to whether more dogs from Leishmania endemic areas could have been exposed to or actively infected by the parasite. This study was therefore initiated to screen domestic dogs in endemic areas to establish the degree of involvement in the spread of the disease.

Over 20 dog sera from kala-azar endemic areas were tested for antibodies to *Leishmania* by indirect FA technique. Three sera, which served as positive controls were obtained from dogs with parasitologically proven leishmania infections. Negative sera were obtained from dogs in non-leishmania areas.

Preliminary results showed extensive cross reactivity among the different antisera. Studies are being conducted to perfect the test as a diagnostic tool.

INSECT PATHOLOGY

INFECTION LEVELS OF A PREIMAGINAL POPULATION OF ANOPHELES GAMBIAE S. L. BY THE FUNGUS COELOMOMYCES INDICUS

Of the parasitic fungi known to attack mosquitoes, *Coelomomyces* sp. are among the more promising for use in the control of preimaginal populations by biological agents. A preliminary survey of preimaginal populations of *A. gambiae* s. l. was conducted during two rainy seasons (1980 short rains and 1981 long rains) in the Rabai area (20 km NW of Mombasa). Samples consisted of larvae collected at weekly intervals from a temporary infection pool (Fig. 2). The larvae were inspected microscopically for *C. indicus,* in the laboratory not later than the day after collection.

The highest level of infection recorded in any single monthly sample occurred in 1980 (November) when 82.41% of the larvae were stricken, but infection was generally high in that season. The high levels of infection noted in July occurred when numbers of larvae in the pond were very low. In that month the standard sample of 100 dips yielded 11 larvae out of which nine were infected.

As a part of a long term sampling regime, preliminary results covering two mosquito growing seasons are presented. Although the level of infection during the short rain is higher (71.81%) than the long rain season (53.53%) it is probably premature to say that the reduction in infection level was anything not within the realm of normalcy.

During the course of these investigations it has been noted that infected fourth instar larvae may live for several days, frequently more than 14, without pupating or dying. The extension of this phase of development of larva beyond the usual

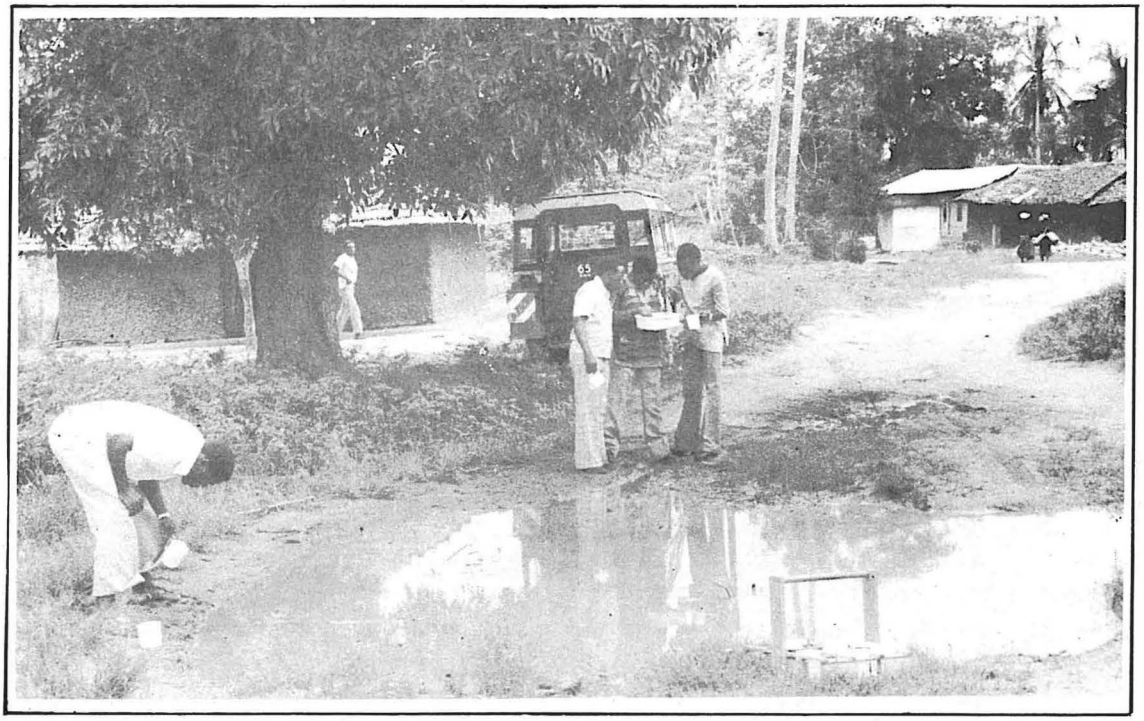


Figure 2. A mosquito *Anopheles gambiae s. l.* breeding habitat: temporary pool, Mwamoni site, near Mombasa.

2 to 4 days, causes an increase in the number of fourth instars over that normally expected to be in the population. The increase is a result of infected fourth instar larvae not leaving the larval population at the normal time, and the proportion of infected larvae in the fourth instar class is thereby increased. Certain researchers are of the view that retaining vector species in the larval stages is a possible control of vector population, as the larvae are exposed to destruction by outside forces, such as predators, wave action and drying of the habitat.

MICROSPORIDIA INFECTIONS OF ANOPHELINE AND CULICINE MOSQUITOES ALONG THE KENYA COAST

The potential of microsporidia as biological control agents has been demonstrated by various researchers using different mosquito species. Microsporidian infections, which may be present at any developmental stage have been reported to have numerous effects on their host. They may reduce the egg-laying capacity, longevity, and resistance of the mosquito to adverse climatic conditions, insecticides, predation and parasitism.

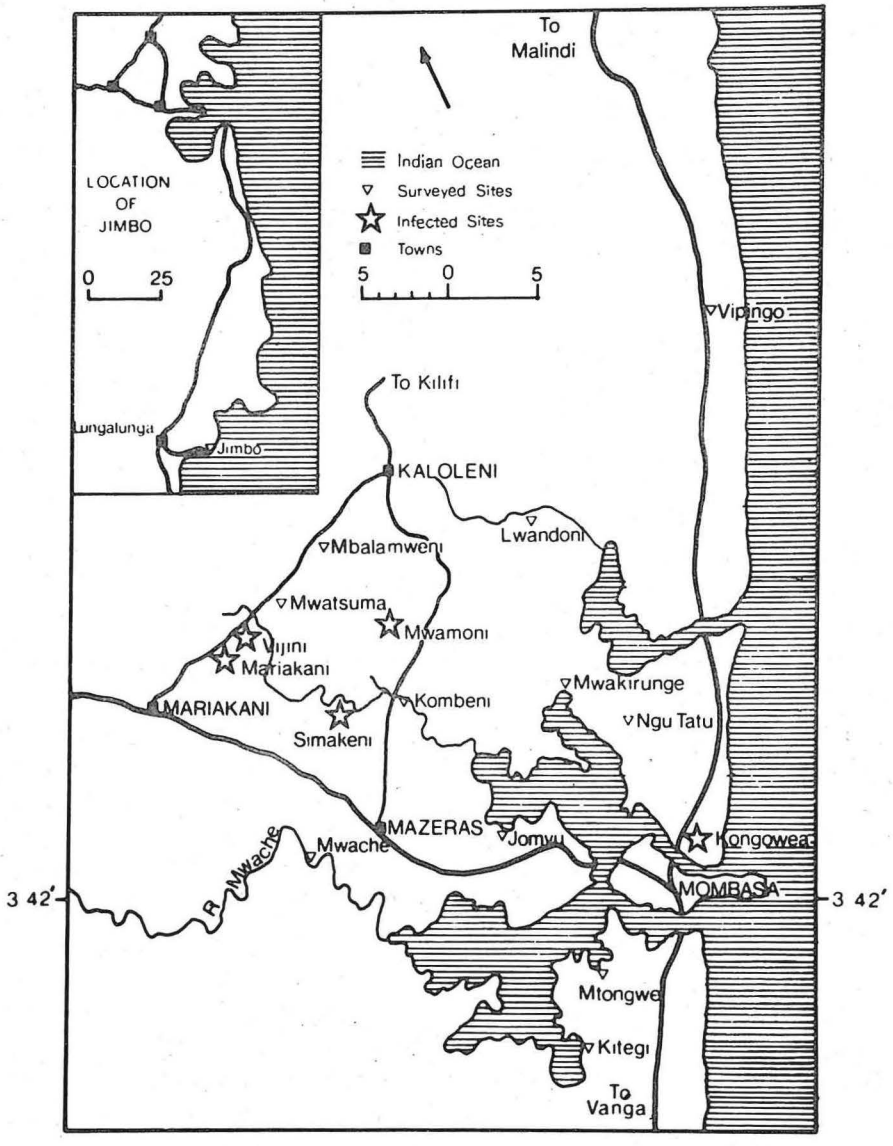


Figure 3. A map of the Kenya Coast showing sites under survey for protozoan infections of mosquito larvae.

A study was carried out, aimed at identifying major microsporidia of Anopheline and Culicine mosquitoes along the Kenya coast, and to determine the extent of distributions of microsporidia infection and the changes in rainfall, temperature, pH and salinity of the breeding sites.

Initially, surveys of different types of breeding sites were carried out. These included salt, brackish and fresh water breeding sites. Larval samples were collected periodically from the sites and checked for infection. At the time of larval collection, the pH, temperature , and salinity of the sites were recorded. Monthly rainfall figures were also taken. These surveys showed four sites to be infected with microsporidia : one freshwater pond and three brackish water pools. The fresh water site and one of the brackish water sites had infection only in September. The study therefore concentrated on the other two brackish water sites at Jimbo and Jomvu (Fig. 3).

Mosquito populations at Jimbo included *Anopheles merus, Culex sitiens,* and *Aedes albocephalus.* Microscopic examination of crushed samples of these mosquito larvae showed the presence of *Nosema* sp. and *Duboscqia* sp. in *A. merus*, and *Nosema* sp. and *Thelohenia* sp. in *C. sitiens.* The unidentified *Culex* sp. and *Aedes albocephalus* were consistently free of microsporidia wherever they occurred in the pools. In both pools, infections were low and occurred intermitently. In Jomvu, infection rates in *C. sitiens* were less than 15%. They were slightly higher in *A. merus,* going up to 20%. In Jimbo, infection rates were even lower in both species being below 5% at all times. Culicine larvae infected with microsporidia were easy to detect in the field. The thorax and the abdominal segments were swollen and turned white. Infections in *A. merus* were not as easy to detect, except for the sluggishness in movement. In both mosquito species, heavy infections were confined mostly to the third and fourth instars. No first instar was ever found with mature spores.

Salinity ranges differed in the two study pools. In Jomvu the range was higher (5—105% sea water). Infections occurred only during times of moderate salinity (18—45% sea water). Only on one occasion did infections occur briefly in 61% sea water, indicating that although high salinities deter microsporidian infections, infective spores are not completely destroyed. In contrast to the Jomvu pool, salinity in Jimbo was moderate at all time (10—47% sea water). The lapses between infections here were no more than one month in *C. sitiens* compared to the longer lapses in the Jomvu pool. Temperatures and pH of the pools remained fairly constant. pH was usually between 7.5—8, while temperatues were between 27°C and 32°C. On rare occasions temperatures went as low as 20°C and as high as 42°C. Water turbidity of both pools also remained constant, usually clear with a biota of beetles, crabs, snails, copepods and larviphagous fish.

It appears that the most prevalent groups of microsporidia along the coast are *Nosema, Thelohenia,* and *Duboscqia,* occurring mostly in semi-permanent sites and particularly in brackish water pools. The patterns of environmental factors at the study sites indicate that no one single factor is responsible for the occurrence, persistence, and distribution of these pathogens. Rainfall seems to have an indirect effect on microsporidia. By causing an overflow of the breeding sites, the rain has the two effects: washing away the larvae and reducing their numbers in the pool and causing a dilution effect in volume of water. This reduces the chances of the few mosquito larvae being infected. It is possible that the infections do not disappear completely but are reduced to such low rates that they fail to be monitored.

Factors determining seasonal occurrence of microsporidia may affect deliberate use of the pathogen in mosquito control procedures. Although they have not been isolated from many places along the coast, their presence indicates that with further studies, they could be manipulated in mosquito control operations against such important vectors as *A. merus* and *A. gambiae* s. l. from which they have been isolated.

INCIDENCE OF SALIVARY GLAND HYPERTROPHY IN FIELD POPULATIONS OF THE TSETSE GLOSSINA PALLIDIPES ON THE SOUTH KENYA COAST

The occurrence of hypertrophy in the salivary gland (HSG) in field populations of tsetse *Glossina* species was first reported from *G. pallidipes* trapped in Zululand. More recent work has traced the cause of cellular hypertrophy and hyperplasia resulting in the glandular enlargement to a large number of virus-like particles (VLPs) occurring in the nuclei and cytoplasm of infected salivary gland epithelial cells.

The present field investigations were planned to carry out a continous study on wild *G. pallidipes, G. brevipalpis* and *G. austeni* from five sites of the Kenya coast in order to follow the course of VLP infection over 12 months. Virus-like particle infection has been associated with abnormality in both male and female reproductive systems, and could therefore contribute to the natural regulation of tsetse numbers.

Tsetse were sampled in the field using the pale blue biconical traps. The five study areas were selected due to their diversity in vegetation, wildlife, and human activity.

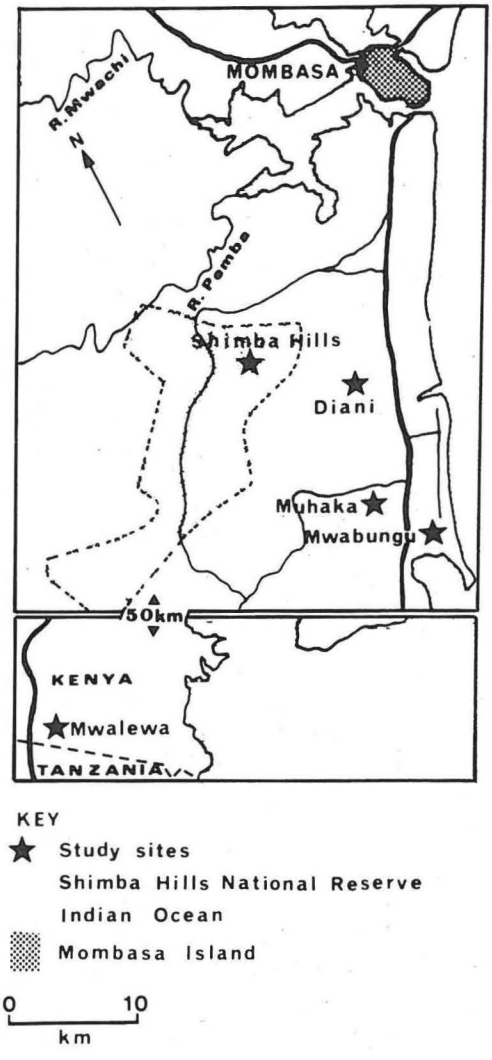


Figure 4. Map showing sites for incidence of salivary gland hypertrophy along the south Kenya coast.

A sample of tsetse from each site were dissected each day and salivary glands examined for hypertrophy. The extent of hypertrophy was graded in nine categories, each category denoting the level of enlargement of the salivary gland. Ages of female tsetse were determined by the ovarian method. Tsetse were also examined for any other pathological condition.

Infected species and symptoms of infection. Hypertrophy of salivary glands was recorded only in *G. pallidipes*. *Glossina brevipalpis* and *G. austeni* from the five trapping sites were also examined, but HSG was not recorded in these two species. Tsetse with hypertrophied salivary glands could not be distinguished from normal tsetse by external examination. In the teneral flies with infected glands however, the white enlarged salivary gland could be seen as a pale outline through the integument and it also formed irregular ridges on the soft and pliable integument. These two symptoms could not be relied on in older flies due to higher pigmentation, toughening of the cuticle, and enlargement of the abdomen by the developing egg and/or larva in the uterus of females. The activity of the flies bearing hypertrophied salivary glands was not impaired.

Pathology of the hypertrophied glands. Hypertrophy was observed to start uniformly throughout the length of the distal part of salivary glands within the abdomen. Both salivary glands showed hypertrophy in all observed cases, and no instances of unilateral hypertrophy were seen. Hypertrophied glands turned to intense blue when they came into contact with water. At the highest infection level the whole of the abdominal haemocoel was filled with the enlarged coiled salivary glands. Though hypertrophy occurred throughout the length of the salivary gland, the greatest enlargement occurred only in the area located in the abdomen. Some of the tsetse dissected for observations on the salivary gland had also enlarged midgut cells with symptoms of infection similar to those on the salivary glands. Hypertrophied glands were present in tsetse from all the study areas where the present investigations were carried out. However, the number of tsetse with HSG varied from one trapping site to the next, even in places of close proximity.

Relationships between level of infection and tsetse density. In Mwabungu, there was an inverse relationship between HSG incidence and tsetse density. Mean tsetse catches per trap per day showed a reduction in tsetse numbers during the months March and October when HSG level was highest. A comparison between tsetse population (mean tsetse catch/trap/day) and mean monthly per cent HSG level did not show an inverse relationship at Muhaka, where there was a low HSG incidence.

The monthly observations on tsetse with hypertrophy of the salivary gland show variation in proportion of *Glossina* with salivary gland hypertrophy, although the pattern of infection does not correspond to any climatic variations, such as rainfall and temperature. Peaks of HSG prevalence are most likely to correspond to peaks in the source of infection.

It is not clear how infection gets to the tsetse in the wild. Two possible pathways have been suggested: a transovarial and/or transovum pathway in which the GLPs recircle within the tsetse population, and a tsetse-animal host-tsetse pathway in which VLPs circle through a vertebrate which acts as a reservoir for VLPs. It has been shown that teneral tsetse can be infected both by microinjection of membrane-filtered VLPs into tsetse haemocoel and by oral infection of tsetse, hence raising the possibility of oral infection through blood meals in the wild. Large numbers of the rod-shaped VLPs have been observed in the negatively-stained salivary gland secretions of HSG in the infected tsetse, further increasing the likelihood of tsetse-vertebrate host-tsetse passage of VLPs.

In the context of microbial control, VLP infection and the subsequent symptom of HSG have been associated with reproductive anomalies in both males and females. A high HSG incidence may have some effect on the reproductive

capability of a tsetse population. The inverse HSG level/tsetse density relationship at Mwabungu may therefore be partly accounted for by VLP as a sterility factor in tsetse. In contrast a comparison between tsetse population (mean tsetse catch/trap/day) and mean monthly per cent HSG level did not show an inverse relationship at Muhaka, where there was a low HSG incidence.

CHEMISTRY AND BIOCHEMISTRY RESEARCH UNIT

INTRODUCTION

The unit has been involved in synthesis of three dimethylpentatriacontanes components of the newly discovered sex-stimulant pheromone of *Glossina pallidipes*. This marked the beginning of synthetic chemistry for the ICIPE and the unit hopes to equip itself to expand these activities even further.

The Finnigan mass spectrometer, now with capillary GC interface and a new electron multiplier, has improved sensitivity. We hope to expand our capabilities many fold when the data access and storage facility is acquired. Manual acquisition and calculation limit the output of the Unit severely. Nevertheless, besides identifying (with GC/MS) the branched alkanes mentioned above, the trial pheromone (Cembrene A) of one of the termites *Trinervitermes bettonianus* being studied at Kajiado has been characterized — another first for the ICIPE chemists.

The Biochemists have been hard at work proving for the first time that insects, like vertebrates, have inactive forms (zymogens) of their digestive enzymes and they have activators (enterokinases) to initiate digestion of the first meal. In tsetse, trypanosomes ingested with the first blood meal may delay activation of trypsin.

Continuing the vitellin research that was described in 1980 the ecdysteroid binding protein from *R. appendiculatus* cross-reacted with antibodies from a rabbit previously immunized with whole engorged female homogenate. This rabbit was resistant to tick infestation in that >80% of the eggs from ticks which fed on the rabbit were non-viable. Ellie Osir

Table 1. Biologically active phytochemicals isolated recently by ICIPE chemists

Plant name	Compound isolated	Activities					
		Antifeeding	Antifungal	IC	IGR	IR	Other
Plumbago capensis	Plumbagin	++	—	—	—	—	+
	Juglone	+	+	—	—	—	+
Rhabdosia spp.	Diterpenoids	—	—	—	+	+	+
Clausena anisata	Imperatorin	—	—	—	—	—	+
	Xanthoxyletin	+	+	—	—	—	+
	Chalepin	—	+	—	—	—	+
	Xanthyletin	+	+	—	—	—	+
Teclea trichocarpa	Tecleantine	—	+	—	—	—	+
	Milicopicine	+	+	—	—	—	+
	Methyl teclean-tine	—	+	—	—	—	+
Milletia thonningii	Isoflavones 1—4	Not determined yet					
Crysanthemum cinerariaefolium	Pyrethrin I	—	—	+	—	+	+
	II	—	—	+	—	+	+
	Jasmolin I	—	—	+	—	+	+
	II	—	—	+	—	+	+
	Cinerin I	—	—	+	—	+	+
	II	—	—	+	—	+	+
Aspilia pluriseta	(-)kaur(16)en-(19)oic acid						
Tovomita mangle	Tovophenone A and B	No determined yet					

Key. IC = insecticidal; IGR = insect growth regulator; IR = repellent; Other = bactericidal etc.

will be continuing research in Tucson on egg proteins. Professor Jan Koolman is advising us on the latest affinity chromatographic methods for purifying the protein.

Ecdysteroid titres during the life-cylce of *Glossina morsitans morsitans* and the mode of action of sterol abortifacients fed to pregnant females were reported to the OAU/STRC meeting in Arusha.

On natural products we continue to isolate and test new compounds for their effect on fungi and on behaviour and development of our target pests (see table 1). In this context, collaboration with Dr. Ramesh Saxena at IRRI (Manila) continues, on phytochemicals which affect the brown plant-hopper. Optimization of the known feeding deterrents for the African armyworm now occupies the minds of our chemists, but it is too soon to report on this aspect.

THE SEX-STIMULANT PHEROMONE OF THE TSETSE *GLOSSINA PALLIDIPES* (AUSTEN)

We have isolated the sex-stimulant pheromone of *G. pallidipes* from the female cuticular waxes and identified it as a mixture of dimethylpentatriacontanes on the basis of gas chromatographic retention times and mass spectroscopic data. The pheromone was tentatively identified as a mixture of 13, 17 and 15, 19—dimethylpentatriacontanes, the former predominating. Figure 1 shows a gas chromatogram of the hydrocarbon fraction from mature females. These hydrocarbons, when deposited on dead male decoy flies washed free of their own cuticular waxes, elicited sexual responses from live male *G. pallidipes* after coming into contact with the decoy.

After fractionation of the hydrocarbons into four fractions, only one fraction containing dimethylpentatriacontanes elicited full sexual activity in the bioassay. The structures 13, 17 and 15, 19—dimethylpentatriacontanes were initially proposed from the mass spectroscopic data. These have been synthesized in five steps from octadecan-1-ol and hexadecan -1-ol respectively. Laboratory bioassay of these compounds indicated that both were active in stimulating mating responses from test males, the former isomer being more active at low doses. Comparison of the synthesized compounds with the natural compounds from fraction 2 showed that a third compound predominated in the natural fraction. Further mass spectral studies led to the proposal of the 13, 23—dimethylpentatriacontane isomer which has now been synthesized for bioassay and chemical comparison. (see Insect Sci. Appl. 2, 181)

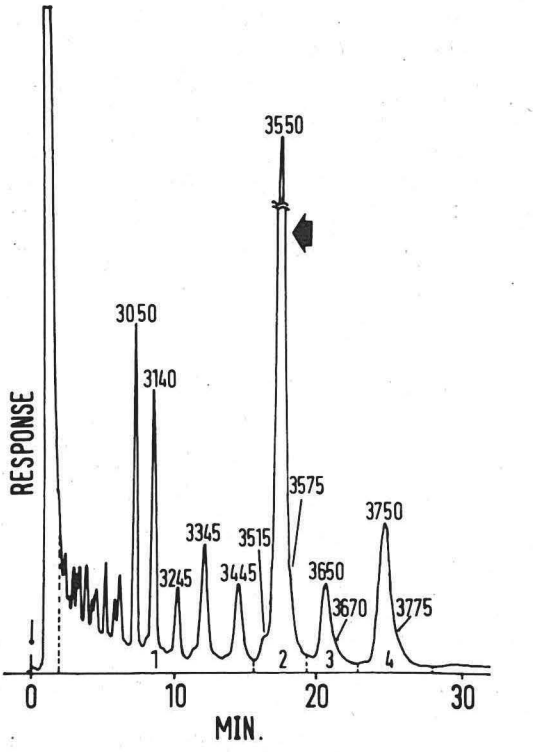


Figure 1. Gas chromatogram of the cuticle hydrocarbons of female *G. pallidipes*. Column conditions: 5% OV-101 (3 m., 2mm. i.d.), isothermal at 320°C, carrier gas nitrogen (20 ml/min.).

CHEMICAL IDENTIFICATION OF THE TRAIL PHEROMONE OF THE TERMITE *TRINERVITERMES BETTONIANUS*

Natural trails of worker *Trinervitermes*

bettonianus laid on a filter paper substrate and extracted with hexane show trail following activity in a figure 8 bioassay. Gas chromatograms of these extracts indicated a complex mixture of components largely of terpenoid composition. After fractionation only one fraction was found to be highly active at very high dilution.

The principal active component in this fraction was identified with a solitary peak. The quantities of material available for analysis by extraction of worker trails, however, were extremely small. Female alates, on the other hand, are known to contain larger quantities of trail active components (usually assumed to play an important role in mating behaviour, also). The hexane extract of female alate sternal glands was chromatographed. Again the same fraction as before was extremely active in the bioassay. The single component in this fraction also corresponds to the previous component from workers (by GC coinjection). In comparison, male alate sternal gland extracts contain very little of this component.

Similarly, whole body extracts of female alates contain large quantities of the active component from which milligram quantities of the compound were isolated for chemical identification. As expected, whole body extracts of male alates contained very little of the active compound. Soldiers, also, contained little of the trail compound.

Chemical and spectroscopic data indicated the diterpene hydrocarbon structure cembrene—A. The mass spectrum showed a molecular weight of 272, with a base peak ion at m/e 68 which is characteristic of this structure. The bromination, silylation, ozonolysis and hydrogenation products of the trail compound compare well with the products of the related compound, cembrene.

ECDYSTEROID TITRES DURING THE LIFE CYCLE OF *GLOSSINA MORSITANS MORSITANS* WESTWOOD

Ecdysteroids could not be detected in *G. m. morsitans* stage III larvae during the hardening of the polypneustic lobes which occurs 2 days before pupariation. Nevertheless, ecdysteroids were later detected by radioimmunoassay (RIA) in the bodies and haemolymph of teneral males of this species. This report describes the use of RIA, gas chromatography with electron capture detector (GC/ECD) and high performance liquid chromatography (HPLC) to monitor ecdysteroids during the life cycle of *G. m. morsitans.*

The levels of free ecdysteroids present during development of *G. m. morsitans in utero* after parturition and pupal — adult apolysis, determined by RIA, are shown in Fig. 2. Ten hours after pupariation the levels are 4.8 ± 0.6 nmoles g^{-1}. Of this, less than half is ecdysterone (1.7 nmoles g^{-1}) and ecdysone (0.9 nmoles g^{-1}) together as determined by GC/ECD.

The first peak (ca. 7.6 nmoles g^{-1}) appears 40—44 h after larviposition. Initially there appears to be a rise in cyclic AMP titre after larviposition but this is followed by a drastic fall from 82 to 22 nmoles g^{-1} fresh weight of larva during the 2 to 3 h when the ecdysteroid titre begins to rise.

A second maximum of 8.9 ± 0.8 nmoles g^{-1} fresh weight is reached 10 days after pupariation. Preliminary HPLC analysis at this stage of development indicates that ecdysterone (5.1 nmoles g^{-1}) and ecdysone (0.5 nmoles g^{-1}) are both present in pharate adults.

The level of ecdysteroids is so low during the third larval instar that RIA cannot detect them except on the sixth to seventh day after ovulation (second cycle) when the titre was 0.4 ± 0.1 nmoles g^{-1}.

Topical application of 1.0 µg of Dimilin in 1 µl of acetone to the thorax of females after the first larva was deposited, resulted in the birth of live larvae which were unable to pupariate normally. Ecdysteroid levels in these offspring 10 h after larviposition were $3.9 + 1.1$ nmoles g^{-1}.

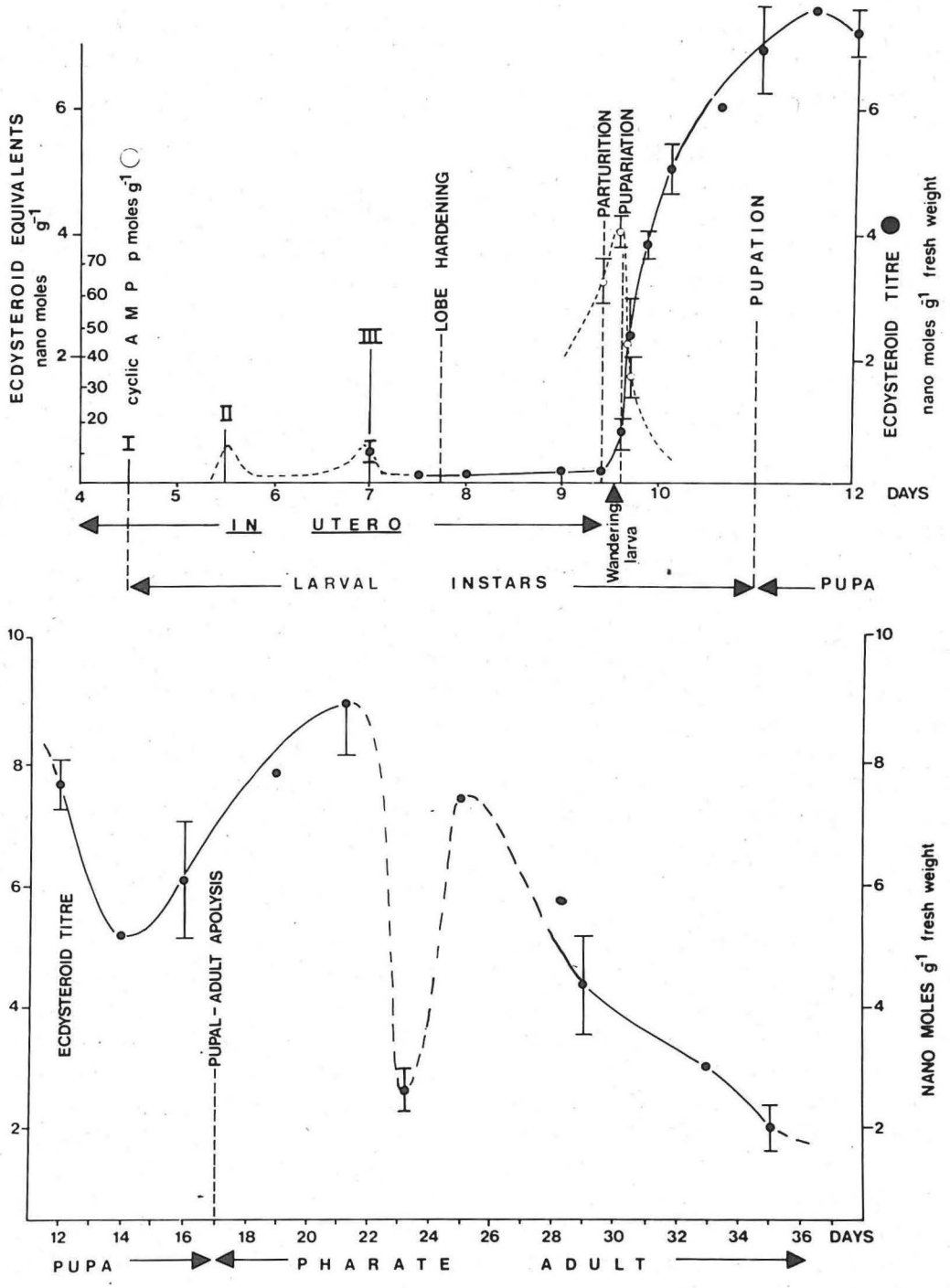


Figure 2. Ecdysteroid titres measured by R.I.A. throughout the major stages of development of *G. m. morsitans* reared at 25°C. (Vertical bars represent 2 x S. E. M. around the means while elsewhere the mean of two determinations is plotted)

SENSORY PHYSIOLOGY RESEARCH UNIT

INTRODUCTION

In insects, behaviour is to a large extent stereotyped and thus predictable. This predictability permits the development of methods of insect pest control by manipulation of behaviour. Since behaviour begins with the reception of one or more signals from the environment, understanding of the initiation of the various components of behaviour requires a study of the function of the various insect sensilla. Knowledge has to be gained of the way in which stimuli are detected and sensory responses initiated. Moreover, the patterns of sensory responses and their consequent behaviour have to be studied.

The Sensory Physiology Research Unit provides services to analyse the role which sensory organs play in behaviour and to understand the range of environmental factors which influence behaviour. Using electrophysiological and behavioural methods, investigations are undertaken in close collaboration with scientists of other research programmes working on target insects of the ICIPE. Particular attention is paid to chemocommunication, as chemical factors appear to be decisive in host and mate selection in most insects, but the unit also investigates other senses when these are suspected to play an important role in the behaviour of a target insect.

In 1981, two new electrophysiological set-ups, in addition to the two already present, were built and experiments started with chemoreceptors of crop-borers, stem-borers, African armyworm, and tsetse. The electrophysiological, behavioural and morphological studies on sensory organs in ixodid ticks and studies on acoustic communication in tsetse flies were continued. Morphological investigations have been initiated to elucidate the structure of the sensory organs on the mouthparts and antennae of stem-borer larvae and adults, and of the alleged pheromone receptors in male tsetse flies, which are supposed to be present on the tibiae.

TICKS

It has been shown that on the first pair of legs of ixodid ticks different types of sensory organs are present. Thermoreceptors were found a decrease in ambient temperature leads to increase in activity, gustatory receptors responding to sodium chloride, and to olfactory receptors. The latter have been studied very extensively using the 'tip-recording' technique, in which the tip of an olfactory hair is cut off with microknives to obtain electrical contact with the olfactory cells in the lumen of the hair.

The olfactory sensilla responded to the tick sex pheromone 2, 6-dichlorophenol and to the odour of washes from larvae and adult ticks. Subsequent behavioural tests indicated that the washes are repellent to adult ticks. In collaboration with the Chemistry and Biochemistry Research Unit investigations are in progress to elucidate the chemical composition of the deterrent.

TSETSE

Sound production in *Glossina morsitans morsitans* shows a rhythm. Young flies in a 12 h light: 12 dark cycle show a U shaped diurnal pattern of singing with peaks in the morning and late afternoon and little singing around midday. In mature flies singing mainly takes place in the morning.

During feeding, sound production is negligible, but most flies sing immediately after feeding, up to about 30 min after engorgement. Semi-gorged flies seldom produce sound. During courtship, most flies only sing during the first 3 min of

mating and for about half an hour after separation. It is assumed that singing may attract other flies. Investigations to determine the behavioural responses of tsetse to the sounds produced by their conspecifics are currently being conducted.

Very recently, investigations have started on the reception of sex pheromones and other chemical stimuli in *G. morsitans morsitans* and *G. pallidipes*. We have succeeded in recording olfactory responses (electroantennograms) from tsetse antennae. This offers a rapid method of screening odours for their activity at the receptor level. Experiments are being done to systematically screen a large number of synthetic and natural chemicals, taking into account the results obtained in field studies and the molecular structure of the substances.

In addition to the sensillae on the antennae, other possible sensory organs involved in the detection of chemicals are being investigated. Priority is paid to various receptors on the tarsi and to the alleged tibial receptors. The electrophysiology as well as the ultrastructure of these organs are being studied.

These studies are undertaken in co-operation with the Tsetse Research Programme, the Chemistry and Biochemistry Research Unit, and the Fine Structure Unit.

CROP-BORERS

In the sorghum shootfly, *Atherigona soccata* Rondani, there is evidence that a deterrent contact pheromone is associated with the glue with which the females attach their eggs to the leaves.

The effects of the deterrent on the cells in tarsal contact chemosensory hairs are being determined by electrophysiological recording from these hairs in gravid female shootflies.

It appears that egg-wash elicits action potentials from a separate type of cell. In addition, the deterrent appeared to have an excitatory effect on the salt sensitive cells (which generally mediate rejection behaviour) and it also seemed to inhibit the responses of the sugar sensitive cells (which mediate acceptable behaviour). Four hydroxy benzoic acid and 4-hydroxy methylbenzoate, which originally were thought to be the active compounds in the deterrent, were found to be electrophysiologically inactive. These results were further strengthened by behavioural experiments, which proved that these substances did not have any deterring effect.

These studies are undertaken in co-operation with the Sorghum Shootfly Programme and the Chemistry and Biochemistry Research Unit.

STEM-BORERS AND AFRICAN ARMYWORM

Studies have been initiated to identify the chemical factors which determine susceptibility of crops to stem-borer and African armyworm adults and larvae. Olfactory and gustatory responses of *Chilo partellus, Eldana saccharina,* and *Spodoptera exempta* are being recorded during stimulation with various plant substances. Moreover, scanning electron microscopical investigations are being done on the chemosensory sensilla on the mouthparts of larvae and on the antennae of adults.

It was observed that in the palps of *Chilo* and *Spodoptera* and in the lateral and medical sensilla styloconica of *Chilo, Eldana* and *Spodoptera,* specific salt and sugar cells are present, the latter being very sensitive to sucrose. All plant substances primarily stimulated the salt cells. In *Eldana,* no significant differences in the stimulatory effects occurred between the plant substances. This is in contrast to *Chilo* and *Spodoptera,* in which vanillic acid appeared to strongly stimulate the lateral sensillum styloconicum.

BIOASSAY RESEARCH UNIT

SERVICES PROVIDED BY THE UNIT

The unit has continued to provide bioassay services to many of the programmes and units in the centre. Most of the services have been given mainly to three programmes, the Livestock Tick Research Programme (Moulting Hormone determinations), the Grassland Termite Programme (Juvenile Hormone assays) and the Chemistry and Biochemistry Research Unit, with which the Unit carries out a collaborative programme on the investigation of African plants for antifeeding, larvicidal, fungicidal, repellant and moulting hormone activities. The unit has recently established a mosquito repellency test to augment the tick climbing test for the study of repellents from pyrethrum flowers. This bioassay is a standard test and involves taking 3—4 day old female mosquitoes *(Aedes aegypti)*, which have been fed only on sugar solution since emergence, and offering cleaned human arm treated with a known concentration of the test material in 70% ethanol. The arm is held in the cage for 5 min and withdrawn. The mosquitoes are immediately removed and the number of engorged females recorded. An arm treated with only 70% ethanol and tested similarly serves as the control. The test is replicated four times and the results analysed.

INVESTIGATIONS OF PLANTS FOR BIOACTIVE COMPOUNDS

The isolation and characterization of two bioactive coumarins, imperatorin and xanthoxyletin from the stem-bark of *Clausena anisata* (Rutaceae) was reported last year. Both compounds showed feeding deterrence activity against the African armyworm *(Spodoptera exempta)* larvae whereas xanthoxyletin also possessed fungicidal properties against *Cladosporium cucumericum*.

Further work on the same plant led to the isolation of two more bioactive coumarins, xanthyletin and chalepin. The compounds were characterized by their UV, IR, NMR and mass spectra. Xanthyletin showed both feeding deterrence (100 ppm) and fungicidal activities, whereas chalepin possessed weak fungicidal properties.

The methanol extract of the stem-bark of another Rutaceae, *Teclea trichocarpa* (Eng) Engl, was found to be moderately active as a fungicide and a feeding deterrent. Fractionation of the extract by column and thin layer chromatography on silica gel led to the isolation of three acridone alkaloids as active components. The compounds were identified as a melicopicine (feeding deterrent), tecleanthine (feeding deterrent and fungicide) and 6-methoxy-tecleanthine (fungicide) from their spectral data.

INSECT AND ANIMAL BREEDING SERVICE

BREEDING OF TSETSE

The *Glossina morsitans morsitans* colony was expanded considerably in 1981. The colony was maintained at 25°C and 70% RH using rabbits as host animals.

Tsetse emergence per month ranged from 6831 females and 7151 males to 10,174 and 9566 respectively. The mean monthly emergence being 8228 females and 8108 males. Mortality in teneral flies was negligible and in mated females did not exceed 0.9% per day (mean mortality was 0.75%).

The mean pupal production per female per month was 2.2 and samples of pupae weighed during the year gave a mean pupal weight of 29.4 µg.

A total of 29,201 males 30,035 females and 5492 pupae were supplied for experimental use by the ICIPE scientists and other research organizations, an increase of more than 100% on the previous year.

BREEDING OF *CHILO PARTELLUS*

The small *Chilo partellus* colony was maintained throughout the year, at the ICIPE, Chiromo, on an artificial wheat germ-based diet. The insects were supplied for sensory physiology work and used for experimentation with other artificial diets.

With the development of the ICIPE Mbita Point Field Station, there is now a demand for large numbers of crop-boring insects for laboratory and field studies. With the assistance of the Bases of Plant Resistance and Crop-Borers Programmes, it is planned to establish insect mass rearing facilities at Mbita Point by 1982.

BREEDING OF AFRICAN ARMYWORM, *SPODOPTERA EXEMPTA*

Demand for the African armyworm declined in the past year. The colony was therefore reduced and moved to smaller facilities. It continues to flourish on a natural maize leaf diet and the problems previously experienced from viral and bacterial infections were overcome this year (1981).

Insects amounting to about 400 per month are supplied to the Chemistry and Biochemistry and Sensory Physiology Research Units.

ANIMAL BREEDING

RABBITS

A breeding stock of 80 to 90 females has been maintained throughout 1981. Survival in young rabbits has remained at around 90% and no major disease problems have been encountered. Demand for rabbits has also increased and the unit supplies 90 to 100 per month for research purposes.

RODENTS

Demand for rodents has fluctuated throughout the year but the colonies are still geared to produce an excess of 75 rats and 100 mice per month.

MAJOR SEMINARS GIVEN AT THE ICIPE DURING 1981

	SPEAKERS	SUBJECT
1.	Dr. Pritam Singh Entomology Division Department of Scientific and Industrial Research Auckland New Zealand	Insect Rearing, Nutrition and Management of Laboratory Reared Insects
2.	Professor W. H. R. Lumsden Department of Protozoology London School of Hygiene and Tropical Medicine England	Diagnosis of Salivarian Trypanosome Infection
3.	Dr. P. A. Langley Tsetse Research Laboratory University of Bristol Bristol	Effects of Mating on Receptivity and Ovulation in Female *Glossina morsitans*
4.	Dr. K. C. Binnington Department of Zoology Cambridge	Ultrastructure of the Tick Neuroendocrine
5.	Dr. J. Hardie Imperial College London	Endocrine Aspects of Aphid Polymorphism
6.	Professor F. C. Kafatos Harvard University U.S.A.	Control of Gene Expression During Development: Advances in Understanding of Eggshell Formation in Insects
7.	Dr. P. A. Lawrence Medical Research Council Laboratory of Molecular Biology University of Cambridge	Compartment in Insect Development
8.	Professor M. Locke Department of Zoology University of Western Ontario London Canada	The Epidermal Feet in Insect Morphogenesis
9.	Dr. S. Yagi Laboratory of Applied Entomology Tokyo University of Agriculture & Fuchu Tokyo	Diapause and Phase Variation in Some Lepidopterous Insects
10.	Professor W. S. Bowers New York State Agricultural Experiment Station Cornell University New York	Insect Growth Regulators — Practice and Promise

11.	Dr. L. Strong Department of Zoology The University of Bristol England	Hormones in Insect Embryos
12.	Professor Baccio Baccetti Institute of Zoology University of Siena Siena Italy	The Dynein Proteins
13.	Dr. John B. Kaddu ICIPE	Cryobiology (Basic and Applied) and its Applications to Leishmaniasis Research
14.	Dr. Joseph O. Olobo ICIPE	Antibodies to *Leishmania tropica* Promastigotes During Infection in Mice of Various Genotypes
15.	Dr. O. Ole Moiyoi ILRAD	Glandular kallikreins — their structure and function
16.	Dr. M.B.A. Nyindo ICIPE	Some Impressions of Australian Biological Research
17.	Dr. A. Hassanali ICIPE	Dehydroamino Acids and D — Amino Acids in Peptide Antibiotics
18.	Professor Robert B. Stewart Department of Microbiology and Immunology Queens University Kingston Canada	Regulation of interferon by AMP and effect of interferon on C type particles
19.	Professor David Goldsmith Department of Chemistry Emory University Atlanta USA	Recent Progress in the Synthesis of Insect Antifeedants
20.	Professor K. N. Saxena University of Delhi India	Scope of Manipulation of Insect Behaviour for Pest Management Programme
21.	Dr. R. D. Dransfield University of Jos Nigeria	Trapping Strategy for Tsetse
22.	Dr. P. G. McDowell ICIPE	Chemical Communication in Termites and Tsetse
23.	Dr. D. A. Otieno ICIPE	Repellent Principles of Pyrethrum Extract
24.	Miss Mary Sampson Legon University Ghana	The Life History of *Eldana saccharina* Walker on Sugarcane in Ghana
25.	Professor J. L. Auclair International Rice Research Institute Manila Philippines	Biochemical Evidence for the Feeding Sites of the Green Leafhopper *(Nephotettix virescens)* within Susceptible and Resistant Rice Plants

26.	Dr. T. Y. Kaufmann	The Behavioural Biology Feeding Habits and Ecology of 3 Major Maize Stem-Borers of Nigeria
27.	Professor G. Dauben Department of Chemistry University of California Berkeley USA	Diterpene Cembrenes

LIST OF PUBLICATIONS FOR 1981

1. Arshad M. A. (1981) Physical and chemical properties of termite mounds of two species of *Macrotermes* (Isoptera, Termitidae) and the surrounding soils of the semi-arid savanna of Kenya. Soil Sci. 132 (2), 161—174.

2. Awiti L. R. S. (1981) A strange multinuclear condition in the epithelial cells of the mesadenial accessory reproductive gland of *Dysdercus fasciatus* Signoret. Insect Sci. Appl. 2 (3), 167—173.

3. Chaudhury M.F.B., Dhadialla T. S. and Kunyiha R. W. (1981) Evidence of neuroendocrine relationship between mating and ovulation in the tsetse fly, *Glossina morsitans morsitans.* Insect Sci. Appl. 1 (1), 161—166.

4. Clark J. V. (1981) Feeding deterrent receptors in the last instar African armyworm *Spodoptera exempta:* a study using salicin and caffein. Ent. Exp. Appl. 29 (2), 189—197.

5. Clark J. V. (1981) The glass microfibre disc method used to quantify feeding in the African armyworm, *Spodoptera exempta.* Ent. Exp. Appl. 30 (2), 195—197.

6. Clearwater J. R., Thiel F. and Kokwaro E. D. (1981) Comparative ultrastructure of the trifoliate organ of *Atherigona soccata* Rondani (Diptera: Muscidae). Insect Sci. Appl. 2 (1/2), 11—23.

7. Clearwater J. R. (1981) Practical identification of the females of five species of *Atherigona soccata* Rondani. (Diptera: Muscidae) in Kenya. Trop. Pest Management 27 (3) 303—312.

8. Dabrowski Z. T. and Patel N. Y. (1981) Investigation on physiological components of *Atherigona soccata* larvae and their interaction with sorghum — I. Larval enzymes. Insect Sci. Appl. 2 (1/2), 73—76.

9. Delobel A. (1981) The distribution of eggs of the sorghum shootfly, *Atherigona soccata* Rondani (Diptera: Muscidae). Insect Sci. Appl. 2 (1/2), 63—66.

10. Delobel A. and Unnithan G. C. (1981) The status of sorghum arundinaceum as a host of *Atherigona soccata* Rondani (Diptera: Muscidae). Insect Sci. Appl. 2 (1/2), 67—71.

11. Golder T. K. and Patel N. Y. (1981) Some effects of trypanosome development on the Saliva and salivary glands of the tsetse fly, *Glossina morsitans.* Eur. J. Cell Biol. 22, 511.

12. Goutex J. P., Challier A. and Laveissiere C. (1981) Modification et essais du piège à glossines (Diptera, Glossinidae) Challier—Laveissiere, Cah. ORSTOM Ser. Ent. med. Parasitol. 19, 87—89.

13. Jaenson T. G. T. (1981) Ecology and behaviour of *Glossina pallidipes* Austen (Diptera: Glossinidae) in Southern Kenya. Bull. Ent. Res. 71 (4), 703—715.

14. Kaaya G. P. and Otieno L. H. (1981) Haemocytes of *Glossina* — I. Morphological classification and the pattern of change with age of the flies. Insect Sci. Appl. 2 (3), 175—180.

15. Kaddu J. B. and Mutinga M. J. (1981) *Leishmania* in Kenyan phlebotomine sandflies — I. *Leishmania aethiopica* in the midgut of naturally infected *Phlebotomus pedifer.* Insect Sci. Appl. 2 (4), 245—250.

16. Kapur V. R. and Mutinga M. J. (1981) Studies of the biology and behaviour of *Phlebotomus* martini (Diptera: Phlebotomidae) from Kibauni, in Machakos District, Kenya. Insect Sci. Appl. 2 (4), 251—257.

17. Khasimuddin S. (1981) Behavioural ecology of the African armyworm, *Spodoptera exempta* (Walker): Observation on population processes during a high density outbreak. Insect Sci. Appl. 1 (2), 143—146.

18. Khasimuddin S. (1981) Phase variation 'off-season' survival of the African armyworm *Spodoptera exempta* (Walker) (Lepidoptera: Noctuidae). Insect Sci. Appl. 1 (4), 357—360.

19. Kokwaro E. D. and Odhiambo T. R. (1981) Spermatophore of the tsetse, *Glossina morsitans morsitans* Westwood: an ultrastructural study. Insect Sci. Appl. 1 (2), 185—190.

20. Kokwaro E. D., Odhiambo T. R. and Murithi J. K. (1981) Ultrastructure and histochemical study of the spermatheca of the tsetse *Glossina morsitans morsitans* Westwood. Insect Sci. Appl. 2 (3), 135—143.

21. Laveissiere C. and Challier A. (1981) La repartition des glossines en Cote d'Ivoire. OTSTOM 89, 33.

22. Lepage M. G. (1981) Etude de la prédation de *Megaponera Foetens* (F) sur les populations recoltantes de Macrotermitinae dans un ecosystème semi-aride (Kajiado, Kenya). Insectes Soc. 28 (3), 247—262.

23. Lepage M. G. (1981) L'impact des populations recoltantes de *Macrotermes michaelseni* (i) (Sjostedt) (Isoptera, Macrotermitinae) dans un ecosystème semi-aride (Kajiado, Kenya). I. L'activité de recolte et son determinisme. Insectes Soc. 28 (3), 297—308.

24. Lorimer N. (1981) Long-term survival of introduced genes in a natural population of *Aedes aegypti* (L.) (Diptera: Culicidae). Bull. Ent. Res. 71 (1), 129—132.

25. Lounibos L. P. and Munstermann L. E. (1981) Ecological and genetic separation of three sympatric species of *Aedes* (Diptera: Culicidae) from the Kenya Coast. Bull. Ent. Res. 71 (4), 639—648.

26. Lounibos L. P. (1981) Habitat segregation among African treehole mosquitoes. Ecol. Entomol. 6 (2), 129—154.

27. McDowell P. G., Whitehead D. L., Chaudhury M. F. B. and Snow W. F. (1981) The isolation and identification of the cuticular sex-stimulant pheromone of the tsetse *Glossina pallidipes* Austen (Diptera: Glossinidae). Insect Sci. Appl. 2 (3), 181—187.

28. Mutinga M. J., Kaddu J. B. and Irungu L. W. (1981) Animal models for feeding Kenyan wild-caught phlebotomine sandflies (Diptera: Phlebotomidae). Insect Sci. Appl. 2 (3), 149—152.

29. Mutinga M. J. (1981) An efficient trap for sandflies (Diptera: Phlebotomidae). Insect Sci. Appl. 1 (2), 203—206.

30. Mutinga M. J. and Madel G. (1981) The role of coprophagous beetles in the dissemination of taeniasis in Kenya. Insect Sci. Appl. 1 (4), 379—382.

31. Mutinga M. J. and Njoka J. M. (1981) Suspected vectors of lizards leishmaniasis in Kenya and their possible role in partial immunization of the human population against *Leishmania donovani* in kala-azar endemic areas. Insect Sci. Appl. 1 (2), 207—210.

32. Njogu R. M. and Nyindo M. (1981) Presence of a peculiar pathway of glucose metabolism in infective forms of *Trypanosoma brucei* cultured from salivary glands of tsetse flies. J. Parasitol. 67 (6), 847—851.

33. Nyindo M., Chimtawi M. and Owor J. (1981) *Trypanosoma brucei:* Evidence suggesting existence of sexual forms of parasite cultured from the tsetse, *Glossina morsitans morsitans.* Insect Sci. Appl. 1 (2), 171—175.

34. Nyindo M. and Rurangirwa F. R. (1981) *Trypanosoma brucei:* Continuous cultivation of antigenically stable parasites at 29°C and induction of antigenic variants at 37°C. Insect Sci. Appl. 2 (4), 263—266.

35. Ochieng' R. S., Okeyo-Owuor J. B. and Dabrowski Z. T. (1981) Studies on the legume pod-borer, *Maruca testulalis* (Geyer) — II. Mass rearing on natural food. Insect Sci. Appl. 1 (3), 269—272.

36. Odebiyi J. B. (1981) Studies on the biology of the cowpea pod-borer, *Maruca testulalis* in Kenya — I. Determination of the larval instar. Insect Sci. Appl. 1 (4), 339—341.

37. Odindo M. O., Turner D. A., Otieno W. A. and Kaaya G. P. (1981) Cuticular lesions: A non-infectious integumental disease of Glossina species. Insect Sci. Appl. 2 (4), 213—217.

38. Odindo M. O., Sabwa D. M., Amutalla P. A., and Otieno W. A. (1981) Preliminary tests on the transmission of virus-like particles to the tsetse *Glossina pallidipes.* Insect Sci. Appl. 2 (4), 219—221.

39. Odindo M. O. (1981) Rearing the American bollworm *Heliothis armigera* on grassmeal diet. Ent. Exp. Appl. 29 (3), 254—258.

40. Odindo M. O. (1981) Time mortality response in *Spodoptera exempta* (Wlk.) infected with heat-treated nuclear polyhedrosis virus. Insect Sci. Appl. 1 (3), 225—230.

41. Ogwaro K. and Kokwaro E. D. (1981) Development and morphology of the immature stages of the sorghum shootfly, *Atherigona soccata* Rondani. Insect Sci. Appl. 1 (4), 365—372.

42. Ogwaro K. and Kokwaro E. D. (1981) Morphological observations on sensory structures on the ovipositor and tarsi of the female and on the head capsule of the larvae of the sorghum shootfly, *Atherigona soccata* Rondani.Insect Sci. Appl. 2 (1/2), 25—32.

43. Okeyo-Owuor J. B. and Ochieng' R. S. (1981) Studies on the legume pod-borers, *Maruca testulalis* (Geyer) — I. Life cycle and behaviour. Insect Sci. Appl. 1 (3), 263—268.

44. Okot-Kotber B. M. (1981) Instars and polymorphism of castes in *Macrotermes michaelseni* (Isoptera: Macrotermitinae). Insectes Soc. 28 (3), 233—246.

45. Okot-Kotber B. M. (1981) Polymorphism and the development of the first progeny in incipient colonies of *Macrotermes michaelseni* (Isoptera: Macrotermitinae). Insect Sci. Appl. 1 (2), 147—150.

46. Oloo G. W. (1981) Specificity of termite trails: Analysis with natural and extract trails of *Trinervitermes macrotermes* and *Odontotermes* (Isoptera: Termitidae) from sympatric populations. Ent. Exp. Appl. 29 (2), 162—163.

47. Oloo G. W. (1981) The sternal gland: variation in size and activity in worker instars of *Trinervitermes bettonianus* (Sjost) (Termitidae). Insect Sci. Appl. 2 (3), 145—147.

48. Owaga M. L. A. (1981) Ecological studies and laboratory rearing of the tsetse species *Glossina longipenis* Corti in Kenya. Insect Sci. Appl. 2 (3), 197—200.

49. Owaga M. L. A. (1981) Relative efficiency of some mechanical traps used in the study of the tsetse species *Glossina pallidipes* Aust. Insect Sci. Appl. 1 (2), 197—201.

50. Owaga M. L. A. (1981) Trypanosome infection rate in the tsetse species, *Glossina pallidipes* Austen, in a rural situation in Kenya. Insect Sci. Appl. 1 (4), 411—416.

51. Patel N. Y., Youdeowei A. Y. and Odhiambo T. R. (1981) The composition of the salivary gland secretion of the tsetse, *Glossina morsitans morsitans* Westwood 1850 (Diptera: Glossinidae). Insect Sci. Appl. 1 (4), 383—387.

52. Persson B. (1981) Population fluctuations of the African armyworm, *Spodoptera exempta* (Walker) (Lepidoptera: Noctuidae), in outdoor cages in Kenya. Bull. Ent. Res. 71 (2), 289—297.

53. Raina A. K. (1981) Deterrence of repeated oviposition in sorghum shootfly *Atherigona soccata* (Diptera: Muscidae). J. Chem. Ecol. 7 (5), 785—790.

54. Raina A. K. (1981) Movement, feeding behaviour and growth of the larvae of sorghum shootfly, *Atherigona soccata.* Insect Sci. Appl. 1 (3), 231—235.

55. Raina A. K., Thindwa H. Z., Othieno S. M. and Cockhill R. T. (1981) Resistance in sorghum to the sorghum shootfly: Larva development, adult longevity and fecundity on selected cultivars. Insect Sci. Appl. 2 (1/2), 99—103.

56. Ramasamy R., Jamnadas H. and Mutinga M. J. (1981) Proteins and surface proteins of Leishmania promastigotes and their possible relevance to the characterization of strains. Int. J. Parasitol. 11 (5), 387—390.

57. Saini R. K. (1981) Communication by sound in tsetse. Span 24 (3), 98—99.

58. Saini R. K. (1981) Effects of age and hunger on the pattern of sound production in the tsetse *Glossina morsitans* Westwood, 1850 (Diptera: Glossinidae). Insect Sci. Appl. 1 (4), 393—397.

59. Saini R. K. (1981) The pattern of sound production by the tsetse fly, *Glossina morsitans morsitans* Westwood, 1850 (Diptera: Glossinidae). Insect Sci. Appl. 1 (2), 167—169.

60. Samaranayaka—Ramasamy M. (1981) Influence of feeding and hormonal factors on sexual maturation in male *Glossina morsitans morsitans* West. (Diptera: Glossinidae). Insect Sci. Appl. 1 (3), 273—280.

61. Samaranayaka—Ramasamy M. and Chaudhury M.F.B. (1981) Precocene treatment of the female tsetse fly *Glossina morsitans morsitans*, sterilizes her female offspring. Experientia. 37, 1027—1028.

62. Saxena R. C., Okech C. H. and Liquido N. J. (1981) Wing morphism in the brown planthopper, *Nilaparvata lugens.* Insect Sci. Appl. 1 (4), 343—348.

63. Subra R. (1981) Biology and control of *Culex pipiens quinquefasciatus* Say, 123 (Diptera: Culicidae) with special reference to Africa. Insect Sci. Appl. 1 (4), 319—338.

64. Turner D. A. (1981) The colonization by the tsetse, *Glossina pallidipes* Austen, of a unique habitat-exotic coniferous plantation — with special reference to the Lambwe Valley, Kenya. Insect Sci. Appl. 1 (3), 243—248.

65. Unnithan G. C. (1981) Aspects of sorghum shootfly reproduction. Insect Sci. Appl. 2 (1/2), 87—92.

66. van Etten J. (1981) Comparative studies on the relative efficiency of two trap types for two allotropic populations of *Glossina pallidipes* in Kenya. Ent. Exp. Appl. 29 (2), 209—217.

67. van Etten J. (1981) A comparison of the performance of laboratory colonies of *Glossina pallidipes* Austen from two allopatric populations in Kenya. Insect Sci. Appl. 1 (2), 177—183.

68. Waladde S. M., Kokwaro E. D. and Chimtawi M. (1981) A cold receptor on the tick, *Rhipicephalus appendiculatus:* Electrophysiological and ultrastructural observations. Insect Sci. Appl. 1 (2), 191—196.

69. Whitehead D. L. (1981) The effect of phytosterols on tsetse reproduction. Insect Sci. Appl. 1 (3), 281—288.

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The International Centre of Insect Physiology and Ecology (ICIPE) was formally established in April 1970 in Nairobi, Kenya. The mandate of the ICIPE is to contribute to increased food production by undertaking mission-oriented research on pests of major crops, vectors of important livestock diseases, and insect carriers of human diseases critical to tropical rural health; and secondly, to increase the capacity of developing countries in pest management research and the application of the results of this research by training selected scientists and technologists in these fields. The Centre has been functional for ten years and is now an established institution contributing vital inputs into the global strategy to increase food production.