



Insect and Pest Control Newsletter



JOINT FAO/IAEA DIVISION OF NUCLEAR TECHNIQUES IN FOOD AND AGRICULTURE
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I. GENERAL INFORMATION

The untimely loss of Dr. André Van der Vloedt (reported in the Insect and Pest Control Newsletter No. 47, May 1992) continues to be felt by our Section. We miss him as a friend and colleague and the absence of his driving energy has been felt in many of our programmes. Concurrently, we have experienced financial and administrative difficulties which have prevented us from recruiting a replacement for André. As shown below, a few short-term replacements have certainly not filled André's shoes especially since Waldy Klassen transferred to the Joint FAO/IAEA Division's Director's Office in July 1992 and Dick Gingrich retired from Seibersdorf in November 1992. We hope that all of you, our friends, collaborators and colleagues can bear with us through these difficult times. Hopefully, now that Don Lindquist has resumed his duties as Head of the Insect and Pest Control Section since 1 December 1992, after an absence of more than two years, and once André's position is filled (hopefully in early 1993) our Section can once again begin to function normally. Even then the full impact of André's absence will continue to be felt for many years.

The Staff

The Section's staff, consisting of those in the Joint FAO/IAEA Division located in the Vienna International Centre and those in the IAEA's Seibersdorf Laboratory, are listed below with their nationality and the year they joined the Agency.

JOINT FAO/IAEA DIVISION

B. Sigurbjörnsson, Director
W. Klassen, Deputy Director (effective 1 July 1992)

Insect & Pest Control Section's Office

L.E. LaChance (USA) 1992	Acting Head (12 October - 12 December 1992)
E.D. Offori (Ghana) 1992	Acting Technical Officer (Tsetse) (20 July - 30 October 1992)
D.A. Lindquist (USA) 1990	Director, SECNA/FP
J. Chirico (Sweden) 1992	SIDA-funded Screwworm Investigator
L. Kruzic (Australia) 1983	Secretary
M. Hallqvist (Sweden) 1989	Secretary
A. Peake (Canada) 1992	Secretary, SECNA (27 April - 6 October 1992)

Entomology Unit, Seibersdorf Laboratory

R.E. Gingrich (USA) 1980	Unit Head (microbiology) (retired 30 November 1992)
U. Feldmann (Germany) 1988	Tsetse Programme Leader (mass-rearing)
J. Hendrichs (Mexico) 1991	Medfly Programme Leader (mass-rearing)
G. Franz (Germany) 1989	Medfly genetic sexing and molecular biology

D.A. Lindquist returned to his former position and resumed duties as Section Head on 1 December 1992.

W. Klassen became Deputy Director of the Joint FAO/IAEA Division on 1 July 1992.

E.D. Offori, former member of staff of the Joint FAO/IAEA Division (Insect and Pest Control Section), who came from retirement to assist the Section, returned home to Ghana on 30 October 1992, after serving two 3-month terms.

M. Vreysen (Belgium), stationed on Zanzibar, Tanzania to oversee the tsetse (*G. austeni*) eradication project, has, since 1 June 1992, transferred to FAO. He is still responsible for the joint project on Zanzibar.

II. THE SECTION'S PROGRAMME

A. Co-ordinated Research Programmes

The following four Co-ordinated Research Programmes are currently in progress:

1. Development of Practices for Area-wide Tsetse Eradication or Control, with Emphasis on the Sterile Insect Technique

Objective: To develop, refine and recommend application of methodologies for applying the Sterile Insect Technique (SIT) to eradicate tsetse flies from critical areas of Africa, in order to control animal trypanosomiasis.

Expected duration: 5 years (1989-93).

Contract holders: (8) from Ethiopia, Ghana, Kenya, Nigeria, Italy, Uganda, UK, Zimbabwe.

Agreement holders: (5) from Canada, Czechoslovakia, Belgium, USA, Kenya.

A Research Co-ordination Meeting is scheduled for September 1993.

2. Laboratory and Field Evaluation of Genetically Altered Medflies for Use in Sterile Insect Technique Programmes

Objective: To refine procedures for selecting conditional lethal mechanisms, characterize the mode of inheritance and work out techniques for translocating the dominant allele to the male-determining chromosome.

Expected duration: 5 years (1989-93).

Contract holders: (8) from Israel, Brazil, UK, Greece, Argentina, Italy, Kenya, Spain.

Agreement holders: (3) from Greece, USA.

3. Genetic Engineering Technology for the Improvement of the Sterile Insect Technique

Objective: To develop and apply genetic engineering techniques to improve SIT operations (emphasizing technology that could readily be transferred to developing countries to be incorporated into pest control programmes).

Expected duration: 5 years (1988-93).

Contract holders: (none).

Agreement holders: (7) from Australia, Greece, Italy, Japan, UK, USA.

4. Evaluation of Population Suppression by Irradiated Lepidoptera and their Progeny

Objective: The major focus will be on field releases of moths given sub-sterilizing doses of radiation. This will require baseline data on field populations. Special attention will be paid to field behaviour of released moths as well as the development of techniques to assess the impact of the released moths and their progeny in suppressing the native population.

Expected duration: 5 years (1992-97).

Contract holders: (16) from Russian Federation, Brazil, Ukraine, Tunisia, Bulgaria, Cuba, Czechoslovakia, Vietnam, Pakistan, Romania, India, Indonesia, Syria, Myanmar, People's Republic of China.

Agreement holders: (1) from USA.

B. Technical Co-operation Programmes

The Section has technical responsibility for a total of 21 technical co-operation projects. They fall under four major problem areas, namely:

1. The tsetse fly.
2. The New World Screwworm.
3. The Mediterranean fruit fly.
4. F¹ Sterility for the control of lepidopteran pests.

A brief review is presented in this issue of some new projects starting in 1993. Others will be presented in later issues.

ARG/5/004: Control of Fruit Fly Using the Sterile Insect Technique (1993-96)

Objectives: To strengthen the research and development capabilities of the national programme to control fruit flies (PRONAMATE) in Argentina.

Background: Argentina produces large quantities of fruit. Exports of fruit could be greatly increased if the fruit fly population could be brought under control. In a joint effort of the Government and the private sector and with the collaboration of the National Institute for Agricultural Technology (INTA), the National Atomic Energy Commission (CNEA) and the National Secretariat for Agriculture, Animal Husbandry and Fisheries (SAGyP), the Government has launched the PRONAMATE programme which aims to control the fruit fly population in various provinces in Argentina. In 1990 an expert mission recommended that Argentina be assisted by the Agency in establishing the PRONAMATE programme.

National Input: The present project will complement the activities being carried out by Argentina to control fruit fly populations. Several institutions, scientists and laboratories are already equipped and committed to this task.

Agency Input: The Agency will provide experts to assist in establishing genetic sexing strains, mass-rearing, fly liberation and field insect collection. Individual training on genetic sexing and sampling, as well as on-the-job training in Seibersdorf are envisaged. Equipment to complement that already available at the research facility, where techniques will be developed, will be supplied.

BGD/5/016: Insect Pest Management by Genetic Manipulation (1994-95)

Objectives: To develop genetic and cytogenetic methods for an improved pest control strategy using the SIT.

Background: Agricultural products such as rice, jute, pulses, oil seeds, fruits and vegetables are abundantly grown in Bangladesh. Insect pests are responsible for causing damage to, and major loss of, these products either in the pre-harvest stage in the field or during post-harvest marketing and storage. Among the several pests of agricultural importance, fruit flies have been identified as one of the most harmful insect pests in Bangladesh. A genetic sexing strain would be helpful in developing a control strategy for this pest without disturbing the natural environment.

National Input: A large group of scientists and technicians is involved in the project. A laboratory with modest equipment is available. The Government is committed to providing the necessary funds to cover the local costs of the project.

Agency Input: The Agency has been requested to provide assistance in introducing genetic and cytogenetic methods for advanced pest control, through the provision of expertise, equipment and training.

CUB/5/012: Control of Borer in Sugar-Cane (1993-94)

Objectives: To develop the capacity to conduct a pilot programme on the use of F¹ sterility for assessment of the technical feasibility of using this technique against the sugar-cane borer.

Background: Sugar-cane is the main crop in Cuba; it plays an important role in the national food programme and is also the main foreign currency earner. The sugar-cane borer (SCB), *Diatraea saccharalis* (Fabricius) is the most widespread pest of sugar-cane in Cuba, causing annual losses of over US\$ 40 million. The insects spend a large part of their development within galleries in the cane stock and are, therefore, inaccessible by conventional means of control. The "Instituto de Investigaciones de Sanidad Vegetal" (INISAV) which is the main institution of the Ministry of Agriculture carrying out research on plant health, has not used conventional methods such as pesticides because of the high cost, and has instead tried a biological control programme using parasites and pathogens. This method has been utilized with some degree of success, but a more integrated approach is sought through the application of radiation-sterilized insects (F¹ sterility concept) in their efforts to control and possibly eradicate the pest. The project will be implemented by INISAV with the co-operation of the Ministry of Sugar and the Centre for Studies Applied to Nuclear Development (CEADEN).

National Input: INISAV will provide laboratory facilities, including equipment usually utilized in an entomology laboratory; the Ministry of Sugar will assist in co-ordination and will make available its agro-industrial complexes; and CEADEN will provide irradiation services and radiological advice. All the implementing institutions will supply sufficient counterpart staff as well as funds for local expenses. Appropriate radiological protection procedures will be followed in accordance with support and advice received from the Centre for Radiation Protection and Hygiene (CPHR/SEAN).

Agency Input: The Agency will finance laboratory equipment required to apply the F¹ technique, experts on production and release of sterile insects, and fellowships on mass-breeding of Lepidoptera and releases. The main counterpart has been trained under a fellowship prior to the initiation of the project.

MAR/5/006: Study on Control of *Plutella xylostella* by F¹ Sterility (1993)

Objectives: To assess the practical feasibility of implementing a programme involving SIT to control the diamondback moth.

Background: The diamondback moth has emerged as a formidable pest of vegetable production around the globe. It has forced farmers in many countries, including Mauritius, to shift from vegetable production to crops of lesser value. The use of conventional methods to eradicate the pest has proved to be ineffective because of the resistance developed by the species against a broad spectrum of insecticides. Therefore, this small project to study the feasibility of the SIT is submitted by the Entomology Division of the Ministry of Agriculture, Fisheries and Natural Resources in search of alternatives to solve the problem.

National Input: The Division of Entomology, which will be the implementing body, has experienced staff and is mainly involved in the control of important pests of both agricultural and veterinary importance. Including the project leader, two scientific officers and two technical officers will be assigned to the project. A mass-rearing laboratory, including a gamma-irradiator and stereoscopic microscopes, are available. In addition, the Government will be responsible for routine operation and maintenance costs.

Agency Input: Essentially, this project request is for the services of an expert to evaluate the possibility of control of *Plutella xylostella* by F¹ sterility.

PAK/5/027: Integrated Management of Fruit Fly (1993-94)

Objectives: To introduce integrated control of fruit flies using the SIT.

Background: Fruit is one of the main export commodities of Pakistan. However, the fruit fly, *Dacus zonatus* (Saunders), a kin of *D. dorsalis*, causes serious losses to fruits such as guava, mango, peach, plum and citrus fruits. A damage of 25-50% is not uncommon in guava orchards alone. The control of this fruit fly by conventional insecticides is difficult to achieve. The Atomic Energy Agricultural Research Centre at Tandojam intends to apply an integrated approach of mass trapping the fruit flies by methyl eugenol traps followed by releases of sexually sterile flies to achieve effective control. Under TC project PAK/5/018, the Agency has already provided expert services to advise on the integrated approach, and a gamma irradiator has recently been delivered. With this assistance, some laboratory and field studies have been conducted. Further Agency assistance is needed to demonstrate the feasibility of integrated control of the fruit fly through the SIT.

National Input: Five scientists have been assigned to carry out the project. A mass-rearing facility and a gamma irradiator, together with other laboratory equipment, are available. The Government is committed to providing such additional funds as may be necessary and to continuing its support beyond the period of Agency assistance.

Agency Input: Under this multi-year project, the Agency has been requested to provide expert services to advise on the SIT. A mixing kettle and some expendable supplies are also needed. Fellowship training is foreseen.

PHI/5/022: Feasibility Study of Integrated Control of Fruit Flies

Objectives: To carry out an economic feasibility study for an area-wide pilot integrated control programme for fruit flies on Guimaras Island.

Background: Fruit and vegetable exports have increased rapidly, and in the years 1991-92 surpassed 4% of all Philippine exports; they thus represent the most rapidly growing export commodity (at a rate of 18% annually). However, fruit flies are a major pest, causing huge losses and a decline in the export of tropical fruits. Insecticides have been used to combat fruit flies, but the insecticide residues are harmful to the public and the environment. Fruit and vegetable exports are limited by quarantine restrictions imposed by fresh fruit importing countries fearing importation of exotic fruit flies and other pests. In this connection, the Philippine Nuclear Research Institute (PNRI), in co-operation with the Guimaras Experiment Station (GES) of the Department of Agriculture, wishes to set up a pilot programme for integrated control of fruit flies on Guimaras Island with Agency assistance. It is intended to use the SIT in conjunction with other conventional techniques. An Agency pre-project mission was undertaken in 1992 to review the request. In line with the recommendations made by the mission, the immediate aim of the project is to conduct an economic feasibility study on the island, followed by an area-wide pilot integrated control programme.

National Input: Suitably equipped laboratories and adequate staff have been assigned to the project by PNRI and GES. PNRI has also conducted various research and development activities related to fruit disinfection using gamma radiation. Small-scale sterile fly production is also maintained at PNRI. GES has been involved in some ecological studies of the oriental fruit fly and other major pests of mango. Furthermore, a co-operative research programme, funded by PNRI, was also initiated by PNRI and GES in 1992. The Government is committed to covering the operational costs of the project.

Agency Input: Under this multi-year project, the Agency has been requested to provide expert services on the determination of fly populations on Guimaras, the adaptation of a geographic information system (GIS) and computer software to process field data of Guimaras, the assessment of taxonomy of flies on Guimaras, as well as on economic analysis of control alternatives. Items of equipment, including a pupal size sorting machine, larval trays, field cages, a stereo microscope, platform balance, diet mixer, reagents and supplies have also been requested. Fellowship training is envisaged as well.

SYR/5/011: Radiation-induced Sterility for Codling Moth Control
(1993-94)

Objectives: To use the SIT to control the codling moth - a key pest in apple production in Syria.

Background: Syria has more than 20 million apple trees and the codling moth is the major crop pest. For pest control, the farmers have been using pesticides, initially DDT (in the 1950s), and later the more expensive organophosphate and carbamate pesticides. The current control method is potentially dangerous for the environment and health and is not cost effective because the insect is developing resistance, thus forcing the farmers to increase the number of applications. To improve the situation, the Department of Agricultural Applications is planning to apply the use of radiation-induced sterility for codling moth control in Syria.

National Input: Staff, as well as an existing laboratory and equipment, are available. Operational funding will be provided by the Government.

Agency Input: The Agency has been requested to provide expertise and fellowships on insect control through the use of SIT, and equipment such as an autoclave, incubator and insect mass-rearing unit.

UGA/5/015: Integrated Tsetse Control Programme (Phase II)
(1993-94)

Objectives: To carry out studies on the SIT as part of an integrated programme to eradicate the tsetse fly.

Background: The tsetse infestation on the mainland and islands of Uganda contributes to the continued transmission of African human and animal trypanosomiasis. Sleeping sickness continues to show a high incidence of cases. The Government is endeavouring to control the situation by joining medical and veterinary specialists in efforts concerned with tsetse control and trypanosomiasis research. The strategy chosen is to break the transmission cycle by attacking both the tsetse flies and trypanosome parasites. To this end, the Agency has been assisting the Government of Uganda since 1988 in its integrated tsetse control programme. Under this project, scientists and technicians have been trained, expert services provided and some equipment delivered. In the proposed project, it is essential to further develop and strengthen tsetse and trypanosomiasis research and control capability.

National Input: The Tsetse Control Department of the Ministry of Animal Industry and Fisheries has good research facilities and qualified staff. The Zoology Department of Makerere University, which has experience in the rearing of flies, will also co-operate in the implementation of the project. The Government will provide funds for laboratory maintenance and operating costs.

Agency Input: Expert services will be provided for rearing and field investigations, including the planning and demarcation of fly release areas. Equipment such as a cobalt-60 gamma source, communication kit and dissecting kits, which are essential for

this and subsequent phases of the project, will be provided. Fellowship training in rearing techniques is also foreseen.

Other Operational Projects

GHA/5/017: Eradication of Riverine Tsetse Fly (Phase II)
MLI/5/012: Integrated Tsetse Control
NIR/5/021: Preventing Tsetse Fly Re-invasion (Phase II)
UGA/5/012: Integrated Tsetse Control Programme
URT/5/007: Tsetse Fly Eradication
ZAM/5/009: Tsetse Fly Control

CHI/5/015: Mediterranean Fruit Fly Eradication
COS/5/012: Medfly Research Laboratory
ECU/5/013: Control of the Fruit Fly
PAK/5/018: Sterile Insect Technique
PAK/5/028: Nesting System of Termites
RAF/5/013: Survey on Extent of Medfly Infestation
THA/5/038: Integrated Control of Fruit Flies

III. MEETINGS

A. Past

1. FAO/IAEA Second Research Co-ordination Meeting on "Laboratory and Field Evaluation of Genetically Altered Medflies for Use in Sterile Insect Technique Programmes", Pavia, Italy, 1-5 June 1992

The meeting was chaired by Dr. Gerald Franz of the Seibersdorf Entomology Unit and attended by 12 research contract holders, 4 faculty members of the University of Pavia and 2 observers. The participants reviewed their activities in medfly genetics and discussed additional research needs to improve genetic sexing of the medfly.

Two sexing systems have reached, or are approaching, full application status; *wp* and *tsl*. The more advanced of the two, *wp*, has been under mass-rearing conditions several times, as well as in the field. The *tsl*-based strain is in the preliminary mass-rearing phase and will be completed by the end of 1992. In addition to the types of selectable markers available, the numbers of translocations that can be used in connection with them has been increased. It is now possible to mass-rear the *tsl*-based strain. The preliminary tests have shown that the breakdown of the sexing system can be kept below 1%. This has been achieved by using translocations with breakpoints very close to the *tsl* mutation.

The results of field evaluation of the *wp* genetic sexing strains were also presented. Field tests have been conducted in Italy, Israel and Hawaii. In general, it was found that male-only releases were far more efficient than the release of both sexes. Field testing of the translocation-based *tsl* genetic sexing strain was conducted in 1992 in Crete and will continue in 1993 in Crete, Argentina, Brazil and Guatemala. The report of this meeting will be available in early 1993.

2. Consultants' Group Meeting on "Tsetse Genetics in Relation to Tsetse/Trypanosomiasis Control/Eradication", 12-16 October 1992

Seven consultants, one observer and the IAEA Entomology staff participated in this meeting. The objectives were to:

- (a) discuss, review and advise on how genetic R&D may be useful for and in managing the tsetse/trypanosomiasis problem;

- (b) identify broad areas of research and development that are most likely to be helpful in supporting current and future activities against tsetse in Africa;
- (c) recommend specific research thrusts to be addressed by a Co-ordinated Research Programme on tsetse genetics planned for 1993-98; and
- (d) write a report that summarizes the above discussions and provides a set of conclusions and implementable recommendations.

The participants conducted an in-depth review of current scientific activity and accomplishments in this area and made a number of recommendations. The report is available on request.

3. International Symposium on Management of Insect Pests: Nuclear and Related Molecular and Genetic Techniques, Vienna, Austria, 19-23 October 1992

Approximately 120 scientists from 52 countries and three international organizations took part in the symposium. Approximately 75 scientific papers and posters were presented during the week-long programme. The subject matter ranged from genetic engineering of insects to action programmes involving the SIT for pest suppression and eradication. Publication of the proceedings is expected in mid-1993.

4. Research Co-ordination Meeting on "Genetic Engineering Technology for the Improvement of the Sterile Insect Technique", 19-23 October 1992

The participants reviewed the current situation regarding transformation, target systems for transformation, genome mapping, and symbiont/insect relationships. The group strongly urged the Joint FAO/IAEA Division to:

- (a) increase its support for research into the development of transformation systems;
- (b) encourage the development of systems for the application of genetically transformed insects; and
- (c) support the expansion of molecular technology into genome mapping.

The report of the group is available upon request.

B. Future

The Second FAO/IAEA Research Co-ordination Meeting on "Development of Practices for Area-wide Tsetse Eradication or Control with Emphasis on the Sterile Insect Technique" will be held in August/September 1993 in Tanga, Tanzania.

IV. TRAINING COURSES

A. Past

FAO/IAEA Interregional Training Course on the Use of Radiation and Isotopes in Insect Control and Entomology

This training course was held at the University of Florida, Gainesville, Florida, USA, from 3 May to 13 June 1992.

Over 120 applications were received from candidates in 47 countries. Unfortunately, due to lack of space, only 20 applicants were selected for the course. This year, the course

emphasized integration of control methodology for area-wide insect management, biology, ecology and dynamics of pest insect populations subjected to control by the SIT, and other methods of insect pest control. The course included radioisotope use and principles of radiation-induced sterility, F¹ sterility and field application of the SIT. The use of computers in population modelling was included in the laboratory exercises.

B. Future

FAO/IAEA Regional Training Course on Tsetse Control Using the Sterile Insect Technique

It is proposed to hold this training course in August/September 1993 in Tanga and on Zanzibar, Tanzania, where there is currently an FAO/IAEA project to eradicate the tsetse fly, *Glossina austeni* using an integrated approach including the SIT.

Detailed information will be given later including course programme and application procedure, however, the nomination deadline would be about April 1993.

V. DEVELOPMENTS AT THE SECTION'S LABORATORY UNIT, SEIBERSDORF

A. Tsetse Fly

1. Mass-rearing and long distance shipment of pupae to TC projects in Africa

The mass-production of *Glossina tachinoides* for the provision of excess pupae to an SIT project in central Nigeria (BICOT) was pursued. The required labour, equipment and supplies needed for a large tsetse colony (up to 120,000 females), colony dynamics and established quality control parameters were reviewed. As already reported (Insect and Pest Control Newsletter No. 47), the diet costs could be reduced by 80%. An extended maintenance of old colony females increases the pupae output and can reduce the need for young female input. The required weekly labour for the maintenance of a 100,000 female *G. tachinoides* colony was reduced from 190 to 140 hours. By late 1992 a total of almost 1.9 million pupae had been provided to BICOT. As of mid-1992 the size of the *G. tachinoides* colony has been reduced and will probably be maintained at 40,000 females to supply field projects and collaborative researchers during 1993.

With some assistance through an FAO TC project, the Entomology Unit is currently expanding its *G. austeni* colony to at least 70,000 females in support of sterile male releases on Zanzibar, United Republic of Tanzania. The target is the eradication of *G. austeni* from Zanzibar. In combination with other conventional tsetse reduction methods, applied as part of an UNDP/FAO animal disease control programme, the Joint FAO/IAEA Division intends to use the SIT for the eradication of the target species particularly in such habitats where the placement of insecticide-impregnated targets or the pour-on treatment of cattle with insecticide is less suitable. Currently, the need for sterile males in different habitats and the requirements in terms of size of fly production colonies are being assessed and the respective budgetary prerequisites will be determined. Test shipments of *G. austeni* pupae from Seibersdorf to Tanga were initiated in April 1992 at three week intervals. As of early 1993 the routine shipment of 15,000 to 20,000 pupae every three weeks will be initiated.

2. Other rearing activities and research

Small stock colonies or maintenance strains of *G. palpalis palpalis*, *G. fuscipes fuscipes*, *G. brevipalpis*, *G. pallidipes*

and *G. morsitans submorsitans* were held at the Entomology Unit for in-house research and to supply material to collaborative researchers. As a direct result of the recommendations from a Consultants' Group Meeting on "Tsetse Genetics in Relation to Tsetse/Trypanosomiasis Control/Eradication", held in Vienna from 12-16 October 1992, a number of scientists at different institutes have initiated special genetic and molecular biology research that is relevant to conventional methods of tsetse control and to the use of sexually sterile tsetse in vector control projects. Such research depends on the availability of suitable tsetse material. The establishment of standard reference strains to support the above research is likely to become an important function of the Entomology Unit.

In anticipation of releasing and recapturing sexually sterile virgin female tsetse flies as indicator insects for the presence of a tsetse population, studies on the mating behaviour of sexually sterile virgin female tsetse were conducted. It was confirmed that female tsetse that were sterilized either as pupae one week before emergence or as adults do not show any differences in mating behaviour, i.e. attractiveness to males, receptivity to mating or mating duration, when compared with fertile females of the same age. Other studies at the Entomology Unit focus on the trans-taxon use of sterile tsetse flies (sterile hybrids) for the control of different species of the *PALPALIS* group.

B. Medfly

1. Mass-rearing

Mass-rearing of temperature-sensitive lethal (*tsl*) strains is continuing. We are refining procedures for colony maintenance and treatment regime to selectively kill female embryos. Strains were held under mass-rearing conditions for eight generations without strain breakdown. Extensive field cage studies were carried out in the greenhouse to assess the behaviour and mating activity of *tsl* males. In addition, a field dispersal-survival test of sterile *tsl* males was carried out in citrus orchards in Chios, Greece.

2. Genetic sexing

Four different genetic sexing strains, all utilizing the same temperature-sensitive lethal mutation as a selectable marker but containing different Y-autosome translocations were tested for up to 18 generations for genetic stability. These four strains were selected from a set of 15 translocations on the basis of the position of the breakpoint on the autosome, i.e. knowing the approximate location of the *tsl* mutation on chromosome 5 allowed us to select those translocations with breakpoints close to this selectable marker. In a laboratory scale experiment (i.e. 2,000 to 2,500 individuals were tested each generation), aberrant flies were detected only very rarely and no accumulation of these genotypes was observed. This high degree of genetic stability has to be compared with the rapid breakdown as observed in a sexing strain containing the translocation T(Y;5)30°C with a breakpoint quite distant from the *tsl* mutation. Two of the new sexing strains have been transferred to our mass-rearing facility.

3. Bacillus thuringiensis

A project to find strains of the entomopathogen, *Bacillus thuringiensis* capable of producing agents that are biocidal for adult medflies was successfully completed.

Several hundred isolates of the organism were examined and many were found that produced potentially useful control agents. A variety of heat stable soluble as well as heat labile insoluble biocidal agents were detected.

VI. SPECIAL REPORT

Drs. E.F. Knipling and R.C. Bushland Honoured with World Food Prize

- A. Founded in 1986, The World Food Prize is the foremost international award recognizing outstanding individual achievement in improving the quality, quantity, or availability of food in the world. The World Food Prize is sponsored by The World Food Prize Foundation, established by John Ruan, and is located in Des Moines, Iowa.

Edward F. Knipling and Raymond C. Bushland developed the innovative theory and technique of using mass-reared sterile insects to overwhelm a wild population of insects. This led to the eradication of the screwworm from the US and Mexico.

In the early 1950s, an era when insect control strategies depended almost entirely on chemical pesticides, Dr. Knipling proposed that insect pests could be controlled by sterilizing males and releasing them to disrupt the reproductive cycle.

Dr. Bushland's work was instrumental in making the theory practicable: He developed the inexpensive diet for mass-rearing screwworm larvae and demonstrated in laboratory and field experiments that exposure to X-rays or gamma rays could render screwworm flies sterile without significant diminution of their vigour or mating behaviour.

The eradication of the screwworm has saved the livestock industry, and ultimately the consumer, billions of dollars.

The technique also has been used effectively against Mediterranean fruit flies, gypsy moths, boll weevils, and tsetse flies.

The World Food Prize is the most recent honour among the many Dr. Knipling and Dr. Bushland have received for their work.

- B. With the authors' permission, we have reproduced the acceptance speeches below. We are confident these will be of interest to all our readers involved in SIT work:

LEARNING ON THE JOB

R.C. Bushland, USDA (retired), Kerrville, Texas

I begin my talk with profound thanks to Mr. John Ruan and his associates for the honor of The World Food Prize and the cordial reception given us last May when Dr. Knipling and I were invited to Des Moines. I am enjoying this week's events more than I can say.

Next, I thank Dr. Norman Borlaug and his Selection Committee for choosing us to receive this great honor. I also thank the leaders of the food industry, those involved in production, distribution, information, science and education who, unknown to us, decided we merited their recommendations. To all of those benefactors - my sincere gratitude - Thank you all!

I am also somewhat embarrassed. I know that I don't really deserve this great honor. I am lucky to have lived 82 years to benefit by all the international publicity given screwworms since they invaded Libya to menace humans, wildlife and livestock in Africa and the Mediterranean areas. Even more, I'm indebted to diligent workers who have, through many years, so ably eliminated screwworms from Africa, the USA, Mexico and are now approaching success in Central America.

Just this summer, the Food and Agriculture Organization of the United Nations published in Rome, Italy a 192-page book entitled, "The New World Screwworm Eradication Programme". This excellent text reviews the history of *Cochliomyia hominivorax* (Coquerel) from 1858 to 1992. In April of this year, FAO also published in

Rome a beautiful 16-page brochure, "Eradicating the Screwworm", summarizing the program from the discovery of the parasite in Libya in 1988 to its eradication in 1991.

Tomorrow, at Iowa State University, D.A. Lindquist, who was in Tripoli to lead the entomological effort for FAO, will describe his African adventure. Therefore, I will not waste your time telling my old screwworm stories that I have relished reciting since 1950 when I first sterilized a screwworm fly. I will only cite a collection of papers, organized and edited by O.H. Graham, published by the Entomological Society of America in December, 1985 as Miscellaneous Publication Number 62 entitled "Symposium on Eradication of the Screwworm from the United States and Mexico". Its 68 pages by entomologists and veterinarians review pioneering and current work.

I'll use the rest of my time to talk about livestock producers and land-grant colleges. Without them, we might still be fighting screwworms in Texas.

After eradication of screwworms from Florida in 1959, the goals that E.F. Knipling, A.W. Lindquist and I had envisioned since 1937 were achieved. However, unusually cold weather in Florida during the winter of 1957-58 caused us to expand our hopes.

For Florida pilot tests, the Entomology Research Division had built a screwworm rearing facility near Orlando with a capacity of two million flies per week. This plant was given to the Animal Disease Eradication Division for training the new eradication staff and for experimental trials while a 50 million fly plant was under development and construction at a former air force base near Sebring.

In average winters, screwworms had survived the cold as far north as Gainesville but the unusual winter of December 1957 and January 1958 apparently destroyed screwworms much further south to the region below Orlando.

R.S. Sharman, veterinarian-in-charge of the Animal Disease Eradication Division's Program, proposed a special effort to take advantage of the reduced screwworm overwintering area. With the enthusiastic agreement of Florida officials and the Entomology Research Division, sterile fly production at Orlando was steadily expanded from 2 million in December to 14 million in June when the Sebring plant started producing 50 million sterile flies weekly.

The sterile flies produced at Orlando were insufficient to scatter over the fly survival area in southern Florida so they were spread over the area north of Ocala as an experimental barrier.

We hoped that northward migration of fertile insects might be impeded by a preponderance of sterile flies. This appeared to succeed since screwworms did not make their usual summer outbreak in Georgia and Alabama.

Southwestern livestock growers wanted to know whether the successful Southeastern program might work in their area. Drs. Knipling and Lindquist permitted me to express our new hope based on the Florida experience.

The overwintering area in Florida of 50,000 square miles was about the same size as the winter survival area in the Rio Grande Valley of Texas. If we could eradicate the overwintering population with 1,000 sterile flies per square mile per week, our insects might then be spread over a 100 mile wide barrier zone from the Gulf of Mexico to deserts of the Southwest. We guessed that fertile flies from Mexico would not penetrate the barrier without stopping to reproduce and be outnumbered by sterile flies.

I voiced this theory in many meetings with livestock producer organizations and was further convinced by their optimism and

enthusiastic planning. The growers discovered that their hopes were not shared by a majority of Texas legislators or Washington agricultural administrators.

The livestock producers of the Southwest are hard-headed businessmen.

They recognized that the Florida program cost about 7 million dollars but it eliminated annual losses of up to 20 million. The 3 to 1 payoff in Florida could be even better in the Southwest where screwworms were estimated to cost the livestock industry about 100 million (1960 dollars) per year.

The Southwestern experiment could not be sold as an eradication program so the producers organized a non-profit, tax-deductible corporation named the Southwest Animal Health Research Foundation (SWAHRF). They elected officers and started a fund drive assessing themselves free-will tax-deductible donations of 50 cents for each cow and horse and 10 cents for every breeding pig, sheep and goat.

They secured the help of the land-grant universities in the Southwestern States, particularly in Texas where screwworms overwintered. The county agricultural agents from state extension services put on local educational programs. These were partly fund drives led by farmers and ranchers within each county. The funds were collected by livestock producers and deposited in county banks for transmittal to SWAHRF. These producers donated more than 3 million dollars to start the program and matched federal funds until State money could be appropriated after the first year.

Federal funds were difficult to obtain with agriculture officials in Washington opposed to a program not adequately preceded by field trials as had been done in Florida. The difficulty was that field trials, extensive enough to convince conservative administrators, would cost much of the money raised by the SWAHRF fund drive, would not protect livestock outside the field trial area, and there was no assurance that funds expended could be replaced. So SWAHRF turned to political persuasion. After Lyndon Johnson became Vice-President in 1961, they were able to get a Congressional appropriation in February 1962.

The program succeeded with the aid of growers who practised good animal husbandry to avoid wounds in their livestock. Statistics on case incidences were obtained through county agricultural agents, vocational agriculture teachers who worked with high school students for samples and information, and practising veterinarians who gave valuable intelligence on screwworms infesting pet animals in cities.

The program was aided by information obtained from growers educated in land-grant colleges or taught in high schools by vocational agriculture teachers. The county agricultural agents, sponsored by State extension services and trained in agricultural colleges were keys to success.

The program in Mexico has been more difficult than in the United States because that country lacks our land-grant college system which has been growing and thriving since President Lincoln first signed Congressional legislation in 1862.

I'm not unbiased in my admiration for land-grant institutions since I earned my degrees at South Dakota State and Kansas State Universities. In my professional experience I have co-operated with other agricultural colleges, experiment stations, and extension services and I have found them all to be real assets to American agriculture.

I am confident that The World Food Prize Foundation will enjoy expanding success with its location in Des Moines and association

with Iowa State University, a pre-eminent agricultural institution located in the heart of America in the country's most productive farm state. In this environment Mr. Ruan's enterprises are ideally located. I am proud to be recognized by his Foundation and I thank all of you.

DES MOINES CEREMONY

E.F. Knipling, USDA (retired), Washington, DC

Mr. Chairman, Mr. Ruan, Dr. Borlaug, and other distinguished guests, colleagues and friends. The World Food Prize is the most prestigious award any agricultural scientist can hope to receive.

Dr. Bushland and I are being honored for our contribution to the technology that led to the elimination of the screwworm from all of the US and Mexico and more recently from Libya, Africa. However, the success of the screwworm programs can be attributed to the contributions of many individuals. Without the ingenuity of several other scientists and engineers, the technology could not have been perfected. Without the vision, confidence and bold actions of a number of representatives of the livestock industry, the programs would not have been implemented; and without the able leadership and hard work of those who conducted the programs, the objectives could not have been achieved. I hope that these individuals will also feel honored by this recognition of the screwworm program's success.

Every agriculturalist who is engaged in food production should be grateful to you, Mr. Ruan, and to you, Dr. Borlaug, for sponsoring a program that calls to people's attention the critical importance of food. In this country, and no doubt in others, most people take for granted an unlimited food supply. Also, most people probably have little appreciation of the high investments, hard work and risks that are involved in food production by farmers. And, most people probably have little knowledge of the role scientific research and development has played in making available the abundant, attractive and affordable food items displayed in supermarkets.

It seems appropriate that The World Food Prize Program is administered in this State. Iowa is in the center of our most productive agricultural region; and Iowa State University is one of the leading educational institutions in the nation and world that has a strong commitment for advancing agriculture and food production.

The importance of your efforts is reflected in a recent report by the Royal Society of London and the US National Academy of Sciences. This report projects a yearly increase of 100 million people in the world, and a total population growth from 5.4 billion to 10 billion by the year 2050. It also notes that 600 million people are now on the verge of starvation.

This situation raises important questions: Is the technology science has today adequate to ensure food for 10 billion people? And is agriculture receiving its fair share of the nation's investment in research and development? It is my understanding that only 1.8% of the total Federal R&D budget is allocated for support of agriculture. This compares with 55% for defense, 14.4% for health and human services, 11.8% for space exploration, and 9% for energy. I do not question the justifications for such investment in these other vital areas. But in view of the need for food for a rapidly expanding world population, and the importance of an efficient agricultural industry for the national economy, I raise the question whether 1.8% is a fair share of the nation's research and development budget.

A number of people here have a much better perspective than I do on the research needs to support soil improvement, crop and animal

improvement through selection and breeding, plant and animal protection from diseases, weed control and other aspects. But my interests relate largely to insect pest problems and I must say, with the level of research support, I have grave concern about our future ability to deal with insect pest problems in an effective and environmentally safe manner. Let me tell you why by briefly reviewing the developments in the area of insect pest management that have occurred during the past 50 years.

The science of insect pest management achieved a breakthrough in insect control technology during the early forties. Within a period of 10 to 20 years, several dozen organic insecticides came into being that had unprecedented insecticidal activity. For the first time, farmers had the means to control almost all of the insect pests affecting crops and livestock. And health authorities, for the first time, had the means for controlling the vectors of some of humankind's most devastating diseases. Many entomologists believed that science had finally achieved dominance over insect pests.

However, such optimism did not prevail for long. As we know too well, the extensive use of these new weapons created a number of critical problems. They endangered the survival of wildlife. Insecticide residues began appearing in meat and milk of livestock treated to control parasites; and in those that consumed forage treated for insect pest control. There was growing public concern that such insecticides might cause serious health problems. And insects demonstrated their resourcefulness by developing resistance to insecticides. A problem of special concern for sound insect pest management was the imbalance between harmful and beneficial insects that resulted from the use of broad-spectrum insecticides. This ironically led to more, rather than fewer, insect pest problems. Despite the benefits of such insecticides, we must acknowledge that when populations of perhaps 100 species of harmless or beneficial insects are seriously depleted in the process of controlling one single insect pest, we are relying on a very crude control method.

Now, insecticides can give excellent control of many pests, so long as the sprays are applied. This results in increased yields and profits for growers. But, as soon as spraying is discontinued, pest populations quickly rebound to their normal -- or even higher -- levels. Therefore, populations of most of the more important pests today still remain at threatening levels and require essentially the same control efforts and costs year after year.

So institutions and their scientists having responsibilities in the area of pest management responded to these developments by intensifying research on alternative methods of insect control. Farmers were encouraged to be more selective and more judicious in the use of insecticides. The term IPM was coined to describe a system of insect control that placed more reliance on natural control factors, host plant resistance, cultural and other methods, and less reliance on insecticides. By and large, however, growers did not follow the advice given and they continued to rely primarily on insecticides as the chief means of insect control.

In the meantime, scientists developed a wealth of new information useful for insect control. Much has been learned about the biology, ecology, and behavior of natural biological agents. The mechanisms whereby insects develop resistance to insecticides are now reasonably well known, although the problem has not yet been solved. Outstanding advances have been made in developing insect attractants. Genetic mechanisms have been discovered that are potentially more effective than the SIT. Advances have been made in developing plant varieties that resist insect attack. A matter of special importance for advancing biological control methods is the progress that has been made in insect rearing technology.

Unfortunately, although much progress has been made in developing alternative methods of insect control, very little of the new technology has been put into practice. To be effective and practical, the promising new techniques must be employed in preventive measures when the pest populations are low due to natural causes, or have been suppressed by other means. In fact, the science of insect pest management has not yet developed effective and practical ways to control insects after populations have reached damage levels, except to apply fast-acting insecticides. And this usually requires the use of insecticides that have broad-spectrum activity.

So, after 50 years, where do we stand on insect pest management? If a list were made of the 25 or so major agricultural insect pests that were prevalent 50 years ago and it was compared with a similar list of those of major importance today, most of the species would be on both lists. The only exception would be the screwworm. And, significantly, the screwworm is the only well-established insect pest in which the total populations were subjected to suppression in an organized way and on an area-wide basis. For all others, growers have relied primarily on the application of insecticides on a farm-by-farm or crop-by-crop basis, as the need arises. The co-ordinated screwworm control programs have saved the livestock industries in the US and Mexico billions of dollars over the past 35 years or so. And the suffering of millions of domestic and wild animals has been averted. I must point out that these benefits have been achieved at costs not exceeding 10% of the losses the pest would have caused had the program not been undertaken.

In the past decades, I have critically analyzed the suppression characteristics of virtually all insect control methods and their influence on the dynamics of a number of insect pests, when they are used alone or appropriately integrated. It is my conviction that our scientists already have -- or could readily develop -- the basic technology to deal with a dozen or more other important insect pests with benefit/cost ratios comparable to that of the screwworm. This could be achieved with little or no environmental hazards.

I recently completed an appraisal of the possibility of rigidly managing populations of a number of our major insect pests if one or more key parasite species were released throughout the pest host ecosystem on an area-wide basis. If reasonably efficient methods of rearing the parasite could be developed, the cost of managing the pests would not likely exceed one-tenth of the losses the pests cause under present control procedures.

We cannot forget the millions of lives that have been saved and the hundreds of millions of people who have been spared illness because of the availability of the many chemical insecticides. We must recognize that these insecticides are one of the reasons that agriculture has been able to produce adequate food in the past. Also, we should keep in mind that these valuable weapons will continue to be essential for protecting human health and producing the food needed for the expanding world population. However, agricultural leaders must be made aware that time is running out on primary dependence on chemical insecticides for the control of insect pests. It is imperative that biological or biologically-based management procedures be thoroughly developed and strategically employed as the chief means of controlling the major pests. Chemical insecticides would serve as supplemental control measures as needed.

Pesticide regulation authorities, spurred by new toxicological information and growing opposition to the use of environmentally hazardous chemicals, are banning or restricting the use of more and more insecticides. Insects continue to develop resistant strains; and no solution to the problem seems to be in sight. Moreover, in view of the high cost of developing and proving the

safety of each new pesticide -- which is currently estimated to be in the order of \$40 to \$50 million dollars -- industry is reluctant to risk such investments.

Thus, we are nearing the end of the road we have been following. Agriculturalists are becoming concerned, as they should be, that within a relatively few years, growers might be faced with important insect pest problems that cannot be dealt with in a satisfactory manner. I am confident that, given sufficient research support, our scientists can develop the basic technology needed to deal with many of the world's major insect pests in an effective, economical and ecologically sound manner. However, the attainment of these goals will require new thinking, joint efforts by private and public interests, and bold actions like those that made the screwworm programs so successful.

Mr. Chairman, permit me to make a few additional comments. It has been my privilege to serve for more than 60 years as a scientist dealing with agricultural and health problems. This has been an interesting, challenging and rewarding experience. For young people who might be considering the career path they would like to follow, I cannot think of a vocation that would be more important than some aspect of agriculture and food production.

I appreciate this opportunity to express my views on the status of insect management as practised in the past; and to share my thoughts about what must be done to deal with many of the major pests in a more rational and environmentally sound manner in the future. Again, I wish to express my deep gratitude to all those who made possible the great honor that I have received today.

In the past decades, I have witnessed the development of a variety of insect control methods and their influence on the dynamics of a number of insect pests. When they are used in an appropriate manner, they can be very effective. However, our scientists are now faced with a new set of problems. The basic technology to deal with a dozen or more other important insect pests with similar or even greater resistance to that of the screwworm. This could be achieved with little or no environmental hazard.

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