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POLICY

OTHER MATTERS

ALTERNATIVE STRATEGIES FOR DESERT LOCUST CONTROL

1. As the Governing Council is aware, UNDP country and intercountry projects have supported the efforts of governments and intergovernmental organizations and the Food and Agriculture Organization of the United Nations (FAO) in desert locust control for a number of years. This support has assisted in the establishment of surveillance and forecasting networks; the development of more appropriate pesticide application techniques; the provision of supplies, protective clothing and communication equipment; the establishment of field control stations; the arrangement of conferences to exchange information on control tactics and plan regional and interregional strategies; and the training of national plant protection staff. UNDP and Special Fund intercountry project costs since 1960 have amounted to approximately $35 million. Approximately $7.5 million have been contributed since 1986 to combat the current desert locust plague in the Arab States and African regions and through FAO.

2. In spite of the efforts of the Governments of locust-affected countries, regional organizations, FAO, and the support of donor organizations, a major outbreak of desert locusts has occurred since 1985. It has the potential to affect as many as 60 countries. Recent reports from FAO suggest that there are indications that the current invasion is still expanding. In recognition of the urgency of the situation, the Administrator proposed to the Governing Council in June 1988 a project entitled "Emergency Assistance to Meet Short and Intermediate Needs for Desert Locust Control" (DP/PROJECTS/REC/29) which was endorsed by the Governing Council in decision 88/32 of 1 July 1988 and which has become operational. In addition, the General Assembly adopted on 22 December 1988 an "International Strategy for the Fight Against Locust and Grasshopper Infestation, particularly in Africa". UNDP is actively responding to this resolution in all of its aspects, including funding for the training of locust control experts, other forms of technical assistance, and collaboration with the Secretary-General in response to the request contained in the decision to establish an international and operational capacity to provide direct support to countries affected by locusts.

3. While the efforts of UNDP are continuing and even increasing in the field of conventional pesticide-based desert locust control, the Administrator took the initiative in early 1988 to examine whether alternative means of locust control to reduce the reliance on synthetic pesticides might be developed. Desert locust control campaigns are dependent on the use of synthetic chemical pesticides. Unfortunately, such massive control campaigns pose very serious environmental hazards. The deleterious effects of synthetic chemical pesticides on the environment, human health, and wildlife have recently been highlighted in "Our Common Future", the report of the World Commission on Environment and Development (also known as the "Brundtland Report"). This report goes on to urge that their use be minimized. In the ensuing consultations undertaken by UNDP, it was determined that research in this area had declined over the past two decades and that a medium- to long-term research and development effort in seeking alternative strategies for desert locust control is needed. To confirm this finding, UNDP convened a consultative meeting of distinguished scientists from Australia, Canada, India, Kenya, the Sudan, the United Kingdom and the United States of America in September 1988. These scientists included entomologists, meteorologists and environmental specialists. It was their conclusion that new technology could and should be developed to limit the environmental stress and health hazards associated with pesticides and possibly contain in the longer term the spiralling costs of conventional pesticide control measures, which FAO estimates may approach $240 million for the period September 1988 to June 1989.

4. These scientists made a number of detailed recommendations of areas where research over 5 to 15 years could yield positive results in developing alternative strategies for desert locust control. These research areas included: modelling and forecasting, biorational mechanisms, genetics, environmental impact and risk assessment, locust pathogens and predators and other means of biological control. In addition, the need to involve institutions in locust-affected developing countries and to develop applied research in these countries was also stressed. The full recommendations of this consultative meeting, including the list of participating scientists, is contained in annex I. It was the unanimous recommendation of this scientific panel that a focused and superior quality research effort would develop environmentally acceptable control strategies.

5. To explore further the desirability of initiating a research programme for the development of alternative strategies for desert locust control, UNDP convened a meeting in Cairo from 12-14 December 1988. It was attended by plant protection specialists from developing and developed countries, representatives of many bilateral development agencies and several international organizations. The recommendations prepared by the UNDP scientific consultation were reviewed and modalities suggested to carry out these recommendations. The meeting, which was opened by the Associate Administrator and the Deputy Prime Minister and Minister of Agriculture of Egypt, was attended by over 75 participants from 22 countries and 11 international organizations. The list of participants is contained in annex II. The full text of the conclusions which were adopted by the participants at this meeting is contained in annex III. The following issues were covered:

(a) The necessity to continue to combat the current desert locust plague using conventional pesticide-based control methods;

(b) The desirability of undertaking research with a view to developing alternative and less environmentally harmful methods for desert locust control;

(c) The identification of certain alternative strategies for desert locust control that could be developed through sustained research;

(d) The need for a long-term commitment on the part of the international community to sustain such research;

(e) The desirability of establishing an international scientific research network for research into alternative strategies for desert locust control which would involve a commitment to research of the highest quality, in addition to institutional strengthening and training for institutions and scientists from developing countries;

(f) The use of UNDP to provide an instrumentality for making grants for the above-mentioned research;

(g) The desirability of a management committee to provide overall policy guidelines for such a research programme, to be composed of representatives of Governments of locust-affected countries, donor organizations and international organizations prepared to contribute to such a programme;

(h) The requirement to establish a scientific advisory panel composed of five to seven individuals, chosen for their individual capacities and for their scientific or other relevant expertise to identify research priorities to review research grant applications, and to monitor the progress and quality of research undertaken by grantees.

6. In the light of the strong endorsement and encouragement by representatives of the scientific community, representatives of locust-affected countries and by representatives of international donor organizations to establish a programme involving research for alternative means of desert locust control, it is the intention of the Administrator to establish such a programme as quickly as possible, subject to the wishes of the Governing Council. In order to do so, the Administrator will require the advice of the Council on three issues: (a) financial resources; (b) the above-mentioned management committee; and (c) the scientific advisory panel.

7. With regard to the first issue, it is not possible at this time to predict accurately how many years of concentrated research will be required before practical results can be achieved, nor the financial resources required to support such a programme. However, experts suggest that research may be required for a period of some 5 to 15 years; based on a comparison with other research endeavours, resources in the amount of $10-$15 million per year could be utilized productively for such a programme. Subject to the agreement of the Council, UNDP could provide in 1989 funds to launch such a programme and begin limited research explorations. In order to defray the administrative expenses of an activity such as the travel of scientific advisers, meetings, consultants, and limited research, the Administrator intends to propose for approval by the Governing Council at its June 1989 session a

global project in the amount of $5 million for the period 1 July 1989 to 30 June 1994. In addition, it is anticipated that, beginning in 1990 or sooner, additional resources will be made available to support research into alternative locust control strategies as appropriate from the regional programmes of the Regional Bureaux for Africa, the Arab States and European Programmes, and Asia and the Pacific. Taken together as a whole, however, these resources will not be adequate to provide the resources required over a sustained period to fund the required programme of research. At this very early stage, firm commitments by other donor organizations to support such a programme are unlikely. Nevertheless, before launching such an initiative, the Administrator would be interested to learn from the Governing Council whether governments and donor organizations might in principle be prepared to assist in supporting such an endeavour.

8. The second issue concerns the management committee for such a programme. Should the Council agree, it would be the intention of the Administrator to constitute such a committee which would meet annually in conjunction with meetings of the Governing Council. Ideally, it would be composed of (a) representatives of those donor Governments or donor institutions which contribute over a certain sum to the research programme; on the model of the Consultative Group on International Agricultural Research (CGIAR), of an equal number of representatives of locust-affected developing countries; and (c) of certain international organizations having special expertise in this technical area. Subject to the advice of the Council and in the light of the difficulties which may be inherent in attempting to establish a more precise composition at this early stage, the Administrator proposes that the Committee be composed of representatives of all members of the Governing Council interested in this endeavour and representatives of interested locust-affected developing countries, whether or not members of the Council. It is also the intention to write to interested international organizations having a current or potential role in this field, such as the United Nations, FAO, the International Fund for Agricultural Development (IFAD), the United Nations Environment Programme (UNEP) and the International Centre of Insect Physiology and Ecology (ICIPE) to participate in the meetings of the Committee. As in the case of certain other collaborative research endeavours in which UNDP participates, foundations might also be eligible to participate in meetings of the Committee as well. At a later stage, the management committee itself may decide that it should evolve into a more formal body. The Administrator also proposes that this Committee be chaired by an officer of the Governing Council and that its Chairman would report to the Governing Council.

9. With regard to the establishment of a scientific advisory panel, the Administrator recommends that it be composed of individuals having scientific experience in environmental science or entomology, knowledge of the countries affected by desert locusts, experience in working with international institutions, and have reasonable geographic balance. It is envisaged that the five to seven members of this panel would be selected by the management committee referred to above on the basis of recommendations by the Administrator, who would receive nominations from appropriate parties. Until such a panel is chosen, the Administrator intends to rely on the advice of members of the Scientific Panel identified in annex I.

10. As noted above, the Administrator will be providing the Council with a specific proposal about such a research programme at its thirty-sixth session. However, because of the urgent calls for action on the part of locust-infested countries and concerned donors, the guidance of the Council is requested on moving forward immediately along the foregoing lines.

Annex I

DEVELOPMENT OF ENVIRONMENTALLY ACCEPTABLE ALTERNATIVES FOR DESERT LOCUST CONTROL a/

CONTENTS

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a/ Text prepared by a scientific panel convened by UNDP at the University of Arizona, Tucson, 27-28 September 1988.

DEVELOPMENT OF ENVIRONMENTALLY ACCEPTABLE ALTERNATIVES FOR DESERT LOCUST CONTROL

INTRODUCTION

Although recognized for centuries as a devastating event, desert locust (Shistocerca gregaria) plagues remain difficult to control. Outbreaks occur at irregular intervals, often in remote regions, and cause great alarm to human populations inundated by locust swarms. Although largely unrecorded, economic losses can be serious. Remedial action in recent times is based on the widespread application of toxic chemical pesticides. For example, FAO estimates that insecticidal treatment of the current locust plague may cost US$240 million for the 12 months beginning July 1988. Unfortunately, little is known about the negative environmental consequences that accompany this insecticide based control strategy. When a locust outbreak subsides, interest in research to develop new locust control technology also diminishes. Consequently, when the next locust outbreak occurs, there are no alternative control strategies available that reduce the need for conventional chemical insecticides.

Locust outbreaks begin with the migration of solitary-living locusts into areas where sufficient rain has recently fallen. Breeding and egg laying then occurs. A sequence of appropriately-timed rains in the winter and summer breeding areas, coinciding with the appearance of each new locust generation, are then required to sustain the high rates of multiplication which lead to outbreaks of mobile swarms. Of crucial importance are the winter rains which often limit locust population increases across the northern and central desert areas of Africa and West Asia. These rains are associated with eastward-moving upper atmospheric troughs which only occur in certain years. At present, these rains can only be predicted a few weeks in advance.

Current control strategy is focused on destroying the first concentrated locust populations (hoppers) that develop after drought-breaking rains. Reduction of populations by pesticides (before such rains) is uneconomic because the solitary locusts are very widely dispersed (1-10 per km2). On the other hand, once the first generation of mobile locust swarms has been produced, control again becomes very difficult because of the problem of locating moving targets and their large size.

The object of this proposed general programme is to provide new knowledge and technology concerning and applicable to desert locust control It recommends a general strategy for research into novel alternative management strategies and tactics that may replace or reduce the use of

toxic chemical pesticides. It should encourage the application of modern concepts of integrated pest management (IPM) in desert locust control. The proposed programme is biologically based, concerned with environmental quality, yet practically oriented. Although it is designed to guide research on the desert locust for many years, it will need to be reviewed periodically in light of new technical developments and research progress. The recommendations are only intended to identify the most promising topics. It is assumed that further indepth consideration of research topics (or proposals) would be accomplished by specialists in the area.

MODELING AND FORECASTING

The control of locust outbreaks depends on national and regional control organizations. The ability of these organizations to respond to an outbreak depends on adequate forecasting of the time and location of such events. Considerable progress has been made in this area since 1940 by the desert locust forecasting service which, on the basis of ground surveys and current weather data, determines the current locust situation and predicts short-term developments for a further six weeks. Simulation modeling is obviously valuable for predicting the increases in area, density and locust phase changes that precede desert locust outbreaks. Models can consider the effects of weather on the environment (especially vegetation), on locust migration, maturation, reproduction, and the status of natural enemies. Currently, forecasting migration is based on some understanding of downwind transport and past events analyzed and displayed in mapped formats. Improved working models would allow alternative strategies and tactics of control to be simulated and thus permit more effective and environmentally acceptable management decisions. Efforts will be needed to simulate aggregation, rates of development and survival of locusts as determined through effects of weather on vegetation, natural enemies, and pest control interventions. Individual attention to both Africa and the Asian sub-continent may be required.

There are a number of emerging computer technologies that enable the entry and intelligent searching of vast amounts of biological, geographical and meteorological information. The application of artificial intelligence (expert systems) and intelligent geographical informative systems (IGIS) in recent years is particularly promising. IGIS, with its applicability to broad, diverse and complex landscape and environmental problems, has particular application to the desert locust problem in Africa and Asia. IGIS provides a powerful methodology to organize, integrate and interpret complex biological, meteorological and environmental information relating to locusts. In addition it can be an invaluable tool in identifying critical areas for additional research. IGIS systems are already being developed by the Food and Agriculture Organization of the United Nations (FAO) for use in locust control and for solving other

agricultural problems. One system (code-named ARTEMIS) generates maps of rainfall, vegetation indices, and water-balance indices on a spatial resolution of 7.6 km from Meteosat and NOAA data.

SELECTED BIORATIONAL MECHANISMS

Principles of Host Selection by Desert Locusts

The factors that lead to host plant selection by desert locusts, especially by immature stages, are not well understood. However, it is thought that volatile compounds (the 6-carbon alcohols and aldehydes) are detected by olfactory organs on the antenna of locusts, and it is possible that these plant compounds play a role in identifying suitable plants for feeding. Visual stimuli in the yellow-green region of the spectrum, (reflectance of chlorophyll and carotenoid pigments) are likely to mediate the behaviour of migrating locusts. Furthermore, chemical stimuli from host plants may influence pre-swarm behaviour by synchronizing development of the immature stages. Since the desert plant Schouruyia is a popular feeding host for newly emerged locusts in the Western Sahara and Tribulus, Aerua, Cenchrus and Indigofera are popular hosts in India, screening of volatiles and other specific chemicals for feeding attractants and feeding stimulators from these and other appropriate hosts is suggested.

Role of Semichemicals in Locust Behaviour

Little is known about pheromones of desert locusts. Locustal (5-ethyl-2-methoxy phenol), which is also found in Locusta migratoria, is thought to be a gregarizing pheromone. However, since locustal is found in two species, it may not be a species-specific gregarizing factor. Three other compounds, phenol, guiacol and ventrole also are found in the volatiles surrounding individuals of both S. gregaria and L. migratoria, and are considered to be aggregation or "cohesion" pheromones. Again, species specificity is unlikely. Finally, a sexual maturation pheromone is produced in dermal cells.

A thorough study of pheromone-mediated events in the desert locust is required. Possible phenomena that could be pheromone-mediated in whole or in part include: sexual attraction, aggregation of nymphs, gregarization, aggregation of adults, sexual maturation, selection of oviposition sites and alarm. These should be studied from a behavioural point of view before studies on pheromone isolation, identification, and synthesis are begun.

If a pheromone is used by desert locusts to identify and select oviposition sites (as found in L, migratoria) it might be used to intensify oviposition in baited areas prior to egg destruction by physical or chemical methods. Similarly, pheromone-mediated aggregation of nymphs might be exploited by encouraging aggregation in limited areas that could then be

treated. In each case, the potential use must be validated by definitive field studies that are evaluated with an integrated pest management perspective.

Hormones and Their Analogues

Hormones and hormone analogues are presently used to interfere with insect behaviour, growth, development, and reproduction. Several commercial products based upon analogues of insect juvenile hormone are used for control of mosquitoes, fleas, flies, cockroaches, crickets and insect pests of stored products. Development of these for ant and termite control is ongoing. The application of juvenile hormones to locust nymphs interferes with their development and could be an important tool in population reduction. Equally important, juvenile hormone application will stop and/or reverse phase transformation in locusts. Juvenile hormone and its analogs act upon insect-specific processes and are not intrinsically toxic, even to insects. Therefore, there may be no serious hazard to humans and the environment in their use.

Antijuvenile hormones are found in plants and are recognized as a component of the plants' defensive strategy against insects. Locusts allowed to feed on these plants (or treated directly) undergo precocious metamorphosis into diminutive, sterile adults. Normal adults are sterilized. Many anti-hormonal substances of natural and synthetic origin are known that could be examined for their action on locust growth, development and reproduction.

Disruption of neurohormone-dependent processes also has potential for locust control. Neurohormones are peptide and protein hormones secreted by nerve cells and serve as the master endocrine regulators of numerous essential physiological processes critical to insect survival. These processes include: molting, metamorphosis and reproduction and are mediated through the effects of neurohormones on juvenile hormone and ecdysteriod production. In addition, neurohormones affect cuticle tanning, molting behaviour and numerous homeostatic processes such as carbohydrate, lipid and protein synthesis, digestion, involuntary muscle contraction and salt and water balance. For example, in locusts, fat body lipid stores are mobilized by the adipokinetic hormone (AKH) and serve as the principal source of energy for the flight muscle during long-term migratory flight. The flight muscle is also stimulated by AKH to metabolize fatty acids more actively for energy production. Disruption of AKH release by suppression of its synthesis or secretion, or the inhibition of AKH action at fat body or muscle receptors would block lipid mobilization or use and suppress the migratory flight capacity of treated locusts. Suitable vectors for introducing neurohormones into locusts will be needed. As with other insect growth regulators, neurohormones are directed against physiological events unique to insects and therefore will have a minimal environmental impact.

Attractants/Repellents

Kairomones are interspecific chemical messengers of adaptive benefit to the perceiver whereas allomones are of benefit to the emitter. Host plant compounds may act as kairomones for locusts, as short-range attractants or feeding stimulants. Conversely, allomones may repel insects from certain plants or deter feeding. Attractants and feeding stimulants, if known, could be incorporated into feeding baits laced with toxicants, pathogens or growth regulators. Alternatively, repellent or deterrent allomones could be used to protect crop plants from depredation or to divert feeding locusts toward trap plants. Feeding, assembly and aggregation attractants may exist in native plants. If isolated and identified, they may enhance the effectiveness of baits. Repellents to feeding and aggregation may also exist among desert plants as a result of adaptive evolutionary pressures and may be of potential value.

Locust Genetics

Schistocerca gregaria is one of the world's most important pests, yet virtually nothing is known about its genome. At a time when science is embarking upon the total elucidation of the human genetic code, this anomaly is unacceptable and incompatible with the need to devise novel strategies for the control of desert locusts.

Insect population genetics is becoming a mature science with the development of modern biochemical techniques. The use of these techniques has resulted in important discoveries about insect speciation and the capacity of genetic variants to act as agricultural pests and threats to public health. Examples include the several races of the European corn borer, Ostrinia nubilalis, that employ distinctive mixtures of isomers as sex pheromones, the varying capabilities of the several races of Anopholes gambiae to vector malaria in Africa, and the separation of the Onchocerciasis vector, Simulium damnosum, into scores of behaviourally distinctive variants or sub-species.

The migrating populations of desert locusts that sweep across Sub-Saharan Africa and Southeastern Asia are believed to be a single species. Nevertheless, until modern genetic probes are employed, it is not possible to assess the possible role of population biology in the development of gregarization. Furthermore, only a broad knowledge of the genetics will reveal any possibilities that exist for the natural spread of genetic incompatibilities (contrived alterations in the genome to produce genetic incompatibilities that produce sterility in mating, etc.) and the feasibility of their use in the control of desert locusts.

Host Genetics

Plants are known to contain insect juvenile hormone analogs as a natural defensive strategy against insect predation. Immature locusts feeding on such plants might suffer developmental derangement and never mature. Adult locusts feeding on such plants would be unable to gregarize, whereas locusts already in the gregarious state might be transformed back into the solitary, non-migratory phase. Antijuvenile hormones also have been found in plants. Immature locusts allowed to feed on these plants might undergo precocious metamorphosis into tiny, sterile adults. Normal adults could be sterilized and their feeding severely inhibited. Thus, hormone and antijuvenile hormone containing plants could be an important element in locust population suppression. Plants containing juvenile and antijuvenile hormones have been discovered among desert adapted species. Certain of these plants might be effective against locusts while others may require selection and adaptive breeding to survive and compete under local conditions.

Genetic transformation of indigenous host plants of locusts into genotypes that restrict locust growth, development, and reproduction may also offer some control over locust populations. For example, plants containing juvenile and anti-juvenile hormones could be the source of genes. Important host plants indigenous to locust breeding areas would be the recipients of these genes. Expression of the genes in the natural host plants of the locusts would interfere with locust biology and reduce the probability of future outbreaks. The introduction of any promising transgenic plant or new species into local habitats would require careful examination of their potential effect on humans, domestic animals, wildlife and non-target insect species.

Biological Control

All developmental stages of the desert locust are attacked by a range of parasites, predators and pathogens. However, migratory populations of desert locusts may escape from natural enemies by only temporarily colonizing habitats created by drought-breaking rains that contain low numbers of natural enemies. On the other hand, when locust populations breed in the same habitat for two or more successive generations, the number of predators and parasites may reach levels which reduce locust populations.

Desert locusts are occasionally infested by low grade pathogens which rarely cause death. Transmission of spores is relatively inefficient and their viability is poor under tropical conditions. The introduction of novel pathogens may cause heavy mortality but the effects are rarely permanent since infected individuals are removed from the population.

Baiting may provide a mechanism for introducing pathogens into locust populations. More virulent pathogens can probably be produced by genetic manipulation. These would be host specific and would be environmentally safe. However, most of these can only be produced in live insects at present. Cell culture lines would be an essential step in the development of genetically manipulated viruses which could be used as biocides.

Although many natural enemies of desert locusts have been identified, none is known that responds to sudden increases in desert locust numbers in a manner that prevents locust outbreaks. It is difficult to manipulate the numbers of indigenous natural enemies under field conditions and over broad areas. Thus, inundative releases of agents (as a biocide) may be the only practical possibility. A strain of Bacillus thuringiensis that might infect desert locusts should be sought. In general, the area of biological control clearly needs attention.

POTENTIAL ENVIRONMENTAL IMPACTS OF CHEMICAL PESTICIDES AND ALTERNATIVE METHODS OF CONTROL

The possible impact on the ecosystem of intervention in the control of locust plagues with pesticides (some such as dieldrin are persistent in the environment), biological control agents, transgenic plants, etc., should be the subject of a thorough investigation. Information from these studies should be evaluated through a systematic ecological risk assessment process. The studies on the impacts on the environment by pesticides or alternative methods might include certain of the following items.

Impacts of Chemical Pesticides

1. Persistence and accumulation within the ecosystem

Information is needed on the form in which the duration that pesticides used for locust control remain in the ecosystem. This information is generally available from both the manufacturer and some governmental agencies for temperate regions, but often not for tropical environments. Plots may need to be established in or near wadis using standard ecological and statistical methods. Soil and vegetation should be sampled periodically and analyzed for specific pesticides in areas where there is a record of pesticide application. Furthermore, pesticides should be applied to some plots at varying concentrations and herbivores and other species higher on the food chain analyzed to determine any bioaccumulation.

2. Toxicity

Information is needed on the toxicity of the pesticides to all species (including humans) in the food chain within these specialized ecosystems. Because of the pattern of rainfall, both plant and animal species often have evolved specialized methods of adapting to drought, high temperatures, and relatively short periods of adequate water. These plant species respond to the presence of water with enormous bursts of productivity and the loss of any species in such a system may be detrimental to future nutrient cycling within the system. For example, little is known about nitrogen fixation in these systems. The loss or reduction in the capacity for nitrogen fixation could result in a permanent reduction in the potential productivity of the system. Nitrification and denitrification must also be considered. Lastly, sampling and analysis of human sources of water in areas where spraying has occurred or is now occurring should be included.

3. Diversity and stability of plant and insect populations

Surveys of insects should be conducted in experimental areas by identifying all species, including parasitoids, predators, pathogens and with special emphasis to those species associated with locusts. The presence, diversity, relative abundance, and biomass of flora and fauna should also be determined. The economic cost associated with the loss of community diversity (normal locust predators, plant species, etc.), human health, and ecosystem productivity, must all be considered.

Alternative Methods for Locust Control

1. Biological control and Biorationals

Selected environmental studies with pox viruses, Bacillus thuringiensis, Metarhizium entomophaga, attractants, pheromones, kairomones, neurohormones, etc., may need to be carried.

2. Introduction of new species or genetically-engineered organisms

In general, species invasions from deliberate introductions raise questions that are similar to those that must be addressed in connection with the release of chemicals into the environment. These involve the fate and transport of the released material and its possible ecological effects. Controlled field studies should be conducted to determine if transgenic plants (e.g., containing juvenile hormones, toxic natural products, etc.) will persist. In addition, any long-term impacts on the plant communities should be identified.

Ecological Risk Assessment

Ecological risk assessment is a systematic process that is now widely used by environmental protection specialists to evaluate the degree of risk associated with the introduction or use of a specific process, agent, etc. It consists of several components such as receptor characterization, toxicological hazard assessment, exposure assessment, and methods used to estimate risk. The use of this systematic approach to determine potential ecological risks may provide vital information for protecting novel ecosystems. It is strongly recommended that a systematic ecological risk assessment be made to evaluate past control methods and to assess the ecological consequences of future alternative methods or strategies for control of locust plagues.

Economic and Social Impact

There are currently few data on the economic damage to agriculture from desert locust plagues. Consequently, field surveys will be needed to assess damage to key crops and to ascertain yield losses in order to calculate economic loss using modern econometric models. In addition, it will be necessary to estimate possible damage to grazing areas by remote sensing or ground surveys. It should be noted that the public's perception of locusts is politically and socially important and must not be ignored.

SCIENTIFIC PANEL

The recommendations were prepared by a scientific panel that was convened by UNDP at the University of Arizona, Tucson, USA, on 27 - 28 September 1988. The panel included the following individuals who were acting in their own capacity as distinguished scientists:

Dr. J.H.Borden
Department of Biological Sciences
Simon Fraser University
Burnaby, BCV5A 1S6
Canada

Dr. William S. Bowers
Department of Entomology
University of Arizona
Tucson, Arizona 85721
USA

Dr. Roger Farrow
CSIRO
Division of Entomology
Canberra, ACT
Australia

Prof. Sayed E. Bashir
Faculty of Agriculture
University of Khartoum
Shambat
Khartoum
Sudan

Dr. Joyce Magor
Overseas Development Natural Resources Institute
Chatham Maritime
Chatham, Kent ME4 4TB, UK
United Kingdom

Dr. F.Maxwell
Department of Entomology
Texas A&M
College Station, Texas 77843
USA

Dr. Robert Metcalf
Department of Entomology
University of Illinois
Urbana, Illinois 61801
USA

Prof. Thomas R. Odhiambo
International Centre of Insect Physiology & Ecology
POBox 30772
Nairobi
Kenya

Dr. R.L.Rajak
Directorate of Plant Protection, Quarantine and Storage, ICAR
New Delhi
India

Dr. L.H.Weinstein
Boyce Thompson Institute
Cornell University
Ithaca, New York 14583
USA

Annex II

LIST OF PARTICIPANTS

DESERT LOCUST CONTROL MEETING, 12-14 DECEMBER 1988, CAIRO

Country	Name	Organization
Australia	J. F. GODFREY	Embassy of Australia
Belgium	Dany GHEKIERE	Ministry of Foreign Affairs
Canada	Claude RICHARD	CIDA
	Yoram HAMIZRACHI	CBC
Chad	Bamtoboin MBORODE	Ministry of Agriculture
Denmark	Jorgen JAKOBSEN	DANIDA Research Council
Egypt	Yassin OSMAN	Ministry of Agriculture
	Moheb ZAKI	Ministry of Agriculture
	Eglal M. RASHED	Observer
	M. ABDEL SALEM	Observer
	M. S. EL-GARHY	Observer
	A. MONTAZ	Observer
	GAMAL EL DIN	Observer
	Pierre ASMAR	Observer
	Youssef HAMDI	Observer (ARE Embassy, Rome)
	M. S. SIMARY	Observer
	Nadia WESSA	Observer
	Sobhy A. TEMECAK	Observer
	Nasr ROHAYEM	Observer
	M. F. HARB	Observer
	Nabil ZAKI	Observer
	Salwa DOGHAIM	Observer
	Joseph T. AWAD	Observer
	M. A. EL GUINDY	Observer
	S. N. GUERGES	Observer
	Mohamed HENDY	Observer
	Mandouh ABDEL HAMID	Observer
Ethiopia	Aynekulu YEMANE	Ministry of Agriculture
France	Marie de VISSCHER	Ministry of Economic Co-operation
	FEGER	Ministry of Foreign Affairs
	P. MONSERRAT	ORSTOM
	Y. GILLON	ORSTOM

Country	Name	Organization
Federal Republic of Germany	Ewald ULRICH	Ministry of Economic Co-operation
	Petra MUTLU	GTZ GmbH
	Hans-Joerg FERENZ	University of Oldenburg
India	Satish CHANDRA	Ministry of Agriculture
Kuwait	G. M. H. AL-BADER	Plant Wealth Department
Mauritania	Sidi Ould ISMAIL	Ministry of Agriculture
Morocco	M. Ahmed BAOU	Vegetable Protection Department
Niger	Tahirou ISSAKA	Crop Protection Department
Norway	Preben OTTESEN	University of Oslo
	Bente HERSTAD	Ministry of Environment
Pakistan	Abdul KAFI	Ministry of Agriculture
Saudi Arabia	M. H. HALAWANI	Agricultural Research Centre
	Mohammed A. AL-HARBI	Agricultural Research Centre
Spain	Eugenio MORALES	Investigacion Y Capacitacion
	Javier M. VASSALO	Agrarias Y Capacitacion
Sudan	Abdalla Ali ABDELLA	Ministry of Agriculture
Tunisia	A. D. JARRAYA	INAT
United Kingdom	Julian METCALFE	British Embassy
United States	William FURTICK	USAID
International organizations		
FAO	Lukas Brader	
IFAD	M. C. MENSAH	
	A. KESSABA	
ECA	B. MULUGETA	
UNEP	Ben WAIYAKI	
ICIPE	M. F. CHAUDHURI	
	W. OTIENO	

International organizations

World Bank	John HAYWARD Moctar TOURE Jeoffrey JACKSON
African Development Bank	Larbi CHOUKRALLAH
Arab Fund for Economic and Social Development	S. Abdel Fattah JARRAD
Islamic Development Bank	Maiga KALILOU Mahmoud S. AHMAD
Saudi Fund for Development	Mohd. M. AL-GHEFILI Abdulaziz AL-HADLAQ

Scientific participants

United Kingdom	Ralph RILEY
University of Arizona (USA)	William S. BOWERS
Texas A & M University (USA)	Fowden G. MAXWELL
ODNRI (UK)	Joyce Irene MAGOR
Simon Fraser University (Canada)	John BORDEN
CSIRO (Australia)	Roger FARROW
University of Khartoum (Sudan)	Sayed EL-BASHIR
ICIPE (Kenya)	Thomas R. ODHIAMBO

Annex III

CONCLUSIONS OF THE MEETING OF THE DEVELOPMENT OF ENVIRONMENTALLY ACCEPTABLE ALTERNATIVES FOR DESERT LOCUST CONTROL*

The following conclusions were generally adopted by a number of governments, representing both locust-affected developing countries and donors, international organizations and scientists who met in Cairo from 12-14 December 1988 at a meeting on the "Development of Environmentally Acceptable Alternatives for Desert Locust Control" under the sponsorship of the United Nations Development Programme (UNDP)**.

1. It is essential that the current desert locust plague be brought under control and that all donors should support locust-affected countries, at both the national and regional levels, in expanding their capacities to meet present and future outbreaks of desert locusts.

2. The work carried out by FAO through its Emergency Centre for Locust Operations deserves full support, including research initiatives by FAO to improve conventional methods of desert locust control through better knowledge of forecasting mechanisms and application practices.

3. Nevertheless, because of their high cost and potentially deleterious environmental effects, reliance on controlling desert locust through pesticides should be reduced by alternative control strategies which, desirably, should be environmentally sound as well as more effective.

4. Alternative strategies for desert locust control which appear to be most promising include research in the areas of: the economic and environmental impact of various control strategies; the survey, modelling and prediction of desert locust outbreaks; the exploitation of locust/plant interactions; locust genetics and biorationals; and potential biological control agents for desert locusts. Other research leading to alternative strategies may also be identified. Close links should be maintained between the development of alternative strategies in the future and research on improved conventional control strategies, which, taken together constitute essential elements of integrated pest management.

5. To conduct the research necessary to achieve success in seeking alternative desert locust control strategies will require a long-term commitment on the part of the international community and financial resources to support research (although modest in comparison to the costs of current control efforts).

6. A promising approach to research into alternative control strategies involves the establishment and administration of an international scientific research

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* See list of Participants.

** As amended following discussion on 14 December 1988.

network involving relevant individuals and institutions in developing and developed countries. The essential characteristics of such a network include a commitment to support high quality, professional scientific endeavours with a focus on field activities, the attraction of scientific talent wherever located, and, to the highest extent possible, institutional strengthening and training support for institutions and scientists in developing countries. Such a network would imply the establishment of information data collection to ensure that all research reports in the field of desert locust control are centrally assembled and publicly available. To carry out such research will require an instrumentality for the provisions of grants based on high standards of scientific review. The elements of such an instrumentality are contained in the following three paragraphs.

7. As a contribution to the search for alternative methods of locust control, and subject to the concurrence of its partner governments, institutions and governing authorities, UNDP is prepared, as a matter of urgency, to place at the disposal of the international community such an instrumentality. It is envisioned that it could serve as a quality control and monitoring function for scientific research aimed at alternative desert locust control strategies. The resources to support research through such a mechanism could come from UNDP and other interested donors. UNDP would also make available its field office network in a supportive role. The operation of such a mechanism should provide fullest possible flexibility to donors consistent with high scientific standards. It is also proposed as an alternative to the creation of new international institutional machinery.

8. A management committee would provide overall policy and guidance to UNDP for the creation of the above-mentioned mechanism. The composition of such a management committee might include contributions in an amount of $_____ or more to research supported through the mechanism, selected representatives of locust-affected developing countries, and other institutions or organizations (e.g. FAO, IFAD, WMO, ICIPE, etc.) prepared to contribute to this endeavour. It is further envisaged that the management committee would meet at least annually to review progress and policies.

9. To support the work of the management committee referred to in paragraph 6, a scientific advisory panel, composed of five to seven individuals, chosen in their individual capacities and on the basis of their scientific or other relevant expertise, will advise on how research might most appropriately be carried out. UNDP will arrange for follow-up consultations with interested multilateral and bilateral donors to reach an agreement on the type, instrumentality and operating procedures required to develop and implement an appropriate research programme. An initial task of this panel will be to review past and present research undertaken in the field of alternative locust control strategies with a view to identifying research gaps and needs, and especially those institutions in developing countries which at present or in the future could play a role in research. The additional roles of such a scientific advisory panel would be to prioritize research goals, review (utilizing consultants as required) research grant applications and proposals for alternative locust control methods (as mentioned in point 6) and to monitor the progress of research undertaken by grantees.

10. In light of the upcoming (11 January 1989) meeting of the Special Programme of African Agricultural Research (SPAAR) to discuss a co-ordinated locust control research programme for sub-Saharan Africa, the foregoing conclusions will be shared with the organizers of the SPAAR Organizing Committee in order to ensure that the efforts of SPAAR and the Global Strategy identified above can be fully integrated and harmonized.
