GTZ; the integrated biological control of locusts and grasshoppers – a GTZ research project

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Abstract

The aim of the integrated biological control project of the GTZ is to develop more acceptable alternative non-chemical methods of controlling locusts and grasshoppers. The existing control measures still rely heavily on chemical pesticides which are the only method available at the present time for cases of severe infestation. The most effective pesticide, dieldrin, is banned in most countries. The substitutes are less effective, more expensive and require multiple applications. It is therefore essential to search for more acceptable, non-chemical alternatives. Preliminary tests have shown that one such alternative could be the use of pathogens and insect growth regulators. The final goal of the project is to localize and attack the problem at the earliest possible stage of development of locust upsurge. This will comprise identifying the problem in the recession areas of the desert locust (*Schistocerca gregaria* (Forskål)) and then treating the insects. In this way the impact on the environment is minimized, the required treatment area is limited, the costs of control are reduced and the potential for crop and grassland damage is negligible. An additional biological, non-chemical alternative method would support this strategy. The programme of the project has nine principal objectives:

- mapping the locust habitat by satellite
- research into gregarization pheromone, to prevent swarm formation
- locust control with insect growth regulators, especially synthetic juvenile hormone analogs
- biological control of the locust with entomopathogenic micro-organisms
- pest management with the help of pyrrolizidine alkaloids
- seed components from *Melia volkensii* and their use for locust control
- field trials with non-chemical alternatives
- research on environmental aspects of the new compounds

- loss assessment and economic studies relating to the effects of locust and grasshopper attack/damage.

Introduction

From 1985–88, after an interval of almost twenty years, outbreaks of the desert locust (*Schistocerca gregaria* (Forskål)) occurred in Africa and the Near East. Climatically favourable conditions in conjunction with the neglect of the warning services and the inaccessibility of some areas due to armed conflict contributed to this mass reproduction. The countries affected were largely unprepared and poorly equipped to cope with the plague. Moreover both donors and recipient countries discovered that since the last plague, hardly any research had been carried out into developing better and more environmentally acceptable control methods. An additional handicap was represented by the banning of the insecticide dieldrin. The advantage of this insecticide, which had been used in all previous plagues, was that, due to its persistence it needed to be applied in the breeding grounds only in widely spaced bands, at large intervals. On crossing these bands the larvae became contaminated and died. When dieldrin was banned the effects of this special method of locust control in Africa had not been analysed sufficiently. Accordingly no alternative agent or methods had been developed to replace dieldrin and in the case of the recent outbreaks, this resulted in mainly short-life insecticides being applied. This in turn resulted in much larger areas having to be treated, and in multiple applications, with all the accompanying negative effects on the environment. On the basis of this unsatisfactory situation a discussion was instigated on the promotion of research into new, biological and integrated control methods. Programmes along these lines were elaborated at international level. The Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) submitted a proposal to the Federal Ministry for Economic Cooperation (BMZ) who made almost 6 million DM available for research into integrated biological control of locusts and grasshoppers. Under the leadership of the GTZ and German research institutions in co-operation with international institutes and organizations as well as technical co-operation projects, research programmes were begun. The first phase of the project will be a three year term which will deal chiefly with practice-oriented research approaches. These approaches are outlined briefly in the following pages. It is intended that the results will be published at appropriate intervals. Field trials in the Sudan, on the Cape Verde Islands and in the Republic of Niger have already produced interim results.

Approaches for research into alternative methods of locust control

Early and remote sensing

Control measures for locust pests can be made environmentally more acceptable by identifying potential epidemics at their beginning and initiating control measures in good time. This is currently effected primarily by surveys and information from the local population, in particular from nomads. This system is efficient but it cannot always be implemented globally and will now be supported by the most modern methods of satellite photography. By evaluating satellite photos (Landsat), maps will be drawn up on a model basis for the Red Sea coast of Sudan, identifying areas which are potentially suitable for mass reproduction of locusts. Such satellite maps, in combination with normal maps, could be of great assistance to prospectors and pilots in the performance of their tasks in future. The present state of technology does not permit a direct identification of locusts by satellite, even when they appear in swarms. The programme outlined here will be implemented under the leadership of Professor Voss at the Institute for Geography of the Technical University Berlin.

Prevention of swarm formation by pheromones

Schistocerca gregaria occurs in a solitary and in a swarming (gregarious) form. In the solitary phase the locusts live in isolation, inconspicuously and as a useful element of a labile ecosystem in areas known as recession areas. Sustained favourable conditions of life lead to explosive mass reproduction. This is accompanied by a gradual change from the solitary to the swarm-forming (gregarious) phase. Adult *S. gregaria* occurring in vast aggregations are able to fly very long distances. They can thus reach areas of agricultural use and cause devastating damage. It appears that the aggregation may be induced by pheromones which influence the behaviour, the appearance, and many of the physiological properties of the locusts. So far none of these potential phase pheromones has been identified, nor is anything known about where they are formed, or their chemical nature. Under the leadership of Professor Ferenz, attempts will be made in the Department of Biology at the University of Oldenburg to identify, isolate and analyse the chemistry of the gregarization pheromone(s). Once the pheromone is synthesized it will be possible to examine the formation and the mode of action of the substance in the locusts. From the resulting knowledge of such a gregarization pheromone and the biological foundations of gregarization, possibilities for targeted intervention in the gregar-

ization process will be developed. However, it is not yet possible to define the exact details of this intervention scheme.

Locust control with juvenile hormone analogs

Juvenile hormones are formed in the insect. They are inter alia, antagonists of the metamorphosis hormone, ecdysone. They prevent metamorphosis to the adult insect; in the case of *S. gregaria*, for instance, there are between five or six larval stages. It is only at the final moulting that the juvenile hormone titre drops so low that an imaginal moulting to the complete insect stage takes place. A synthetic increase in the juvenile hormone titre by additional administration brings about disturbances in the moulting process. The insects die since they are unable to free themselves from the old larval skin. Furthermore, juvenile hormones play an important role in the phase change of *S. gregaria*, affecting the mating behaviour of the male, the egg maturation in the female and possibly the accumulation of lipids (energy reservoirs for the long migration flights). Juvenile hormones have been biochemically analysed so that in the meantime it has been possible to synthesize more than 2,000 analogs. Under the leadership of Professor Dorn of the Institute of Zoology at the University of Mainz, juvenile hormone analogs from as many different chemical groups as possible will be screened for effective interference with the above processes. Tests to investigate the active mechanisms will also be conducted. This concerns both the role of the endogenous juvenile hormone in disturbing physiological processes, and the effects achieved by the analogs. Alongside the juvenile hormones, the so-called anti-juvenile hormones which have not yet been the subject of much research will be examined.

Locust control with entomopathogenic microorganisms

Locusts are attacked by viruses, bacteria, fungi and protozoa. It is the task of the Institute for Biological Pest Control at the Federal Biological Institute for Agriculture and Forestry in Darmstadt (Biologische Bundesanstalt für Land- und Forstwirtschaft) to conduct surveys of the occurrence of microbial antagonists of various types of locust and grasshopper, of their isolation, characterization and behaviour in response to environmental factors, and to test their effectiveness under laboratory conditions (Zelazny, these proceedings). To this end, specimens of dead or suspected diseased locusts and soil samples from various regions of Africa are collected and screened. Both new and previously recognized pathogens are tested in the laboratory for their effectiveness and their environmental behaviour. The aim is to elaborate formulations which can then be used in the field.

Pest management on the basis of pharmacophagous reactions to pyrrolizidine alkaloids

Pyrrolizidine alkaloids are secondary plant substances which occur in many plant species and serve primarily as protection against being eaten. Professor Boppré of the Institute of Forestry Zoology at the University of Freiburg is heading research into the relations between a specific locust species (*Zonocerus variegatus* (Linnaeus)) and one of its host plants which contains pyrrolizidine alkaloids (*Chromolaena odorata*). The alkaloids are taken up by the locusts and exercise the same function as in the plants – protection against being eaten. They do not serve nutritional purposes. For this reason such behaviour is termed pharmacophagy. The plants exert a strong attraction on the insects. Whether the alkaloids have additional influence on *Z. variegatus* is a subject for research. It is known that certain butterflies use pyrrolizidine alkaloids as precursors in the synthesis of sexual pheromones. The goal of the research is to use the alkaloids for the production of bait-like substances, and thus lure the locusts so as to tackle them selectively in small areas. Field trials are being conducted in the Republic of Benin (West Africa). The extent to which this insect-plant relation exists in *S. gregaria* also is to be investigated in preliminary laboratory tests.

Plant components as locust control agents

As in *Azadirachta indica* (neem), compounds suitable for insect control also occur in *Melia volkensii.* Under the leadership of Professor Rembold, the Max-Planck Institute in Martinsried will investigate this component. Seeds of the plant are to be collected and treated in co-operation with an international institute in Kenya. The active agents will be isolated and analysed. Laboratory tests will be conducted with crude extracts in order to test the development-inhibiting impact on locusts. By clarifying the structure of the active agents it may be possible to provide initiatives for the synthesis of new control agents.

Test of new products under practical conditions

There are already new kinds of product on the market or at the checking stage, which might represent promising alternatives to the synthetic insecticides employed so far. These include in particular the development of moulting inhibitors. They act in a manner similar to that of the juvenile hormone analogs already described. Pathogenic micro-organisms which have been formulated as control preparations also exist. These and the other preparations derived from the previously described research approaches must be tested under field conditions. Only in this way will it

be possible to assess their potential for subsequent large-scale application. Testing of these agents will be conducted under the leadership of the GTZ in various African countries. The microsporidian *Nosema locustae* Canning (as bait formulation) has so far been tested on the Cape Verde Islands against *Oedaleus senegalensis* (Krauss) and *Diabolocatantops axillaris* (Thunberg). In 1991 series of trials were conducted in Niger. In field cage trials, beside the pathogenic effects of *Beauveria bassiana* (Balsamo) Vuillemin and *Nosema locustae*, the impact of neem and teflubenzuron were tested on *S. gregaria.*

Parallel ecotoxicological tests

Since the new kinds of products are not necessarily environmentally benign, even though they possess a lower degree of toxicity for warm-blooded animals than conventional insecticides, a continuous ecotoxological back-up programme will be implemented. Professor Müller from the Institute for Biogeography of the University of the Saarland heads a team which is backing up all practical trials with tests for possible side-effects of the agents employed. This has already been implemented for the Sudan, the Cape Verde Islands and Niger. In addition, preliminary tests with new active agents will be conducted in the laboratory.

Studies on economic aspects and loss assessment

Our present knowledge concerning the potential and actual damage caused by locusts to food crops and pasture plants is extremely meagre. Under the direct leadership of the GTZ losses on millet will be investigated and economic calculation models will be set up. Model field tests are being conducted in Niger in co-operation with the GTZ plant protection project. Papers on losses due to grasshopper and locust damage and on loss assessment on millet in Niger are available.

Prospects

The initial term of the project is three years. For this reason approaches have been selected which may reasonably be expected to produce results within this period. These approaches include testing the latest generation of preparations, research on pathogenic micro-organisms, or production of bait based on pyrrolizidine alkaloids. Other components, such as research into pheromones, must be considered as more long-term programmes. Should this first phase of the project be successful and further research appear necessary and promising, an extension could follow.