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LOCUST, GRASSHOPPER AND GRAIN-EATING BIRD CONTROL IN MALI

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I. SUMMARY

The primary reason for this project was a devastating infestation of grasshoppers and locusts in mid-1985 in several sectors of Mali. This infestation of sedentary and migratory insects moved at up to 45 kilometers per day and caused in many areas total losses of the major food crops, sorghum and millet. Grain-eating birds compounded the problem, and many donors were asked to help in an emergency control action. FAO in 1985 was the primary donor. The U.S. Agency for International Development (AID) through its Office of U.S. Foreign Disaster Assistance (OFDA), decided only to sponsor this fact-finding survey to determine how AID could help prevent future grain losses due to such pest control emergencies. Working closely in Mali during October/November, 1985 with USAID/Bamako, FAO, and the Malian Plant Protection Service (OPSR), a pest control specialist from MASI observed field control operations, collected 21 soil and plant samples, interpreted plant residue laboratory analyses done in Switzerland, made conclusions with special sensitivity to the pesticides used in Mali that are unacceptable for environmental reasons in the USA, and herein makes to AID recommendations for an environmentally cautious program that includes (a) immediate plus (b) longer term considerations to minimize the chances for future outbreaks. Of immediate concern is the fact that the huge grasshopper/locust populations in 1985 deposited eggs in the soil which will hatch from the rains in June, 1986 if not effectively treated beforehand.

Species of attacking locusts were *Locusta migratoria migratorioides* and *Schistocerca gregaria*. Problem grasshopper species are *Oedaleus*

senegalensis, Aiolopus simulator, Catantops haemorrhoidalis, C. axillaris, Cataloipus cymbifera, C. fuscocoerulipes, Kraussaria angulifera, Hieroglyphus daganensis, and Jagoa gwynni. Grain-eating birds causing damage primarily were Quelea quelea and Auripasser luteus. It was estimated that grasshoppers, especially Oedaleus senegalensis, caused a 24% reduction of millet and sorghum production from 135,000 tons estimated before the outbreak down to 103,000 tons after. Greatest estimated regional losses of 35% were in Nara and Yélimané. Birds commonly caused another 50% loss. The highest densities of oothecae in the soil were found near Mourdiah at 23 oothecae per square meter that average 25 eggs each. Assuming a 50% kill, it is estimated that 287 larvae per square meter could hatch in June, 1986 (1985 emergency densities: 40—60/m^2).

The MASI specialist observed the grain-eating bird control operations by OPSR, OCLALAV and OICMA in the Office du Niger where 40,000 ha of irrigated rice were at risk. Aerial spraying of roosts at night was required, and while effectively performed using fenthion, the work is dangerous for the pilot.

Samples of soil and plant materials were analyzed for pesticide residues, 21 samples from Mourdiah-Dilly and 2 from Yélimané. As to food contamination, the results were dieldrin residues plus HCH metabolites and HCB which are not permitted in the U.S. and a number of other countries. Additionally, in Koloumba fenitrothion residue on sorghum leaves were unusually high (Maximum Residue Limits prescribed by Codex Committee on Pesticide Residues of U.N.). As to

environmental contamination, soils seemed satisfactory, but aerially sprayed dieldrin, fenitrothion and lindane contamination on uncultivated land and waterways are threats to humans and animals. OPSR, OICMA and OCLALAV teams handled the chemicals safely for self-protection, and obviously have been well-trained.

It was noted that pesticide concentrates (active ingredients) are ordered from Abidjan and take 2 months for delivery to Bamako where they may be formulated for distribution. Pesticide storage in Mali is difficult, and OPSR transport is inadequate. Aerial spraying, since one of the two OICMA planes crashed, would also be difficult unless a Piper Pony or PR18 is brought in.

The regional OICMA and OCLALAV organizations have in the past performed grasshopper/locust and bird control services throughout West Africa. These services will now have to be provided by a local, Malian government agency such as the OPSR because those organizations are disbanding due to lack of funds. Grasshopper/locust, and bird control must be continued in Mali, and the Government of Mali needs an expanded and strengthened OPSR.

The program recommended to meet Mali's pest control needs is in two phases for donors and specifically, AID, to consider:

Immediate (Prior to Rains in June, 1986)

Soil sampling to evaluate egg densities in infested areas began in Mali after the MASI specialist left in December, 1985. It is suggested a program start immediately in April, 1986 to procure and distribute

pesticides for application by OPSR and farmers trained by the OPSR before the rains begin in June. The pesticide PROPOXUR should be procured immediately in Abidjan. The program should be implemented through the OPSR with FAO assistance and with an AID-supported technical supervision and project management monitoring team (2 persons) throughout the April - June period. Additionally, the AID team would prepare a design for a long term project to strengthen OPSR over a 3 year period. Details are in Annexes IV and III A.

Projected costs for the first phase are:

Insecticide PROPOXUR 500 tons	US $1,000,000
Dusters & bags	95,000
Other Costs	630,000
Sub-Total	1,725,000
GOM Contribution as in 1985	317,000
AID Technical Assistance Team	129,000
	2,171,000

Intermediate

The dissolution of OICMA and OCLALAV means that OPSR must be strengthened and expanded to perform all the grasshopper/locust and grain-eating bird control operations in Mali. If the larvae hatch in June because the pesticides program was inadequate, OPSR power sprayers on the ground and aerial sprays will have to be used. OICMA and OCLALAV technicians will be needed in OPSR. 10 day refresher courses or 3 week fundamental courses are suggested

for OPSR technicians. Refresher courses for 25 persons would cost approximately U.S. $15,000, fundamental courses for 25 persons approximately U.S. $40,000.

A rough estimate (principally FAO figures) of U.S. $3 million is given for a 3 year period to strengthen OPSR. However, AID should have a project design team look in more detail at such estimates to reflect environmental and management complexities. In general, the $3 million program assumes development of an OPSR Center in Bamako to cover all plant protection disciplines and a network of branch stations with companion transportation and communication facilities.

Finally, the MASI specialist has commented about possible implications of what is happening in Mali for grasshopper, locust and grain-eating bird control programs in neighboring countries. Locust migrations should be particularly watched in the Gao area and the Chad Basin. Grasshopper infestations within the $13^{o}30'$ to $15^{o}30'$ North latitudes are anticipated, particularly in Mauritania. Senegal, Niger and Burkina Faso may also have attacks. H. daganensis attacks on rice in Senegal will likely occur again in 1986. With the halt of the Integrated Pest Management Project and the consequent disbanding of the regional organizations, OICMA and OCLALAV, the national plant protection services in the countries at-risk to these grasshopper/locust infestations and grain-eating birds will have to be strengthened for self-sufficiency in local control programs. These insect and bird problems will continue, and they are controllable. If the regional strategy of the IPM was lacking in management effectiveness, serious consideration by AID should be given to

bilateral assistance with interventions that guarantee host country acceptance of such probable primary donor concerns as management effectiveness, accountability for disbursed funds, and environmental impacts.

II. INTRODUCTION

In the Sahelian Regions of Mali, crop losses due to pests including weeds are in the range of 50% for millet and sorghum. This figure does not take into consideration damage caused by grasshoppers and locusts in years of outbreaks. In 1985, the high grasshopper populations, mainly composed of the species Oedaleus senegalensis, were responsible for an additional 25% loss, a figure which could have been largely exceeded in the absence of extensive control operations.

As regards grain-eating birds, it was anticipated that 1985 could be a dangerous year calling for increased attention but this has as yet not been the case. Still, it is disturbing to note that under the generally critical conditions that prevailed in 1985, Mali and other Sahelian countries have to face a new situation as the two Regional Organizations OICMA (Organisation Internationale Contre le Criquet Migrateur Africain) and OCLALAV (Organisation Commune de Lutte Anti-Acridienne et de Lutte Anti-Aviaire) which assumed responsibilities in surveying and controlling the birds, grasshoppers and locusts, are no longer operational for lack of funds. Under these circumstances it is now the responsibility of individual countries to secure their own protection and to this end they need assistance.

The emergency situation which resulted from the heavy grasshopper outbreaks and migrations in regions known for their chronic food shortage triggered rapid action and funding from FAO, UNDP, EEC, USAID and the Malian Government. The funds thus made available

amounted to US $866,610: USAID allocated US $25,000 for reconnaissance operations and wanted to be informed on the following points before getting more deeply involved:

1. Grasshoppers/locusts

   - the overall situation in affected areas and incurred crop losses;
   - the potential danger for 1986 and the measures to be taken to meet the expected new outbreaks;
   - the pesticide residue situation on and in food crops after the 1985 campaigns;
   - the environmental impact of the chemicals applied;
   - the control strategy to be recommended with a view to its safety and effectiveness.

2. Grain-eating birds

   - the overall situation;
   - the control operations performed in 1985;
   - the control strategy to be recommended.

For the collection of these data, USAID decided to organize a consultancy through Multinational Agribusiness Systems Incorporated (MASI). The study was carried out from October 20 to December 2, 1985 in Mali. The detailed terms of reference of the consultancy are given in Annex I. Pesticide residue analyses were done in Switzerland in December - February and incorporated into this Report.

The MASI specialist travelled through many high risk areas and had extensive discussions with FAO, TDRI (Tropical Development and Research Institute, Great Britain), OICMA and OCLALAV experts. Annex II provides an overview of the itinerary, main activities and persons contacted.

Before leaving Mali, the MASI specialist established in collaboration with G. Popov, FAO consultant, and with the agreement of M. Sissoko, Director-General of the Malian Plant Protection Department (Opération Protection des Semences et des Récoltes: OPSR), a "Project for an Emergency Assistance to the Government of the Republic of Mali for Grasshopper Control" as a follow-up action to the 1985 campaign (see Annex III). It was believed that the grasshopper situation could further deteriorate in the face of a weak OPSR, and that provisions should be made to take measures well in advance to avoid the return of extensive spraying from the air. Another study was devoted to the "Evaluation of the Effectiveness of Pesticides to be Used against Grasshoppers" (Annex IV) since this aspect is of paramount importance in determining control strategies which should be in line with the FAO policies. Furthermore, there was a need for an evaluation of millet and sorghum losses due to grasshoppers. Such figures were meant to help assess the amount of the requested food aid (see Annex V). Consideration was given to the strategy to be recommended for the control of Oedaleus senegalensis in Mali (Annex VI).

Pesticide residues were analyzed in a laboratory in Switzerland, and the MASI specialist evaluated the results (Annex VII). In consultation with the MASI home office, a recommended technical assistance

program for the critical April - June, 1986 period was given to the Office of Foreign Disaster Assistance, AID/W (Annex III A). Finally, results of the observations in Mali were extrapolated for their implication to other Sahelian countries. These comments are incorporated in this Report.

III. BACKGROUND

The migratory pests for which FAO assumes responsibilities include locusts, some grasshoppers, grain-eating birds such as *Quelea quelea* and other pests. The FAO Committee of Experts on Pest Control and the FAO Desert Locust Control Committee are the relevant bodies for securing international coordination of action and to advise individual countries accordingly.

A. Locusts

There are two species of major importance: *Schistocerca gregaria* and *Locusta migratoria migratorioides*. They are characterized by alternating periods of large numbers of swarms, that is, plague periods and periods with few or no swarms (recession periods). The speed with which plagues may develop and the extent of damage caused to traditional agriculture are also common features.

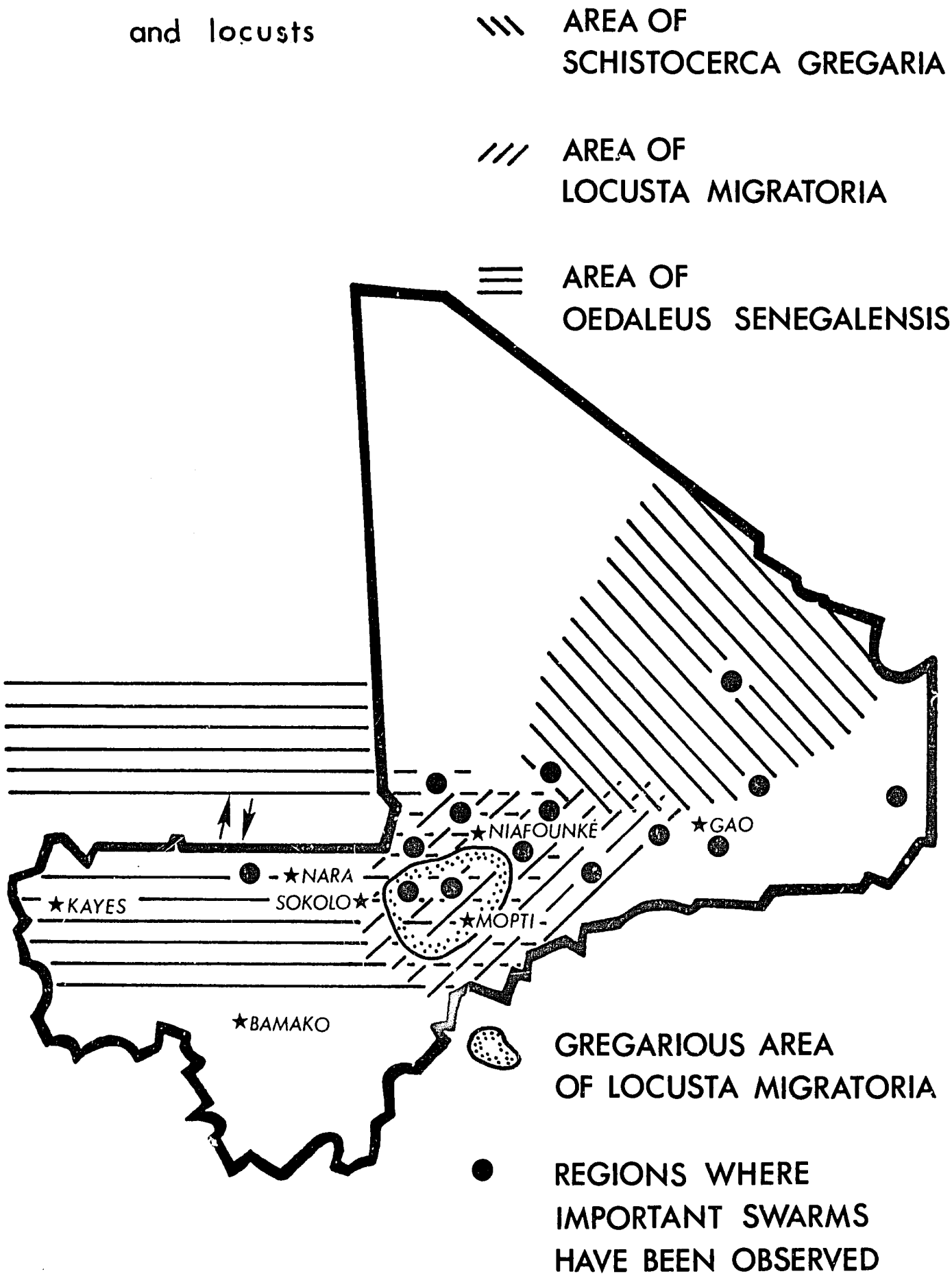
1. *Locusta migratoria migratorioides*, the African migratory locust, has typical outbreak areas, such as in the central delta of the Niger in Mali and the Lake Chad Basin (see Map 1).

2. *Schistocerca gregaria*, the Desert locust, has also its own areas of gregariousness in various parts of Africa. In Mali, a critical area for accumulation is in the north-east of the country (see Map 1).

map 1

REPARTITION OF GRASSHOPPERS

and locusts



B. Grasshoppers

They are semi-migratory or sedentary and of a national or sub-regional nature rather than truly international. They constitute a problem of increasing importance in most African countries. Their damage is more frequent than those of the migrant locust species mentioned above, and their distribution is widespread. Therefore, damage and economic impact are more serious. During the 1985 consultancy the following main species were encountered:

1. *Oedaleus senegalensis*

   This species turned out to be particularly detrimental in the Sahelian belt of Mali. In 1985 the populations grew to enormous levels between the latitudes 13 degrees 30 minutes and 15 degrees 30 minutes North (see Map 1) and moved far beyond the Malian border to the northern latitude (16 to 18 degrees N.), after which return flights returned to Mali with the change in the inter-tropical front. These big swarms were observed towards the end of August and in September; they caused severe damage to maturing crops (mainly to millet for which total losses were registered). *Sorghum* was also seriously affected, but to a lesser extent, since stems and leaves were not favored (Picture 1).

2. *Aiolopus simulator*

   This species is frequently encountered on heavy clay soil in flood recession areas. It attacks seedlings and

PICTURE 1: Millet field - total loss due to *Oedaleus senegalensis*; Mourdiah, 1985

PICTURE 2: Sorghum seedlings destroyed by *Aiolopus simulator*, flood recession crop; Yélimané, 1985

difficult to control because it hides in cracks under the soil surface (Pictures 2 to 4). Extensive acreage may be ruined.

3. Catantops haemorrhoidalis and C. axillaris
Both species are found in association with Oedaleus senegalensis mainly in sandy soil.

4. Cataloipus cymbifera and C. fuscocoerulipes

5. Kraussaria angulifera

6. Hieroglyphus daganensis
The species lives in a humid environment and partly under water; it can be very damaging to irrigated rice and is difficult to control.

7. Jagoa gwynni
The species mentioned under B.2. to B.7. were found in association with Oedaleus senegalensis. They constitute year after year an increasingly preoccupying problem, especially in the flood recession areas of Kayes and Yélimané where since 1972 preventive control has been carried out by OICMA and OCLALAV. The biology and behavior of most of these species are still insufficiently known; there would be merit in promoting research on them.

PICTURE 3: Sorghum seedling partly destroyed by *Aiolopus simulator*, flood recession crop; Yélimané, 1985

PICTURE 4: Typical flood recession area near Kayes, 1985

IV. CHRONOLOGY OF 1985 EVENTS

A. Grasshoppers

1. Sector Mourdiah-Nara-Dilly-Ballé-Fallou (see Map 2)

August

The sedentary *O. senegalensis* populations developed to a considerable extent within a belt expanding from the latitudes 13°30' to 15°30' North--at first on uncultivated land (*Cenchrus biflorus*, a widely distributed, wild gramineous plant is favored), then, in a second phase attacking leaves, halms and heads of millet.

On August 22, N. Jago (TDRI) sent a radio message to OICMA announcing a heavy build-up of *O. senegalensis* in the Mourdiah-Nara-Dilly area.

September

During the first decade the return migration of the populations continued (G. Popov, FAO consultant confirmed that there was an emergency situation in that area).

From September 9th to 25th aerial and ground treatments were performed, mainly using dieldrin and fenitrothion. Towards the end of September the main crops grown during the rainy season were nearing maturity throughout the region. The invasion was widespread, and in certain areas south of Mourdiah harvesting had begun in order to

Map 2

SITES VISITED
IN MALI

avoid total loss due to grasshoppers, including O. senegalensis, Catantops haemorrhoidalis, Cataloipus cymbiferus and Kraussaria amabile.

October

Corn and millet were harvested, and sorghum was in the maturing phase. The high populations observed since August persisted during the first half of the month. O. senegalensis was dominant (90% of the populations with densities up to 60/m^2). Treatments from the ground were performed during the period October 1st—13th on 4,993 ha, and from the air (10th—14th: 39,248 ha). Towards the end of the month the populations were declining, and the females were depositing their eggs into the soil.

November

O. senegalensis was still present but in relatively small numbers. Egg laying was still occurring. During the month evaluations on egg densities in the soil were performed by the MASI specialist.

2. Sector Kayes-Yélimané-Niougomera (see Map 2)

September

During the first third of the month there was a heavy build-up of local grasshopper populations (larvae: 30 to 50/m^2). From mid-September there was an invasion of migrators from the north-east that brought the populations

to very high levels (up to 100/m^2), including the following species: O. senegalensis, Cataloipus cymbifera, Hieroglyphus daganensis, Jagoa gwynni, Kraussaria angulifera.

October

The crops in the flood recession areas (sorghum, corn) were in the seedling - shooting stage. Concentration levels of 20 to 40 grasshoppers/m^2 were in all valleys (tributaries to the Senegal River). Frequent damage was observed on young shoots. The populations were composed of the same species as above with the addition of Aiolopus simulator. The following treatments were performed during the period October 17th to November 1st: from the air: 43,930 ha; from the ground: 2,544 ha.

November

The populations were decreasing, and egg laying was continuing. Investigations on egg densities and overall damage were made by the MASI specialist.

3. Sector Mopti-Douentza

September

Invasions of O. senegalensis and Hieroglyphus daganensis occurred. The situation became critical, calling for protection measures: 3,167 ha treated from the ground.

October

The situation was quiet, but in isolated low places some *Locusta migratoria migratorioides* populations and *Aiolopus simulator* were still causing damage.

4. Sector Niafunke

October

During the second ten days of this month an invasion by *O. senegalensis* took place (densities of 40 to 60/m^2). From the 24th to 26th October 7,280 ha were sprayed from the air.

B. Grain-eating Birds

1. Sector San

August

Nesting sites of *Quelea quelea* were detected.

September

Treatments from the ground between the 23rd and 29th of September were on 85 ha.

2. Sector Central Delta

Reconnaissance from the ground during the period 17th to 25th of October revealed that the situation was not yet critical.

3. Sector Office du Niger

In this sector rice production is dominant and *Quelea quelea* is the main species that attacks this crop. In November the population densities were comparable to those observed in former years. On November 23rd treatments from the air were carried out by two planes: BNT2 ACF and Cessna 185 FT 2 ACR. On November 26th the twin engine BNT2 ACF crashed. Control operations were scheduled again for January, 1986.

V. EVALUATION OF THE SITUATION BY SECTORS

A. Bamako

During the course of numerous meetings with representatives of FAO, OPSR (Malian Plant Protection Organization) and OICMA, it became clear that due to lack of funds OICMA would have to cease its activities on December 31, 1985 (this happened). Only about 10% of its staff would remain during the liquidation phase (OICMA's debts amount to some US $400,000). Since the Organization was already struggling in 1985, OPSR had to handle the grasshopper control operations. It hired from OICMA the necessary equipment (planes and vehicles) and bought the pesticides, part of which were stocks remaining from earlier campaigns. OICMA personnel were also engaged on a temporary basis (scouting teams, a pilot and specialists for chemical treatments). Because of the emergency funding, these operations were financed. In the future OPSR will not only be in charge of the reconnaissance and control operations for grasshoppers and locusts but also for grain-eating birds. OCLALAV has funding problems similar to those of OICMA.

This situation is critical and calls for the following steps:

1. Strengthening of the Central Crop Protection Service in Bamako to cover the following disciplines, each forming a special unit:

    a. identification, surveillance, and forecasting of all pests presenting a threat to crops, that is, locusts, grasshoppers, birds, rodents, stem-borers, et cetera;

b. field experimentation and application of research results (there are no working links between OPSR and the Integrated Pest Management (IPM) and both are located in Bamako) plus efficacy testing of pesticides;

c. control of migratory pests (the control of other pests should gradually be done by the farmers themselves providing they receive proper instruction;

d. extension, providing basic knowledge to farmers and transfer of technology to agricultural agents;

e. quarantine, export, import, domestic;

f. registration of pesticides, including testing for effectiveness.

2. Establishment of a more consistent network of plant protection branch stations throughout the country with proper liaison. There are 8 regions in Mali (Kayes, Koulikoro , Sikasso, Ségou, Mopti, Tombouctou, Gao, Bamako). Currently only 3 or 4 poorly equipped bases exist for the whole country. Five branch stations should be established covering Kayes, Nioro du Sahel, Ballé, Office du Niger, and Central Delta (Koro). Gao and Mourdiah should be strengthened.

3. Establishment of a chemical laboratory for registration of pesticides.

4. Establishment of a quarantine laboratory connected with 3 to 4 border stations.

5. Proper staffing: the number of engineers working with the plant protection service (actually 7) should be expanded to 15 (40 more technicians are needed).

6. Training in modern crop protection technology has to be obtained (abroad for engineers, in special local courses for technicians).

7. Providing the necessary equipment (vehicles, sprayers, 2 planes, pilots and crew for maintenance, equipment for liaison).

Implementing such a project (without salaries for personnel) can be estimated at roughly U.S. $ 3 million (extrapolation from other countries). The proposed development could take place within 3 years as bilateral or multilateral assistance or in the form of an FAO/UNDP project. It would provide the necessary infrastructure without which the most ambitious agricultural projects are likely to fail in the face of the high crop losses (50% to 70%) due to pests. Mali could thus take full responsibility for its own plant protection problems; any revival of regional organizations such as OICMA and OCLALAV would be redundant.

Such considerations are of paramount importance when bearing in mind that emergency situations are going to occur in the future. The lack of a solid organization in place will prevent effective operations to combat the threats.

B. Mourdiah-Nara-Dilly-Ballé Sector

Visits to this area took place from October 26th to 28th and from November 4th to 6th.

1. Treatments and Behavior of *O. senegalensis*

In September spraying from the air started on the 9th only because of logistical problems and came to an end on the 25th. The spray technique consisted of establishing pesticide barriers (about 200 m. wide and 30 to 80 km. long) so as to block the swarms coming from the north-east. In areas with particularly high population pressure, two or more parallel barriers had to be established. Dieldrin mixed with fenitrothion was mainly used and applied with a micronair device. This combination proved particularly effective, fenitrothion having an immediate killing effect but with a persistence of only a few days; whereas dieldrin, known for its persistence, prolonged the effect over several weeks.

The ground treatments were meant to secure close protection of crops. It consisted mainly in treatments of the uncultivated land surrounding the crops. As mentioned earlier the uncultivated land constitutes a reservoir

from where the pest populations move to the cultivated areas, mostly in close proximity to villages. These operations were performed with nozzle sprayers mounted on 3 "Unimog" trucks (only 1 of the 3 trucks turned out to be really operational). The compound mostly used was lindane (PROCIDAGRI 10 or 16%).

Ideally, treatments should be made by the farmers themselves during the build-up phase of the first generation. The larvae hatch from eggs, having diapaused in the soil once they have been soaked by the first rains (about 15 days after the beginning of the rain). At the larval stage (especially the first ones) they can be easily killed with compounds such as PROPOXUR presented in powder form. Lindane can also be used successfully, but for toxicological reasons, this chemical is banned for major uses in the US.

Accumulation of O. senegalensis was centered at Koloumba near Nara, and the invasion of winged adults and 5 instar larvae from the north-east was intense during the second half of September but already started before the beginning of the month. O. senegalensis is attracted by millet plants whereas sorghum has a rather repellent effect. Sorghum heads, however, attract the insects.

In October the high populations observed since August persisted, calling for further extended spraying. Thus, altogether (September/October) 94,865 ha were sprayed with 28,700 liters of various pesticides.

2. Effectiveness of treatments against grasshoppers

When the MASI Specialist arrived on October 26th the grasshopper populations were naturally declining. Therefore, any appraisal of the effectiveness of the applications was not possible. Figures obtained from OPSR assessments were as follows: 2 to 4 days after spraying with the combination of fenitrothion and dieldrin the efficacy ranged from 75 to 98%; and after spraying with PROCIDAGRI (lindane) 73 to 89%.

Additional information may be collected at the headquarters of the British-Malian Research Project at Mourdiah. This joint TDRI/OPSR Project is aiming at developing simple millet protection systems (2 biologists from TDRI, 3 engineers from OPSR plus technicians, drivers, et cetera). Experiments are carried out on about 15 ha and the first investigations reveal that Acigona ignefusalis (stalkborer), Raghuva albipunctella and some Meloid species are responsible for more than 50% of the crop losses. According to N. Jago, the experimental plots could be protected from grasshoppers by using PROPOXUR powder 2%.

3. Sampling for pesticide residue analyses

In accordance with the MASI specialist's terms of reference, the problem of pesticide residues had to be studied through sampling of soil and plant material. Accordingly 21 representative samples were taken in the area for chemical analysis. The details on the sampling and the results obtained are given in Annex VII.

4. Evaluation of crop losses on millet and sorghum due to grasshoppers

The evaluations were mainly made during the second visit in the area (November 4th - 6th). For millet the best assessment of damage could be made at threshing sites where the specific damage due to grasshoppers could be readily distinguished from other pests (see Pictures 5 and 6). An overall assessment could also be made in fields which had not yet been harvested or just abandoned because of total loss. These findings are summarized in Annex VIII.

5. Evaluation of the egg densities in the soil as a means of assessing the potential danger presented in 1986 by hatching larvae

The assessments were systematically made along the route from Yélimané to Nioro du Sahel-Ballé-Dilly-Koloumba-Mourdiah-Bamako. Annex IX gives an overview of the results.

C. Kayes-Yélimané Sector

The visit was from October 29th to November 3rd.

PICTURE 5: Millet heads at the threshing site; typical damage caused by grasshoppers near Dilly. Photo by Popov.

PICTURE 6: Millet heads at the threshing site near Ballé. Photo by Popov.

1. Evaluation of the general situation

This area comprises about 300,000 ha of cultivated land and forms a dense network of waterways which are ideal for flood recession crops and accordingly provides possibilities for year-round cultivation. The rainfed crops were badly hit by O. senegalensis and other species being well adapted to the prevailing conditions. Thus Aiolopus simulator, Hieroglyphys daganensis and Kraussaria angulifera which have high potentials for gregariousness, are also detrimental to flood recession crops.

A. simulator living as already mentioned in heavy clay soil attacks sorghum at all stages and is often causing major damage to young seedlings in recession areas. Since 1972 the grasshoppers have year after year seriously damaged crops and been subjected to preventive control measures. These treatments were carried out by OICMA from a base in Kayes (now taken over by OPSR) and by OCLALAV from a base at Niougoméra near Yélimané (now also in the hands of OPSR). However, despite these repeated operations the situation is not under control. Real improvements are only likely to be obtained through indepth studies of the species which are poorly known.

As regards grain-eating birds there is also a chronic problem on rainfed crops in June and July. The flood recession crops are attacked mainly by Quelea quelea and

Auripasser luteus during November and December. In this area OCLALAV was controlling the bird populations, a task which rests now with OPSR.

2. Evaluation of the spray operations

Three planes were engaged in the grasshopper campaigns (BNT 2 ACF, Cessna 185 FT 2 ACR, and Piper Pony). Reconnaissance flights, scouting on the ground and treatments were carried out from October 17th to November 1st, covering an area of 43, 930 ha. As to the various teams engaged in these operations, they were composed of personnel transferred from OICMA and OCLALAV to OPSR, having a long experience in grasshopper and bird control. Maintenance of the planes and equipment were correct, as well as the calibration of spray devices and pesticide dosage.

As true in the Nara-Dilly-Mourdiah area, the pesticide mixture generally used was fenitrothion 50 plus dieldrin 5% (2/3:1/3) at a rate of 0.5 l/ha (sometimes more in uncultivated land).

The personnel in charge of mixing the ingredients and filling the containers were directed by an experienced technician, and all the necessary precautions such as wearing gloves and gas masks were taken.

The spray technique consisted of establishing a safety belt around flood recession crops (these crops are sown in relation to the gradual drying out of waterways and swamps). These belts are all the more important as there is a daily migration from uncultivated land to crops during the morning hours and a reverse movement in the evening, apparently because it is cooler (greater radiation) on land with less vegetation. This means that spraying has to be performed during the early morning hours. Here too the 3 to 4 weeks' persistence of dieldrin (killing effect maintained) is welcome, whereas the immediate killing effect produced by fenitrothion is desirable to decimate the target populations.

The applications from the air always entail a certain degree of hazard because of the drift. In addition, people already working in the fields, animals grazing and smaller villages might be directly hit by the compounds. Using dieldrin under these conditions is more than questionable and, therefore, should be rejected. Fenitrothion is acceptable, but except propoxur and lindane (gamma HCH), there are no compounds adequately tested and likely to replace dieldrin. Besides, lindane though less questionable than dieldrin, is restricted in the US.

The MASI specialist analyzed the efficacy of aerial spray operations in the Yélimané area. It was evident that prior to the chemical applications considerable damage

had been made to corn and millet. Total loss especially for corn was not uncommon (see Picture 7).

As regards the evaluation of reductions of the population levels, two factors rendered such estimations difficult: absence of population assessments prior to the applications from the air and the natural decline of O. senegalensis populations. However, it was striking to notice that smaller sectors, which for topographical or any other reason had not been touched by the insecticides, had high levels of Hieroglyphus daganensis and Kraussaria angulifera and relatively higher densities of O. senegalensis as compared with the sprayed areas. Such sectors were sprayed from the ground.

The rainfed sorghum had been harvested at many places, and samples were taken for residue analyses at threshing sites. Damage to sorghum leaves resulting from phytotoxic effects of fenitrothion (at 0.5 l/ha and more) did not seem to affect the yield at a late maturing stage (see Picture 8 for typical phytotoxicity symptoms).

D. Route from Yélimané to Bamako via Kirané, Nioro du Sahel, Ballé, Dilly, Koloumba, Mourdiah

This trip was by land cruiser from November 2nd to 6th (see Map 2) and was planned and implemented in collaboration with the FAO consultant and expert in acridology, G. Popov (Tropical Development

PICTURE 7: Total loss of corn; Boakéré. Photo by Popov

PICTURE 8: Sorghum leaves burned by pesticides; Boakéré

and Research Institute). Information was obtained on crop losses suffered along a road going straight through the outbreak and invasion area. The observations permitted an evaluation of the potential danger for 1986 from the eggs found in the soil. To this end a great number of sites were studied at random (8 between Yélimané and Nioro du Sahel; 8 between Nioro du Sahel and Ballé; 4 between Ballé and Dilly; 7 between Dilly and Mourdiah; and 2 more around Mourdiah). Annex VIII summarizes the data collected, and Annex IX provides an overview of O. senegalensis densities assessed in the various sectors.

E. Conclusions

1. The evaluations, though performed in a limited time, have nevertheless provided results of great value. The sector stretching from Yélimané to Nioro du Sahel has suffered from high grasshopper populations, O. senegalensis being by far the dominant species. Next to that specie were Kraussaria spp. and Cataloipus spp.; both of these could also reach high population levels. For millet the losses suffered were in the range of 60%, a figure which was observed in the triangle Dilly-Nara-Mourdiah and where total loss was not uncommon.

   On sorghum an average figure of 10% loss due to grasshoppers seemed accurate. Here again there is a similarity between Yélimané and the mentioned triangle.

2. The section from Nioro du Sahel to Ballé had a more patchy distribution apparently as a consequence of a migration further south. The formerly high populations could be recognized by the still present grasshopper faeces on the soil surface. The uncultivated land was void of grasshoppers, a situation which has also been encountered between Yélimané and Nioro du Sahel.

3. It is to be stressed that the adults need proteins for the egg laying and that in the absence of these proteins, especially on uncultivated land, population movements are to be expected.

4. The highest densities of oothecae in the soil have been found near Mourdiah after extended sampling in millet fields which had been completely destroyed by grasshoppers. A figure of 23 oothecae/m^2 with an average of 25 eggs each means that per m^2 287 larvae are likely to hatch at the beginning of the 1986 rainy season since about 50% of the eggs are parasitized and destroyed.

5. These preliminary investigations across outbreak areas indicate:

   a. that in general there is a considerable potential danger of heavy initial emergence of larvae at the onset of the 1986 rainy season;

b. that in the face of a partially patchy distribution of eggs in the soil there is a need for a systematic sampling throughout the endangered area (between latitudes 13°30' and 15°30' North). This sampling has to be initiated several months before the rainy season 1986 so as to locate the most exposed areas with a view toward securing a timely distribution of pesticides for applications by the farmers themselves. It is indeed extremely important that the populations are cut down before they start their build-up. Once out of hand, important control measures will be mandatory, especially the hazardous spraying from the air. This concern is reflected in the "Project for an Emergency Assistance to the Government of the Republic of Mali for Grasshopper Control" (see Annex III). It is important that the pesticide distribution be initiated in time because of poor communications and poor storage facilities. At the beginning of the rainy season the tracks and even major roads may be flooded and unpassable.

6. The average crop losses for the Nara, Nioro du Sahel, Diéma, Yélimané, and Kayes regions are summarized in Annex V. The losses are shown for millet and sorghum and include the Niafunké region which was not visited by the MASI specialist.

The overall crop loss attributed to grasshoppers was estimated at 25%.

7. It is certain that the control operations from the air and on the ground were effective. This has been clearly revealed in accidentally unsprayed smaller portions in the Yélimané area. In the Dilly-Nara-Mourdiah-Fallou area the spraying started rather late because of logistical problems but nevertheless clearly stopped several huge swarms which were advancing in a southwesterly direction at a speed of about 45 Km/day. In the Kayes-Yélimané area the spraying was also delayed for the same reasons. The control operations started at a moment when millet and corn were already badly damaged by O. senegalensis and some other species, but further disaster was prevented.

VI. GRAIN-EATING BIRDS PROBLEM

A. General

At the beginning of the sixties the grain-eating birds were mentioned as serious pests in the Niger Central Delta, a rice area in Mali where birds destroyed 10 to 20% of the harvest (Angladette, 1966), but until about 1975 there was a general lack of information on the extent of damage in Mali. In the second half of the seventies evaluations of losses were conducted in sub-saharan Africa, mainly under the supervision of FAO (Manikowski, 1984). This specialist, who is a member of the FAO Plant Protection Service, has spent about ten years in Mali and undertook systematic crop loss assessments. Map 3 provides an overview of the areas which, year after year are exposed to bird damage, the species involved being mainly *Quelea quelea* and *Auripasser luteus*.

According to Manikowski, the five most important bird pests may be:

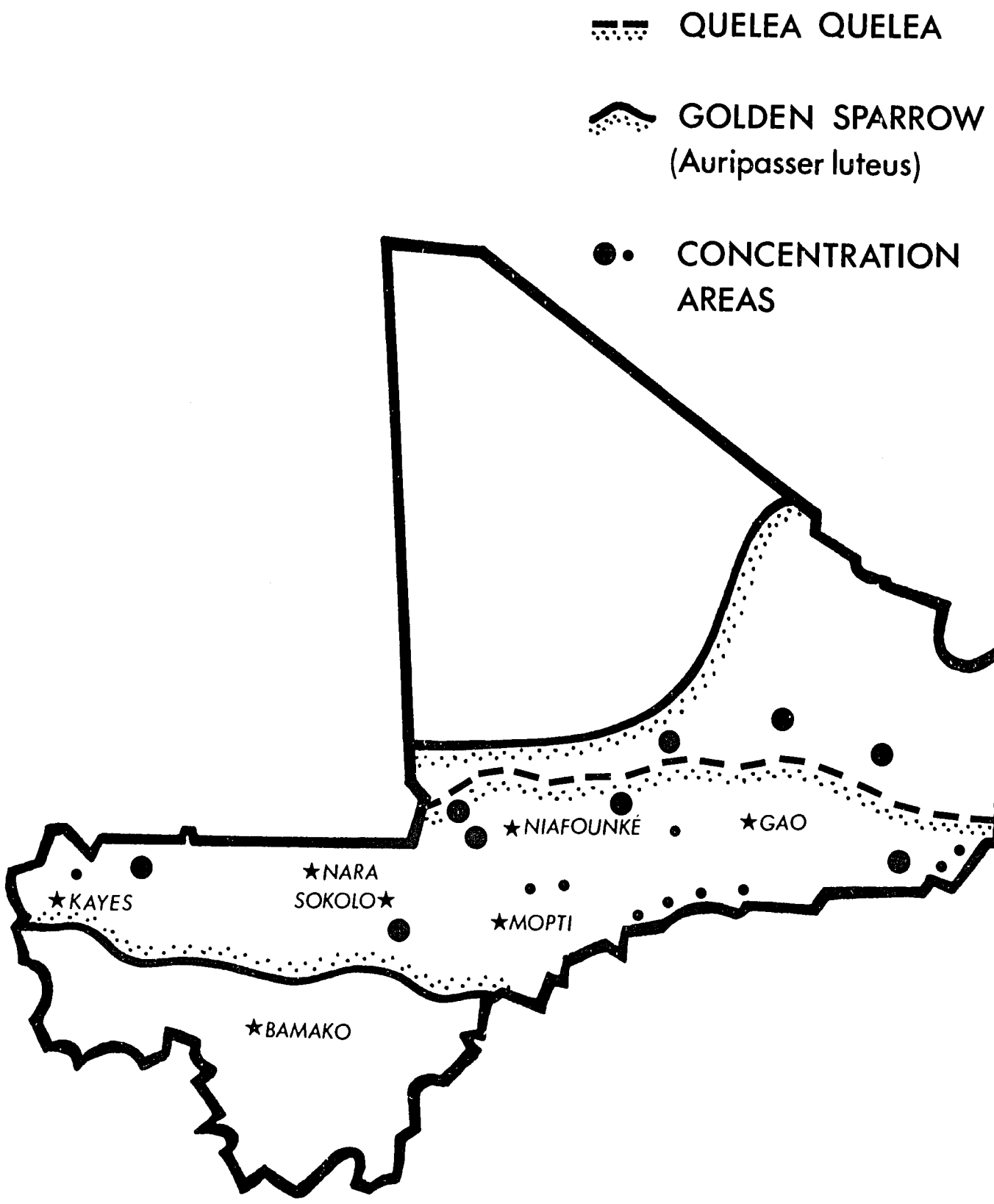
1. *Quelea quelea* the black-faced dioch causing an average loss of 15%;
2. *Ploceus cucullatus* the village weaver with 10% loss;
3. *Quelea erythrops* the red-headed dioch causing up to 40% loss;

Le Riz by Angladette, A., Maisonneuve et Larosse, Paris; 1966, 930 pages.

"Birds Injurious to Crops in West Africa" by Manikowski, S., *Tropical Pest Management*, Volume 30, (4), 1987, pp. 379--387.

Map 3

REPARTITION OF GRAIN-EATING BIRDS



4. Auripasser luteus the golden sparrow (10% loss)
5. Ploceus melanocephalus the black-headed weaver (10% loss).

B. Studies at the Office du Niger

Our investigations were concentrating on the Office du Niger area where there is extensive irrigated rice production, covering about 40,000 ha. Bird damage to ears of rice, with seeds at the milky or doughy stage (damage could be recognized by the presence on ears of squeezed seed husks with remains of albumen), had already begun.

OCLALAV ground teams working on behalf of the Malian Plant Protection Service (OPSR) were systematically inspecting the lands around rice fields in order to detect the roosts. Two OICMA planes were available for aerial reconnaissance and control operations (Norman and Cessna).

The ground team had to localize the bird concentrations in the fields (in this area the repartition of species was about 90% Quelea quelea and 10% Auripasser luteus), after which a reconnaissance from the air took place in the late afternoon, followed by aerial spraying of the roosts after sunset.

The well-trained and experienced ground teams did an excellent job; most of the roosts were located in reeds, a circumstance which renders efficacy studies after the spraying rather difficult.

With respect to the suitability of the two planes for this type of spray operation, it appeared that both were not sufficiently easy

to handle. Great flexibility in maneuvering is needed to encircle the flocks which get startled in the roosts and fly in all directions. This is important if a maximum number of birds are to be hit by the avicide (in this case, fenthion). At the first fly-over of the roost, the majority of the population will try to escape. The pilot must be so skilled in flying in narrow circles that the birds are contained.

Spraying during darkness is in itself a dangerous enterprise because of the difficulty of proper orientation. In addition, the frightened birds are bumping into the plane and crash into the windshield, leaving the pilot without visibility (the crash of the Norman plane on November 26th was apparently the result of such a circumstance). Furthermore, the birds may obstruct the aeration outlets for the cooling of the engine cylinders and can precipitate a dangerous overheating.

It must be stressed also that the pilot must be guided to the roost by marking them with torches, a procedure which is not routinely done.

As to the calibration of the distribution system of the avicide, it was facilitated by using micronair which is easy to handle. The dosage of fenthion was correct and the precautions taken for the safety of the ground crew and the operators did not give rise to objections.

Although the efficacy of fenthion is recognized, some operations failed for already mentioned reasons. Nevertheless, the overall result was positive.

C. Conclusions

1. Spray operations during darkness remain a dangerous enterprise.

2. The scouting and reconnaissance from the air were properly done, but it appeared that the two planes available were not sufficiently maneuverable for spray operations on roosts; a PR 18 or a Piper Pony would be needed.

3. The spraying with fenthion was performed after calibration of the spray equipment and the dosage appeared to be correct; it produced a containment on the *Quelea quelea* populations and consequently reduced crop losses.

4. For bird control OCLALAV has well-experienced teams which should be incorporated within the Malian OPSR.

5. Unless new control techniques are developed, spraying of roosts in exposed areas has to be done routinely, year after year (Kayes-Yélimané, Central Delta area, Office du Niger).

6. It is advisable to emphasize the destruction of nesting sites, thus preventing the build-up of populations rather

than trying to control such enormous flocks. The detection of nesting sites is often difficult, but new techniques such as radio detection are promising and should be further developed.

7. There would be merit in experimenting further with a new technique consisting of an ultra low volume droplet screen of pesticide around the recognized roosts before the quelea birds occupy the roost for the night; the incoming birds have thus to fly through the screen and are killed.

8. Pesticide residue problems are practically non-existent since neither pasture nor crops are sprayed; however, hazards may result for people eating poisoned birds (Codex tolerance: 0.1 ppm).

9. As a fact, the range of methods to be used to protect crops against birds is narrow, and protective measures sometimes cost more than the value of the grain harvest.

10. Using colored flags to protect ripening rice against *Quelea quelea* might be an interesting alternative when fields are close to the roosts.

11. Guarding as it is currently done in the Office du Niger (about 50% of the fields) is often effective but takes the time of the farmers and their families.

VII. ASSESSING HUMAN AND ENVIRONMENTAL IMPACT OF PESTICIDES USED IN THE GRASSHOPPER AND GRAIN-EATING BIRD CAMPAIGNS

A. General

Special attention has been paid to this topic since two pesticides, dieldrin and lindane, are severely restricted in the US and were extensively applied in Mali during the 1985 grasshopper campaign. The question which immediately arises is to know if there are alternative, less questionable compounds possible in control operations. A study of this kind reflecting considerations on efficacy is included in Annex IV. It reveals that lindane in powder form can be substituted by propoxur, but that there is as yet no replacement for dieldrin which is often used in combination ith fenitrothion.

According to FAO practice both dieldrin and lindane can be used for grasshopper/locust control provided that certain precautions are observed. The MASI specialist had to evaluate this situation and in particular to take representative samples of soil and plant material for residue analyses. Twenty one samples were taken in the Mourdiah-Dilly area and two more in the vicinity of Yélimané.

The analyses of the samples for pesticide residues was carried out by the "Institut d'Hygiène, Laboratoire Cantonal de Chimie" in Geneva, Switzerland and the interpretation of the results is based on the Maximum Residue Limits (MRL's) established by the Codex Committee on Pesticide Residues (CCPR). The CCPR is an arm of FAO that attempts to encourage a worldwide harmonization of residue tolerances.

The level of pesticide residues, which is highest immediately after the application, declines more or less rapidly, and at harvest the officially tolerated MRL's should not be exceeded. This means that the safety interval between the last chemical application and harvest must be strictly respected. Such a rule cannot be respected in cases of emergency; this was the case during the campaigns in Mali.

Both aerial and ground treatments have been carried out with due consideration of fundamental safeguards for operators and the observance of a correct dosage and calibration. Treatments from the air entail an increased hazard to the environment because of the drift and the relatively high speed of the plane that render precise operations difficult. This was particularly true when no demarcations on the soil are used.

In the Yélimané area where several aerial treatments were performed with a mixture of fenitrothion and dieldrin, isolated huts and even smaller villages were overflown without interrupting the pesticide spray. People in the field and livestock were directly hit by the pesticide mixture. It is extremely difficult to avoid such mishaps when thousands of hectares are sprayed.

The problem of livestock grazing shortly after spraying is another aspect which renders spray operations on extensive acreages questionable. It is well known that organochlorines (dieldrin and lindane) accumulate in the fatty tissues and in the milk of animals.

This presents another hazard. However, the probability of absorbing larger quantities of chemicals in this way is minimal since the applications are generally not repeated.

B. Study of the Residue Analyses

1. Traore Farm (7 Km. North of Mourdiah)

Eight samples were taken at this farm which is used for experiments by the Anglo-Malian Project on millet protection. It was thus possible to get precise indications on the chemicals used and the dates of application.

About two months elapsed between the last pesticide treatment and the cold storage of the samples which stops the pesticide degradation process. Thus, the millet consumed already in September had accordingly higher residue levels than those revealed by the analyses.

Two chemists/toxicologists of the Hygiene Institute in Geneva (Dr. Vogel and Dr. Corvi) were consulted for proper interpretation of the figures obtained.

a. Millet grain

On and in millet grains (samples lg and lh), see Annex VII, are not alarming but α and Δ HCH and HCB, though at low levels, are unwanted on food. It seems that this contamination is the result of drift, Procidagri (lindane) having been sprayed on adjacent uncultivated land. The values found on millet are hereafter compared with the

Maximum Residue Levels (MRL's) of the Codex Committee on Pesticide Residues (CCPR):

-sample 1g	ppm	MRL's of CCPR
Cypermethrine	<0.06	0.05 (corn)
γ HCH	0.04	0.5
α HCH	0.01	not tolerated
Chlorpyrifos	0.06	0.1 (rice)

-sample 1h		
Cypermethrine	0.06	0.05
γ HCH	0.01	0.5
α HCH	0.002	not tolerated
HCB	0.01	not tolerated
pp'DDT	0.004	0.1
Δ HCH	0.002	not tolerated
Chlorpyrifos	0.12	0.1

b. Millet leaves

Experience has shown that on grain the residues are about 10 times lower than on leaves due in part to the relationship between surface and weight. With this in mind, rough extrapolations from leaves to grain can be made.

-sample 1a reveals relatively high residues:

Cypermethrine	7.1	5 sorghum fodder
γ HCH	0.24	0.5

α HCH	0.02	not tolerated
HCB	0.03	not tolerated
Δ HCH	0.12	not tolerated
Chlorpyrifos	0.89	0.1 (rice)

-sample 1c: it does not give rise to special concern.

c. Soil

The soil contamination due to HCH, chlorpyrifos and DDT is low and could reflect a general pollution of the environment, especially as regards DDT.

d. Panicum spp.

The pollution is low but the remarks made for α HCH, Δ HCH and HCB apply.

2. Samana (18 km Northeast of Mourdiah)

Whereas soil does not reveal any contamination, there is a clear HCH contamination on sorghum leaves as shown under 2c:

	ppm	MRL's of CCPR
γ HCH	7.00	0.5
α HCH	0.93	not tolerated
β HCH	4.20	not tolerated
Δ HCH	2.20	not tolerated

in sample 2 b Propoxur could be found in excess on millet leaves:

Propoxur	2.34	0.5 (reconsidered)

3. Koloumba (50 km North of Mourdiah)

The area suffered from high population densities and was reportedly sprayed from the air with a mixture of malathion and dieldrin. According to the residues it seems more likely that the mixture used was fenitrothion and dieldrin.

a. Cenchrus spp. (3b)

The sample reveals high concentrations of dieldrin and fenitrothion:

Dieldrin	0.31	0.02; has to disappear
Fenitrothion	3.20	10

b. Sorghum and millet leaves

The situation regarding dieldrin and fenitrothion is alarming especially on sorghum (3c):

Dieldrin	7.74
Fenitrothion	58

However, the concentrations are also rather high for millet 3d:

Dieldrin	1.20
Fenitrothion	4.40

4. Sorokori (near Dilly)

The two samples did not reveal the presence of fenitrothion but only traces of diazinon and chlorpyrifos.

5. Damba (near Dilly)

Soil and millet leaves were generally contaminated with organochlorines but at low levels.

6. Vira (near Dilly)

There was no soil contamination in sample la but on millet leaves dieldrin and fenitrothion appeared at relatively low levels:

Dieldrin	0.11
Fenitrothion	0.77
Chlorpyrifos	0.27

7. Boakéré (near Yélimané)

The sorghum grains (3a) and the sorghum leaves (3b) had relatively high dieldrin and fenitrothion concentrations:

3a:

Dieldrin	0.02
Fenitrothion	0.32
Chlorpyrifos	0.03;

3b:

Dieldrin	0.27
Fenitrothion	3.16
Chlorpyrifos	0.17

VIII. CONCLUSIONS AND RECOMMENDATIONS

The tasks assigned to the MASI specialist entailed several field trips and extensive discussions and studies with organizations directly concerned with grasshopper/locust/grain-eating bird problems such as FAO, UNDP, OICMA, OCLALAV, OPSR (Malian Plant Protection Service), TDRI (Tropical Development and Research Institute, U.K.), ICRISAT and the IPM Group. The questions raised are answered as follows:

1. Magnitude of the grasshopper problem in 1985

   In 1985 the high grasshopper populations, *Oedaleus senegalensis* being the dominant species, reached a magnitude which had not been registered in Mali since 1974/75; in the critical, famine prone Sahelian belt situated between the latitudes 13°30' and 15°30' N, these grasshoppers caused an average crop loss of about 25% for sorghum and millet taken together. Other pests appeared to be responsible for another 50% loss.

   There is substantial evidence that the 25% figure would have been exceeded without the extensive chemical control operations, which together with the bird control operations amounted to about US $850,000.

2. Potential danger presented by grasshoppers and locusts in 1986 and action to be taken

   The potential danger is presented by high grasshopper populations composed mainly of *Oedaleus senegalensis*

currently diapausing in the soil in the form of eggs. This situation calls for action prior to the rainy season is expected in June. Furthermore, certain similarities with earlier situations indicate that locust outbreaks could present a major threat. Actions taken against grasshoppers are aimed at preventing the build-up of initial populations appearing some 15 days after the first significant rains. In combating the initial larval populations, the seedlings can be protected. There is a good chance of cutting extensive insect population development that is so difficult to control.

The measures to be taken as a follow-up action to the 1985 campaign include:

a. evaluation of the egg densities (eggs deposited in the soil) through systematic sampling;

b. distribution of safe pesticides to be applied by the farmers themselves;

c. training of farmers in handling simple devices for the application of these pesticides in the form of powders;

d. distribution of pesticides to be applied by the Malian Plant Protection Service.

It is of paramount importance that the distribution and storage of pesticides in the at-risk areas determined by the inspections is completed before the rains start.

If, despite the above-mentioned control operations the populations exceed critical threshold levels, the at-risk areas have to be treated:

i) from the ground with powerful sprayers operated by the Plant Protection Service; currently available pesticides are fenitrothion, propoxur and lindane (this latter should be a pure γ HCH compound); Fenvalerat seems promising but should be further tested;

ii) aerial treatments only if the situation goes out of control, using fenitrothion, lindane, dieldrin.

Treatments from the air are particularly hazardous because of drift and practical difficulties in marking out. Furthermore, there is a need to complete the network of airstrips if long distance flights are to be avoided.

Recommendations for the emergency program (April - June, 1986) that might involve a multi-donor approach are contained in Annex III. In addition, if AID decides to be a significant donor, it is recommended that a small technical and logistics management team supported by AID monitor the implementation of the emergency program in

April - June, 1986 and that the team design a longer term program to strengthen the Malian Plant Protection Service (OPSR). Annex III A describes the recommended technical services for the emergency program.

3. Environmental pollution and food contamination

a. Emergency situation

In cases of emergency, the observance of safety intervals is not possible. Consequently excess residues on crops, uncultivated land and pollution of waterways, especially in flood recession areas, will be unavoidable.

b. Sampling for pesticide residues

The sampling of soil and parts of plants was carried out in sites where the chemicals used and the date of their application could be traced with reasonable accuracy. The 23 samples were stored under cool conditions which stops the degradation process, about 50 or more days after the pesticide application. Thus grains (sorghum/millet) consumed shortly after harvest had higher residues than those indicated in Annex VII.

i) Food contamination

Food contamination has certainly occurred

during the grasshopper campaign, but it may be argued about the real risk to which the populations were exposed. When comparing the residues found, it appears that the Maximum Residue Limits as proposed by the Codex Committee on Pesticide Residues were partly exceeded. The disturbing fact, however, is the presence of dieldrin residues and certain HCH metabolites (α, β, Δ HCH) and HCB for which many countries, including the U.S., have strong reservations. It is also disturbing to notice such exceedingly high values of fenitrothion, which in Koloumba reached 58 ppm on sorghum leaves, even if this concentration has to be divided by a factor of ten for extrapolation on grain.

ii) Environmental contamination

Soil As regards soil contamination, there is apparently no real reason for concern, the organochlorine residue levels being rather low.

Uncultivated land, waterways, humans and animals

There may be locally some contamination on uncultivated land, as shown in Koloumba, with dieldrin reaching 0.31 ppm in a sample, thus presenting a risk for grazing livestock. Similarly waterways, people in the field and

livestock are endangered when overflown and sprayed with a mixture of dieldrin and fenitrothion or with lindane.

Safety precautions in handling pesticides

The safety precautions for aerial treatments were met with respect to handling of pesticides, calibration and dosage. Gas masks and gloves were worn by the crew that had direct contact with pesticides. The OICMA and OCLALAV teams were well-trained and experienced.

Concerning procedures for bird control by aerial spraying, difficulties occurred because the roosts were not properly marked for night operations. Spray operations on the ground were not observed by the MASI specialist, but it appeared that the responsible head of the Plant Protection Service who directed these operations is a good technician and has modern equipment at his disposal.

4. Procurement of pesticides

The most convenient procurement source for pesticides is in Abidjan (Ivory Coast) where international pesticide firms have agents. After ordering it will take about two months to have the pesticides delivered at Bamako.

There are good governmental facilities for the formulation of pesticides in Bamako so that transporting active ingredients only reduces the costs.

5. Storage of pesticides

The storage problem remains difficult, especially in the rural areas. Close cooperation of local agricultural directorates is essential to bridge this important gap. Transportation of pesticides within the country will have to be performed by the Plant Protection Service, but its current transportion facilities are inadequate.

6. Grain-eating birds

In 1985 the bird problem was apparently not worse than other years, but there is a need for careful surveillance every year. The Plant Protection Service should be properly equipped for this activity. For control operations, spraying from the air remains an important tool, but there is now only one plane available (a Cessna which is not maneuverable enough). The Service should be equipped with a PR 18 or a Piper Pony.

Hazards arising from bird control operations are minimal but birds treated with fenthion shouldn't be eaten. People must be warned of this danger.

7. Training

Training of the Malian technicians in grasshopper/locust and grain-eating bird control has two parameters:

a. provided the technicians from OICMA and OCLALAV are transferred to the Malian Plant Protection Service, a 10 days refresher course is needed every second year;

b. if (a) does not apply, a 3 weeks fundamental course is needed in 1986 for covering the following topics:

-basic knowledge for the identification of major species of grasshoppers/locusts/grain-eating birds;

-evaluation of population densities and determining critical thresholds of these pests;

-techniques for ground treatments and preparation of containers for aerial applications.

The costs for the (a) type course for 25 technicians can be assessed at U.S. $15,000.

The costs for the (b) type course for 25 technicians will be about U.S. $40,000.

These are rough extrapolations from similar courses held in other countries (UNDP/FAO organized in 1985 at the Office du Niger a three weeks course on grain-eating birds).

8. Strengthening the Malian Plant Protection Service (OPSR)
Since OPSR must now assume the grasshopper/locust/grain-eating bird control next to all other plant protection problems, it should be strengthened. In Bamako, the OPSR Center has to be developed to cover all plant protection disciplines, including forecasting, warning, surveillance, control operations, extension, quarantine and pesticide registration. A network of branch stations has to be established in the various provinces with proper transport and communication facilities. This type of investment is basic since concerted action in agricultural development must achieve a reduction of the current crop losses due to pests, which for sorghum and millet are in the range of 50%, not including grasshopper/locust damage in years of outbreaks.

The envisaged restructuring of OPSR could take place within a three years' period and would entail expenses in the range of U.S. $3 million. Such a project is urgently needed and could be initiated by FAO.

9. Discussion of the potential danger presented by the locusts/grasshoppers/grain-eating birds in countries neighboring Mali
This evaluation is on a weak basis since the MASI specialist did not have the opportunity to visit and study the situation in countries other than Mali. Therefore, the remarks are an extrapolation made from data collected

in Mali, from discussions with several acridologists and experts of OICMA and OCLALAV as well as reports obtained from Sahelian countries.

a. Locusts

Various indications which can be interpreted as announcing migrations call for special care in 1986. Recommended is an intense surveillance of the situation in areas of gregariousness, especially the regions of Gao, the Central Delta of Mali, the Chad Basin and centers situated further east.

b. Grasshoppers

i) Oedaleus senegalensis

The remarks made for Mali apply to some extent to the other Sahelian countries. Mauritania is directly exposed to invasions coming from the multiplication centers situated between the latitudes 13°30' and 15°30'N. This may well be true also for Senegal, Niger and Burkina Faso where similar movements are likely to occur.

ii) Aiolopus simulator, Hieroglyphus daganensis, Catantops spp. and Kraussaria spp.

In regions where flood recession cultivation is practiced, the crop production potentials are high because they offer the possibility

of several harvests per year. These regions suffer from joint attacks perpetuated by the above-mentioned species to which O. senegalensis has to be added. It is to be expected that this shall apply also in 1986 to all Sahelian countries. Furthermore, the severe losses suffered in Senegal on rice crops as a consequence of an invasion by H. daganensis are most likely to occur again in 1986.

iii) Zonocerus variegatus

This species is of particular concern in tropical humid areas, but there are no indications which could be interpreted as announcing particularly heavy outbreaks.

c. Grain-eating birds

It seems also for birds that there is no special reason for concern in 1986. The situation is expected to be as it was in earlier years. However the already announced cessation of activities by OCLALAV will entail an additionally heavy burden on the national plant protection services.

Funding of the Integrated Pest Management Project has ceased, and the dissolution of the regional organizations OICMA and OCLALAV means that individual governments will have to strengthen their own plant protection services to

control grasshoppers, locusts, birds and other pests. The insect and bird problems will continue, and something must be done to control them. It makes little sense for donors to fund agricultural development programs to boost small farmer production if the small farmer loses all his food crop to the insects and birds.

If donors concluded the regional organizations were too difficult to control, then bilateral assistance that includes adequate management, fund disbursement reporting, and human/environmental sensitivities to the applied pesticides must be an intervention, at least for the countries of high infestation risk.

ANNEX I

Terms of reference for the consultancy on locusts/grasshoppers and grain-eating birds
Mali 1985

The contractor's consultant will be based on observations and all relevant available data

Task 1: Participate in the magnitude of the locust/grasshopper problem and monitor the environmental effects of the control program.

Task 2: Work in conjunction with the Organization International Contre Le Criquet Migrateur African (OICMA) the Malian Crop Protection Service (CPS), FAO and other donors.

Task 3: Assist the CPS AND OICMA to assess the actual and potential magnitude of the grasshopper infestation.

Task 4: Travel throughout infested or at-risk areas to ensure the accurate information is obtained on the location of observations, movements of swarms, number of insects per M2 in natural vegetation and on crops, area estimated to be infested, estimated damage to crops and the likelihood of a second generation attack.

Task 5: Based upon his analysis of the data, he will make recommendations to USAID for a control strategy which conforms to USEPA guidance on pesticides use and provide to USAID his professional opinion on the control strategy adopted by the CPS and OICMA.

Task 6: Collect samples of soil and crop residues as appropriate for analysis of pesticides in representation areas where the pesticide treatment, and dosages used can be accurately determined. He will then secure contact with a laboratory in Europe or the US to perform the analysis of those samples.

Task 7: Assess human and environmental impact of soil samples results due to pesticide currently in use and make recommendations for a sound control strategy that conforms to USEPA regulations on pesticide use and can serve as a basis upon which to USG can respond to a similar crisis.

Task 8: Observe both aerial and ground treatment operations and note that all safety pre-cautions are being observed relative to the pesticide being applied and the method employed. He will bring recommendations for improved practices to the attention of CPS and OICMA officials, as well as USAID and other donors.

Task 9: Determine for insecticides recommended, the nearest procurement sources, storage problems, transportation problems, application, dosage etc.

Task 10: Determine the type, length of time required and approximate cost of training for locust/grasshopper control operation by Government of Mali technicians who work with international organizations.

If mission still feels this necessary and feasible within the 45 days time frame the Quelea Bird contractor's consultant will also perform the below:

Task 1: In consultation with the Government of Mali and the Organization Commune de Lutte Anti-Acridienne et Lutte Anti-Aviaire (OCLALAV) make an accurate assessment of the present and potential danger from the quelea bird and the magnitude of its threat to food grains and other crops.

Task 2: Observe quelea bird control operations in Mali and determine their effectiveness.

Task 3: Recommend effective control measure, including ground and aerial, for combatting quelea birds.

Task 4: Assess the effectiveness use, and environmental impact of the utilization of fenthion a.k.a queletox.

Task 5: Recommend substitute chemicals if fenthion/queletox are environmentally hazardous and/or ineffective.

Required Reports

Task 1: Contractor's consultant will orally brief appropriate USAID/Bamako staff prior to leaving Mali. Based on these discussion, the consultant will prepare a draft report which will [a] describe in detail the recommendations of each of the above tasks and provide institutionalized strategy for combatting locusts/grasshoppers and quelea birds, and [b] provide training recommendations which will assist Malian technicians to combat locust/grasshoppers and quelea bird pests.

Task 2: After discussing draft report above with USAID/Bamako and based on its comments, consultant will provide final report to be submitted to the Mission at a time to be agreed on between the consultant contractor and USAID/Bamako. All reports will be in English. If French reports are required consultant will be advised by USAID/Bamako during his initial conference with staff upon entry in Mali.

ANNEX II

ITINERARY - Main Activities - Persons Met

10/20/85: Flight to Bamako

Geneva, Switzerland, departed 0815 SR 722; Paris arrived 0915
Paris departed 1245 PA 035; Bamako arrived 1800

10/21/85 Bamako: USAID and Plant Protection Department, OPSR

- R. Newberg, Program Officer, USAID, BP 34, Bamako
- M. Sissoko, Director-General, Operation Protection des Semences et des Recoltes (OPSR), BP 1560, Bamako
- S. Sountera, Head, Plant Protection Service (OPSR), Bamako
- N. Jago, Project Leader, British-Malian Research Project at Mourdiah, Tropical Development and Research Institute (TDRI), College House, Wrights Lane, London W 85 SJ, United Kingdom
- J. Rowley, Deputy to N. Jago
- E. Chiavaroli, Mission Director, USAID/Bamako
- W. Thomas, Chief, Agricultural Development Office, USAID/Bamako

10/22/85 Bamako: Study of documents

10/23/85 Bamako: Contacts, discussions USAID, OICMA (Organisation Internationale Contre le Criquet Migrateur Africain), ICRISAT, Agrometeorology, IPM

- J. Scheuring, Breeder, ICRISAT, Bamako
- A. Diallo, Program Officer, USAID/Bamako
- M. Konate, Director, Agrometeorology, BP 237, Bamako
- Mrs. Kere, Administrator, OICMA, BP 136, Bamako

10/24/85 Bamako: USAID, study of documents, discussions

10/25/85 Bamako: USAID, study of the Integrated Pest Management (IPM) Project

- Y. Doumbia, Director, IPM Project, Bamako
- M. Bonzi, Entomologist FAO, IPM Project

10/26/85 Bamako-Mourdiah: Field trip, USAID jeep, study of the grasshopper situation in the Mourdiah-Nara area with Plant Protection Inspector Kieta

- N. Jago, Project Leader, Mourdiah
- J. Rowley, Deputy to N. Jago
- M. Sissoko,Jr, Malian counter-part for the Project
- F. Berthe, Chief, Plant Protection Base, Mourdiah

10/27/85 Mourdiah-Nara region: study of the grasshopper situation and sampling for pesticide residues

10/28/85 Mourdiah-Dilly region: Field studies and return to Bamako

10/29/85 Flight from Bamako to Kayes (OICMA plane); in Kayes, reconnaissance flights

- M. Sissoko, Director-General, OPSR
- J. Kervinio, French pilot, 17, rue des Moineaux, 56100 Lorient (France)
- G. Popov, FAO consultant (Acridologist, TDRI, London)
- D. Adama, OICMA pilot, Bamako
- M. Diko, Chief, OCLALAV base at Niougoméra (Organisation Commune de Lutte Anti-Acridienne et Anti-Aviaire)

10/30/85 Kayes: Pesticide treatments from the air to control grasshoppers; at noon, flight to Niougoméra (Yélimané) afternoon, reconnaissance flights

10/31/85 Niougoméra: Evaluation of the grasshopper situation by Land Rover

11/1/85 Niougoméra: Study of the grasshopper fauna; discussions on control strategies (special meeting)

- M. Sidibe, Regional Director (Senegal-Mauritania), OCLALAV
- M. Sissoko, Director-General, OPSR
- G. Popov, FAO consultant
- D. Adama, OICMA pilot
- J. Kervinio, French pilot

11/2/85 Niougoméra-Nioro du Sahel: Evaluation of the grasshopper situation (Land Rover) with G. Popov

11/3/85 Nioro du Sahel-Ballé: Study of the grasshopper and bird situation with G. Popov

- P. Dambele, Chief, Agricultural Division, Nioro du Sahel

11/4/85 Ballé-Dilly: Study of situation with G. Popov

- S. Bengali, Chief, Agricultural Division, Ballé

11/5/85 Dilly-Mourdiah: Study with G. Popov

- M. Sidy Kane, Secretary-General for Dilly
- N. Dao, Plant Protection Inspector, OPSR, Dilly
- N. Jago, Mourdiah
- J. Rowley, Mourdiah

11/6/85 Mourdiah and return to Bamako: study of infestation status by Land Rover

11/7/85 Bamako: morning with OICMA, afternoon with USAID

- H. Alomenou, Director-General, OICMA
- Y. Tadesse, FAO Representative, Bamako
- G. Popov, FAO consultant
- N. Jago, TDRI, U.K.

11/8/85 Bamako: morning at OICMA to discuss request for funding 1986 campaign; afternoon at USAID for preparation of documents

11/9/85 Bamako: Study of documents

11/10/85 Bamako: Identification of collected grasshoppers

11/11/85 Bamako: OICMA-USAID, finalizing the request for funding

11/12/85 Bamako: meeting at OICMA to discuss bird problems

- H. Alomenou, Director-General, OICMA
- S. Manikowski, FAO, Rome, Bird Specialist
- G. Popov, FAO consultant
- N. Kere, OICMA
- Y. Tadesse, FAO Representative, Bamako

- M. Sissoko, OPSR

afternoon at USAID for preparation of documents

11/13/85 Bamako: USAID-OPSR, Study of bird problems

11/14/85 Bamako: USAID-OPSR

11/15/85 Bamako: USAID, preparation of documents

11/16/85 Bamako: morning USAID, preparation of documents

afternoon, study of grasshopper collection

11/17/85 Bamako: morning, hotel discussions

- M. Sissoko

- G. Popov

afternoon, discussions continued

11/18/85 Bamako: USAID, study of documents

11/19/85 Bamako: Hotel, discussion with M. Sissoko

11/20/85 Bamako: morning, USAID discussion with UNDP for 1985 campaign funding

- J. Lorge, Deputy regional representative, UNDP, BP 120, Bamako

- R. Skav, FAO senior officer in charge of migratory pests

11/21/85 Bamako: USAID, preparation of documents

11/22/85 Bamako-Kogoni-Kourouma: Office du Niger by OICMA plane

- M. Sissoko, OPSR

- M. N'Diaye, Director, FAO Workshop on birds (10/23-12/12)

- S. Sountera, Lecturer for technical matters

- M. Koulibaly, Chief, OCLALAV base, Gao

11/23/85 Kourouma: Reconnaissance and control operations

11/24/85 Kourouma: same

11/25/85 Kourouma: Study of effectiveness of spray operations

11/26/85 Kourouma-Bamako: departed 0930, arrived Bamako 1500 by Land Rover

11/27/85 Bamako: USAID-OPSR-OICMA, discussions on the bird situation

11/28/85 Bamako: morning, Thanksgiving at U.S. Embassy

- R. Ryan, U. S. Ambassador, Bamako

11/29/85 Bamako: OPSR-USAID, debriefing

11/30/85 Bamako: USAID, preparation of documents

12/1/85 Bamako-Geneva: departed 0000 hours RK 036

12/2/85 Geneva: arrived Paris 0730 hours
arrived Geneva 1145 hours

ANNEX III

PROJECT FOR AN EMERGENCY ASSISTANCE TO THE GOVERNMENT OF THE REPUBLIC OF MALI FOR GRASSHOPPER CONTROL

Follow-up action to the Project TCP/MLI/3508 (E)

1. Justification

In Mali prevailing favorable conditions during the rainy season of 1985 (good rainfall over widespread areas) have resulted for the first time in ten years, in heavy outbreaks, gregarization and migrations of grasshoppers, thus ruining the expectations for a good crop.

At the end of August the infested area was estimated at 9000 km2 with densities ranging from 40 to 60 per square meter. Important damage was registered on millet which is the major crop of the infested area.

The National Plant Protection Service, which had mobilized all its ressources, was not in a position to cope with the problem largely exceeding its resources and becoming every day more serious due to particularly favorable conditions for the development of the grasshoppers.

Under these alarming conditions the Government of the Republic of Mali called for an emergency aid from FAO with a view to enforce the national resources.

The response from FAO has been rapid and generous resulting in the aid Project TCP/MLI/3508 (E) amounting to 238,000 $ US and meant to finance the purchase of pesticides and the aerial and terrestrial applications to be carried out by OICMA. Simultaneously FAO made a plea to other donors which resulted in an additional aid from UNDP (160,000 $) USAID (25,000 $) and FED (150,000 Ecus = 126,610 $). To this total amount of 549,610 $ the Malian Government added 317,000 $ and the money thus made available allowed to launch a control campaign in the infested areas.

However, the grasshopper situation deteriorated increasingly during September and October. In addition to the Nara - Dilly - Ballé region, the areas around Niafunké and Yélimané - Kayes were invaded.

As a consequence the ongoing terrestrial control operations were enforced by aerial spraying starting on September 9th, and ending on the 1st of November 1985.

The treated areas represent in total:

Nara - Dilly area:	94,865 ha	sprayed with	28,700 l	of various pesticides
Yélimané - Kayes area:	43,930 ha	"	22,635 l	"
Niafunké area:	7,280 ha	"	2,400 l	"
	146,075 ha	"	53,735 l	"

These operations have largely exhausted the accorded credits but it is certain that they have saved the major parts of the crop in affected areas. In the face of the considerable mass of grasshoppers, the extent of infested areas, the difficulties of communications and the inevitable delay in getting the operations underway, these latter could not be fully successful and prevent all damage and the reproduction of grasshoppers. There are currently diapausing eggs of Oedaleus senegalensis and of certain other species, deposited in the soil on extended acreages of the infested areas. These egg masses, of which a great part is located in the vicinity or within the cropping areas represent an average density of 10 ootheca per square meter, each ootheca containing from 20 to 30 eggs. Although natural mortality factors reduce the hatching potential it is known that at least 50 % of the eggs will be preserved and are thus likely to survive. The hatching of the larvae will occur with the first rains of the rainy season and the newly borne larvae which are very mobile will attack the vulnerable seedlings. A similar situation prevailed in 1974 and 1975 and forced many farmers to re-sow 3-4 times or even finally often to abandon any attempts at cropping.

2. Follow-up action

~~Therefore, it~~ is essential to envisage follow-up operations in 1986. The main objectives are as follows:

Phase 1

Campaign at the beginning of the rainy season 1986 to be carried out by the peasants and the plant protection teams. This campaign entails the following operations:

a) inspection of infested areas in order to delineate and register the zones and villages being most affected;

b) making available pesticides and materials needed by the farmers and the plant protection teams;

c) dissemination of pesticides and material to centres concerned, well in advance of the rains expected in May-June;

d) motivation and training of farmers by plant protection inspectors and agriculturists;

e) implementation of the campaign using all available means.

Under the provision that enough means are made available the campaign should secure a good protection of the seedlings. It should also largely contribute to an important reduction of the grasshopper masses in the zones surrounding the cropping areas. However with a view to the magnitude of the surfaces concerned it would be impossible to secure total destruction of the grasshopper populations further away from cultivated fields. It must be borne in mind that the potential for control by the teams operating on the ground are limited in the face of infestations which, at the beginning of the season, are generally patchy and difficult to find. Furthermore, under these conditions aerial spraying is generally not effective.

Therefore, it is likely that a part of the early season grasshopper populations will not be affected by the control operations and in a position to leave at the winged stage the southern part of the area of distribution (between latitude 13 degrees 30 - 15 degrees 30 North) and move to the northern latitude (16 - 18 degrees N), far beyond the Malian border where detection and control become much more difficult. If the conditions for reproduction are as favorable as they were in 1985 one may expect during the course of the two successive generations a development of populations equal or even superior to those registered in 1985. In relation to the dynamic of the intertropical front the return flights to Mali at the end of the rainy season will occur near mid-August 1986 and accordingly endanger cereal crops mostly at the heading stage. This situation would impose the need to pursue control operations during the 1986 rainy season.

Phase 2

Campaign 1986 expanding from the mid to the end of the rainy season.

This campaign is aimed at conducting control operations by all available means and in particular by aerial application on grasshopper concentrations, it comprises the following operations:

a) Inspection of the air strips and reparation of these at Mourdiah, Ballé, Lere (West of Niafunké) and the construction of an airfield at Fallou (South of Dilly). These villages are located in the high risk area and there is an urgent need to dispose of landing sites in order to cut the distances for spray operations.

b) Supply of pesticides needed for the 1986 campaign; repartition of the teams working on the ground.

c) Pursuance of the inspections and control actions (as from phase 1 campaign).

d) Mobilization of two aircraft for treatments once the first arrival of grasshopper swarms is reported.

3) Operational Budget for the Emergency Situation Calling for Immediate Action

3.1 Inspection of the reproduction sites; registration of villages at risk 2 teams, each composed of an inspector, 1 driver, 2 aides 1 vehicle (4 weels drive).	
Hiring vehicles, fuel and salaries for teams	12,000
3.2 Repairing air strips at Mourdiah, Ballé, Lere and establishing a new landing site at Fallou	200,000
3.3 For treatments to be secured by farmers	
- Propoxur powder 2 % delivered at Bamako 500 t at 2 $/kg	1,000,000
- Hand dusters MG 5: 1000 x 90	90,000
- Dusting bags: 10,000 (purchase and local confection) 3,000 + 2,000	5,000
TOTAL	1,307,000

4. Operational Budget for 1986

4.1 Ground treatments by special teams, hiring vehicles	
- Land Rover 16 x 2500 km x 0.9	36,000
- Unimog 8 x 2000 km x 1.0	25,600
- Truck 2 x 2000 km x 1.8	7,200
4.2 Running costs	30,000
4.3 Camping equipment for 25 persons (camping beds, kitchen equipment etc)	10,000
4.4 Pesticides (ground and airial treatments)	
Dieldrin 5 % 20 000 l x 4	80,000
Fenitrothion 50 % 20,000 l x 8	160,000
4.5 Hiring 2 airplanes	
100 h for spray operations, 20 h preparation, transport	52,500
Fuel 120 l/h x 0.75 x 120 h	10,800
Expenses for crew	6,000
TOTAL	418,100

5. Contributions from the Malian Government (tentative), as in 1985

Insecticides 10.000 l Fenitrothion	80,000
Material for treatment	30,000
Control Teams Working on the Ground	170,000
Fuel	15,000
Personnel	12,000
Transport	10,000
TOTAL	317,000

FUNDS SO FAR SPENT IN THE 1985 GRASSHOPPER CAMPAIGN
(Information from M. Sissoko)

Organizations	Receipts	Expenses	Balance
FAO	$ 238,000		
	CFA 95,200,000	88,908,175	6,291,825
	FAO Superv.	4,000,000	4,000,000
			2,291,825
UNDP advance on FAO funding	$ 260,000		
	- $ 100,000		
	$ 160,000		
	CFA 64,000,000	46,932,010	17,067,990
EEC	Ecus 150,000		
	CFA 50,644,000	50,444,000	200,000
USAID	$ 25,000	breakdown not ready	
	CFA 10,000,000		

NB: Out of the 53,735 l of pesticides used, 6600 l of dieldrin
5 % have not yet been payed CFA 10,692,000
plus fuel 8 500 l 2,439,500
plus hiring airplane 33 h 10,000,000

CFA 23,131,500

Breakdown of cost for FAO — Status 15.11.85

Received 238,000 = CFA 95,200,000

Spent: Salaries, allowances etc	3,849,650	
Fuel for vehicles	2,468,225	
Hiring vehicles	12,391,300	
Pesticides	39,999,000	
Spraying by plane	21,600,000	
Logistics	8,600,000	
TOTAL	88,908,175	
+ supervision FAO	4,000,000	
	92,908,175	92,908,175
Balance		CFA 2,291,825

UNDP Received	260,000 $		
Advance for FAO funding	100,000 $		
	160,000 $	CFA	64,000,000

Plane flight h. 64 Niougoméra - Kayes	15,863,735	
16 Nara - Dilly	4,103,750	
20 Niafunké	4,981,600	
Various operations and small equipment	2,565,745	
Fuel - lubrification	4,219,180	
" from OPSR	238,140	
Hiring vehicles (Niafunké)	2,456,800	
" trucks	5,534,500	
vehicles (Yélimané)	4,528,400	
Salaries - allocation drivers	1,670,600	
pilots and mechanicians	769,560	
	46,932,010	46,932,010
Balance		17,067,990

EEC

Received Ecus 150,000	CFA	50,644,000

Expenditures for pesticides

Fenthion 1000 ULV = 3250 x 7705 l	2,503,750	
Dieldrin 5 % 1620 CFA x 19,400 l	31,428,000	
Procidagri 10 % ULV 2450 x 3000 l	7,350,000	
Fenthion Queletox 60 % 2850 x 440 l	1,254,000	
Malathion 96 % ULV 2850 x 1595 l	4,545,750	
Lindane 20 % 2850 x 1250 l	3,362,500	
	50,444,000	50,444,000
Balance		200,000

ANNEX III A

RECOMMENDED TECHNICAL SERVICES FOR GRASSHOPPER EMERGENCY CONTROL PROGRAM DURING APRIL-JUNE, 1986 IN MALI

Objectives

1. Provide adequate technical supervision and management services for monitoring the Grasshopper Emergency Control Program in Mali from April to June, 1986 in order to assure that AID-approved pesticides are procured, distributed and applied in an effective manner.

2. Design a 3 year project to strengthen the Malian Plant Protection Service (July, 1986).

3. Provide through Contractor's Home Office back-up support for procurement of pesticides, AID/W liaison, report editing, and arranging laboratory analyses.

Description

1. A field team of (1) a Pest Control Specialist to assure proper technical and environmentally concerned supervision of the AID-supported program and (2) a Logistics and Management Specialist to assure procurement and distribution of the AID-approved pesticides in accordance with AID procedures and regulations would be in Mali during April, May and June 1986.

2. The field team would send soil and plant residue samples to a laboratory for analyses as needed.

3. Contractor's Home Office staff of a Project Director and an Assistant Director (Entomologist) would provide support to the field team as needed in procurement, liaison with the laboratory, liaison with AID/W, report editing, translating and typing.

4. The field team would concurrently prepare a design of a long term project to strengthen the Malian Plant Protection Service. The Pest Control Specialist would finalize the project design in cooperation with Contractor's Home Office and AID/W in Washington in July, 1986.

Estimated Costs

See sheet following.

GRASSHOPPER EMERGENCY CONTROL PROGRAM

MALI

DAILY FIXED RATES:		
Pest Control Specialist @ $261.30/day x 2 IQC multiplier = $523/day; 4 months, 26 days/mo.; 104 days	$ 54,392	
Logistics & Management Specialist @ $140/day x 2 IQC multiplier = $280/day; 3 mos., 26 days/mo.; 78 days	21,840	
Project Director (Home Office) @ $261.30/ day x 2 IQC multiplier = $523/day; 15 days	7,845	
Assistant Project Director (Home Office) @ $125/day x 2 IQC multiplier = $250/day; 15 days	3,750	
Secretarial (Home Office) @ $106.73/day x 2 IQC multiplier = $214/day; 20 days	4,280	
Sub-Total		$ 92,107
DIRECT EXPENSES:		
Airfares, Geneva/Bamako/Abidjan/Bamako/ Geneva/Washington/Geneva $1,677 + 1,555	3,232	
Airfares, Washington/New York/Bamako/ Abidjan/Bamako/Washington	2,323	
Per Diems		
-Mali, 65 days x 2 persons @ $130 Bamako	16,900	
-Mali, Other Cities, 25 days x 2 persons @ $28	1,400	
-Ivory Coast, Abidjan, 5 days x 2 persons @ $110	1,110	
-Washington, 5 days @ $75	375	
	19,785	
Laboratory Analyses	3,000	
Visas, medical, 2 persons @ $200	400	
Vehicle Rental	3,000	
Secretarial services in Mali	1,500	
Insurance, DBA	836	
" , SOS	240	
Miscellaneous, copying, comminication, couriers	2,000	
Sub-Total		36,316
T O T A L		$ 128,423

Evaluation of the effectiveness of pesticides to be used against grasshoppers

For dusting (especially by farmers)

Lindane (e.g. Procidagri)

Excellent immediate killing effect against all stages and persistence up to 15 days; cheap. Lindane is restricted in the US.

Propoxur 2% (e.g.Unden, Arprocarb, Baygon)

Excellent effect, especially on larvae with rapid killing and a persistence of about 10 days (gave very good results in 1985 at Mourdiah under controlled conditions); expensive: 2 $/kg; good safety for humans (LD 50 dogs, oral: 100 ppm).

There are no other compounds likely to be used in powder form (Malathion and Carbaryl were not satisfactory).

For ground and aerial application

Fenitrothion 50% (e.g. Sumithion)

Excellent immediate killing effect also on adults but persistence not exceeding 4-5 days.

Dieldrin 5%

No immediate killing effect but long persistence (3-4 weeks) with a slow lethal action on all grasshopper stages. Cancelled in the US for most uses, toxic to humans and animals.

It is a common practice to combine fenitrothion and dieldrin to establish safety belts against migrating grasshoppers. This mixture should not be used on crops.

Malathion ULV 96%

Good immediate killing effect but no persistence at all, especially good on larvae; not stable in storage.

Carbaryl

Good effect but only on young larvae

Lindane

Very effective and persistent but very corrosive

Fenvalerat

New japanese pyrethroid, looks promising (safe and persistent) but not yet sufficiently tested; expensive.

ANNEX V

REVISED ESTIMATES OF MILLET AND SORGHUM PRODUCTION AFTER THE 1985 GRASSHOPPER OUTBREAKS

egions	Estimates before the grasshopper outbreaks MT	Estimates of losses due to grasshoppers	Revised estimates for 1985 MT
'es	45,753	20 %	36,603
imané	13,433	35	8,732
a	21,645	35	14,070
ro	28,627	22	22,330
ma	17,036	12	14,992
funké	8,325	25	6,244
	134,819	149 25 %	102,971

Initial estimate: 134,819
Loss due to grassh. 102,971

·oduction gap 31,848 = 23.7%

ANNEX VI

PROPOSED STRATEGY FOR THE CONTROL OF OEDALEUS SENEGALENSIS IN MALI

1. General

Since neither OICMA (International African Migratory Locust Organization) nor OCLALAV (Joint Anti-Locust and Anti-Aviarian Organization) are likely to survive control of migratory pests is now the responsability of the National Crop Protection Service (OPSR) which has to be strengthened accordingly. The regional support formerly received through OICMA and OCLALAV will indeed no longer be available in cases of emergencies.

Basically OPSR should be in a position to secure surveillance of the Malian territory through a network of inspectors assuming responsibilities in areas prone to grasshopper, locust and bird concentrations. Furthermore, OPSR must have the equipment and skill to act immediately in cases of emergency. The network of inspectors is also meant to provide advice and assistance to farmers for any other plant protection problem.

2. Approach towards grasshopper control in general

There are basically three avenues to be retained:

a) Identification of areas where outbreaks are expected on the grounds of systematic investigations and surveillance carried out during the dry season (eggs are then diapausing in the soil and their density can be evaluated).

b) Knocking down of the first larval populations, a means providing a good safeguard against the build-up of future generations (the first generation in the case of Oedaleus senegalensis will generally move to more northern regions and later on come back as swarms following the dynamic of the inter-tropical front):

- through treatments secured by farmers (on their fields and on adjacent uncultivated land) with safe pesticides and simple devices;

- through OPSR with more sophisticated and powerful equipments operating mainly on extended uncultivated land (safe compounds).

c) Spraying from the air with powerful chemicals to stop migrations and destroy locally the swarms. This operation has to be carried out only in cases of emergency.

3. Practical follow-up action recommended after the 1985 invasions

3.1 Immediate launching of inspections in the 1985 invasion areas (2 teams with vehicles).

3.2 On the grounds of these investigations distribution of simple equipment for dusting and Propoxur 2 % for farmers (protection of their seedlings and prevention of build-up).

3.3 Training of farmers in using the dusting equipment.

3.4 Replenishing of pesticide stocks for ground and aerial spraying: Fenitrothion , Dieldrin , Lindane.

3.5 Preparation of adequate landing strips at Nouroiah, Ballé, Fallou and Lere.

4. Conclusions

4.1 Defining areas at risk through systematic inspections is of paramount importance.

4.2 The only satisfactory compound to be used safely by farmers (minimal impact on the environment) is Propoxur 2 % for dusting. Spraying has to be avoided at the farmer's level (too complicated).

4.3 It is important to secure distribution of pesticides prior to the rainy season, as long as the roads are practicable. After ordering, about two months are needed for the delivery of pesticides. In the case of Propoxur 2 % it is essential that the inert support ingredient is talcum (stability). The formulation of Propoxur can be secured by OPSR Bamako.

4.4 If the OPSR has to treat from the ground, Propoxur should be used as far as possible; in more critical situations a mixture of Fenitrothion and Dieldrin (2:1) is appropriate, as well as Lindane.

4.5 Aerial spraying should be avoided, but in a situation of crisis it is a most powerful tool. In this case the mixture as under 4.4 should be used; using Lindane is also appropriate.

4.6 Ecological studies are needed to better define the role of natural enemies and the impact of pesticides on them. According to Dr Magema, Entomologist in the IPM team in Mauritania, Propoxur does not affect non target species (pers. communication).

4.7 Ecological studies are also needed on Kraussaria spp, Hieroglyphus daganensis and Aiolopus simulatrix which are detrimental in flood recession areas.

ANNEX VII

SURVEY ON SOIL AND PLANT MATERIAL SAMPLES TAKEN IN MALI IN 1985 FOR THE PURPOSE OF PESTICIDE RESIDUE ANALYSES

The "Institut d'Hygiene Cantonal of Geneva"(Switzerland) conducted the analyses of samples in January/February, 1986 through its Laboratory of Chemistry.

ORIGIN	SAMPLE	PESTICIDES APPLIED	DATE
1. Traore Farm Road Mourdiah-Nara	a) Millet leaves	Cypermethrine ULV	8/29,9/13
	b) Soil	Same	
	c) Millet leaves	Untreated	
	d) Soil	Untreated	
	e) Panicum spp.	Procidagri 16%	9/26
	f) Soil	Same	
	g) Millet grain	Cypermethrine ULV	8/29,9/13
	h) Millet grain	Untreated	
2. Samana	a) Soil	Propoxur 2%	?
		Propoxur 10%, 16%	9/24
	b) Millet leaves	Same	
	c) Sorghum leaves	Same	
3. Koloumba	a) Soil	Malathion 50 ULV + Dieldrin 20% ULV	9/21
	b) Cenchrus spp.	Same	
	c) Sorghum leaves	Same	
	d) Millet leaves	Same	
4. Sorokori	a) Soil	Sumicombi 60 CE	9/3
	b) Millet leaves	Same	
5. Damba	a) Soil	Dieldrin 5%	9/11
	b) Millet leaves	Same	
6. Vira	a) Soil	Fenitrothion	9/11
		Dieldrin 5%	?
	b) Millet leaves	Same	
7. Boakéré	a) Sorghum grains	Fenitrothion 50 ULV + Dieldrin 5%	10/18
	b) Sorghum leaves	Same	

Samples taken in areas treated against grasshoppers and results obtained from pesticide residue analyses

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Mali, 1985

Sample 1 a)

Location: Traore Farm (km 7 on the road Mourdiah-Nara); experimental fields of the Anglo-Malian Project

Material sampled	Sample taken on:	Cold storage as from:	Analysis
millet leaves	10/26/85	11/2/85	January 86

Treatments applied and dosage	Date of treatments	Spraying
Cypermethrine ULV: 39 g a.m./ha Procidagri 16% ULV (HCH has been treated on the nearby uncultivated land)	8/29 and 9/13 9/26	from the ground

Results obtained after analysis

Cypermethrine	ppm	7.1
γ HCH	ppm	0.24
HCB	ppm	0.03
Δ HCH	ppm	0.12
Chlorpyrifos	ppm	0.89
α HCH	ppm	0.02

Remark
~~Only~~ Cypermethrine reaches a relatively high level even if millet leaves are considered as fodder (MRL/CCPR proposes 5ppm).

Sample 1 b)

Location: Traore Farm (km 7 on the road Mourdiah-Nara); experimental fields of the Anglo-Malian Project

Material sampled	Sample taken on:	Cold storage as from:	Analysis
Soil	10/26/85	11/2/85	January 86

Treatments applied and dosage	Date of treatments	Spraying
Cypermethrine ULV: 39 g a.m./ha	8/29 and 9/13	from the ground
Procidagri 16% ULV (HCH has been treated on the nearby uncultivated land)	9/26	

Results obtained after analysis

Cypermethrine	ppm	< 0.06
γ HCH	ppm	0.01
HCB	ppm	0.02
pp' DDT	ppm	0.003
op' DDT	ppm	0.01
Chlorpyrifos	ppm	0.03

Sample 1 c): check

Location: Traore Farm (km 7 on the road Mourdiah-Nara); experimental fields of the Anglo-Malian Project

Material sampled	Sample taken on:	Cold storage as from:	Analysis
millet leaves	10/26/85	11/2/85	January 86

No treatments on the sampling plot but on the nearby uncultivated land Procidagri 16% ULV has been used

Results obtained after analysis

	Cypermethrine	ppm	0.3
γ	HCH	ppm	0.14
α	HCH	ppm	0.02
Δ	HCH	ppm	0.04
	Chlorpyriphos	ppm	0.33

Sample 1 d): check

Location: Traore Farm (km 7 on the road Mourdiah-Nara); experimental fields of the Anglo-Malian Project

Material sampled	Sample taken on:	Cold storage as from:	Analysis
soil	10/26/85	11/2/85	January 86

No treatments on the sampling plot but on the nearby uncultivated land Procidagri 16% has been used

Results obtained after analysis

	Cypermethrine	ppm	< 0.06
γ	HCH	ppm	0.01
Δ	HCH	ppm	0.003
	Chlorpyrifos	ppm	0.04

Sample 1 e)

Location: Traore Farm (km 7 on the road Mourdiah-Nara); experimental fields of the Anglo-Malian Project

Material sampled	Sample taken on:	Cold storage as from:	Analysis
Panicum spp.	10/26/85	11/2/85	January 86

Treatment applied and dosage	Date of treatment	Spraying
Procidagri 16% ULV	9/26/85	from the ground

This treatment was meant to establish a barrier against the grasshopper flights

Results obtained after analysis

	Cypermethrine	ppm	0.15
γ	HCH	ppm	0.04
α	HCH	ppm	0.01
	HCB	ppm	0.01
Δ	HCH	ppm	0.05
	Chlorpyrifos	ppm	0.35

Sample 1f)

Location: Traore Farm (km 7 on the road Mourdiah-Nara); experimental fields of the Anglo-Malian Project

Material sampled	Sample taken on:	Cold storage as from:	Analysis
Soil	10/26/85	11/2/85	January 86

Treatment applied and dosage	Date of treatment	Spraying
Procidagri 16% ULV	9/26/85	from the ground

This treatment was meant to establish a barrier against the grasshopper flights

Results obtained after analysis

Cypermethrine	ppm	<0.06
γ HCH	ppm	0.01
α HCH	ppm	0.002
Δ HCH	ppm	0.003
Chlorpyrifos	ppm	0.02

Sample 1 g)

Location: Traore Farm (km 7 on the road Mourdiah-Nara); experimental fields of the Anglo-Malian Project

Material sampled	Sample taken on:	Cold storage as from:	Analysis
millet grain	10/26/85	11/2/85	January 1986

Treatments applied and dosage	Date of treatment	Spraying
Cypermethrine ULV, 39 g a.m/ha	8/29 and 9/13	from the ground
Procidagri 16% sprayed on adjacent uncultivated land	9/26/85	

Results obtained after analysis

Cypermethrine	ppm	$<$0.06
γ HCH	ppm	0.04
α HCH	ppm	0.01
Chlorpyrifos	ppm	0.06

Sample 1 h) check

Location: Traore Farm (km 7 on the road Mourdiah-Nara); experimental fields of the Anglo-Malian Project

Material sampled	Sample taken on:	Cold storage as from:	Analysis
millet grain	10/26/85	11/2/85	January 86

Untreated field but treatments on adjacent uncultivated land with Procidagri 16% ULV

Results obtained after analysis

Cypermethrine	ppm	< 0.06
γ HCH	ppm	0.01
α HCH	ppm	0.002
HCB	ppm	0.01
pp'DDT	ppm	0.004
Δ HCH	ppm	0.002
Chlorpyrifos	ppm	0.12

Sample 2 a)

Location: Samana 18 km NE Mourdiah

Material sampled	Sample taken on:	Cold storage as from:	Analysis
soil (field formerly with millet crops)	10/26/85	11/2/85	January 1986

Treatments applied and dosage	Date of treatments	Spraying
Propoxur 2%	?	from the ground
Procidagri 10% and 16% 0,5 kg/ha	9/24	

Results obtained after analysis

Propoxur	ppm	not found
γ HCH	ppm	0.01

Sample 2 b)

Location: Samana 18 km NE Mourdiah

Material sampled	Sample taken on:	Cold storage as from:	Analysis
millet leaves	10/26/85	11/2/85	January 86

Treatments applied and dosage	Date of treatments	Spraying
Propoxur 2%	?	
Procidagri 10% and 16% 0.5 kg/ha	9/24/85	from the ground

Results obtained after analysis

Propoxur	ppm	2.34
γ HCH	ppm	0.11
Δ HCH	ppm	0.14

Sample 2 c)

Location: Samana 18 km NE Mourdiah

Material sampled	Sample taken on:	Cold storage as from:	Analysis
sorghum leaves	10/26/85	11/2/85	January 86

Treatments applied and dosage	Date of treatments	Spraying
Propoxur 2%	?	from the ground
Procidagri 10% and 16% 0.5 kg/ha	9/24/85	

Results obtained after analysis

Propoxur	ppm	not found
γ HCH	ppm	7
α HCH	ppm	0.93
β HCH	ppm	4.20
Δ HCH	ppm	2.20

Sample 3 a)

Location: Koloumba, km 50 road Mourdiah-Nara

Material sampled	Sample taken on:	Cold storage as from:	Analysis
soil	10/27/85	11/2/85	January 86

Treatment applied and dosage	Date of treatment	Mode
Malathion 50 ULV + Dieldrin 20% ULV	9/21/85	from the air

Results obtained after analysis

Dieldrin	ppm	0.01
Malathion	ppm	not found
γ HCH	ppm	0.005
pp'DDE	ppm	0.01
pp'DDT	ppm	0.03
op'DDT	ppm	0.01
Δ HCH	ppm	0.005
Chlorpyrifos	ppm	0.05
Fenitrothion	ppm	0.30

Sample 3 b)

Location: Koloumba, km 50 road Mourdiah-Nara

Material sampled	Sample taken on :	Cold storage as from:	Analysis
Cenchrus biflorus (wild graminaceus plant)	10/27/85	11/2/85	January 86

Treatment applied and dosage	Date of treatment	Spraying
Malathion 50 ULV+ Dieldrin 20% ULV	9/21/85	from the air

Results obtained after analysis

Dieldrin	ppm	0.31
Malathion	ppm	not found
α HCH	ppm	0.01
γ HCH	ppm	0.03
Chlorpyrifos	ppm	0.38
Fenitrothion	ppm	3.20

Sample 3 c)

Location: Koloumba, km 50 road Mourdiah-Nara

Material sampled	Sample taken on:	Cold storage as from:	Analysis
sorghum leaves	10/27/85	11/2/85	January 86

Treatment applied and dosage	Date of treatment	Spraying
Malathion 50 ULV + Dieldrin 20% ULV	9/21/85	from the air

Results obtained after analysis

Dieldrin	ppm	7.74
Malathion	ppm	not found
Fenitrothion	ppm	58
Chlorpyrifos	ppm	0.25

Remarks

Exceedingly high levels of Dieldrin and Fenitrothion.

Sample 3 d)

Location: Koloumba, km 50 road Mourdiah-Nara

Material sampled	Sample taken on:	Cold storage as from:	Analysis
millet leaves	10/27/85	11/2/85	January 86

Treatment applied and dosage	Date of treatment	Spraying
Malathion 50 ULV + Dieldrin 20% ULV	9/21/85	from the air

Results obtained after analysis

Dieldrin	ppm	1.20
Malathion	ppm	not found
Chlorpyrifos	ppm	0.40
Fenitrothion	ppm	4.40

Sample 4 a)

Location: Sorokori, 7 km NE Dilly

Material sampled	Sample taken on:	Cold storage as from:	Analysis
soil	10/28/85	11/2/85	January 86

Treatment applied and dosage	Date of treatment	Spraying
Sumicombi 60 CE (Fenitrothion) 1/2 l/ha	9/3/85	from the ground

Results obtained after analysis

Fenitrothion	ppm	not found
Chlorpyrifos	ppm	0.038
Diazinon	ppm	0.009

Sample 4 b)

Location: Sorokori, 7 km NE Dilly

Material sampled	Sample taken on:	Cold storage as from:	Analysis
millet leaves	10/28/85	11/2/85	January 86

Treatment applied and dosage	Date of treatment	Spraying
Sumicombi 60 CE (Fenitrothion), 1/2 l/ha	9/3/85	from the ground

Results obtained after analysis

Fenitrothion	ppm	not found
Chlorpyrifos	ppm	0.320

+ Traces of an unknown compound

Sample 5 a)

Location : Damba, 10 km SW Dilly

Material sampled	Sample taken on:	Cold storage as from:	Analysis
soil	10/28/85	11/2/85	January 86

Treatment applied	Date of treatment	Spraying
Dieldrin 5%	9/11/85	from the air

Results obtained after analysis

	Dieldrin	ppm	0.007
α	HCH	ppm	0.001
γ	HCH	ppm	0.005
	pp'DDE	ppm	0.004
	pp'DDT	ppm	0.003
	op'DDT	ppm	0.002
Δ	HCH	ppm	0.004
	op'DDE	ppm	0.003

Sample 5 b)

Location: Damba, 10 km SW Dilly

Material sampled	Sample taken on:	Cold storage as from:	Analysis
millet leaves	10/28/85	11/2/85	January 86

Treatment applied	Date of treatment	Spraying
Dieldrin 5%	9/11/85	from the air

Results obtained after analysis

Dieldrin	ppm	0.021
α HCH	ppm	0.005
γ HCH	ppm	0.019
pp'DDE	ppm	0.008
pp'DDT	ppm	0.007
op'DDT	ppm	0.007
DDD	ppm	0.010
op'DDE	ppm	0.028
Δ HCH	ppm	0.012

Sample 6 a)

Location: Vira, 5 km SW Dilly

Material sampled	Sample taken on:	Cold storage as from:	Analysis
soil	10/28/85	11/2/85	January 86

Treatments applied and dosage	Date of treatments	Spraying
Fenitrothion 50 ULV 0.5 l/ha	9/11/85	from the air
Dieldrin 5% ULV	?	from the air

Results obtained after analysis

Dieldrin	not found
Fenitrothion	not found
Chlorinated hydro-carbons (others)	not found
Organophosphates (others)	not found

Sample 6 b)

Location: Vira, 5 km SW Dilly

Material sampled	Sample taken on:	Cold storage as from	Analysis
millet leaves	10/28/85	11/2/85	January 86

Treatments applied and dosage	Date of treatments	Spraying
Fenitrothion 50 ULV 0.5 l/ha	9/11/85	from the air
Dieldrin 5% ULV	?	from the air

Results obtained after analysis

Dieldrin	ppm	0.11
Fenitrothion	ppm	0.77
Chlorpyrifos	ppm	0.27

Sample 7 a)

Location: Boakéré, 15 km NE Niougoméra

Material sampled	Sample taken on:	Cold storage as from	Analysis
sorghum grain	11/2/85	12/9/85	January 86

Treatment applied and dosage	Date of treatment	Spraying
Fenitrothion 50 ULV + Dieldrin 5% ULV	10/18/85	from the air

Results obtained after analysis

Dieldrin	ppm	0.02
Fenitrothion	ppm	0.32
Chlorpyrifos	ppm	0.03

Sample 7 b)

Location: Boakéré 15 km NE Niougoméra

Material sampled	Sample taken on:	Cold storage as from:	Analysis
sorghum leaves	11/2/85	12/9/85	January 86

Treatment applied and dosage	Date of treatment	Spraying
Fenitrothion 50 ULV + Dieldrin 5% JLV	10/18/85	from the air

Results obtained after analysis

Dieldrin	ppm	0.27
Fenitrothion	ppm	3.16
Chlorpyrifos	ppm	0.17

ANNEX VIII

Evaluation of sorghum/millet losses due to grasshoppers and survey on oothecae found in the soil(2-6 Nov.1985)

Regions -Localities	Crop loss due to grasshoppers Millet %	Sorghum	Oothecae in the soil /m^2	Remarks
Yélimané area	50	25	-	
Yélimané - 20km W Nioro				
1. Kodie	30	10	0	treated
2. Kremiss	h.	25	0	untreated
3. Kouroungourou	h.	20	8	untreated
4. Bougoudré	100	10	0	untreated
5. Koriga	h.	10	4	
6. 5km E. Koriga	uncultivated		0	untreated
7. 10 km E. Koriga	uncultivated		0	untreated
8. 15 km E. Koriga	uncultivated		0	untreated
20 km W Nioro du Sahel - 25 km W Ballé				
1. Palal	30	20	4	untreated
2. 10 km NE Palal	100	-	6	untreated
3. Nioro du Sahel	35	10	5	untreated
4. 10 km E. Nioro	40	10	0	untreated
5. 10 km SE Tourougombé	15	-	-	untreated
6. Gourca	10	-	0	untreated
7. Madina-Fofara	35	10	0	untreated
25 km SW Ballé- 15 km NW Dilly				
1. 15 km SW Ballé	35	-	0	untreated
2. Vouainca	uncultivated		0	untreated
3. Ballé (gen. estim.)	45	20	-	untreated
4. Tarandela	40	20	5	treated
15 km NW Dilly-Mourdiah				
1. 15 km NW Dilly	uncultivated		0	treated
2. 12 km NW Dilly	20	20	-	treated
3. Amdalay	60	10	-	treated
4. Dilly	80	10	0	treated
5. 10 km E Dilly	60	10	0	treated
6. Goumbou	35	-	0	treated
7. 10 km SW Goumbou	65	-	0	treated
Mourdiah				
1. Experimental plot	90	10	23	treated
2. Experimental plot	90	-	12	treated

h = harvested
- = not possible to assess

Evaluation of grasshopper densities in various areas

Date	Site	Population densities/m^2 sorghum*	millet	uncultivated	Remarks (for millet)
10/26	N'Galafuga (60 km S Mourdiah)	40	40		harvested
	Doubadougou (40 km S Mourdiah)	40	40		"
	Traore Farm (7 km N Mourdiah)	10	10	10	"
	Samana (18 km NE Mourdiah)	10	10	5	"
10/27	Koloumba (20 km S Nara)	10	10	5	"
10/28	Dilly	10	10		"
	Sorokori		5		"
	Damba	10	10		"
	Vira	10	10		"
11/1	Boakéré (Niougoméra)	30	30	0	"
11/2	Yélimané-Nioro du Sahel				
	1. Kodie		10		"
	2. Kremiss		10		"
	3. Kouroungourou	10	10	not	"
	4. Bougoudré		20		harvested
	5. Koriga		40	0	"
	6. 5 km E Koriga			0	-
	7. 10 " "			0	-
	8. 15 " "			0	-
11/3	Nioro du Sahel-Ballé				
	1. Palal		20		harvested
	2. 10 km NE Palal		10		"
	3. Nioro du Sahel	10	10		"
	4. 10 km E. Nioro (Korkodio)		10		"
	5. 10 km SE Tourougoumbé			0	-
	6. Gourca			0	-
	7. Madina-Fofara			0	-
11/4	Ballé-Dilly				
	1 15 km SW Ballé		5		harvested
	2. Vouainca			0	-
	3. Ballé		0	0	harvested
	4. Tarandela		5		"
11/5	Dilly-Mourdiah				
	1. 15 km NW Dilly		10		"
	2. 12 km NW Dilly		10		"
	3. Amdalay		5		"
	4. Dilly		5		"
	5. 10 km E Dilly		10		"
	6. Goumbou		10		"
	7. 10 km SW Goumbou		5		"
11/6	Mourdiah (7km N)				
	1. Experimental plot		5		"
	2. Experimental plot		5		"

* mostly not yet harvested