Département amélioration des méthodes pour l'innovation scientifique Cirad-amis

Collaboration avec l'Université du Kordofan sur les acridiens ravageurs au Soudan

Rapport des principales activités en 2005

Michel Lecoq
My Hanh Luong-Skovmand

CIRAD-AMIS
U.P.R. Acridologie

CIRAD-AMIS N° 23/2005

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Résumé

Cette mission, financée par l'Ambassade de France au Soudan, s'inscrivait dans le cadre de la poursuite de la collaboration avec l'Université du Kordofan.
Elle était destinée à préparer les travaux de recherche de terrain au Soudan de 3 étudiants (2 Ph D., 1M Sc.) de l'université du Kordofan devant réaliser leur travaux de recherche sur le problème des criquets ravageurs (Criquet sénégalais et Criquet arboricole). Elle devait également permettre, dans la poursuite d'une première mission réalisée en 2004, de juger de l'état d'avancement de la concertation entre les différentes institutions soudanaises pouvant être impliquées dans un projet de développement sur le thème de la sécurité alimentaire dans les zones affectées par les récents conflits.

Référence

Michel Lecoq et My Hanh Luong-Skovmand, 2005. Collaboration avec l'Université du Kordofan sur les acridiens ravageurs au Soudan. Rapport des principales activités en 2005. Cirad-Amis n° 23/2005, Montpellier, France. 23 p.

Mots-clefs : Recherche acridienne, Soudan, *Oedaleus senegalensis*, *Anacridium melanorhodon*, Gomme arabique.

Table des matières

Annexes

Introduction

Les actions en cours en 2005 entrent dans le cadre de la préparation d'un projet de lutte contre les criquets ravageurs au Soudan élaboré par l'Université du Kordofan, en collaboration avec le CIRAD. Ce projet est destiné à l'amélioration de la gestion des criquets ravageurs dans la zone semi-aride de l'Ouest du Soudan, pour la protection des cultures vivrières et des Acacias producteurs de gomme arabique. Le projet doit cibler les deux principaux problèmes de protection des cultures dans la région du Kordofan :

- Le Criquet arboricole *Anacridium melanorhodon*, ravageur chronique sur les Acacias producteurs de gomme arabique ;
- Les sauteriaux et en particulier *Oedaleus senegalensis*, le Criquet sénégalais, important ravageur des cultures vivrières

Deux principales activités financées par l'Ambassade de France au Soudan ont ainsi pu être menées :
Une mission de terrain dans les différentes zones écologiques du Kordofan (du 19 septembre au 3 octobre 2005) suivie d'une session de formation en acridologie pratique pour trois stagiaires doctorants soudanais au Cirad de Montpellier du 10 octobre au 8 novembre 2005.

1. Mission dans le Kordofan

Cette mission, s'inscrivait dans le cadre de la poursuite de la collaboration avec l'Université du Kordofan. Elle était destinée à préparer les travaux de recherche de terrain au Soudan de 3 étudiants (2 Ph D., 1 M Sc.) de l'université du Kordofan devant réaliser leur travaux de recherche sur le problème des criquets ravageurs (Criquet sénégalais et Criquet arboricole). Elle devait également permettre, dans la poursuite d'une première mission réalisée en 2004, de juger de l'état d'avancement de la concertation entre les différentes institutions soudanaises pouvant être impliquées dans un projet de développement sur le thème de la sécurité alimentaire dans les zones affectées par les récents conflits.

La présente mission au Soudan a permis de prendre contact avec l'ensemble des zones écologiques du Kordofan (Nord et Sud) pouvant être concernées par les travaux du projet et des étudiants. Des visites de terrain ont été réalisées depuis les zones nord-sahéliennes au voisinage de Bara (250mm de pluie par an), jusqu'aux zones de végétation soudanienne typique (régions de Rashad et de Kadugli dans les monts Nouba recevant entre 800 et 1000mm d'eau, et fortement affectées par les récents conflits), en passant par toutes les zones de transition de type sahélien entre Dilling et El-Obeid.

Les zones fréquentées par le criquet sénégalais ont été visitées, de la zone de reproduction initiale de début de saison des pluies, sans doute dans les régions de type soudano-sahélien, à la zone de reproduction de pleine saison des pluies plus vraisemblablement dans les zones de type sahélien ou nord-sahélien. Pour le criquet arboricole, la visite de plantations d'Acacias a permis de se faire une meilleure idée des possibilités d'expérimentations. Enfin, le parcours de ces zones a mis en évidence les difficultés logistiques (importantes) et permis de contacter les diverses institutions pouvant être impliquées dans le cadre de tels travaux, tout d'abord comme source possible d'informations de terrain pour les étudiants, ensuite comme partenaires potentiels d'un projet (surveillance, vulgarisation). Citons en particulier les sociétés privées productrices de gomme arabique, les services de protection des cultures et les services de l'agriculture en général, les stations de recherche, l'IFAD (pour son implantation locale et son réseau de vulgarisation).

2. Les actions de formations en 2005

Dans le cadre de ce projet, il est prévu plusieurs formations diplômantes de niveau doctorat et master. Deux étudiants doctorants (Ph.D.) ont été sélectionnés par l'université du Kordofan, ainsi qu'un étudiant en master (Ms.Sc.). Ces derniers devraient être inscrits soit à l'université du Kordofan, soit à l'université de Khartoum et commencer leurs travaux en 2006. Dans une première étape, ils ont effectué du 10/10 au 8/11/2005 grâce à un financement de l'Ambassade de France - un stage d'un mois au CIRAD au sein de l'unité d'Acridologie du département AMIS. Ce stage a permis de mieux définir leurs projets de recherche respectifs (Annexe 1) et de les former à diverses techniques utilisées dans le domaine de l'acridologie (élevage d'acridiens, techniques d'échantillonnage, dissections, expérimentations de terrain, caractérisation des phases, dynamique des populations...) (Annexe 2).

On notera que les travaux des étudiants sont essentiellement des travaux de terrain, sur une problématique majeure du développement et de la sécurité alimentaire des régions concernées, et qu'ils impliquent la mise en place, non seulement d'expérimentations, mais aussi d'un réseau d'observations et de collecte de données très étendu qui ne pourra être monté qu'avec l'appui de diverses institutions partenaires locales. A titre d'exemple, le projet comporte le financement de techniciens et de manoeuvres indispensables pour la collecte des échantilllons d'acridiens et la conduite des expérimentations, ainsi que les frais de fonctionnement nécessaires pour des déplacements fréquents dans l'ensemble des zones devant faire l'objet d'échantillonnages réguliers au Sud comme au Nord Kordofan. Les coûts de tels travaux sont couverts environ pour moitié (Annexe 3) au niveau de l'Université d'El Obeid qui devrait à partir des programmes de travail définitif établi avec les étudiants lors de leur séjour à Montpellier être soumis à l'attaché de l'Ambassade de France à Karthoum afin d'étudier au mieux les diverses possibilités de financement (français ou autres).

3. Les perspectives d'un projet intégré dans le domaine de la sécurité alimentaire au Kordofan

Une première mission de Gérard Chuzel (CIRAD-AMIS), réalisée en février 2004, avait permis de définir un cadre possible de coopération scientifique et technique dans le domaine agricole, dans le cadre des actions post-conflit qui devraient être menées par la coopération internationale, tout en s'appuyant sur les acquis de la coopération franco-soudanaise. Lors d'une précédente mission (M. Lecoq, avril 2004) cet aspect avait été abordé sous l'angle strict des actions possibles dans le domaine de la protection des cultures, en ciblant les contraintes phytosanitaires majeures pesant sur les principales cultures vivrières et de rente de la zone semi-aride du Soudan. Les possibilités de développer une coopération en acridologie entre le CIRAD et les universités de Kordofan, Khartoum et Dilling avaient été étudiées. Les principaux problèmes de défenses des cultures dans les zones de cultures pluviales et irriguées de la zone semi-aride avaient été discutés et les actions prioritaires envisagées avec nos partenaires soudaniens. Parmi les principaux ravageurs, les criquets étaient placés en première priorité et considérés comme représentant l'un des principaux freins à la sécurité alimentaire de la région.

Un cadre global de coopération scientifique et technique dans le domaine agricole entre le Soudan et des institutions de recherche françaises est en préparation par nos partenaires sous l'impulsion de l'Ambassade de France à Khartoum. Les universités de Kordofan, Gezira, Dilling ainsi que la compagnie sucrière Kenana devraient y jouer un rôle moteur. Des projets en collaboration avec le CIRAD et l'INRA pourraient ensuite être présentés par les partenaires soudanais. Ils devraient s'intégrer dans des perspectives à long terme, être centrés sur des aspects prioritaires du développement agricole et intégrer tous les acteurs nationaux nécessaires, de la recherche à la vulgarisation. Le projet acridien pourrait être une composante importante de ce projet intégré. Il devrait inclure aussi bien des aspects recherche, que de développement, de vulgarisation et de

formation et impliquer comme partenaires à part entière aussi bien l'université du Kordofan que toutes les autres institutions locales concernées.

Suite aux entretiens avec l'Ambassade de France à Khartoum avec le nouveau Conseiller de coopération au Soudan, en remplacement de J.P Le Daim, et l'Attaché culturel, il semble que les perspectives de développer un tel projet sécurité alimentaire sur fonds UE soient moins nettes que ce qui était apparu lors de la précédente mission.

Cependant, la concertation entre partenaires soudanais a avancé avec une réunion générale en mars dernier qui a permis de renforcer les liens et de préciser les priorités du développement agricole dans les deux zones écologiques ciblées (cultures irriguées à l'est et cultures pluviales à l'ouest). L'Ambassade attend le résultat de cette concertation entre institutions soudanaises concernées (Univ. Gezira, Univ. Kordofan, Univ. Dilling et Kenana) pour approcher éventuellement les partenaires financiers potentiels (soit l'AFD, soit l'UE) ainsi que les opérateurs français (CIRAD, INRA) sur les possibilités de monter un tel projet. Un TD devrait être expédié prochainement par l'Ambassade à l'AFD pour tenter de les intéresser à un tel projet et des contacts seront pris avec l'UE.

4. Les perspectives pour 2006

Le contexte de coopération avec le Soudan reste très favorable. Les institutions soudaniennes sont fortement demandeuses. La problématique locale est très intéressante et l'aspect criquet est évoqué par tous comme une contrainte fondamentale au développement. Pour 2006, et quels que soient les résultats de la démarche globale évoquée ci-dessus, la coopération dans le domaine acridien avec l'université du Kordofan devrait se poursuivre avec le soutien financier de l'Ambassade de France (plusieurs séjours de soudaniens en France et au moins deux missions CIRAD au Soudan prévues par l'Ambassade, ainsi que des frais de fonctionnement pour l'Université d'El Obeid

Annexe 1 : 1ère proposition de programme de recherche

Studies on bio-ecology and socio-economic impact of the Tree Locust, *Anacridium melanorhodon melanorhodon* (Walker, 1870) on the gum arabic production in Kordofan

Ph. D. Research proposal, by Omer Rahama Mohamed
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El Obeid, Sudan

Introduction

Anacridium melanorhodon melanohordon (Walker, 1870) (Acrididae: Cyrtacanthacridinae) is commonly known as Sahelian tree locust. It has been known to cause occasional damage mainly to the foliage of cultivated trees (Centre of overseas Pest Research, 1982). Damage has also been recorded to milky stage of sorghum in Sudan (Dirsh and Uvarov, 1953), particularly during dry spells.
Gum Arabic tree *Acacia senegal*, which provide important income in Sudan, and some other trees are regularly attacked by the tree locust (Popov and Ratcliffe, 1968). The distribution area of *Anacridium m. m.* extended across the Sahelian zone, within the gum arabic belt, approximately between the latitudes 11 - 15° N (Dirsh and Uvarov, 1953).

The gum arabic plays vital role in the economy of the Sudan and has a great economic importance to farmers. Sudan is nearly in a monopol position in the world gum market by producing 80% of the total world production. But in the recent years (Ballal, 1987) gum production in Sudan has been decreasing; this decline is the result of many reasons one of them is defoliation of gum trees during nigh by *Anacridium m.* Kordofan State has central position in the gum Arabic belt in Sudan. And therefore increases the awareness on the importance of the defoliation by tree locust on gum Arabic production (El Bashir, 1994).

Very few studies have been conducted on this locust, in Sudan and elsewhere. As a consequence, and regarding the economic importance of this species, more studies are needed to better understand the ecology of the tree locust and to improve the strategy of control.

Objectives

The general objective of this study is to understand the key factor leading to the outbreaks which contribute to increase the economic importance of this locust on gum Arabic trees.

The specific objectives are:
- observations on bio-ecology of the tree locust, specially the reproductive potential, phase status, and displacement behaviour;
- by means of questionnaires to study the key factors contributing to the socio-economic impact of the tree locust on gum Arabic production.

Methodology

1. Bio-ecology of the tree locust

Most part of the studies will be carried out in ARC (Agricultural research Centre) plantation where meteorological data are available. Observations will be conducted in the plantations and in caged

insects in the field. Questionnaire will be held in different part of Kordofan state to evaluate the socio-economic impact of the tree locust on gum Arabic production.

1.1. Life cycle

The reproductive performances of ♀ will be evaluated from the onset of the rainy season by dissecting the ovaries on females collected in the field (from May to July).

Reproductive performance:

- Environmental conditions: egg production will be correlated to environmental conditions (rainfall, temperature, humidity...) (10-15 females dissected, 2 time a week).
- Diet : to study the impact of the diet in lab conditions on the reproductive performances, females will be fed with Acacia only and Acacia plus various host plants(Sorghum, millet, Balanites...); egg production will be studied by ovary dissection (oosorption or egg production). (5M + 10 F / cage, 4 replicates).

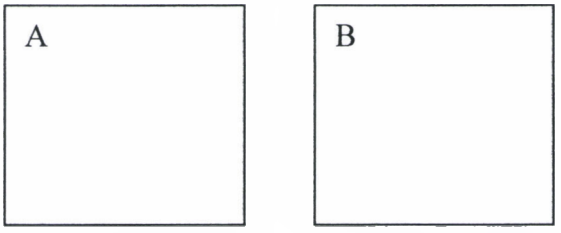
Egg survival rate will be studied on caged mature females before the first laying. The number of hatchlings will be compared to the number of eggs produced (by digging the egg pods and by dissecting the females). 6 females in 5 cages and cages placed in different environments (sand, sand and clay, clay, different drainage conditions, shade).

Nymphal stage will be studied from hatchling to final moult (in plantation and with cages in the lab). The number of nymphal stage, duration of each stage will be determined in relation with temperature and humidity.

1.2. Population dynamic

By regular survey in the plantations (2 times per week), the density of hoppers and adults will be evaluated. Samples will be collected to establish the structure of the population in order to built the population dynamic from G1 (parents) to G2 (offspring).

The study will be conducted in a ARC plantation. In the plantation the study area will be divided in two parts: one for density estimations (A) and one for sampling (B).



Environmental parameters important for dynamic population (temperature, rainfall, ITCZ...) will be collected in the meteorological station of ARC, not far from the study area.

2. Phase polymorphism

By studies in experimental conditions on low, medium and high densities, morphometric measurements will precise the phase status of *Anacridium*.

The measurement of E, F and C on adults emerging from hoppers reared at low density (10 L1 /cage), medium density (100 L1/cage) and high density (500 L1/cage) will provide indication on the

density threshold for gregarisation in the Tree locust as well as indication about the more sensitive parameters to density variations.

The L1 introduced in the cages will come from egg-pods produced by females at low density coming from the field. Hoppers will be reared in cages of 50X50X50 cm. Low density cages should be placed far from high density cages. 4 replicates for each density. The main colour modifications during the hopper development will also be recorded. A day by day data on density will be reported . In order to complement the densities in case of high mortality, specially in very high densities, a mass rearing cage will provide hoppers at the suitable stage.
The second year, similar experiments will be undertaken, taking into account the results of the first year to adjust the density of hoppers in the cages.

3. Displacement behaviour

Anacridium m. is named the night wanderer. The locust is active mostly from sunset (laying, feeding) and displacement take place at night under unknown conditions (T°, wind, rainfall, ITCZ movements etc..).

Records will be carried on conditions of take off by direct observations and by light trap during the dry season when populations are wandering and at the onset of the rainy season on mature populations.

Time of displacement observed
Direction of the flight
T°, wind speed and direction at low level (wind maps are needed)
Fluctuations of the ITCZ

Comparison of density evolution during the dry season in the two parcels (A and B) will give indications on migrations during the dry season, as well as on the character local (non simultaneous events) or regional (simultaneous events) of these migrations.

4. Impact on economic and sociologic aspects by AMM

Socio economic impact of AMM will be précised using a questionnaire to be carried out in the gum Arabic belt in Kordofan during the dry season.

Experiments will also be undertaken by artificial infestation on caged trees and the consequences on gum Arabic yield.

5. Expected out put

1- Data on the bio-ecology and behaviour of the tree locust will be synthesized into a rule based model which generations changes in population size in response to meteorological factors.
2- Population dynamics will be followed for a better understanding of the tree locust out break.
3- Distribution of the tree locust is essential for the development of an economic control strategy and consequently increase in farmer income and hence food security
4- Basis for a sustainable program for locust management will be established.

Collaboration Institutes

1- University of Kordofan
2- Agricultural Research Corporation (ARC).
3 Centre for International research and agriculture development (CIRAD)

Plan of work

In Sudan :

- Questionnaire in January and February, displacement behaviour and phase polymorphism and bio-ecology from march to September
- November and December 2006 and 2007 in France to analyse data for the 1st and 2nd year.
- 2008 : by the end of the field work, 4 months in France to finalize the analysis and writing the thesis

Questionnaire

General informations

1- Serial number 2-State 3- Locality
4- Rural council 5- Village 6- Population number
7- Date 8-Gender (male) (female)
9- Age : less than 20 years 21-30 years 31-40 years more than 41

Pest informations

1- please estimate the magnitude of damage inflected by the tree locust in gum production ?
a- very serious ( ) b- moderate ( ) c- slight ( )
2- At what time the infestation with locust starts?
a- early in the season ( ) b- late ( )
3-specify the months ( )
4- Do you usually tap your gum trees (hashab) when there is locust infestation?
a- yes ( ) b- no, ( )
5- If yes specify
6- What are the most damaging stages of the locust?
a- Young nymph ( ) b- Late nymph ( ) c- Adults ( )
7- What are the other host plant attacked by the tree locust?
a- Dura ( ) b- Millet ( ) c- Orchard ( ) d- Vegetation ( )
8- Is there any link between the locust outbreak and the rainfall distribution?
a- yes ( ) b- No (.)
9- What are the source of the locust infestation?
a- Local swarms ( ) b- Immigrant swarms ( )
10- Do you know the breeding place of the tree locust?
a- Yes ( ) b-No. ( )
11- If yes specify?
12- At what time of the season the locust infested the gum trees?
a- Dry season ( ) b- Rainy season ( )
13- If at dry season which stages?
a- Hoppers ( ) b- Adult ( )
14- If hoppers what is the colour?
a- Green ( ) b- black ( ) c- Others ( )
15- If at rainy season ?
a- Hoppers ( ) b- Adults ( )
16- If hoppers mention the colour?
a- Green ( ) b- Black ( ) c-Others ( )
17- What are the gum yield per tons/hector?
18- When tree locust infested gum trees what are the decreasing of the yield ton/hectors?
19- How can you control the tree locust?
a- Insecticides ( ) b- Traditional methods ( )
20- What is the result after application?
a- positive ( ) b- negative ( )
21-If the application by insecticides, from where?
a- Market ( ) b- PPD ( ) c- Others ( )
22- If traditionally specify?
23- Which method of control infective?
24- In which stages you usually control the tree locust?
a- Hoppers b- Adults

Annexe 2 : 2ème proposition de programme de recherche

Bio-ecology of the Senegalese Grasshopper *Oedaleus senegalensis* (Krauss) in Kordofan State, Sudan,

Ph.D research proposal, by Abdel Manan Elzein Hassan, B sc (1981) Univ. of Tanta, Egypt, M sc (1996) Univ. of Khartoum, Sudan, Plant Protection Sciences Department, Faculty of Natural Resources and Environmental Studies, University of Kordofan

Introduction :

Locust and grasshoppers (Orthoptera, Acrididae) are the oldest insect known in history. They are mentioned since Faraonic era and in the holly Quran and also in the holly Bible (Wani,1995). Many acridologists and locust experts view locust and grasshopper as serious pests, especially in Africa (Abdalla, 2004). The desert locust *Schistocerca gregaria* (Forsk.) is very important during plague periods and attracts many funds from international donors. But it is sporadic and invasions are separated by long recessions periods. On the other hand, every year, grasshoppers are reported as regular pests to cereal crops. However it receives few attention and support. The Senegalese grasshopper *Oedaleus senegalensis* is the most important pest grasshopper in Africa continent especially in West Africa where it has been studied extensively. This species develop three generations per year during the rainy season (monsoon). Its distribution area extending from 10°N to 18°N. Each generation takes about two months (Rowley, 1993; Benson et.al , 1995). During 1974 and 1986 large outbreaks occur over an extensive area in West Africa. But each year, regular damage are recorded in many places.

In Sudan *O. senegalensis* is considered to be one of the most important pest of the two cereal crops, sorghum and millet which constitute the stable food of the area. Serious outbreaks took place in 1945, 1968, 1974, 1986 and 1989 (Khalafalla,1995). In Kordofan *O. senegalensis* and other grasshopper species are becoming increasingly important since 1995. Damage reported by Plant Protection Department were estimated at 75% in 1999-2000 season on millet, sorghum and some pasture grasses. In Sudan grasshoppers are considered as local pest and are not within the PPD mandate and the control is mostly done by farmers .Many information is available from studies undertaken in West Africa and South-West Asia, but information on this species in Sudan and East Africa is scanty. Surprisingly, in Sudan, very few studies has been conducted on this important pest. Therefore, more information about the bio-ecology of this species is highly needed. This could be achieved through comprehensive surveys and monitoring of *O. senegalensis* populations.

1. Objectives of the study

The general objective of this study is to provide basic information about *Oedaleus senegalensis* to establish a sustainable control strategy for this important pest species in the Kordofan state.

The specific objectives are:
1. to better understand the bio-ecology of *Oedaleus senegalensis*;
2. to precise the impact of some key factors on the population dynamic and migrations which may help in the future to manage this pest better.

2. Methodology

2.1. The study area

The study area is Kordofan State which lies within lat.12°10 – 16°35 N, long. 27°-32° E. In this area ecological data will be collected with regards of the ecological requirements of then Senegalese grasshopper : topography, vegetation, soil, land use system, rainfall (annual and mean monthly for 30-50 years), temperature, wind direction, soil humidity and the average position of the ITCZ (Inter-Tropical Convergence Zone). These information will be integrated in a GIS (Map Info) allowing to manipulate the key ecological factors for the Senegalese grasshopper.

2.2. Field studies on the bio-ecology of OSE

It will be the core of the work in order to collect asset of original data. Four study zones are proposed. From South to North of the Kordofan state: Kadugli, Dilling, El-Obeid and Bara.

Samples will be made in natural vegetation and on crops during the season in places with sandy soil suitable for the Senegalese grasshopper and also taking into account the experience of local people, farmers, PPD (archives) about occurrence of *OSE* in the different regions. Population dynamic will be followed. Special data sheet will be designed to record the information in the field (cf. Annexe). Light-Traps will be established in order to get an estimate of the number of migrant insects.

2.3. Interviews of stakeholders on *Oedaleus* and grasshopper problems

Field visits interviewing farmers and various local government officials to collect data from at 50 respondents in each of the four locations (cf. questionnaire in Annexe).
The study will cover all zones of ecological importance for the Senegalese grasshopper.
This study will be conducted during two consecutive years during the dry season. It will allow to better understand the ecology and economic importance of *OSE* in the study area.

3. Planning of the work

Zone	Activity	Months	Remarks
BARA	Survey	Jun to Dec	Two seasons
	Population dynamic	Jun to Dec	Two seasons
	Light Trap	May to Nov	Two seasons
EL OBEID	Survey	Jun to Dec	Two seasons
	Population dynamic	Jun to Dec	Two seasons
	Light Trap	Apr to Nov	Two seasons
DILLING	Survey	Jun to DEC	Two seasons
	Population dynamic	Jun to Dec	Two seasons
	Light Trap	Apr to Dec	Two seasons
KADUGLI	Survey	May to Dec	Two seasons
	Population dynamic	Apr to Dec	Two seasons
	Light Trap	Mar to Dec	Two seasons

Questionnaire will be done during March, April and May for each locality.
Visits to France are scheduled as follow:

First year (2006) : November-December
Second year (2007) : March-April
Third year (2008): 4 months (analysis and to finalize the study).

4. Expected out put

1. Set of original field data on the population dynamic of the Senegalese grasshopper in Sudan.
2. Population dynamic of the pest better understood and used to develop a control strategy.
3. Different people involved in the project trained to field methods of survey and population dynamic studies.
4. Farmers indigenous knowledge will be documented.

Annexes

1. Survey form

2. Population dynamic form

3. Ovary dissection form

4. Questionnaire

Survey of Grasshoppers

District: ..... Village: .....

Name: ..... Date: .....

1- Sex: Male [ ] Female [ ] **Age**..... **Years**.....

2- Educational level:

Illiterate [ ] Khalwa [ ] Primary [ ] Intermediate [ ] Secondary [ ] Beyond secondary [ ]

3- Marital status: Single [ ] Married [ ] Widowed [ ]

4- Occupation: Farmer [ ] Pastoralist [ ] Farmer and pastoralist [ ] Others (Specify) [ ]

5- Mode of production: Rain fed [ ] Others (Specify) .....

6- Crops grown: Millet [ ] Sorghum [ ] Sesame [ ] Vegetables [ ] All crops [ ]

Others (Specify) .....

7- Production relationship: Farm owner [ ] Rent [ ] Shared [ ]

8- Cultivated area in feddan yearly:

Millet..... Sorghum..... Sesame..... Vegetables..... All crops.....

9- The production in bags per feddan:

Millet ..... Sorghum ..... Sesame..... Vegetables .....

10- For how many have you been growing crops?

Less than one year [ ] 1-3 years [ ] 4-6 years [ ] 7- 10 years [ ] More than 10 years [ ]

11- Is your production decreased and when? Yes [ ] in..... No [ ]

12- When the production decreased to what do you refer this?

Rainfall [ ] Pests [ ] Other (specify).....

13- What is the more harmful pest of these?

Grasshoppers [ ] Rats [ ] Locusts [ ] Others [ ]

14- Can you differentiate between locust and grasshoppers?

Yes [ ] No [ ] If yes specify.....

15- Do you know species of grasshoppers?

Yes [ ] No [ ]

If yes: OSE [ ] Aio [ ] Diabolo [ ] Kraus [ ] Others [ ] Just grasshoppers [ ]

16- What is the most important species of the above?

OSE [ ] Aio [ ] Diabolo [ ] Kraus [ ] Others.....

17 - When do you notice OSE in your area (specify stage and month) ?

Hoppers J F M A M J J A S O N D

Adults J F M A M J J A S O N D

18- When does the damage happens?

Early stage [ ] Growing stage [ ] Milky stage [ ]

19- What sort of weeds in your area?

1..... 2..... 3..... 4..... 5.....

20- Do you see any grasshopper (s) feeding on them?

Yes [ ] on ....., ..., ... No [ ]

21- The damage of grasshoppers happened:

Every year [ ] Periodically [ ] Some times [ ]

22 Is there any correlation between rain fall and grasshoppers?

Yes [ ] No [ ]

Explain:.....
.....
.....

23 How do you rate the damage of grasshoppers :

Severe [ ] Moderate [ ] Slight [ ]

24 Whom do you contact when outbreak happened?

Sheikh [ ] PPD inspector [ ] Extension service [ ]

I contact nobody [ ] Why .....

25- Do you use chemicals to control grasshoppers regularly by your self?

Yes [ ] No [ ]

26- Way of application: spraying [ ] dusting [ ] Others.....

27- When do you start control of grasshoppers usually:

In early season [ ] Mid season [ ] Late season [ ]

28- If you use pesticides, what pesticides used?

1..... 2..... 3..... 4.....

29- How many times you spray in the season?

Only one [ ] Two times [ ] Three times [ ] More than three [ ]

30-Do you calculate the cost of spraying? Yes [ ] No [ ]

31- Do you use another ways of grasshopper control ?

Specify and give details:……
……
……

32- Do you observe any insects feeding on / attacking grasshoppers?

Yes [ ] No [ ] If yes (specify)……
……
……

Annexe 3 : 3ème proposition de programme de recherche : Integration of bio-pesticides and botanicals in the control of the Tree Locust, *Anacridium melanorhodon melanorhodon* (Walker)

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Introduction

Acacia Senegal (Hashab) - from which the world wide known gum arabic has been produced- is the most important economic and ecological component in the savannah of Sudan, on either sandy (goz) or clay soil (Badi *et al.*, 1989). Sudan is the main world producer and exporter of gum Arabic. In addition to gum production, *Acacia senegal* is used for sand dunes stabilization and sand soil amelioration through nitrogen fixation, as well as a source of firewood, and as fodder (Elfeel, 1996). Ballal (1987) reported that there are many pests that attacked *Acacia senegal* and has a negative effect on gum production, such as rats, animals and some insects pests that feed on the different parts of *Acacia spp.* Among pests and diseases that attacked and negatively affected *Acacia spp*, the Tree Locust - *Anacridium melanorhodon melanorhodon* (Walker) - is considered to be the most destructive pest.

Justification

The Tree Locust (*A. m. melanorhodon*) depends primarily on Hashab leaves for it's nourish and this lead to low productivity of gum as a result of decreasing the photosynthesis rate. El Bashier (1994) reported that the main losses in gum production by (*A. m. melanorhodon*) in season 1991 and 1992 were estimated at 86.5%. Thus the protection of Hashab trees against this tree locust is very important. It is well known that there are hazards in using only chemical pesticides. In the few recent years extensive studies on *Metarhizium* ssp as locusticide were done on Desert Locust and grasshoppers in different areas, but few investigations were done on Tree Locust. In this study *Metarhizium* spp will be used to control the Tree Locust. Within the fact that pathogens doesn't act fast, Neem seed oil will be used to reduce the food consumption of *A. m. melanorhodon* until the action of *Metarhizium* spp begin.

Objectives

The study will target nymphs of the Tree locust. Its main objectives are:
1- To evaluate the efficacy of *Metarhizium* spp. as a locusticide.
2- To compare between biological and chemical control.
3- To evaluate the efficacy of a biocontrol agents (*Metarhizium* spp and Neem) in comparison with standard chemicals.
4- To assess the compatibility of a mixture of the two products (*Metarhizium* spp and Neem) in field and lab conditions.

Methodology

1. Compatibility of Neem and *Metarhizium*

Compatibility of the entomopathogenic fungus *Metarhizium* spp. mixed with (1) Neem Seed Oil (N.S.O) and (2) kerosene will be investigated under different environments viz: temperature and relative humidity under controlled laboratory conditions. Germination of *Metarhizium* blastospores

and the growth of its mycelium will be observed. Potato - dextrose - agar (PDA) will be used as media for spores culture in Petri dishes containing various concentrations of N.S.O and kerosene.

2. Efficacy of different pesticides (chemical and biological)

This study will be conducted at the Acacia company area, 35Km South East El Obeid, Northern Kordofan state, about 6000 feddan are planted with 5 years old *Acacia senegal* trees (hashab).

Contaminated area with Tree locust nymphs will be selected and divided into 15 plots separated by 200 meters. Each plot has 50 x 50 m size and contain around 50 *Acacia* trees. All the treatments will be applied on the 4th instar nymphs of *A. m. melanorhodon* using Ultra Low Volume (ULV) sprayers (Micro ULVA). A pre-spray count will be conducted to estimate the population density of *Anacridium* nymphs by counting the number of nymphs present on 15 trees randomly selected in each plot.

The treatment will be conducted as follow:

1. Preparation of *Metarhizium* spp. (M): 20 g of *Metarhizium* spp. powder will be diluted in kerosene and the recommended dose will be applied (3 replicates).
2. Preparation of neem seed oil (N.S.O.), according to the method developed by the National research center, applied at the recommended dose (3 replicates).
3. Preparation of the mixture N.S.O. + M. at the recommended doses for each product (3 replicates).
4. Three plots (untreated with 4th instar nymphs) will serve as control, from which the natural death will be determined.
5. Recommended dose of Malathion will be applied as a standard (3 replicates).

15 treated 4th instar nymphs will be collected from each plot 1 day after application, and put in small cages 50 x 50 x 50 cm. The cages will be transferred to a field lab and nymphs daily provided with uncontaminated *Acacia* shoots. Data on mortality/survival in *Anacridium* nymphs will be collected on a daily basis from the field trials (visual evaluation of survival nymphs) and from the laboratory tests as well. Moreover, the volume of locusts faecal output will be recorded 48h after the application to evaluate the anti feeding effect.

From (M) and (N.S.O. + M) treatments, samples of dead nymphs (both collected in the field and in the cages) will be transferred to Petri dishes with wet filter paper to examine the fungus growth.

The experimental lay-out is as follow :

T1	T4	T2
T4	T2	T1
T3	T3	T5
T5	T1	T3
T2	T5	T4

Metarhizium spp. (T1), Neem (T2), M + neem (T3), Malathion (T4), Control (T5)

Treatments will be distributed randomly among the experimental units as mentioned above. Randomized Complete Block Design (RCBD) will be used. An ANOVA table will be used for data analysis. Least Significant Difference (LSD) will be used in the presence of significance.

Planning

2006		2007	
Period	**Activities**	**Period**	**Activities**
February (1) month in Sudan	Preparation of equipments and materials	January --- April 4) months in Sudan	Literature and net work
--- May 1 month in France	1- Experiments on the fungus growth in Cirad lab 2- Training on calibration and application methods	May ---- June (2) months in Sudan	Preparation for the second season
June ---- September (4) months in Sudan	1-Training of supporting staff 2-Field work:	July ---September (3) months in Sudan	Field work for the second season
Oct -- 1 month in France	Analysis of data for the first season	Oct--November (2) month in France	1-Analysis of data for the second season 2-Thesis preparation

Collaborative institutes :
Care
PPD
Cirad
University of Kordofan

Annexe 4 : Programme du séjour des étudiants soudanais à Montpellier

PROGRAM OF THE STAY IN CIRAD ACRIDOLOGY - MONTPELLIER				
			Morning	**Afternoon**
OCTOBER	Lundi	10		
	Mardi	11	Arrival	
	Mercredi	12	Contact with EGIDE and CIRAD administration. Program presentation	
	Jeudi	13	Discussion research program OSE (ML-MHLS)	Locust survey (course) (MHLS)
	Vendredi	14	Discussion research program AME PhD, MSc (ML-MHLS)	
	Samedi	15	Rewriting improved research program	
	Dimanche	16	Rewriting improved research program	
	Lundi	17	TP - Rearing methods, population structure (AF)	Locust collect (field work)
	Mardi	18	TP - Dissection of locust, preparation, conservation methods (AF)	
	Mercredi	19	TP - Application techniques for experiments (TR)	Dissection of ovaries
	Jeudi	20	Biology, reproduction, population dynamics (MHLS)	
	Vendredi	21	TP - Application techniques for experiments (TR)	
	Samedi	22		
	Dimanche	23		
	Lundi	24	Bibliographical research (introduction)	TP -Dissection of ovaries
	Mardi	25	Discussion research program OSE, AME (ML-MHLS)	Improving programs by students
	Mercredi	26	Finalisation of research program and budgets (whole day)	
	Jeudi	27	Phase polymorphism (course) (MHLS)	TP - Phase polymorphism (ML)
	Vendredi	28	Bibliographical research	
	Samedi	29	Analysis of bibliography	
	Dimanche	30		
	Lundi	31	Rewriting improved research program	
NOVEMBER	Mardi	1	Analysis of bibliography	
	Mercredi	2	Analysis of bibliography	TP - GPS training in the fied (whole day) (AF)
	Jeudi	3	Final review of research program (ML-MHLS)	Final review of research program (ML-MHLS)
	Vendredi	4	Analysis of bibliography	
	Samedi	5		
	Dimanche	6		
	Lundi	7	Synthesis and final report	
	Mardi	8	Departure	

Annexe 5 : Estimation du coût des trois programmes de recherche

Etude bio-écologique et sociologique d'*Anacridium melanorhodon melanorhodon*

Activities	Details	Amount/SD
Field work	Survey (light trap 4 labour x 6 month x5000SD + Population Dynamic studies .4 lab.x 6 mon.x 5000 SD +nymphal study 4 lab.x 3 mon.x5000SD + polymorphism.4 lab.x 3 months.x 5000SD + Dissection)	400 000
Equipments	Cages (48 small x 5000 SD + 16 Large x 75000 SD) and light traps (2 sides x 20000 SD)	400 000 *
Questionnaire	6 lab.x 5 (days) x 5000 SD	150 000
Fuel	7 barrels for field work x 16500 SD +2 bar. (For questionnaire)	150 000 *
Training	4 Supporting assistant staff x 4 days x 5000 SD +100 SD ticks + 3 lecturers x 10000 + 30000SD refreshment.	150 000
Stationary	Paper, files and others.	50 000
Travelling expenses	Ticks EL Obeid / khartoum vice verse during the study period.	150 000
Meteorological data	T°, RH, Rain fall, Wind direction and ITCZ	100 000
Net search	Literature review	20 000 *
computer	For preparing the thesis	140 000
Rent	Car for Survey	300 000
Ph.D fees		1000000 *
Total au Soudan		**3010000 SD soit 10273 euros**

dont 52% couverts par l'Université *

PM : billet avion en 2006 , 2007, 2008

2 mois de stage en 2006 et 2007,

4 mois en 2008

Etude bio-écologique d'*Oedaleus senegalensis*

Activities	Details	Amount in SD
Field work	Survey (4sites x 2labours x 8months x 2seasons x 5000SD)	640000
	Light trap equipments (lamps + trays x 4sites)	50000 *
	Questionnaire (pre-test +filling)	140000
	Fuel (264 gallon x 375SD x 4 sites) in 6 months	396000 *
Training	Supporting staff (8 labours x 3 days) + refreshment + Lecturers	130000
Stationary		50000
Travelling	Expense to visit the sites monthly for 16 months	150000
Data	Data from Meteorology Department (T°; rain fall; wind; humidity)	200000
Internet	Literature Review	20000 *
Computer	PC for Data analysis, writing of the thesis...	150000
Rent a car	for survey (1car x 4days x 5000 SD x 4sites x 4 months)	320000
PH.D research	Ph.D fees in the Univ. of Kordofan....	1000000*
Total au Soudan		**3246000 SD soit 11078 euros**
45% couverts par l'Université *		**1466000**
PM : 3 billets avion et 8 mois en France		

Biopesticides en lutte anti-acridienne

Activity	Details	Amount/ SD
Field work	Pre count, application and observation	200000
Equipments and materials	Cages and ULV sprayers	150000 *
Fuel		100000 *
Training	Supporting assistant staff	100000
Stationary		50000
Travelling in Sudan		50000
Net search		20000 *
P.C.		140000
Rent	Car for field work	200000
M.Sc. fees		450000 *
Work in France	Travel and X month in CIRAD	
Total au Soudan		**1460000 SD soit 4983 euros**

dont 49% couverts par l'Université *

PM : 2 billets avion en 2006 et 1 en 2007

2 mois en 2006 et 2 mois en 2007

Récapitulatif	Coût total du projet au Soudan	Reste à financer
Omer	10273 euros dont 5342 à la charge de l'Université	4931
Manan	11078 euros dont 4985 à la charge de l'Université	6093
Wail	4983 euros dont 2442 à la charge de l'Université	2541
	Total à financer	**13565 euros**

PM : 9 billets d'avion et 20 mois de stage en France

Remarque : le matériel optique (loupes binoculaires indispensables pour les dissections et étude du fonctionnement ovarien) serait disponible à l'université mais cela reste à vérifier, en particulier quant à sa qualité et son adéquation aux travaux proposés. Des fonds seraient sans doute à prévoir pour couvrir cet aspect (compter environ 3000 euros pour deux loupes binoculaires).