# STATIC AND DYNAMIC CARTOGRAPHIES OF THE BIOTOPES OF THE GRASSHOPPER Rhammatocerus schistocercoides (REHN, 1906) IN THE STATE OF MATO GROSSO, BRAZIL.

**Evaristo Eduardo de MIranda**
**Ivo Pierozzi Jr.**
**Mateus Batistella**

*Nucleo de Monitoramento Arnbiental (EMBRAPA/NMA)*
*Av. Dn Julio Soares de Arruda, 803 - 13088-300 Carnpinas, SP, BRAZIL*
*Phone: 55-192-525977- Fax: 55-192-541100*
*E-mail: postmaster@nma. embrapa. br*

**Jean-François Duranton**
**Michel Lecoq**

*PRIFAS Acridologie opérationnelle - Ecoforce Intemationale*
*GERDAT-CIRAD*
*2477, Avenue du Val de Montferrand - BP 5035 - 34032 Montpellier, Cedex 1, FRANCE*
*Phone: 67 61 58 00 - Fax: 67 41 09 58*

ISPRS, COMMISSION VII, WORKING GROUP 5

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## Abstract

**Since the 1980's, populations of the grasshopper Rhammatocerus schistocercoides (Rehn, 1906) (Acrididae, Gomphocerinae) have caused damage to the agriculture in savanna areas of the State of Mato Grosso, Brazil. The pullulations occur only in specific biotopes, inside the entire distribution area of the species, located between the geographic coordinates 12° -15° S and 51° - 61° WGr. Through a detailed study which incorporates field data and geoprocessing techniques, maps about suitable and unsuitable biotopes for insect reproduction, development and survival are being made. A static cartography, scale 1:250.000, was developed based on analogic interpretation of LANDSAT TM images; their integration in a geographic information system (GIS), with other basic data, have already been made for a pilot area of 71.399 km², resulting four thematic maps. The NOAA images are also being used to elaborate the dynamic cartography, which will aim to monitor the phenological evolution of vegetation beyond the pilot area, including other regions with potential infestation risks. This research will provide the basis for a methodological development of remote sensing and geoprocessing applications to approach wide range entomological problems such as this one in Mato Grosso.**

## 1. INTRODUCTION

Brazilian grasshoppers do not represent a serious problem when compared with African species, but recently they have caused considerable preoccupation to entomologists and authorities because of pullulations observed in different regions. Distinct species are involved and spatial-temporal components of pullulations are variable from year to year, even though these outbreaks are more regular in some zones than in other ones (Lecoq, 1991; Lecoq & Pierozzi Jr, 1993c; 1994e; Lecoq et. al. 1993).

The main pullulation zones in Brazil at the present time are located in the Northeast Region and in the states of Rio Grande do Sul, Mato Grosso and Rondônia. In these last two states, where lands became greatly valorized and recently colonized, the situation seems to be critical since 1984 with problems caused by Rhammatocerus schistocercoides (Rehn, 1906) Great discussions have emerged about pullulation origins while governmental organisms and farmers have made intensive and extensive chemical control (Lecoq & Pierozzi Jr., 1993c; 1994e).

Several hypotheses have been proposed to explain this phenomenon. Intensive deforestation is commonly blamed suggesting, that it creates suitable biotopes for this grasshopper and upsets the ecological balance which, in turn, causes a marked reduction of their natural enemies and, thus, promotes outbreaks. Nevertheless there is actually no scientific evidence to confirm this argumentation (Lecoq & Pierozzi Jr, 1994a; 1994e).

In this context the Environmental Monitoring Center of the Brazilian Agency for Agricultural Research (EMBRAPA-NMA), the NGO ECOFORCE - Research & Development and the PRIFAS (Acridologie Opérationnelle/Écoforce Intemationale) - Centre de Coopération Intemationale en Recherche Agronomique pour le Développement (CIRAD), at Montpellier, France, have proposed a joint research project to be developed in the period 1992-96 and partially financed by the Comission of European Community (CEC). This project aims to study the relationships among the grasshopper pullulations and land agricultural occupation, natural landscape modifications and general evolution of the environmental conditions.

After this first year of research, this paper presents some preliminary results that allow inferences about the suitability of using remote sensing and geoprocessing applications to approach wide range entomological problems such as this one in Mato Grosso.

## 2. MATERIAL

### 2.1 Study area

Recent pullulations of R. schistocercoides were observed on an extensive surface which crosses the central area of the State of Mato Grosso, from southeastern Rondônia to the limits of Goiás. This represents approximately 300.000 km$^2$, located between the geographic coordinates 12° -15° S and 51° - 61° WGr characterized as follow (Duranton, 1993; RADAMBRASIL, 1982):

The region comprises relief zones such as the South American Peneplains, the Plateau of Parecis and the Meridional Amazonian Lowlands. The geology includes pleistocenic, neogenic and paleogenic sedimentary recovering; sedimentary and igneous rocks from Mesozoic and Middle Proterozoic and crystalline shields (Archean). There is a great variety of soils and, considering their surface recovering, the main ones are the ultisols, the oxysols and the quartzpsamments.

The observed climates are tropical and equatorial, warm and humid. The annual temperature average is between 24-26° C, although there are places where the daily minimums are inferior to 12° C during the coolest month, such as in Chapada dos Parecis, where it has already been registered 0° C. This phenomenon is due to the invasion of anticyclones of polar origin and continental route, oftenly in the winter. The annual precipitation average varies from place to place, inside the considered area, from 1.500 mm in its south limit, until 2.000 mm in northern points.

The region presents a great contact area between different types of vegetation. The general climax is the Brazilian savanna (cerrado s.l.) with several structural variations. The savanna areas are found extensively at Chapada dos Parecis, crossing the middle of the State from the westem limits with Rondônia until the eastem limits with Goiás.

Since the 70's, agricultural modemization and the incorporation of new lands have been responsible for the expansion of agricultural and cattle raising, resulting in diversified areas due to the evolution of the human occupation process.

### 2.2 Bibliographic and cartographic material and satellite Images

The bibliographic research included 124 titles related with the subject. The complete inventory was edited in a book (Lecoq & Pierozzi Jr., 1994e). This is a preliminary critical synthesis of different documents that have been published to date, enhanced with personal comments and observations of the authors. The document presents a commentated bibliography organized in chronological order to provide an overview of the problem since its appearance to the beginning of the project.

The cartographic data base was a collection of maps, scales 1:250.000 and 1:1.000.000 (Brasil, 1982a; 1982b; 1983a; 1983b; 1983c; IBGE, 1979a; 1979b).

The static cartography of the biotopes was based on the analogic interpretation of the following LANDSAT TM products: (color composition, paper and positive transparency, band 3, 4 and 5 RGB), identified respectively by its orbit/point and date of passage:

224/69 (10.31.93); 224/70 (10.31.93); 225/69 (08.13.93); 225/70 (08.03.93); 225/70 (07.20.91); 226/68 (11.14.93); 226/69 (12.04.90); 226/69 (08.26.93); 226/70 (12.04.90); 226/70 (11.14.93); 226/70 (06.27.91); 226/71 (12.04.90); 227/68 (07.16.93); 227/69 (03.12.92); 227/69 (07.16.93); 227/70 (12.02.91); 227/70 (10.10.91); 227/70 (07.16.93); 227/71 (02.28.91); 228/68 (06.21.93); 228/69 (12.10.91); 228/69 (07.23.93); 228/70 (12.06.90); 228/70 (07.10.91); 228/70 (07.23.93); 228/71 (02.27.91); 229/68 (09.16.93); 229/69 (09.16.93); 229/69 (11.23.90); 229/70 (09.16.93); 229/70 (11.22.90); 229/71 (09.19.91).

The dynamic cartography of the biotopes was based on a NOAA-11/AVHRR (1, 2 and 3 bands) set of images, scale 1:1.000.000, from the following dates of satellite passages: 06.12.92; 07.28.92; 08.22.92; 09.08.92 and, 04.27.93.

### 2.3 Equipments and softwares

The digital cartography, based on satellite images, was made with the Image Processing and Geographic Information Systems (SITIM/SGI 340, Version 2.4), both developed by the National Institute of Space Research (INPE).

The analogic interpretation was improved by the visualization of the images in an optic amplifier (PROCOM 2) to evaluate the macro-heterogeneity of the area.

A GPS was also used for field orientation, data validation, trajectory generation and limits adjustments.

The visual documentation of the biotopes was made with photographic reflex cameras and 35 x 70 mm lents.

The basic configuration of computational equipments has included microcomputers (central processor 80486 - 16 bits, floater point coprocessor 8087/80487 and 8 Mbytes RAM); peripherics (180 Mbytes hard disc, 5.1/4" and 3.1/2" floppy disc drivers and Super VGA colored video terminal); UVI-340 graphic terminal (1024 x 768 image visualization unit, 256 levels and 8 bits/pixel): VGA graphic controller; A0 digitizing tablet; polychromatic electrostatic plotter and laser printers.

# 3. METHODS

## 3.1 Static cartography of the biotopes

The static cartography was made by the integration of the analogically interpreted data from LANDSAT TM images with other basic informations like hydrographic and road networks. The GIS functions such as data digitizing, conversion of topological formats and map generation were used for cartographic data handling (Batistella, 1993).

The maps, scale 1:250.000, were drawn up, characterizing natural and human affected vegetation types in the study area.

Simultaneously, periodic expeditions for field surveys were made (Lecoq & Pierozzi Jr., 1993a, 1993b; 1993d). Each vegetation type was characterized following a specific sample plan and acridological, botanical, agronomic and ecological criteria, validating and complementing the data of satellite image interpretation.

Subsequently, with the GIS facilities, the cartographic documents were generated and the final products were plotted in a polychromatic electrostatic plotter.

## 3.2 Dynamic cartography of the biotopes

The temporal dynamics of the grasshopper biotopes are being made with NOAA images and vegetation indexes. After this, obtained data would also be, integrated into the SGI composing a whole digitally database. Incipient essays have been made to integrate NOAA images into GIS's (Gastellus-Etchegorry & Laumonier, 1993) but development of specific procedures is yet necessary to digitally process and analyze the images.

The set of NOAA satellite images was examined and one of them (date 07.28.92) was selected for tests due to its low cloud coverture. Digital treatments in SITIM were made using several algorithms for automatic classification.

The vegetation map of RADAMBRASIL Project (Brasil, 1982b) was the comparison basis to validate the classification obtained from digital treatments of NOAA images.

# 4. RESULTS

## 4.1 Static cartography of the biotopes

Recent R. schistocercoides outbreak areas stretch from the southeastem portion of the State of Rondônia to the borders of the State of Goiás, including much of Mato Grosso. For this study, a pilot area with 71.399 km$^2$ was selected (geographical coordinates 14° 00'-15° 00' S and 60° 00' - 54° 00' WGr). This represents 24% of the entire area of pullulations and was, chosen due to its acridological importance and logistics facilities.

Four maps of the main vegetation types were drawn up, scale 1:250.000 (Miranda & Duranton, 1993a; 1993b; 1993c; 1993d), with a preliminary legend which was elaborated to translate the suitable and unsuitable biotopes for grasshopper reproduction. development and survival: Forest, Disturbed Forest, Riparian Forest, Wetland Forest, Savanna, Disturbed Savanna, Rocky Savanna, Herbaceous Savanna, Disturbed Herbaceous Savanna, Herbaceous Savanna with Riparian Forest, Natural Grassland, Disturbed Natural Grassland, Natural Grassland with Riparian Forest, Flooded Natural Grassland, Areas with strong, median and weak human activities, Hydrographic Networks, Road Networks and Urban Areas (Fig. 1).

After this experience, other four maps (SD.21-V-A; SD.21 -V-B; SD.21 -V-C and SD.21 -V-D), in the same scale, are being made at the present time, expanding the cartography beyond the pilot area.

Ecological data from field surveys have demonstrated that R. schistocercoides biotopes are concentrated in the natural grasslands and herbaceous savanna zones with sandy soils. These vegetation types represent 18.000 km$^2$ or 25% of the pilot area. The LANDSAT TM images show that these zones are strongly related to the hydrographic network and are generally observed in the valleys. Crops are implanted in more suitable edaphic zones and those sandy ones remain in a natural state which become suitable for the grasshopper reproduction and development.

Cultivated areas, mainly occupied by annual crops of rice, maize and sugar cane, are largely unsuitable for insect reproduction because of regular soil preparation, but they represent a good source of nourishment to the grasshopper and can be greatly attacked.

The maps that were drawn up have showed great zones of crops completely rounded by acridian suitable biotopes. The synthetic cartography with localization of both grasshopper habitats and crops allows to plan preventive control strategies based on surveys of the insect populations.

## 4.2 Dynamic cartography of the biotopes

The tests of NOAA data using the SITIM have indicated that the Maximum Likelihood Classification (MLC) method allows more interactive possibilities to help the elaboration of biotopes dynamic cartography in preliminary phases. The results obtained with MLC method for vegetation types, when compared with those from RADAMBRASIL vegetation map (Brasil, 1982b), showed coherencies.

Field surveys have confirmed these positive results, showing that NOAA images could be potentially used for the characterization of acridian biotopes in the study area, permitting the incorporation of a dynamic component to the cartography: using vegetation indexes it is possible to follow and monitor vegetation phenophases and then evaluate their influence on insect populations.

The vegetation becomes green after the first rains in September and October. At the same time the grasshopper starts its reproduction. The females lay their eggs in the soil and the nymphal development occurs througout the summer, when grasses are the main source of food for the insect (Lecoq & Pierozzi Jr., 1994b). Crops are attacked when natural resources become locally scarce. During this period it is easier to control the grasshopper due to its low range dispersion and greater susceptibility to chemical insecticides. Out of the rain season, bumings can affect the vegetation and after a short time it becomes green. This phenomenon allows to the grasshopper concentrate in recently bumed zones (Lecoq & Pierozzi Jr., 1994c; 1994d) and can also be monitored by NOAA data (Miranda, 1993).

# 5. CONCLUSION

This is the first time in Brazil that applications of remote sensing and geoprocessing have been used to approach such an entomological problem like this one in the State of Mato Grosso. The wide range dispersion of R. schistocercoides justifies satellite image utilization for better understanding and mapping of the factors that determine the insect pullulations. The synthetic cartography, with possibilities of periodic bulletins about phenological status of the vegetation, will be helpful to authorities and farmers for programming more efficient, economic and safe control strategies.

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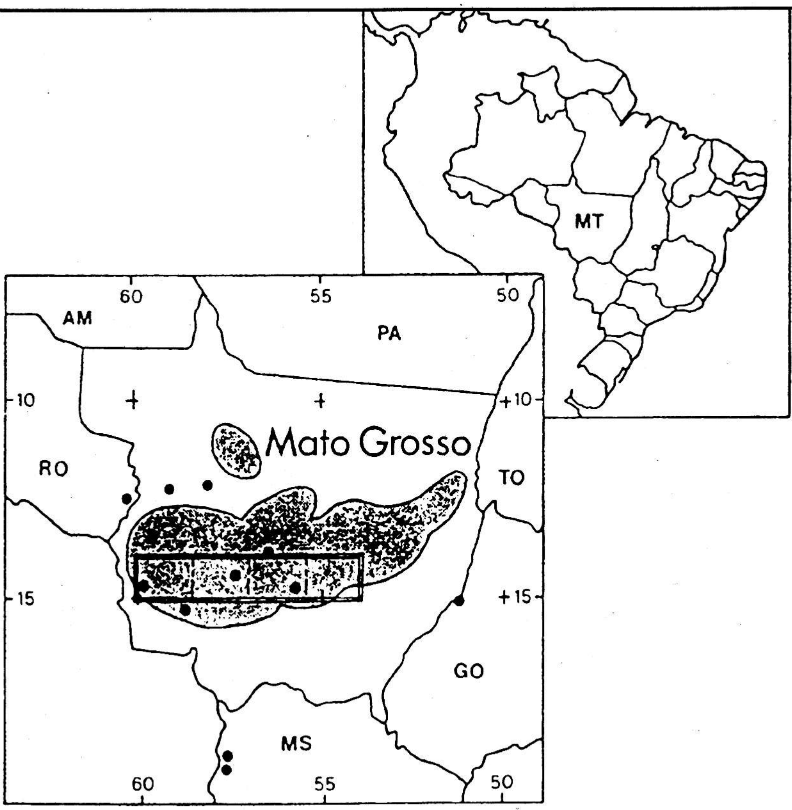


Fig. 1.– Location of the main *Rhammatocerus schistocercoides* outbreak areas in Mato Grosso.

Grey zones : main outbreak areas from 1984 to 1986

Black spots : Outbreak areas reported by CARBONELL (1988).

Brazilian states : AM, Amazonas ; GO, Goias ; MS, Mato Grosso do Sul ; MT, Mato Grosso ; PA, Para ; RO, Rondônia ; TO, Tocantins

═══ Project pilot research area for which vegetation maps have already been drawn up

***Fig. 1. Location of the main Rhammatocerus schistocercoides outbreak areas in Matto Grosso, Brazil***

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