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Effect of cultural techniques: Rotation and fallow on the distribution of *Oedaleus senegalensis* (Krauss, 1877) (Orthoptera: Acrididae) in Senegal

Mamour TOURE[1]*, Mady NDIAYE[1] and Aliou DIONGUE[2]

[1]Laboratoire Biologie de Reproduction, Département de Biologie Animale, Faculté des Sciences et Techniques, Université Cheikh Anta Diop de Dakar. B P: 5005 Dakar Fann, Dakar, Senegal.
[2]Direction of Plant Protection, Ministry of Agriculture, Senegal.

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The Senegalese grasshopper, *Oedaleus senegalensis* Krauss is a major pest in Sahel of West Africa. The present work reports the insect distribution and cultural techniques influence within two Senegalese localities. Methodology used is based on sampling and density estimates for a comprehensive study of Senegalese grasshopper in natural environment. Adult density was evaluated by visual counting on 100 m paths and larva density by counting one hundred sample surfaces of one square meter each. Sampling was conducted in fields of millet, bean, groundnut and fallows. The research work was performed for three consecutive years from 2006 to 2008. The Senegalese grasshopper distribution depends on biotope type, rainfall intensity and year. Its density was estimated monthly between 2 and 30 individuals per square meter. Larva density was significantly more abundant in fallow field than other fields. Crop rotation reduced density of Senegalese grasshopper and fallows favor the presence of the insect. These data suggest that field, rainfall intensity has an important effect of *O. senegalensis* distribution.

Key words: *Oedaleus senegalensis*, density, cultures, rotation, fallow.

INTRODUCTION

Senegalese grasshopper *Oedaleus senegalensis* Krauss is a crop pest. Movements in Sahel zone are in north-south direction isohyet 1000 mm (Lat. 110-120N) southern limit and isohyet 150 to 200 mm (Lat. 170-180N) northern limit. The population moves seasonally in the wave of the inter-tropical convergence zone (ITCZ) or intertropical front (ITF) (Kabeh, 2008). Level of damage caused to crops depends on populations and movements of *Oedaleus* in the fields. It attacks mainly food crops of populations in Africa.

In 1980 it caused 40% loss for crops in Sahel (Launois and Launois-Luong, 1989; Cheke, 1990; Krall, 1994; Popov, 1996). Many other losses were recorded, 30% on average harvests in India (Bhatia and Ahluwalia, 1967), 20 to 40% on millet, sorghum and rice in Niger (Cheke et al., 1980), 70 to 90% in combination with other grasshopper species in five years in Mali (Jago et al., 1993). Last major upsurge Senegalese grasshopper occurred in 1985 to 1987. However, outbreaks are observed in some countries in Sahel.

In Senegal, each year, *O. senegalensis* swarm in groundnut zone. Popov (1980) reports damage on millet in Senegal and Mali. It is the most economical important grasshopper in West Africa (Launois, 1978; Launois-Luong and Lecoq, 1989). In 2003, for crop prospects were not favorable by an infestation of *O. senegalensis*

*Corresponding author. E-mail: touresnfst@yahoo.fr, Tel: 221 77 564 29 23. Fax: 221 33 824 63 18.

on fields of sorghum, maize and millet in Senegal (FAO, 2003). Chemical control of grasshoppers is so far the best among control approaches available. However, use of pesticides on a large scale has raised concerns for effects on human health and environment (Van der Valk et al., 1999). It is essential to integrate management of the Senegalese grasshopper. *O. senegalensis* may differ on locality and following year.

Research on the distribution of Senegalese grasshopper environment is necessary to predict invasion of this pest (Bak et al., 2007; Fisker et al., 2007). The aim of this paper is to understand the invasive ability of this species in different habitats, which enables monitoring and managing its populations in Senegal.

MATERIALS AND METHODS

Study area

The present survey was conducted in rural community of Mbar and Noto. Mbar is located at 14° 31' N latitude and 16° 58' W longitude (Fatick region, Senegal). Its rainfall over the past decade is irregular and varies between 300 and 800 mm. Temperature varies from month to month (24°C on January and 39°C on May). Noto is situated at 14° 42' N latitude and 15° 49' W longitude (Thies region, Senegal). Indeed this area is in a transition zone under the influence of sea winds and harmattan, with an average temperature of 32°C, annual precipitation 400 to 700 mm spread over four months. There were both in the groundnut localities.

Determination of adult density

The surveys were conducted during five months in rainy season (July, August, September, October and November). Number of adults per square meter was measured by counting along hundred meters. The prospector counts the adults of *O. senegalensis* flying in his away. Fifty repetitions of the same activity were made and the average is day value. Four monthly surveys are conducted and is average monthly value. Experiments were conducted on groundnut field, bean field, millet field and fallow field with random sample. It takes four pieces of paper that annotates groundnut field, bean field, millet field and fallow field. For each step we draw one of four pieces of paper and this type of field that is explored and so on until the last parcel. Repeat this for three consecutive years (2006, 2007 and 2008).

The prospected lands vary from year to year but the following four types of field. For three years, seventy two fields of each type were inspected. So we studied the Senegalese grasshopper distribution variation with fields, years, months and rainfall during the study period. The sampling is to obtain the structure of grasshopper population and this repetition in time allows the study of the dynamics of population.

Determination of hopper density

Hopper density was measured by the method of counting on discontinuous one square meter quadrats. The prospector defines a few steps before him, an area of one square meter. He counts all hopper of Senegalese grasshopper inside the area, searching carefully the vegetation of the square. Forty repetitions were made and randomly throughout the area studied, the square is a few meters apart from each other. Larval density (square meter) was calculated using the formula from transecting data:

$$d = \frac{n}{N \times S}$$

d: larval density per area; n: number of larvae observed; N: number of counts made; S: prospected surface area.

Four surveys were conducted monthly in each month of the five months in rainy season (July to November). Experiments were conducted on groundnut field, bean field, millet field and fallow field in 2006, 2007 and 2008. The prospected lands vary from year to year but the following four types of terrain. Hopper density of Senegalese grasshopper was evaluated according to the types of fields, years, months and rainfall during the study period. The monthly density of individuals present on field was analyzed by the software Rogui (R version 2.8). The exploratory data analysis, the number of observations in each level of factor, adjusting a model for positive values and Chi-square analysis were used.

RESULTS

Adult density

Mbar area

In 2006 adult density of Senegalese grasshopper was estimated at 4 individuals per square meter in 60% of the area surveyed. In groundnut field, we recorded the lowest density that less 2 individuals per square meter during 2007 (Figure 1). In bean field density of 2 individuals per square meter was the most common and occupied over 30% (Figure 2). For the millet field the highest density is the most representative and we recorded a uniform distribution (Figure 3).

In September 2008, the highest density of Senegalese grasshopper was recorded in the fallow field. Rainfall intensity was very important for this density (Figure 4). The residues (the difference between results obtained through theoretical calculation and those obtained through observation) were significantly important in fallow field (Table 1). Factor rainfall is more significant ($P=0.02 < 0.05$).

Noto area

In the bean field the highest density of *O. senegalensis* was observed in September 2006. The distribution in the groundnut field varied in density of 4 to 12 individuals per square meter and was least common in 2007 .

No significance difference among the density of *O. senegalensis* in the millet field and fallow field during the years was statistically the same, however, showed the highest density in September of tree years. More rainfall intensity increases, the density of *O. senegalensis* is high (Table 2). Factor month is more significant ($P=0.00 < 0.05$).

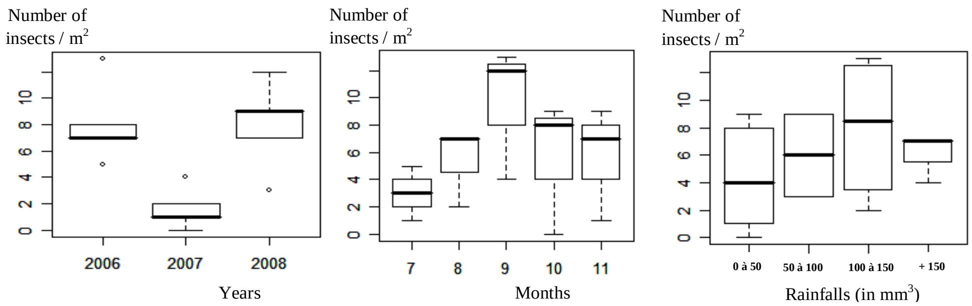

Figure 1. Density of Senegalese grasshopper adult in groundnut field at Mbar.

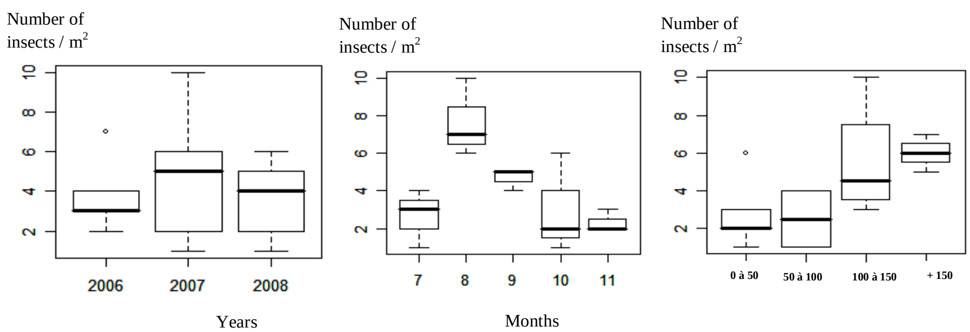

Figure 2. Density of Senegalese grasshopper adult in bean field at Mbar.

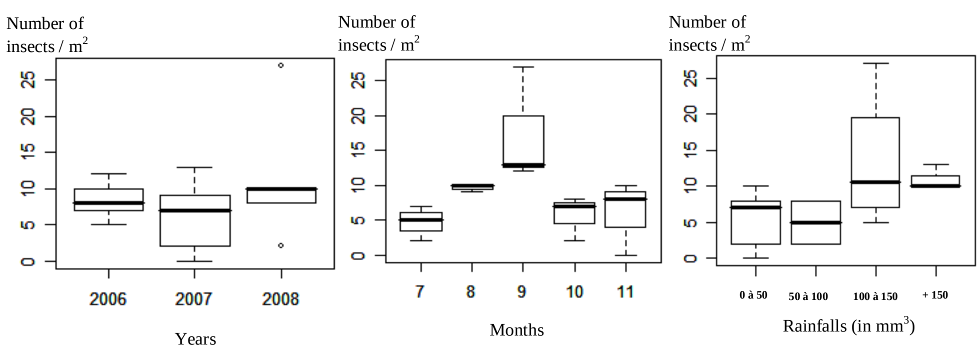

Figure 3. Density of Senegalese grasshopper adult in millet field at Mbar.

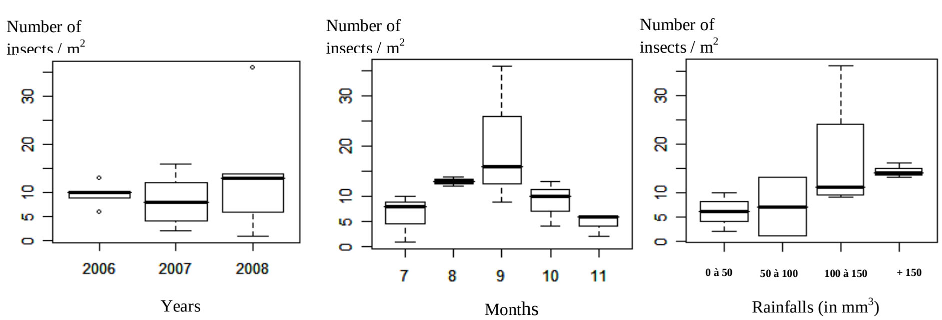

Figure 4. Density of Senegalese grasshopper adult in fallow field at Mbar.

Table 1. Variance of influence factors on distribution of *Oedaleus senegalensis* in Mbar area.

Factors	% variance			
	Groundnut field	Bean field	Millet field	Fallow field
Year	12.34	4.75	32.05	34.71
Month	18.14	67.03	25.70	28.69
Rainfall	51.64	4.61	30.49	8.12
Month couple Rainfall	14.83	15.24	0.43	12.35
Residual	3.05	8.37	11.34	16.13
Total	100	100	100	100

Table 2. Variance of influence factors on distribution of *Oedaleus senegalensis* in Noto area.

Factors	% variance			
	Groundnut field	Bean field	Millet field	Fallow field
Year	60.48	30.77	12.27	9.04
Month	30.60	41.52	58.46	48.82
Rainfall	2.41	2.43	9.66	10.80
Month couple Rainfall	5.31	9.23	7.60	5.70
Residual	1.20	16.05	12.01	25.64
Total	100	100	100	100

Table 3. Overall larval density/m^2 for field type.

Field type	Groundnut	Bean	Millet	Fallow
Larval density	15	46	104	179

The larva density

Larva density was calculated by this formula only in the locality of Noto in the year 2008. The results for other years and in the locality of Mbar can not apply to this formula as being less than 2 larvae per square meter. This is the fallow field that presents the larval density monitoring millet field then the field is finally bean and groundnut field that has the lowest density (Table 3).

DISCUSSION

The Senegalese grasshopper distribution was different within fields. A clear indication of diversity was obtained in density correlation analysis. Nymphs migrated from other fields to grass in fallow fields. These movements represent a form of migration between successive areas. Senegalese grasshopper preferred fallow and millet fields. Our results are different from those of Launois and Launois-Luong (1989). They stated that in Sahel, the insect preferred to mixed crops, monoculture of grasses crops, fallow natural vegetation. For all parameters month was most significant with presence and abundance of grasshopper. *O. senegalensis* was observed in all fields and time of survey except November when the insect was probably in diapauses as eggs. Dingle (1986) and Taylor (1986) are not observed a movement of Senegalese grasshopper during this period. However Maiga et al. (2008) attribute absence in field to response at adverse conditions in which embryonic diapauses occurs in eggs. For Lecoq (1978), the insect is present until December when it completely disappears to reappear at the beginning of the rainy season in sudanian zone in West Africa.

September which the insect was most abundant correspond when rainfall is more important. These crop damages at such times are often minimal because plants are an advanced stage development. Rainfall also is very important in Senegalese grasshopper distribution. Rainfall intensity also determine the others important factors as condition of vegetation and moisture environment. If rains alternating with periods of drought, the population size of *O. senegalensis* follows the rainfall variations (Colvin and Holt, 1996). The residue observed in the fallow field shows that the grasshopper distribution in field depends largely on factors not explicit. Launois-Luong (1979) reveals damage is mainly based on number of individuals. Human activities alter insect environments and thus create an infestation of crops. The fallow field was cultivated last year so with a clear ground the environment is most attractive to females gravid for oviposition. Flora composition of habitat leads to some heterogeneity of distribution of Senegalese grasshopper when environments shown belong to same conditions.

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