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Insect pests of pearl millet in Sahelian West Africa I. *Acigona ignefusalis* (Pyralidae, Lepidoptera): distribution, population dynamics and assessment of crop damage†

(*Keywords* pearl millet stemborer *Acigona ignefusalis* Sahel rainfall)

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Abstract. Pests were surveyed in farmers fields in Burkina Faso Niger and northern Nigeria from 1980 to 1983 and field trials at research stations in Burkina Faso (1980 and 1981) and at the ICRISAT Sahelian Center in Niger (1984 and 1985) *Acigona ignefusalis* is widely distributed in West Africa but its predominance as the major stem borer of millet varies with location There are two generations of the pest annually with peaks in moth population in July and September Diapausing larval population declines during the dry season from November to May A progressive decline in borer infestation was recorded between 1983 and 1985 in Niger Damage to early-sown millet was usually low while late sowing resulted in severe stem tunnelling and unproductive tillers However under low levels of borer infestation an unprotected crop gave higher grain yield than one which was protected with insecticide

Introduction

Pearl millet, (*Pennisetum americanum* (L) K Schum) is the staple crop in the diet of several million people in the Sahelian region of West Africa West Africa grows an estimated 12 2 m ha of millet and over 93% of this area is cultivated in Burkina Faso, Mali, Niger, Nigeria and Senegal, where landraces are mostly grown with little production inputs and average yields vary from 200–600 kg/ha

Several constraints, both biotic and abiotic, limit the realization of the yield potential of both landraces and improved varieties While some of these constraints are common to other millet growing regions of Africa and India, the two major insect pests of pearl millet in West Africa, the millet stem borer, *Acigona ignefusalis* Hmps and the earhead caterpillar, *Raghuva albipunctella* De Joannis, are either not known to exist elsewhere, or if they do, are of no economic importance (ICRISAT, 1984) As a result, only limited studies have been conducted on these species (Harris, 1962, Vercambre, 1978, Ndoye, 1979, Ajayi, 1980, Guerremont, 1980, 1981, 1982, ICRISAT 1981, 1982, 1984) A review by Gahukar (1984) on the pests of pearl millet in West Africa indicated that information on their bioecologies and economic importance was incomplete

The development of pest management programmes requires knowledge of the distribution of the pests, their bioecologies, their seasonality of occurrence, and the damage they cause This paper covers the results of detailed studies on the stem borer, *A. ignefusalis*, referred to henceafter as *Acigona* It reports results from extensive surveys in Burkina Faso, Niger and parts of northern Nigeria and from field studies on population dynamics and the evaluation of crop damage at research stations in Burkina Faso and at the ICRISAT Sahelian Center (ISC), at Sadore Niger

Materials and methods

1 Pest surveys

The distribution of *Acigona* was determined by sampling pearl millet crops in farmers fields In 1980 and 1981, extensive field surveys were conducted on 64 farms in Burkina Faso, 78 in Niger, and 34 in Northern Nigeria In 1982 and 1983 additional surveys were conducted on 203 farms in Niger Fields were selected at random at intervals of 10–40 km depending on their distribution, road accessibility and zone to be sampled during each survey

The incidence of *Acigona* was assessed by splitting millet stems and examining them for borer damage When a survey involved crops at the flowering stage, depending on farmer cooperation usually 5–10 stems were randomly selected At harvest, up to 25 stems/farm were sampled The following observations were recorded percentage infested stems, percentage internodes tunnelled, number of borer larvae per stem, and species identification

2 Population studies

The annual fluctuation of borer population was monitored in 1980 and 1981 at two reseearch stations in Burkina Faso, (Kamboinsé near Ouagadougou and at Farako-Bâ, near Bobo Dioulasso), and in Niger in 1983, 1984 and 1985 at Sadoré At each location counts of *Acigona* larvae (using the stem-splitting method) were made during the crop season in millet fields that were sown at monthly intervals with the local cultivar and an improved variety, Nigerian Composite The trials were laid out in four replications in a randomized split plot design with sowing dates as main plots and cultivars as subplots (5 × 5 m) Irrigation was supplied during the dry season from October to May

At weekly intervals, 25 stems per sub-plot were randomly selected, split and examined for borer damage During the

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Table 1. Incidence of stem borers in pearl millet in seven locations in Sahelian West Africa†

Location	Country		Annual rainfall (mm)	stems	Species frequency‡ *Acigona ignefusalis*	*Sesamia*	*Eldana saccharina*
Gorom-Gorom	Burkina Faso	14° 27′ N	355	33·1	100	0	0
Niamey	Niger	13° 34′ N	456	45·0	95·5	0	4·5
Maradi	Niger	13° 29′ N	502	58·6	100	0	0
Kamboinsé	Burkina Faso	12° 27′ N	760	61·9	84·6	7·0	8·4
Kano	Nigeria	12° 22′ N	900	59·2	100	0	0
Farako-Bá	Burkina Faso	11° 15′ N	909	71·0	55·7	36·6	7·7
Samaru	Nigeria	11° 05′ N	1183	68·9	93·2	3·7	3 1

†Average of 5 farms surveyed per location
‡Frequency expressed as % of total larvae observed in millet stems

post-harvest period (November–May) in 1983–1985, populations of diapausing larvae were monitored by examining 200 randomly selected stems (eight replications of 25) from crop residues in experimental fields at Sadore.

Populations of adult moths were also monitored during the crop season at Sadoré with two portable 25 W fluorescent light traps. The traps were placed in millet fields of the research centre and operated on alternate nights for 2 h, usually between 1900 and 2100 h

3. Crop damage assessment

Date of sowing trial. Sowing of millet in the Sahel may extend over several weeks depending on rainfall pattern, labour availability and farm size. Earlier reports from Nigeria (Harris, 1962) and Burkina Faso (ICRISAT, 1982) suggest that late-sown crops were more severely damaged by *Acigona* than early-sown crops. In order to investigate the extent of *Acigona* damage in relation to crop development, date of sowing trials were conducted at Kamboinsé, Burkina Faso in 1981 and 1982 with the varieties Nigeria Composite, Ex-Bornu, and a local cultivar Similar studies were repeated in Niger at Sadoré in 1984 and 1985 using the varieties HKBtif, CIVT, and a local cultivar. The trials were laid out in four replications in a randomized split plot design with sowing dates as main plots and cultivars as subplots (5 × 5 m) Sowing dates varied with location and year of study but were usually in June and July at intervals of 2–4 weeks All standard recommended agronomic practices were followed. Observations on borer infestation were recorded at 35 days after sowing (d.a.s.), 50 d.a.s. and at harvest (Tables 2 and 3)

Insecticide trial. In another trial, losses in grain yield due to borer infestàtion were estimated by comparing the grain yields obtained from insecticide treated and untreated plots Two varieties, Nigeria Composite and a local cultivar were sown on 3 July 1984 and 10 July 1985 in a randomized split plot design in six replications with varieties as main treatments and insecticide application of Rogor (dimethoate, 500 g a.i./ha) as subtreatment. The first insecticide treatment was applied at 15 d.a.s. and subsequently at two week intervals for a total of four applications. Observations on borer infestation were also recorded at 35 d.a.s., 50 d.a.s. and at harvest (Table 4) and were taken from an effective area of 5 × 5 m within subplots of 8 × 8 m. Grain yield from harvested panicles, after sun-drying and threshing, was recorded

Table 2 Effect of date of sowing on the extent of damage caused by infestation of Acigona ignefusalis *on pearl millet at Kamboinsé, Burkina Faso (mean of 1981 and 1982)*

	Variety	% Deadheart (35 d.a s)	% Infested stems (at harvest)	% Bored internodes	No larvae/ 10 stems	% Non-productive stems
	Ex-Bornu	0 9	72 5	28 9	2·0	9·4
First sowing	Nigeria					
10/6/80	Composite	1·0	69·4	24 9	2·0	4·8
5/6/81	Local	0·4	51·0	11 7	2 0	8·4
	Mean	0·8	64 3	21·8	2·0	7·5
	S.E ±	0·2	2·6	2·0	0·0	3·0
	Ex-Bornu	4·0	72·5	28·7	4·0	6·1
Second sowing	Nigeria					
8/7/80	Composite	6 5	71·2	29·8	1·0	7·3
26/6/81	Local	3·9	50·1	11·7	1·0	4·0
	Mean	4·8	64·6	23·4	2·0	5·8
	S.E. ±	1·8	3·5	3·3	0·17	2·0
	Ex-Bornu	7·5	88·7	50·4	3·0	7·9
Third sowing	Nigeria					
5/8/80	Composite	9·4	91·9	51·6	3·5	27·2
24/7/81	Local	7·2	74·8	30·6	1·5	6·3
	Mean	8·0	84·8	44·3	2·6	11·3
	S.E. ±	1·5	2·4	3·9	0·2	7·7

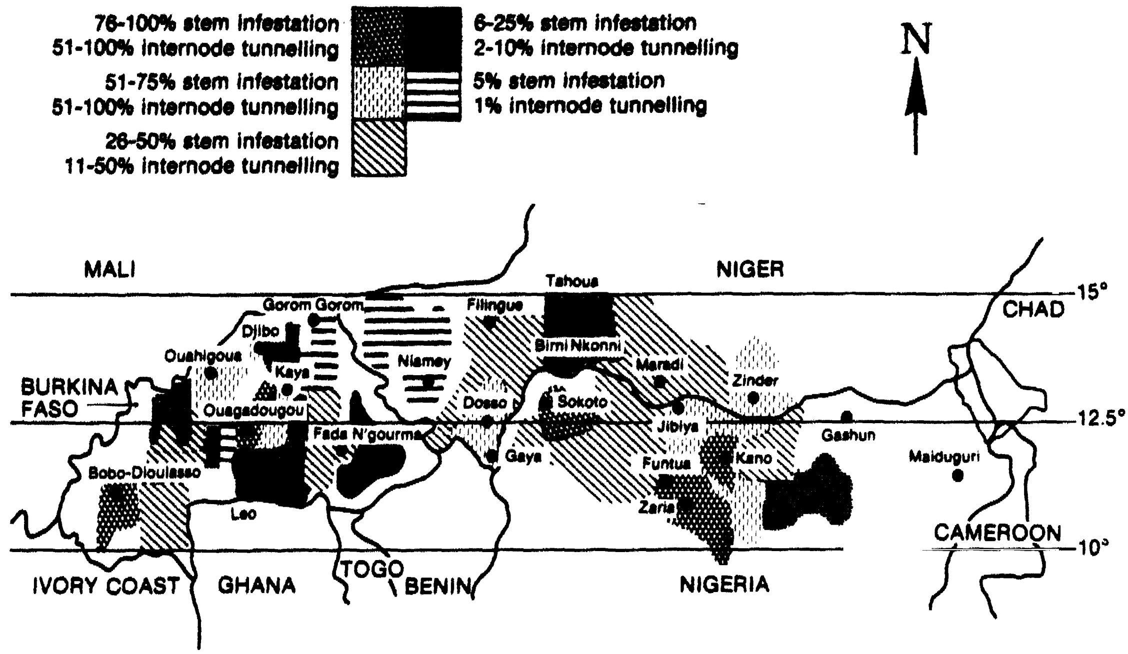

Figure 1. Distribution of millet stem borers in West Africa (Burkina Faso, Niger and northern Nigeria). In the south: Acigona ignefusalis — 81%; Eldana saccharina — 14% Sesamia calamistis — 5%. *Other regions:* A. ignefusalis — 100%.

incidence was higher than in 1981 and was recorded in 166 of the 203 farms examined, stem damage ranged from 24–76% ($n = 1097$) and internode tunnelling from 3·9–34·3%. The Dosso–Gaya axis and the Filingue, Magaria and Maradi areas had the highest borer incidence in 1982 and 1983.

In Burkina Faso, borer infestation in 1980/81 was recorded in all 64 farms surveyed and stem damage was in the range of 23–89% ($n = 682$) with a mean of 25% internodes tunnelled. Borer infestation was highest in the south in the Bobo–Dioulasso area (11° 15'N). Other locations with considerable crop damage included the Ouagadougou area and Ouahigouya and Djibo in the north.

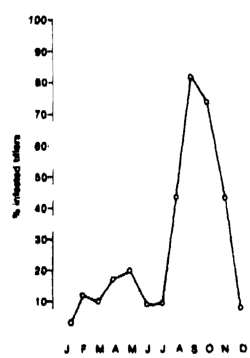

Figure 2. (a) Annual fluctuation of stem borer infestation. (b) Relative frequencies of stem borer species in pearl millet stems. [Kamboinse, Burkina Faso (mean of two years, 1980 and 1981)]. Note: S. calamistis *was the only borer species from January to May.*

Population dynamics

Pearl millet can be infested by stem borers all year round if a growing crop is available in the field. This situation may occur at research stations in Burkina Faso (Figure 2a) where dry season irrigated millets are sown, although major infestations occur between July and November. Similarly, normal infestation in farmers' fields occurred between July and October when *Acigona* was the predominant borer species (Figure 2b). Since the millet stem borer goes into diapause at the end of the crop season, dry season (November–May) borer damage which occurred on irrigated research station fields in Burkina Faso was primarily caused by *S. calamistis. Eldana saccharina* was the predominant species only during interphase periods (June and December) when a change in predominance occurred between *Acigona* and *S. calamistis*. The situation at Sadore was different. No borer infestation occurred during the dry season nor were *S. calamistis* and *E. saccharina* recorded in millet stems during the crop season.

Results obtained from larval counts in infested stems in Burkina Faso in 1980 and 1981 indicated that two generations of *Acigona* were produced during the crop season at both locations (Figure 3). Larval peaks occurred in August and October at Faraka-Bâ and in June and September at Kamboinsé. Lower population peaks of *Acigona* were recorded at Faraka-Bâ and this may be attributed to the competitive presence of *S. calamistis*, which is more abundant at Faraka-Bâ (37%) than at Kamboinsé (7%) (Table 1). Studies at Sadoré, Niger, in 1984 and 1985 also produced similar results (Figure 4). Light trap studies in Niger further confirmed that two distinct generations of *Acigona* occur in the Sahel with peaks in moth population occurring in July and

September (Figure 4). Harris (1962) reported three generations at Samaru, Nigeria where the rains begin much earlier (March/April) and the crop season is longer.

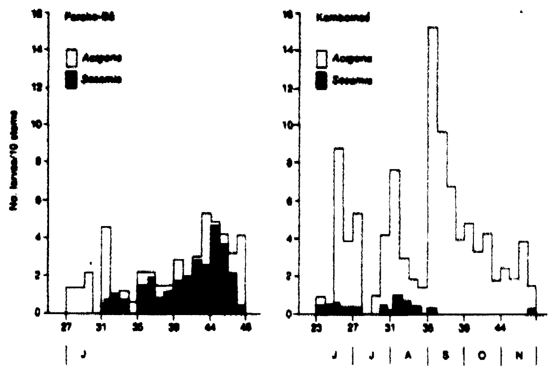

Figure 3. Weekly counts of larvae of Acigona ignefusalis *and* Sesamia calamistis *in millet stems during the crop season at two locations in Burkina Faso (mean of two years, 1980, 1981).*

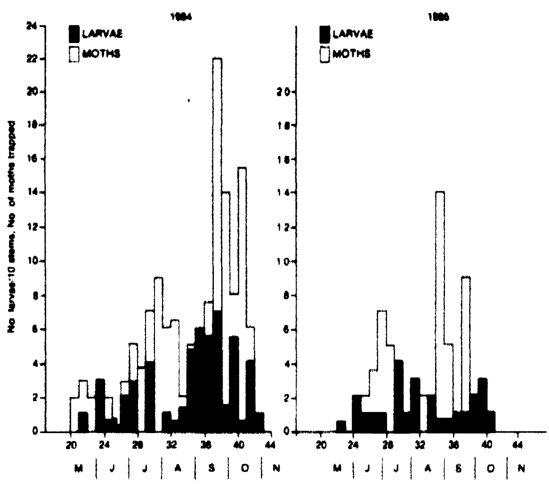

Figure 4. Population dynamics of larvae and adults of the millet stem borer, Acigona ignefusalis *at the ICRISAT Sahelian Center, Sadoré, Niger, 1984 and 1985.*

The population of diapausing larvae in stems declined between November and May and dropped considerably after March (Figure 5). It was also found that during the crop season borer infestation declined between 1983 and 1985 and that the size of the carry-over diapausing population at the end of the dry season affected the subsequent crop season borer population. Both the time of onset of rains and total rainfall appeared to affect borer population development. In May 1983, an average of three diapausing larvae per 10 stems was recorded. Total rainfall that year was 595 mm and good rains fell as early as 15 May. Crop infestation was very severe with an average of 2·8 larvae/stem between June and September (Figure 5). However, in 1984, compared to 1983, less than half as many diapausing larvae (1·3/10 stems) were recorded in May. Good rains also fell as early as mid May, but only a total of 260 mm was received in 1984. Borer infestation was low that year with less than one larva/stem between June and September. In 1985, with similar initial carry-over population as in May 1984 and a higher total rainfall of 559 mm, rains were however not established until mid June. Borer numbers did not increase until towards the end of the crop season in September and were much lower than previous years. These observations indicate that rainfall could be a vital factor in pest population dynamics in the seasonally dry semi-arid sahelian region. An analysis of long term related rainfall data sets and insect populations may provide indications of pest infestations.

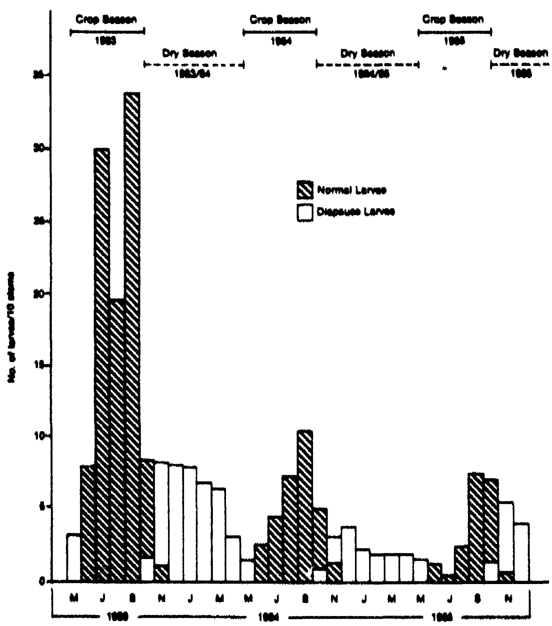

Figure 5. Seasonal fluctuation of larvae of Acigona ignefusalis *recorded in millet stems at the ICRISAT Sahelian Center, Sadoré, Niger, 1983–1985.*

Assessment of crop damage

Date of sowing trial. Initial crop damage caused by *Acigona* infestation is usually observed as deadhearts of seedlings and is attributed to the feeding activities of young larvae of the first generation (Harris, 1962). Leaf feeding has not been recorded.

Deadheart formation was significant in the Kamboinsé trials in 1980 and 1981 (Table 2) but was very low and negligible at Sadoré (Table 3). There were no significant differences in deadheart formation between varieties but differences were observed between sowing dates with the late crop having more deadhearts than the early crop. Similarly, at both locations, stem damage increased with a delay in sowing. The early sown millet is attacked by first generation larvae but since the population is at a low level, damage is low.

But the late sown crop, which may escape infestation by the first generation, is exposed to the higher populations of the second generation and stems are often completely riddled by larvae. This trend was confirmed by results obtained at both locations with much more stem infestation and internode damage on the third sown crop (means of 84 and 44% respectively at Kamboinsé; 85 and 41% at Sadoré) than on the first crop (mean of 65 and 3% at Kamboinsé, 27 and 1·5% at Sadoré). In these trials, grain yield data were confounded by bird damage but data collected on stem productivity also indicated a corresponding increase in non-productive stem with a delay in sowing.

In both locations and years, the local cultivar was the least affected by borer damage. Earlier studies (ICRISAT, 1982) indicated that larval densities and differences in plant physical and chemical characteristics between varieties and at different growth stages may determine initial borer preferences. For example, while the differences between HKBtif and the local variety at 50 d.a.s. in the first date of sowing at Sadore were negligible, they were three-fold at harvest (Table 3). However, in the third date of sowing, while these differences were already almost three-fold at 50 d.a.s., they were much less pronounced at harvest.

Insecticide trial. Although planted in mid-June 1985, the level of borer infestation was low in this trial. No significant differences were observed in crop damage within varieties for the insecticide protected and unprotected treatments (Table 4). However, between varieites, Nigeria Composite was more infested than the local cultivar. It was also observed that low levels of borer infestation resulted in slight increases in yield of the unprotected treatment over the control (Nigeria composite 12%, Sadoré local 1%). It is suggested that low levels of borer infestation may (1) in early infestation, trigger a compensatory mechanism which results in tillering or (2) in later infestation, the destruction of the internode may divert nutrients from destroyed pith tissue into the developing panicle, resulting in increased grain production. It is also possible that the insecticide, dimethoate, may have been phytotoxic. However, similar results were also obtained by Harris (1962) although in a separate experiment with a high amount of borer attack, he also recorded a grain yield loss of 15%. Although stem tunnelling may not have a direct effect on grain filling, unless the vascular bundles are affected, it may so weaken the stems that they break and limit the formation of grain. This has been observed at Samaru in Nigeria and at Farako-Bâ in Burkina Faso. It should be noted that even the protected check plots had between 17 and 37% stems infested.

Conclusion

The millet stem borer, *Acigona* is widely distributed in West Africa but its occurrence and severity of infestation varies between locations and years. Crop infestation is affected by rainfall pattern and may not always result in grain yield loss. The practice of Sahelian farmers of planting with the first major rains is a first step in ensuring a crop in any particular year. This practice may also be linked with farmers' knowledge that early planted millet suffers less stem borer damage than the late crop. Results from the studies reported here and elsewhere support this practice.

Results also indicate the need for regional surveys to determine the distribution of common pests and their economic importance in the Sahel, where a multiplicity of projects are involved in agricultural research and development. A knowledge of diapausing populations and the relationship between insect pests and rainfall in the seasonally dry Sahelian zone, where sporadic outbreaks of pests often surprise both farmers and governments, emphasizes the need for information on population dynamics and yield loss. These are the building blocks of pest management strategies. Furthermore, the results obtained in the insecticide trial on yield loss underline the need to determine accurate economic injury levels and thresholds at which insecticides should be used.

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References

AJAYI, O., 1980. Insect pests of pearl millet in Nigeria. Samaru Miscellaneous Paper No. 97. Institute of Agricultural Research (IAR), Ahmadu Bello University, Zaria, Nigeria. pp. 10.

GAHUKAR, R. T., 1984. Insect pests of pearl millet in West Africa: a review. *Tropical Pest Management* **30**, 142–147.

GUEVREMONT, H., 1980. Recherches sur l'entomofaune du mil: rapport annuel de recherches pour l'année 1979. Laboratoire d'entomologie, Centre National des Recherches Agronomiques de Tarna, Maradi, Niger. Pp. 48

GUEVREMONT, H., 1981. Etudes sur l'entomofaune du mil: rapport annuel de recherches pour l'anné 1980. Laboratoire d'entomologie, Centre National des Recherches Agronomiques de Tarna, Maradi, Niger. Pp. 31.

GUEVREMONT, H., 1982. Etudes sur la mineuse de l'épi et autres insectes du mil: rapport annuel de recherches pour l'année 1981. Section Protection des vegetaux, Centre National de Recherches agronomiques de Tarna, Maradi, Niger. Pp. 57.

HARRIS, K. M., 1962. Lepidopterous stem borers of cereals in Nigeria. *Bulletin of Entomological Research* **53**, 139–171.

ICRISAT, 1981. International Crops Research Institute for the Semi-Arid Tropics. Upper Volta Cooperative Program Annual Report 1980. Entomology, pp. F1–F36. Ougadougou, Upper Volta.

ICRISAT, 1982. International Crops Research Institute for the Semi-Arid Tropics, Annual Report 1981. Pantancheru, A.P. 502 324, India.

ICRISAT, 1984. International Crops Research Institute for the Semi-Arid Tropics. ICRISAT Sahelian Center Annual Report, 1983. Entomology, pp. 31–37. ICRISAT Niamey, Niger.

NDOYE, M., 1979. L'entomofaune nuisible du mil a chandelle (*Pennisetum typhoides*) au Senegal, pp. 515–530. In *Proceedings of the International Conference on Biological Control of Pests: its Potential in West Africa*. Dakar, Senegal: USAID Regional Food Crop Protection Project.

NWANZE, K. F., 1981. Les borers des tiges des céréales en afrique de l'Ouest Sahélienne: distribution, importance relative et controle, pp. 109–115. *Lutte Biologique contre les ravageurs et ses possibilités en Afrique de l'Ouest*. Dakar, Senegal, 9–13 Fevrier 1981. USAID Project 625–0928 Phase II.

VERCAMBRE, B., 1978. *Raghuva* spp. et *Masalia* sp. Chenilles des Chandélles du mil en zone sahélienne. *Agronomie Tropicale* **33**, 62–79.