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Sorghum insect pest distribution and losses in West and Central Africa

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Abstract — Collaborative research between Icrisat, Cirad and the national agricultural research systems of West and Central Africa in 1988-1996 have added to our existing knowledge of sorghum insect pests. Spittle bugs and head bugs have been recognized as important pests both in research stations and farmers' fields. Spittle bugs cause damage directly through feeding and indirectly by transmitting the yellow leaf blotch disease of sorghum. *Eurystylus oldi* Poppius attacks both local and improved sorghum cultivars. It is more common on improved cultivars and in the more humid zones. The pest causes direct damage by feeding on and ovipositing inside developing grains and indirectly. It is now considered as the major constraint to the adoption of improved sorghum cultivars in the region. Surveys showed that post rainy season sorghum is attacked by a leaf hopper and by stem borers. Stem borers are endemic and often cause severe damage in local farms. However, there have been no successful attempts to determine the yield loss attributable to each stem borer species in farmers' field. During village-level surveys conducted in 1989-1996, the most important storage insect pest of sorghum was the lesser grain borer, however, weight loss due to insects was less than 1% in local vitreous-grained sorghums stored as bundles of heads in mud granaries.

Résumé — Insectes ravageurs du sorgho en Afrique de l'Ouest et du Centre : répartition et pertes occasionnées. Les recherches Icrisat-Cirad menées en collaboration avec les systèmes nationaux de recherche d'Afrique de l'Ouest et du Centre de 1988 à 1996 ont mis en évidence l'importance des cercopides et des punaises des panicules sur les stations de recherche et en champs paysans. Les cercopides causent des dégâts directs par leur alimentation, et indirects par la transmission de la maladie des taches chlorotiques du sorgho. La punaise *Eurystylus oldi* Poppius attaque à la fois les variétés de sorgho locales et améliorées. Cette espèce est plus fréquente sur les variétés améliorées et dans les zones les plus humides, elle cause des dégâts directs par ses piqûres d'alimentation et d'oviposition dans les grains, mais aussi indirects. Cette punaise est à présent considérée comme la principale contrainte à l'adoption dans la région de variétés améliorées. Des prospections ont montré que le sorgho de contre-saison était attaqué par une cicadelle et des foreurs de tiges. Les foreurs sont endémiques et l'on considère qu'ils causent des dégâts importants en champs paysans. Les tentatives visant à quantifier la contribution de chaque espèce de foreur à la perte en rendement en champs paysans sont restées vaines. Lors d'études menées de 1989 à 1996 dans les villages, le plus important insecte ravageur des stocks de sorgho a été le petit capucin des grains, toutefois, les pertes pondérales dues aux insectes ont été faibles (moins de 1 %) dans le cas des variétés locales à grains vitreux, stockées en bottes de panicules dans des greniers en terre.

Sorghum (*Sorghum bicolor* L. Moench) is the most important food crop in the savanna areas of West and Central Africa. The grain is used predominantly for food and beverages while the stalks are fed to animals, or used for building, fencing, or firewood.

Insect damage, both in the field and in storage, constitutes a serious limiting factor to increased production of sorghum in West and Central Africa. Various authors have reviewed the incidence, distribution and economic importance of sorghum insect pests in the region (Nwanze, 1985; Ajayi, 1989; Ratnadass and Ajayi, 1995). This paper summarizes aspects of the distribution and yield losses caused by some insect pests of sorghum based on work done between 1988 and 1996 by the Icrisat and Icrisat-Cirad entomology teams based respectively at Kano, Nigeria and Bamako, Mali in collaboration with their counterparts in the national agricultural research systems in the region.

Insect pests of sorghum

The most important insect pests of sorghum in West and Central Africa are shootfly, spittle bugs, stem borers, grain midge, head bugs and storage pests like the lesser grain borer.

Shootfly

Shootfly, *Atherigona soccata* Rondani (Diptera: Muscidae), occurs across the West and Central Africa region. However, it is usually more important where the sowing of sorghum is late (table I) or staggered. Farmers in the region normally sow sorghum early in the season and so escape shootfly damage. Sometimes, however, poorly distributed rainfall encourages repeated sowings which result in high shootfly infestation. Shootfly could also be important especially in the high rainfall zones where attempts are made to sow early maturing cultivars late to avoid high grain mold damage.

Spittle bugs

Several species of spittle bugs attack cultivated cereal crops, especially sorghum, millet, maize, rice and sugar cane throughout the West and Central Africa region. Those commonly found on sorghum include *Poophilus costalis* (Walker) (Homoptera: Aphrophoridae), and various species of *Locris* (Homoptera: Cercopidae) particularly *L. rubens* Erichson and *L. erythromela* Walker. *Poophilus costalis* and *L. erythromela* prefer the wetter zones of the savanna whereas *L. rubens* is more common in the drier parts (Icrisat, 1993).

The life cycle of *L. rubens* on sorghum has been studied (Ajayi, 1995a). It lays eggs in the epidermis of the leaf sheath; there are five nymphal instars and development from egg to adult takes about 33 days. Both *L. rubens* and *P. costalis* feed on all growth stages and parts of sorghum, causing leaf scorching and death in severe infestations (Icrisat, 1991). In addition, it was established that *L. rubens* transmits the bacteria (*Xanthomonas* sp.) which cause the yellow leaf blotch disease of sorghum (Akpa *et al.*, 1995). Under artificial infestation in field cages, the severity of damage increased with an increase in spittle bug population (tables II and III); infestation by 15 pairs of adult *L. rubens* over a period of five weeks reduced grain yield by 35%. Chemical protection using Carbofuran, Lambda-cyalothrin or Dimethoate was effective for controlling spittle bugs, resulting in yield gains of 24-35% (table IV).

Table I. Effect of carbofuran and planting date on shoot fly damage on sorghum, Bagauda, Nigeria, 1992[1].

	Shoot fly deadheart (%)		Grain yield (t/ha)	
Date of planting	Untreated	Carbofuran	Untreated	Carbofuran
3 June	0.2 (1.3)[2]	0 (0)	2.44	3.07
1 July	1.6 (5.8)	0.2 (1.4)	4.83	5.19
15 July	0.8 (2.6)	0.8 (4.4)	3.79	4.02
22 July	16.5 (23.8)	0.4 (2.7)	2.30	2.70
5 August	83.5(69.4)	2.1 (8.2)	0.63	1.44
Se (± 4.31)		(± 1.21)	± 0.17	± 0.14
Cv (%)	(41.9)	(72.7)	12.30	8.40

1. Randomized complete block design with 4 replications; plot size = 15 m².

Table II. Effect of artificial infestation with *Locris rubens* on sorghum (Icsv 247) at Bagauda, 1992[1].

	Infestation for 2 wk			Infestation for 5 wk.		
Number of spittle bugs per plant (pairs)	% of leaf area with yellow blotch	grain wt. per plant (g)	100 grain wt. (g)	Grain wt. per plant (g)	Reduction in grain wt. (%)	100 grain wt. (g)
0	0	14.9	4.0	6.7	0	2.6
2	20.0	17.3	3.2	6.1	9	2.8
5	33.8	17.5	3.5	4.8	27	2.3
10	84.5	13.0	3.4	4.3	36	3.3
15	85.5	16.7	3.3	4.3	35	3.4
Mean	44.8	15.9	3.5	5.2		2.9
SE	± 3.74	± 3.94	± 0.30	± 1.42		± 0.44
df	9	9	9	11		11

1. Adult *L. rubens* were confined onto 8 wk old plants for 2 or 5 wk.

Table III. Effect of *Locris rubens* on plant height and yield parameters in sorghum (Icsv 400) at Bagauda, Nigeria, 1994[1].

Number of spittle bug adults caged per plant (pairs)	Plant height (cm)	Weight of panicle (g)	Grain yield per panicle (g)
0	169.8 (0)[2]	23.4 (0)[2]	17.5 (0)[2]
1	155.4 (9)	20.4 (13)	16.5 (6)
2	151.0 (11)	19.2 (18)	14.6 (17)
3	140.2 (18)	16.2 (31)	12.8 (27)
5	142.1 (16)	15.2 (35)	11.2 (36)
Mean	151.6	18.9	14.5
SE	± 3.96	± 4.21	± 3.59
df	35	12	12

(1) Adult *L. rubens* collected from the field were caged on 4 wk old plants for 22 d using muslin cloth cages.
(2) Numbers in parentheses are % reductions for the given parameters.

Stem borers

Sorghum is attacked by several stem borers in the region. On rain-fed sorghum, the following species have been reported: Noctuidae - *Busseola fusca* (Fuller), *Sesamia calamistis* Hampson, *S. poephaga* Tams & Bowden, and *S. penniseti* Tams & Bowden; Pyralidae - *Eldana saccharina* Walker, *Coniesta ignefusalis* (Hampson), and *Chilo diffusilineus* J. de Joannis.

Busseola fusca, is the dominant species in the wetter zones below latitude 11° 30′ N (higher than 900 mm annual rainfall) (Nwanze, 1988) and its abundance decreases further north in relation to the other stem borer species (Nwanze, 1985). *Caniesta ignefusalis* is primarily a pest of pearl millet, *Pennisetum glaucum* (L.) R. Br., but is a minor pest of sorghum in a sorghum/millet intercrop (Ajayi, 1989). *Chilo diffusilineus* is of little importance and has been reported from Burkina Faso (Dakouo, 1988). In the southern Guinea savanna, *S. calamistis* predominates and *E. saccharina* assumes a certain importance (Abu, 1986a, 1986b).

Attempts have been made to quantify yield losses caused by sorghum stem borers in the region. A yield loss of 24% was recorded in on-station trials involving the use of insecticides in Burkina Faso in 1988 (Dakouo and Lankoande, 1992). In Nigeria, spraying sorghum in farmers' fields in 1990 increased grain yield twofold, although this increase was partly due to the control of spittle bugs *L. rubens* and *P. costalis* (Icrisat, 1991); in that year, 63% of the stem borer larvae and pupae collected in the Sudan savanna of Nigeria were *B. fusca,* 30% were *S. calamistis,* 1% was *C. ignefusalis* and 6% were unidentified.

In 1991 and 1992, chemical control in farmers' fields in northern Nigeria improved grain yields by 63% and 21% respectively; the stem borers involved were *B. fusca, C. ignefusalis, S. calamistis* and *E. saccharina* (Icrisat, 1992). Stem borer control in the southern Guinea savanna, where *Sesamia* predominates, improved yield by 16-19% (Abu, 1986a). Similar stem borer control in the northern Guinea savanna, where *B. fusca* predominates, improved yield by 49% (Ajayi, 1987). However, yield loss determinations have not been conducted separately for each stem borer species. Thin-stemmed varieties exhibit more

Table IV. Effect of insecticide application on spittle bug (*Poophilus costalis,* and *Locris rubens*) damage on sorghum, Bagauda, Nigeria, rainy season, 1991[1].

Insecticide	Plants with chlorotic blotches (%)[2]	Grain yield (t/ha)
Carbofuran (Furadan(R) 3G @ 1.0 kg a.i./ ha)	9.5 (17.6)[3]	2.34
Lambda-cyhalothrin (Karate(R) EC@ 0.015 kg a.i./ha)	15.6 (23.0)	2.12
Dimethoate (Rogor(R) EC @ 0.9 kg a.i./ha)	15.2 (22.8)	2.09
Non treated control	32.5 (34.7)	1.73
Se	(± 0.02)	± 0.204
Mean	18.2 (24.5)	2.07
Cv (%)	(16.5)	19.7

1. Randomized complete block design with 4 replications; plot size 15m².
2. Counted per 2 central rows per plot.
3. Figures in parentheses are angular transformed values.

severe damage than thick-stemmed ones and it is assumed that stem borers will cause more yield reduction as more farmers adopt improved, thin-stemmed varieties (Ajayi, 1989).

Post rainy season sorghum is attacked by *S. calamistis, S. cretica* and *E. saccharina* in Cameroon, Chad, and Nigeria (Ajayi *et al.,* 1996a, and by *S. poephaga* in Mali[1] (Ratnadass *et al.,* 1992). Infestation and damage were quite high in farmers' fields but actual yield loss is yet to be determined. Versteeg (1995) reported that farmers who were involved in a diagnostic survey in the Canton de Madiagho in Chad in 1995 ranked stem borers 5th among the constraints to the production of post rainy season sorghum in the area with only birds, grasshoppers, shortage of water, and storage problems considered as being more important.

(1). Specimens collected in northern Mali by Ratnadass *et al.* (1992), first misidentified as *Sesamia penniseti* Tams & Bowden, were later reidentified as *S. poephaga*.

Midge

The incidence of the sorghum midge, *Stenodiplosis (= Contarinia) sorghicola* (Coq.) is usually low in West and Central Africa, although infestation levels can be high in certain locations, especially where alternate wild host plants are available (Bowden, 1965). Surveys suggest that the intensity of midge attack is highest above latitude 9° N in Nigeria (Nwasike, 1995), and below latitude 13° N in Burkina Faso (Nwanze, 1988).

Midge infestation and yield loss are usually high when planting or flowering of sorghum is staggered. This occurs when rainfall is low or poorly distributed; farmers then have to sow the same field several times or intercrop both early and late maturing varieties in the same farm. Most farmers in the region do not recognize that the empty panicles of sorghum are caused by midge and are unaware of the midge itself (Nwasike, 1995). Some attribute the emptiness of the panicles to other causes such as pollen wash and poor soils. Midge incidence is therefore probably more frequent than is usually reported. Ratnadass and Ajayi (1995) have highlighted reported incidences of midge in Benin, Burkina Faso, Cameroon, Chad, Mali, Niger, Nigeria, Senegal and Togo. Nwanze (1988) reported areas in Burkina Faso where midge damage resulted in losses ranging from 75 to 100%.

Head bugs

By far the greatest amount of new knowledge generated on sorghum insect pests in this region between 1988 and 1996 has been on head bugs. Ratnadass and Ajayi (1995) have summarized available informa-

Table V. Main genera and species of sorghum head bugs (Heteroptera: Miridae) reported from 10 countries of West and Central Africa.

Head bug	Benin[1]	Burkina Faso	Cameroon	Chad	Côte d'Ivoire	Mali	Niger	Nigeria	Senegal	Togo
Eurystylus oldi Poppius	x	x	x	x	x	x	x	x	x	x
Campylomma spp.		x				x	x	x	x	x
Creontiades pallidus Rambur		x				x	x	x	x	x
Megacoelum apicale Reuter		x				x	x		x	x
Paramixia sp.							x	x		
Taylorilygus sp.						x	x	x		
Adelphocoris apicalis Poppius						x		x		
Tytthus parviceps Reuter							x			
Stenotus transva-alensis Distant							x			

(1): x = Presence of insect reported on sorghum.
Sources: Nwanze (1985), Sharma (1985), Sharma (1986), Doubia and Bonzi (1989), McFarlane (1989), Steck *et al.* (1989) Ratnadass and Cissé (1990), Ratnadass (1991), Ratnadass (1992a), Ratnadass (1992b), Ajayi (1993), Ajayi (1995b),

Table VI. Incidence of *Eurystylus oldi* on sorghum in farmers' fields in northern Nigeria, 1993.

State	Bauchi	Borno	Kaduna	Kano	Plateau	Sokoto	Yobe	Mean (Total)
No of fields sampled	12	11	14	18	6	10	5	(76)
% of fields infested	67	91	64	67	50	90	100	74
Total no of panicles sampled	60	55	70	92	30	50	·25	(382)
% of panicles infested	32	60	30	51	13	40	48	41
Mean no of head bugs per panicle	0.8	13	4	6	0.3	1	2	5
(Range)	(0-80)	(0-142)	(0-159)	(0-190)	(0-5)	(0-25)	(0-17)	(0-190)

Table VII. Incidence of *Eurystylus oldi* on sorghum in farmers' fields in 10 States in Nigeria, the Federal Capital Territory (FCT), and Niger October- November 1994.

	Nigeria											Overall Mean		
	Bauchi	Jigawa	Kaduna	Kano	Katsina	Kogi	Kwara	Niger	Plateau	Sokoto	FCT	Nigeria	Niger	Nigeria and Niger
Fields sampled	6	2	9	19	13	6	4	5	15	8	1	88	8	96
Fields infested (%)	83	50	100	89	100	50	75	100	47	88	100	81	100	82
Total panicles sampled	45	10	72	150	65	30	20	25	70	40	5	532	40	572
Panicles infested (%)	71	50	74	43	77	30	15	44	20	58	20	50	85	52
Mean head bugs per panicle	10	1.5	7.6	3.62	40	0.8	0.15	1.6	0.69	22	0.2	9.68	23.70	10.66

tion on these panicle pests up to 1993. Several species of panicle feeding bugs of the family miridae have been reported as pests of sorghum in West and Central Africa. The current list of the most common species in nine countries is provided in Table V.

The head bug complex is dominated by *Eurystylus oldi* Poppius which had been variously reported as *E. bellevoyei* (Reuter) from Burkina Faso (Nwanze, 1985), *E. rufocunealis* Poppius from Nigeria (MacFarlane, 1989), *E. marginatus* Odhiambo from Niger (Steck *et al.,* 1989) and Mali (Doumbia and Bonzi, 1985; Gahukar *et al.,* 1989, Doumbia and Bonzi, 1989), *E. immaculatus* Odhiambo from Nigeria, Mali and Burkina Faso (Sharma, 1989), *E. risbeci* Schouteden from northern Cameroon (Descamps, 1954) and Burkina Faso (Nibouche, 1993). Stonedhal (1995) has confirmed that all these earlier reports refer to only one species, *E. oldi*, which has now been recorded as a pest of sorghum in Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Mali, Niger, Nigeria, Senegal and Togo (Descamps, 1954; Doumbia and Bonzi, 1985; Nwanze, 1985; Doumbia and Bonzi, 1989; Gahukar *et al.,* 1989; MacFarlane, 1989; Sharma, 1989; Steck *et al.,* 1989; Ratnadass and Cissé, 1990; Ratnadass *et al.,* 1994; Ratnadass, 1991, 1992a, 1992b, 1993; Sharma *et al.,* 1992; Icrisat, 1994; Ratnadass and Ajayi, 1995; Ajayi, 1993, 1995b, Ajayi *et al.,* 1996b).

The first extensive survey of farmers' fields was made in 1993 and covered 73 locations in seven states in Nigeria (Icrisat, 1994, 1995a). *E. oldi* was found at two-thirds of the locations, and on just over half of the 390 panicles sampled. At 11 locations, every panicle in the sample was infested (table VI).

Farmers' fields in northern Benin, southeastern Niger, and northern Nigeria were surveyed in 1994 to determine the incidence and distribution of *E. oldi* (Ajayi, 1995; Icrisat, 1995a, 1995b). The head bug was observed in the following states in Nigeria: Bauchi, Jigawa, Kaduna, Kano, Katsina, Kwara, Niger, Plateau, Sokoto and the Federal Capital Territory of Abuja. In the Republic of Niger, *E. oldi* was seen in the provinces of Maradi and Tahoua and in Goubafari and Guené in northern Benin. Of the 96 fields sampled, 82% were infested by *E. oldi;* 52% of the 572 panicles examined had a mean population of 11 bugs per panicle (table VII). Compact and semi-compact panicles were more frequently infested and had larger populations than loose ones.

Table VIII. Incidence of *Eurystylus oldi* on sorghum in farmers' fields in Cameroon and Chad, October, 1995.

Particulars	Cameroon	Chad
Fields sampled (#)	19	8
Fields infested (%)	88	100
Panicles sampled (#)	160	73
Panicles infested (%)	66	79
Mean head bugs/panicle	16	15
Range of head bugs/panicle	0-178	0-173

A further survey of farmers' fields was conducted in Cameroon and Chad in 1995 (Ajayi *et al.,* 1996b). *E. oldi* infested 92% of the 27 farms and 70% of the 233 panicles inspected, with a mean of 16 head bugs per panicle and a range of 0-78 (Table VIII). In Nigeria, it occurs in all the agroecological zones in which sorghum is grown between latitudes 7° 40′ N and 13° 5′ N. However, it is more problematic on improved cultivars with short glumes and soft grains and in the more humid savanna zones, particularly below latitude 11° N. Total yield loss (100%) occurred on Icsv 400 sown by outgrowers at Kudu, Nigeria (latitude 9° 3′ N) in 1995.

Surveys in Mali and Burkina Faso between 1993 and 1996 also showed that *E. oldi* is the most important mirid head bug of sorghum in these countries, having been recorded at Nogolasso and Konobougou (Ratnadass, 1994a), Farako-Ba, Kouare, Zorgho, Kamboinse and Sona (Ratnadass, 1994b), Nogolasso and Longorola (Ratnadass and Cissé, 1995), Tiorobougou and N'Guenea (Ratnadass *et al.,* 1995), and Ngolobougou (Ratnadass, 1995).

Several species of *Campylomma* are also pests of sorghum in the region. *Campylomma angustior* Poppius and *C. subflava* Odhiambo were reported from Samaru by MacFarlane (1989), and *C. plantarum* from the same location by Deeming (1981). Ratnadass (unpublished data) indicated that *C. angustior* and *C. subflava* also occur on sorghum in Mali. Indeed, *Campylomma* spp. were sometimes more abundant than *E. oldi* on sorghum at Nogolasso (Ratnadass, 1994a). Other species, including *C. citronella* Odhiambo and *C. unicolor* have been reported as pests of cotton (Deeming, 1981; Nibouche, 1993). *Creontiades pallidus* Rambur was the most abundant head bug species at Bambey in 1992 (Ratnadass, 1992a) and at Nogolasso in 1995 (Ratnadass and Cissé, 1995). *Megacoelum apicale* Reuter was present at eight of the 14 locations surveyed in Mali between 1993 and 1995.

Head bug feeding and oviposition punctures on maturing sorghum grains result in severe quantitative and qualitative losses, particularly on improved compact panicled types (Doumbia and Bonzi, 1985; Steck *et al.,* 1989; Ratnadass *et al.,* 1994; Sharma *et al.,* 1992; Sharma *et al.,* 1994; Ajayi, 1995b; Icrisat, 1995a). Head bug attack is also generally associated with greater grain mold incidence (Steck *et al.,* 1989, Sharma *et al.,* 1992). In Niger, a commonly grown indigenous sorghum variety, Mota Galmi, suffered 14% yield loss and 19% grain vitrosity reduction in field trials in which *E. oldi* density averaged 80 per panicle. Among 14 other sorghum varieties grown under natural conditions, vitrosity decreased by 20% on an average (Steck *et al.,* 1989). In Mali and Burkina Faso, head bug infestation caused a 50% reduction in seed size in S-34 (improved caudatum type) and additional 30% quantitative loss, in terms of a reduction of dehulling recovery rate. Its germination was reduced by 50%, and the proportion of low-density grains increased three fold (Ratnadass *et al.,* 1994). Although local non-tan guinea cultivars generally did not show a marked reduction for most quantity and quality loss parameters, they showed a noticeable decrease in acceptability of the color of tô (a local stiff porridge) (Ratnadass *et al.,* 1994a).

At Bagauda, Nigeria, chemical control of head bugs improved grain yield by 86%, seed size by 65 %, and reduced the proportion of low-density grains by 45% in 1989 (Icrisat, 1990). In 1990, 20% decrease in grain yield, 6% reduction in grain size and 24% increase in proportion of low-density grains were attributed to head bug damage (Icrisat, 1991). Head bug attack also significantly reduced the rate of ger-

Table IX. Head bug damage on sorghum in outgrowers' scheme in Nigeria, 1995.

Location	Latitude	Treatment	Grain yield (t/ha)	Head bug attack	Crop management
Danbatta	12° 5′ N	Not sprayed	3.5	Very low	Good
Danbatta	12° 5′ N	Not sprayed	2.0	Very low	Fair
Danbatta	12° 5′ N	Not sprayed	0.8	Very low	Poor
Bagauda	11° 7′ N	Not sprayed	2.2	Very low	Good
Bagauda	11° 7′ N	Not sprayed	1.8	Very low	Fair
Jalingo	8° 9′ N	Not sprayed	0.5	Heavy	Good
Kudu	9° 3′ N	Two sprays	1.0	Little damage	Good
Kudu	9° 3′ N	One spray	0.4	Heavy damage	Good
Kudu	9° 3′ N	One spray	0	Total damage	Good

Adapted from Guinness Nigeria Plc, "Gnplc handling of Icsv 400" 1996.

mination (Icrisat, 1992). The degree of damage was correlated with head bug population. The economic injury level was 2.52 *E. oldi* per panicle in 1989 and 0.97 in 1990 (Ratnadass *et al.,* 1995).

When six sorghum cultivars, including three hybrids, were protected against head bug attack at Samaru, Nigeria in 1995, grain yield increased by 85.8% and grain size by 13.9% (Beyo, 1997). Based on the experience of Guinness Nigeria Plc, the second largest breweries in Nigeria which contracted 300 local small holder farmers to produce Icsv 400 in 1995, head bug is the most important factor limiting the adoption of the latter, and resistance to head bug is imperative. Furthermore, head bugs are less problematic above latitude 11°7′ N and a good crop of sorghum can be obtained without applying insecticides. However, below this latitude, insecticides need to be applied (Table IX).

Storage insects

Ratnadass *et al.* (1994b, 1997) conducted surveys of losses caused by storage insect pests of sorghum in some villages of the second and third regions of Mali. They found that the most important storage pests were *Rhyzopertha dominica* (Fabricius) and *Sitotroga cerealella* (Olivier), followed by *Sitophilus zeamais* Motschulsky and *Corcyra cephalonica* (Stainton). A list of all insects and their status is given in table X. Except in sorghum stored in bags, weight losses (when applied to the total amount of grain stored and considered over the whole storage period) were very low, generally less than 1%, especially in local guinea sorghum stored as bundles of heads in mud granaries, in the third region. Damage was higher (2-3% over the whole storage period) on improved caudatum varieties, or when threshed grain was stored in bags, irrespective of the variety, particularly in the second region.

Other pests

The list of lepidopterous caterpillars, head beetles, heteropteran bugs other than mirids, and earwigs reported to feed on sorghum panicles has been provided in Ratnadass and Ajayi (1995). Yield loss assessments are yet to be done for these insects, although they occur throughout the West and Central Africa region.

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Table X. List of insect species associated with sorghum grain stored in villages of the 2nd and 3rd regions of Mali.

Order	Family	Species	Pest status
Coleoptera	Bostrychidae	*Rhyzopertha dominica* (Fabricius)	Primary
	Cucujidae	*Cryptolestes* sp.	Secondary
	Curculionidae	*Sitophilus oryzae* (Linnaeus)	Primary
		Sitophilus zeamais (Motschulsky)	Primary
	Dermestidae	*Attagenus fasciatus* (Thunberg)	Secondary
		Trogoderma sp.	Primary
	Nitidulidae	*Carpophilus* sp.	Secondary
	Silvanidae	*Oryzaephilus mercator* (Fauvel)	Secondary
	Tenebrionidae	*Alphitobius diaperinus* (Panzer)	Secondary
		Tribolium castaneum (Herbst)	Secondary
		Tribolium confusum Jacquelin du Val	Secondary
Lepidoptera	Gelechiidae	*Sitotroga cerealella* (Olivier)	Primary
	Pyralidae	*Corcyra cephalonica* (Stainton)	Primary
		Plodia interpunctella (Hübner)	Primary
Heteroptera	Anthocoridae	*Xylocoris flavipes* (Reuter)	Predator
	Reduviidae	*Amphibolus venator* (Klug)	Predator
Hymenoptera	Pteromalidae	*Anisopteromalus calandrae* (Howard)	Parasitoid

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