Incidence and distribution of the stem borer, *Coniesta ignefusalis* (Hampson) (Lepidoptera : Pyralidae), in cereal crops in northern Ghana

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ABSTRACT

Studies were conducted on the incidence and geographical distribution of the stem borer, *Coniesta ignefusalis* (Hampson), in the millet belt of northern Ghana between 1996 and 1997. Results clearly showed the existence of the insect at all locations surveyed, but with a higher incidence in the Sudan savanna. The insect was more abundant on millet followed by sorghum, and stalks of these cereals provide refuge for diapause larvae and thus contribute to population carry-over from one season to another. Though maize stalks and stubble showed signs of stem borer attack, no *C. ignefusalis* larvae were extracted from them, suggesting that maize is not very important in the population ecology of the insect. It is concluded from the studies that proper management of cereal stalk and stubble after harvest could help reduce the population carry-over of the insect from one season to another. Additionally, growing maize in rotation or in association with millet could be a useful tool for reducing *C. ignefusalis* incidence and damage in the millet-based farming systems of northern Ghana.

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RÉSUMÉ

TANZUBIL, P. B. & MENSAH, G. W. K.: *Le taux et la distribution d'insecte térébrant* Coniesta ignefusalis *(Hampson) (Lepidoptera: Pyralidae) en cultures de céréales.* Les études se sont déroulées dans la région de millet du nord Ghana entre 1996 et 1997. Les résultats démontraient clairement l'existence de l'insecte à tous les sites enquêtés mais avec un taux plus élevé dans le Soudan savane. L'insecte était plus abondant en millet suivi par le sorgho et les tiges de ces céréales sont sources de refuge pour les larves de diapause contribuant ainsi au transfert de population d'une saison à l'autre. Bien que les tiges et les chaumes de maïs montrent des signes d'une attaque d'insecte térébrant, aucun larve de *C. ignefusalis* n'était extrait d'eux, suggérant que le maïs n'est pas très important dans l'écologie de la population de l'insecte. La conclusion est tirée des études que le bon aménagement de tige et de chaume céréale après la moisson pourrait aider à réduire le transfert de population de l'insecte d'une saison à l'autre. De plus, la cultivation de maïs en rotation ou en association avec le millet pourrait être un moyen utile pour réduire le taux de *C. ignefusalis* et les dégâts dans les systèmes de cultures basés sur le millet du nord du Ghana.

Introduction

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is an important staple food crop for a large proportion of the population of Ghana. It is estimated that a total of 244,000 hectares of land was put to the crop in 1990, giving a national output of 80,000 tonnes of grain (PPMED, 1991). The main areas of production of the crop are the northern Guinea and Sudan savanna zones where it is the main staple cereal, and is grown by up to 60 per cent of farmers. This figure increases northwards to the Upper East Region (UER), where an estimated 97 per cent of farmers grow the crop (SARI, 1994). Millet is now grown as a subsistence crop, usually in association or relay with other cereals (sorghum, maize) and/or legumes, notably cowpea (*Vigna unguiculata* L. Walp), groundnuts (*Arachis hypogaea* L.), and bambara nut (*Vigna* *subterranea* (L.) Verdc.).

Although the potential yield of millet at research stations in Ghana (Nyankpala and Manga) can be as high as 2000 kg ha^{-1}, yields obtained by farmers seldom exceed 600 kg ha^{-1} (Tanzubil & Yakubu, 1997). In the West African sub-region, millet yields in farmers' fields are generally very low, ranging from 200 to 600 kg ha^{-1}, depending on country and season (Gahukar, 1988, 1989; Nwanze, 1989). These low yields are attributable to the low and erratic rainfall, the inherently poor and degraded soils as well as the proliferation of insects, diseases, and weeds. In recent surveys conducted in the UER, farmers ranked insect pests second only to low soil fertility among constraints to increased food production in the region (SARI, 1994).

Unfortunately, as a crop, millet has in the past received very little research attention in Ghana, owing probably to its status as a subsistence crop. Very little information is thus available on the crop, and virtually no innovations are available for coping with some of the aforementioned problems, especially those relating to pest and disease control. Tanzubil & Yakubu (1997) recently studied the relative importance of various members of the millet pest complex in Ghana and concluded that head feeders were the most damaging followed by the stem borer, *Coniesta ignefusalis* (Hampson). They further observed, from yield loss assessments, that although stem borer damage can be substantial, it is usually unnoticed and farmers have grown to tolerate it.

Coniesta ignefusalis was widely believed to be restricted in its distribution to the northern savanna zone of West Africa (Harris, 1962). However, Bosque-Perez & Mareck (1990) have recently reported infestation of maize by *C. ignefusalis* in southern Nigeria. Nwanze (1989) studied the distribution and importance of the insect in Burkina Faso, Nigeria, and Niger and concluded that although the insect was widely distributed in most parts of the millet belt of the sub-region, its predominance as the major pest of millet varied with location. In Ghana, the geographical distribution of the insect has not been established. A sound knowledge of the distribution and importance of the insect is essential for studies on its population ecology and also as an aid to devising strategies for reducing its damage to crops. Surveys covering the millet-growing zone of the country were, therefore, conducted during the cropping season in 1996 to establish the geographical spread of the insect and assess its relative incidence across various locations.

Coniesta ignefusalis is known to survive the dry season as diapause larvae (Harris, 1962), and the size of carry-over populations depends on the ability of such larvae to survive through the dry season in cereal stalk and stubble. A preliminary examination of the study area confirmed that farmers usually conserve stalks of different cereals after harvest for various purposes. However, the relative contribution of stalks of the different cereals stored by farmers to supporting dry season survival of *C. ignefusalis* is unknown.

For a better understanding of the population ecology of an insect, it is important to determine the type and variety of suitable hosts available in its area of distribution. Most insects have evolved with one or a few plants which constitute their preferred hosts. Their survival, growth, and development are best sustained by these plants (Beck, 1965; Visser, 1986). However, under less favourable conditions an insect may use other plants for sustenance. The study of alternate hosts of an insect and their influence on its bioecology can, therefore, contribute to measures that can be taken to control it.

Coniesta ignefusalis is reported to be primarily a pest of millet but is believed to be a potential pest of other cereal crops (Harris, 1962; Youm, 1990; Youm, Harris & Nwanze, 1996). In Ghana, farmers generally practise mixed cropping, and millet is often grown in association with other cereal crops, particularly sorghum and maize. The contribution of these potential hosts to supporting population growth, diapause development, and dry season survival of the insect in Ghana has not been studied.

The objectives of these studies were, therefore, as follows:

1. To establish the geographical spread of the insect and assess its relative incidence across the millet belt of Ghana.
2. To verify the existence of diapause populations at the different locations, and identify the important types of crop residue that support diapause larval populations through the dry season.

Materials and methods

Distribution and relative incidence of C. ignefusalis *on millet across the Guinea and Sudan savanna zones*

The distribution of *C. ignefusalis* was determined by sampling millet crops in farmers' fields. Four locations typical of the millet zone in vegetation and the predominant farming systems were selected for this part of the study. Table 1 shows the locations and their characteristics. At each location, 10 farms, each situated at least 10 km apart, were randomly selected from a list maintained at the local agriculture office, and were visited during August and September in the period of flowering, and again in October and November at maturity.

On each farm, a table of random numbers was used to select 500 millet plants. The plants were cut and examined for borer damage. The total number of plants infested by stem borers was recorded, and all infested stems were split open along their length to recover larvae and pupae which were collected and later identified. The number of larvae belonging to each borer species was recorded and expressed as a percentage of the total number of borer larvae collected. The total number of borer larvae per location and the proportions of these that were *C. ignefusalis* were subjected to one-way analysis of variance (ANOVA) to detect differences in infestation rate and species composition among locations.

Distribution of diapause larvae of C. ignefusalis *in stalks and stubble of different crops in the Guinea and Sudan savanna*

The distribution and relative abundance of diapause larvae in stalks and stubble of the different cereal crops grown in northern Ghana were assessed at two locations during the dry seasons of 1996 and 1997. This was a follow-up to the first survey which considered the distribution of the insect in relation to geographical area during the cropping season. The locations used for this study were Nyankpala in the Guinea savanna and Manga in the Sudan savanna.

Ten farms or farmers at each location, selected randomly as before, were visited in the middle of

TABLE 1

Sites Surveyed for Incidence of C. ignefusalis *in Northern Ghana*

Location	*Vegetation type*	*Annual rainfall (mm)*	*Millet types grown*	*Main upland cereals in order of importance*
Nyankpala (Northern Region)	Northern Guinea savanna	900 - 1200	Late	Maize, Sorghum Millet
Tumu (Upper West Region)	Northern Guinea savanna	800 - 1000	Late	Sorghum, Millet Maize
Bongo (Upper East Region)	Sudan savanna	800 - 900	Early Late	Millet, Sorghum Maize
Manga (Upper East Region)	Sudan savanna	800 - 900	Early Late	Millet, Sorghum Maize

the dry season in March and, depending on the location and quantity available, 50 to 100 stalks of each of the main upland cereal crops (Table 1) were randomly selected and examined. The number showing borer damage, as indicated by bored internodes, was recorded. Each stalk was then split open to recover the larvae which were sent to the laboratory, identified, and counted. *Coniesta ignefusalis* larvae were distinguished from others by reference to preserved specimens and descriptions provided by Harris (1962) and Meijerman & Ulenberg (1996). Stalks of sorghum and millet were available at both locations while maize stalks were sampled only at Nyankpala, being unavailable at Manga during the dry season. All stalks sampled at Manga were collected from stacks stored by farmers in their homes, while at Nyankpala, sampling was done in most of the farms as crop residues were not collected by farmers after harvest.

Results

Abundance and distribution of non-diapause larvae across the Guinea and Sudan savanna zones

Infestation levels during the first sampling at flowering were extremely low. Moreover, sampling at flowering presented problems, because farmers were reluctant to allow the scale of destructive sampling required for reliable data. Only data for the second sampling at crop maturity were thus collected and analyzed. The percentage of millet stalks damaged by stem borers was significantly higher at Manga and Bongo than at the other locations ($P<0.001$; $F_{3,27} = 19.78$) (Table 2). At Nyankpala and Tumu, *C. ignefusalis* larval populations per millet stalk were only a quarter and a sixth, respectively, of those recorded at Manga. The lowest borer populations were recorded at Tumu, but crop damage figures (33.6 %) were not significantly different from those recorded at Nyankpala (38.5%).

Table 3 shows the species composition of the borer larvae extracted from millet stalks at the four locations. *Coniesta ignefusalis* was recovered from plants sampled at all four locations. However, the incidence of the pest varied with location, being significantly higher at Bongo and Manga in the Sudan savanna area than at

TABLE 2

Abundance and Distribution of Stem Borers on Millet in Northern Ghana

Location	*Percent infested stalks*	*Total larvae collected*	*Mean stem borer larvae per millet plant*
Nyankpala	38.5 ± 10.2 b	11000 b	2.2 ± 0.67 b
Tumu	33.6 ± 6.8 b	7170 c	1.4 ± 0.55 c
Bongo	80.6 ± 14.7 a	40841 a	8.2 ± 1.21 a
Manga	78.8 ± 9.9 a	42992 a	8.6 ± 0.98 a

Within any column, figures followed by the same letter are not significantly different from each other ($P< 0.001$)

TABLE 3

Species Composition of Stem Borers Infesting Millet at Four Locations in Northern Ghana

Location	*Mean total* larvae/farm**	*Mean MSB* larvae/farm**	*Percent* C. ignefusalis	*Percent other borer species* S. penniseti	B. fusca	E. saccharina
Nyankpala	31.6 ± 2.9 b	30.3 ± 2.9 b	95.9 ± 1.1 b	3.92	0.15	0.04
Tumu	26.8 ± 2.4 b	26.2 ± 3.4 b	97.9 ± 1.0 ab	1.98	0.13	0.00
Bongo	63.9 ± 3.3 a	63.9 ± 3.3 a	100.0 ± 0.0 a	0.00	0.00	0.00
Manga	65.5 ± 5.1 a	65.6 ± 5.1 a	100.0 ± 0.0 a	0.00	0.00	0.00
Mean	46.98	46.83	98.40	1.48	0.07	0.01

Within the same column, figures followed by the same letter are not significantly different from one another at $P = 0.001$. *Figures are square root values of original means. MSB = Millet stem borer

Nyankpala and Tumu in the Guinea savanna ($P<0.001$; $Fe_{3,27}=29.62$). It was the predominant species, accounting for over 95 % of all borer larvae collected at the four locations. At Bongo and Manga, it was only borer species that infested millet stalks.

However, at Nyankpala and Tumu the pink borer, *Sesamia penniseti* (Tams and Bowden) and the sorghum borer, *Busseola fusca* (Fuller), were also recorded infesting millet. At Nyankpala, a fourth borer species, *Eldana saccharina* (Walker), was observed but its incidence was very low, constituting less than 0.05 per cent of the borer population (Table 3).

Fig. 1 shows the range of *C. ignefusalis* larval numbers per bored millet stalk across the four locations. Across locations, the mean number of larvae/stalk varied from as low as 7.1 to as high as 19 at Tumu and Manga, respectively. At Tumu and Nyankpala, borer larval populations per bored stalk were generally lower than 15, supporting the fact that the incidence and damage to millet by *C. ignefusalis* is lighter at these locations than at Manga and Bongo.

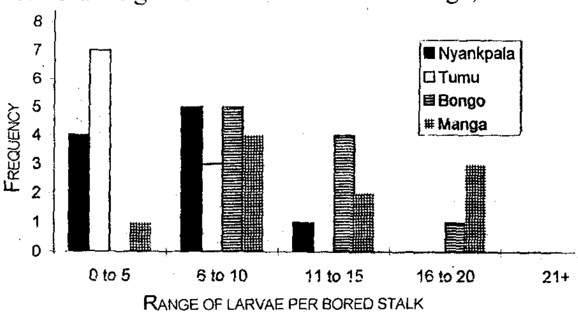

Fig. 1. Frequency of non-diapause *C. ignefusalis* larvae in millet stalks during the 1996 cropping season at four locations in northern Ghana (n = 10 farms/location).

Distribution of diapause larvae in different hosts during the dry season

Diapause larvae of *C. ignefusalis* were recovered from sorghum and millet stalks (Fig. 3), being significantly higher in the latter at both locations ($P<0.001$, $F_{3,27}=19.5$). No *C. ignefusalis* larvae were recovered from maize stalks during the sampling period. The percentage of millet stalks showing borer damage (Fig. 2) and the number of diapause *C. ignefusalis* larvae per stalk (Fig. 3) were also significantly higher at Manga than at Nyankpala. Larval populations in sorghum stalks followed the same trend (Fig. 3). These results agree totally with those from the earlier survey presented above, to the effect that *C. ignefusalis* incidence and hence crop damage is higher at Manga than it is at Nyankpala. Also, the high *C. ignefusalis* larval numbers in the different crops at Manga appeared to be generally associated with high crop damage, and no damage was recorded in stalks that harboured

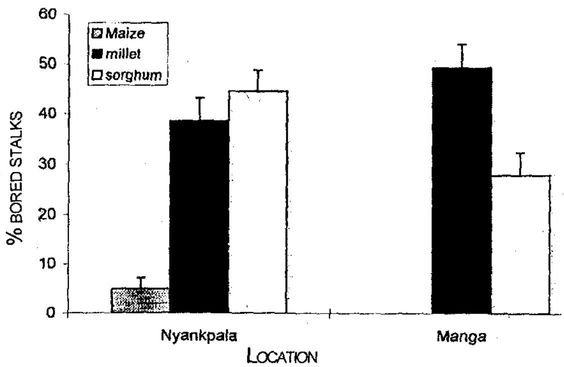

Fig. 2. Distribution of stem borer damage in stalks of different crops in northern Ghana.

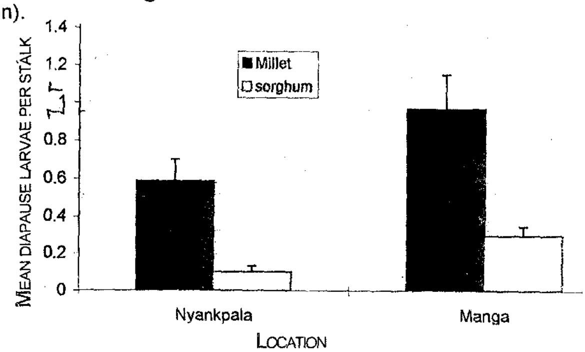

Fig. 3. Distribution of diapause *C. ignefusalis* larvae in stalks of different crops in northern Ghana.

no larvae of this insect (Fig. 2 and 3). However, the same was not true for Nyankpala. On sorghum, for instance, stem borer damage was very high at this location, even though *C. ignefusalis* larval populations were low.

Stem borer damage was also recorded in maize, but no larvae of this species were recovered from stalk samples of this crop.

Discussion

Given the fact that the study sites are considered as representative of the millet belt for the purposes of agricultural research and technology generation (Runge-Metzger & Diehl, 1993), the data for this study clearly show that *C. ignefusalis* is widely distributed throughout northern Ghana. However, the incidence of the insect was higher in the Sudan savanna than in the Guinea savanna locations. This may be attributed to differences in the farming systems prevalent in these areas as well as to the relative importance of the millet crop at each location. In Bongo and Manga, where millet is the main staple crop, both the early and late types are grown while late millet alone is grown in the other locations. Early millet is usually planted with the first rains in May, and this early crop probably provides oviposition sites for *C. ignefusalis* moths emerging from the diapause generation as well as nutrition for the resulting larval populations.

In areas where early millet is not grown, therefore, first generation moths derived from diapause larvae from the previous season would presumably have limited sites that are suitable for oviposition and subsequent larval development. Larval population build-up on subsequent crops in such a system could thus be significantly reduced as is suggested by these studies. The inference is that *C. ignefusalis* infestation would usually be more severe in areas where late and early millet are cultivated than in areas where farmers grow only late millet. Larval populations of up to 20 larvae per bored stalk were recorded only on farms at Manga and Bongo, while most farms at Tumu and Nyankpala had larval populations of less than 16 larvae/bored stalk. In earlier studies at Manga, up to 30 *C. ignefusalis* larvae were recorded in a single millet stem (Tanzubil & Dekuku, 1991), confirming the high incidence of this pest at that location.

For borer species composition, *C. ignefusalis* constituted over 95 per cent of all borer larvae collected across locations, indicating that it is the predominant species infesting millet in the study area. At Bongo and Manga, it was the only borer species recovered from millet stems throughout the study period. Girling (1980) also found *Acigona (= Coniesta) ignefusalis* to be the most abundant borer on sorghum at Nyankpala, and the existence and relative importance of this insect in the farming systems of the UER have recently been reported on by Tanzubil & Yakubu (1997). The other important borer species encountered during the study was *S. penneseti* which accounted for about 4 and 2 per cent of the larval population at Nyankpala and Tumu, respectively. *Busseola fusca* and *E. saccharina* accounted for the remaining 0.22 per cent of the larval population recorded, and are probably best considered as secondary pests of millet in Ghana.

Results from the survey of diapause larvae at different locations confirmed the existence and importance of competing stem borer species, especially in the Guinea savanna. In those surveys, higher stalk damage was recorded for sorghum and maize than could reasonably be explained by the levels of *C. ignefusalis* larval populations. The implication is that not all stem tunnelling in these crops is attributable to *C. ignefusalis* larvae. Other competing stem borer species, especially *S. penniseti* and, to a lesser extent *B. fusca* and *E. saccharina,* were probably responsible for such damage. These insects are reported to be important stem borers of maize and sorghum in northern Ghana (Endrody-Younga, 1968; Kumar & Sampson, 1982).

Many stem borer pests of cereal crops in Africa have been reported to pass the dry season in diapause in the stalk and stubble of their host plants. In eastern and southern Africa, the stem borers *B. fusca* and *Chilo* spp. diapause in maize and sorghum stalks (Gebre-Amlak, 1989; Kfir, 1991; Pats, 1996), and similar observations have been made for *B. fusca* in many parts of West Africa (Harris, 1962; Usua, 1970). The studies reported in this paper on the distribution of *C. ignefusalis* in different cereal stalks and stubble in Ghana produced very important results. Diapause larvae were recovered from the Guinea and Sudan savanna zones of the country, therefore suggesting that this insect survives the dry season in both agroecological zones as diapause larvae. Control methods based on the improved management of cereal stalk and stubble, therefore, need to cover both areas to be effective. At both sites, diapause populations were highest on millet, followed by sorghum with none on maize. This indicates that sorghum stalks can also be important in the carry-over of larval populations from one season to another. The results further suggest that maize is not a preferred host of this insect, and under free choice conditions, the insect may not attack it. This observation, however, seems at variance with the results of Bosque-Perez & Mareck (1990) who found *C. ignefusalis* larvae on maize in all four locations they surveyed in southern Nigeria. However, they did not comment on its pest status in such a system.

Harris (1962) similarly observed a higher preference for millet over guinea corn and maize by *C. ignefusalis,* but attributed its larvae found on these other crops to the practice of mixed cropping which resulted in some degree of larval migration between different hosts growing close together. Although between-plant larval migration might partially explain some aspects of the current results, it is important to stress the fact that some of the sorghum stalks that contained diapause *C. ignefusalis* larvae were sampled from farms planted to sole sorghum crops. Larval infestations in such situations could certainly not be due to migration from a more suitable host. There is a need to examine this further, as possibilities for host shifting exist especially for insects living in unstable habitats where the preferred host is absent during a large portion of the year.

These studies have shown that *C. ignefusalis* survives the dry season in northern Ghana as diapause larvae in millet and sorghum stalks. Cultural control measures need to be extended over the whole area to be effective. The insect has a higher preference for pearl millet as far as population development, crop damage, and diapause development are concerned, but in the field it also feeds and develops well on sorghum. Maize was not attacked by the insect and diapause development is not supported by this crop. Growing maize in rotation or in association with millet could thus prove useful in reducing *C. ignefusalis* population carry-over.

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