Distribution, pest status and agro-climatic preferences of lepidopteran stem borers of maize in Kenya

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Abstract. Lepidopterous stem borers are the main field insect pests that attack maize, *Zea mays* L. in tropical Africa. A survey was carried during the long and short rain cropping seasons of 2002 / 2003 across six main agro-climatic zones (ACZs) to determine the spatial distribution of important stem borer species in Kenya. A total of 474 visits were made in the seventy-eight localities conveniently chosen to represent each of the six ACZs. 189,600 stems were checked for infestation, of which 27,799 infested stems were destructively cut and dissected for stem borer larvae identification. An average of 1.4 stem borer larvae were recovered per infested plant. 54.5% of the recovered larvae were identified as ***Chilo partellus*** (Swinhoe) (Crambidae), 39.7% as ***Busseola fusca*** (Fuller) (Noctuidae), 4.5% as ***Sesamia calamistis*** Hampson (Noctuidae) and 0.8% as ***Chilo orichalcociliellus*** (Strand) (Crambidae). Minor species present included ***Eldana saccharina*** Walker (Pyralidae), ***Sesamia nonagrioides*** (Lefebvre) (Noctuidae), ***Sesamia cretica*** Lederer (Noctuidae), ***Sesamia*** sp. (Noctuidae), ***Sciomesa piscator*** Fletcher (Noctuidae), ***Busseola*** sp near ***phaia*** (Noctuidae), ***Chilo*** sp, ***Ematheudes*** sp 1 (Pyralidae) and ***Ematheudes*** sp 2 (Pyralidae). Farms were grouped into respective ACZs for statistical analysis and subsequent comparison of dominant species. Results indicated that ***B. fusca*** was the dominant stem borer species in high potential zones (highland tropics, moist transitional zone and moist mid-altitude) while the exotic ***C. partellus*** dominated smallholder farms in low potential zones (dry mid-altitude, dry transional and lowland tropical zone). Within each ACZs, there was evidence of variation in species proportions between seasons. These spatio-temporal differences in community structure are discussed in terms of agro-climatic biological adaptations.

Résumé. Distribution, ravages et préférences agro-climatiques des lépidoptères foreurs de tige du maïs au Kenya. Une enquête a été menée dans les 6 principales régions agro-écologiques du Kenya, pendant les longues et courtes saisons des pluies de 2002/2003, afin de déterminer la distribution spatiale des lépidoptères foreurs de graminées attaquant le maïs *Zea mays* L. Un total de 474 échantillonnages a été réalisé dans les 78 localités représentatives des six régions agro-écologiques. On a vérifié l'infestation de 189,600 tiges et les 27799 tiges infestées ont été récoltées et disséquées afin d'identifier les foreurs. En moyenne, 1,4 larves de foreur ont été trouvées par plante infestée; 54,5% des larves récoltées étaient des *Chilo partellus* Swinhoe (Crambidae), 39,7% des *Busseola fusca* (Fuller) (Noctuidae), 4,5% des *Sesamia calamistis* Hampson (Noctuidae) et 0,8% des *Chilo orichalcociliellus* Strand (Crambidae). Des espèces peu importantes ont également été trouvées telles que *Eldana saccharina* Walker (Pyralidae), ***Sesamia nonagrioides*** Lefebvre (Noctuidae), ***Sesamia cretica*** Lederer (Noctuidae), ***Sesamia*** sp. (Noctuidae), ***Sciomesa piscator*** Fletcher (Noctuidae), ***Busseola*** sp near ***phaia*** (Noctuidae), ***Chilo*** sp, ***Ematheudes*** sp 1 (Pyralidae) et ***Ematheudes*** sp 2 (Pyralidae). Les localités ont été regroupées par région agro-écologique pour les analyses statistiques et la comparaison des 4 principales espèces. Les résultats indiquent que ***B. fusca*** est l'espèce dominante dans les régions à haut potentiel de production (hautes terres tropicales, zone humide de transition et zone d'altitude moyenne humide) alors que l'espèce exotique ***C. partellus*** est dominante dans les petites exploitations à faible potentiel de production (zone d'altitude moyenne sèche, zone sèche de transition et zone tropicale de basse altitude). On a pu mettre en évidence, dans chaque région agro-écologique, une variation de la proportion des différentes espèces selon la saison. On discute de ces différences spatio-temporelles de la structure des communautés en relation avec des adaptations biologiques aux conditions agro-climatiques.

Keywords: *Zea mays*, agro-climatic zones, *Busseola fusca, Chilo partellus*, Kenya.

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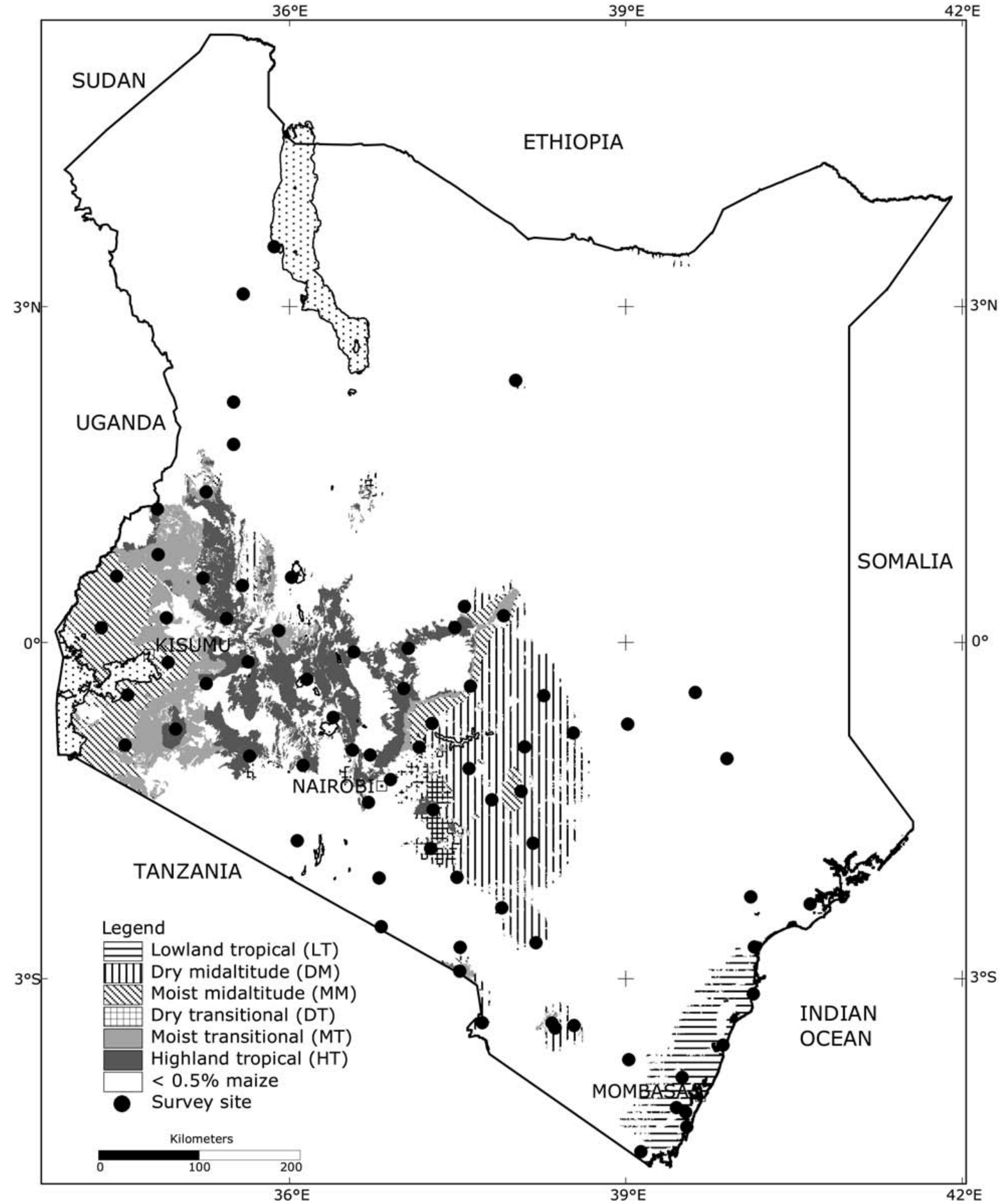

Figure 1
Map of Kenya showing localities surveyed during the long and short rain growing seasons in 2001/2003.

Lepidopteran stem borers are generally considered to be the most damaging field insect pests of maize, *Zea mays* L. in Africa (Seshu Reddy 1998; Overholt *et al.* 2001). Maes (1997) reported 20 economically important stem borer species whose distribution, relative abundance and pest status are expected to vary with environmental conditions (Megenasa 1982; Songa *et al.* 1998; Ndemah *et al.* 2001). Although some species like *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae), *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) and *Eldana saccharina* Walker (Lepidoptera: Pyralidae) are found throughout sub-Saharan Africa (Polaszek & Khan 1998), their pest status vary depending on the region. *S. calamistis* and *E. saccharina* are the major pests that cause heavy losses in West Africa whereas *B. fusca* and the exotic *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) are the dominant species in East Africa (Overholt *et al.* 2001). However, some of the *Sesamia* and *Chilo* species are restricted to either eastern or western Africa. Understanding species distribution and abundance, and factors responsible for the structuration of stem borer communities will constitute basic information necessary for future development of management strategies.

In Kenya, the distributions of the stem borer pest species *B. fusca, C. partellus, S. calamistis* and *C. orichalcociliellus* (Strand) are different but often overlap in space and time (Seshu Reddy 1983; Khan *et al.* 1997; Overholt *et al.* 2001). In previous studies (Songa *et al.* 1998; Seshu Reddy 1983; Guofa *et al.* 2002), distributions of these species were analysed based on the provincial blockings which might not have real biological significance compared to agro-climatic zones (ACZs). These resulted in presentation of contradicting distribution patterns (Overholt *et al.* 1994; Songa *et al.* 1998; Guofa *et al.* 2002) which may be attributed to differences in time of the season, maize growth stages and sampling sites (Megenasa 1982; Songa *et al.* 1998).

Nonetheless, the amount of food made unavailable to humans through stem borer pest infestations is quite substantial and calls for effective management. Successful design of suitable management options will rely on the understanding of pest species distribution limits and their response to environmental gradient. This can be achieved by describing these distributions in relation to ACZ variables. In this study, we analysed a nationwide standardised survey of stem borer species distribution and abundance for their relationships with agro-climatic zonation in an attempt to improve our understanding of their ecology.

Materials and methods

Description of the Kenya's ACZs

This work was carried out in benchmark sites within the six out eight ACZs previously delineated by Kenya's maize database project (MDBP) (Corbett *et al.* 2000). Surveyed ACZs i.e. highland tropics, moist transitional zone, moist mid-altitude, dry mid-altitude, dry transitional and lowland tropical zone are the main maize producing areas (Fig 1). Extent of these ACZs does not depend on Kenya's administrative boundaries but represent distinct production potentials (Hassan *et al.* 1998). The highest potential areas are moist transitional followed by highland tropics (De Groote 2002). Together, these two zones represent 64% of the total production area and produce approximately 80% of Kenya's maize. Other zones make up about 30% of the total maize area but produce only 15% of Kenya's maize. Among these, lowland tropics and dry mid altitude zones are regarded as the lowest potential areas, with sandy humus soils characterised with both low inherent fertility and low moisture retention. Dry mid-altitude and moist mid-altitude zones are considered as medium potential.

Rainfall levels in all the six ACZs are highly variable in timing, duration and intensity. Most of the localities surveyed have a bimodal rainfall distribution that allow for two cropping seasons, the first lasting between March / April and May / August (referred to as the long rain growing season , *LR*) and the second from October to December (short rain season, *SR*). Farmers in Kenya regard *LR* season as the most important growing season as it has less variable rainfalls. Some farmers in highland tropics, moist transitional zone and lowland tropics plant only during the *LR* growing season. However, more than 50% of farmers in moist mid-altitude zone try the second (*SR*) cropping season.

Research implementation

A total of 78 localities randomly distributed in Kenya's maize producing area were sampled (fig. 1). In each locality, four farms of maize corresponding to the cardinal points (north, south, east and west) were selected for the study. Localities were nested in respective zones and only data from localities occurring within the six ACZs were considered for subsequent analysis. Yield losses associated with stem borer infestation has never been estimated in regions producing less than 0.5 % of maize and thus data from 9 localities occurring within this region were excluded from the analysis. Each locality was visited twice during the first 10 weeks of crop emergence in each growing season (*LR* and *SR*); majority of the visits were made during the 5^{th} and 8^{th} week. These early visits were meant to capture only the first generation of stem borer population. A total of 474 visits were made in the six ACZs during both the *LR* and *SR* growing seasons of 2002 / 2003. In each visit, 400 randomly selected stems of maize were checked for stem borer infestation. Infested stems were then destructively cut and transported to the laboratory for dissection. Recovered larvae were identified to species level using external morphological features as described by Overholt *et al.* (2001). The larvae were later reared to adulthood for confirmation of species identity. During rearing, the larvae were singly introduced into perforated 15 cm long, two months old, freshly cut maize stems. The stems were held vertically in plastic vials where the larvae were maintained. Larvae were transferred to fresh stems after every 4 days until pupation. Pupae were individually transferred to separate plastic vials where they were maintained until adult emergence and morphological identification. Pascal Moyal of IRD, CNRS Gif-sur-Yvette cedex, confirmed taxonomic identity of adult moths and materials will be finally deposited to the Museum national d'Histoire naturelle in Paris.

Table 1. Seasonal variability in average stem borer species composition (%) in different agro-climatic zones in Kenya.

Agro-climatic zones	Season	Average percentage stem borer composition			
		B. fusca	*S. calamistis*	*C. partellus*	*C. orichalco.*
Highland tropics	*LR*	95.63 ± 1.78 [a]	04.23 ± 1.77 [bc]	00.14 ± 0.08 [e]	0.00 ± 0.00 [c]
	SR	96.83 ± 1.64 [a]	02.99 ± 1.64 [bc]	00.17 ± 0.12 [e]	0.00 ± 0.00 [c]
Moist transitional zone	*LR*	96.24 ± 1.89 [a]	02.04 ± 1.51 [c]	01.72 ± 1.21 [e]	0.00 ± 0.00 [c]
	SR	88.19 ± 5.35 [a]	01.20 ± 0.73 [c]	10.01 ± 5.39 [e]	0.00 ± 0.00 [c]
Moist mid-altitude	*LR*	60.27 ± 6.61 [b]	06.00 ± 2.06 [bc]	33.72 ± 6.67 [d]	0.00 ± 0.00 [c]
	SR	53.13 ± 4.55 [cb]	07.63 ± 1.80 [bc]	39.24 ± 4.62 [d]	0.00 ± 0.00 [c]
Dry mid-altitude	*LR*	43.36 ± 6.68 [c]	04.27 ± 1.54 [bc]	52.36 ± 6.84 [c]	0.00 ± 0.00 [c]
	SR	18.10 ± 4.33 [d]	09.61 ± 2.20 [bc]	72.29 ± 4.47 [cb]	0.00 ± 0.00 [c]
Dry transitional	*LR*	3.31 ± 1.64 [d]	06.47 ± 2.10 [bc]	90.22 ± 2.91 [a]	0.00 ± 0.00 [c]
	SR	3.56 ± 3.40 [d]	06.65 ± 2.53 [bc]	89.79 ± 4.60 [a]	0.00 ± 0.00 [c]
Lowland tropical	*LR*	0.12 ± 0.08 [d]	14.58 ± 3.39 [a]	78.72 ± 3.56 [b]	6.58 ± 1.78 [a]
	SR	0.12 ± 0.12 [d]	21.15 ± 5.48 [a]	74.51 ± 5.60 [cb]	4.21 ± 1.47 [b]
F		72.86	4.07	43.82	11.20
Df		473	473	473	473
p		< 0.0001	< 0.0001	< 0.0001	< 0.0001

LR = Long rain; SR = Short rain; *F* = Fischer's distribution; *Df* = degrees of freedom; *p* = probability value;

Mean (± SE) within columns followed by the same superscripts do not differ significantly at the 5% threshold (SNK test)

Data analysis

The effects of ACZs classification and growing season on percentages of infested stems were analysed. Average percentages of infestation per season for different localities were computed and compared separately for each ACZ using Students' *t* test. One way analysis of variance (ANOVA) was used to compare proportions (%) of respective stem borer species between different ACZs after arcsine transformation and significantly different means (< 0.05) separated using Student-Newman-Keuls (SNK) multiple range test (SAS 1992).

To estimate pest status of respective stem borer species in different ACZs, estimated annual losses associated with stem borers previously presented by Hassan *et al.* (1998) was divided proportionate to the computed proportions of stem borer species in each ACZ.

Results

Species composition

A total of 474 visits were made in the sixty-nine localities conveniently chosen to represent each of the six ACZs. 189,600 stems were checked for infestation of which 27,799 were found infested. A total of 38,918 stem borer larvae belonging to 13 different species were recovered including 7 Noctuidae, 3 Pyralidae and 3 Crambidae. 54.5% of the recovered larvae were identified as *C. partellus*, 39.7% as *B. fusca,* 4.5% as *S. calamistis* and 0.8% as *C. orichalcociliellus*. The other species, *E. saccharina, S. nonagrioides, S. cretica*, *Sesamia* sp., *Sciomesa*

Table 2. Average (± SE) percentage stem borer infestation in the six ACZ surveyed during the study.

Agro-climatic zones	Mean (± SE) percentage of infestation			
	B. fusca	*S. calamistis*	*C. partellus*	*C. orichal*
Highland tropics	96.08 ± 1.27 [a]	3.77 ± 1.27 [b]	0.05 ± 0.07 [e]	0.00 ± 0.00 [b]
Moist transitional zone	93.65 ± 2.25 [a]	1.75 ± 1.01 [b]	4.60 ± 2.07 [e]	0.00 ± 0.00 [b]
Moist mid-altitude	55.55 ± 3.75 [b]	7.08 ± 1.38 [b]	37.37 ± 3.80 [d]	0.00 ± 0.00 [b]
Dry mid-altitude	31.04 ± 4.23 [c]	6.88 ± 1.36 [b]	62.08 ± 4.25 [c]	0.00 ± 0.00 [b]
Dry transitional	3.40 ± 1.63 [d]	6.54 ± 1.61 [b]	90.06 ± 2.49 [a]	0.00 ± 0.00 [b]
Lowland tropical	0.12 ± 0.07 [d]	16.96 ± 2.94 [a]	77.20 ± 3.03 [b]	5.72 ± 1.26 [a]
F	151.84	7.86	95.32	23.51
Df	468	468	468	468
P	< 0.0001	<0.0001	< 0.0001	< 0.0001

LR = Long rain; SR = Short rain; *F* = Fischer's distribution; *Df* = degrees of freedom; *p* = probability value;

Mean (± SE) within column followed by the same superscripts do not differ significantly at the 5% threshold (SNK test)

Table 3. Mean (± SE) annual and seasonal variation in stem borer infestations (%) in different Agro-climatic zones.

Agro-climatic zones	Mean (± SE)	Seasonal average infestation (Mean ± SE) %				
	(%)	Long rain	Short rain	*t*	*df*	*p*
Highland tropics	11.7 ± 2.4^{b}	10.00 ± 2.08^{b}	11.10 ± 3.20^{c}	2.77	35	< 0.01*
Moist transitional zone	20.7 ± 2.8^{ba}	20.20 ± 3.30^{ba}	21.81 ± 5.40^{bac}	0.04	65	> 0.05
Moist mid-altitude	20.3 ± 2.4^{ba}	16.23 ± 2.55^{b}	20.52 ± 2.44^{bc}	1.31	62	> 0.05
Dry mid-altitude	20.6 ± 2.0^{ba}	15.95 ± 2.18^{b}	26.56 ± 3.32^{bac}	2.77	71	< 0.01*
Dry transitional	21.5 ± 2.9^{ba}	15.94 ± 3.25^{b}	30.33 ± 4.86^{a}	2.46	52	< 0.01*
Lowland tropical	30.0 ± 3.3^{a}	30.04 ± 3.27^{a}	26.56 ± 3.32^{ba}	3.12	42	< 0.005*
F	2.95	4.76	4.33			
Df	333	218	179			
P	0.0128	0.0004	0.001			

LR = Long rain; SR = Short rain; *F* = Fischer's distribution; *Df* = degrees of freedom; *p* = probability value;
Mean (± SE) within column followed by the same superscripts do not differ significantly at the 5% threshold (SNK test)

piscator, *Busseola* sp near *phaia*, *Chilo* sp, *Ematheudes* sp 1 and *Ematheudes* sp 2 constituted the minor proportion (< 1%).

Proportions of economically important species varied between the growing seasons as well as ACZs (Table 1 and 2). *B. fusca* varied in its proportion between growing seasons and ACZs ($F_{5, 468} = 151.84$; $p = 0.0001$). However, significantly higher proportions (> 90%) were recorded in high potential zones (highland tropics and moist transitional zones). In contrast, lower proportions (< 5%) of *B. fusca* were recorded in low potential zones (dry transitional and lowland tropics) dominated by *C. partellus* (Table 2). Proportions of *C. partellus* significantly varied between ACZs ($F_{5, 468} = 95.32$; $p < 0.0001$). It dominated over the other pests in low altitude zones [dry transitional (90.06 ± 2.49%), lowland tropics (77.2 ± 3.03%) and dry mid-altitude zones (62.08 ± 4.25 %)]. *S. calamistis*, the second most important noctuid species occurred in all ACZs surveyed but in varied proportions with highest proportion of 16.96 ± 2.94% in lowland tropics ($F_{5, 468} = 7.86$, $p = 0.0001$).

Stem borers abundance

Stem borer infestation levels varied between ACZs with higher levels (30.0 ± 3.3%) in lowland tropics and lowest levels (11.7 ± 2.4%) in highland tropics ($F_{5,333} = 2.95$; $p = 0.0128$; Table 3). Infestation levels in the other ACZs (moist transitional zone, moist mid-altitude, dry mid-altitude and dry transitional zone) were intermediate and varied between 20.3 and 21.5% showing no evidence of variation ($p > 0.05$). There was evidence of variation in infestation between the growing seasons in some ACZs (Table 4). More stem borer attacks were observed during the *SR* growing season in dry mid-altitude ($t_{71} = 2.77$; $p < 0.01$), dry transitional ($t_{52} = 2.46$; $p < 0.01$) and highland tropics ($t_{35} = 2.77$; $p < 0.01$). Conversely, in lowland tropics, infestations were significantly higher during the *LR* growing season ($t_{42} = 3.12$; $p < 0.005$).

Agro-climatic zones ranked differently for their average infestation level during the *LR* and *SR* rain growing seasons (Table 3). There were higher infestations in lowland tropics (30.04 ± 3.27%) during

Table 4. Estimated maize production (tons), average maize loss due to stem borer infestation and proportions (%) attributed to different stem borer species in different ACZs.

Agro-climatic zones (ACZs)	Production ('000 t) *	Loss (t/ha) *	Average % loss			
			Bf	*Sc*	*Cp*	*Co*
Highland tropics	909	0.32	10.70	0.42	0.01	0.00
Moist transitional zone	1234	0.386	13.60	0.25	0.67	0.00
Moist mid altitude	231	0.374	15.50	1.98	10.43	0.00
Dry mid altitude	162	0.175	5.54	1.23	11.09	0.00
Dry transitional	76	0.315	0.93	1.79	24.67	0.00
Lowland tropical	53	0.346	0.03	4.55	20.71	1.53

Bf = Busseola fusca; Sc = Sesamia calamistis; Cp = Chilo partellus; Co = Chilo orichalcociliellus; * = informations from Hassan et al. (1998).

the *LR* growing season followed by moist transitional zone (20.20 ± 3.30%). During the *SR* growing season, dry transitional had the highest average infestation (30.33 ± 4.86%), followed by lowland tropical zone (26.56 ± 3.32%). However, intermediate levels varying between 20.5 and 26.56% were recorded in other ACZs.

Pest status

Hassan *et al.* (1998) estimated average maize losses associated with stem borer infestation to vary between 0.315 – 0.386 t/ha except in dry mid-altitude zone where it was lower (0.175 t/ha) (Table 4). These losses represent higher percentage of total production in low to medium potential areas – between 26.8 and 27.9%, except for dry mid-altitude zones where this represent about 18% (Hassan *et al.* 1998).

This study indicates that more than 10% of potential maize harvest is lost due to infestation by *B. fusca* in highland tropics, moist transitional zone and moist mid-altitude zones (Table 4). About 1% is lost due to *B. fusca* infestation in low potential area (dry mid-altitude and lowland tropics) while losses associated with *S. calamistis* together accounts for less than 5% of potential harvest. *C. partellus* is responsible for the bulk of losses in dry transitional (24.7%), lowland tropics (20.7%) and approximately 10% in medium potential areas (moist mid-altitude and dry mid altitude). In highland tropics and moist transitional zone, *C. partellus* is responsible for less than 1% of the damage. *C. orichalcociliellus* was only present in lowland tropical zone where it is estimated as responsible for a loss below 1.5%.

Discussion and conclusion

The present study aimed at understanding the distribution of different species of maize stem borers in relation to Kenya's ACZs provided by Hassan *et al.* (1998). Results revealed that stem borer species are more diverse in maize crop than previously reported. Despite the species diversity, *B. fusca, S. calamistis, C. partellus* and *C. orichalcociliellus* are the main pest species, corroborating earlier reports (Seshu Reddy 1983; Overholt *et al.* 2001; Guofa *et al.* 2002). Among the stem borer pests, *C. partellus* and *B. fusca* dominated the stem borer community though they respectively varied in dominance between ACZs as well as seasons. Variations in dominance among these species indicate that they have specific adaptations in their ecological requirements. However, other stem borer species found together with these pests included *E. saccharina, S. nonagrioides*, *S. cretica*, *Sesamia sp*., *Sciomesa piscator*, *Busseola sp* near *phaia*, *Chilo* sp, *Ematheudes* sp 1and *Ematheudes* sp 2. Among these, only *S. cretica* and *E. saccharina* had earlier been recovered from cultivated cereals in Kenya (Nye 1960).

The bulk of maize consumed in Kenya comes from high potential areas which include highland tropics and moist transitional zone (De Groote 2002). These two zones, produce approximately 80% of the total maize in the country (Hassan *et al.* 1998; De Groote 2002). The remaining proportion (20%) is produced by subsistence farmers who are randomly distributed in the other ACZs. However, about 15% (395,000 tonnes) of the potential yield is lost annually due to stem borer infestations (Hassan *et al.* 1998). This loss is substantial considering the poor maize harvests (tonnes/ha) particularly among the peasant farmers who subsist only on the farm produce. Important among the stem borer pests are the exotic *C. partellus* and the indigenous *B. fusca* which vary in dominance between the ACZs and seasons. Losses associated with stem borer infestation are relatively high in relation to the total yields during the *SR* growing season considering that average infestations are the same through out the year. This has serious implication in terms of food security since the farm produce from the *SR* harvest is expected to supplement the *LR* harvest in both high and low potential areas (De Groote 2002). Thus understanding the extent of distribution of important species (*C. partellus* and *B. fusca*) would provide important information required for the design of suitable management strategy.

The exotic *C. partellus* has been targeted in several control attempts in Eastern Africa. Important among such attempts was the release of the larval endo-parasitoid *Cotesia flavipes* Cameron (Hymenoptera; Braconidae) imported from Taiwan (Overholt *et al.* 1994). It was thought that *C. flavipes* after establishing in Eastern Africa would control populations of *C. partellus* and reduce losses associated with its infestation (Polaszek & Khan 1998). However, 10 years after the release and subsequent establishment of *C. flavipes* along the Kenyan coast, *C. partellus* remains an important pest in low altitude areas. The current data indicate that its distribution has expanded into high potential areas (mainly highland zones) where it used not to occur. Establishment of *C. partellus* in these zones is favoured by suitability of ecological conditions. However, Ingram (1958) showed that *C. partellus* could not survive above 1220m asl in western Uganda or above 1524m asl in eastern or northern Uganda. This prediction was based on the low average annual temperature, which he considered as a limiting factor in the physiological development. This prediction is not verified in our data, as this species was present in relatively high altitude zones (moist high and moist mid altitude zones) known to have low temperature regimes. Similarly, Kfir (1997) found *C. partellus* colonising areas known to have harsh winter conditions in South Africa. Successful establishment of *C. partellus* in areas originally colonised by other indigenous stem borer species can be attributed to the plasticity of its biology that gives it an advantage over the indigenous species (Ofomata *et al.* 1999). The indigenous *B. fusca*, the second most important pest species accounted for the highest potential annual loss (300,000t). Bulk of these losses comes from moist transitional and highland tropical zones (161,480 and 96,310t respectively). Even though this species is important in terms of losses associated with its infestations, little effort was made in the past to reduce its population in cereal fields. This species (*B. fusca*) may have been ignored, due to large-scale farming that characterise maize production in high potential areas.

Information on the ecological requirement that is reflected in geographic distribution and population dynamics along the seasons is a prerequisite in priority setting for stem borer management. Findings from this study have particular relevance to maize and sorghum production in Kenya. It revealed that stem borer population builds during the *LR* and heavily infests cultivated maize and sorghum in the subsequent *SR* growing season. This increases losses during the *SR* growing season. Our study indicates that stem borer species are limited in their distribution to specific ACZs except for *S. calamistis* that show spatial overlap across different ACZs. Based on the estimation given by farmers, potential losses were relatively high in low potential areas (Hassan *et al.* 1998; De Groote 2002). Our data also suggests a trend for increased infestation from high potential to low potential, although this trend is based on the difference of two ACZs only namely the highland tropics (with high yield and low infestation) and the moist low tropics (with low yield and high infestation) the other being intermediate and not significantly different. Is this higher infestation in low potential area only due to low investment by farmers in pest control? Or could this trend mean that harsh conditions in low potential areas are capable of reducing plant defence mechanism that resulting in higher plant damages and yield losses?

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