Stem Borer Species Composition on Maize and Two Non-Cereal Hosts in the Forest Zone of Kisangani, DRC

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Abstract: Lepidopteran stem borers are the most damaging pests of maize in Sub-Saharan Africa. Despite the growing importance of maize in the forest zone of Democratic Republic of Congo, no data is available regarding stem borer pest species present and their relative importance. It is thus important to gather information likely to guide future research in this area. This study was undertaken to catalogue stem borer pest species identity and assess their relative infestation levels on maize. Surveys were carried out in wild and cultivated habitats in Kisangani. Five species were collected on maize, i.e., Sesamia calamistis Hampson (1910), Eldana saccharina Walker (1865), Busseola fusca Fuller (1901), Chilo sp. Strand (1913), and Mussidia nigrivenella Ragonot (1888). In the wild habitats, Poenoma serrata Hampson, B. fusca and S. calamistis were collected on Pennisetum purpureum whereas Chilo sp. was collected on Panicum maximum. Our results suggest that P. maximum might affect the population dynamics of Chilo sp. whereas P. purpureum is expected not to influence the population dynamics of other stem borers owing to its scarcity in the interior of the forest.

Key words: Stem borers, maize, Busseola fusca, Chilo sp., Eldana saccharina, forest zone, Kisangani.

Nomenclature

H Kruskal-Wallis statistic (nonparametric)
df Degree of freedom, associated with calculation of the statistic H
P P value related to the calculation of H. The level of significance was set to 0.05
U Mann-Whitney statistic for nonparametric

1. Introduction

Maize (Zea mays L.) is the most important cereal crop in Democratic Republic of Congo (DRC). In 1999, it covered 69% of land under cereals cultivation. It is mainly grown in the Provinces of Katanga, Bandundu and Kasai which provided 63% of the domestic production in 2007 (1,155,720 tons) [1]. In the rain forest zone of DRC, while cassava was the main staple food until the 1980s, maize has gradually come to replace it in many areas. Several factors have fostered this shift. These include the short production cycle of maize and the local climatic conditions that allow for an almost continuous maize production [2].

Various constraints limit maize production in
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Sub-Saharan Africa. In the forest zone of Cameroon, an area where ecological conditions are similar to those in the rain forest of DRC, fungal diseases, low soil fertility and insect pests are major constraints to maize production [3]. Among insects that attack maize in Sub-Saharan Africa, stem borers are the most important [4, 5]. They have been reported to cause losses ranging between 5% and 73% of the potential yield [6, 7]. These yield losses, however, vary with several local factors such as the season and the pest community composition [5, 8].

While the species *Eldana saccharina* (Lepidoptera: Pyralidae) and *Sesamia calamistis* (Lepidoptera: Noctuidae) are the main stem borers of maize in West Africa, *Chilo partellus* (Lepidoptera: Crambidae) and *Busseola fusca* (Lepidoptera: Noctuidae) predominate in Eastern Africa [9]. In Central Africa, *B. fusca* is the most important stem borer across all ecological zones of Cameroon except in the coastal zone where *S. calamistis* predominates [10]. In DRC, *S. calamistis, E. saccharina, Mussidia nigrivenella* (Lepidoptera: Pyralidae) and *B. fusca* were reported in the savanna zone. The latter species is regarded as the most important around Lubumbashi, a locality situated at 1,200 m above sea level (masl) [11, 12].

Wild habitats are considered a reservoir for stem borers [13]. In fact, many stem borer species infesting cereals have wild graminaceous hosts. For instance, the host range of *Busseola fusca* in the wild includes graminaceous plants such as *Pennisetum purpureum*, *Panicum maximum*, *Sorghum arundinaceum* and *Echinochloa pyrmidalis* [14]. For this reason, a thorough knowledge of these host plants is recommended when studying stem borer population dynamics and natural enemies [15].

In the forest zone of DRC, there is lack of information on the composition of stem borer community in the wild and cultivated habitats. This study aimed to document stem borer species present on maize and two wild grasses commonly found around Kisangani, namely, *Panicum maximum* Stapf and *Pennisetum purpureum* Moench, and assess the level of their infestation on maize.

2. Materials and Methods

2.1 Description of Survey/Study Sites

This study was conducted from September 2006 to June 2007 in the area surrounding Kisangani (0°31′N, 25°11′E, 376 masl), Capital of the Eastern Province of DRC (Fig. 1). Kisangani is situated in the Congo Basin which hosts the world second largest rainy forest. The rainfall averages 1,748 mm per year. Average relative humidity is 85% and the monthly average temperature is 25 °C with low amplitudes throughout the year. The region is characterized by a bimodal rainfall regime. Short rains are experienced from March to June (here designated as season A) while long rains come from September to December (here designated as season B).

The study was conducted in four locations: Bangoka (0°28′N, 25°20′E, 428 masl), Mobi (0°20′N, 25°24′E, 422 masl) situated South-East of Kisangani along Kisangani-Lubutu road, Batiafeke (0°37′N, 25°10′E, 414 masl) and Basule II (0°52′N, 25°09′E, 426 masl) situated North of Kisangani along the Kisangani-Buta.

2.2 Collection and Identification of Stem Borers

Twenty-four fields distant from each other by not less than 200 m and with maize as the only cereal were surveyed. Seven fields were surveyed in Bangoka as well as in Batiafeke and Mobi. In Basule II, three fields were surveyed. Three crop cycles were included in this study: the long rainy season of 2006, the short rainy season of 2007 and the long dry season between the two rainy seasons. The maize growing cycle was divided into three stages: pre-tasselling which corresponded to the growth phase between plant emergence and tasselling, the reproductive phase spanning from tasselling to ear maturity and the senescence phase corresponding to plant dessication.
Data were collected using the procedure as described by Ndemah et al. [16]. For maize being in pre-tasselling phase, the collector observed 100 plants, 50 on each diagonals of the field. The planting holes were chosen systematically at equal distance depending on the size of the field starting from a randomly chosen point in one corner. The infestation rate was determined by counting the number of infested and divided by total plants sampled in the field. Ten infested plants were cut at ground level and dissected to recover stem borers and determine the populations composition. During reproduction and senescence growth stages, only 24 plants were sampled on one diagonal of the field to avoid loss of maturing ears. Since maize is grown almost continuously in the Kisangani region, we found maize plants at various developmental stages throughout the sampling period. In wild habitats, patches of *P. maximum* and *P. purpureum* growing in the vicinity of fields and on the roadsides were sampled by active searching for infestation symptoms (frass, scarified leaves, dead hearts) [17]. Infested plants were cut and dissected to recover stem borers.

Field collections of larvae and pupae were brought to the laboratory and reared at room temperature in plastic bottles covered with lids fitted with a metal mosquito netting to ensure air circulation. Larvae were fed with cuttings of maize stalks until pupation. Species identification was conducted on larvae and pupae based on morphological descriptions provided by Tran [18], Moyal and Tran [19, 20] and Silvie [21, 22]. Few specimens of moths were identified using genitalia observation and kept at ICIPE (Nairobi, Kenya). Kruskal-Wallis test was performed to estimate differences in maize infestation and stem borers abundance on maize in relation to seasons and sites. Significantly different means were submitted to pairwise comparison using Mann-Whitney test. The SSPS 14.0 statistical analysis software was used for the analysis. Statistical significance was set at 0.05. Estimates of data from Batiafeke and Basule II were pooled due to the small number of field visits to the latter.
3. Results and Discussion

3.1 Lepidopteran Stem Borer Species and Their Host Plants

A total of 635 larvae and pupae of lepidopteran stem borers were collected and six species were identified: *B. fusca*, *M. nigrivenella*, *E. saccharina*, *S. calamistis*, *Chilo sp.*, and *Poenoma serrata*. *E. saccharina* was found to be the most abundant species on maize (58.72%). On the contrary, *Chilo sp.* was the least abundant whereby only two specimens were recovered (0.58%). *Chilo sp.* was present in maize and *P. maximum* (Table 1). This species is most abundant on *P. maximum*. *P. serrata* was collected only from *P. purpureum*. The grasses *P. maximum* and *P. purpureum* also hosted unidentified stem borer.

In the forest zone of Cameroon, a country in Central Africa, species *B. fusca*, *E. saccharina*, *M. nigrivenella* and *Cryptophlebia leucotreta* (Meyrick) were encountered [16]. In this country, *B. fusca* and *E. saccharina* together represented the bulk of stem borer community accounting for 80% in the whole.

In Kisangani, however, the two species accounted for only 41.2%. This difference in the structure of the maize stem borers community within the same ecological zone highlights how difficult it is to generalize the results of research. Indeed, many authors have emphasized that the composition of maize stem borer communities and the relative importance of species are controlled by several abiotic and biotic factors such as season, elevation, vegetation composition and natural enemies [5-9, 16, 23]. Thus, the average temperature difference of 1.5 °C between the forest zone of Cameroon (23.5 °C) and Kisangani (25 °C) can be one of the factors behind the observed difference.

These results also show that some species of maize borers feed on wild grasses as well. This is the case for *Chilo sp.* that was collected from maize and *P. maximum*. The latter grass is widespread in the Kisangani region where it colonizes fallow and other open areas [24]. In our study, 95.9% of individuals of *Chilo sp.* were collected from *P. maximum* while only 4.1% were collected from maize. For this reason, *P. maximum* is expected to represent a reservoir for *Chilo sp.*. Considering the ongoing forest clearing around Kisangani, *P. maximum* might play a role in the infestation of maize by *Chilo sp.*. As for *P. purpureum*, although this grass has fresh shoots all the year around to maintain stem borers, it remains scarce away from the road side. For this reason, it is expected not to affect the population dynamics of stem borers.

Our results suggest the presence of *B. fusca*, *S. calamistis* and *P. serrata* on *P. purpureum*. In Cameroon, Ndemah et al. [25] reported the same three species on *P. purpureum*. In East Africa, Matama-Kauma et al. [26] reported five groups of species in Uganda on the same grass, i.e., *Busseola* spp., *Sesamia* spp., *Manga* spp., *Chilo* spp., *Poenoma* sp. and *Eldana* sp. In the present study, some stem borers from *P. purpureum* could not be identified. Thus, the stem borer diversity on this grass is expected to be higher than that here reported.

3.2 Abundance of Stem Borers in Relation to Different Stages of Maize Development

Community composition and abundance of species...
The infestation rate was not significantly different among the three seasons ($H = 3.857; df = 2; P = 0.145$). The same trend is observed for abundance of $S. calamistis$ ($H = 2.828; df = 2; P = 0.243$), $E. saccharina$ ($H = 1.777; df = 2; P = 0.411$), $M. nigrivenella$ ($H = 4.369; df = 2; P = 0.113$) and mean density of stem borers ($H = 2.089; df = 2; P = 0.352$). The abundance of $B. fusca$, however, showed a significant difference between seasons A and B ($U = 2.000; P = 0.016$) (Table 3).
Table 3  Number of stem borers on maize over different seasons (mean ± SE).

<table>
<thead>
<tr>
<th>Season</th>
<th>Infestation (%)</th>
<th>B. f</th>
<th>S. c</th>
<th>E. s</th>
<th>M. n</th>
<th>Mean density (insects/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Season A (N = 8)</td>
<td>9.4 ± 2.6a</td>
<td>0.6 ± 0.4a</td>
<td>4.6 ± 3.2a</td>
<td>0.4 ± 0.3a</td>
<td>0°</td>
<td>0.1 ± 0°</td>
</tr>
<tr>
<td>Season B (N = 6)</td>
<td>44.5 ± 18.2a</td>
<td>6.0 ± 3.0a</td>
<td>0°</td>
<td>28.7 ± 19.3a</td>
<td>1.3 ± 0.8a</td>
<td>1.4 ± 0.8a</td>
</tr>
<tr>
<td>Season BA (N = 8)</td>
<td>19.4 ± 8.6a</td>
<td>1.5 ± 0.5b</td>
<td>2.3 ± 1.6c</td>
<td>8.4 ± 5.6a</td>
<td>2.9 ± 1.4a</td>
<td>0.6 ± 0.3a</td>
</tr>
<tr>
<td>Total (N = 22)</td>
<td>22.3 ± 6.2</td>
<td>2.0 ± 0.7</td>
<td>2.7 ± 1.4</td>
<td>9.2 ± 4.5</td>
<td>1.5 ± 0.7</td>
<td>0.6 ± 0.2</td>
</tr>
</tbody>
</table>

Within column means per site followed by the same letter were not significantly different from each other at $P < 0.05$ following pair-wise comparisons. $N =$ number of fields visited per season. BA: dry season between rainy seasons A and B.

Table 4  Number of stem borers in relation to sites (mean ± SE).

<table>
<thead>
<tr>
<th>Site</th>
<th>Infestation (%)</th>
<th>B. f</th>
<th>S. c</th>
<th>E. s</th>
<th>M. n</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangoka (N = 8)</td>
<td>17.7 ± 9.8a</td>
<td>1.6 ± 0.6a</td>
<td>1.0 ± 0.7a</td>
<td>7.6 ± 6.7a</td>
<td>2.4 ± 1.4a</td>
<td>0.5 ± 0.3a</td>
</tr>
<tr>
<td>Batiafeke (N = 9)</td>
<td>7.3 ± 2.2a</td>
<td>0.4 ± 0.4a</td>
<td>5.8 ± 3.1a</td>
<td>0.2 ± 0.2a</td>
<td>0°</td>
<td>0.1 ± 0.03a</td>
</tr>
<tr>
<td>Mobi (N = 7)</td>
<td>46.8 ± 14.9b</td>
<td>5.4 ± 2.5b</td>
<td>0a</td>
<td>27.6 ± 15a</td>
<td>3.0 ± 1.8a</td>
<td>1.4 ± 0.6a</td>
</tr>
<tr>
<td>Total (N = 24)</td>
<td>22.3 ± 6.2</td>
<td>2.0 ± 0.7</td>
<td>2.7 ± 1.4</td>
<td>9.2 ± 4.5</td>
<td>1.5 ± 0.7</td>
<td>0.6 ± 0.2</td>
</tr>
</tbody>
</table>

Within column means per site followed by the same letter were not significantly different from each other at $P < 0.05$ following pair-wise comparisons. $N =$ number of fields visited per site.

Several workers reported infestations by *B. fusca* starting in the vegetative stage of maize during which some plants perish (dead heart) [16, 26]. In addition, our data suggest the development of two generations of *B. fusca* during a cropping cycle. Thus, this species is expected to play the most important role in maize infestation in the study area.

3.4 Importance of Stem Borers in Relation to the Sites

Abundance of *B. fusca* in Mobi was significantly different from Batiafeke ($U = 2.000$, $P = 0.004$). Infestation rate between the two sites was also significantly different ($U = 6.000$, $P = 0.005$). By contrast, the difference was not significant for the population density of *S. calamistis* ($H = 3.244$, $df = 2$; $P = 0.197$), *E. saccharina* ($H = 4.627$; $df = 2$; $P = 0.099$), *M. nigrivenella* ($H = 5.921$; $df = 2$; $P = 0.052$) and the mean density of stem borers among the three sites ($H = 5.300$; $df = 2$; $P = 0.071$) (Table 4).

Although vegetational composition was not measured during present study, this factor is thought to be responsible for the difference in *B. fusca* abundance between sites. While the vegetation in Batiafeke was dominated by grasses, secondary forest was the main vegetation type in Mobi. As hypothesized by Ndemah et al. [10], low grass abundance should favor *B. fusca*. This species enters diapause in the larval stage inside maize stem during the dry season. By contrast, grassy habitats should favor non-diapausing species such as *S. calamistis* that switches to wild hosts in absence of maize. As such, the ongoing anthropization of the lowland forest in DRC is expected to shape cereal stem borers populations as it leads to a change in the vegetation composition.

4. Conclusions

This study represents a pioneer account of the cereal stem borers in the forest zone of DRC. It was designed to document the composition of lepidopteran stem borer community on maize and two selected wild host grasses in the region of Kisangani. Five species were recovered from maize, namely, *B. fusca*, *M. nigrivenella*, *S. calamistis*, *E. saccharina* and *Chilo* sp.. Regarding wild host plants, *P. serrata* was identified on *P. purpureum* while *Chilo* sp. was identified on *P. maximum*. To date, this list is considered as provisional. Given the high biodiversity pertaining to the Congo Basin, the ongoing study is expected to bring more information on the maize stem borer community diversity.
Acknowledgments

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References


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Stemborer Pests along Altitudinal Gradient in Kenya.”


