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Spatial and Agronomic Stage Distribution Dynamics of Maize Stem Borers (Lepidoptera) in the Agricultural Development Zone B of Niger State, Nigeria

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Abstract

Maize farmers in Nigeria have been facing challenges as efforts towards the cultivation of maize is seriously hampered by insect pest infestation in maize fields, of which stem borers are a major culprit. The study was carried out to identify the species of stem borers present and their abundance in Agricultural development Zone B of Niger State. Farm sites located in Beji, Chanchaga, Paiko and Shanu, were selected and sampled for stem borers, during vegetative, reproductive and harvest stages of the field maize crops. Identification was done using standard taxonomic keys. The results indicated the presence of three species of stem borer belonging to three families. A species each from Noctuidae, Crambidae and Pyralidae consisting of Busseola fusca (n = 1639, 68.24%), Chilo partellus (n = 160, 6.66%) and Eldana saccharina (n = 603, 25.10%) respectively. Generally, all sites had two species of the stem borer (B. fusca and E. saccharina) present in all growth stages of the maize plant during the destructive sampling with the exception of Chilo partellus that was rarely found; occurring only in one site (Beji), all amounting to a total of 2402 stem borers collected during the study period. Among all the growth stages of the maize plants in all sampled sites the level of infestation varied significantly ($p < 0.05$), in an increasing order: vegetative stage < reproductive stage < harvest stage of the maize plants. The findings of this study suggest that there is a serious stem borer pest infestation in the maize farms of Agricultural development Zone B of Niger state that could pose threats to maize (Zea mays) production in the area; thus, requiring urgent interventions on the parts of all stakeholders.

Keywords: Farmers, Maize, Stem borers, Maize crop stage,

INTRODUCTION

Nigeria is currently the tenth largest producer of maize in the world, and the largest maize producer in Africa (IITA, 2012). It is estimated that seventy percent of the farmers are

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smallholders, accounting for 90 percent of total farm output (Cadini and Angelucci, 2013). About 17.5% increase in yield between 2000 and 2011 was the estimated figure for its production in 2011 (Ekoja *et al*., 2015), which is very disappointing from other nations of the World, despite the availability of large arable land in Nigeria.

The importance of maize (*Zea mays*) cannot be over emphasized and its production, whether for exportation or as subsistence farming makes the demand for maize high. It is a multipurpose crop with great nutritional value for human consumption, fodder for livestock, raw material for biofuel and in agro allied industries. The plant is also used as raw materials for food and non-food products (Siddalingappa *et al*., 2010; Ekoja *et al*., 2015). The utilization of maize as a staple food in making various meals in the different agro-ecological regions of Nigeria is as old as the country itself and the ever increasing number of its citizen has resulted to serious demand in production (Ekoja *et al*., 2015).

Maize crop which started as a subsistence crop in Nigeria, has gradually risen to a large scale commercial crop, on which many agro-based industries depend (Iken & Amusa, 2014). Even though majority of the cultivators are household farmers up until now. Maize farmers in Nigeria still encounter challenges, as efforts in the cultivation of maize is seriously hampered by both abiotic and biotic factors which result in poor yield (Ebenebe *et al*., 2013; Dejen *et al*, 2014; Aziz *et al*., 2017). Attributed to such disheartening situation is the insect pest infestation of maize fields, of which the stem borer species are a major culprit, severely affecting the production of maize (Lucius & Oniemayin, 2011). The stem borer, belonging to the family Lepidoptera, have been reported to cause significant damages to crops and this is unacceptable to farmers irrespective of the farmer being into household or commercial (large scale) farming. The common species infesting maize in Nigeria include: *Busseola fusca* Fuller (Noctuidae), *Eldana saccharina* Walker (Pyralidae), *Sesamia calamistis* Hampson (Noctuidae), *Chilo partellus Swinehoe* (Cambridae) and *Acigona ignefusalis* Hampson (Pyralidae) (Ekoja *et al*., 2015).

Although, some species like *Busseola fusca* (Lepidoptera: Noctuidae), *Eldana saccharina* (Lepidoptera: Pyralidae), *Sesamia calamistis* (Lepidoptera: Noctuidae), and the invasive *Chilo partellus* (Lepidoptera: Crambidae) are found throughout sub-Saharan Africa (Polaszek & Khan 1998; Overholt *et al*., 2001; Ong'amo *et al*., 2006), their pest status may significantly vary depending on the regions (Ong'amo *et al*., 2006). Studies have shown that populations of stem borers in Eastern and Southern Africa appear to be adapted to different environments from those in West Africa (Tekle, 2016). In the Eastern and Southern parts of the continent, *B. fusca*, just like some other species of stem borers, is restricted to mid-and high elevations areas (>600m), whereas in West Africa, the same species may be found in all elevations, as well as it been abundant in the Savanna Zone (Overholt *et al*., 2001; Tekle, 2016). Stem borer attack results in significant yield losses ranging from 10 to 88% (Kfir *et al*., 2002) of the potential grain output, depending on pest population density and phonological and/ growth stage of the crop at infestation (Midega *et al*., 2015)

Stem borer pest activities, therefore, constitute a major setback faced by maize farmers and the use of pesticides, even though had been discouraged, it is still the most common method of control used by maize farmers. Recently, habitat management techniques and integrated approach have been recommended (Chabi-Olaye *et al*., 2005; Wale *et al*., 2006; Tekle, 2016) to improve total productivity and control of cereal stem borers. However, to fully establish these control methods the identity of the stem borers present on the field is highly paramount. It is imperative that to put in place an integrated pest Management, the very first step of approach

is to assess the diversity, spatial distribution, relative abundance of the pest and, thereafter, determine the pest status of the targeted insect.

Currently, there are no recent scientific information on the identity of maize stem borers in agro-ecological zone B of Niger State. This study was, therefore, designed to elucidate stem borer species compositions and its relative abundance on infested maize crops in agro-ecological zone B of Niger State.

Materials and Methods

Description of study area

Niger state is one of the states in the North central region of Nigeria, it lies on latitude 3.20^0 east and longitude 11.30^0 north. The state is one of the largest in terms of land mass in Nigeria and has a land area of about 86,000sqkm, which represents 9.30% of the total land area of the Country with 85% arable land .The state has a tropical climate with mean annual temperature and relative humidity of 30.20^oC and 61.00% respectively. The climate presents two distinct season, a rainy season between May and October and a dry season between November and April with annual rainfall varying from 1,100mm and for 150 days in the northern part to 1,600mm and also 120 days in the southern part (Olayemi *et al*., 2009). The soil types are two: the Ku soil which has little erosion hazard and the Ya soil which has better water holding capacity. The major tribes in Niger state are Nupe, Gbagyi and Hausa. Generally, the major occupation of Niger state populace is farming, the fertile soil and hydrology of the state permits the cultivation of most of Nigeria's staple crops and still allows sufficient opportunity for grazing and fresh water fishing (Ismaila *et al*., 2010). The crop production output cuts across all crop horizons including food and cash crops, and the major ones being rice, sorghum, maize, millet, groundnuts, cowpeas, soybean, sesame, cotton, yam, cassava, sweet potatoes, sugarcane, melon and vegetables of all kinds (Ismaila *et al*., 2010). The annual production of the major fadama crops such as rice, maize, sugarcane and assorted vegetables over the year is estimated to be over 200,000 metric tons among others, however, these annual crop production outputs remains very low compared to the state potentials. The most important cereals grown in Niger state are sorghum, maize, sugarcane, rice and millet (Ismaila *et al*., 2010).

Description of Farm Sites

The State comprises of 25 Local Government Areas (LGA), which is further divided into three Agricultural Development Zones (ADZ) A, B and C with each zone having 8, 9 and 8 LGAs respectively, taking into account the diversity in agro climatic features. All the sampling stations were located in Agro-ecological zone B for ease of sampling, and for security purposes as farmers and herdsmen crisis were prominent at the time of the study, in Zones A and C. Four localities were randomly selected in the zones (Beji, Chanchaga, Paiko and Shanu). Each locality had 2 sampling stations and the selected farms had sizes not more than 2.0 acres (Aziz *et al*., 2014). The farms selected were easily accessible and the farmers' consents were duly obtained and even they were adequately compensated for any destruction caused on the maize stems by sampling procedures.

Beji is located North-West along Minna – Maikunkele – Kagara road the sample station is about 8.63km from FUT Minna. Chanchaga Located North east of agro-ecological zone B. Where the sample station is situated is 11.01km away from Federal University of Technology Minna (FUT) the central reference point of this study in Minna metropolis. Paiko sample station has a distance of 24.16km from FUT Minna located north east of agro ecological zone B. Shanu is about 4.45km from FUT in Minna metropolis.

Collection of Maize Plants and Stem Borer Specimens

In each farm, four experimental plots of 3m x 3m was randomly designated in a zig-zag pattern (Dejen *et al.*, 2014). Sampling was done only in the mornings between the hours of 0800 and 1100 hours, during the vegetative, reproductive and harvest stages of the maize plants.

Five plants from each plot were randomly selected making a total of 20 maize stands from each field, after been recognized as infested with the presence of the entry and exit holes on the stem. The plants were then uprooted, cut opened immediately on the field with the aid of well sharpened kitchen knife (Tounou *et al*., 2013).

Handling and Identification of Stem Borer Specimens

Stem borers species present were then collected in clean labelled sterile bottles containing 70% alcohol, from where the stem borers collected were later retrieved, carefully counted and identified (Tounou *et al*., 2013; Rahaman *et al*., 2014).

Identification was done using stereo binocular microscope and with the aid of keys as described by Overholt *et al*. (2001) and also based on the morphology proposed by Meijerman and Ulenberg (1996). Half-grown or fully grown larvae (3^{rd} – 6^{th}) were the easiest to identify based on the position and presence of pinacula, the presence of asetose tubercles and the arrangement of crochets on the prolegs (Meijerman & Ulenberg, 1996; Overholt *et al*., 2001).

Data Analysis

Data on collected samples from the plots in a site were pooled together to show species encountered while, species relative abundance was calculated and expressed as simple percentages. Chi square analysis was used to determine the frequency of distribution in mean densities of the stem borer species with respect to collection site and agronomic stage. P value less than 0.05 was employed to establish if the frequencies are significantly different. Microsoft excel 2010 and Statistical Package for Social Sciences 20^{th} version were used.

Results

The species of stem borers found on maize farms in the study sites of agro-ecological Zone B of Niger State were *Eldana saccharina* (top), *Chilo partellus* (bottom), (Plate1) and *Busseola fusca* (Plate II). The plates show distinct morphological differences of the stem borer species obtained from the maize plants.

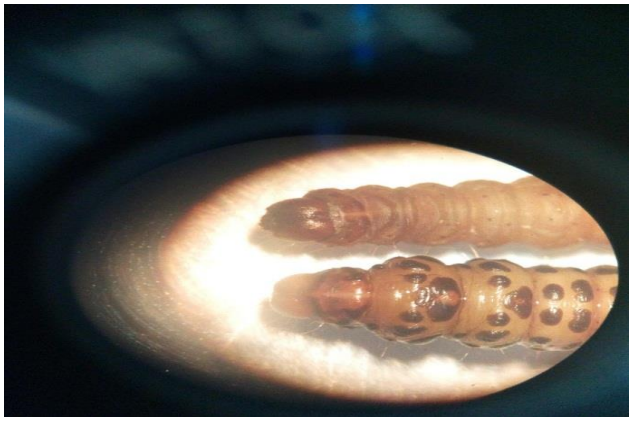

Plate I: External features of the anterior end of stem borer species: *Eldana saccharina* (top) and *Chilo partellus* (bottom), from Agricultural Zone B of Niger state, Nigeria

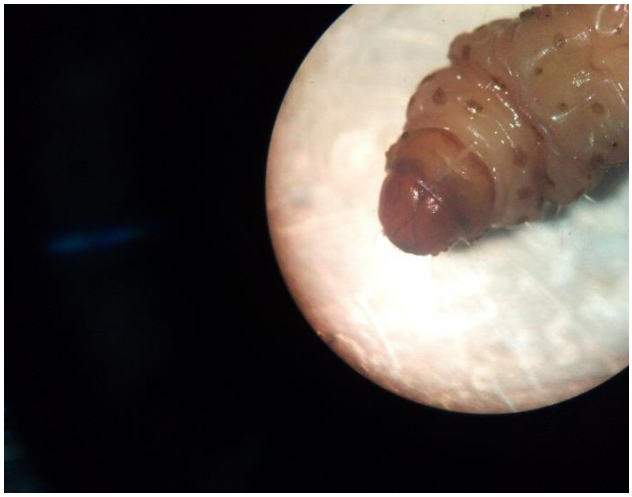

Plate II: External features of the anterior end of stem borer species: *Busseola fusca* from Agricultural Zone B of Niger state, Nigeria

A total of 2402 stem borer specimens were retrieved from the sampling sites in the study area during the study period. The stem borers collected belonged to three families namely, Noctuidae, Crambidae and Pyralidae, with each family represented by one species, in order of relative abundance: *Busseola fusca* (n = 1639, 68.24%), *Chilo partellus* (n = 160, 6.66%) and *Eldana Saccharina* (n = 603, 25.10%), respectively (Table 1**)**.

Table 1: Stem borer species composition and relative abundance infesting maize plants in agricultural development zone B of Niger state, Nigeria

Family	Species	No. collected	Relative Abundance (%)
Noctuidae	*Busseola fusca*	1639	68.24
Crambidae	*Chilo partellus*	160	6.66
Pryalidae	*Eldana saccharina*	603	25.10
Aggregate		2402	100

Generally, all sites had two of the stem borers (i.e., *B. fusca* and *E. saccharina*) present in all growth stages of the maize plants during the destructive sampling while *Chilo partellus* was rarely found, occurring in only one out of the four sites sampled. With respect to growth stages of the maize plants, in all sampled sites the disparity in abundance of the stem borer species varied significantly during the vegetative stage of the maize plants. While, Beji site had all three (3) stem borer species present (*Busseola fusca*, *Chilo partellus* and *Eldana saccharina*), all other sites had two (2) species with the exception of Shanu that recorded only one species (*Busseola fusca*) (Table 2). There was significant variations in the percentage abundance across the sites of Agro Ecological Zone B of Niger state (df = 3, X^2cal = 103.6, $p < 0.05$) and (df = 3, X^2cal = 58.1, $p < 0.05$) for *Busseola fusca* and *Eldana saccharina*, respectively (Table 2). On the other hand, the spatial distribution of *Busseola fusca* was highest in Beji Site (n = 158, 34.96%), followed by Paiko (n = 149, 32.96%), then Chanchaga (n = 123, 27.21%) and the lowest been Shanu (n = 22, 4.87%). *Eldana saccharina* was not encountered in Shanu, but its spatial distribution was highest in Beji (n = 56, 50.45%), followed closely by Chanchaga (n = 34, 30.63%) and the lowest encountered was in Paiko (n = 21, 18.92%) (Table 2).

Table 2: **Relative abundance of stem borer species of maize plants during vegetative growth stage in agricultural development zone B, Niger state, Nigeria**

Sampling Sites	*Busseola fusca* (%)	*Chilo partellus* (%)	*Eldana saccharina* (%)	Aggregate (%)
Beji	158(34.96)*	28(100)	56(50.45)	242(40.95)
Chanchaga	123(27.21)	0 (0.00)	34(30.63)	157(26.57)
Paiko	149(32.96)	0 (0.00)	21(18.92)	170(28.70)
Shanu	22(4.87)	0 (0.00)	0(0.00)	22(3.72)
Aggregate	452(100)	28(100)	1 11(100)	591(100)
Chi-square	103.56	0.000	58.12	
df	3	0	3	
Pr > chisq <	0.05	0.05	0.05	

*Values in parenthesis are the percentage abundance

The relative abundance of the stem borer species during the reproductive stage is detailed in Table 3. On the general note, the abundance of the stem borer varied significantly at $p< 0.05$ among the sampling sites. *Busseola fusca* was the highest in Beji (n = 205, 41.6%), followed by Chanchaga (n = 144, 28.92%) which was not the case during the vegetative stage in Table 2. While Paiko had (n = 111, 22.29%), the least was Shanu with (n = 38, 7.63%) (Table 3). *Eldana saccharina* was highest in Beji, followed by Chanchaga then Paiko and the least encountered in Shanu, n = 82 (44.32%), n = 58 (31.35%), n = 30 (16.22%) and n = 15 (8.71%), respectively (Table 3). The relative abundance observed was significantly different at $p < 0.05$, df = 3 (X^2cal = 116.7 and X^2cal = 57.4) for *Busseola fusca* and *Eldana saccharina*, respectively (Table 3).

Table: 3 **Relative abundance of stem borer species of maize plants during reproductive growth stage in agricultural development zone B, Niger state, Nigeria**

Sampling Site	*Busseola fusca* (%)	*Chilo partellus* (%)	*Eldana saccharina* (%)	Aggregate (%)
Beji	205(41.16)*	54(100)	82(44.32)	341(46.39)
Chanchaga	144(28.92)	0 (0.00)	58(31.35)	202(27.48)
Paiko	111(22.29)	0 (0.00)	30(16.22)	141(19.18)
Shanu	38(7.63)	0 (0.00)	15(8.71)	53(7.21)
Aggregate	496(100)	54(100)	185(100)	735(100)
Chi-square	116.67	0.000	57.44	
df	3	0	3	
Pr > chisq <	0.05	0.00	0.05	

*Values in parenthesis are the percentage abundance

Stem borer species relative abundance on maize plants during the harvest life stage of maize plants in agricultural development zone B of Niger State in Table 4, showed that Beji maintained the lead at all times with respect to the spatial distribution of the stem borer species recorded. The stem borer species spatial distribution trend was in the following order of decreasing abundance: Beji > Chanchaga > Paiko > Shanu. While, n = 258 (37.45%) > n = 190 (27.58%) > n = 145 (21.04%) > n = 96 (13.93%) was recorded for *Busseola fusca*, and n = 122 (39.74%) > n = 89 (28.99%) > n = 56 (18.24%) > n = 40 (13.03%), respectively was recorded for *Eldana saccharina* from the sampling sites (Table 4). There was significant difference in the densities of *Busseola fusca* and *Eldana saccharina* among the sites (df = 3, X^2cal = 82.6, $p < 0.05$ and df = 3, X^2cal = 51.8, $p < 0.05$, respectively).

Table: 4 **Relative abundance of stem borer species of maize plants during harvest life stage in agricultural development zone B, Niger state, Nigeria**

Sampling Site	*Busseola fusca* (%)	*Chilo partellus* (%)	*Eldana saccharina* (%)	Aggregate (%)
Beji	258(37.45)*	78(100.00)	122(39.74)	458(42.64)
Chanchaga	190(27.58)	0 (0.00)	89(28.99)	279(25.98)
Paiko	145(21.04)	0 (0.00)	56(18.24)	201(18.72)
Shanu	96(13.93)	0 (0.00)	40(13.03)	136(12.66)
Aggregate	689(100)	78(100)	307(100)	1074(100)
Chi-square	82.58	0.000	51.84	
df	3	0	3	
Pr > chisq <	0.05	0.00	0.05	

*Values in parenthesis are the percentage abundance

Chilo partellus was recorded in Beji alone and its relative abundance varied significantly during the vegetative, reproductive and harvest stages of the maize plants, in the following increasing order: n = 28 (17.50%) < n = 54 (33.75%) < n = 78 (48.75%) respectively (Tables 2, 3 and 4).

Discussion

The species of stem borers collected in this study confirmed several reports which have indicted that the insect is an economically important pest of maize in Nigeria and Africa as a whole. According to Ong'amo *et al*. (2016), *B. fusca* and *C. partellus,* among other stem borers such as *S. calamistis* (Iliassa *et al*.,, 2015), have a great economic impact in maize cultivation in most countries of Africa. It was also earlier reported by Natural Resources Institutes (NRI) (1996), Polaszek & Khan (1998), and Okweche & Umoetok (2012) that *B. fusca*, *S. calamistis*, *C. partellus*, *E. saccharina* and *C. ignefusalis* are the most important and widely distributed lepidopterous stem borers in Nigeria. Rahaman *et al.* (2014) also mentioned in his study that 42% of the 76 field investigated were infested with stem borers, where *Busseola fusca* and *Chilo partellus* were the most injurious.

Busseola fusca which is native to Africa and often considered the most important field pest of cereals in sub-Saharan Africa (Sylvain & Tuarira, 2015), is further confirmed in this study, as it was the most abundant species encountered in all four sampling sites. In Cameroon, it was also the most predominant borer species, accounting for more than 90% of all species across

all eco-zones and altitudes (Sylvain & Tuarira, 2015). The fact that *Chilo partellus* is an invasive pest and a highly competitive species, may be the reason why it was found in just one location (Beji) in this study. *Chilo partellus* is considered to be excessively damaging, showing a relative abundance of 100% and a maximum high infestation in maize fields where encountered (Aziz *et al*., 2017).

The present study reported a situation where not all stem borer species were encountered in a particular farm. This observation is similar to the results of Aziz *et al*. (2017) who also encountered three (3) Lepidoptera stem borer species but had situations where only one species was found in a station. Also, the fact that these stem borer species were often observed in mixed populations in the same plant or field as well as in individual fields / plants was also implicated as reported by Catalayud *et al*., (2014).

The species type encountered in this study did not conform to the study of Okweche and Umoetok (2012) in Cross Rivers State, Nigeria where more stem borer species were encountered than this study (5 species), even though *Busseola fusca* was still the most abundant and, *Eldana saccharina* and *Chilo partellus* were also reported. Furthermore, Ekoja *et al*. (2015) reported to have encountered five (5) species from three (3) maize types in Makurdi, Southern Guinea Savanna Agriculture Eco Zone of Nigeria and three (3) species from Abeokuta Rainforest AEZ of Nigeria, where *B. fusca* was consistently the most abundant borer species. Reasons for disparity in species type may be due to the region of the country and differences in the ecotypes of the study areas.

A study carried out in Democratic Republic of Congo by Kankonda *et al.* (2014), reported that abundance of borers varied through the three stages of maize development (pre-tasseling, reproductive and senescence). The results obtained by the authors revealed that stem borer presence suggests the development of multiple generations during the maize crop cycle. At senescence, *E. saccharina* was the most abundant species (79%) towards the end of the growing cycle, indicating that *E. saccharina* may have started infesting maize after anthesis (flowering), while *B. fusca* and *S. calamistis* infested young maize plants (tassels and other fresh plant parts) and were present throughout the cropping season (Kankonda *et al*., 2014). According to Rahaman *et al*. (2014), the population density of borer pest complex in different growth stages of the rice plant revealed that stem borer infestation was lowest in seedling stage of rice as against other stages; with larval density varying between crop stages of sampled periods.

Larval species encountered in this study did vary among the sampling sites in diversity and abundance, which also concurred with other studies that indicated high disparity in larval densities among different districts of their sampling stations (Ong'amo *et al*., 2014; Dejen *et al*., 2015; Ekoja *et al*., 2015).

Conclusion

This study was undertaken to provide information on the identity of stem borer species of maize in agricultural development zone B of Niger State, Nigeria. The results obtained revealed that *Busseola fusca*, *Chilos partellus* and *Eldana saccharina* are present on the maize farms sampled, with *B. fusca* been the most abundant species. Also, significant spatial and species variations did occur among the sampling sites, the species were relatively abundant in increasing order from vegetative to reproductive to harvest stages of the maize plants. While further studies should be conducted to estimate the extent of stem borer damage to maize plants in the zones, similar studies should be conducted in other agro ecological zones of Niger State.

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