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Larval of Abundance and Infestation of Fall Armyworm (*Spodoptera frugiperda* J. E. Smith) on Maize in Edo State, Nigeria

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Abstract
The fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) invaded many parts of Nigeria including Edo State in 2016, causing substantial damage to maize. Since its observation in the State, no quantitative information on the pest is available. This study was therefore carried out to provide some baseline information on the abundance and infestation rate of FAW on maize in Edo State. Sampling for larval abundance and infestation level on maize farms was done in the early and late maize cropping season of 2019 in Edo South, Edo Central and Edo North agro-ecological zones (AEZs) of the state. Data was analysed using non-parametric Analysis of Variance (ANOVA) and correlation. Results showed that in the early season, mean larval abundance ranged from 5.83±3.76 in Edo Central to 8.25±3.45 in Edo South and mean percentage infestation ranged from 49.17±23.96% in Edo Central to 66.67±8.76% in Edo North while in the late maize cropping season, mean larval abundance and mean percentage infestation was 1.00±1.41 and 10.00±11.55% in Edo Central and 2.50±3.39 and 16.67±20.90% in Edo South respectively. These values were not significantly different ($P<0.05$) in the three AEZs but were significantly different ($P>0.05$) in the early and late cropping seasons. There was a positive correlation between larval abundance and percentage infestation. FAW was present wherever maize was grown in the three AEZs of the State, and infestations were more in the early season which is the main cropping season for maize in Edo State.

Keywords: Fall armyworm, maize, agroecological zone, cropping seasons

Introduction

Maize (*Zea mays* L), is a major cereal and one of the most important food crops in Nigeria. It serves as a staple food which is consumed in different forms: roasted, baked, fried, pounded or fermented (Agbato, 2003). It also serves as raw material in the breweries and Livestock feed manufacturing Industry. Nigeria is the second largest maize producer in Africa, after South Africa, with an estimated 10.79 million MT produced in 2014 (FAOSTAT, 2014). It is cultivated in the rainforest and the derived savannah zones of the country. Maize is produced in virtually all the states in Nigeria including Edo State. Maize production is affected by a number of abiotic and biotic factors. One of the limiting factors of maize production is insect infestation. Various insects are known to attack maize. These include stem borers, earworms, aphids, leaf-eating beetles, grasshoppers and armyworm. Armyworm is a common early-season pest that can cause occasional losses in maize. The most common species of armyworm found in Nigeria is the African armyworm (AAW), *Spodoptera exempta* (Walker) (family: Noctuidae, order: Lepidoptera). Outbreaks of armyworm usually begin at the onset of raining season after a long period of drought. Recently, the presence of another species of armyworm in the genus *Spodoptera*, the fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) invaded Africa causing substantial damage to maize and other crops. It is native to the tropical regions of the Western Hemisphere from the United States to Argentina. *S. frugiperda* is believed to have been introduced to the continent through imported produce. Since its introduction, it has spread to 44 countries in sub-Saharan Africa (Prasanna *et al*., 2018). In Nigeria, the first observation on fall armyworm attacks was made on maize plants in the rain forest of South West Nigeria in late January 2016 and in IITA maize fields in Ibadan and a farm in Ikenne. In early June 2016, the Federal Government of Nigeria raised an alarm on the emergence of armyworm upsurges in maize fields in

Edo State, Nigeria (IITA News, 2016). While FAW has a preference for maize, it can also affect many other major cultivated crops, including sorghum, rice, sugarcane, cabbage, beet, groundnut, soybean, Potato, alfalfa and cotton (Day, *et al.,* 2017; FAO, 2018; Prasanna *et al.,* 2018). Damage is caused by the larvae. During the maize vegetative phase, constant feeding by the larvae results in skeletonized leaves and heavily windowed whorls loaded with larval frass. Infestations during the mid-to-late corn stage may result in yield losses of 15-73% when 55-100% of the plants are infested (Hruska and Gould, 1997). Nigeria appears at risk of suffering increased pest outbreaks given their environmental suitability for FAW, or the relative proportion of maize grown in suitable areas. The presence of FAW in Edo agroecosystem could result in serious damage to maize production and thus affect the livelihood of the people. Since its observation in Edo State, no quantitative information on the pest is available. This study attempts to provide baseline information on the abundance of this species and the level of infestation in the State which could inform proper management decisions.

Materials and Methods

Study Area

Edo State lies between 5°05' and 6°40' E and 5°15' and 7°34' N and elevations between 500 feet (150m) in the south and more than 1800 feet (550m) in the north. To conduct the survey, proportionate sampling of ten (10) out of the eighteen (18) Local Government Areas (LGAs) in the State was carried out across the three (Edo South, Edo Central and Edo North) agro-ecological zones. Four Local LGAs in the south, three LGAs in the north, and three LGAs in the central zone (Fig. 1). Ten (10) farms were identified in each LGA and out of these; two farms were randomly sampled. In total, 20 farms were sampled in10 LGAs across the three agro-ecological zones in the early season viz: Ikpoba-Okha LGA (Aduwawa: 6°21′.724″N, 5°40′.232″E, Urora, 6°22.659′N, 5°41.139′E), Uhunmwode LGA (Urhokosa, 6°26′25.60″N, 5°47′31.04″E, Iguozebaru, 6°29′13.66″N, 5°50′21.08″E), Ovia North-East LGA (Iguosa, 6°26′14.90″N, 5°35′01.37″E, Uwan, 6°26′07.06″N, 5°37′38.33″E), Egor LGA (Iyoba College, 6°22′21.16″N, 5°36′58.29″E, Eweka, 6°23.073′N, 5°38.045′E), Esan-West LGA (Idumwinge, 6°30′.501″N, 6°12′.159″E, Idunmwinge-Eguare, 6°30′.704″N, 6°12′.136″E), Igueben LGA (Ojomo Quaters, 6°36′.813″N, 6°14′.773″E, Ekekhen Quaters, 6°36′41.31″N, 6°14′27.79″E), Esan-Central LGA (Umelen-Ugbegun, 6°38′.934″N, 6°15′.045″E, Umelen-Idumwun, 6°38′07.72″N, 6°14′46.48″E), Owan-West LGA (Ovieokhuan, 6°55′17.25″N, 5°56′16.57″E, Uhumora-Ora, 6°51′34.50″N, 5°57′27.50″E), Owan-East LGA (Ugbebe, 6°59′54.23″N, 6°4′05.91″E, Okhumore-Afuze, 6°59′33.39″N, 6°3′22.30″E), and Estsako-West LGA (Okhuroba, 6°59′33.39″N, 6°3′22.30″E, Uguanikhua, 6°59′33.39″N, 6°3′22.30″E), while only 11 farms in 8 LGAs across the three agroecological zones were available for sampling in the late season viz: Ikpoba-Okha LGA (Aduwawa, 6°21′.724″N, 5°40′.232″E, Urora, 6°22′.15.94N, 5°41′.16.65E), Uhumwode LGA (Urokhosa, 6°26′25.60″N, 5°47′31.04″E, Iguozevbaru, 6°29′13.66″N, 5°50′21.08″E), Ovia North-East LGA (Iguosa, 6°26.216′N, 5°35.358′E), Egor LGA (Iyoba College, 6°22.904′N, 5°37.591′E), Esan-West LGA (Idumwinge-Eguare, 6°30.704′N, 6°12.136′E), Igueben LGA (Ojomo Quarters, 6°36.856′N, 6°14.717′E, Ekekhen Quarters, 6°37.077′N, 6°14.493′E), Esan-Central LGA (Umelen-Ugbegun, 6°38.934′N, 6°15.045′E), and Owan-East LGA (Ugbebe, 6°59.976′N, 6°03.702′E). The climate in the State is tropical, and primarily regulated by rainfall. The average daily temperature is about 27°C. The wet and dry seasons are April – October and November – March respectively. Annual rainfall in the northern part of the State occasionally exceeds 2000mm and ranges from 1800mm to 2780 mm in the southern part of the State (Emeribe *et al.* 2016). The wet season has double rainfall peaks during July and October with a short break in rainfall called "August break" in between the peaks. The study was conducted in the early maize cropping season (April – July, 2019) and late maize cropping season (August- November 2019).

Sampling Methods and Data Collection

Field surveys were carried out in the morning from 7.00 hours to 11 hours or in the evening from 16.00 hours to 19.00 hours. In each farm, 100 maize stands were mapped out from which 20 plants were randomly sampled for abundance of FAW larvae and level of infestation. The sampled maize plants were from the early whorl stage to the late whorl stage. Rows of plants at the boarder of the field were excluded to avoid boarder effect. Live larvae were counted to determine larval abundance and preserved in 70% ethanol for identification. Data on the presence of fresh frass or live larvae in the leaf funnel and fresh foliar damage (irregular damage cuts on first 2-3 leaves) were recorded; these were used to calculate percentage infestation in the farm. Percentage infestation was calculated as follows:

% of FAW Infested plants = Number of Infested plants/Total number of plants × 100 (Prasanna *et al.,* 2018)

Identification

Larval samples collected were identified at the Department of Crop Science Entomology Laboratory using morphological keys by (Prasanna *et al.,* 2018). Larval specimens were examined under the microscope to reveal the inverted Y-Shape in the head capsule and the set of four dots forming a square on the upper surface of the last abdominal segment that is characteristic of *Spodoptera frugiperda*.

Data Analysis

FAW larval abundance and percentage infestation in the farms in each agro-ecological zone in the early and late maize cropping season were analysed using Kruskall Wallis non-parametric independent sample analysis. Spearman correlation was used to compare larval

abundance with percentage infestation. Observations were considered significant at p<0.05. All tests were performed using SPPS (16.0).

Results and Discussion

FAW incidence in the Agroecological zones

This study aimed to investigate the abundance and infestation rate of fall armyworm, *Spodoptera frugiperda* on maize in Edo State. Results revealed that *Spodoptera frugiperda* was present in all the farms surveyed across the three agro-ecological zones (AEZs) of the State in the early maize cropping season with mean larval abundance ranging from 5.83±3.76 in Edo Central AEZ to 8.25±3.45 in Edo South AEZ (Fig. 2a) and mean percentage infestation ranging from 49.17±23.96% in Edo Central AEZ to 66.67±8.76% in Edo North AEZ (Fig. 3a). These values were however, not significantly different in the three AEZs for larval abundance ($\chi^2(3) = 1.663$, $p>0.05$) and percentage infestation ($\chi 2(3) = 2.153$, $p>0.05$) respectively. In the late maize cropping season, *Spodoptera frugiperda* presence was recorded only in Edo South and Edo Central AEZs with mean larval abundance of 1.00±1.41 in Edo Central and 2.50±3.39 in Edo South (Fig. 2b) and mean percentage infestation of 10.00±11.55% in Edo Central and 16.67±20.90% in Edo South. (Fig. 3b). These values for larval abundance and percentage infestation also did not differ significantly ($\chi 2(3) = 1.431$, $p>0.05$) and ($\chi 2(3) = 1.198$, $p>0.05$) respectively between the zones. There was no infestation in the farm visited in Edo-North in the late season. This is similar to reports by Koffi *et al.,* 2020 in a study conducted in Togo and Ghana which revealed little or no difference in larval abundance or infestation levels across the agroecological zones. However, FAW infestation varied within locality in a study by Toumnou *et al.,* 2018 to assess the FAW infestation in one part of Central African Republic. They recorded FAW incidence ranging from 20% to 80%. There was a decreasing trend of FAW incidence from the humid forest zone towards the Sahelian zone. In another study on *Spodoptera frugiperda* infestation in Nigeria by Odeyemi, *et al.,* 2020, FAW infested fields were reported in some South-Western states in Nigeria of varying damage severity; with Ogun, Oyo and Ondo States recording the highest percentage of severely affected fields (high to very high). Fotso Kuate *et al.* (2019) reported the presence of *S. frugiperda* in 10 regions of Cameroon, with incidence ranging from 22.9±5.7% in the Far North region recorded during the second survey, to 79.2±3.4% in the West region during the third survey. They recorded a greater number of larvae per field in the West region (20.1±2.30) followed by the East (15.9±2.45) and the Northwest (15.3±2.14), while the lowest number of larvae was recorded in the Far North region (6.59±1.39).

FAW incidence in the cropping seasons

Though larval abundance and percentage infestation did not differ significantly in the three AEZs, there was, however, a significant difference in larval abundance ($\chi 2(3) = 12.076$, $p=0.001$) and percentage infestation ($\chi^2(3) = 11.667$, $p=0.001$) in both cropping seasons. As seen from Fig. 4 higher values were recorded in the early maize cropping season than in the late maize cropping season for mean larval abundance and percentage infestation. This difference in FAW incidence in early and late cropping season might be due to the proportion of maize grown in both seasons. Edo State is characterized by a bimodal rainfall pattern with peaks during July and October. Yields decline with the lateness of planting after an optimum time, usually the start of the rains (Iken and Amusa, 2004). The optimum planting time in the state is April to May in Edo South and Edo Central and May to June in Edo North as such maize cultivation in the State begins at the onset of the rainy season and stops around July when the volume of rainfall is at its peak. This means most of the maize farming in the state is done in the early season and this is why fewer farms were available for sampling during the late cropping season. Extensive maize cultivation in the early season in the three agroecological zones may have facilitated the higher populations observed. The difference in FAW infestations in both seasons in this study agrees with findings by Fotso Kuate *et al.,* (2019) in Cameroon, where FAW larval incidence and severity varied between sampling periods. They stated that in bimodal rainfall zones, there seems to be population build up during the first planting season characterized by more growing fields. Ojumoola *et al.,* 2022 also reported higher larval abundance in the early season in Ibadan, Southwest Nigeria. Aside the relative proportion of maize grown in both seasons, continuous precipitation characteristic of late season maize cultivation in the state might have contributed to the lower FAW incidence recorded in the late season in this study. Several studies (Garcia *et al.,* 2018; Early *et al.,* 2018) suggests that population of FAW is negatively influenced by pluviometric conditions because when the maize whorl is filled up with water, the larvae of FAW are forced to abandon the whorl and also, egg masses and small larvae are washed off onto the ground, reducing by consequence, the pest population. There was a positive and highly significant correlation (r=0.662, n=20, p<0.01) between *S. frugiperda* larval population and percentage infestation in the early maize cropping season and also in the late maize cropping season (r=0.922, n=11, p<0.01) in this study (Table 1). Fotso-Kuate *et al.* (2019) also reported a positive correlation between larval count and damage severity.

Conclusion

This study provided baseline quantitative data to confirm the presence and infestation levels of *Spodoptera frugiperda* on maize in Edo State, Nigeria. *S. frugiperda* was present on maize farms in the localities sampled across the three agroecological zones in the State. FAW larval abundance and infestation rate was positively correlated and uniform across the zones. With the high rates of infestation observed across the zones; especially in the main cropping season and during the vegetative stage of the crop, *S. frugiperda* has shown to be an economically important pest of maize in the State.

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Table 1: Spearman's correlation of larval abundance and percentage infestation

	Correlation Value
Early season	
Larval abundance vs Percentage infestation	0.662**
Late season	
Larval abundance vs Percentage infestation	0.922**

***** correlation is significant at the 0.01 level***

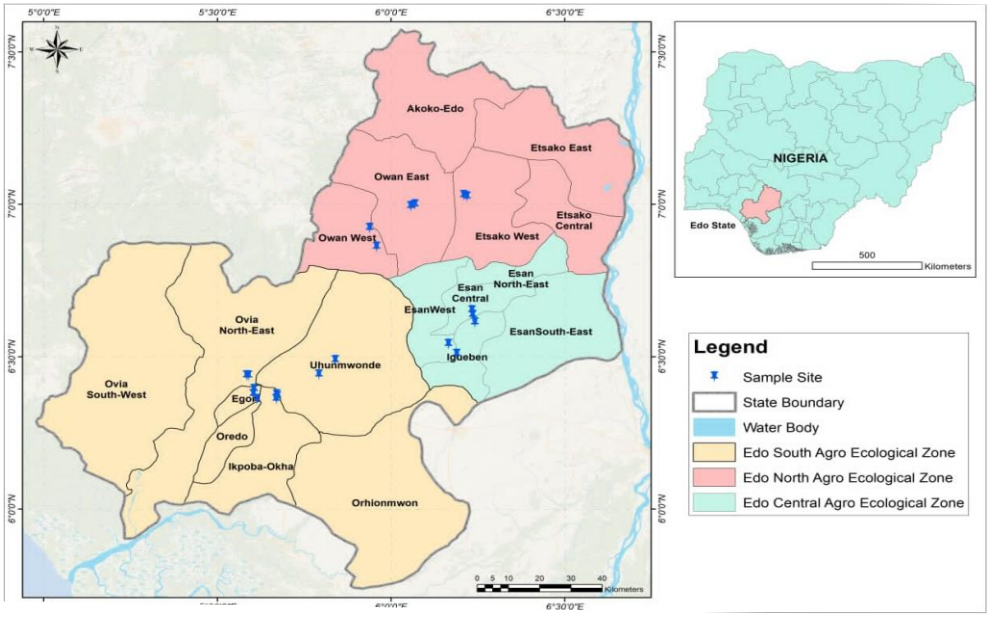
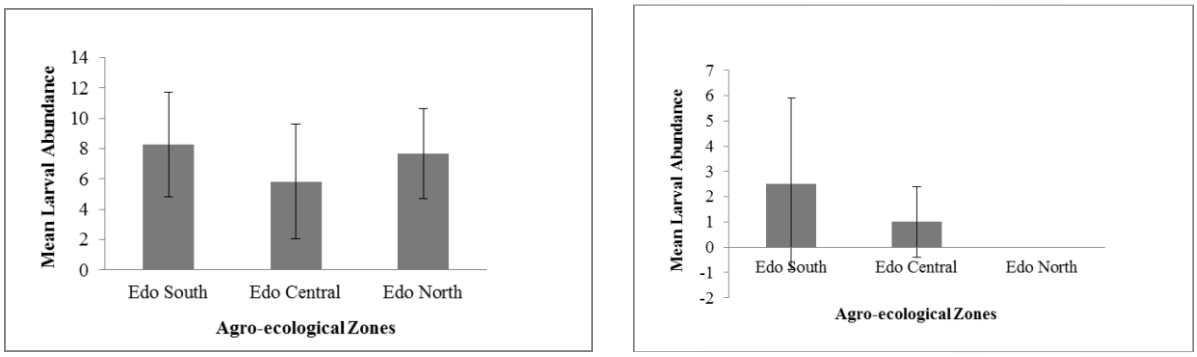
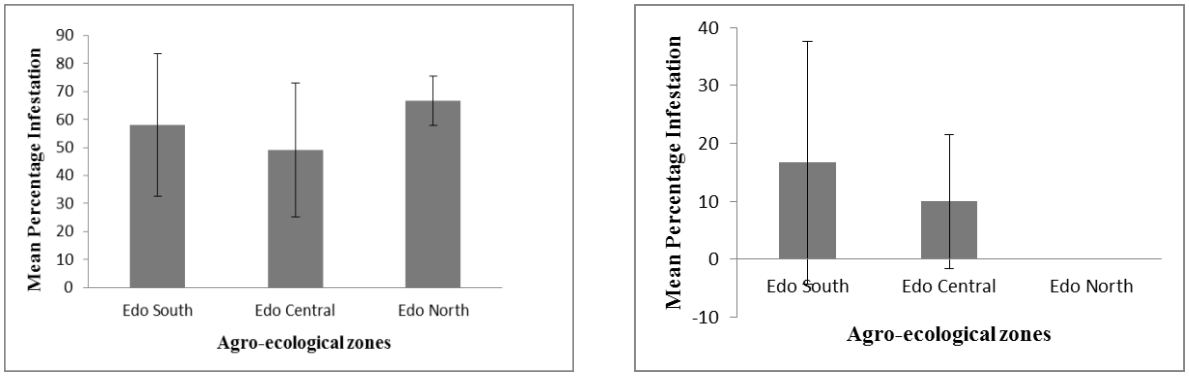


Fig. 1: Edo State map showing the sampling sites across the three agroecological zones



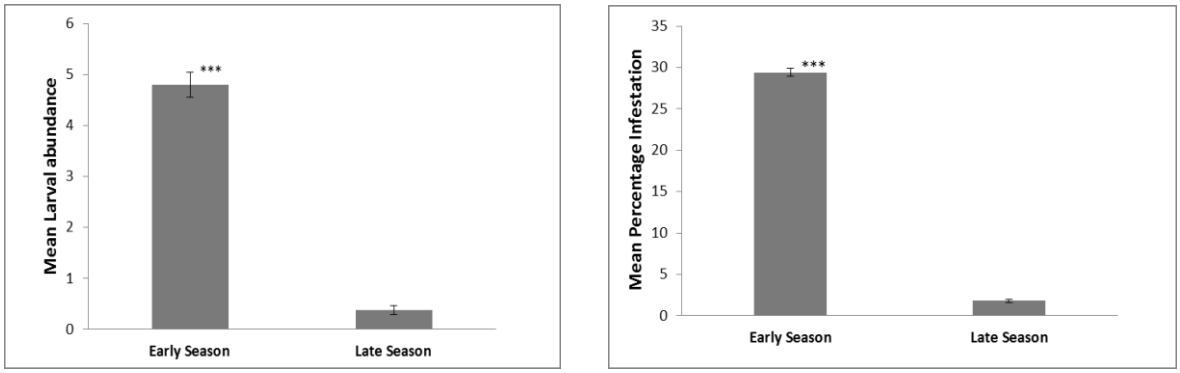
a. b.

Fig. 2: Mean larval abundance ± SE of FAW on maize in the three AEZs of Edo State in 2019 (a) early cropping season (b) late cropping season



a. b.

Fig. 3: Mean percentage infestation ± SE of FAW on maize in the three AEZs of Edo State in 2019 (a) early cropping season (b) late cropping season



a. b.

Fig. 4: (a) Mean larval abundance ± SE of FAW in early and late cropping season (b) Mean percentage infestation ± SE of FAW in the early and late cropping season. Means with asterisks (***) are significantly different at p<0.001