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Occurrence and Dynamics of Arthropod Predators Associated with Fall Armyworm, *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) on Maize in Benin City, Edo State, Nigeria

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ABSTARCT: The Fall armyworm (FAW), *Spodoptera frugiperda* JE Smith recently introduced in Nigeria, is a destructive pest of maize. Safer and more economically beneficial management outcomes have involved biological control constituting the use of predators, parasitoids and pathogens. There is limited information on predators of FAW in Nigeria. A study was therefore carried out in the Benin City, Edo state during the early and late maize cropping seasons of 2019 to identify arthropod predators of FAW on maize, assess their abundance and the relationship between their population and FAW abundance. Sampling was done weekly from the early whorl stage to the reproductive stage of maize plants. Insects collected were preserved using 70% ethanol and identified using morphological keys. Data were subjected to Analysis of Variance (ANOVA) and significant means separated using Duncan Multiple Range test (DMRT). T-test was used to compare predator abundance in both cropping seasons. Predator abundance was correlated with larval abundance using Pearson correlation analysis. The predators recorded in this study included species in the family Formicidae, Forficulidae, Blattellidae, Pentatomidae, and Araneae. Species in the family Formicidae were the most abundant in the early (55.85%) and late (95.67%) cropping seasons. Predator abundance was significantly different ($p < 0.001$) across the sampling weeks. There was a significant negative correlation between larval abundance and predator abundance in the early season and a significant positive correlation in the late season. This study has provided base line data on some locally existing predators of FAW in Benin City, Edo State, Nigeria.

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Maize, *Zea mays* L. Poaceae is one of the most important staple food crops in Africa. It is grown predominantly by small holder farmers. It is a major host of the Fall armyworm, *Spodoptera frugiperda* JE Smith which attacks over 80 different crop species, but with a preference for graminaceous crops. The Fall armyworm (FAW) is an invasive pest, native to South America. Its presence was first reported in Africa in 2016 (Goergen et al., 2016). The larval stage of FAW has great destruction tendencies (Day et al., 2017) and can damage maize plants in nearly all stages of development but most especially the vegetative stage (Omoregie et al., 2023). FAW can be one of the most difficult insect pests to control in field maize. This is due to its ability to breed rapidly, migrate, and feed on a wide range of host plants, all of which makes it very difficult to control. Some management tactics used by farmers to manage this pest include: host plant

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resistance, insecticide applications and biological control (Cisneros et al., 2002). Biological control involves the use of natural enemies to reduce pest population (Barbosa, 1998). Natural enemies such as entomopathogens, parasitoids and predators have been reported for biological control of FAW in its native region (Prasanna, 2018). Predators are important mortality factors for FAW, some include various ground beetles (Coleoptera: Carabidae); the striped earwig, *Labidura riparia* (Pallas) (Dermaptera: Labiduridae); the spined soldier bug, *Podisus maculiventris* (Hemiptera: Pentatomidae); and the insidious flower bug, *Orius insidiosus* (Hemiptera: Anthocoridae) (Capinera, 2001). The occurrence of some natural enemies has been reported in Ibadan, Oyo State, Nigeria (Ogunfumilayo et al., 2021). However there remains a dearth of information on locally existing natural enemies of FAW in maize cropping system; its diversity and abundance in Nigeria. Promotion of conservation biological control is based on such information (Wyckhuys and Neil 2006). This study is part of a larger research on population dynamics of the Fall armyworm, *Spodoptera frugiperda* on maize in the early and late cropping seasons of 2019 in Benin City, Edo State, Nigeria (Omoregie et al., 2023). Hence, this paper evaluates the occurrence and dynamics of arthropod predators associated with fall armyworm, *Spodoptera frugiperda* JE Smith (Lepidoptera: noctuidae) on maize in Benin City, Edo State, Nigeria

MATERIALS AND METHODS

Study Area: The experiment was carried out in the Teaching and Research Farm of Crop Science, Faculty of Agriculture, University of Benin, Ugbowo Campus, Benin City, Edo state during the early maize cropping season (April to July, 2019) and late maize cropping season (August- November, 2019). This area is located at 6°24.105'N longitude, 5°37.508'E latitude and an elevation of 94m above sea level. This location is in the rainforest zone of Nigeria and is characterized by a bimodal rainfall pattern with peaks in June and September.

Land Preparation/Planting/Agronomic Practices: A plot size of 200m^2 was manually cleared, ploughed and poultry manure applied two weeks before and after planting then six weeks after planting at the rate of 40.5kg/hectare. Maize seeds were sown at a depth of 2-3cm at the rate of 3 seeds per stand with a spacing of 75 × 25cm and were thinned to one seed per stand two weeks later. Weeding was done when necessary.

Sampling Methods and Data Collection: Sampling was carried out weekly from the early whorl stage (V2) to the beginning of the reproductive stage (R1) between 7.00hrs and 11.00hrs. Predators were surveyed on twenty (20) randomly selected maize plants from each of 20 sq. m area randomly selected at five locations in the bulk plot following a 'W' pattern. Arthropod predators (those found preying on eggs or young larvae and those known from literature as predators of FAW) were collected using a sweep net, hand picking and by bagging the maize plant with a plastic or mesh bag and immediately removing the leaves for further predator count. The insects were preserved in 70% ethanol and identified in the Department of Crop Science laboratory using morphological keys by Bland and Jaques (2010). Voucher specimens were deposited at the Department of Crop Science insect museum.

Data Analysis: Data from this study were square root transformed and subjected to Analysis of Variance (ANOVA). Significant means were separated using Duncan Multiple Range test. T-test was used to compare predator abundance in both cropping seasons. Predator abundance was correlated with the published data for larval abundance on maize in the early and late cropping seasons of 2019 in Omoregie *et al.,* 2023 using Pearson correlation analysis. All analyses were done using SPSS 16.0 software.

RESULTS AND DISCUSSION

Occurrence and abundance of arthropod predators of FAW: A total of 419 and 393 predators were collected in the early and late season respectively (Table 1). They included species in the family Formicidae, Forficulidae, Blattellidae, Pentatomidae, and order Araneae. Species in the family Formicidae were the most abundant, constituting 55.85% of the entire predator complex recorded in the early cropping season and 95.67% in the late cropping season. This was followed by species in the family Forficulidae with 26.49% and 2.80% percentage abundance in the early and late season respectively. Species in the family Pentatomidae and order Araneae were the least abundant in this study. Koji et al., 2007 reported the most numerous predator groups to be species in the family Formicidae (50.5%), Forficulidae (17.1%) and order Aranaea (13.2). Ogunfumilayo et al., 2021 observed species of predators in various niches of maize plants in Nigeria. Wyckhuy and O'Neil (2006) also recorded a diversity of arthropod predators including earwigs, ants, spiders, social wasps, stinkbugs and ground beetles; earwigs were the most abundant species in their study. Ants, spiders and earwigs were the most common potential predator groups of stem borers recorded on maize plants in Kenya. Other predators included coccinelids, lacewings, bush crickets, cockroaches and slaphylinids, although populations of these groups

were very small (Bonlof, 2000). As reported by Bonlof, 2000, the predator population in the study varied considerably between seasons and plant growth stage. A similar situation can be observed in this study, where the predator numbers gradually increased across the sampling weeks (corresponding to maize growth stages). However, predator population did not vary between seasons as there was no significant difference in the predator abundance when both seasons were cpmpared (Figure 1). Koji et al., 2007 also stated that densities of all predators of the stem borer, *Chilo partellus* in the study differed among sampling dates.

Table 1: Occurrence of *Spodoptera frugiperda* arthropod predators in the early and late maize cropping seasons

Predators		**Early cropping season**		**Late cropping season**	
Order	**Family**	Abundance	% Abundance	Abundance	% Abundance
Hymenoptera	Formicidae	234	55.85	376	95.67
Dermaptera	Forficulidae	111	26.49	11	2.80
Blattodea	Blattellidae	55	13.13	3	0.76
Hemiptera	Pentatomidae	6	1.43	1	0.25
Araneae		13	3.10	-	-
Total		419		393	

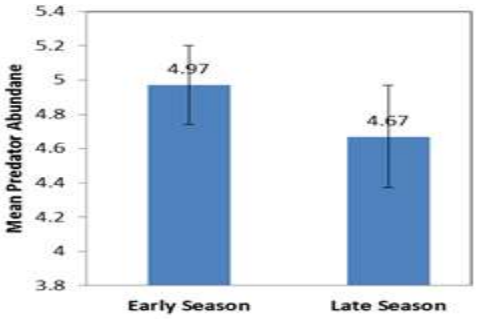

Fig 1: Mean ±SE of predator abundance in the early and late cropping seasons

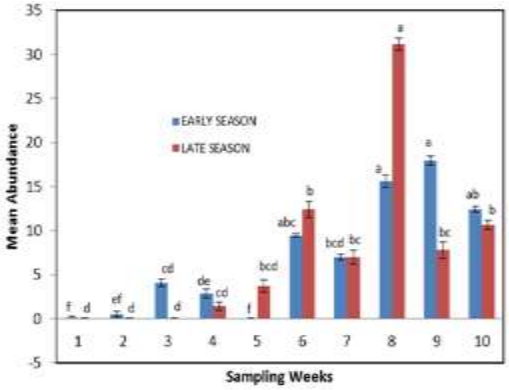

Fig 2: Mean ± SE of predator abundance across the sampling weeks in the early and late cropping seasons.

The predator abundance was significantly different ($p < 0.001$) across the sampling weeks in the early and late season (Figure 2). Predator abundance was highest in the 9th (17.93 ± 0.53) and 8th (15.61 ± 0.68) SW and lowest in the 5th (0.05 ± 0.00) and 1st (0.15 ± 0.16) SW in the early season while the late season recorded highest abundance in the 8th (31.17 ± 0.69) SW and lowest abundance in the 1st (0.05 ± 0.00), 2nd (0.05 ± 0.00) and 3rd (0.05 ± 0.00) SW. As seen from the population trend across the sampling weeks, predator abundance gradually increased from the whorl stage up till the reproductive stage of the plant. According to Bonlof (2000), predator abundance increased with time and was highest in the last weeks of the growing season when plants were matured. The abundance of the various families of predators is shown in Figures 3 – 7. Species in the family Formicidae were present in almost all the sampling weeks corresponding to different stages of the plant were mostly abundant in the tasseling and silking stage in both seasons (Figure 2). This was followed by members of the family Forficulidae which were present from the 3rd SW to the 10th SW in the early season and present in the 8th, 9th and 10th SW in the late season; their abundance were more in the early season than in the late season (Figure 3).

Species in the family Blattodea, Pentatomidae, and order Aranaea recorded low numbers in both seasons. In a similar study, species in the family Formicidae were more abundant and were found from the first sampling date onwards, though their numbers were comparatively low earlier in the first weeks, their densities however increased rapidly from the 9th weeks after emergence (WAE). In the same study members of the family Forficulidae occurred fairly late in the growing season (Bonlof 2000). Ngangom and Kumar (2019) reported in their study that ant species were active throughout the cropping season and as predators of pest, they may be useful in pest management.

Relationship between Spodoptera frugipera larval abundance and predator abundance: There was a significant negative correlation ($r=-0.388$, $p<0.01$) between larval abundance and predator abundance in the early season, however a significant positive correlation was observed in the late season ($r=0.319$, $p<0.05$) (table 2). As seen from result in this study, larval abundance was influenced by predator abundance in the early cropping season.

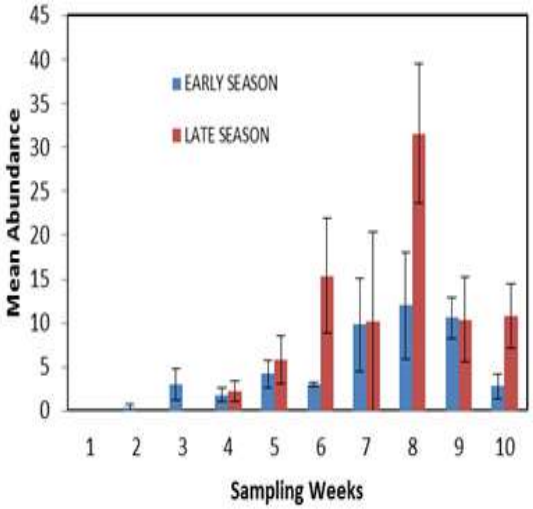

Fig 3: Mean ± SE of ants in the early and late cropping seasons of 2019.

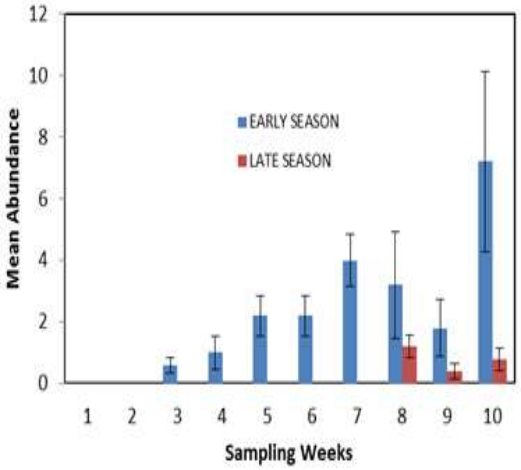

Fig 4: Mean abundance ± SE of earwigs in the early and late cropping seasons of 2019.

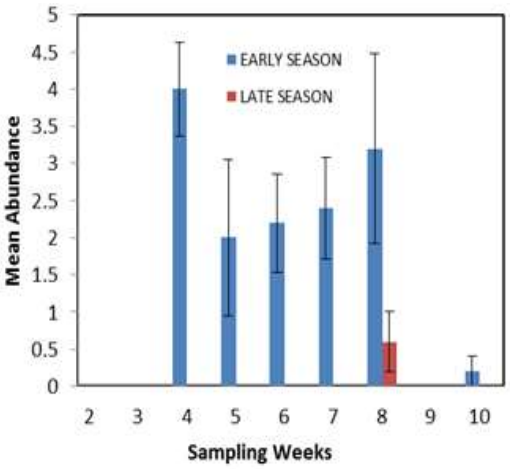

Fig 5: Mean abundance ± SE of cockroaches in the early and late cropping seasons of 2019.

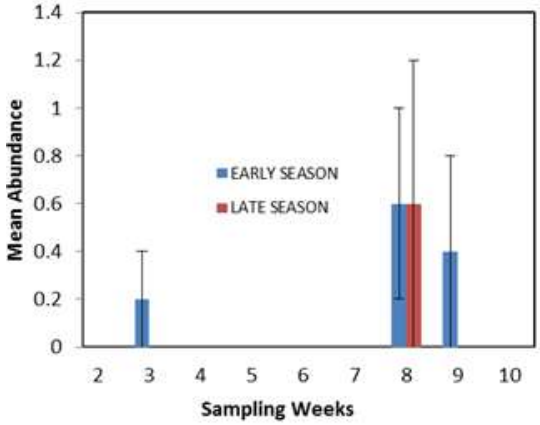

Fig 6: Mean abundance ± SE of bugs in the early and late cropping seasons of 2019.

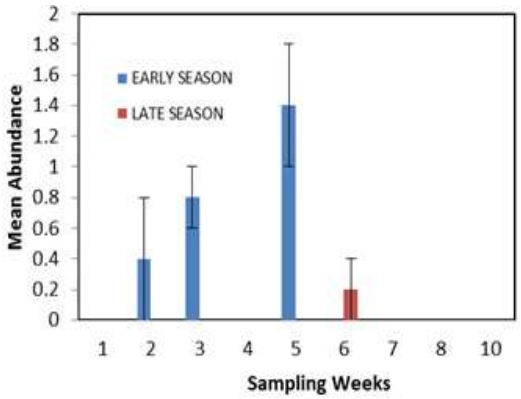

Fig 7: Mean abundance ± SE of spiders in the early and late cropping seasons of 2019.

Table 2: Correlation between *Spodoptera frugiperda* larval and predator abundance

	Correlation value
Early season	
Larval abundance vs Predator abundance	- 0.388**
Late season	
Larval abundance vs Predator abundance	0.319*

***correlation is significant at the 0.01 level (2-tailed);*
**correlation is significant at the 0.05 level (2-tailed)*

The larval population across the sampling weeks reduced as the predator population increased. Conversely, in the late season, the larval population was relatively low and an increase in FAW larvae (prey), led to an increase in predator population. Wyckhuy and O'Neil (2006) reported significant associations between predators and Fall armyworm infestation levels. The increase in certain predators (ants, earwigs, spiders and ground beetles) led to lowered Fall armyworm infestation. Ivette (1991) reported natural ant community as a possible source of biological control for the Fall armyworm in irrigated maize in the pacific plains of Nicaragna as ants were found to significantly reduce Fall armyworm

abundance as well as damage by FAW to maize plants. In an experiment by Koji et al., 2007, predator removal in maize fields resulted in a significant increase in stem borer densities.

Conclusion: This study has provided information on occurrence and dynamics of some locally existing predators of FAW in Edo State, Nigeria which will help in conservation biological control. The abundance of these predators varied with the crop phonological stage but not between seasons. This study also suggests an influence of predators on FAW larval populations especially in the early cropping season.

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