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Occurrence and Seasonal Dynamics of the Bio-control Agents of Fall Armyworm, *Spodoptera frugiperda* J. E. Smith on Maize Varieties in Benin City

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Abstract

The production of maize in sub-Saharan Africa faces serious threats from the fall armyworm (FAW). Since its arrival to Nigeria in 2016, its rapid spread and destructive feeding habits have raised urgent concerns for effective control. This research assessed the biological control capacity of FAW natural enemies through seasonal field observations in Benin City, Edo State. Field trials were conducted in 2020 and 2021 at the University of Benin Experimental Farm. A split-plot design involving four maize varieties and fifteen sampling intervals (days after sowing, DAS) were used. Arthropod predators were monitored through direct plant sampling, while parasitoids were identified from laboratory rearing of FAW egg masses and larvae. Data were analyzed using Aanalysis of Variance and T-tests. Natural enemies recorded included insect predators from the families Forficulidae, Formicidae, Pentatomidae, Coccinellidae, and Blatellidae, spiders (Araneae), and parasitoids from Platygastridae, Braconidae, and Trombidiidae. Abundance did not vary significantly across maize varieties but differed with crop growth stages and between years. Predator peaks occurred at 65 DAS (1.22) and 75 DAS (5.50) in early and late season in the year 2020, and 65 DAS (6.79) in early 2021. Parasitoids' peaks were observed at 30 DAS (1.54) in early 2020, and at 30 DAS (0.64) and 15 DAS (0.87) in early and late 2021, respectively. These results highlight the ecological importance of natural enemies and their potential integration into sustainable pest management strategies for maize production in the region.

Keywords*:* Biological control**,** Fall armyworm*,* Maize production*,* Natural enemies*,* Seasonal variation

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INTRODUCTION

Maize (*Zea mays* L.) is a staple crop of immense economic and nutritional importance in Nigeria, particularly among smallholder farmers in regions like Benin City, Edo State. However, its cultivation has come under increasing threat from the invasive fall armyworm (*Spodoptera frugiperda* J. E. Smith) (FAW), a voracious pest indigenous to the America continent. Following its detection in sub-Saharan Africa in 2016 and subsequent spread across the region, the activities of FAW has caused substantial reduction in yield, undermining food security (Goergen *et al.,* 2016; Kumela *et al.,* 2018). To control FAW, many farmers have largely depended on the use of synthetic insecticides. While initially effective, this approach has proven unsustainable due to rising costs, environmental concerns, and FAW's growing resistance to chemical treatments (Hailu *et al.,* 2018; Prasanna *et al.,* 2018). Consequently, attention has shifted toward ecologically sound alternatives, particularly the use of bio-control agents such as predators and parasitoids.

In agricultural ecosystems, the majority of insect species are not harmful, as their numbers are kept in balance by ecological relationships with natural enemies such as predators, parasites, and disease-causing organisms (Sharma, 2016). Predators such as earwigs (Dermaptera), true bugs (Hemiptera), ants, beetles (Coleoptera), and spiders (Araneae) (Capinera, 2001; Wyckhuys and Neil 2006) attack multiple developmental stages. In Africa, 18 predator species have been documented (Abbas, 2023). Parasitoids, typically more host-specific, include egg parasitoids (*Trichogramma* spp., *Telenomus* spp.), larval parasitoids (*Cotesia icipe*, *Chelonus curvimaculatus*, *Charops ater*, *Coccygidium luteum*), and dipteran parasitoids like *Palexorista zonata* (Abbas *et al.,* 2022). Across Africa, 48 parasitoid species have been reported, dominated by Braconidae (19 species), followed by Ichneumonidae (11), Tachinidae (9), and Trichogrammatidae (5) (Abbas, 2023). Entomopathogens also play a significant role, including bacteria (*Bacillus thuringiensis*), fungi (*Metarhizium anisopliae*, *Beauveria bassiana*), viruses (SfMNPV), and nematodes (*Heterorhabditis bacteriophora*, *H. indica*, *Steinernema carpocapsae*) (Negrisoli *et al.,* 2010; Abbas *et al.,* 2022).

Natural enemies are fundamental to the regulation of pest populations and form the basis of integrated pest management (IPM) strategies. Among them, parasitoids have demonstrated considerable potential in suppressing fall armyworm (FAW) populations across diverse agroecological zones (Sisay *et al.,* 2019). Nevertheless, despite reports of natural enemy activity in certain regions of Nigeria (Ogunfumilayo *et al.,* 2021), FAW appears to have initially thrived in an "enemy-free space" within the country. The scarcity of information on locally occurring predators and parasitoids in Edo State continues to constrain the development of site-specific IPM programs. The present research investigated the occurrence and seasonal dynamics of predators and parasioids of FAW on different maize varieties in Benin City, Edo State. The findings aimed to supply background information for sustainable FAW management and support the integration of biological control into cultivation of maize in the region.

MATERIALS AND METHODS

Site Description

The experimental site for this research was the Department of Crop Science Research Farm, University of Benin, Edo State, located at Latitude 6°24,105'N, Longitude 5°37.508'E, and elevation of 94 m above sea level. It was carried out from March to October in 2020 and 2021. The ecological zone of this location is tropical rainforest (Ewansiha and Osaigbovo, 2016).

Maize Variety

White hybrid (Oba 98) and yellow hybrid (Oba super 6) were obtained from Premier Seeds Nigeria Limited while white and yellow open pollinated varieties (OPV) were obtained from Uselu market in Benin City.

Experimental Design and Treatments

The experiment was fitted into a Split-plot design (SPD) replicated three times with main treatment plots measuring 9 × 3 m. Each main treatment plot and replicate was separated by 1m. Half of each row of maize was designated as the sub plot. There were four main treatments (maize varieties) viz: Oba 98, Oba super 6, Local white OPV, Local yellow OPV and fifteen sub treatments (Intervals of Days After Sowing (DAS)) viz: 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70 and 75 DAS.

Cultural Practices

Site Preparation/Planting/Weeding

The selected plots of well-drained sandy-loam soil were cleared and manually ploughed. At two and six weeks after planting, NPK 15:15:15 and urea fertilizer was incorporated into the soil at the rate of 500 kg/ha and 75 kg/ha respectively. In the field, seeds of the various maize varieties were sown 2 – 3 cm deep in plots at the rate of three seed per stand and at 75 x 25 cm spacing (75 cm between the rows and 25 cm between plant to plant within the row). Thinning was done to one seed per stand two weeks after sowing. Primenstra Gold herbicide was applied at the rate of 4 L/ha immediately after sowing to control weeds. Subsequently, weeding was done manually when necessary.

Data collection

Sampling was conducted on five maize plants per subplot. Predators of FAW eggs and larvae were collected either using sweep net, forceps, direct visual counts, or by covering maize plants with a net or polythene bag followed by leaf removal for examination. Braconid wasp larval parasitoids were sampled both directly from the plants and by rearing FAW larvae collected from the field. Egg parasitoids were obtained by rearing FAW egg masses collected from maize plants (Prasanna *et al.,* 2017), while mite parasitoids were sampled directly from FAW larvae in the field.

Collection of Meteorological Data

Meteorological data on total rainfall, average temperature and relative humidity covering the period of study was obtained from the University of Benin's National Centre for Energy and Environment.

Identification

Samples of predators and parasitoids were examined under a dissecting microscope (AmScope Trinocular model) for identification to the family level using morphological keys of Bland and Jaques (2010). Identification was based on diagnostic traits including body shape, wing venation, antennal segmentation, and other family-specific features. Predators were distinguished by characteristic morphologies: Coccinellidae (ladybird beetles) exhibited dome-shaped convex bodies, non-extended pronotal corners, and three distinct tarsal segments; Forficulidae (earwigs) possessed 12–16 segmented antennae, a lobed second tarsal segment extending beneath the third, and pincerlike cerci; Formicidae (ants) were recognized by elbowed antennae and petiole nodes; Pentatomidae (spined soldier bugs) displayed five-segmented antennae, a shield-shaped body, and a triangular scutellum; while Blattellidae (German cockroaches) were identified by their flattened oval bodies, long filiform antennae, pale brownish-yellow coloration, and two longitudinal pronotal stripes. Araneae (spiders) were distinguished by their two-segmented body plan (cephalothorax and abdomen), eight legs, absence of antennae, and presence of chelicerae with fangs (Yoloye, 1987). Parasitoids were characterized by their slender form and specialized wing and antennal structures: Braconidae were typically 2 – 5 mm in length, with long segmented antennae and forewings bearing closed cells and a recurrent vein; Platygastridae were minute, with 9–10 segmented antennae, hairy often veinless wings, and compact bodies; and Trombidiidae were distinguished by their bright red coloration, oval body shape, and parasitic larval stage (Krantz *et al.,* 2009). Voucher specimens were preserved at the Insect museum of the Department of Crop Science, Faculty of Agriculture, University of Benin.

Data analysis

Data from the experiment first underwent a differential square root transformation to ensure homogeneity of variance after which one-way Analysis of Variance was used to analyse the data. Duncan's Multiple Range Test (DMRT) was used to separate significant means at 5% level of significance. Predator and parasitoid abundance was compared between seasons using t-test. Their relationship with weather parameters were analysed using Pearson correlation. GenStat version 12.1 statistical software was used to carry out these analyses.

RESULTS AND DISCUSSION

Occurrence and abundance of predators and parasitoids in the early and late maize cropping seasons of 2020 and 2021 in Benin City, Edo state

The occurrence and abundance of the predators and parasitoids have been recorded and a total of 96, 370, 498, and 232 predators were obtained in the early and late cropping seasons of 2020 and 2021, respectively (Table 1). Five predator groups belonging to the orders Dermaptera, Hymenoptera, Hemiptera, Coleoptera, Blattodea, and Araneae were observed across most seasons, with the exception of Blattodea, which was absent in the early cropping season of 2020. While among the parasitoids, a total of 104, 10, 52, and 68 individuals were recorded from the eggs and larvae of S. frugiperda in the early and late cropping seasons of 2020 and 2021, respectively. In early 2020 and 2021, two parasitoid species belonging to the families Braconidae and Platygastridae (order Hymenoptera) were recorded. Moreover, in late 2020, only one parasitoid species from the family Braconidae was observed, while in late 2021, species from the families Braconidae and Platygastridae, along with a mite parasitoid from the family Trombididae, were also identified.

This study recorded a diverse predator community—including earwigs (Dermaptera), ants (Hymenoptera), hemipteran bugs, ladybird beetles (Coleoptera), spiders (Araneae), and cockroaches (Blattodea)—capable of attacking S. frugiperda (FAW) eggs and larvae in maize fields. Similar assemblages have been reported in Nigeria (Ogunfunmilayo *et al.,* 2021) and Cameroon (Abang *et al.,* 2021), where generalist predators contribute to FAW mortality and complement parasitoid activity in IPM programs. Ants were consistently dominant across seasons, reflecting their aggressive foraging behavior, adaptability, and ability to exploit multiple prey stages (Gathalkar and Sen, 2018). Their importance has also been highlighted in Ghana and Kenya (Sisay *et al.,* 2019). The seasonal presence of Blattodea in late 2020 and 2021 suggests shifts in predator composition, possibly linked to climatic, cropping patterns, or prey availability. While cockroaches are not traditionally highlighted as key FAW predators, their omnivorous feeding habits may allow opportunistic predation on exposed egg masses or larvae, particularly under high pest densities.

Egg parasitoids in the family Platygastridae, particularly Telenomus remus, are recognized as highly effective FAW control agents, achieving parasitism rates up to 100% in Nigeria (Ogunfunmilayo *et al.,* 2021) and widely valued in IPM programs for preventing larval emergence (Kenis *et al.,* 2019). Larval parasitoids in the family *Braconidae*—including Cotesia marginiventris, Chelonus insularis, and Apanteles spp.—are among the most common FAW natural enemies globally, reducing feeding damage while developing within the host (ICIPE*,* 2025). Their higher abundance in this study reflects findings from Uganda (Otim *et al.,* 2021) and Ghana (Sisay *et al.,* 2019). Additionally, a parasitic mite (Trombidiidae) was observed in late 2021, which, though less common, can reduce larval feeding and survival (Ogunfunmilayo *et al.,* 2021).

Table 1: Occurrence and abundance of predators and parasitoids in the early and late maize cropping seasons of 2020 and 2021

		2020		2021	
Predators		**Early**	**Late**	**Early**	**Late**
Order	**Family**				
Dermaptera	Forficulidae	61	71	327	23
Hymenoptera	Formicidae	6	282	136	189
Hemiptera	Pentatomidae	5	2	3	1
Coleoptera	Coccinelidae	1	5	3	1
Blattodea	Bllatelidae	-	2	19	3
Araneae (spiders)		23	8	10	15
Total		**96**	**370**	**498**	**232**
Parasitoids					
Order	**Family**				
Hymenoptera	Braconidae	12	10	32	26
	Platygastridae	92	-	20	38
Acari	Trombidiidae	-	-	-	4
Total		**104**	**10**	**52**	**68**

Influence of maize varieties on Predators and parasitoids in the early and late maize cropping seasons of 2020 and 2021

Mean number of predators and parasitoids did not differ significantly ($p < 0.05$) on the four maize varieties in most of the seasons except in late 2020 where there was a significant difference ($p < 0.05$) in the number of predators, with Oba 98 recording the highest number (2.42) of predators. However, there was no significant difference in the number of parasitoids that same season (Table 2).

This agrees with Anyanda (2024), who found that natural enemy populations in Kenyan maize fields were shaped more by seasonal factors and crop stage than by varietal differences, particularly when varieties were of similar maturity groups and plant architecture. An exception was the higher predator abundance on Oba 98 in late 2020, possibly linked to traits such as husk cover, leaf surface, or nectar/pollen availability that enhance predator foraging. Similar studies (Alasabte *et al.,* 2022; Kallaf *et al.,* 2023) associate predator attraction with volatile organic compounds (VOCs) and habitat structure. Parasitoid abundance showed no varietal differences, consistent with Sisay *et al.* (2019), who reported that parasitoid occurrence depends mainly on host density and phenology. Parasitoids such as T. remus (Platygastridae) and Cotesia icipe (Braconidae) respond strongly to host presence and kairomones but are less influenced by plant morphology (Kenis *et al.,* 2019).

Table 2: Influence of maize varieties on Predators and parasitoids in the early and late maize cropping seasons of 2020 and 2021

	2020		**2021**	
Predators				
Varieties	**Early**	**Late**	**Early**	**Late**
Oba 98	0.35 (0.92)	2.42 (1.71)^{a}	1.78 (1.51)	0.94 (1.20)
Oba super 6	0.52 (1.01)	1.30 (1.34)^{ab}	1.87 (1.54)	0.64 (1.07)
White OPV	0.48 (0.99)	0.52 (1.01)^{b}	1.75 (1.50)	0.62 (1.06)
Yellow OPV	0.36 (0.93)	1.09 (1.26)^{b}	2.03 (1.59)	0.73 (1.11)
Sig.	ns	*	ns	ns
Parasitoids				
Varieties	**Early**	**Late**	**Early**	**Late**
Oba 98	0.02 (0.72)	0.05 (0.74)	0.09 (0.77)	0.05 (0.74)
Oba super 6	0.03 (0.73)	0.02 (0.72)	0.09 (0.77)	0.16 (0.81)
White OPV	0.42 (0.96)	0.05 (0.74)	0.19 (0.83)	0.17 (0.82)
Yellow OPV	0.31 (0.90)	0.05 (0.74)	0.12 (0.79)	0.11 (0.78)
Sig.	ns	ns	ns	ns

*means are significantly different at $p < 0.05$, ns= means are not significantly different ($p > 0.05$), transformed means are in parenthesis.

Seasonal and temporal variations in predator and parasitoid abundance

Mean predator and parasitoid abundance across days after sowing (DAS) are shown in Tables 3 and 4. In early 2020, predator abundance ranged from 0.06–1.22, peaking at 65 DAS, while parasitoids ranged from 0.06–1.54, with peaks at 25 and 30 DAS. Both varied significantly ($p < 0.01$ for predators; $p < 0.05$ for parasitoids). In late 2020, predators varied significantly (0.06–5.50; peak at 75 DAS, $p < 0.001$), but parasitoids did not ($p > 0.05$). In early 2021, both groups varied significantly ($p < 0.001$); predators peaked at 60–75 DAS (up to 6.79), while parasitoids peaked at 30 DAS (0.64). In late 2021, predators showed no significant variation, but parasitoids did ($p < 0.001$), peaking at 15 and 25 DAS (insert figures of the means). Predator abundance was higher (insert figures of the means) in late 2020 ($p < 0.001$) and in early 2021 (insert figures of the means), with overall counts greater (insert figures of the means) in 2021 than 2020 ($p < 0.01$). Parasitoid abundance was higher (insert figures of the means) in early 2020 ($p < 0.05$), but no seasonal differences were observed in 2021, and overall abundance remained similar between years.

The present study reveals pronounced seasonal and temporal fluctuations in predator and parasitoid populations across four consecutive cropping seasons in two years. These patterns underscore the dynamic nature of natural enemy communities and align with previous research emphasizing the influence of crop phenology, prey availability, and climatic conditions on their abundance and activity. Parasitoid populations consistently exhibited early-season peaks, particularly at 25–30 DAS in 2020 and 30 DAS in 2021. This pattern aligns with Andrade *et al.* (2015), who reported inter-annual variation in parasitoid abundance driven by host density and environmental variability. Interestingly, late 2021 showed peaks at 15 and 25 DAS, diverging from earlier patterns, likely due to early host availability and synchronization of parasitoid life cycles with host emergence.

Despite seasonal fluctuations, overall parasitoid abundance remained relatively stable across seasons, which is quite consistent with Shameer and Hardy (2024), who noted that host specialization and life-history traits buffer parasitoid populations against short-term climatic variability. Predator populations, in contrast, tended to peak later in the season, particularly between 65–75 DAS. This lagged response suggests bottom-up regulation, with predator abundance increasing in response to rising prey densities or enhanced habitat complexity (e.g., canopy closure and microhabitat development). Significant temporal variation was observed in early and late 2020 and early 2021, but not in late 2021, possibly due to inter-annual climatic variability or fluctuations in pest pressure.

The seasonal shifts in predator abundance suggest strong responsiveness to climatic conditions, crop phenology, and prey availability. Omoregie *et al.* (2023) similarly reported seasonal variation in predator populations associated with *S. frugiperda* in maize fields, attributing late-season peaks to increased prey density and favorable microclimates. Corcos *et al.* (2017) also emphasized that landscape-scale heterogeneity and seasonal resource availability strongly influence predator diversity and abundance, often more than local-scale factors.

Table 3: Mean number of predators across the days after sowing (DAS) in the early and late maize cropping seasons of 2020 and 2021

	2020		**2021**	
DAS	**Early**	**Late**	**Early**	**Late**
5	0.06 (0.75)^{c}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)
10	0.00 (0.71)^{c}	0.06 (0.75)^{e}	0.06 (0.75)^{d}	0.21 (0.84)
15	0.00 (0.71)^{c}	0.06 (0.75)^{e}	0.00 (0.71)^{d}	0.00 (0.71)
20	0.00 (0.71)^{c}	0.06 (0.75)^{e}	0.19 (0.83)^{d}	0.54 (1.02)
25	0.33 (0.91)^{abc}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.80 (1.14)
30	0.38 (0.94)^{abc}	0.36 (0.93)^{de}	0.26 (0.87)^{cd}	0.89 (1.18)
35	0.17 (0.82)^{bc}	0.67 (1.08)^{cde}	1.46 (1.40)^{bc}	0.54 (1.02)
40	0.56 (1.03)^{abc}	1.84 (1.53)^{bcde}	1.66 (1.47)^{b}	2.78 (1.81)
45	0.29 (0.89)^{abc}	1.49 (1.41)^{bcde}	1.11 (1.27)^{bcd}	1.46 (1.40)
50	0.62 (1.06)^{abc}	1.30 (1.34)^{bcde}	1.57 (1.44)^{b}	0.82 (1.15)
55	0.64 (1.07)^{abc}	2.89 (1.84)^{abc}	6.68 (2.68)^{a}	0.89 (1.18)
60	0.92 (1.19)^{ab}	3.11 (1.90)^{ab}	4.70 (2.28)^{a}	0.99 (1.22)
65	1.22 (1.31)^{a}	3.91 (2.10)^{ab}	6.79 (2.70)^{a}	0.62 (1.06)
70	0.78 (1.13)^{abc}	2.29 (1.67)^{abcd}	6.16 (2.58)^{a}	0.73 (1.11)
75	0.94 (1.20)^{ab}	5.50 (2.45)^{a}	6.58 (2.66)^{a}	0.82 (1.15)
Sig.	**	***	***	ns

^{abc}means in the same column are significantly different at $p < 0.05$, *means are significantly different (** = $p < 0.01$ and *** = $p < 0.001$), ns = means not significantly different ($p > 0.05$), transformed means are in parenthesis.

Table 4: Mean number of parasitoids across the days after sowing (DAS) in the early and late maize cropping seasons of 2020 and 2021

	2020		2021	
DAS	**Early**	**Late**	**Early**	**Late**
5	0.00 (0.71)^{b}	0.00 (0.71)	0.00 (0.71)^{c}	0.06 (0.75)^{b}
10	0.00 (0.71)^{b}	0.21 (0.84)	0.00 (0.71)^{c}	0.12 (0.79)^{b}
15	0.00 (0.71)^{b}	0.17 (0.82)	0.00 (0.71)^{c}	0.87 (1.17)^{a}
20	0.00 (0.71)^{b}	0.12 (0.79)	0.17 (0.82)^{bc}	0.26 (0.87)^{b}
25	1.38 (1.37)^{a}	0.00 (0.71)	0.33 (0.91)^{abc}	0.75 (1.12)^{a}
30	1.54 (1.43)^{a}	0.00 (0.71)	0.64 (1.07)^{a}	0.12 (0.79)^{b}
35	0.06 (0.75)^{b}	0.00 (0.71)	0.52 (1.01)^{ab}	0.00 (0.71)^{b}
40	0.56 (1.03)^{ab}	0.06 (0.75)	0.06 (0.75)^{c}	0.00 (0.71)^{b}
45	0.06 (0.75)^{b}	0.00 (0.71)	0.12 (0.79)^{c}	0.00 (0.71)^{b}
50	0.00 (0.71)^{b}	0.06 (0.75)	0.12 (0.79)^{c}	0.00 (0.71)^{b}
55	0.00 (0.71)^{b}	0.00 (0.71)	0.00 (0.71)^{c}	0.00 (0.71)^{b}
60	0.00 (0.71)^{b}	0.00 (0.71)	0.00 (0.71)^{c}	0.00 (0.71)^{b}
65	0.00 (0.71)^{b}	0.00 (0.71)	0.00 (0.71)^{c}	0.00 (0.71)^{b}
70	0.00 (0.71)^{b}	0.00 (0.71)	0.00 (0.71)^{c}	0.00 (0.71)^{b}
75	0.00 (0.71)^{b}	0.00 (0.71)	0.00 (0.71)^{c}	0.00 (0.71)^{b}
Sig.	*	ns	***	***

^{abc}means in the same column are significantly different at $p < 0.05$, *means are significantly different (* = $p < 0.05$ and *** = $p < 0.001$), ns = means are not significantly different ($p > 0.05$), transformed means are in parenthesis.

CONCLUSION

This study has shown the diverse natural enemies of *S. frugiperda*—including predators and parasitoids—occur consistently on maize in Benin City, Edo State, with distinct seasonal dynamics: parasitoids peaking early in the crop cycle and predators later. Abundance did not differ among maize varieties but varied with crop growth stage and season, with predators showing higher counts in 2021 and parasitoids remaining relatively stable. Overall, the results underscore the ecological importance of natural enemies in maize agro-ecosystems and their potential role in reducing FAW pressure under field conditions. To capitalize on this ecological service, biological control should be central to integrated pest management (IPM) strategies for maize in Nigeria. Key actions include conserving parasitoids and predators through reduced pesticide use, adopting habitat management practices that sustain their populations, and raising farmer awareness of their benefits. Integrating these measures into IPM frameworks offers a sustainable pathway to reduce fall armyworm pressure and enhance maize productivity in Edo State and beyond

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Conflict of Interest
The authors confirm that there are no conflicts of interest associated with this publication.

REFERENCES

Abang, A. F., Nanga, S. N., Kuate, A. F., Kouebou, C., Suh, C., Masso, C., Saethre, M. G, and Fiaboe, K. K. M. (2021). Natural enemies of fall armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in different agroecologies. *Insects,* 12(6): 509–532. https://doi.org/10.3390/insects12060509

Abbas, A., Ullah, F., Hafeez, M., Han, X., Dara, M. Z. N., Gul, H., and Zhao, C. R. (2022). Biological control of fall armyworm, Spodoptera frugiperda. Agronomy, *12*(11): 2704–2726. https://doi.org/10.3390/agronomy12112704

Abbas, M. S. (2023). Entomophagous Insects of The Invasive Fall Armyworm, *Spodoptera frugiperda* (Nixon) in African and Asian countries. *Egyptian Academic Journal of Biological Sciences A.Entomology,* 16(2): 51–67. https://doi.org/10.21608/eajbsa.2023.299255

Alsabte, A., Ahmed, Q. H., Kayaham, A. and Karaca, I. (2022). Effects of Volatile Organic Compounds (VOCs) emitted by citrus infested with *Aonidiella aurantii* on the predator *Rhyzobius lophanthae* attraction. Phytoparasitica, 50(4): 645–653. https://doi.org/10.1007/s12600-022-00978-4

Andrade, T. O., Outreman, Y., Krespi, L., Plantegenest, M., Vialatte, A., Gauffre, B. and van Baaren. J. (2015). Spatiotemporal variations in aphid-parasitoid relative abundance patterns and food webs in agricultural ecosystems. *Ecosphere,* 6(7):1–14. http://dx.doi.org/10.1890/ES15-00010.1

Anyanda, G. N. (2024). Maize variety performance under fall armyworm infestation and associated natural enemies in Machakos, Kilifi, Makueni, Embu, Kakamega and Trans-Nzoia Counties, Kenya [Master's thesis, Kenyatta University]. Kenyatta University Institutional Repository. https://ir-library.ku.ac.ke/bitstreams/d2915bc2-d928-4ed1-bcc8-eca8a005f5de/download

Bland, R. G. and Jaques, H. E. (2010). *How to know the insects.* Waveland Press, Inc. 3rd Edition. 409 pp

Capinera, J. L. (2001). Handbook of Vegetable Pests. San Diego, CA: Academic Press. 729 pp.

Corcos, D., Inclán, D. J., Cerretti, P., Mei, M., Di Giovanni, F., Birtele, D., Rosa, P., De Biase, A., Audisio, P. and Marini, L. (2017). *Environmental heterogeneity effects on predator and parasitoid insects vary across spatial scales and seasons: A multi-taxon approach. Insect Conservation and Diversity, 10(5): 462–471.* https://doi.org/10.1111/icad.12238

Ewansiha, S. U. and Osaigbovo, A. U. (2016). Cowpea for a changing environment in the rainforest of South-South Nigeria. *Journal of Tropical Agriculture, Food, Environment and Extension,* 15(1): 23-28.

Gathalkar, G. B., and Sen, A. (2018). *Foraging and predatory activities of ants. In: The Complex World of Ants (*Shields, V. D. C. ed*), pp. 51–70. IntechOpen. https://doi.org/10.5772/intechopen.78011*

Goergen, G., Kumar, P. L., Sankung, S. B., Togola, A. and Tamò, M. (2016). First report of outbreaks of the fall armyworm, Spodoptera frugiperda (J. E. Smith) (Lepidoptera: Noctuidae), a new alien invasive pest in West and Central Africa. PLOS ONE, 11(10): e0165632. https://doi.org/10.1371/journal.pone.0165632

Hailu, G., Niassy, S., Zeyaur, K., Ochatum, N. and Subramanian, S. (2018). Maize–legume intercropping and push–pull for management of fall armyworm, stemborers, and striga in Uganda. Agronomy Journal, 110(6): 2513–2522. https://doi.org/10.2134/agronj2018.02.0110

ICIPE (2025). Fall armyworm natural enemies. The Tropical Insect Science Institute. Retrieved December 13, 2025, from https://www.icipe.org/news/fall-armyworm-natural-enemies.

Kenis, M., du Plessis, H., Van den Berg, J., Ba, M. N., Goergen, G., Kwadjo, K. E., Baoua, I., Tefera, T., Buddie, A., Cafà, G., Offord, L., Rwomushana, I., and Polaszek, A. (2019). Telenomus remus, a candidate parasitoid for the biological control of Spodoptera frugiperda in Africa, is already present on the continent. *Insects, 10(4): 92–105 https://doi.org/10.3390/insects10040092*

Khallaf, M. A., Sadek, M. M. and Anderson, P. (2023). Predator efficacy and attraction to herbivore-induced volatiles determine insect pest selection of inferior host plant. *Iscience,* 26(2): 106077 https://doi.org/10.1016/j.isci.2023.106077

Krantz, G. W., and Walter, D. E. (2009). A manual of Acarology (3rd ed.). Lubbock, TX: Texas Tech University Press. 807 pp.

Kumela, T., Simiyu, J., Sisay, B., Likhayo, P., Gohole, L. and Tefera, T. (2018). Farmers' Knowledge, Perceptions, and Management Practices of the New Invasive Pest, Fall Armyworm (*Spodoptera frugiperda*) in Ethiopia and Kenya. *International Journal of Pest Management,* 65: 1–9. https://doi.org/10.1080/09670874.2017.1423129

Negrisoli, A. S., Garcia, M. S., Negrisoli, C. R., Bernardi, D. and Da Silva, A. (2010). Efficacy of entomopathogenic nematodes (Nematoda: Rhabditida) and insecticide mixtures to control *Spodoptera frugiperda* in corn. *Crop Protection,* 29 (7): 677–683.

Ogunfunmilayo, A. O., Kazeem, S. A., Idoko, J. E., Adebayo, R. A., Fayemi, E. Y.,

Adedibu, O. B., Oloyede-Kamiyo, Q. O., Nwogwugwu, J. O., Akinbode, O. A., Salihu, S., Offord, L. C., Buddie, A. G. and Ofuya, T. I. (2021). Occurrence of natural enemies of Fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in Nigeria. *PLoS One*. 16 (70): e0254328.

Omoregie, M. E., Enobakhare, D. A. and Omoregie, A. O. (2023). Population dynamics of the Fall armyworm, *Spodoptera frugiperda* J. E. Smith (Lepidoptera: Noctuidae) on early and late season maize. *Animal Research International,* 20 (1): 4734–4740.

Otim, M. H., Aropet, S. A., Opio, M., Kanyesigye, D., Opolot, H. N. and Tay, W. T. (2021). Parasitoid distribution and parasitism of the fall armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in different maize producing regions of Uganda. *Insects,* 12 (2): 121 – 137.

Prasanna, B. M., Huesing, J. E., Eddy, R. and Peschke, V. M. (2018). *Fall Armywjrm in Africa: A Guide for Integrated Pest Management.* First Edition. USAID; CIMMYT. 109pp.

Prasanna, B. M., Mugo, S. N., Bruce, A. Y. and Beyene, Y. (2017). Fall armyworm in Africa: status and management. CIMMYT. A presentation to International Committee of the Red Cross (ICRC) Agro Workshop, "Resilience" Within ICRC Linked to Climate Risks and Agro/Livestock Production in Places of Detention", Nov. 28, 2017, Amber Hotel, Kilimani, Nairobi.

.

Shameer, K. S. and Hardy, I. C. W. (2024). Host–parasitoid trophic webs in complex agricultural systems. *Current Opinion in Insect Science*, 65:101253. https://doi.org/10.1016/j.cois.2024.101253

Sharma, H. C. (2016). Climate change vis-a-vis pest management. In Conference on National Priorities in Plant Health Management (pp. 1–17). Plant Protection Association of India & NBPGR, Hyderabad. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Telangana, India. Retrieved from https://oar.icrisat.org/9333/

Sisay, B., Simiyu, J., Mendesil, E., Likhayo, P., Ayalew, G., Mohamed, S., Subramanian, S., and Tefera, T. (2019). Fall armyworm, Spodoptera frugiperda infestations in East Africa: Assessment of damage and parasitism. Insects, 10(7): 195–109. https://doi.org/10.3390/insects10070195

Wyckhuys, K. A. G. and Niel, R. J. (2006). Population dynamics of *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) and associated arthropod natural enemies in Honduran subsistence maize. *Crop Protection*, 25(11): 1180–1190. https://doi.org/10.1016/j.cropro.2006.03.003

Yoloye, V. L. (1987). Basic invertebrate zoology, *Lecture notes for 100 and 200 level students*. University of Ilorin. 318 pp

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