# Identification of *Drino quadrizonula* Thomson and *Chelonus* sp. as Larval Parasitoids of *Spodoptera frugiperda* J. E. Smith in the Guinea Savanna Agroecological Zones of Nigeria

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**Summary**

The fall armyworm (FAW), *Spodoptera frugiperda* J.E. Smith, is a destructive invasive pest threatening maize production across sub-Saharan Africa. With rising concerns over chemical pesticide resistance and environmental safety, biological control offers a sustainable alternative for FAW management. This study was conducted to identify larval parasitoids of FAW in the Southern and Northern Guinea Savanna agroecological zones of Kwara State, Nigeria. A total of 100 FAW larvae were collected from maize fields in each zone using a W-shaped sampling pattern and reared individually in the laboratory under controlled conditions. Emergent parasitoids were morphologically identified and their abundance in each zone recorded. Two larval parasitoids were identified: *Drino quadrizonula* Thomson (Diptera: *Tachinidae*) and a species of *Chelonus* (Hymenoptera: Braconidae). *D. quadrizonula* accounted for 100% of the parasitoids recovered in the Northern Guinea Savanna but only 6.25% of the total parasitoids. *D. quadrizonula* was also recorded in the Southern Guinea Savanna, accounting for 31.25% of the total parasitoids. *Chelonus* sp. was the most abundant overall, comprising 62.50% of the total parasitoids across both zones. However, it was only observed emerging from larvae collected in the Southern Guinea Savanna. This is the first documented report of *D. quadrizonula* and *Chelonus* sp. parasitizing FAW larvae in these agroecological zones in Nigeria. Further studies are recommended to assess the seasonal dynamics, parasitism efficacy, host specificity, and ecological adaptability of these parasitoids as part of an integrated FAW management strategy in West Africa.

**Key words**

biological control, fall armyworm, parasitoids, guinea savanna, Nigeria

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## Introduction

The fall armyworm (FAW), *Spodoptera frugiperda* J.E. Smith, is a highly invasive pest posing a serious threat to global food production and trade in agricultural products (Kasoma et al., 2020). Native to North and South America (Goergen et al., 2016), FAW was first detected in West Africa, including Nigeria, in 2016 (Goergen et al., 2016). Within three years of its arrival, it had spread to nearly all Sub-Saharan African countries, except Lesotho and Equatorial Guinea, where it had not yet been reported (Assefa et al., 2019).

The fall armyworm is a highly polyphagous insect, feeding on over 350 plant species across different families, including grasses, vegetables, and shrubs (Montezano et al., 2018). However, it shows a strong preference for maize, the primary staple crop in Sub-Saharan Africa, attacking leaves, tassels, and ears, leading to severe defoliation and reduced photosynthesis (Ojumoola et al., 2022). In the region, maize yield losses due to FAW are estimated at an average of 21.53% annually (Prasanna et al., 2018; Day et al., 2017).

In response to FAW outbreaks, many farmers in Africa have heavily relied on insecticides, despite the significant environmental and health risks they pose to humans and animals (Bateman et al., 2018; Prasanna et al., 2018). Prolonged use of insecticides can also contaminate food and eliminate natural enemies that help regulate FAW populations (Sisay et al., 2019). Furthermore, FAW has developed resistance to several classes of insecticides, including pyrethroids, organophosphates, and carbamates (Day et al., 2017). Given the challenges associated with chemical control and FAW's growing resistance, biological control is increasingly recognized as a vital component of sustainable FAW management in Africa (Prasanna et al., 2018).

In North and South America, various biological agents have been deployed to control FAW, with over 150 parasitoid species recorded as natural enemies of FAW in their native range (Molina-Ochoa et al., 2003; Estrada et al., 2013). Among these are *Telenomus remus* Nixon (Hymenoptera: Platygastridae), an egg parasitoid of multiple lepidoptera species originally from Malaysia, and *Trichogramma chilonis* Ishi (Hymenoptera: *Trichogrammatidae*), which also targets the eggs of FAW larvae. In Africa, *T. remus* has also been recorded in Benin, Ghana, Côte d'Ivoire, Kenya, Nigeria, and South Africa, while *T. chilonis* has been found in Kenya, Benin, and Ghana, achieving up to 45% parasitism rates against FAW eggs and larvae (Kenis et al., 2019; Tefera et al., 2019). In Benin and Ghana, *Chelonus bifoveolatus* and *Coccygidum luteum* were identified as the most effective parasitoids for controlling FAW (Agboyi et al., 2020). Additionally, a newly identified parasitoid, *Cotesia icipe* (Hymenoptera: *Braconidae*), was discovered in Kenya, Ethiopia, and Tanzania (Sisay et al., 2018). In Nigeria, Ogunfunmilayo et al. (2021) working in Ibadan (a Derived Guinea Savanna agroecological zone in Nigeria) identified *T. remus*, *Euplectrus laphygmae* a larval parasitoid, and a mite, tentatively identified as *Trombidium* species as natural enemies of FAW in the country.

Since FAW is a relatively new pest in Nigeria, there is limited information on its natural enemies in the different agroecological zones or regions within the country. Therefore, this study aims to identify larval parasitoids associated with field-collected FAW larvae in the Southern and Northern Guinea Savanna agroecological zones of Kwara State, Nigeria.

## Material and Methods

### Study Location

Fall armyworm larvae were collected in May, during the early maize planting season, from two infested maize farms each in Ilorin-South Local Government Area and Moro Local Government Area, representing the Southern and Northern Guinea Savanna agroecological zones of Kwara State, respectively (Fig. 1). The collected larvae were subsequently reared in the Crop Protection Laboratory, Faculty of Agriculture, University of Ilorin, Kwara State, Nigeria.

### Field Sampling and Rearing of Fall Armyworm Larvae

Two maize farms infested with FAW were purposively selected within each agroecological zone. From each farm, 50 larvae were collected from infested maize plants using a W-shaped sampling pattern (McGrath et al., 2018) resulting in 100 larvae per zone. The larvae were placed in plastic containers containing sufficient maize leaves to prevent cannibalism and transported to the laboratory for rearing. In the laboratory, each larva was transferred into a separate 200 mL cup covered with muslin cloth (Ojumoola and Omoloye, 2023). The 100 individual cups from each zone were then arranged in separate larger containers. Larvae were fed every other day with two grams of fresh maize leaves (excluding the midrib) until pupation.

### Parasitoids of Fall Armyworm Larvae

Every two days after the commencement of laboratory rearing, the muslin-covered cups housing FAW larvae were examined for emerging parasitoids. When parasitoid emergence was observed, the development of the parasitoid was monitored until pupation. Pupal cases or cocoons were left undisturbed in the cups until the adult parasitoids emerged. Upon emergence, close-up photographs of the adult parasitoids and their pupal cases were taken using an iPhone 13 equipped with a 12-megapixel camera. The specimens were then preserved in 70% ethanol. Morphological identification of the hymenopteran parasitoid was carried out using published identification guides including Shaw and Huddleston (1991), Goulet and Huber (1993), Zack (1997) and Ji (2001). Similarly, the dipteran parasitoid was identified based on published literatures including O'hara et al. (2009) and O'Hara and Cerretti (2016).

### Data Collection and Analysis

Data were collected every other day from the onset of rearing on the number of surviving FAW larvae, pupae, and emerged moths in each cup. In addition to FAW abundance, data were also recorded on the number of newly emerged parasitoid larvae, newly formed parasitoid pupae, and newly emerged adult parasitoids. Descriptive statistics were used to summarize the abundance data, which were then visualized using multiple bar charts generated in Microsoft Excel (2016). In addition, Pearson correlation was conducted to assess the relationship between the number of fall armyworm and parasitoids at each developmental stage using the

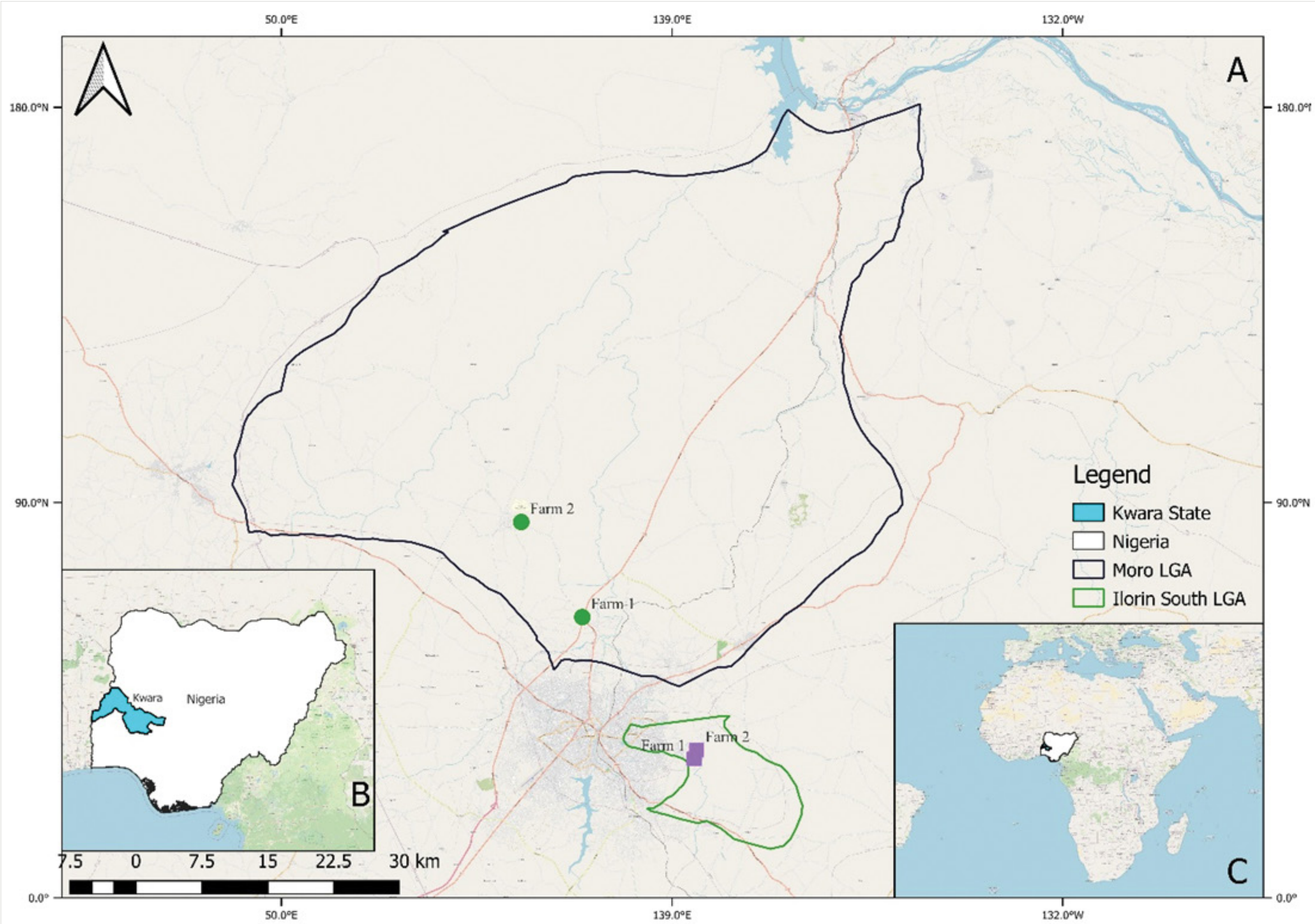



**Figure 1.** Map of the study location (**A**) Location of farms in two Local Government Areas (LGA) where fall armyworm larvae were sampled; (**B**) Location of Kwara State (blue section) in Nigeria; (**C**) Location of Nigeria (black border) on the continent of Africa

cor() function in R version 4.4.3 (R Core Team, 2025). To visualize the associations, scatter plots with fitted regression lines were generated using the ggplot() function from the ggplot2 package in R. Multiple plots were arranged into a composite figure using the ggarrange() function from the ggpubr package in R.

## Results

### Abundance of Fall Armyworm and Parasitoid Larvae

Parasitoid emergence in the Southern Guinea Savanna increased progressively over ten days, with small batches of six to seven larvae emerging every two days, while FAW larval numbers declined sharply from 100 to 5 during the same period (Fig. 2-A). In contrast, in the Northern Guinea Savanna, the number of FAW larvae dropped from 100 to 6 within the first eight days (Fig. 2-B). Also, only two parasitoid larvae emerged (one on the fourth day and another on the sixth day) during the entire observation period. Thereafter, no further parasitoid larval emergence was observed.

### Abundance of Fall Armyworm and Parasitoid Pupae

In the Southern Guinea Savanna zone, a steady increase was observed in the number of FAW pupae from day two to the tenth day, peaking at 62, with 7 parasitoid pupae appearing at day four and peaking at 9 on day ten (Fig. 3-A). A gradual decline followed, with both FAW and parasitoid pupae decreasing to 10 and 0, respectively, by day eighteen. In contrast, in the Northern Guinea Savanna zone, FAW pupae increased rapidly, reaching a peak of 77 by day eight, while only one parasitoid pupa was recorded (Fig. 3-B). From day ten to sixteen, the number of FAW pupae declined from day 75 to 14, respectively. An additional parasitoid pupa was found on day ten, after which no further parasitoid pupae were observed.

### Abundance of Fall Armyworm and Parasitoid Adults

In the Southern Guinea Savanna, adult emergence began on the twelfth day with 5 FAW moths and 8 parasitoid adults (Fig. 4-A). Subsequent days saw a steady rise in FAW moths and fewer parasitoid adults, with final counts on the eighteenth day showing 9 FAW moths and 3 parasitoid adults. In contrast, adult emergence in the Northern Guinea Savanna began on the tenth day with 7 FAW moths and no parasitoid adults (Fig. 4-B). Peak emergence occurred on the twelfth and fourteenth days with 31 and 33 FAW moths, respectively, while only one parasitoid adult emerging on the twelfth day. No further parasitoid adults were recorded through to the eighteenth day.

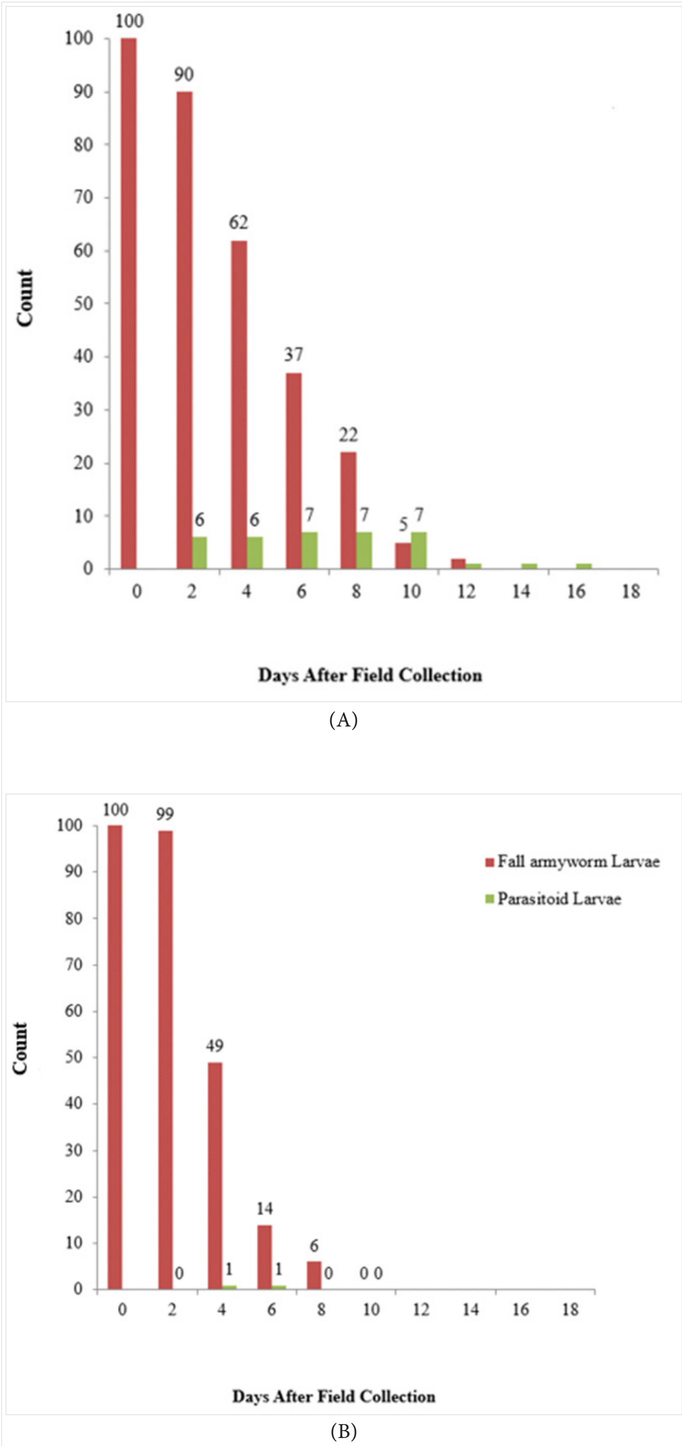



**Figure 2.** Abundance of fall armyworm and parasitoid larvae collected from the (**A**) Southern Guinea Savanna and (**B**) Northern Guinea Savanna agroecological zones of Kwara State

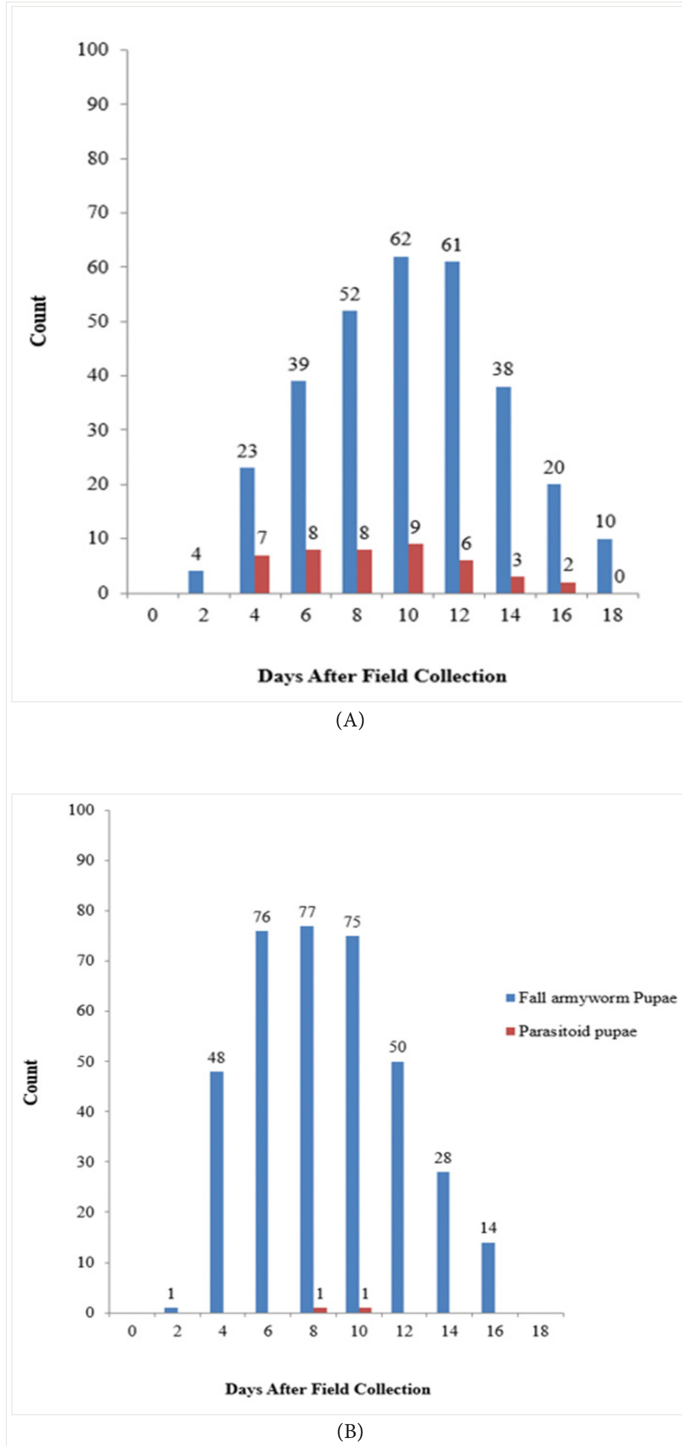
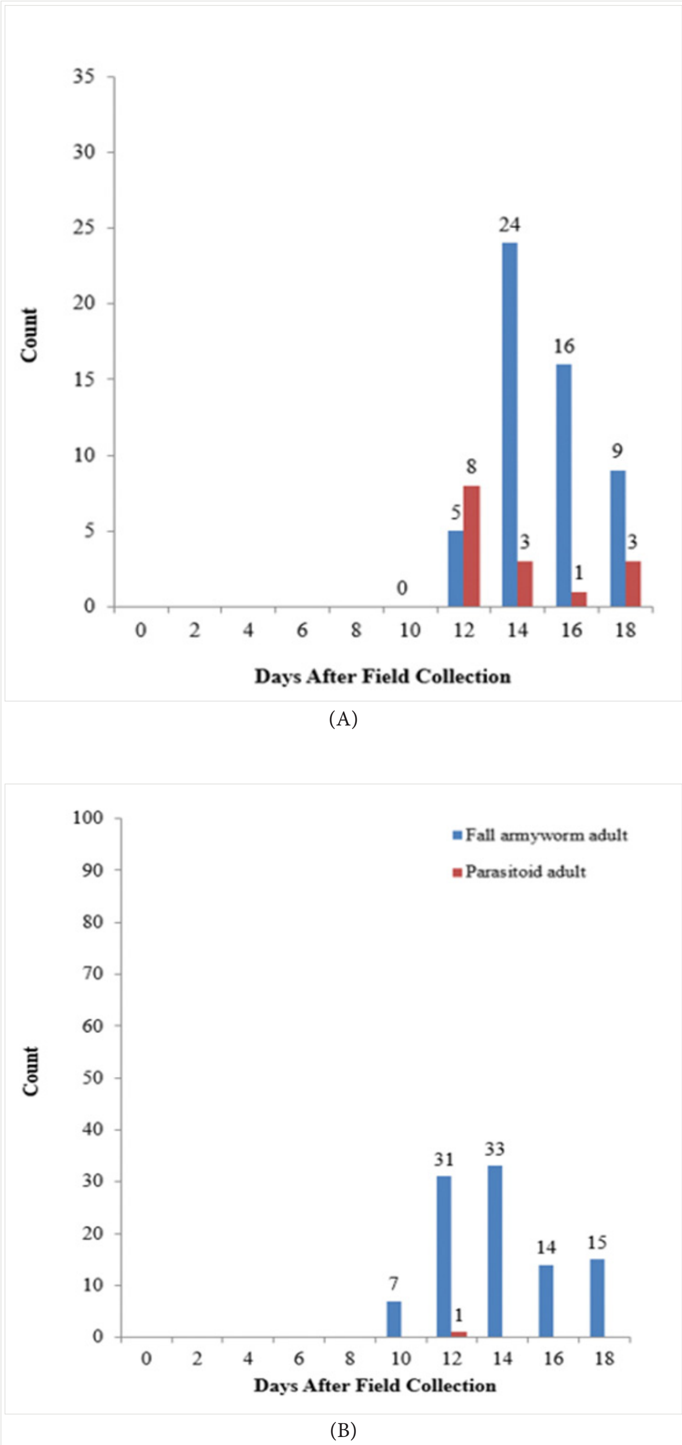



**Figure 3.** Abundance of fall armyworm and parasitoid pupae collected from the (**A**) Southern Guinea Savanna and (**B**) Northern Guinea Savanna agroecological zones of Kwara State




(A)

(B)

**Figure 4.** Abundance of fall armyworm and parasitoid adults collected from the (**A**) Southern Guinea Savanna and (**B**) Northern Guinea Savanna agroecological zones of Kwara State

### Relationship between Fall Armyworm and Parasitoid Abundance at Different Life Stages

A very weak but positive correlation (r = 0.19) was observed between the number of parasitoids and FAW larvae collected from the Southern Guinea Savanna agroecological zone (Fig. 7-A). In contrast, a strong positive correlation (r = 0.84) was found between pupa parasitoid abundance and FAW counts in the same zone (Fig. 7-B). The correlation between parasitoid adults and FAW moths in the zone (Fig. 7-C) was, however, moderate and positive (r = 0.37). In the Northern Guinea Savanna agroecological zone, the relationship between larval parasitoids and FAW larvae (Fig. 7-D) was very weak and negligible (r = 0.06). As with the Southern zone, a strong positive correlation (r = 0.63) was found between pupa parasitoids and FAW numbers (Fig. 7-E), while a moderate positive correlation (r = 0.57) was observed between adult parasitoids and FAW moths (Fig. 7-F) in the Northern zone.

### Type of Fall Armyworm Larval Parasitoid

In this study, two species of parasitoids emerged from field parasitized FAW larvae collected from the Northern and Southern Guinea Savanna agroecological zones of Kwara State. The first (Fig. 5A-C) is a braconid and egg-larval endoparasitoid in the genus *Chelonus*, subfamily *Cheloninae*, family *Braconidae*, superfamily Ichneumonoidea and order Hymenoptera. The species is suspected to be *C. bifoveolatus* De Saeger, 1948 due to the presence of two distinct foveae on the mesoscutum; nonetheless, molecular analysis may be required to further confirm its identity and exclude other closely related species common in West Africa. The second (Fig. 5D-F) was confirmed to be *Drino quadrizonula* (Thomson, 1869), a tachinid larval parasitoid in the genus *Drino*, subfamily Exoristinae, family *Tachinidae*, superfamily Oestroidea and order Diptera. *Chelonus* sp. accounted for 62.50% of all the larval parasitoids collected in this study while the rest were *D. quadrizonula*. Additionally, the braconid wasp was only found parasitizing fall armyworm larvae sampled from the Southern Guinea Savanna agroecological zone, while *D. quadrizonula* was found in both agroecological zones (Fig. 6).

## Discussion

Since the initial report of FAW in Africa in 2016, considerable efforts have been made to raise awareness and implement control strategies, including cultural practices, host plant resistance, integrated FAW management, chemical methods and biological control (Goergen et al., 2016; Prasanna et al., 2018). Yet, chemical control remains the most widely used method for managing the pest globally, though its success rate varies (Yu et al., 2003; FAO, 2018). The repeated and indiscriminate use of synthetic insecticides for managing FAW may, however, undermine integrated pest management approaches targeting other key maize pests such as stemborers (Agboyi et al., 2020). Although environmentally friendly alternatives like botanical insecticides have been explored for FAW control in Africa, their uptake remains limited due to issues of cost and accessibility (Bateman et al., 2018; Baudron et al., 2019). Given these challenges, control using natural enemies like predators and parasitoids presents a sustainable solution for managing FAW, particularly for resource-limited smallholder farmers in Africa (Agboyi et al., 2020).

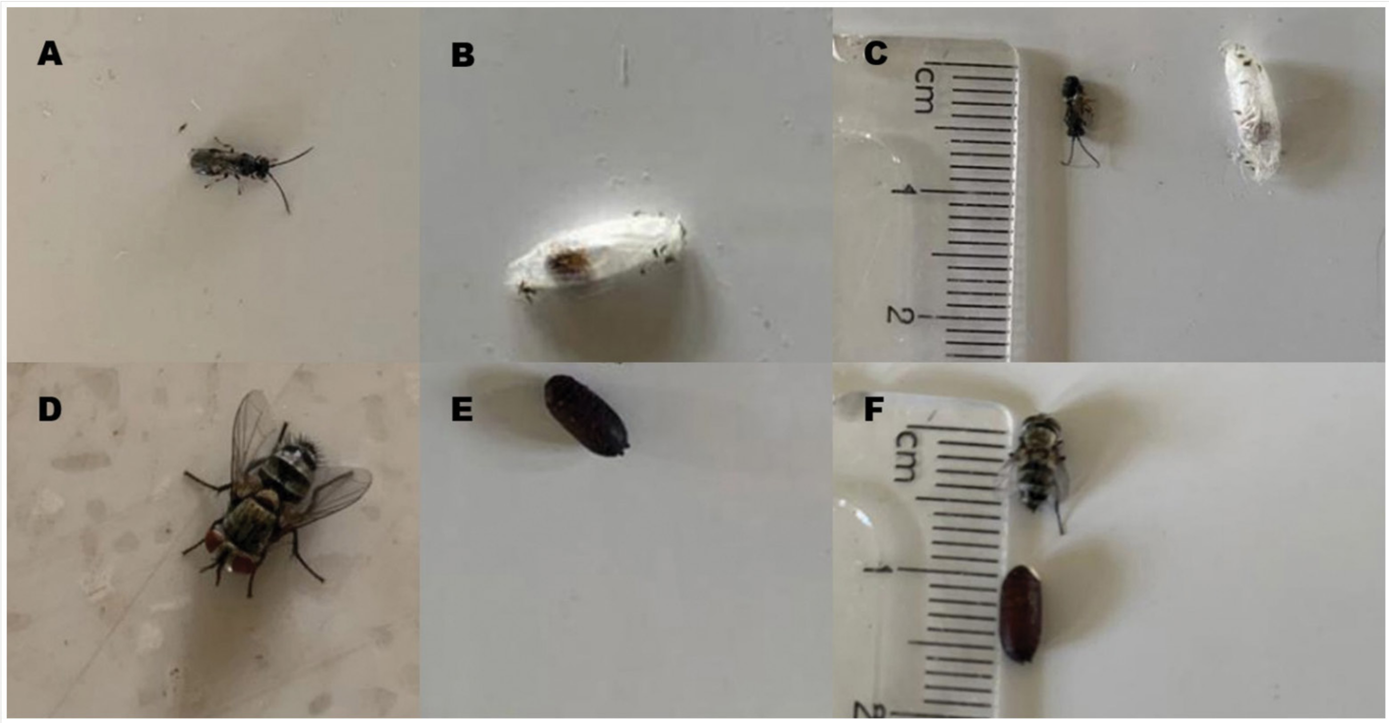



**Figure 5.** Parasitoids of fall armyworm larvae in the Southern and Northern Guinea Savanna agroecological zones of Kwara State (**A**) The braconid wasp, *Chelonus* sp. (**B**) Cocoon of the wasp parasitoid (**C**) Wasp measures approximately 5 mm in length (**D**) The parasitic fly, *Drino quadrizonula* (**E**) Pupal case of the fly parasitoid (**F**) Fly measures approximately 5 mm in length

Information on the occurrence and rates of parasitism of indigenous natural enemies has a paramount importance in designing biological control of FAW either through conservation of native natural enemies, introduction from aboriginal or augmentative release (Sisay, 2018). Since that first detection in 2016, substantial research documenting its natural enemies across the continent has been conducted. For example, in East Africa, Sisay et al. (2018) identified various natural enemies, including a complex of parasitoids in countries such as Ethiopia, Kenya, and Tanzania. Likewise, native natural enemies of FAW have been reported in Senegal (Tendeng et al., 2019). In West Africa, Kenis et al. (2019) highlighted the potential of the Platygastrid egg parasitoid, *Telenomus remus* Dixon and the larval parasitoid *Coccygidium luteum* Brullé as effective biological control agents against FAW. Agboyi et al. (2020), working on the parasitoid complex of FAW in Benin and Ghana, also identified *T. remus*, the trichogrammatid egg parasitoid – *Trichogramma* sp., the braconid larval parasitoids – *C. luteum* (Brullé) and *Cotesia icipe* Fernandez-Triana and Fiaboe, the ichneumonid larval parasitoids – *Charops* sp. and *Pristomerus pallidus* (Kriechbaumer) and the larval-pupal parasitoids, Meteoridea cf. testacea (Granger) and *Metopius discolor* Tosquinet in one or both countries. In addition to these, they also found a tachinid larval parasitoid, *Drino quadrizonula* (Thomson) and an egg-larval braconid parasitoid, *Chelonus bifoveolatus* Szépligeti. From infested FAW eggs and larvae collected from maize fields in Ibadan, Nigeria, Ogunfunmilayo et al. (2021) identified the larval parasitoid, *Euplectrus laphygmae* (Hymenoptera.: Eulophidae), the egg parasitoid, *T. remus*, and *Trombidium* sp. (Acari.: Trombidiidae)—a parasitic mite.

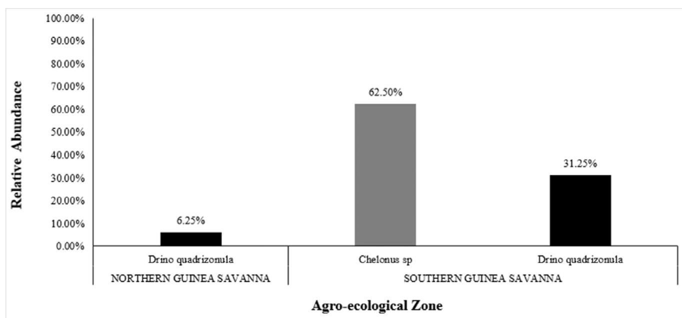



**Figure 6.** Distribution of the larval parasitoids, *Chelonus* sp. and *Drino quadrizonula* across the Southern and Northern Guinea Savanna agroecological zones of Kwara State, Nigeria

Two parasitoid species were identified in the present study: the braconid *Chelonus* sp. and the tachinid *Drino quadrizonula*. Nevertheless, the hymenopteran, *Chelonus* sp. was observed in higher numbers than the dipteran. This finding aligns with Feener and Brown (1997), who reported that dipteran parasitoids constituted only about 20 percent of all parasitoid species, with the majority belonging to the order Hymenoptera. Furthermore, until this present study, species in the genus *Drino* and *Chelonus* have not been reported as parasitoids of FAW larvae in Nigeria. The identification of *Chelonus* sp. and *D. quadrizonula* in the Guinea Savanna agroecological zones of Kwara, Nigeria and their absence in samples collected in Ibadan (a Rainforest/Derived Savanna zone) by Ogunfunmilayo et al. (2021) suggest that the distribution of FAW parasitoids in the country may be influenced by factors such as rainfall, fall armyworm density and maize growth stage (Durocher-Granger et al., 2021; Chipabika et al., 2023). In Nigeria, the Southern Guinea Savanna receives between 1000 and 1500 mm of annual rainfall while the Northern Guinea Savanna gets between 900 and 1200 mm (Oriola et al., 2010; Ojumoola et al., 2022). Differences in rainfall and other agroecological factors may explain the predominant presence of *Chelonus* species in the Southern Guinea Savanna and their complete absence in the Northern Guinea Savanna in this study. Furthermore, the strong positive association observed between parasitoids and fall armyworm pupae in this study indicates good host synchrony, which is an essential trait for the effectiveness of a biological control agent (Cingolani et al., 2025). Nevertheless, in the context of climate change, host–parasitoid interactions may become disrupted (Di Marco et al., 2023), potentially reducing natural pest control and prompting increased insecticide use as growers react to avert crop losses. This underscores the need for in-depth studies on how changing agro-climatic conditions affect host–parasitoid dynamics in agro-ecosystems across Nigeria and other sub-Saharan African countries, with the goal of mitigating food insecurity, curbing indiscriminate pesticide use and addressing the associated environmental and health challenges.

The egg–larval parasitoid *C. bifoveolatus* Szépligeti is a key parasitoid of FAW in Ghana and Benin (Agboyi et al., 2020). Considering the geographical proximity of these West African countries to Nigeria and the morphological characteristics of the collected specimens, it is most likely that the *Chelonus* species in this study is also *C. bifoveolatus*. In contrast, Sisay et al. (2018, 2019), reported that *C. curvimaculatus* Cameron was the predominant species in Kenya, East Africa. Indeed, *C. bifoveolatus* is a widespread parasitoid of other *Spodoptera* species across several African countries, including Nigeria (Madl and van Achterberg, 2014; Yu et al., 2005). Notably, the present study is the first to report its possible occurrence as a larval parasitoid of *S. frugiperda* in Nigeria. Similarly, the tachinid fly, *D. quadrizonula* identified in this study is a well-documented parasitoid in sub-Saharan Africa, known to parasitize moth larvae, particularly those of the family Noctuidae (Crosskey, 1970; Agboyi et al., 2020). Surveys conducted in Ghana and Benin by Agboyi et al. (2020) also recorded *D. quadrizonula*, although it was observed at lower occurrence levels. In addition to *D. quadrizonula* and *Chelonus* sp., it is likely that other parasitoid species – such as those reported by Ogunfunmilayo et al. (2020) – might have been detected if larval sampling had covered more farms across a broader geographic range within each agroecological zone.

Given the foregoing, studies on the seasonal dynamics, parasitism efficacy, host specificity and ecological adaptability of native fall armyworm parasitoids across Nigeria's diverse agroecological zones are needed to support their effective integration into integrated pest management (IPM) programs.

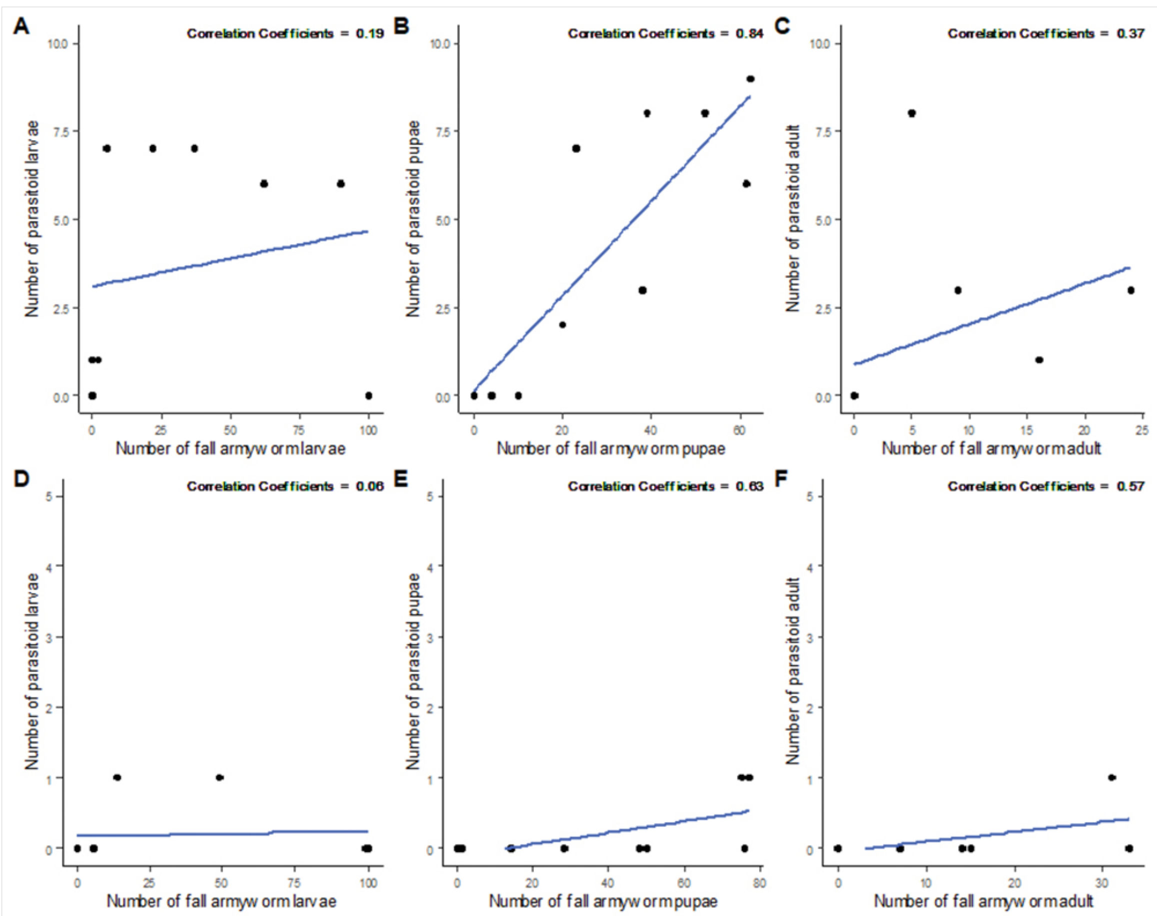



**Figure 7.** Correlation between the number of parasitoids and fall armyworm at different life stages in the Southern and Northern Guinea Savanna agroecological zones of Kwara State, Nigeria: (**A**) larvae, (**B**) pupae, and (**C**) adults in the Southern Guinea Savanna; (**D**) larvae, (**E**) pupae, and (**F**) adults in the Northern Guinea Savanna

## Conclusion

This study confirms the presence of the tachinid fly *D. quadrizonula* and the braconid wasp *Chelonus* sp. as larval parasitoids of FAW in the Southern and Northen Guinea Savanna agroecological zones of Nigeria. Parasitoids are among the most widely utilized natural enemies in insect pest management. They maintain a close association with specific developmental stages of their hosts, with the developing parasitoid larvae ultimately killing the host. To promote sustainable FAW management and reduce maize yield losses, strategies for the conservation, mass rearing, and field deployment of these parasitoids should be further explored and implemented.

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## CRediT Authorship Contribution Statement

**Ojumoola Olusegun Adebayo:** Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Formal analysis, Validation, Writing – original draft. **Usman Azeezat Arinola:** Investigation Writing – original draft. **Falola-Olasunkanmi Judith Adejoke:** Conceptualization, Supervision Writing – review editing. **Lawal Mujidat Temidayo:** Supervision Writing – review editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## References

Agboyi L. K., Goergen G., Beseh P., Mensah S. A., Clottey V. A., Glikpo R., Buddie A., Cafà G., Offord L., Day R., Rwomushana I. Kenis M. (2020). Parasitoid Complex of Fall Armyworm, *Spodoptera frugiperda*, in Ghana and Benin. Insects 11(2): 68. doi: 10.3390/insects11020068

Assefa F. Ayalew D. (2019). Status and Control Measures of Fall Armyworm (*Spodoptera frugiperda*) Infestations in Maize Fields in Ethiopia: A Review. Cogent Food Agric 5 (1): 1641902. doi: 10.1080/23311932.2019.1641902

Bateman M. L., Day R. K., Luke B., Edgington S., Kuhlmann U., Cock M. J. W. (2018). Assessment of Potential Biopesticide Options for Managing Fall Armyworm (*Spodoptera frugiperda*) in Africa. J Appl Entomol 142 (9): 805–819. doi: 10.1111/jen.12565

Baudron F., Zaman-Allah M. A., Chaipa I., Chari N. Chinwada P. (2019). Understanding the Factors Influencing Fall Armyworm (*Spodoptera frugiperda* J.E. Smith) Damage in African Smallholder Maize Fields and Quantifying Its Impact on Yield: A Case Study in Eastern Zimbabwe. Crop Prot 120: 141–150. doi: 10.1016/j.cropro.2019.01.028

Chipabika G., Sohati P. H., Khamis F. M., Chikoti P. C., Copeland R., Ombura L., Kachapulula P. W., Tonga T. K., Niassy S., Sevgan S. (2023). Abundance, Diversity and Richness of Natural Enemies of the Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), in Zambia. Front Insect Sci 3: 1091084. doi: 10.3389/finsc.2023.1091084

Cingolani M. F., Barakat M. C., Cerretti P., Chirinos D. T., Ferrer F., Gaviria Vega J., Grenier S., Kondo T., Pape T., Plowes R., Salas J., Vargas G., Whitmore D., Dindo M. L. (2025). Dipteran Parasitoids as Biocontrol Agents. BioControl 70 (3): 285–300. doi: 10.1007/s10526-025-10317-1

Day R., Abrahams P., Bateman M., Beale T., Clottey V., Cock M., Colmenarez Y., Corniani N., Early R., Godwin J., Gomez J., Moreno P. G., Murphy S. T., Oppong-Mensah B., Phiri N., Pratt C., Silvestri S., Witt A. (2017). Fall Armyworm: Impacts and Implications for Africa. Outlooks on Pest Management 28 (5): 196–201. doi: 10.1564/v28_oct_02

Durocher-Granger L., Mfune T., Musesha M., Lowry A., Reynolds K., Buddie A., Cafà G., Offord L., Chipabika G., Dicke M., Kenis M. (2021). Factors Influencing the Occurrence of Fall Armyworm Parasitoids in Zambia. J Pest Sci 94: 1133–1146. doi: 10.1007/s10340-020-01320-9

Estrada V. O., Cambero Campos J., Robles Bermudez A., Rios Velasco C., Carvajal Cazola C., Isiordia Aquino N. (2013). Parasitoids and Entomopathogens of the Fall Armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in Nayarit, Mexico. Southwestern Entomologist 38 (3): 339–344.

Feener D. H. Jr., Brown B. V. (1997). Diptera as Parasitoids. Ann Rev Entomol 42: 73–97. doi: 10.1146/annurev.ento.42.1.73

Food and Agriculture Organization of the United Nations – FAO (2018). Integrated Management

of the Fall Armyworm on Maize: A Guide for Farmer Field Schools in Africa. Rome, Italy,

Available at: http://www.fao.org/3/I8665EN/i8665en.pdf [Accessed 27. 6. 2025]

Goergen G., Kumar P. L., Sankung S. B., Togola A. 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. doi: 10.1371/journal.pone.0165632

Goulet H., Huber J. T. (1993). Hymenoptera of the World: An Identification Guide to Families. Ottawa, ON: Centre for Land and Biological Resources Research.

Ji Q. E. (2001). Classification of *Cheloninae* (Hymenoptera: *Braconidae*) from China. Fuzhou, China: Fujian Agriculture and Forestry University.

Kasoma C., Shimelis H., Laing M. D. (2020). Fall Armyworm Invasion in Africa: Implications for Maize Production and Breeding. J Crop Improv 34 (5): 635–658. doi. 10.1080/15427528.2020.1802800

Kenis M., du Plessis H., Van den Berg J., Ba M. N., Goergen G., Kwadjo K. E., Baoua I., Buddie A., Cafà G., Offord L., et al. (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. doi: 10.3390/insects10040092

Madl M. van Achterberg C. (2014). A Catalogue of the *Braconidae* (Hymenoptera: Ichneumonoidea) of the Malagasy Subregion. Linzer Biologische Beiträge 46 (1), 5–220.

McGrath D., Huesing J. E., Beiriger R., Nuessly G., Tepa-Yotto T. G., Hodson D., Kimathi E., Felege E., Abah Obaje J., Mulaa M., Mendes A. P., Amer Mabrouk A. F. Belayneh Y. (2018). Monitoring, Surveillance, and Scouting for Fall Armyworm, In: Fall Armyworm in Africa: A Guide for Integrated Pest Management (Prasanna B. M., Huesing J. E., Eddy R., Peschke V. M., eds.), Mexico, CDMX, 11–28 pp.

Microsoft Corporation (2016). *Microsoft Excel* (Version 2016) [Computer software]. Microsoft Corporation

Molina-Ochoa J., Carpenter J. E., Heinrichs E. A. Foster J. E. (2003). Parasitoids and Parasites of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas and Caribbean Basin: An Inventory. Florida Entomologist 86(3): 254–289.

Montezano D. G., Specht A., Sosa-Gómez D. R., Roque-Specht V. F., Sousa-Silva J. C., Paula-Moraes S. V., Peterson J. A. Hunt T. E. (2018). Host Plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas. African Entomology 26 (2): 286–300.

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., Ofuya T. I. (2021). Occurrence of Natural Enemies of Fall Armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in Nigeria. PLOS One 16 (7), e0254328. 10.1371/journal.pone.0254328

O'Hara J. E., Shima H., Zhang C. (2009). Annotated Catalogue of the *Tachinidae* (Insecta: Diptera) of China. Zootaxa 2190: 1–236.

O'Hara J. E., Cerretti P. (2016). Annotated Catalogue of the *Tachinidae* (Insecta, Diptera) of the Afrotropical Region, with the Description of Seven New Genera. ZooKeys 575: 1–344.

Ojumoola O. A., Omoloye A. A., Umeh V. C. (2022). Seasonal Differences in Fall Armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae), Abundance and Plant Injury on Selected Maize Varieties in Ibadan, Southwest Nigeria. Int J Pest Manag 70 (4), 981–991

Ojumoola O. A. Omoloye A. A. (2023). Influence of Food Quantity, Larval Density and Size of Rearing Container on Intra-Instar Cannibalism in Fall Armyworm, *Spodoptera fruigiperda* (J. E. Smith) (Lepidoptera: Noctuidae). Int J Trop Insect Sci 44: 363-368. doi: 10.1007/s42690-023-01140-1

Ojumoola O. A., Odeje V. E, Folorunsho D. C. Adebayo F. E. (2022). On-Farm Assessment of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) Infestation and Damage to Early-Whorl and Late-Whorl Maize in a Southern Guinea Savanna Agro-Ecology. Appl Trop Agric 27(1): 59 – 63.

Oriola E., Ifabiyi I., Hammed A. (2010). Impact of Reforestation in a Part of Degrading Natural Ecological System of Ilorin, Kwara State, Nigeria. African Journal of Agricultural Research 5: 2811 – 2816.

Prasanna B. M., Bruce A., Winter S., Otim M., Asea G., Sevgan S., Ba M., van den Berg J., Beiriger R., Gichuru L., Trevisan W., Williams P., Oikeh S., Edge M., Huesing J.E. Powell T. (2018). Host Plant Resistance to Fall Armyworm. Fall Armyworm in Africa: A Guide for Integrated Pest Management (Prasanna B.M., Huesing J. E., Eddy R., Peschke V.M., eds.), Mexico, CDMX, pp. 45–62.

R Core Team (2025). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria

Shaw, M. R., Huddleston, T. (1991). Classification and Biology of Braconid Wasps (Hymenoptera: *Braconidae*) (Vol. 7, W. R. Dolling R. Askew, Eds.). The British Museum (Natural History).

Sisay B., Simiyu J., Malusi P., Likhayo P., Mendesil E., Elibariki N., Wakgari M., Ayalew G., Tefera T. (2018). First Report of the Fall Armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae), Natural Enemies from Africa. J Appl Entomol 142 (9): 800–804. doi: 10.1111/jen.12534

Sisay B., Simiyu J., Mendesil E., Likhayo P., Ayalew G., Mohamed S., Subramanian S., Tefera T. (2019). Fall Armyworm, *Spodoptera frugiperda* Infestations in East Africa: Assessment of Damage and Parasitism. *Insects* 10 (7): 195. doi: 10.3390/insects10070195

Tefera T., Goftishu M., Ba M., Muniappan R. (2019). A Guide to Biological Control of Fall Armyworm in Africa Using Egg Parasitoids (1st ed.). International Centre for Insect Physiology and Ecology (ICIPE)

Tendeng E., Labou B., Diatte M., Djiba S., Diarra K. (2019). The Fall Armyworm *Spodoptera frugiperda* (J.E. Smith), a New Pest of Maize in Africa: Biology and First Native Natural Enemies Detected. Int J Biol Chem Sci 13 (2): 1011–1026.

Yu S. J., Nguyen S. N. Abo-elghar G. E (2003). Biochemical Characterization of Insecticide Resistance in the Fall aAmyworm, *Spodoptera frugiperda* (J. E. Smith). Pesticide Biochemistry and Physiology 77: 1-11.

Yu D. S., van Achterberg K., Horstmann K. (2005). World *Ichneumonoidea* 2004: Taxonomy, Biology, Morphology, and Distribution [CD/DVD], Taxapad.

Zack R. S. (1997). Manual of the New World Genera of the Family *Braconidae* (Hymenoptera). Annals of the Entomological Society of America 92: 615–616.

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