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ASSESSMENT OF DAMAGE AND BIOCONTROL AGENTS OF FALL ARMYWORM SPODOPTERA FRUGIPERDA (JE SMITH, 1797) (LEPIDOPTERA, NOCTUIDAE) ON MAIZE IN SOUTHERN OF BENIN REPUBLIC

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ABSTRACT

Spodoptera frugiperda (JE Smith, 1797) prefer maize over a diverse range of host plants threatening food security in West Africa. Since the invasion of *S. frugiperda* in Africa in 2016, farmers have developed different pest management strategies including the use of pesticides from various sources which may prove dangerous to humans' health and environment. In order to devise integrated pest management knowledge of damage incidence in ecological zones and respectively associated natural enemies is needed. Survey was carried out in different agroecological zones including "lar land zone (ZAE 6), depression zone (ZAE 7) and fisheries zone (ZAE 8) of maize production in southern Benin during June to October, 2019. A total of 1350 larvae and 26 egg masses of *S. frugiperda* were collected by sampling 60 untreated fields of maize crops from 20 locations. An average of 120 eggs were counted in total or each egg mass. The results showed different levels of pest damage upto 100% plants devastated by the attack of the pest. Natural enemies were brought in the laboratory for identification. The parasitism rate was 3.35 %. The parasitoids identified from Hymenoptera were *Cotesia icipe* Fernandez-Triana & Fiaboe, *Chelonus bifoveolatus* (Szépligeti), *Telenomus remus* Nixon, Charops Sp., *Pristomerus pallidus* (Kriechbaumer) with overall parasitism of 3.33. The predators belonged to the families-Coccinellidae [*Coccinella septempunctata*], Forficulidae [*Forficula senegalensis* (Serville)] and Formicidae [*Pheidole megacephala* (Fabricius), *Lasius niger* (Linnaaeus)]. The most abundant predators were from Formicidae (94%), followed by Coccinellidae (3.67%) and Forficulidae (1.84%). Minor predators (0.57%) of different such other families as Mantidae, Reduviidae (Rhynocoris sp.) and Pentatomidae were also collected from the fields. The higher damage level and the abundance natural enemies were observed in the depression zone 7.

Key words: *Spodoptera frugiperda*, damage, parasitoids, predators, biological control

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INTRODUCTION

With an unmatched preference for maize, a main staple food for the Sub-Saharan Africa population (Day *et al*., 2017; Ekpa *et al*., 2018), the fall armyworm *Spodoptera fruigiperda* (Lepidoptera, Noctuidae) is an emerging pest attacking many other important crops (Prasanna *et al*., 2018). It causes damage of economic importance particularly to maize with yield losses ranging from 15 to 73% recorded when 55 to 100% of the plants are infested, especially in the middle and at the end of the crop development cycle (Hruska and Gould, 1997). The larval stages of *S. frugiperda* appear to be much more damaging to maize than most other *Spodoptera* species. With the current findings in several agroecological zones, the issue related to the integrated management of the fall armyworm remains incontestable regarding to the speed of its progression and the damage it creates to farmers with impacts on agricultural production and food security in Africa (Badiane *et al*., 2015). Indeed, parasitoids species remained the *S. frugiperda* major's natural enemies *(*Molina-Ochoa *et al*. 2003) which include insect (Sisay *et al*. 2018) and diverse taxa of predators (Koffi *et al*. 2020). There is currently little information on the natural enemies of *S. frugiperda* in Africa (Agboyi *et al*. 2020) and although some recent studies have reported some natural enemies of *S. frugiperda* in, Senegal (Tendeng *et al*. 2019), Benin, Côte d'Ivoire and Ghana (Agboyi *et al*. 2020; Koffi *et al*. 2020), Niger (Laminou *et al*. 2020), Mozambique (Caniço *et al*. 2020), Burkina Faso (Ahissou *et al*., 2021) and India (Shylesha *et al*. 2018, Sharanabasappa *et al*. 2019). These studies indicated that the natural enemies of fall armyworm varied from country to country, although

some species (i.e., *Coccygidium* spp., *Chelonus* spp., *Campoletis* spp., *Metopius* spp., *Trichogramma* spp., *Telenomus* sp., *Hexamermis* sp. and earwigs) have been widely reported in many parts of the world (Ahissou *et al*. 2021).

This study aims to contribute on the better knowledge of the evolution of *Spodoptera frugiperda* damage and the assessment of its natural enemies (parasitoids and predators) in maize agroecological production zones in the southern of Benin Republic.

MATERIALS AND METHODS

Sampling area of study: Assessment of damage by fall armyworm was conducted in the fields during two seasons; once between May and June 2019 during the long rainy season in Benin, and again during the short rainy season between September and October in the same year. The field survey was carried out in 20 localities in South of Benin Republic, covering three agroecological zones (Figure 1; Table 1) namely a valley and low land zone (ZAE 6) located in the southern part of Benin, a ferralitic soil zone (ZAE 7) located between the depressions of Tchi and Lama and the fishing land zone (ZAE8). These zones are part of the eight agroecological zones defined in Benin and classified based on relative homogeneity, taking into account climatic, agro-pedological parameters, cropping systems, population density and plant cover (MAEP, 2009). All insect samples were brought to the isolation room of the laboratory of the International Institute of Tropical Agriculture (IITA), Benin Station. The conditions for monitoring the insects in the laboratory were 26 ± 1°C, 70% RH and a photophase of 12 hours.

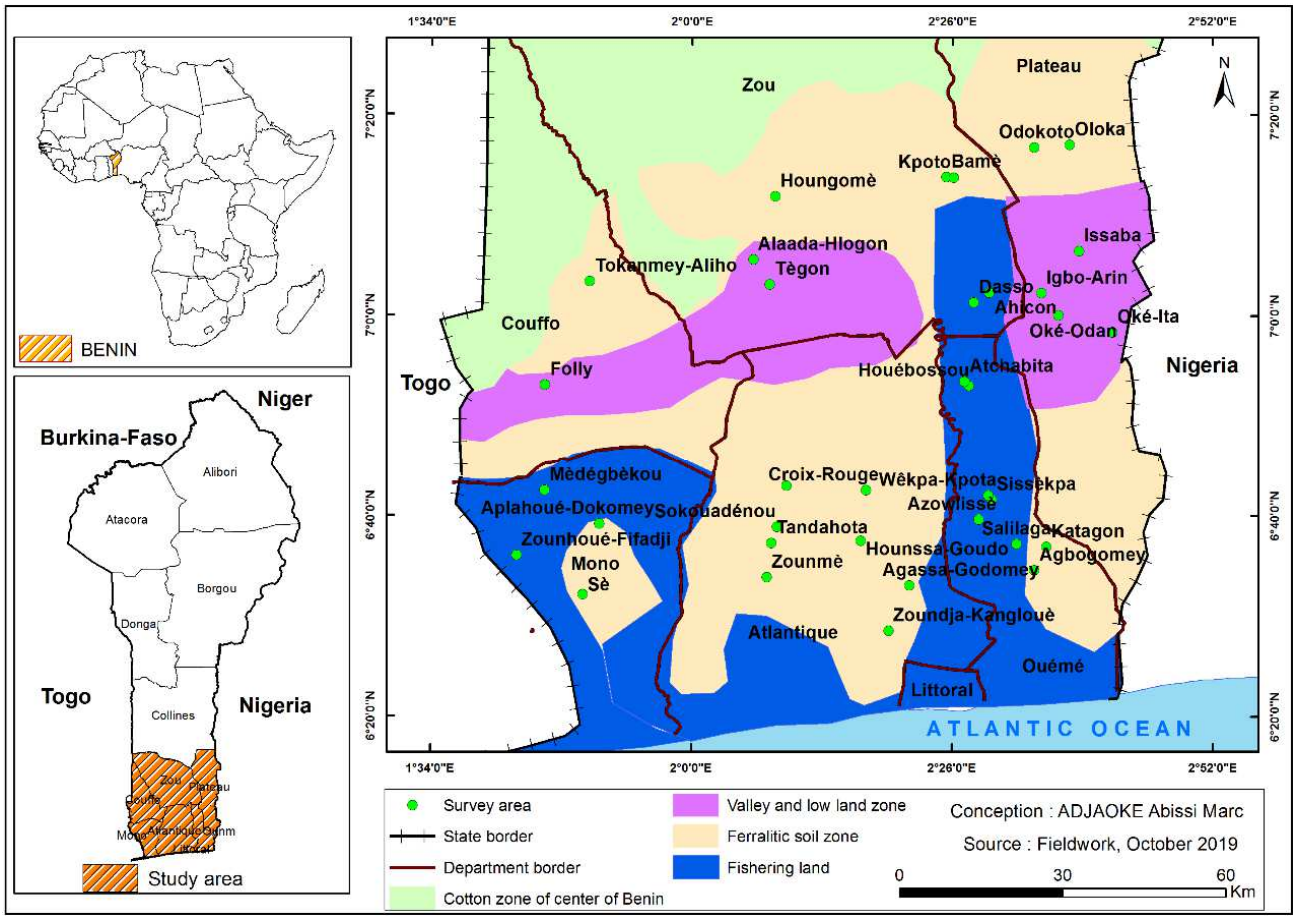

Figure 1. Area of Study (Adjaoke, 2019)

Maize fields surveyed: The surveyed fields were untreated and met following fundamental criteria (i) the size of the area (less than $^1/_4$ hectare), (ii) the plant growth stage (field before heading) (iii) the specific purity of the species (sole maize crop). The maize fields were georeferenced for quantitative presence of the pest and the natural enemies associated with maize depending on the agroecological zones targeted and the seasons fit for potential maize production. Agricultural statistics were obtained from the Ministry of Agriculture, Livestock and Fisheries (MAEP) of the Benin Republic.

In the various agroecological zones surveyed, qualitative and quantitative data were recorded in a pre-established collection sheet. A total of 60 fields were surveyed across 20 locations with three fields per location; all in three agroecological zones in the departments of Atlantique, Zou, Ouémé, Plateau, Mono and Couffo. The collected data were as follows: (i) incidence of *S. frugiperda* damage in the fields, (ii) stage specific of the different larval stages of *S. frugiperda* per maize plant and (iii) presence or not of natural enemies associated with the pest For characterization of the presence or absence of potential parasitoids associated with *S. frugiperda* in the different prospected agroecological zones, clusters of eggs and larvae of young stages aged approximately 1 to 3 days were collected and monitored under laboratory conditions. The fields were sampled in each locality following a 5-point W-scouting scheme (McGrath *et al*. 2018) for a total of 100 plants per field with 20 plants per point in each field (Figure 2).

Table 1. Characteristics of the agroecological zones targeted in the study

Zone	Localisation	Characteristics
"Bar land" zone (ZAE 6)	This area is one of the most complex and referred to as the "bar land area" because of the characteristics of these soils. It is located in the southern part of Benin and includes the municipalities of Abomey-Calavi, Allada, Kpomassèe, Tori-Bossito, Zè in the Atlantic department, of Djakotomey, Dogbo, Klouékanmè, Houeyogbe, Toviklin in the department of Mono, d'Adjarra, Akpro-Misseréte, Avrankou, Ifangni, Porto-Novo, Sakete, in the department of Oueme, Abomey, Agbagnizoun, Bohicon, Cove, Za-Kpota and Zagnanado in the department of Zou	The climate is marked by two rainy seasons (March-July; October-November) and two dry seasons (December-February; August). Rainfall heights vary between 1000 to 1400 mm.
Depression zone (ZAE 7)	Located in a depression which, from west to east, is called the Tchi depression in the Mono (Municipality of Lalo), the Lama depression in the Atlantic and the Zou (respectively Municipalities of Toffo and Zogbodomey) and Issaba in Ouémé (Municipalities of Adja-Ouèrè and Pobè).	From a climatic point of view, it is quite comparable to the zone of bar lands with, however, a high relative humidity (around 85%).
Fisheries zone (ZAE 8)	The fisheries zone is the southernmost and occupies the fluvio-lacustrine area of the departments of the Atlantic, Mono, Ouémé and Zou where it covers the municipalities of Athiémé, Grand-Popo, Bopa, Lokossa, Comé in the Mono department, Ouidah and Sô-Ava in the Atlantic department, Sèmè-Kpodji, Aguégués, Dangbo, Adjohoun and Bonou in the Ouémé department and Ouinhi in the Zou department.	development of inland and sea fishing in addition to plant and animal production

Source: (MAEP, 2009).

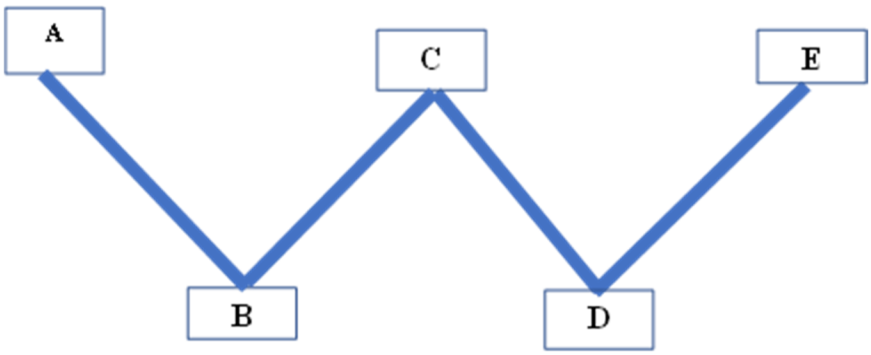

Figure 1. W-scouting scheme (McGrath *et al.* 2018)

Incidence of *S. frugiperda* in the field: To evaluate the incidence of the damage caused by *S. frugiperda* on maize, a direct observation was made plant by plant on the 100 maize plants sampled in the prospected field. This incidence **I** was determined by the formula: **I** =

$\frac{\mathbf{NIP}}{\mathbf{TNPs}}$**x100** where **I** is the incidence in percentage, **NIP** is the number of the infested plants and **TNPs** is the total number of plants sampled. Concerning the damage levels caused by *S. frugiperda* larvae in the different fields surveyed, the leaf damage assessment scale of Prasanna *et al*. (2018) in maize, adjusted from Davis and William (1992) was used. The scores considered for the evaluation of the critical level of damage likely to have an impact on the yield of the plant were those greater than or equal to 4. This scale classifies damage levels ranging from 1 to 9 depending on the evolution of the severity of damage (Figure 3).

Figure 3. Leaf damage assessment scale (Prasanna *et al*., 2018).

During the observations made in the maize fields, the levels of infestation (damage) were linked to the larval stages of *S. frugiperda,* which was observed on each plant of maize sampled. Based on the damage severity score developed by Prasanna *et al*. (2018), three damage assessment classes were defined namely damage levels 1 (low) with a score ranging from 1 to 3, damage levels 2 (medium) with a score ranging from 4 to 6 and damage levels 3 (high) with a score of 7 to 9.

Inventory of predators and parasitoids collected in the field: To inventory the natural enemies including parasitoids, each maize plant was observed to detect the entomological material. On each maize plant sampled, all *S. frugiperda* larvae were counted according to larval stages ranging from larval stages (L1 to L6). On the same maize plants, 3 days old larvae were collected and isolated in disinfected mini boxes. The egg clusters, on the leaf carefully removed from the plants, were also collected, preventing them from detaching from the leaf.

To achieve this, a sharp pruner was used to cut both ends of any leaf on which the egg clusters were found. These cut leaves were then placed in mini raising boxes, labeled, and dated with mention of the GPS coordinates for monitoring in the laboratory. To find the larvae in the fields, it was often necessary to cut open the still rolled maize leaves, as this is the pest's preferred place of refuge and predilection for food. In the prospected fields, observations were made in the morning before 9 a.m. and in the cool hours of the afternoon.

To inventory the natural enemies, observations were also made plant by plant to record the presence or not of the latter on the maize plants. For predators, the checklist of the earwigs, ladybirds and other predators of Chad (Dermaptera) (Girod *et al*., 2017; Nicolas *et al*., 2015) were used. The entomological material was brought to the laboratory for follow-up after quarantine. Once in the laboratory, each egg mass and larvae were placed individually and carefully in closed breeding box to prevent the escape of larvae after hatching. They were observed until the emergence of fall armyworm imago, or parasitoids. Using the determination keys (van Achterberg, 1990), a morphologically identification of parasitoids has been done. Emerged parasitoids were preserved in 90% ethanol and send to a laboratory in United Kingdom for molecular identification.

Parasitism rates: Samples were randomly collected from all fields studied. Only fields that have been detected by predators and natural enemies of the pest have been classified in a table with their geographic coordinates and agroecological zones. Parasitism rate (PR) of each parasitoid species was calculated by the following formula (Pair *et al*. 1986; Legaspi *et al*. 2001): $\boldsymbol{PR = \frac{Lp}{TL} x\ 100}$ Where PR represent Parasitism rate, Lp represent number of larvae and eggs parasitized and TL represent the total number of fall armyworm larvae and eggs collected.

Statistical analysis: Data collected from the incidence of damage were analyzed using both descriptive statistic such as frequency distribution, percentage and means. The data pertaining to different biological attributes were analyzed using ANOVA and the treatment means were separated by Tukey HSD test. All analyzes were performed using R 4.2.0 (R Core Team, 2020).

RESULTS

Incidence of *Spodoptera frugiperda* damage: The level of damage caused by *S. frugiperda* larvae varied according to the agroecological zone (ZAE), larval stages and seasons. Statistically, there was significant difference in damage levels of *S. frugiperda* between agroecological zones (Figure 6) (Table 2).

Among the seasons and between zone and seasons there were no significant difference (P > 0,05%) in the level of damage but there is significantly difference from one season to another (P< 0,05%) (Table 2).

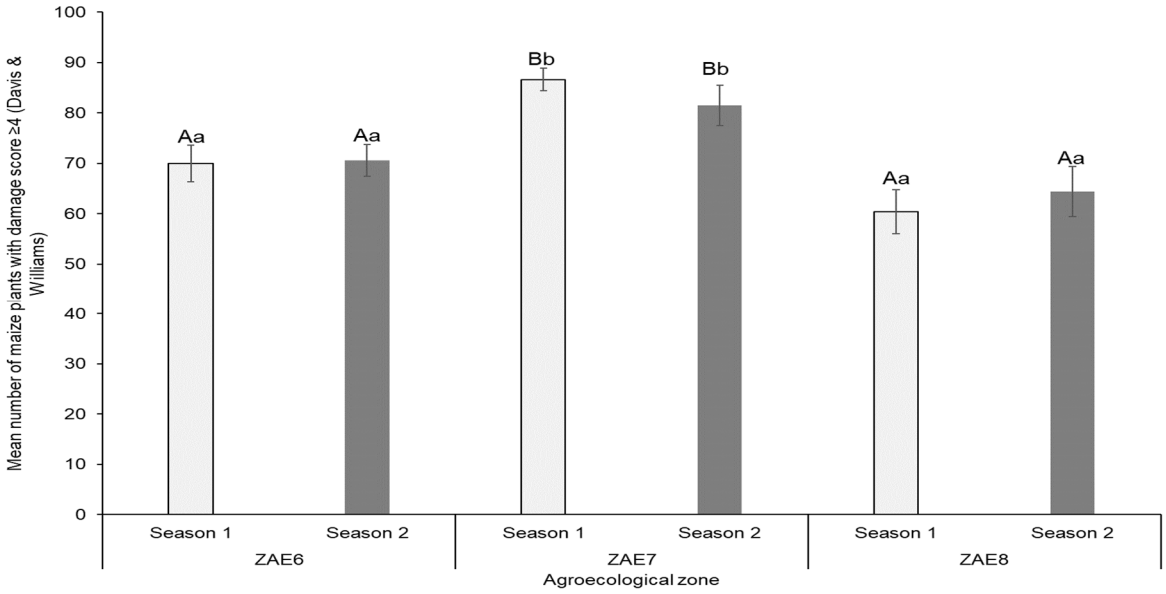

Figure 4. Evaluation of damage levels according to seasons and agroecological zones (mean ± SD). The means assigned different letters (Aa and Bb) are significantly different both with regard to the agroecological zones (ANOVA followed by Tukey (HSD); p < 0.05). Means with the same letters (Aa or Bb) are not significantly different both for agroecological zones and for seasons (ANOVA followed by Tukey (HSD); P > 0.05).

Table 2. Analyses of variance of S. frugiperda damage in the study areas.

	Df	Sum Sq	F value	Pr (>F)
Zone	2	2771.5	7.1954	0.001635 **
Seasons	2	11.5	0.0298	0.970623
Zone : Season	2	105.0	0.2726	0.762351

The direct observations made in fields showed that the level of damage caused by the larvae has changed proportionally with the stage of the larvae, their abundance per plant (Figure 4) as well as with the amount of precipitation in each agroecological zone according to the seasons (Table 1). In the three agroecological zones surveyed, the high damage of the pest was recorded in agroecological zone 7 with 85% during the long rainy season (season 1) and 74% during the short rainy season (season 2) (Figure 6), followed by agroecological zones 6 and 8 respectively with 70 % for the long season and 70 % for the short season and 65 % for the long season and 60 % for the short season.

Inventory of natural enemies in study areas

Parasitoids: Five species of parasitoids were identified from larvae reared in laboratory, viz., *Telenomus remus* Nixon (egg parasitoid), *Chelonus bifoveolatus* Szépligeti (ovo-larval parasitoid) and larval parasitoids (*Charops* sp., C*otesia icipe* Fernandez-Triana and Fiaboe and *Pristomerus pallidus* (Kriechbaumer)). The highest number of parasitoids was recorded in agroécological zone 7 during the long rain season. *Charops* sp. ranked highest with 3% of parasitism rate followed in descending order by *C. icipe* (0,17%), *P. pallidus* (0,09%), *C. bifoveolatus* (0,06 %) and *T. remus* (0,03 %). (Table 3 and Table 4).

Table 3. Parasitoids of *Spodoptera frugiperda* identified in the study area.

Order	Family	Specices	Type	Agroecological zone (ZAE)	Location (Village)	GPS coordinats	
						X	Y
Hymenoptera	Braconidae	*Cotesia icipe* Fernandez-Triana and Fiaboe	Larval	ZAE7	Zogbodomey (Allada-Hlogon)	7.092675	2.102505
					Zogbodomey (Tegon)	7.051823	2.129257
		Chelonus bifoveolatus Szepligeti	Egg-larval		Zogbodomey (Allada-Hlogon)	7.092675	2.102505
	Ichneumonidae	*Charops sp.*	Larval	ZAE6	Akpro-Misserete (Agbogome)	6.576244	2.570447
				ZAE8	Adjohoun (Azowlisse)	6.660018	2.478145
				ZAE6	Allada (Sekoudenou)	6.647592	6. 214231
				ZAE8	Adjohoun (Wekpa-Kpota	6.700357	2.493442
		*Pristomerus pallidus (*Kriechbaumer*)*	Larval	ZAE7	Zogbodomey (Allada-Hlogon)	7.092675	2.102505
	Scelinoidae	*Telenomus remus* Nixon	Egg	ZAE6	Allada (Sekoudenou)	6.647592	2.142315
				ZAE7	Zogbodomey (Tegon)	7.092675	2.102506

Table 4. Parasitism rate.

ZAE	*Charops* sp.			*Telenomus remus* Nixon			*Cotesia icipe* Fernandez-Triana and Fiaboe			*Chelonus bifoveolatus* Szépligeti			*Pristomerus pallidus* (Kriechbaumer)		
	TL	Lp	PR (%)	TE	Ep	PR (%)	TL	Lp	PR (%)	TE	Ep	PR (%)	TL	Lp	PR (%)
ZAE6-S1	206	15	7,3	550	0	0	206	0	0	550	0	0	206	0	0
ZAE6-S2	148	0	0	480	0	0	148	0	0	480	0	0	148	0	0
ZAE7-S1	194	7	3,61	545	1	0,18	194	2	1,03	545	2	0,37	194	1	0,52
ZAE7-S2	153	0	0	510	0	0	153	0	0	510	0	0	153	0	0
ZAE8-S1	192	11	5,7	560	0	0	192	0	0	560	0	0	192	0	0
ZAE8-S2	142	0	0	475	0	0	142	0	0	475	0	0	142	0	0
Mean rate		**3**			**0,03**			**0,17**			**0,06**			**0,09**	
Global PR								**3,35%**							

PR = Parasitism rate; **Lp** = number of larvae and eggs parasitized; **TL** = total number of fall armyworm larvae and eggs collected

Predators: Various species of predators were observed in the field with relative abundance depending on agroecological zone (Table 5a). The predator complex in agroecological zones was dominated numerically by Formicidae (94%) followed by Coccinellidae (3,67%) and Forficulidae (1,84%). The other predator's species were found to be less abundant (RA < 1%) (Table 5b). All of predators were observed associated with different stages of fall armyworm. In many fields, ants are the most frequently encountered species. Highest number of predators was recorded in agroecological zone 7 during the long rain season.

Table 5a. *Spodoptera frugiperda* predators identified in the study area

Ordre	Family	Specices	Commun name	Agroecological zone (ZAE)	Location (village)	GPS cordinate	
						X	Y
Coleoptera	Coccinellidae	*Coccinella septempunctata*	Ladybird	ZAE6	Akpro-Misserete (Hazoume)	6.564930	6.581404
				ZAE7	Pobe (Oke-Ita)	6.972395	2.700004
				ZAE6	Zagnanado (Kpoto)	7.229093	2.435723
				ZAE7	Zogbodomey (Ayougon)	7.077942	2.107277
				ZAE8	Ouidah (Tove II)	6.366333	2.098598
				ZAE8	Ouinhi (Ahicon)	7.038482	2495526
				ZAE8	Adjohoun (Azowlisse)	6.660018	2.478145
Dermaptera	Forficulidae	*Forficula senegalensis*	Earwig	ZAE6	Akpro-Misserete (Agbogome)	6.576244	2.570447
				ZAE6	Zagnanado (Kpoto)	7.229093	2.435723
				ZAE7	Zogbodomey (Ayougon)	7.077942	2.107277
				ZAE8	Ouidah (Tove II)	6.366333	2.098598
				ZAE8	Ouinhi (Ahicon)	7.038482	2495526
				ZAE7	Ketou (Odokoto)	7.279175	2.569667
				ZAE8	Dangbo (Salilaga)	6.619603	2.540763
				ZAE8	Adjohoun (Hessa)	6.671613	2.504463
Hymenoptera	Formicidae	*i) Pheidole megacephala* *ii) Lasius niger*	Ant	ZAE6	Akpro-Misserete (Agbogome)	6.576244	2.570447
				ZAE8	Ouidah (Tove II)	6.366333	2.098598
				ZAE8	Ouinhi (Ahicon)	7.038482	2495526
				ZAE6	Zakpota (Folly)	5.200422	2.141275
				ZAE6	Zagnanado (Kpoto)	7.229093	2.435723
				ZAE7	Kétou (Odokoto)	7.279175	2.569667

Table 5b. *Relative abundance* of predators in the study area

ZAE	Ants			Leadydird			Earwig			Other specices		
	Nt	Ni	RA (%)	Nt	Ni	RA (%)	Nt	Ni	RA (%)	Nt	Ni	RA (%)
ZAE6-S1	1040	987	94,9	1040	32	3,08	1040	9	0,87	1040	8	0,769
ZAE6-S2	910	870	95,6	910	23	2,53	910	12	1,32	910	5	0,549
ZAE7-S1	858	814	94,9	858	27	3,15	858	15	1,75	858	2	0,23
ZAE7-S2	720	669	92,9	720	31	4,31	720	14	1,94	720	6	0,833
ZAE8-S1	698	641	91,8	698	35	5,01	698	18	2,58	698	4	0,573
ZAE8-S2	656	610	93,0	656	26	3,96	656	17	2,59	656	3	0,457
Mean			94			3,67			1,84			0,57
						Global PR						**100**

Ni = Number of individuals of a given species
Nt = Total number of all individuals collected
RA= Relative Abundance

DISCUSSION

This study confirms the presence of *Spodoptera frugiperda* in different agroecological zones of Benin. From the direct observation and the data collected, it comes out that all the field surveyed were attacked by the pest with high level of damage. Fields with low rate of insect attacks where those natural enemies were abundant. The absence of *S. frugiperda* was noticed despite its damage in some fields. This can be explained by various environmental factors like the rainfall (Prasanna *et al*., 2018). Heavy rainfall can hit maize plants to let young larvae fall along with water dripping. These results are in accordance with those obtained by Prasanna *et al*. (2018) who concluded that heavy rains can kill 1st, 2nd and 3rd instar larvae of *S. frugiperda* and reduce their population. The rainfall, irrigation and the cold annual weather were the important factors that affect negatively the survival of the larvae and nymph (Day *et al*., 2017). In additional, the assessment of the incidence of damage showed that agroecological zones 6, 7 and 8 all have experienced damage from *S. frugiperda* with the presence of different species of natural enemies. The global mean of incidence of damage for all the agroecological zone neighboring 70% made of serious threat for farmers since it can cause economic losses and weaken their resilience. This result is similarly with the finding of Navik *et al* (2021) who assessed the occurrence, incidence and damage severity of fall armyworm in 126 maize fields in 10 districts of Karnataka during the rainfed condition and revealed that the fall armyworm was well distributed across the maize growing regions of Karnataka with 44% to 100% field infestation. In addition, the same's authors observed that the damage incidence of *S. frugiperda* was 22.13% to 46.83% with damage severity 0 to 4.9 on the 0 to 9 scale.

Concerning the parasitoids, it was observed that 3,35% of the total number of parasitoids counted in the laboratory comes from entomological material (eggs & larvae) collected from the area of study. *Telenomus remus*, *C. bifoveolatus* and *C. icipe*, parasitoids of eggs, ovo-larvae and larvae of *S. frugiperda* were found in the agroecological zones prospected. This can be explained by the fact that they have an optimal climatic condition for the development of these parasitoids.

In south and north of America, studies showed that 53 species of *S. frugiperda* parasitoids belong to 43 families and 10 genera. The families of Braconidae, Ichneumonidae and Tachinidae represented in this group respectively 16, 19 and 47 % of genera and 15, 17 and 53 % of species (Ashley, 1979). Likewise, Cokola (2018) identified 10 species of *S. frugiperda* parasitoids composed of Hymenoptera belonging to five families during a survey in the East of the Democratic Republic of Congo. These results are in line with those of Meagher *et al*. (2016) who identified during a survey, *C. insularis* and *C. marginiventris* as the main parasitoids of the eggs and larvae of *S. frugiperda*. These two parasitoids have been cited as being the most abundant in northern Sinaloa (López *et al*., 2018). Watercress of *C. insularis* and Watercress of *C. marginiventris* were identified by Meagher *et al*. (2016) as the main parasitoids of *S. frugiperda* eggs and larvae in three south Florida counties. Also, the studies of Navik *et al* (2021) found five parasitoids parasitizing the egg, egg-larval, larval and larval-pupal stages of *S. frugiperda* such as *Trichogramma chilonis* Ishii and *Telenomus remus* Nixon egg parasitism rates were 15.81–23.87% and 5.44–8.78%, respectively. Regarding to the predators, ants, ladybirds and earwigs were recorded in almost all of the areas of the maize fields surveyed in varying proportions depending on the agroecological zones and the seasons. This is in line with the finding of Ahissou *et al*. (2021) who observed that the most abundant predators were members of the Forficulidae (51%), Formicidae (15%) and Coccinellidae (13%). Field observations and calculated data showed that the more predators there are, the less presence of late-stage *S. frugiperda* larvae and the less damage is predicted. In addition, Shylesha *et al*. (2018) and Silva *et al*. (2013) concluded based on the prospective and observation, that predators of *S. frugiperda* belong to insect families such as *Formicidae, Carabidae, Pentatomidae, Forficulidae* and *Coccinellidae.* These authors have shown that predators of these families have been identified as important predators of *S. frugiperda.* Wyckhuys and O'Neil (2006) found similar results. The Forficulidae were identified as the major's predator of *S. frugiperda* (Shylesha *et al*. 2018). *Eriopis connnexa* was identified as potential predators for *S. frugiperda* management. Some species of Coccinellidae like *Harmonia axyridis* can also attack *S. frugiperda* (Silva *et al*. 2016).

Conclusion: The study assessed the incidence of damage by *S. frugiperda* in maize fields across three agroecological zones of Benin and inventoried the various natural enemies associated with the presence of the pest in the field. There is higher relative abondance of natural enemies observed in the agroecological zone 7 compare to agroecological zone 6 and 8. The abondance predator observed were ants while the abondance parasitoids were *Charops* sp. (larval parasitoid). The agroecological zone 7 remained the optimal zone for the development of *S. frugiperda* natural enemies and for maize crop production in the southern of Benin Republic.

The results obtained from this study can be used for developing and achieving efficient and sustainable management of the invasive fall armyworm pests by integrating conservative and augmentative biological control into an IPM package.

Conflicts of interest: The authors state that there is no conflict of interest.

Contributions from authors: AMA followed the trials, collected, processed, analyzed the data and wrote the manuscript; GTY supervised the overall monitoring of the trials, participated in data analysis and drafting of the manuscript; AA supervised the work and contributed to the correction of the manuscript.

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