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INVENTORY OF ENTOMOFAUNA ASSOCIATED WITH AFRICAN EGGPLANT (*SOLANUM AETHIOPICUM* L.) ACCORDING TO THE PHENOLOGICAL STAGES AND ASSESSMENT OF DAMAGES CAUSED BY INSECT PESTS

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ABSTRACT

A study was conducted from January to July 2013, to inventory the insects associated with African eggplant, *Solanumaethiopicum* and to assess the damages caused by insect pests in the locality of Azaguié situated in south of Côte d'Ivoire. Fourteen days after transplanting , insects were collected every week until the end of harvesting fruit. Catches were made manually, with pliers and sweep net by mowing technique. In total 25 species belonging to 18 families regrouped in seven orders were recorded. Throughout the cycle of eggplant , 1758 individuals were collected with 265 at the stage before flowering, 498 at the flowering stage and 995 at the fruiting stage. The analysis of the relative abundance of orders according the phenological stages showed that the Homoptera and Orthoptera were the most abundant at the stage before flowering, representing 79.23 % of the catch. The of flowering and fruiting stages only Homoptera was the most abundant with 73.3 % (flowering) and 71.36 % (fruiting) of the catches. The study of the relative abundance of species according the phenology of the plant revealed that both species *Aphis gossypii* and *Bemisiatabaci* were majority compared to other species in each phenological stage. The attack rates plants varied depending the phenological stages and groups of insects. Defoliating (leaf-eater) and sucking insects caused higher rates of attack that this one caused by borer. At the fruiting stage, borer has induced a higher attack rates than defoliating and sucking insects.

Keywords : Entomofauna, *Solanumaethiopicum*, phenological stages, insect pests.

1. INTRODUCTION

The African eggplant (*Solanumaethiopicum*) is one of the most important fruit vegetables commonly consumed in West Africa [1, 2]. The eggplant fruits are eaten raw, cooked or fried with spices in stews, or dried and pound as condiments in West Africa [3, 4]. It is an essential component of the human staple diet because of its high nutritional value [3, 5, 6]. [7] estimated the annual production of fruits to 60000 tonnes in Côte d'Ivoire. The production is ensured by producers living in rural and urban areas and is a source of revenue for these [8]. The leaves and fruits are used in various culinary techniques [9]. The eggplant crop is unfortunately constrained by many biotic factors which the most important are insect pests. These insects cause considerable damage to eggplant by their defoliating, drill, biting-sucking action and carrier of virus [10].

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Besides investigation of [11] and [12] who respectively carried on the inventory of insects vegetable crops in Abidjan and inventory of insect pests and their impacts on the performance of three accessions of eggplant in Anguédédou (Côte d'Ivoire), literature does not mention investigation on the insect pests of eggplant in the locality of Azaguié. In Côte d'Ivoire control methods against insect pests of eggplant are ineffective because of the ignorance of these pests according the phenological stages of the plant. This study therefore aims to inventory all insects subservient to the plant in order to establish an effective method of struggle against insect pests that considers the plant phenology.

2. MATERIAL AND METHODS

2.1. Study area

The study was conducted in the of Azaguié (5 ° 37 north latitude, 4 ° 02 'west longitude) located in south of Côte d'Ivoire. The sub-equatorial climate is characterized by four seasons [13, 14] : a long dry season from December to March ; a long rainy season from April to mid-July; a small dry season from mid-July to mid-September; a small rainy season, from mid-September to November. The study period extended from January to July 2013 with average temperatures between 24.9 and 28.8 ° C, relative humidity between 80.3 and 88.5% and a rainfall of 856.74 mm.

2.2. Material

2.2.1. Biological material

It includes animal material which consists of all insects caught on the experimental plot and plant material consisted of N'drowaissia variety of the species *Solanumaethiopicum.*

2.2.2. Technical material

It consists of a sweep net for catching flying insects, a clip for to capture insects which have developed mandibles, small bottle containing alcohol at 70 ° for the collection and preservation of insects captured. A binocular microscope was used for observed insects in order to identify them. The keys were used for the identification of the collected insects [15, 16, 17, 18, 19].

2.3. Methods

2.3.1. Experimental plot

The experimental plot consisted of three blocks spaced of 3 meters. Each block measuring 9 meters long and 3.6 meters wide, was composed of 30 plants. The plants were to plant out in three rows, each row comprising 10 plants. On the same line, plants were spaced 1 meter and the lines are separated of 1.5 meters.

2.3.2. Capture and identification of the insects

Catches of insects began the 14th Day After Transplanting (DAT) until the end of harvesting fruit. Every week, plants of each block have been thoroughly inspected to catch all the insects. The catches of insects were performed between 6.00 a.m. to 10.00 a.m. in the morning and between 3.00 p.m. to 6.00 p.m. in the afternoon. The least mobile insects were caught with pliers and sometimes with hand protected hand gloves. As for the flying insects were captured sweep net by mowing. Insects captured were put in small bottles labeledcontaining alcohol at 70 ° C. Using identification keys based on morphological characters different species have been identified.

2.3.3. Assessment of the damages caused by insect pests

Damage assessment was made with counting the plants attacked, at of their leaves, shoot and fruit. The rate of attacked plants was calculated using the formula following [20, 21].

$$\text{Rate ofattacked plants (\%)} = \frac{\text{Number of attacked plants}}{\text{Number of total plants}} \times 100$$

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2.4. Data analysis

All data collected were subjected to analysis of variance (ANOVA) using the statistical software, version 7.1. The comparison of means was performed by the test Newman - Keuls at the 5 % threshold.

3. RESULTS

3.1. Insects inventoried

During the study, 1758 insects in total were captured. They belong to 25 species distributed in 18 families and 7 orders. The numbers of insects according phenological stage were 265 at the stage before flowering, 498 at the flowering and 995 at the fruiting representing 15.07 %, 28.33 % and 56.6 % respectively of total captured insects (Table 1).

3.2. Relative abundance of insect orders according to phenological stages

3.2.1. Stage before flowering

The order most abundant was Homoptera (54.34 %), followed by the Orthoptera (24.91 %). These two orders accounted for over three quarters of total insects with 79.25 %. The order Hymenoptera represented 10.56 %. Coleoptera, Diptera, Lepidoptera and Heteroptera recorded small numbers of respective 8, 8, 6 and 5 representing 3.02 %, 3.02 % , 2.26 % and 1.89 % of the captured insects (Figure 1 A).

3.2.2. Flowering stage

Homoptera was abundant with of 365 insects on a total of 498. This number represented 73.29 % of total captured insects. The other orders were minority with a total of 133 insects (26.70 %) (Figure 1 B).

3.2.3. Fruiting stage

Homoptera was still the most abundant with 71.36 % of the captured insects. Following by Hymenoptera, Coleoptera, Lepidoptera, Diptera and Heteroptera were a minority with respective abundances of 7.84, 7.44, 7.44, 3.82 and 1.8 %. Orthoptera recorded a very lower abundance of 0.3 % (Figure 1 C).

Table 1. Number of the insects captured according to the phenological stages of the eggplant

			Number			
			phenological stage			All the three stages
Order	Family	Species	S.b.flow	Flow.	Frui.	Total
Coleoptera	Coccinellidae	*Cheilomenessulphurea* Olivier, 1791	5	16	47	68
	Cetoniidae	*Pachnodacordata* Drury, 1773	0	5	5	10
	Chrysomelidae	*Nisotratadilecta*Dalman, 1823	2	5	8	15
	Tenebrionidae	*Lagriavillosa*Fabricius, 1781	0	0	3	3
		Chrysolagriacuprina Thomson, 1858	1	3	11	15
Diptera	Alisidae	*Tolmeruscingulatus*Fabricius, 1781	3	5	16	24
	Dolichopodidae	*Condylostylus sp.*	5	9	22	36
Heteroptera	Miridae	*Helopeltisschoutedeni* Reuter, 1906	1	2	5	8
		Nezaraviridula Linnaeus, 1758	1	0	4	5

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	Pyrrhocoridae	*Dysdercusvolkeri* Schmidt, 1932	3	3	9	15
Homoptera	Aleyrodidae	*Bemisiatabaci*Gennadius, 1889	71	203	413	687
		*Trialeurodesvaporariorum*Westwood, 1856	2	5	9	16
	Aphididae	*Aphis gossypii*Glover 1877	63	140	265	468
	Jassidae	*JacobiascahybridaBergevin&Zanon*, 1922	8	17	23	48
Hymenoptera	Formicidae	*Lasius sp.*	28	46	78	152
Lepidoptera	Noctuidae	*Spodopteralittoralis*Boisduval, 1833	1	2	5	8
		*Anomisflava*Fabricius, 1775	0	4	0	4
	Pyralidae	*Leucinodesorbonalis*Guenee, 1854	5	22	69	96
Orthoptera	Acrididae	*Acridaacuminata*Stål, 1873	8	3	1	12
		Chorthippusbigutulus Linnaeus, 1758	7	0	1	8
		Stenobothruslineatus Panzer, 1796	3	0	0	3
	Gryllidae	*Brachytrupesmembranaceus* Drury, 1770	4	0	0	4
	pyrgomorphidae	*Zonocerus variegatus*Linné, 1758	30	4	1	35
		Pygomorphaconica Bolivar, 1904	7	4	0	11
	Tettigonidae	*Tettigoniaviridissima*Linné 1758	7	0	0	7
7 orders	18 families	25 species	265	498	995	1758
			(15.07 %)	(28.33 %)	(56.6 %)	(100 %)

S.b.flow : Stage before flowering ; Flow : Flowering stage ; Frui : Fruiting stage

3.3. Relative abundance of species

The numbers of insect species inventoried have varied according on the phenological stages. Among of all the species caught, *Aphis gossypii* and *Bemisiatabaci* were most abundant in all three phenological stages. *B. tabaci* was majority with a total of 687 individuals representing 26.80, 40.80 and 41.50 % of total insects caught respectively stage before flowering, flowering and fruiting stages. Following by *A. gossypii* with a total of 468 individuals with 23.80 % (stage before flowering), 28.11% (flowering stage) and 26.63% (fruiting stage) of total insects caught in each stage. The other species were minority with less than 12 %, 10 % and 8 % of total insects caught at stage before flowering, flowering and fruiting stages respectively.

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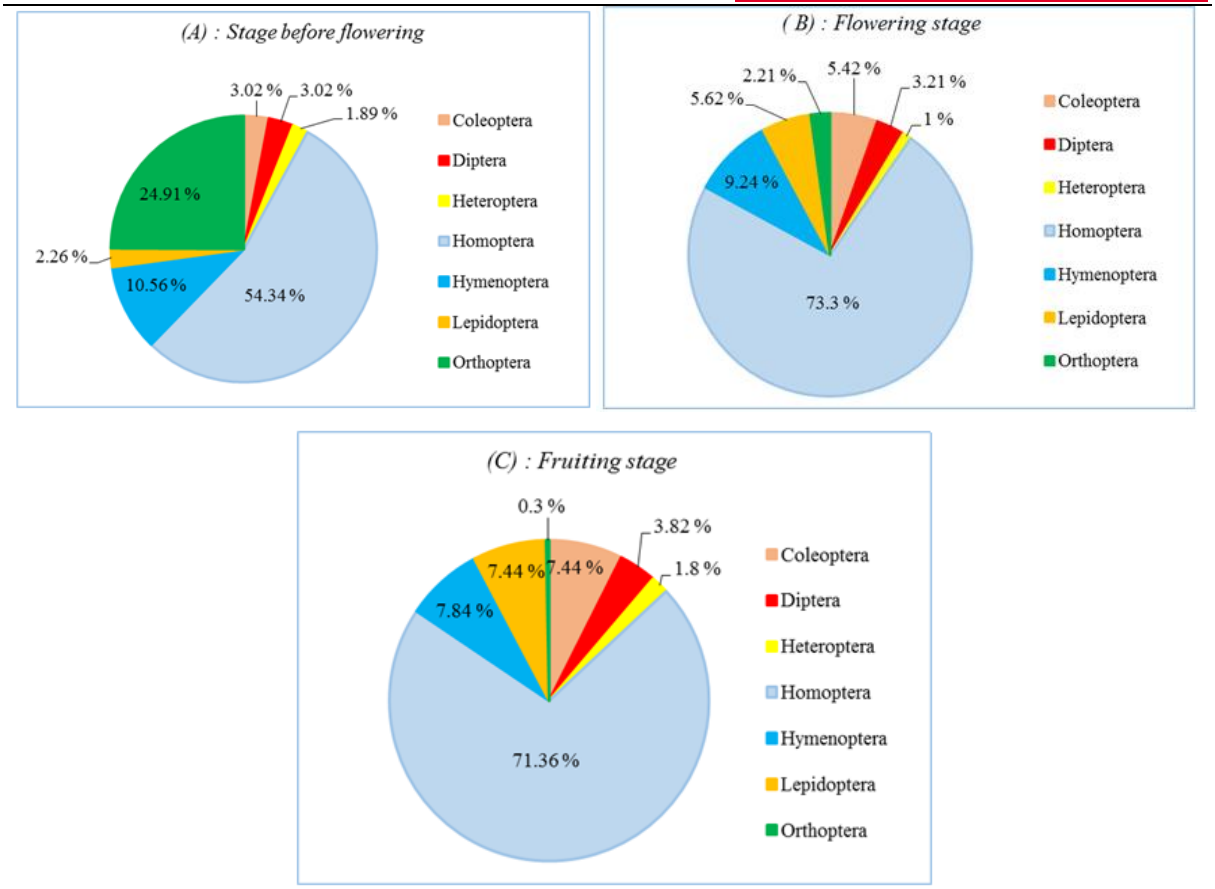

Figure 1. Relative abundance of the insect orders during of the three phenological stages

3.4. Damages caused by insect pests

3.4.1. Action of the insect pests on the eggplant

Among the 25 species captured, 21 species are pests, three are formidable predators (*Cheilomenessulphurea*, *Tolmeruscingulatus*and *Condylostylussp*). One species (*Lasius sp*.) was associated with *A. gossypii*. The insect pests were grouped into three categories according the damages on the plant. There are defoliating insects (leaf – eater), sucking insects and shoot and fruit borer (Table 2).

3.4.2. Assessment of the damages caused by the insect pests according to the phenological stages

3.4.2.1. Stage before flowering

During the stage before flowering, defoliating insects caused highly attack rate (40.52 ± 2.15 %.), followed by sucking insects which caused an attack rate of 35.56 ± 1.88 % and the lowest attack rate (12.04 ± 1.21 %) was caused by the borer. Statistical analysis showed significant differences ($df = 2$, $F = 30.80$, $P < 0.001$) between the attack rates of the three groups of insects. (Figure 2).

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3.4.2.2. Flowering stage

At flowering stage, defoliating insects, sucking insects and the borer have induced attacks rates respective of 31.78 ± 2.56 %, 32 ± 1.25 % and 30.8 ± 2.1 %. Statistical analysis no revealed significant differences (df = 2, F = 1.23, P = 0.3) between the attack rates of the three groups of insects (Figure 2).

3.4.2.3. Fruiting stage

During fruiting stage,the highest attack rate (41.11 ± 1.39 %), was induced by the shoot and fruit borer (*L. orbonalis*) and the lowest attack rate (9.92 ± 0.83%) was caused by defoliating insects (leaf – eater). Sucking insects induced an attack rate of 15.28 ± 1.34 %. Analysis of variance showed significant differences (df = 2, F = 222.37, P < 0.001) between the attack rates of the three groups of insects (Figure 2).

Table 2. Classification of the insect pests according to their damage on the eggplant

Group of insects	Order	Family	Species
	Coleoptera	Cetoniidae	*Pachnodacordata*
		Chrysomelidae	*Nisotratadilecta*
		Tenebrionidae	*Lagriavillosa*
			Chrysolagriacuprina
	Lepidoptera	Noctuidae	*Spodopteralittoralis*
			Anomisflava
Defoliating insects (leaf-eater)	Orthoptera	Acrididae	*Acridaacuminata*
			Chorthippusbigutulus
			Stenobothruslineatus
		Gryllidae	*Brachytrupesmembranaceus*
		Pyrgomorphidae	*Zonocerus variegatus*
			Pygomorphaconica
		Tettigonidae	*Tettigoniaviridissima*
	Heteroptera	Miridae	*Helopeltisschoutedeni*
			Nezaraviridula
Sucking insects		Pyrrhocoridae	*Dysdercusvolkeri*
	Homoptera	Aleyrodidae	*Bemisiatabaci*
			Trialeurodesvaporariorum
		Aphididae	*Aphisgossypii*
		Jassidae	*Jacobiasca hybrida*
Shoot and fruit borer	Lepidoptera	Pyralidae	*Leucinodesorbonalis*

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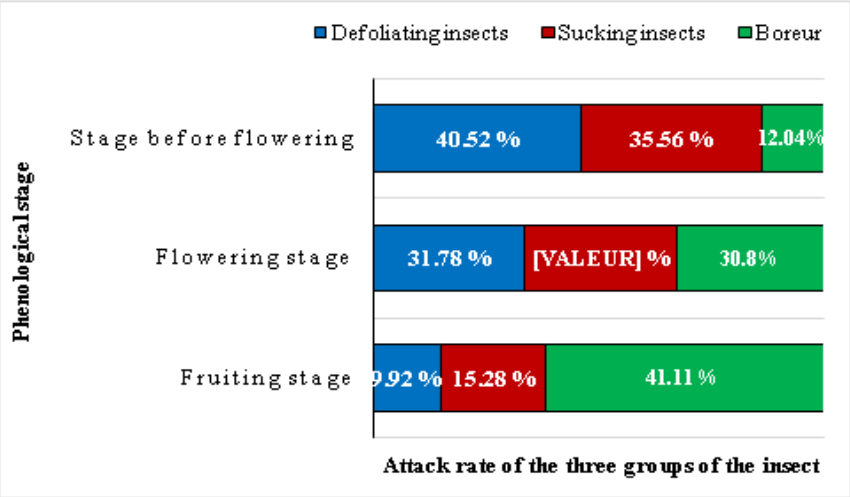

Figure 2. Attack rates of the plants induce by the three groups of insects during the phenological stages

4. DISCUSSION

Study revealed the presence of many insects to three phenological stages of eggplant. It shows that this culture such as many food crops is subject to attack by insect pests during the three phenological stages, [13] also captured the many insects at stage before flowering , flowering and fruiting stages of eggplant. [22, 23], reported their work in the cultivation of tomato that is a solanaceae as eggplant was also attacked by multitude of insect pests belonging of different orders. [24] also reported the presence of many insects in all phenological stages of cowpea. [25] revealed that development stages of the rice are attacked by multitude insects belonging to several orders.

During our samples, at total 25 species belonging to 18 families in seven orders were identified. Similar studies on eggplant by [26] in Bangladesh have permitted to inventory 20 species in total belonging to 17 families regrouped into six orders. [27] in its work to Benin on insect fauna cowpea revealed the presence of 35 species belonging to 18 families and 7 orders. In the same country [28] in their study on the tomato have reported 37 species belonging to 26 families and nine orders.

In total 1758 individuals were captured including the highest number (56.60 % of total captured insects) have been obtained at fruiting stage. This high number at this stage would be due to the strong attraction of volatile substances emitted by plants on a large number of insect. Our results are close of [24] who obtained a higher number insect on cowpea at the fruiting stage. The relative abundance of the seven orders (Coleoptera, Diptera, Heteroptera, Homoptera, Hymenoptera, Lepidoptera and Orthoptera) showed that only Homoptera were most abundant comparatively to other orders during the three phenological stages. This high number of Homoptera would be the fact that, Homoptera are sucking insects which have food availability during the development cycle of the plant. They would have been much attracted by the volatile substances emitted by plants. Indeed, these sucking insects stinged and sucked the sap and sometimes transmit viruses at the plant [29]. This slowing the growth of the plant. The similar observation of a high number of the Homoptera on eggplant was made by [26] and [12].

The analysis of the relative abundance of species showed high numbers of *A. gossypii* and *B. tabaci* compared to other species that have been minority during the three phenological stages. The higher abundance of these species is justified by the fact that they generally live in colonies on the leaf surface. These

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two species have of great capacity of reproductive by multiply sexual and asexually [30, 31]. High numbers of *A. gossypii* and *B. tabaci* have also been reported by [26].

Species *Cheilomenessulphurea* (Coccinelidae), *Tolmeruscingulatus* (Alisidae) and *Condylostylus sp*. (Dolichopodidae) observed in the minority are the formidable predators that feed of insect pests such as aphids, jassids and other small insects [32]. Indeed [33] reported in their work that the larval and adult of *C. sulphurea* , is an excellent predator of *A. gossypii*. In addition to feeding of aphids, *C. sulphurea*also eat larvae *L. orbonalis* [34]. As for *T. cingulatus*, their presence on eggplants would probably be due to the presence of *A. gossypii, J. hybrida B. tabaci* and other tiny insects. This predator feeds of aphids and other small insects such as *J. hybrida*, *B. tabaci* [35].

Different insect pests have regrouped into three categories according to the contested part of the plant. There are defoliating insect, sucking insects, shoot and fruit borer. At the stage before flowering, the attack rates caused by defoliating and sucking insects were higher at attack rate induce by borer. These high attack rates is justified by the fact at this stage, plant organs which are the leaves and shoot are tender and sap has risen in the plant . So these insects have most attacked the plant. defoliating insect consume the leaves by cutting the edges of limbo provoking irregular deformations in limbo. Sucking insects stinged and sucked the sap the leaves and tender shoot weakening the plant. The same observation was made by [24] which reported that repeated bites Homoptera in the various bodies of cowpea plants were causing stunting and training embossed leaves and their fall. These sucking insects, feeding sometimes transmit viruses to plants [29]. At the flowering stage, the attack rates induced by defoliating and sucking insects have decreased . This could be justified by the fact that at as the plant grows, organs such as leaves and stems harden and became increasingly difficult to consume by these insects. At the fruiting stage, rate of attacks induced by the Lepidoptera borer, (*L. orbonalis*) were significantly higher than those caused by defoliating and sucking insects. This high rate would be due to the fact at this stage of the plant, borer more attacking shoot also attack fruit. Also this could be due to the fact that the plants would attract a large number of adult *L. orbonalis* for mating and laying on the several eggplants.

4. CONCLUSION

The inventory showed that the insects associated with African eggplant varied in abundance and diversity according to the phenological stages of the plant. At the stage before flowering has hosted a lower individuals than the flowering and fruiting stages. Fruiting stage registered more insects. Homoptera were the most abundant throughout the cycle of the plant. Among the species, the aphid, *A. gossypii* and whitefly, *B. tabaci* were the majority during the three phenological stages. However, the presence of three species of natural enemies were noted, *C. sulphurea*, *T. cingulatus* and *Condylostylus sp*. which are formidable predators of insect pests. The rate of attacked plants varied according to phenological stages and groups of insects. The inventory of the insect fauna of the eggplant have permitted to target of insect pests a view to control these pests according to the phenology of the plant.

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