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Preliminary Ecological Studies of Insect Species Associated with Different Accessions of Eggplant (*Solanum melongena* L.) in Southern Ghana

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Authors' contributions

This work was carried out in collaboration between all authors. Author ESKO performed the statistical analysis and wrote the first draft of the manuscript. Authors NA and EKQ designed the study. Authors HMA and MO made significant contributions to the editing and proofreading of the final manuscript together with the above mentioned authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To determine the relative abundance and diversity of insects on twenty-two accessions of eggplants, as a guide to instituting control measures against unacceptable damage of egg plants grown under field conditions in the Coastal Savannah agro-ecological zone of Ghana.

Study Design: The experimental treatments were deployed in a Randomized Complete Block Design (RCBD), replicated three times.

Place and Duration of Study: Nuclear Agriculture Research Center (NARC) farms and the laboratories of Radiation Entomology and Pest Management Center (REPMC) of Biotechnology and Nuclear Agriculture Research Institute (BNARI), between September 2012 and November 2012.

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Methodology: The fields were divided into three replicates each containing twenty-two different accessions of eggplant *S. macrocarpon*, *S. gilio* GH8769, *S. aethiopicum*, *S. gilio* GH8771, *Nroroye* F, *Ntorewa* K, *S. gilio* GH8770, *S. melongena* GH 3949, *Ntropo* B, *Ndroshy*e E, *Ndroshye* C, *Ndroshye*, *Nroroye* A, Black beauty, *Nroroye* G, *Ntropo* K, *Ntropo* I, Sammy, *Ntropo* G, *Nroroye* D, *Ntropo* H, *Nroroye* J. The seeds were sown in a nursery and transplanted 35 days after germination to an experimental plot measuring 40 m x 11.4 m in the centre of one acre area so that the experimental plot was surrounded by a homogeneously managed terrain. The experimental treatments were deployed in a Randomized Complete Block Design (RCBD), replicated three times. Each replicate was allotted a plot size of 19.8 m x 8.4 m. Each sub-plot planted to one accession consisting of 22 plants at a spacing of 0.9 m x 0.6 m. Plots were separated by a distance of 2 m. Random sampling technique was used on weekly basis to study the relative abundance, diversity and behaviour of the insect species on the accessions.
Results: Fifteen different insect species were identified on the twenty two accessions of eggplant from the vegetative through to the maturity stage. These comprised three beneficial insects (*C. lunata*, *Camponotus* sp. and *M. religiosa*) and twelve pests (*A. craccivora*, *B. tabaci*, *B. invadens*, *Dysdercus* sp., *G. compestris*, *L. orbonalis*, *P. mali*, *Podagrica* sp., *O. virudulus*, *N. viridulus*, *Phenacoccus* sp. and *Z. variegatus*). Their relative abundance ranged from 0.20–8.78% for beneficial insects and 0.03 – 45.63% for pests. The highest abundance of insects were found on the accessions *Ndroshye* (14.09%) and *Nroroye* G (9.80%). *Nroroye* F registered the highest diversity of insect species, while *Ntropo* B and Sammy recorded the least diversity.
Conclusion: There was high abundance of insect species (65.85%) on the field of study. High diversity of insect species was noted and this could be a guide in instituting control measure before pest numbers go beyond the economic thresh-hold level.

Keywords: Pest; abundance; diversity; eggplant; ecology; Ghana.

1. INTRODUCTION

Eggplant (*Solanum melongena* L.), also called aubergine or brinjal, is one of the top ten vegetables in the world [1]. It is grown on more than 2 million ha with a production of nearly 49 million tonnes [1]. India and Indochina are considered the centers of origin for eggplant [2]. It is a common and popular vegetable crop grown in the Subtropics and tropics [3], which is well adapted to high rainfall and high temperatures, and is among the few vegetables capable of high yields in hot-wet environments [4]. In Ghana it is one of the most important vegetable crops extensively cultivated, especially in the forest zone, during both the major and the minor seasons [5]. This vegetable is cultivated largely on small, family-owned farms in Ghana where weekly sale of its produce brings income to the family.

Eggplant is a potential export crop for Ghana, but only a very small share of the total production 48,980 tonnes [1] is exported, with a marketable surplus of about 20% of annual production. Export values are however on the ascendancy [6].

Despite its importance in terms of nutrition and export potential for foreign exchange, increasing damage by arthropod pests is a major setback to eggplant cultivation [7]. The major pests of eggplant including those associated with eggplants in Ghana have been listed by other authors [8,9,10]. The most important ones which inflict severe damage to the plant and thereby reduce economic yield include *Selepa docilis* Butter (*Lepidoptera: Nolidae*), *Scrobipalpa blapsigona* Meyr (*Lepidoptera: Gelechiidae*), and *Leucinodes orbonalis* Guen (*Lepidoptera Crambidae*). These attack the leaves, flowers, shoots and fruits respectively [2,3,11,12]. White flies *Bemisia tabaci* [Genn.] (*Hemiptera: Aleyrodidae*), transmitter of viral diseases, and thrips (*Thrips tabaci* Lind. (*Thysanoptera: Thripidae*) represent the most economic important pests of eggplant [13]. The defoliators of the plant include the *Acraea peneleos peneleos* (Ward) (*Lepidoptera: Nymphalidae*), *Acraea pharsalus pharsalus* (Ward) (*Lepidoptera: Nymphalidae*), *Zonocerus variegatus* (L.) (*Orthoptera:Pyrgomorphidae*), *Eulioptera* sp., *Urentius hystericellus* (Richter) (*Hemiptera: Tingidae*), *Aphis gossypii* (Glover) (*Hemiptera: Aphididae*) and *Phaneroptera nana* (Stal.) (*Orthoptera: Tettigoniidae*) [14,13].

In the eggplant field, various arthropod species both pests and natural enemies prevail from nursery to the harvesting stage. El-Shafie [15]

observed 28 species of insect pests under seven different insect orders from the eggplant ecosystem while Nayar et al. [16] reported 53 species of insect pests of eggplant.

Cultivation of egg plants in Ghana without insect control leads to severe insect damage. This damage drastically reduces market value of produce meant for export. In order for Ghana to fully exploit its competitive advantage over other vegetable producers there is a need to maintain high quality of produce. Even though farmers complain incessantly, there is no information on abundance and diversity of insects affecting eggplant production in Ghana. This knowledge gap makes it impossible to plan and implement strategies for their effective control. Data on relative abundance and diversity of insects in an area will also serve as safeguard against overtreatment with pesticides. The aim of the study was to determine the relative abundance and diversity of insects on twenty-two accessions of eggplants, as a guide to instituting control measures against unacceptable damage of eggplants grown under field conditions in the Coastal Savannah agro-ecological zone of Ghana.

2. MATERIALS AND METHODS

2.1 Study Site and Experimental Layout

The study site is located about 20 km north of Accra. Details of the study area has been described previously by Ofori et al. [17]. The study was carried out under open field conditions from September, 2012 to November, 2012. The soil at the site is the Nyigbenya-Haatso series, which is a typically well-drained savannah Ochrosol (Ferric Acrisol) derived from quartzite Schist [18]. All the 22 accessions were sourced locally. The choice of materials was based on their widespread cultivation and economic importance. These included one *S. macrocarpon*, *S. gilio* GH8769, *S. aethiopicum*, *S. gilio* GH8771, *Nroroye* F, *Ntorewa* K, *S. gilio* GH8770, *S. melongena* GH 3949, *Ntropo* B, *Ndroshy*e E, *Ndroshye* C, *Ndroshye*, *Nroroye* A, Black beauty, *Nroroye* G, *Ntropo* K, *Ntropo* I, Sammy, *Ntropo* G, *Nroroye* D, *Ntropo* H, *Nroroye* J. *Solanum. macocarpon*, *Nroroye* F, *Ntropo* B were sourced from Abura in the Central Region of Ghana. *Solanum gilio* GH8769, *S. aethiopicum*, *S. gilio* GH 8771, *S. gilio* GH 8770 and *S. melongena* GH 3949 were sourced from Plant Genetics Resources Research Institute (PGRRI) at Bunso in the Eastern Region of Ghana. *Ntorewa* K was sourced from Kwabenya in the Greater Accra region of Ghana. *Ndroshy*e E and Sammy were sourced from Dome in the Greater Accra region of Ghana. *Ndroshye* C and *Ndroshye* were sourced from Mankesim in the Central Region of Ghana. Black beauty was sourced from Atomic in the Greater Accra Region of Ghana. *Nroroye* G, *Ntropo* K, *Ntropo* I, *Ntropo* G and *Nroroye* J were sourced from Taifa in the Greater Accra Region of Ghana. *Nroroye* D was sourced from Cape Coast in the Central Region of Ghana. Finally, *Ntropo* H was sourced from Akotokyir in the Central Region of Ghana.

Border effects were considered in setting up the research field to cancel out the activities of suspected insects hibernating in neighbouring alternative host plants. The seeds were sown in a nursery and transplanted 35 days after germination to an experimental plot measuring 40 m x 11.4 m in the centre of one-acre area so that the experimental plot was surrounded by a homogeneously managed terrain. The experimental treatments were deployed in a Randomized Complete Block Design (RCBD), replicated three times. Each replicate was allotted a plot size of 19.8 m x 8.4 m. Each sub-plot planted to one accession consisting of 22 plants at a spacing of 0.9 m x 0.6 m. Plots were separated by a distance of 2 m. The nursery was watered thoroughly during pre-and post-seed germination to facilitate healthy seedling establishment. Polyfeed (N-30%, P-10%, K-10%, Fe-500 ppm, Mn-250 ppm, Zn-75 ppm, Cu-55 ppm, Mo-35 ppm) was applied at a rate of 40 g per 13 liters of water to the roots to enhance active root formation and shoot growth. Neither pesticide nor fertilizer was applied after transplanting. Observations were recorded once every week starting from first day of transplanting till last day of harvest on various insects that were found on the 22 accessions of eggplants at different crop growth stages.

2.2 Sampling of Entomofauna on Eggplants

Insect sampling was done by observing 10 randomly selected plants at vegetative (15 days after transplanting (DAT) and 21 DAT), reproductive (35 DAT, 42 DAT and 49 DAT) and maturity (63 DAT) stages of crop growth. Visual surveys have been shown to be an effective and efficient method for censuring insect species richness and abundance on a variety of host plants [19]. The leaves in each selected plant were observed (naked eye) from the base of the

stem to the crown to take an inventory of all insects present and their behaviour. Records were made on the different types and numbers of insect species found on sampled plants on weekly basis.

Sampling took place between 6 am and 9 am to avoid the excessive mobility of the adult insects after this time, but nevertheless, the migration of the fast moving and mobile adults from one plot to the other could not be totally avoided. During sampling any adult insect seen was recorded on a data score sheet. Adult insects encountered were carefully collected into labelled glass vials containing 70% alcohol. Sorting and identification to species level and curation of the insects were done in the laboratory using insect voucher specimens from the Entomological Museum of the Department of Animal Biology and Conservation Science, University of Ghana, CAB manual keys and descriptions [20] as well as literature [21,22]. A total of 9 observations were recorded for evaluation and statistical analysis. The data were analyzed by performing an analysis of variance (ANOVA) at 95% level of significance, using the statistical package for agricultural sciences Genstat Software version 12 release 12.1 [23]. The least significant difference (LSD) was used to separate the means of treatments that showed significant "F" values. The diversity of the experimental area was calculated using Simpson index, $Ds=1-\Sigma (n_i (n_i-1))/ (N(N-1))$ where Ds=Simpson's index of diversity; N=total number of individuals of all species; n_i=total number of individuals of the species.

3. RESULTS AND DISCUSSION

3.1 Species Abundance

A total of 10,685 insects belonging to fifteen different families were collected throughout the sampling period on the eggplant accessions studied (Table 1). The number of insects collected was close to the figure of Ofori et al. [18] on tomato within the same geographical area but in a different season recorded 10,562 insects belonging to fourteen different families. The highest collection of 1,506 insects was collected on *Ndroshye*. This was followed by *Nroroye* G with 1,048 insects. *S. aethiopicum* attracted the least number of insects (210). *Bemisia tabaci* constituted the dominant group on *Nroroye* G with an abundance of 542 followed by *Nroroye* J which had an abundance of 322 of the same species. Eight insects were predominant on the twenty accessions of eggplant. These included *A. craccivora* (2,456), *B. tabaci* (4,876) *Camponotus* sp., (938), *C. lunata* (131), *Om.virudulus* (45) *Podagrica* sp., (38), *P. mali* (2,456) *Z. variegatus* (41). Other insect species collected namely *Dysdercus* sp., *Phenacoccus* sp., *M. religiosa*, *L. orbonalis*, *B. invadens*, *G. compestris* and *N. virudula* had relatively lower abundances, between 2 and 40.

Table 2 lists the different types of adult insects (both pests and predators) found at different growth stages on the twenty-two different accessions of eggplant.

Twelve different insect species were recorded at the vegetative stage of the twenty two accessions of eggplant. These included pests such as *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyroidae), *Aphis craccivora* (Koch) (Hemiptera: Aphididae), *Podagrica* sp., (Order: Family) *Nezara viridula* (Linnaeus) (Heteroptera: Pentatomidae), *Zonocerus variegatus* (Linnaeus) (Orthoptera: Pyrgomorphidae), *Psylla mali* (Schmidb) (Hemiptera: Psyllidae), *Leucinodes orbonalis* (Guenee) (Lepidoptera: Crambidae) *Omocestus virudulus* (Linnaeus) (Orthoptera: Acrididae) and predators such as *Camponotus* sp., (Order: Family) *Mantis religiosa* (Linnaeus) (Mantodea: Mantidae), *Cheilomenes lunata* (*Fabricius*) (Coleoptera: Coccinellidae). Similarly, fifteen insect species were recorded at the reproductive stage. These included pests such as *A. craccivora*, *Podagrica* sp. and *N. viridula B. tabaci*, *Bactrocera invadens* Drew, Tsura & White (Diptera: Tephritidae), *Phenacoccus* sp. (Order: Family) *Z. variegatus*, *P. mali*, *L. orbonalis*, *Om. virudulus*, *Gryllus compestris*, *Dysdercus* sp. (Order: Family) and predators such as *Camponotus* sp., *M. religiosa* and *C. lunata*. At the matured stage, fourteen different insects were recorded. These include *A. craccivora, Podagrica* sp., *Z. variegatus, N. viridula B. tabaci*, *B. invadens*, *Phenacoccus* sp., *P. mali*, *Om. virudulus*, *Gryllus compestris* (Linnaeus) (Orthoptera, Gryllidae), and *Dysdercus* sp. were insect pests identified on the accessions of eggplant while *Camponotus* sp., *M. religiosa* and *C. lunata* were predators found. *Bemisia tabaci* recorded the highest percentage abundance (45.63%) while *N. viridula* had the least (0.02%). Mean number of the seven most dominant insects are shown in Table 3. *Aphis craccivora* was the most dominant pest sampled on *Ndroshye*. *Bemisia tabaci* is the next dominant insect pest collected. This was collected on

Nroroye G. Similarly, *Camponotus* sp. was the most dominant predator on *Ndroshye*. For the rest of the genotypes, there were no significant difference (*P*=.05) in mean number of insects sampled per accession. Most of the insects sampled on eggplant consisted of 80% pests.

3.2 Species Diversity

Fifteen (15) different insect species of the families; Formicidae (1 genera), Aphididae (1 genus), Coccinellidae (1 genus), Chrysomelidae (1 genus), Pentatomidae (1 genus), Acrididae (1 genus), Mantidae (1 genus), Pyrgomorphidae (1 genus), Aleyrodidae (1 genus), Pseudococcidae (1 genus), Psyllidae (1 genus), Crambidae (1 genus), Gryllidae (1 genus), Pyrrhocoridae (1 genus) and Tephritidae (1 genus) were recorded. Four genera of insects commonly occurred on all the twenty-two different accessions of eggplant (Table 1). Frimpong and Buahin [24] reported the presence of 146 insect species on eggplant, with 58 species of these feeding on different parts of the plant at various stages of growth. There were, however, some groups which were specific and found only on two accessions of eggplant. For example, *G. compestris* was found on *Ntropo* B and *Nroroye* F while *N. viridula* was found on Black beauty and *S. melongena* GH 3949. The prevalent insects were *A. craccivora*, *B. tabaci*, *Camponotus* sp., *C. lunata*, *Om. virudulus*, *Podagrica* sp., *N. viridula* and *Z. variegatus*. Four species namely, *B. tabaci*, *Camponotus* sp., *Podagrica* sp. and *P. mali* were found on all the twenty-two accessions of eggplant (Table 1). *C. lunata* was found on all the other accessions except Sammy (Table 1).

Mochiah et al. [25] recorded six (6) insects namely; aphids (*A*. *gossypii* Glover), whiteflies (*B. tabaci*), *U*. *hysterricellus* (Richter), shoot and fruit borers (*L*. *orbonalis* Guenée), cotton stainers (*D. superstitiosus*) and variegated grasshoppers (*Z. variegatus* L.) as pests on eggplant in Ghana. El-Shafie [15] recorded 28 species of insect pests under 7 different insect orders from the eggplant ecosystem in Sudan.

In a similar work done by Latif et al. [12], twenty species of insect pests were recorded from the eggplant agroecosystem throughout the cropping season. Latif et al. [12], recorded 10 different predaceous species on eggplant. The present study recorded three predators. These include *C. lunata*, *Camponotus* sp., and *M. religiosa*. Further, the predator species recorded in this study are not efficient enough to exert any effective natural control on the high pest diversity and abundance. Latif et al. [12], observed a predatory behavior of *Cheilomenes* sp. feeding on *A. craccivora*. This supports the predatory behaviour of *Cheilomenes* sp. as observed in the present study. Picket et al. [26] and later Chowdhury et al. [27] noted that ladybird beetles, or ladybugs are important predators of aphids and could be exploited more effectively as biological control agents. The high diversity of insects in the study area coupled with the pest status of the majority necessitates prompt institution of control measures to prevent economic loss. At the vegetative stage of the eggplant, 11 different insects were recorded. These include 8 insect pests and 3 predatory insects. Damage caused by these insect resulted in upward curling of leaves. During the Reproductive stage of the study recorded 15 different insect species. On the contrary, El-Shafie [17] recorded seven species of insect pests at the reproductive stage. In their study, *A*. *craccivora* ravaged the crop foliage resulting in wilting and chlorosis of leaves. This activity of *A. craccivora* was observed on the field as some of the leaves of the accessions wilted. El-Shafie [17] recoded eggplant shoot and fruit borer at the fruiting stage of eggplant. However, the present study did not record any eggplant shoot and fruit borer during the fruiting or matured stage. Fourteen insect species were associated with the matured stage of the crop in the current study. Several researchers reported the severity of attack of jassid (*Amrasca biguttula biguttula*) and white fly (*B. tabaci*) in eggplant [28,29,8]. Although some researchers reported thrips (*Thrip palmi*) and red mites (*Tetranychus urticae*) as important sucking pest in some location [29]. These were not found in the present study. However, the variation of the results is logical because arthropod complex may vary in different geographic locations and seasons of the year. The estimated Simpson's diversity index (Ds=0.702) shows that the experimental area is highly diversified (Table 4), a reflection of species heterogeneity within the area. There is more likelihood of finding a lot more of these insects in an eggplant agro ecological zone in Southern Ghana. Specifically, you are less less likely to find one species dominating in the eggplant ecosystem. Ofori et al. [30] in a related study on pepper recorded a high diversity index around the same geographical area but on a different experimental plot. The high diversity in this present study is due to the many equally or nearly equal abundant species recorded.

Table 1. List of insect species and their abundance on twenty-two accessions of eggplants in Kwabenya, Ghana

	Accessions																						
Name of insect	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**Total**
Podagrica sp.	8	47	7	17	6	19	2	12	5	9	7	12	12	6	5	14	10	5	24	31	9	5	272
Bemisia tabaci	194	236	144	133	248	311	181	207	170	198	195	237	172	173	542	248	187	112	279	182	195	332	4876
Leucinodes orbonalis	1	2	0	2	1	2	0	1	0	2	2	5	1	1	1	2	2	0	4	3	0	1	33
Gryllus compestris	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Psylla mali	128	146	33	112	137	136	112	146	50	98	122	137	106	124	258	120	81	43	118	90	31	128	2456
Cheilomenes lunata	4	2	2	6	7	8	2	3	9	3	1	24	8	7	15	1	8	0	10	5	1	5	131
Camponotus sp.	54	29	12	39	47	56	16	29	21	42	26	227	14	27	74	28	30	38	35	29	36	29	938
Zonocerus variegatus	2	3	1	2	3	5	3	2	0	4	2	1	1	3	4	1	1	1	0	2	0		41
Aphis craccivora	117	58	5	42	54	82	318	1	0	19	3	857	8	17	139	0	0	17	27	50	3	0	1817
Bactrocera invadens	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	3
Omocestus viridulus	0	1	3	2	2	0	2	5	1	2	2	0	1	2	8	3	4	0	2	1	2	2	45
Mantis religiosa	0	5	1	3	2	1	1	1	0	2	0	0	1	0	1	0	1	0	0	2	0	0	21
Phenacoccus sp.	0	0	0	0	2	4	0	0	0	12	1	11	0	0	1	0	2	1	3	0	0	1	38
Dysdercus sp.	1	1	2	0	0	0	0	1	0	0	0	0	0	2	1	0	0	0	1	0	0	0	9
Nezara viridula	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
Total	508	528	210	356	508	622	637	408	256	389	359	1,506	323	362	1048	415	324	217	499	392	277	502	10,685
Ds	0.73	0.70	0.50	0.73	0.67	0.68	0.64	0.61	0.51	0.66	0.59	0.62	0.61	0.65	0.90	0.60	0.60	0.66	0.62	0.71	0.4	0.50	

1=S.macrocarpon, 2=S. gilio GH8769, 3=S. aethiopicum, 4=S. gilio GH8771,5= Nroroye F, 6=Ntorewa K, 7=S. gilio GH8770, 8=S. melongena GH 3949, 9=Ntropo B, 10=Ndroshye E, 11=Ndroshye C, 12=Ndroshye, 13=Nroroye A, 14=Black beauty, 15=Nroroye G, 16=Ntropo K, 17=Ntropo I, 18=Sammy, 19=Ntropo G, 20=Nroroye D, 21=Ntropo H, 22=Nroroye J, Ds- Simpson Diversity Index

Table 2. List of insect pests and predators observed at various growth stages of twenty-two accessions of eggplants grown on the field

Crop growth stage	Common name	Scientific name	Nature of insect	Damaging stage of pest	Plant part (s) damaged
Vegetative stage	Aphid	*Aphis craccivora*	Pest	Adult	Leaves
(15 DAT)	Flea beetle	*Podagrica* sp.	Pest	Adult	Leaves
	White fly	*Bemisia tabaci*	Pest	Adult	Leaves
	Green grasshopper	*Omocestus virudulus*	Pest	Adult	Leaves
	Apple sucker	*Psylla mali*	Pest	Adult	Leaves
	Variegated grasshopper	*Zonocerus variegatus*	Pest	None	None
	Carpenter ant	*Camponotus* sp.	Predator	None	None
	Lady bird beetle	*Cheilomenes lunata*	Predator	None	None
	Praying mantid	*Mantis religiosa*	Predator	None	None
Vegetative stage	Aphid	*Aphis craccivora*	Pests	Adult	Leaves
(21 DAT)	Flea beetle	*Podagrica* sp.	Pest	Adult	Leaves, fruits
	Green stink bug	*Nezara viridula*	Pest	Adult	Fruit, fruit bud
	Whitefly	*Bemisia tabaci*	Pest	Adult	Leaves
	Apple sucker	*Psylla mali*	Pest	Adult	Leaves
	Green stink bug	*Nezara viridula*	Pest	Adult	Leaves, fruits
	Green grasshopper	*Omocestus virudulus*	Pest	Adult	Leaves
	Shoot borer	*Leucinodes orbonalis*	Pest	Adult	Shoot
	Carpenter ant	*Camponotus* sp.	Predator	None	None
	Lady bird beetle	*Cheilomenes lunata*	Predator	None	None
	Praying mantid	*Mantis religiosa*	Predator	None	None
Reproductive stage	Aphid	*Aphis craccivora*	Pest	Adult	Leaves
(35 DAT)	Shoot borer	*Leucinodes orbonalis*	Pest	Adult	Shoot
	Green grasshopper	*Omocestus virudulus*	Pest	Adult	Leaves
	Flea beetle	*Podagrica* sp.	Pest	Adult	Leaves
	Mealy bug	*Phenacoccus* sp.	Pest	Adult	Leaves
	Field Cricket	*Gryllus compestris*	Pest	Adult	Leaves
	Green stink bug	*Nezara viridula*	Pest	Adult	Fruit, fruit bud
	Cotton stainer	*Dysdercus* sp.	Pest	Adult	Leaves
	Variegated grasshopper	*Zonocerus variegatus*	Pest	Adult	Leaves
	Carpenter ant	*Camponotus* sp.	Predator	None	None
	Lady bird beetle	*Cheilomenes lunata*	Predator	None	None
	Carpenter ant	*Camponotus* sp.	Predator	None	None
	Praying mantid	*Mantis religiosa*	Predator	None	None
Reproductive stage (42 DAT)	Aphid	*Aphis craccivora*	Pest	Adult	Leaves
	Variegated grasshopper	*Zonocerus variegatus*	Pest	Adult	Leaves

Crop growth stage	Common name	Scientific name	Nature of insect	Damaging stage of pest	Plant part (s) damaged
	Green grasshopper	*Omocestus virudulus*	Pest	Adult	Leaves
	Whitefly	*Bemisia tabaci*	Pest	Adult	Leaves
	Mealy bug	*Phenacoccus* sp.	Pest	Adult	Fruit, fruit bud
	Apple sucker	*Psylla mali*	Pest	Adult	Leaves
	Cotton stainer	*Dysdercus* sp.	Pest	Adult	Leaves, fruit
	Fruit fly	*Bactrocera invadens*	Pest	Adult	Fruit
	Flea beetle	*Podagrica* sp.	Pest	Adult	Leaves
	Shoot borer	*Leucinodes orbonalis*	Pest	Adult	Shoot, fruit
	Carpenter ant	*Camponotus* sp.	Predator	None	None
	Lady bird beetle	*Cheilomenes lunata*	Predator	None	None
	Praying mantid	*Mantis religiosa*	Predator	None	None
Reproductive stage (49 DAT)	Aphid	*Aphis craccivora*	Pest	Adults	Leaves, fruit
	Apple sucker	*Psylla mali*	Pest	Adult	Leaves
	Variegated grasshopper	*Zonocerus variegatus*	Pest	Adult	Leaves
	Whiteflies	*Bemisia tabaci*	Pest	Adult	Leaves
	Cotton stainer	*Dysdercus* sp.	Pest	Adult	Leaves, fruit
	Apple sucker	*Psylla mali*	Pest	Adult	Leaves
	Field Cricket	*Gryllus compestris*	Pest	Adult	Leaves
	Mealy bug	*Phenacoccus* sp.	Pest	Adult	Leaves
	Shoot borer	*Leucinodes orbonalis*	Pest	Adult	Shoot, fruits
	Carpenter ant	*Camponotus* sp.	Predator	None	None
	Lady bird beetle	*Cheilomenes lunata*	Predator	None	None
	Praying mantid	*Mantis religiosa*	Predator	None	None
Maturity stage (63DAT)	Aphid	*Aphis craccivora*	Pest	Adults	Leaves, fruits
	Apple sucker	*Psylla mali*	Pest	Adult	Leaves
	Mealy bug	*Phenacoccus* sp.	Pest	Adult	Leaves
	Cotton stainer	*Dysdercus* sp.	Pest	Adult	Leaves, fruit
	Green grasshopper	*Omocestus virudulus*	Pest	Adult	Leaves
	Field Cricket	*Gryllus compestris*	Pest	Adult	Leaves
	Whiteflies	*Bemisia tabaci*	Pest	Adult	Leaves
	Flea beetle	*Podagrica* sp.	Pest	Adults	Leaves
	Green stink bug	*Nezara viridula*	Pest	Adults	Fruit, fruit bud
	Fruit fly	*Bactrocera invadens*	Pest	Adult	Fruit
	Variegated grasshopper	*Zonocerus variegatus*	Pest	Adults	Leaves
	Carpenter ant	*Camponotus* sp.	Predator	None	None
	Lady bird beetle	*Cheilomenes lunata*	Predator	None	None
	Praying mantid	*Mantis religiosa*	Predator	None	None

Table 3. Mean numbers of dominant insect on the twenty two accessions of eggplants

Accessions	Scientific name of insect							LSD
	Aphis craccivora	***Bemisia tabaci***	***Camponotus* sp.**	***Cheilomenes lunata***	***Podagrica* sp.**	***Psylla mali***	***Zonocerus variegatus***	
1	39.0^{ab}	64.7^{a}	18.0^{bc}	1.3^{c}	2.7^{c}	42.7^{ab}	0.7^{c}	32.54
2	19.3^{b}	78.7^{a}	9.7^{b}	0.7^{b}	15.7^{b}	56.7^{a}	1.0^{b}	34.77
3	1.7^{b}	48.0^{a}	4.0^{b}	0.7^{b}	2.3^{b}	11.0^{b}	0.3^{b}	13.39
4	14.0^{b}	44.3^{a}	13.0^{b}	2.0^{b}	5.7^{b}	40.7^{a}	0.7^{b}	21.14
5	18.0^{c}	82.7^{a}	15.7^{c}	2.0^{c}	3.3^{c}	52.7^{b}	1.0^{c}	27.43
6	27.3^{b}	103.7^{a}	18.7^{b}	2.7^{b}	6.3^{b}	49.7^{b}	1.0^{b}	27.76
7	60.3^{a}	60.3^{a}	5.3^{b}	0.7^{b}	0.7^{b}	42.0^{a}	1.0^{b}	24.09
8	0.3^{b}	69.0^{a}	9.7^{b}	1.0^{b}	4.0^{b}	52.3^{a}	1.0^{b}	36.73
9	0.0^{b}	56.7^{a}	7.0b^{c}	3.0^{b}	1.7^{b}	15.0^{c}	0.0^{b}	9.62
10	6.3^{c}	66.0^{a}	14.0^{c}	1.0^{c}	3.0^{c}	35.3^{b}	1.3^{c}	17.52
11	1.0^{c}	65.0^{a}	8.7^{c}	0.3^{c}	2.3^{c}	43.0^{b}	0.7^{c}	13.26
12	286.0^{a}	79.0^{a}	76.0^{a}	8.0^{b}	4.0^{b}	47.0^{ab}	0.0^{b}	249.3
13	0.0^{b}	57.3^{a}	4.7^{b}	2.7^{b}	4.0^{b}	39.0^{a}	0.3^{b}	26.06
14	5.7^{c}	57.7^{a}	9.0^{c}	2.3^{c}	2.0^{c}	43.3^{b}	1.0^{c}	10.37
15	46.3^{ab}	180.7^{c}	22.3^{ab}	5.0^{a}	1.7^{a}	91.0^{b}	1.3^{a}	74.73
16	0.0^{b}	82.7^{a}	9.3^{b}	0.3^{b}	4.7^{b}	33.0^{c}	0.3^{b}	19.28
17	0.0^{b}	62.3^{c}	10.0^{ab}	2.7^{a}	3.3^{a}	28.3^{ab}	0.3^{a}	21.93
18	5.7^{bc}	37.3^{a}	12.7^{b}	0.0^{c}	1.7^{c}	13.3^{b}	0.3^{c}	9.30
19	9.0^{b}	93.0^{a}	11.7^{bc}	3.3^{b}	8.0b^{c}	46.0^{c}	0.0^{b}	38.86
20	16.7^{b}	60.7^{a}	9.7b	1.7^{b}	9.3^{b}	32.7^{b}	0.7^{b}	24.70
21	1.0^{b}	65.0^{a}	12.0^{b}	0.3^{b}	3.7^{b}	9.7^{b}	0.0^{b}	20.84
22	0.0^{b}	0.0^{b}	8.7^{b}	1.7^{b}	2.0^{b}	46.3^{c}	1.3^{b}	17.65

Means followed by the same letters within the rows are not significant (P =.05)

Table 4. Abundance and diversity of insect species recorded during the study period

Name of insect	No. of individuals per 10 plants (n_i)	% abundance	$n_i(n_i-1)$
Aphis craccivora	1,817	17.00	3,299,672
Bactrocera invadens	3	0.03	6
Bemisia tabaci	4,876	45.63	23,770,500
Camponotus sp.	938	8.78	878,906
Cheilomenes lunata	131	1.23	17,030
Dysdercus sp.	9	0.08	72
Gryllus compestris	3	0.03	6
Leucinodes orbonalis	33	0.31	1, 056
Mantis religiosa	21	0.20	420
Nezara viridula	2	0.02	2
Omocestus virudulus	45	0.42	1,980
Phenacoccus sp.	38	0.36	1,406
Podagrica sp.	272	2.55	73,712
Psylla mali	2,456	22.99	6,029,480
Zonocerus variegatus	41	0.38	1,640
Total	10,685	100	34,075,888

Simpson's index of diversity, Ds = 0.702

4. CONCLUSION

Fifteen different insect species were identified on the twenty-two accessions of eggplant from the vegetative through to the maturity stage. These comprised three beneficial insects (*C. lunata*, *Camponotus* sp., and *M. religiosa*) and twelve pest insects (*A. craccivora*, *B. tabaci*, *B. invadens*, *Dysdercus* sp., *G. compestris*, *L*. *orbonalis*, *P. mali*, *Podagrica* sp., *O. virudulus*, *N. viridulus*, *Phenacoccus* sp. and *Z. variegatus*). Their relative abundance ranged from 0.20–8.78% for beneficial insects and 0.03 – 45.63% for pests. The highest numbers of insects were found on the accessions *Ndroshye* (14.09%) and *Nroroye* G (9.80%). *Nroroye* F registered the highest diversity of insect species, while *Ntropo* B and Sammy recorded the least diversity. The high abundance of insect pests in the study area coupled with the pest status of the majority (65.85%) necessitates prompt institution of control measures, in the case of commercial cultivation, to prevent economic loss.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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