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Infestation and Parasitism Dynamics of the Leaf Miner *Liriomyza trifolii* in Different Pea (*Pisum sativum* L.) Varieties

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Abstract: Pea (*Pisum sativum* L.), a cool-season crop of global significance, serves as a vital source of nutrition, with green seeds consumed as vegetables and dry grains as staple food. Among its pests, the leaf miner *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) is one of the most destructive, causing substantial damage to pea plants. This study, conducted in El-Rahmaneia region, Beheira Province, during the 2022/2023 and 2023/2024 seasons, aimed to survey insect pests and investigate infestation patterns of *L. trifolii* on pea varieties. The research focused on infestation percentage, larval counts, mines, seasonal abundance of *L. trifolii*, and parasitism by hymenopterous parasitoids. Ten insect pests were identified, including five Hemiptera species and one species each from Lepidoptera, Thysanoptera, Tetranychidae, and Diptera. Infestation varied significantly among varieties, with the highest on Entisar 2, followed by Sokari and Master B. Predators observed included 11 species across six orders, while parasitoids comprised 20 species from six families of Hymenoptera. Key parasitoids included *Opius dissitus* (Braconidae), *Diglyphus sp.*, and *Diglyphus isaea* (Eulophidae). Significant differences in infestation and parasitoid activity were linked to temperature and relative humidity, with peaks observed in October and December. *D. isaea* was the predominant parasitoid, contributing to 54.55%, 50.00%, and 33.33% parasitism in the 2022/2023 and 2023/2024 seasons. Natural parasitoids, particularly *D. isaea*, played a crucial role in suppressing *Liriomyza* populations, highlighting their importance in integrated pest management programs for sustainable pea production.

Key words: Parasitoids, integrated pest management (IPM), pea varieties, seasonal abundance, biological control.

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1. Introduction

Pea (*Pisum sativum* L.) is cultivated as a cool-season crop across the world and belongs to the family Leguminosae: Fabaceae. It is widely utilized as a nutritious vegetable and represents one of the most important food sources for human consumption (**Foba, 2015**). Pea plants produce green seeds that are consumed as vegetables and dry grains that

serve as staple food. The crop's nutritional and economic significance makes it a vital component of agricultural systems globally.

Among the major pests threatening pea cultivation, the leaf miner *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) is recognized as one of the most destructive insect pests attacking *P. sativum* plants (**Jyani *et al*., 1995**). *L. trifolii* is a polyphagous pest that feeds on a wide range of plants and vegetable crops worldwide, including Egypt (**Ibrahim, 1999**). Flies of the genus *Liriomyza* are known for their mining behavior, which can cause significant damage to the foliage, reducing photosynthetic capacity and overall crop yield (**Chabi-Olaye *et al*., 2008**).

Control of *Liriomyza* spp. largely relies on natural enemies, particularly parasitoids. More than 150 species of parasitoids have been recorded attacking various life stages of *Liriomyza* species (**Murphy and LaSalle, 1999; Claudio and Welter, 2001)**. Among these, the genus *Diglyphus* (Hymenoptera: Eulophidae) is particularly important due to its effectiveness in managing *Liriomyza* populations (**Liu *et al.*, 2009**). For instance, *Diglyphus isaea* (Walker) (Hymenoptera: Eulophidae) is a solitary ectoparasitoid that has been widely recognized as a dominant natural enemy of *L. trifolii*. Other parasitoids, such as *Opius dissitus* (Hymenoptera: Braconidae), also play a significant role in suppressing *Liriomyza* populations (**Ibrahim, 1999 and Aneesa, 2024**).

The interaction between *L. trifolii* and its natural enemies has been the subject of extensive research. Studies by **Metwally (1991)** and **Shoaib *et al.* (2020)** highlighted the diversity of hymenopterous parasitoids associated with *Liriomyza* spp., noting their critical role in regulating pest populations under field conditions. Notably, the seasonal abundance of *L. trifolii* and its parasitoids has been linked to climatic factors such as temperature and relative humidity, which influence pest activity and parasitism rates (**Awadalla *et al*., 2018 and Eid, 2008**).

This study was therefore carried out to identify the field insect pests associated with pea cultivation, examine the infestation levels across different pea varieties, and investigate the population abundance of *L. trifolii* larvae. Additionally, the seasonal activity of *L. trifolii* parasitoids, including their peaks and effectiveness, was analyzed to provide insights into their role in integrated pest management (IPM) programs for sustainable pea production.

2. Materials and Methods

2.1. Study Area

The study was conducted at the El-Rahmaneia region, Beheira Governorate, Egypt, during the 2022/2023 and 2023/2024 growing seasons on pea plants (P. sativum). Meteorological data, including daily temperature (°C) and relative humidity (RH%), were obtained from the Agricultural Meteorological Station in El-Rahmaneia.

2.2. Experimental Design

The experimental field covered approximately ¾fedan (1 fedan = 0.42 hectares) and was divided into 12 equal plots (262.5 m² each). Three pea varieties “Master B, Entisar 2, and Sokari [Mangetout]” were tested, with each variety grown in four plots. Plots were spaced 10 m apart to minimize insect migration and border effects. The crops were sown in mid-August and harvested in January. All recommended agricultural practices, excluding insecticide

2.3. Sampling and Data Collection

Sampling began one month after sowing and continued weekly until harvest. For each variety, 100 mined leaflets infested by *L. trifolii* were randomly collected per sampling from each plot. These leaflets were stored in jars at room temperature to allow larvae to pupate. Emerging parasitoids and leaf miners were recorded and preserved in 75% ethanol for identification. The specimens were subsequently identified to species level at the Taxonomy Department, Plant Protection Research Institute, Dokki, Egypt.

Infestation percentages were calculated using the formula:

$$\text{Infestation \%} = \frac{\text{No. of infested leaflets}}{\text{Total No. of examined leaflets.}} \times 100$$

Parasitism percentages were calculated as:

$$\text{Parasitism \%} = \frac{\text{No. of parasitized larvae}}{\text{Total No. of examined Larvae}} \times 100$$

2.4. Statistical Analysis

Data were analyzed using one-way ANOVA through the General Linear Model procedure (**SAS, 1994)**. Significant differences among treatments were assessed using **Duncan's Multiple Range Test (1955)**. Correlation, partial regression, and explained variance analyses were conducted to evaluate the impact of temperature and RH% on parasitism and infestation rates. All statistical analyses were performed using COSTAT software (2005 version).

3. Results and Discussion

3.1. Survey of Insect Pests Affecting Pea Varieties in Beheira, Egypt

Data in Table (1) illustrates a list of insect species recorded on pea (*P. sativum*) plants during the cropping seasons of 2022/2023 and 2023/2024. A total of ten insect pests were identified, belonging to eight different families across various orders. These include five species from Hemiptera, one from Lepidoptera, one from Thysanoptera, one from Tetranychidae, and two from Diptera. The pest infestation of pea crops was significantly affected by different pea varieties, with pest species targeting various plant parts such as leaves, shoots, and pods. The most significant damage was caused by *L. trifolii*.

Among the pests recorded, aphids (*Aphididae*: Hemiptera) were prominent, with both nymphs and adults observed sucking sap from the undersides of leaves and tender shoots. Aphids typically appeared during the vegetative stage of crop growth**. Sunil *et al.* (2015)** documented five insect pests across three orders and three families infesting pea varieties at different stages of growth. Two species each belonged to Lepidoptera; and Diptera, while Hemiptera included one species. These pests were observed infesting major plant parts such as pods, seeds, leaves, and stems.

Dabier (1994) reported that foliage green pea crops sown in autumn were damaged by larvae of *Spodoptera exigua* (Hübner), while pods sown in spring and summer were attacked by *Helicoverpa armigera* larvae, thrips (*Thrips spp.*), and *Megalurothrips sjostedti* (bean flower thrips). These pests, along with their associated natural enemies, were recorded during this study.

Natural enemies were also identified during the investigation, with three major species associated with pea pests. A key species was *Diglyphus sp.*, known to parasitize *L. trifolii* and *Ophiomyia phaseoli* (Tryon) (Agromyzidae: Diptera). The stem fly, *O. phaseoli*, was considered a minor pest on peas, with maggots feeding by boring into stems, causing yellowing leaves, browning stems, and slight swelling. These findings align with those of **Foba *et al*. (2015)**, **Shalan and El-Ghanam (2016)**, and **Bayoumy *et al*. (2018)**, who documented the roles of natural enemies in pest suppression.

Table (1). Insect pests recorded from pea varieties (Entisar 2, Master B, and Sokari [Mangetout]) during 2022/2023 and 2023/2024 seasons

Order	Family	Scientific name	Status
Hemiptera	Aphididae	*Aphis cracivora* (Koch) *Aphid gossypii* (Glover)	Pest
	Cicadellidae	*Empoasca decipiens* (Paoli)	Pest
	Aleyrodidae	*Bemisia tabaci* (Gen.)	Pest
	Pentatomidae	*Nezara viridula* (L.)	Pest
Lepidoptera	Noctuidae	*Spodoptera litoralis* (Bosi.)	Visitor
Thysanoptera	Tripicidae	*Thrips tabaci* (Lin.)	Pest
Diptera	Agromizidae	*Lirimyza trifoli* (Burgess) *Ophiomyia phaseoli* (Tryon)	Pest
Tetranychidae	Acaridídae	*Tetranychus urticae* (Koh)	Pest

3.2. Natural Enemies of Insect Pests on Pea Plants

- Predator Species

Data presented in Table (2) shows that the most common predators on pea plants included 11 species belonging to six orders. These predator species were recorded on pea varieties (Entisar 2, Master B, and Sokari [Mangetout]) during the 2022/2023 and 2023/2024 growing seasons. The identified predators were: *Cocinella undecimpunctata* (L.), *Scymnus spp.*, *Scymnus interruptus* (Goeze) (Coleoptera: Cocinellidae), *Orius spp.* (Hemiptera: Anthocoridae), *Ischnura senegalensis* (Rambur) (Odonata: Coenagrionidae), *Hemianax ephippiger* (Burmeister) (Odonata: Aeshnidae), *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae), *Paederus alfierii* (Koch) (Coleoptera: Staphylinidae), and spiders such as *Thomisus sp.* (Thomisidae) and *Thanatus sp.* (Philodromidae). Aditional species included the syrphid fly *Eupeodes corollae* (Fabricius) (Diptera: Syrphidae). These predator species play a critical role in controlling pest populations and maintaining ecological balance in pea crops.

Table (2). List of abundant predator species collected from pea varieties (Entisar 2 Master B and Sokari [Mangetout]) during 2022/2023 and 2023/2024 seasons

Order	Family	Scientific name
Coleoptera	Cocinellidae	*Cocinella undecimpunctata* (L.)
		Scymnus spp.
		Scymnus interruptus (Goez)
	Staphylinidae	*Paederus alfierii* Koch
Hemiptera	Anthocoridae	*Orius* spp.
Odonata	Aeshnidae	*Hemianax ephippiger* (Burmeister)
	Coenagrionidae	*Ischnura senegalensis* Rambur
Araneae	Thomisidae	*Thomisius* sp.
	Philodromidae	*Thanatus* sp.
Diptera	Syrphidae	*Eupeodes corollae* (F.)
Neuroptera	Chrysopidae	*Chrysoperla carnea* (Stephens)

- Parasitoid Species

Data in Table (3) indicates that 20 species of parasitoids belonging to six families within the order Hymenoptera were recorded on pea plants. These parasitoids primarily targeted leaf miners, including *L. trifolii* and *O. phaseoli*. The most significant parasitoids included *O. dissitus* (Braconidae), *Diglyphus sp.* (Eulophidae), and *D. isaea* (Walker) (Eulophidae). Among these, *D. isaea* was the most abundant species, effectively reducing the population of pea leaf miners. In contrast, *O. dissitus* was less common and classified as a minor parasitoid.

Gencer (2004) documented seven parasitoid species from the Eulophidae family, which are known to parasitize leaf miners. Similarly, **Bhat and Bhagat (2009)** reported seven hymenopteran parasitoids of the agromyzid leaf miner *Chromatomyia horticola* (Gourear) in Kashmir, which included five eulophids and two braconids (*Opius sp.* and *Dacnusa sp.*). These findings are consistent with this study, further emphasizing the importance of parasitoids in natural pest control systems.

Table (3). Hymenopterous parasitoids species collected from pea varieties (Master B, Entisar 2and Sokari [Mangetout]) during 2022/2023 and 2023/2024 seasons

Family	Genus and species
Pteromalidae	*Sphegigaster* sp.
	Halticoptera sp.
	Hemiptarsenus zilahisebessi (Erods)
	Zagrammosoma sp.
	Halticoptera circulus (Walker)
Ichneumonidae	*Gelis* sp.
	Ophion sp.
Chalcididae	*Brachymeria* sp.
Platygastridae	*Trissolcus* sp
Braconidae	*Cotesia* sp.
	Opius sp.
	Chelonus sp.
	Bracon sp.
	Hyposter sp.
	Opius basalis Fischer
Eulophidae	*Neochrysocharis formosa* (Westood)
	Neochrysocharis pentheus (Walker)
	Diglyphus sp.
	Diglyphus isaea (Walker)
	Chrysocharis pentheus (Walker)

3.3. Pea Leaf Miner Infestation during the First Season (2022/2023)

- Infestation of Pea Leaf Miners

The results presented in Table (4) revealed that pea leaf miner (*L. trifolii*) infestation was significantly ($P \leq 0.01$) affected by different pea varieties (Master B, Entisar 2, and Sokari [Mangetout]) as well as the time of sampling. The interaction between time and variety also showed highly significant

differences between weeks, particularly during the second and seventh weeks ($P \leq 0.01$) of the season. The infestation occurred under environmental conditions of 24.80°C and 53.5% relative humidity (RH).

Significantly higher infestation percentages were recorded during the second and third weeks of December. On the Master B variety, infestation rates of 84.21% and 84.32% were observed in the second and third weeks of December at 20.03°C and 19.88°C, with RH values of 62.11% and 81.89%, respectively. Conversely, lower infestations were recorded in the first week of October and the last week of December, with rates of 24.0% and 20.0% at 21.01°C and 30.05°C, and RH values of 63.9% and 66.22%, respectively.

On the Entisar 2 variety, the highest infestation rates were recorded at 88.29% and 80.33% during the second and third weeks of December, respectively. Lower infestation rates were observed on September 24 (19.70%) and December 31 (30.19%). Similarly, the Sokari [Mangetout] variety showed significantly higher infestation rates during the first and third weeks of December, with rates of 75.65% and 71.60%, respectively. Lower infestations of 25.0% and 0.0% were recorded on October 1 and January 7, respectively.

- Numbers of Larvae per Sample

Data in Table (4) indicated that the mean number of larvae per sample was significantly affected by the pea varieties and sampling times. Higher significant differences ($P \leq 0.01$) were observed during the third, fourth, fifth, and fifteenth weeks of the season under conditions of 24.80°C, 25.65°C, 23.72°C, and 17.11°C, with RH values of 53.5%, 60.3%, 63.3%, and 74.22%, respectively.

The number of larvae per sample exhibited four peaks on the Master B variety, with counts of 39.0, 36.0, 30.0, and 27.0 during the third, second, and first weeks of December, and the last week of November, respectively. Corresponding environmental conditions included temperatures of 19.88°C, 20.03°C, 21.01°C, and 19.63°C, and RH values of 66.22%, 62.11%, 66.22%, and 57.0%.

On the Entisar 2 variety, the number of larvae peaked at 45.25, 42.0, 36.75, and 33.25 larvae per sample during the second and first weeks of December, the third week of December, and the last week of November, respectively. For the Sokari [Mangetout] variety, four peaks were observed with counts of 36.50, 33.0, 30.50, and 30.25 larvae per sample during the first week of December, the third and last weeks of November, and the third week of December, respectively.

- Numbers of Mines per Sample

In the first season, pea leaf miner infestation, expressed as the number of mines per sample, was significantly affected by the pea varieties and sampling dates ($P \leq 0.01$). Higher significant differences were observed during the fifteenth week at 17.11°C and 74.22% RH.

On the Master B variety, the numbers of mines per sample peaked at 85.25, 81.25, 78.75, 75.0, 63.0, and 61.50 during the third, first, and second weeks of December, and the last, second, and third weeks of November, respectively. Corresponding temperatures were 19.88°C, 21.01°C, 20.03°C, 19.63°C, 20.70°C, and 19.63°C, with RH values of 81.89%, 66.22%, 62.11%, 57.0%, 46.56%, and 57.0%.

On the Entisar 2 variety, the numbers of mines per sample were highest during the first week of December (99.25), the second week of December (96.50), the last week of November (84.75), and the third week of December (82.50). On the Sokari [Mangetout] variety, peaks occurred during the first week of December (84.75), the last week of November (81.50), and the second and third weeks of November (76.0 and 69.75), respectively.

Table (4). Infestation percentage, number of larvae, and mines of the leaf miner (*Liriomyza trifolii*) on different pea varieties (Master B, Entisar 2, and Sokari [Mangetout]) during 2022/2023 season

+	inf. %			Empty			Larvae			Total mines			Temp. ºC	R.H. %
	Master B	Entisar 2	Sokari	Master B	Entisar 2	Sokari	Master B	Entisar 2	Sokari	Master B	Entisar 2	Sokari		
24 Sep	0.00	0.00	0.00	0.0	1.00	0.00	0.0 a	0.0a	0.00a	0.0	1.00a	0.00±	27.54	56.66
1 Oct.	24.00 ± 0.57 a a	19.70 ± 0.57 a	25.00 ± 0.50 a a	12.5	16. 5	12.00	3.00 ± 0.57a	3.25 ± 0.57 a a	3.00 ± 0.50 a a	15.5 ± 0.57 b	19.75 ± 0.57 a	15.00 ± 0.50 b	30.05	63.9
8 Oct.	70.58 ± 0.58 a	31.76 ± 0.57 c	36.99 ± 0.50 b	12.75	21.25	18.25	9.00 ± 0.57 a	6.75 ± 0.57 b b	6.75± 0.50 b	21.75 ± 1.00 b	28.0 ± 0.57 a	25.00 ± 0.50 b	24.80	53.5
15 Oct.	58.73 ± 0.57 a	48.65 ± 0.57 b	38.67 ± 0.50 c	15.75	18.50	18.75	9.25 ± 0.57 a a	9.00 ± 0.57 a	7.25 ± 0.50 b	25.0± 0.57 b	27.50 ± 0.57 aa	26.00 ± 0.50 ab	25.65	60.98
22 Oct.	72.62 ± 0.56a	45.95 ± 0.57 c	61.86 ± 0.50 b	21.0	27.75	24.25	15.25 ± 0.57 a a	12.75 ± 0.57 b	15.00 ± 0.50 a b	36.25 ± 0.57 c	39.50 ± ±0.57 b	49.25 ± 0.50 a	23.72	63.3
29 Oct.	71.07 ± 0.56 a	65.99 ± 0.57 b	63.70 ± 0.50 c	30.25	36.75	33.75	21.50 ± 0.57 b b	24.25 ± 0.57 a	21.50 ± 0.50 b	52.0 ±0.57 c	61.00 ± 0.57 a	55.25 ±0.50 b	23.35	68.64
5 Nov.	55.30 ± 0.63 b b	56.47 ± 0.57a b	58.22 ± 0.50 a a	33.00	42.50	36.50	19.25 ± 0.57 b	24.00 ± 0.57 a	20.75 ± 0.50 b b	15.25 ± 0.57 c	66.50 ± 0.57 a	57.75 ± 0.50 b	21.67	62.03
12 Nov.	61.53 ± .057 a	61.33 ± 0.57 a a	54.14 ± 0.50 b	39.00	45.25	45.25	24.00 ± 0.57 b	27.75 ± 0.57 a	24.50 ± 0.50 b b	63.0± 0.57 c	73.00 ± 0.57 a	69.75 ± 0.50 b	21.92	66.93
19 Nov.	43.86 ± 0.58 c	50.00 ± 0 .57 b	67.03 ± 0.50 a	42.75	48.50	45.50	18.75 ± 0.57 c	24.25 ± 0.57 b	30.50 ± 0.50 a	61.50 ± 0.57 c	72.75 ± 0.57 b	76.00 ± 0.50 a	20.70	46.56
26 Nov.	56.25 ± 0.57 c	64.56 ± 0.57 b	68.04 ± 0.50 a	48.00	51.50	48.50	27.00 ± 0.57 b	33.25 ± 0.57 a a	32.50 ± 0.50 a	75.0 ± 0.57 c	84.75 ± 0.57 a	81.50 ± 0.50 b	19.63	57.0
3 Dec	58.54 ± 0.57 b	73.36 ± 0.57 a	75.65 ± 0.50 a a	51.25	57.25	48.25	30.0± 0.57 c	42.00 ± 0.57 a	36.50 ± 0.50 b	81.25 ± 0.57 c	99.25 ± 0.57 a	84.75 ± 0.50 b	21.01	66.22
10 - Dec	84.21 ± 0.75 b	88.29 ± 0.57 a	46.40 ± 0.50 c	42.75	51.25	45.25	36.0± 0.57 b	45.25 ± 0.57 a	21.00 ± ±0.50 c	78.75 ± 0.88 b	96.50 ± 0.57 a	66.25 ±0.50 c	20.03	62.11
17 Dec	84.32 ± 0.75 a	80.33 ± 0.57 b	71.60 ± 0.50 c	46.25	45.75	42.75	39.0± 0.57 a	36.75 ± 0.57 b	29.75 ± 0.50 c	85.25 ± 0.57 a	82.50 ± 0.57 b	24.25 ± 0.50 c	19.88	81.89
24 Dec	58.54 ± 0.57 b b	83.05 ± 0.57 a	60.42 ± 0.50 b	30.75	39.50	36.00	18.0± 0.57 c	24.50 ± 0.57 a	21.75 ± 0.50 b	48.75 ± 0.57 c	64.0± 0.57 a	57.75 ± 0.50 b	15.76	86.02
31 Dec	20..0 0± 1.00c	30.19 ± 0.57b	40± 0.50a	10.00	13.25	6. 25	2.00± 0.57 aa	4.00± 0.57 aa	2.50± 0.50 a	12.0± 0.57 a	17.25 ± 0.57 a	8.75 ± 0.50 c	17.11	74.22
7 Jan.	0.00b b	57.89 ± 0.57 a	0.00 b	5.00	4.75	2.75	0.00 b	2.75± 0.57 a	0.0bb	5.50± 0.57 a	7.50± 0.57 aa	2.75± 0.50b	17.59	70.94
Total				428.25	483.5	439.5	271.00	320.5	274.75	676.75	840.0	700.0		
Mean				28.55	34.54	31.39	16.94	20.03	17.17	42.30	52.55	43.75		

*Values are means ± standard deviation. Means within each column followed by different letters are significantly different ($p < 0.01$).

3.4. Pea Leaf Miner Infestation during the Second Season (2023/2024)

- Infestation of Pea Leaf Miners

The results presented in Table (5) indicate that pea leaf miner (*L. trifolii*) infestation was significantly (P≤0.01) affected by different pea varieties and sampling intervals during the 2023/2024 season. Interaction between sampling time and varieties also showed significant differences (P≤0.01) at the second and third weeks under environmental conditions of 30.05°C and 24.80°C with 63.9% and 53.5% RH, respectively.

For the Master B variety, significantly higher infestation rates were recorded during the second and third weeks of December, with rates of 71.35% and 70.59% observed under conditions of 17.59°C and 19.48°C with RH values of 56.04% and 73.51%, respectively. Lower infestation was observed in the first week of October, with a rate of 20.00% recorded under 26.93°C and 60.37% RH.

On the Entisar 2 variety, the highest infestation rates were 74.61% and 70.37%, recorded on December 10 and December 17, respectively, under conditions of 17.59°C and 19.48°C with RH values of 56.04% and 73.51%. The lowest infestation occurred on October 1, with a rate of 33.33%.

For the Sokari [Mangetout] variety, the highest infestation rates were 80.62% and 78.34%, recorded during the third week of December and the last week of November under conditions of 19.48°C and 19.03°C with RH values of 73.51% and 52.67%, respectively. The lowest infestation rates were recorded in the first week of October (33.33%) and the second week of October (38.09%).

- Numbers of Larvae per Sample

Data in Table (5) indicates that the mean number of larvae per sample was significantly affected by different varieties, with higher significant differences (P≤0.01). On the Master B variety, three peaks were recorded at 36.0, 35.0, and 33.0 larvae per sample during the third, first, and second weeks of December, respectively, under conditions of 19.48°C, 20.16°C, and 17.59°C with RH values of 73.51%, 77.25%, and 56.04%. Lower numbers of larvae were recorded in the first and second weeks of October and the last week of December.

On the Entisar 2 variety, four peaks were observed with 38.00, 36.00, 32.00, and 32.00 larvae per sample recorded on December 17, December 10, December 3, and November 26, respectively, under conditions of 19.48°C, 17.59°C, 20.16°C, and 19.03°C with RH values of 73.51%, 56.04%, 77.25%, and 52.67%. The lowest numbers of larvae were recorded on October 1, with 12 larvae per sample.

On the Sokari [Mangetout] variety, three peaks were observed with 40.00, 38.00, and 34.00 larvae per sample during the last week of November, the first week of December, and the second week of November, respectively, under conditions of 19.03°C, 20.16°C, and 24.84°C with RH values of 52.67%, 77.25%, and 74.28%.

- Numbers of Mines per Sample

In the second season, the number of mines per sample showed significant differences (P≤0.01) across varieties and sampling times. On the Master B variety, peaks were recorded at 89.00, 87.00, 86.00, and 81.00 mines per sample during the third week of November, the third week of December, the last week of November, and the first week of December, respectively, under conditions of 24.84°C, 19.48°C, 19.03°C, and 20.16°C with RH values of 74.28%, 73.51%, 52.67%, and 77.25%. Lower mine counts were observed in the first week of October.

For the Entisar 2 variety, the highest counts were 92.00, 90.00, 88.00, and 83.00 mines per sample during the third week of December, the first week of December, the last week of November, and the second week of November, respectively, under conditions of 19.48°C, 20.16°C, 19.03°C, and 24.84°C with RH values of 73.51%, 77.25%, 52.67%, and 74.28%. The lowest count was observed in the first week of October (19 mines per sample).

On the Sokari [Mangetout] variety, peaks were recorded at 91.00, 90.50, and 88.00 mines per sample during the last week of November, the first week of December, and the third week of November, respectively, under conditions of 19.03°C, 20.16°C, and 21.08°C with RH values of 52.67%, 77.25%.

Table (5). Infestation percentage, number of larvae, and mines of the leaf miner (*Liriomyza trifolii*) on different pea varieties (Master B, Entisar 2, and Sokari [Mangetout]) during 2022/2023season

Sampling date	Inf.%			Empty			Larvae			Total mines			Tem p.ºC	R.H. %
	Master B	Entisar 2	Sokari	Master B	Entisar 2	Sokari	Master B	Entisar 2	Sokari	Master B	Entisar 2	Sokari		
24 Sep	0.0^{a}	0.00^{aa}	0.00 ^{a}	0.00	0.00	0.00	0.00^{a}	0.00	0.00	0.00	0.00	0.00	29.33	66.61
1 Oct.	17.00 ±2.51 ^{b}	33.33 ±0.57 ^{aa}	33.33 ±0.50 ^{a}	10.00	15.00	12.00	2.33± 0.33^{b}	5.00± 0.57^{aa}	4.00± 0.50^{a}	12.00 ± 0.57^{c}	19.00 ± 0.57^{a}	16.00 ± 0.50^{b}	26.93	60.37
8 Oct.	50.79 ±0.57 ^{a}	40.00 ±0.57 ^{b}	38.09 ±0.50 c	15. 75	25.00	21.00	8.00± 0.57 ^{a}	10.00 ±0.57 ^{aa}	8.50± 0.50 ^{aa}	23.75 ± 0.57^{c}	35.00 ± 0.57^{a}	29.00 ± 0.50^{b}	25.71	63.71
15 Oct.	46.43 ±0.57 ^{b}	51.00 ±0.57 ^{a}	40.91 ±0.50 c	21.00	25.00	22.25	9.75± 0.57 ^{bb}	12.75 ±0.57 ^{a}	9.00± 00.50 ^{b}	30.75 ± 0.75 ^{b}	37.75 ± 0.57^{a}	31.25 ± 0.50^{bb}	24.63	61.61
22 Oct.	46.15 ±0.33 ^{b}	58.82 ±0.57 ^{a}	42.86 ±1.00 ^{c}	26.00	34.00	28.25	12.00 ±0.57 ^{b}	20.00 ±0.57^{a}	12.00 ±0.50 ^{bb}	38.00 ± 0.57^{b}	54.00 ± 0.57^{a}	40.25 ± 0.50^{bb}	24.79	71.64
29 Oct.	55.56 ±0.57 ^{b}	50.00 ±0.57 ^{c}	60.13 ± 0.50 ^{a}	36.00	46.00	38.25	20.00 ±0.57 ^{b}	23.00 ±0.57^{a}	23.50 ±0.50^{a} ^{a}	50.0± 0.57^{c}	69.00 ± 0.57^{a}	61.25 ± 0.50^{b}	25.75	73.0
5 Nov.	48.50 ±0.57 ^{b}	50.48 ±0.57 ^{bb}	58.33 ±0.50 ^{a}	50.00	52.00	48.00	24.25 ±0.57 ^{b}	26.25 ±0.57^{a} ^{b}	28.00 ±0.50^{a} ^{a}	74.25 ± 0.57^{b}	78.25 ± 0.57^{aa}	77.0± 0.50^{a}	25.28	65.30
12 Nov.	58.93 ±0.57 ^{b}	56.60 ±0.57 ^{c}	75.56 ±0.50 ^{a}	56.00	53.00	45.25	33.00 ±0.57^{a}	30.00 ±2.84^{a}	34.00 ±0.50^{a} ^{a}	89.00 ± 0.57^{a}	83.00 ± 0.57^{b}	79.25 ± 0.50^{c}	24.84	74.28
19 Nov.	42.59 ±0.57 ^{b}	39.29 ±0.57 ^{c}	58.18 ±0.50 ^{a}	54.50	56.00	55.50	23.00 ±0.57 ^{bb}	22.00 ±0.57 ^{b}	32.50 ±0.50^{a}	77.5± 0.57^{b}	78.00 ± 0.57^{bb}	88.00 ± 0.50^{a}	21.08	59.38
26 Nov.	53.57 ±0.57 ^{c}	57.14 ±0.57 ^{b}	78.43 ±0.50 ^{a}	56.00	56.00	51.00	30.00 ±0.57 ^{b}	32.00 ±0.57 ^{bb}	40.00 ±0.50^{a}	86.0± 0.57^{b}	88.00 ± 0.57^{bb}	91.00 ± 0.50^{a}	19.03	52.67
3 Dec	62.50 ±0.57 ^{b}	55.17 ±0.57 ^{c}	73.08 ±0.50 ^{a}	56.00	58.00	52.00	35.00 ±0.57 ^{b}	32.00 ±0.57^{c}	38.00 ±0.50^{a}	81.25 ± 0.57 ^{b}	90.00 ± 0.57^{a}	90.50 ± 0.50^{aa}	20.16	77.25
10 Dec	71.35 ±0.57 ^{b}	74.61 ±0.57 ^{a}	57.50 ±0.50 ^{c}	46.25	48.25	40.00	33.00 ±0.57^{a}	36.00 ±0.57^{a} ^{a}	23.00 ±0.50 ^{b}	79.25 ± 0.57^{b}	84.00 ± 0.57^{a}	63.00 ± 0.50^{c}	17.59	56.04
17 Dec	70.59 ±0.57 ^{b}	70.37 ±0.57 ^{bb}	80.62 ±0.50 ^{a}	51.00	54.00	40.00	36.00 ±0.57^{a} ^{b}	38.00 ±0.57^{a} ^{a}	32.25 ±0.50 ^{b}	87.0± 0.57^{b}	92.00 ± 0.57^{a}	72.25 ± 0.50^{c}	19.48	73.51
24 Dec	52.50 ±0.57 ^{c}	64.29 ±0.57 ^{a}	60.66 ±0.50 ^{b}	32.25	42.00	33.00	20.00 ±0.57 ^{bb}	27.00 ±0.57^{a}	19.50 ±0.50 ^{b}	52.25 ± 0.57^{bb}	69.00 ± 0.57^{a}	53.00 ± 0.50^{b}	18.73	79.45
31 Dec	66.67 ±00.58 ^{a}	60.00 ±10.15 ^{b}	40.00 ±0.50 ^{c}	12.00	10.00	20.00	8.00± 0.57^{aa}	6.00± 0.57^{a}	7.50± 0.50^{aa}	20.00 ± 0.57^{b}	16.00 ± 0.57^{c}	28.00 ± 0.50^{a}	17.48	78.54
7 Jan.	0.00^{a}	0.00^{a}	0.00^{a}	0.00	0.00	3.00	0.00	0.00	0.00	0.00^{b}	0.00b	3.00 ± 0.50^{a}	17.58	61.66
Total				507.00	549.25	468.50	294.00	320.00	311.75	801.00	893.00	822.25		
Mean				33.80	36.25	33.46	18.37	20.00	19.48	50.06	55.81	51.39		

*Values are means ± standard deviation. Means within each column followed by different letters are significantly different ($p < 0.01$).

3.5. Parasitism Percentage of *L. trifolii* (Burgess) on Pea Varieties during the First Season (2022/2023)

Results presented in Table (6) revealed significant parasitism of *L. trifolii* on pea varieties during the first season (2022/2023). The Master B variety exhibited four peaks in parasitism percentages, with the highest values recorded at 50.00%, 19.67%, 18.60%, and 18.52% on the last week of December, October 22, October 29, and the last week of November, respectively. These peaks corresponded to

environmental conditions of 17.11°C, 23.72°C, 23.35°C, and 19.63°C with relative humidity (RH) values of 74.22%, 63.3%, 68.64%, and 57.0%.

For the Entisar 2 variety, three peaks of parasitism were observed, with percentages of 50.00%, 36.36%, and 29.63% recorded during the last week of December, January 7, and the second week of October, respectively. The environmental conditions during these peaks were 17.11°C, 17.59°C, and 24.80°C with RH values of 74.22%, 70.94%, and 53.5%, respectively.

The Sokari [Mangetout] variety showed two significant peaks of parasitism, with percentages of 39.00% and 33.33% recorded during the last week of October and the second week of December, respectively. These peaks occurred under conditions of 23.35°C and 20.03°C with RH values of 68.64% and 62.11%, respectively.

Metwally (1991) identified 12 hymenopterous parasitoid species attacking *Liriomyza* spp. in Egypt, including *Opius pallipes* Wesmael (Braconidae), *Halticoptera circulus* (Walker) (Pteromalidae), and *D. isaea* (Walker) (Eulophidae). *O. pallipes* is a solitary larval-pupal endoparasitoid of both *L. trifolii* and *Liriomyza bryoniae* (Kaltenbach) (Diptera: Agromyzidae). **Ibrahim (1999)** noted similar parasitoid species, emphasizing their role in biological control. **Saleh *et al.* (1983**) reported that parasitism of L. trifolii by O. pallipes in Egypt was low early in the season and peaked during March. Additionally, **Ode and Heinz (2002)** and **Liu *et al.* (2009)** highlighted that D. isaea is a solitary ectoparasitoid of agromyzid leaf miner larvae, including *L. trifolii*, *Liriomyza huidobrensis* (Blanchard), and *Liriomyza sativae* Blanchard.

Table (6). Parasitism percentages of *Liriomyza trifolii* pea varieties (Master B, Entisar 2, and Sokari [Mangetout]) during the first seasons 2022/2023

Sampling date	Seasons (2022/2023)										
	No. of Larvae			No. of Parasitoids			Parasitism%			Temp.°C	R.H.%
	Master B	Entisar 2	Sokari	Master B	Entisar 2	Sokari	Master B	Entisar 2	Sokari		
24 Sep	0.0	0.0	0.00	0	0	0	0.00	0.00	00.0	27.54	56.66
1 Oct.	3.00	3.25	3.00	0	0	0	00.0	0.00	0.00	30.05	63.9
8 Oct.	9.00	6.75	6.75	1	2	1	11.11	29.63	14.81	24.80	53.5
15 Oct.	9.25	9.00	7.25	1	2	1	10.81	22.22	13.79	25.65	60.98
22 Oct.	15.25	12.75	15.00	3	2	2	19.67	15.68	13.33	23.72	63.3
29 Oct.	21.50	24.25	21.50	4	4	2	18.60	16.56	39.00	23.35	68.64
5 Nov.	18.25	24.00	21.25	3	5	3	16.44	20.83	14.12	21.67	62.03
12 Nov.	24.00	27.75	24.50	4	6	3	16.66	21.62	12.24	21.92	66.93
19 Nov.	18.75	24.25	30.50	3	6	5	16.00	24.74	16.39	20.70	46.56
26 Nov.	27.00	33.25	33.00	5	7	5	18.52	21.21	15.15	19.63	57.0
3 Dec	30.0	42.00	36.50	3	8	6	10.00	19.04	16.44	21.01	66.22
10 Dec	36.0	45.25	21.00	3	4k	7	8.33	8.84	33.33	20.03	62.11
17 Dec	39.0	36.75	30.25	4	4	4	10.26	10.88	13.22	19.88	81.89
24 Dec	18.0	24.50	21.75	2	3	2	11.11	12.24	9.20	15.76	86.02
31 Dec	2.00	4.00	2.50	1	2	0	50.0	50.00	0.00	17.11	74.22
7 Jan.	0.00	2.75	0.0	0	1	0	0.00	36.36	0.0	17.59	70.94
Total	**271.00**	**320.5**	**274.75**								
Mean	**16.94**	**20.03**	**17.17**								

3.6. Parasitism Percentage of *L. trifolii* (Burgess) on Pea Varieties during the Second Season (2023/2024)

In the second season, *L. trifolii* larvae recorded low numbers at the beginning of the season. Results in Table (7) showed significant peaks of parasitism percentages across varieties. For the Master B variety, the highest peaks were 24.49%, 23.08%, and 21.43%, recorded during the third week of October, the second week of November, and the fourth week of October at 25.65°C, 21.92°C, and 23.72°C with RH values of 60.98%, 66.93%, and 63.3%, respectively.

For the Entisar 2 variety, the highest percentages of parasitism were 26.67% and 25.00%, recorded during the third week of October and the last week of December at 25.65°C and 17.11°C with RH values of 60.98% and 74.22%, respectively.

On the Sokari [Mangetout] variety, three significant peaks of parasitism were observed at 24.49%, 23.08%, and 21.43%, recorded during the third week of October, the second week of November, and the fourth week of October at 22.65°C, 21.67°C, and 23.72°C with RH values of 60.98%, 62.03%, and 63.3%, respectively.

Table (7). Parasitism percentages of *Liriomyza trifolii* pea varieties (Master B, Entisar 2, and Sokari [Mangetout]) during the second seasons 2023/2024

Sampling date	Seasons (2023/2024)									Temp. ºC	R.H. %
	No. of Larvae			No. of Parasitoids			Parasitism%				
	Master B	Entisar 2	Sokari	Master B	Entisar 2	Sokari	Master B	Entisar 2	Sokari		
24 Sep	0.0	0.0	0.00	0	0	0	0.00	0.00	0.00	27.54	56.66
1 Oct.	5.00	6.00	4.00	1	1	0	00.0	16.67	00.0	30.05	63.9
8 Oct.	11.00	12.25	10.00	2	2	3	18.19	16.33	18.19	24.80	53.5
15 Oct.	12.25	15.00	15.25	4	3	4	24.49	26.67	24.49	25.65	60.98
22 Oct.	14.00	17.00	20.00	2	3	5	21.43	11.76	21.43	23.72	63.3
29 Oct.	22.00	24.00	20.00	5	4	3	18.18	20.83	18.18	23.35	68.64
5 Nov.	24.00	26.00	24.00	5	5	5	20.83	19.23	20.83	21.67	62.03
12 Nov.	26.00	30.00	28.00	6	6	6	23.08	20.00	23.08	21.92	66.93
19 Nov.	28.00	34.00	33.00	7	3	6	10.71	20.59	10.71	20.70	46.56
26 Nov.	30.00	35.00	37.25	6	6	4	20.00	17.14	20.00	19.63	57.0
3 Dec	32.0	40.25	35.00	7	5	5	15.63	17.50	15.63	21.01	66.22
10 Dec	33.0	48.00	34.00	5	6	4	18.18	10.42	18.18	20.03	62.11
17 Dec	36.0	42.00	32.25	4	5	6	13.89	9.52	13.89	19.88	81.89
24 Dec	14.0	20.50	22.00	4	1	3	7.14	20.00	7.14	15.76	86.02
31 Dec	5.00	8.00	6.0	2	1	1	20.00	25.00	20.00	17.11	74.22
7 Jan.	0.00	1.50	0.0	0	0	0	0.00	0.00	0.00	17.59	70.94
Total	**292.25**	**359.5**	**320.75**	**60.00**	**51.00**	**55.00**					
Mean	**18.27**	**22.47**	**20.05**	**3.75**	**3.19**	**3.44**					

3.7. Seasonal Abundance of *L. trifolii* on Pea Varieties

- Seasonal Trends and Peaks

During the two investigated seasons (2022/2023 and 2023/2024), *Liriomyza* spp. pupae exhibited five peaks of occurrence. These were observed on December 3, November 26, November 19, November 12, and December 10, with pupae counts of 65, 57, 55, 48, and 45 per 100 pea leaflets, respectively. Figures (1 and 2) illustrate that *O. dissitus* emerged from all larval samples, except for those collected on September 24, December 24, December 31, and January 7. Two distinct peaks of *O. dissitus* parasitism were recorded on October 22 (23.73%) and October 15 (15.0%) during the first season.

Diglyphus isaea emerged from all *Liriomyza* spp. pupae throughout the season and exhibited higher numbers compared to other parasitoids. The highest peaks of *D. isaea* parasitism were recorded on October 22 (54.55%), October 10 (50.00%), October 8 (33.33%), and October 15 (30.00%). *Diglyphus sp.* recorded its highest peak on October 22, with a parasitism percentage of 13.64%.

During the second season, *O. dissitus* recorded three peaks of parasitism on October 10 (16.67%), December 17 (15.38%), and October 22 (15.00%). Meanwhile, *D. isaea* showed three peaks of parasitism on October 10 (50.00%), October 8 (45.00%), and October 22 (40.00%). *Diglyphus sp.* recorded its highest peak on October 22 (15.00%).

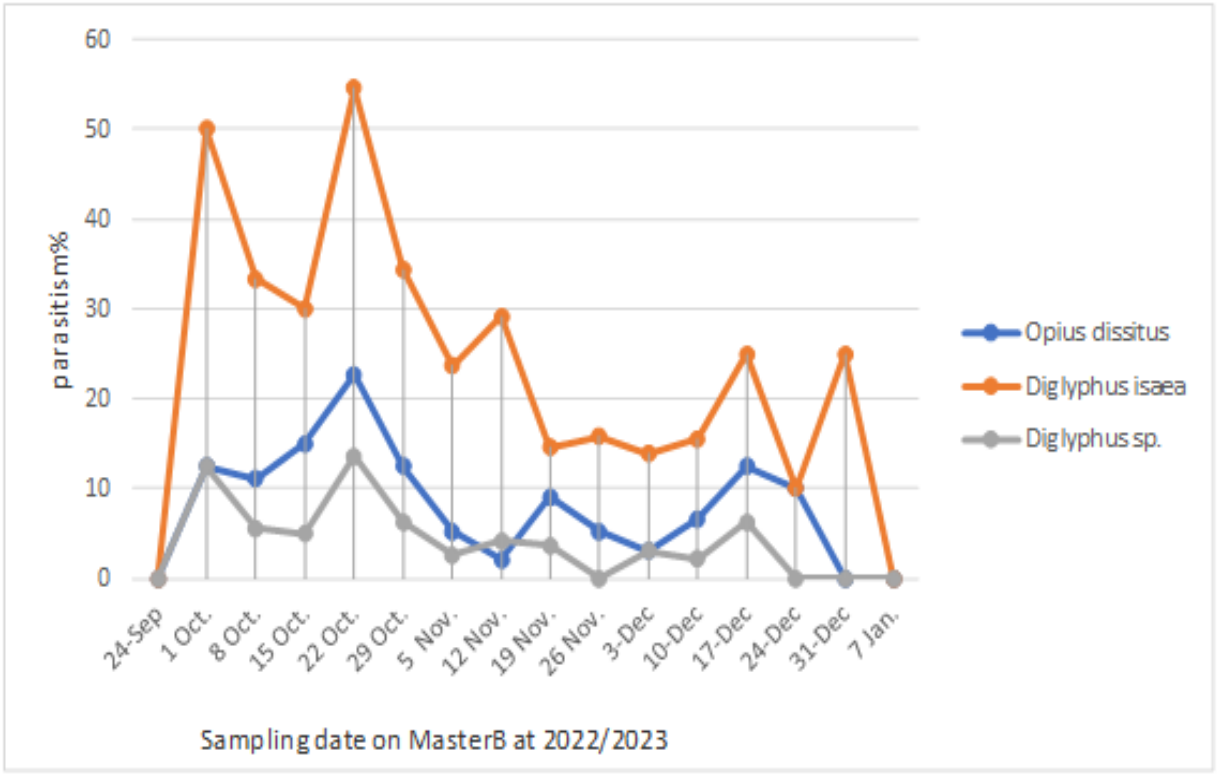

Fig. (1). Parasitism percentage of *Opius dissitus*, *Diglyphus isaea* and *Diglyphus* sp. on Master B pea variety during 2022/2023 Season

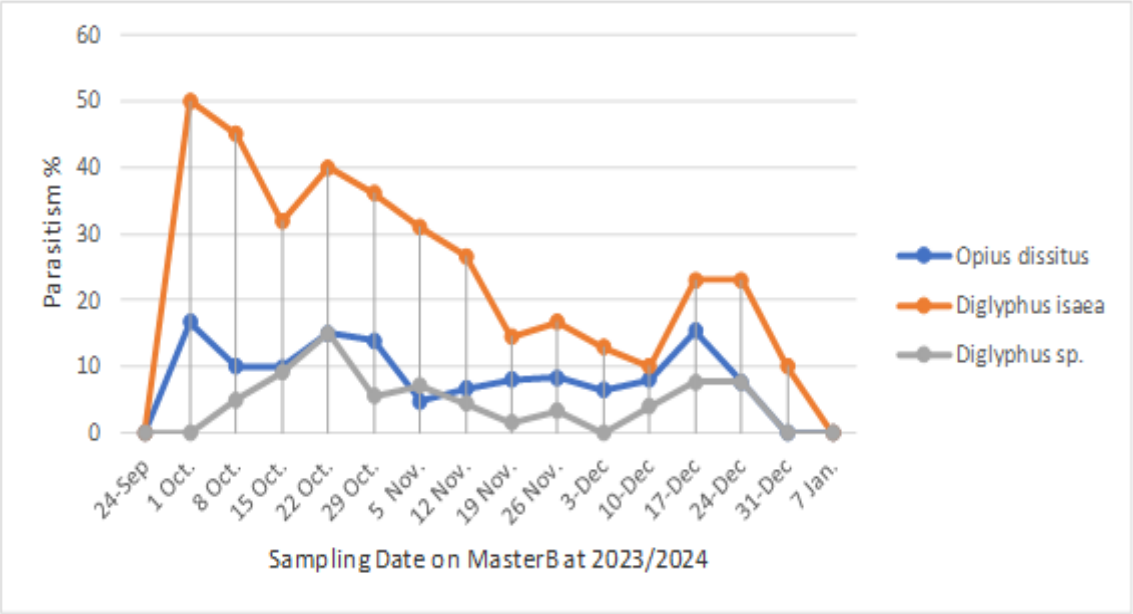

Fig. (2). Parasitism percentage of *Opius dissitus*, *Diglyphus isaea* and *Diglyphus* sp. on Master B pea variety during 2023/2024 Season

- Parasitism on Different Varieties

For the Entisar 2 variety during the 2022/2023 season, the highest peaks of *O. dissitus* parasitism (Figures 3 and 4) were recorded on October 22 (26.67%) and October 1 (23.08%). Lower peaks were observed in December samples. *D. isaea* appeared in higher numbers compared to other parasitoids, with its highest peaks recorded on October 1 (61.54%), October 22 (53.33%), October 29 (44.44%), October 8 (40.01%), and October 15 (32.00%). *Diglyphus sp.* showed parasitism peaks on October 10 (15.38%), October 22 (13.33%), October 15 (12.00%), and December 17 (11.76%).

In the second season, the highest peaks of *O. dissitus* parasitism for Entisar 2 were observed on October 8 (24.00%), October 29 (23.53%), October 22 (18.75%), and October 15 (18.18%). Lower parasitism was recorded on December 31 and January 7. *D. isaea* had its highest peaks on October 1 (56.25%), October 22 (47.06%), October 29 (46.38%), and October 8 (40.00%). *Diglyphus sp.* recorded a parasitism peak of 12.50% on October 1 and December 24, with lower peaks on December 31 and January 7.

For the Sokari [Mangetout] variety during the first season, *D. isaea* recorded its highest parasitism percentage on October 22 (46.67%) and December 17 (40.00%). The second season showed *D. isaea* peaks at 56.25% (October 1), 47.06% (October 22), and 46.38% (October 29). Figures (5 and 6) illustrate that *D. isaea* maintained activity throughout the growing season, increasing in number as the leaf miner populations increased, particularly in October and December.

This study aligns with previous findings by Aneesa (2024), who recorded four hymenopterous parasitoids emerging from *Liriomyza* spp. pupae, including *D. isaea* (Eulophidae), *O. dissitus* (Braconidae), *Pediobius spp.* (Eulophidae), and *D. crassinervis* Erdos (Eulophidae). **Awadalla *et al.* (2018)** observed peak abundance of *L. huidobrensis* larvae on pea (*P. sativum*) during January, with average parasitism rates of 28% for *D. isaea*. Similarly, **Shoaib *et al.* (2020)** reported that *D. isaea* was the most dominant ecto-larval parasitoid of *L. trifolii*.

Eid (2008) found high parasitism percentages of *L. trifolii* by hymenopterous parasitoids on cowpea varieties, with rates of 86.64% in the first season and 65.49% in the second season. **El-Khawas (2012)** noted that *D. isaea* was the predominant parasitoid species on pea, accounting for 68.3% and 41.4% of total parasitoids during two consecutive seasons. **Elkhouly *et al.* (2020)** reported that *L. trifolii* exhibited 3-4 peaks of abundance on multiple host plants, with *D. isaea* remaining the primary parasitoid species.

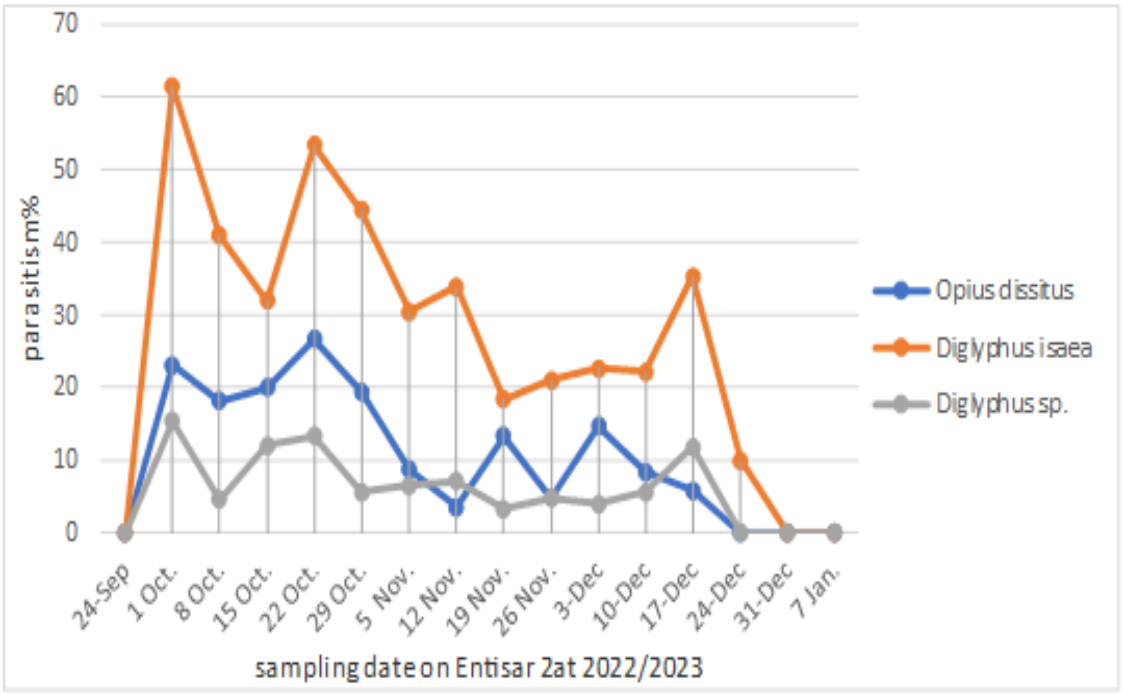

Fig. (3). Parasitism percentage of *Opius dissitus*, *Diglyphus isaea* and *Diglyphus* sp. on Entisar 2 pea variety during 2022/2023 Season

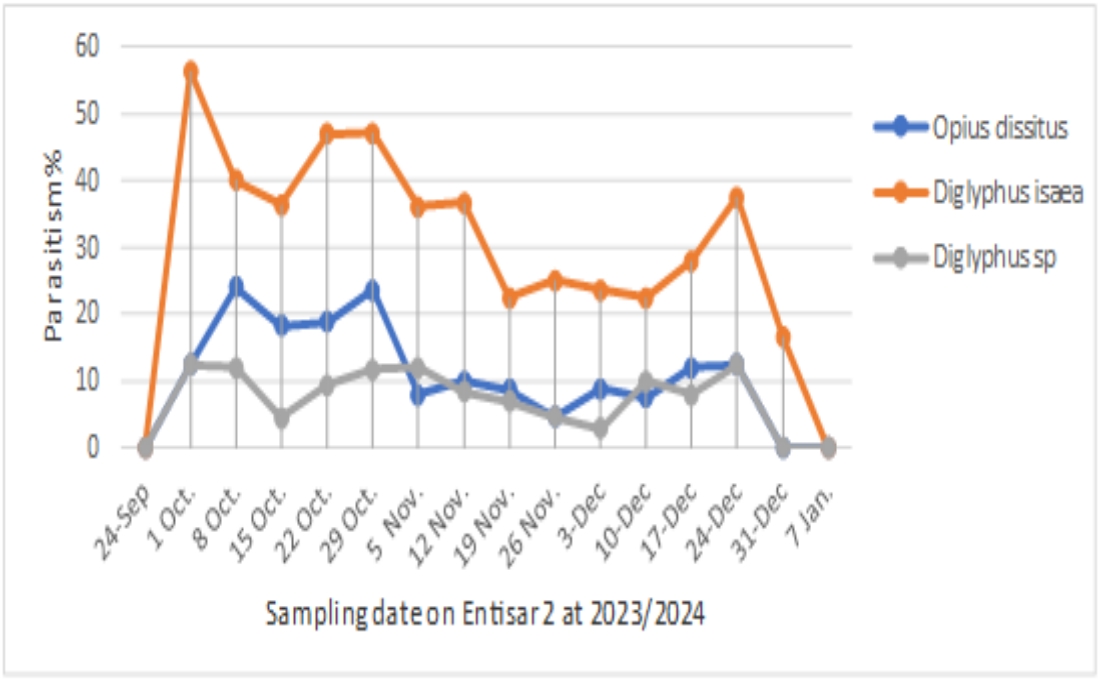

Fig. (4). Parasitism percentage of *Opius dissitus*, *Diglyphus isaea* and *Diglyphus* sp. on Entisar 2 pea variety during 2022/2023Seasons

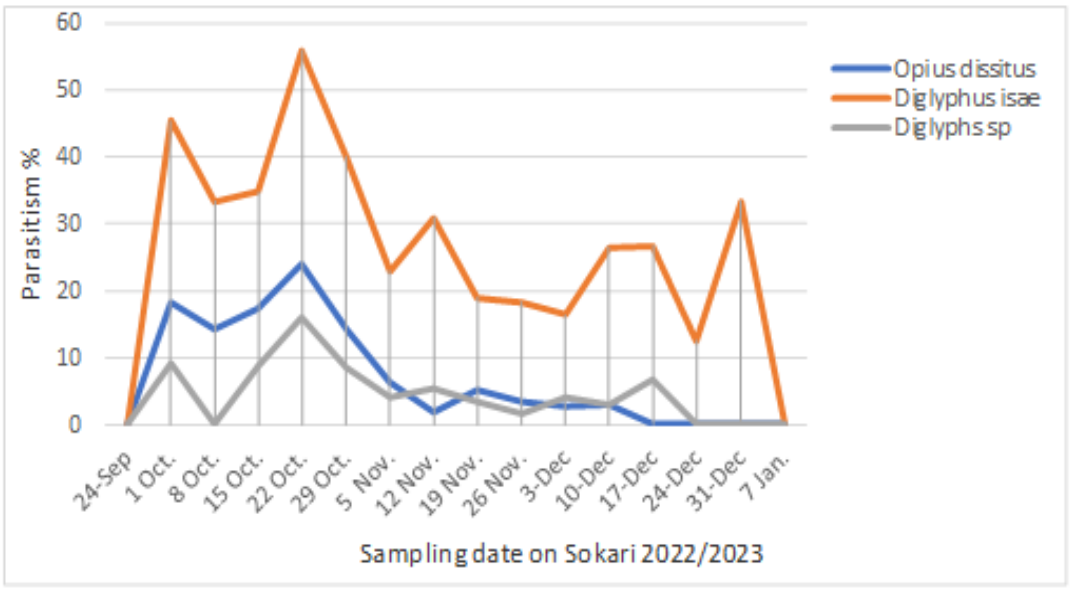

Fig. (5). Parasitism percentage of *Opius dissitus*, *Diglyphus isaea* and *Diglyphus* sp. on Sokari pea variety during 2022/2023 Season

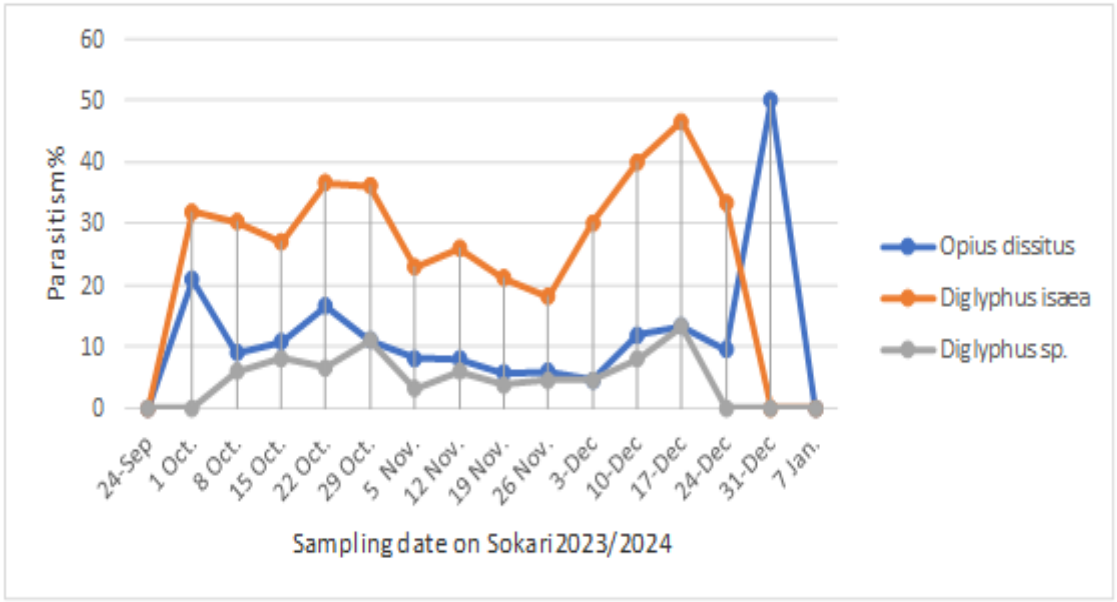

Fig. (6). Parasitism percentage of *Opius dissitus*, *Diglyphus isaea* and *Diglyphus sp.* on Sokari pea variety during 2023/2024 Season

This study highlights the seasonal abundance and parasitism patterns of *L. trifolii* across three pea varieties during two growing seasons. The findings underscore the significant roles of key parasitoids, including *O. dissitus* and *D. isaea*, in regulating leaf miner populations. *D. isaea* emerged as the predominant parasitoid, displaying consistent activity throughout the seasons and aligning with previous reports of its efficacy in biological control. These results emphasize the importance of integrating natural parasitoids into pest management programs for sustainable agricultural practices, particularly in pea cultivation. Further studies should focus on enhancing the conservation of these beneficial insects to optimize their impact on pest suppression.

References

Aneesa, S. Sadek (2024). Insect pests, snails, and spider mites associated with cultivated field peas, and *Liriomyza* spp. parasitoids. Journal of Applied Entomology, 4(3): 1–8.

Awadalla, S. S., El-Serafi, H. A., El-Fakharany, S. K., and Abou-Attia, S. F. (2018). Field studies on the pea leaf miner *Liriomyza huidobrensis* (Blanchard) and its associated ectoparasitoid *Diglyphus isaea* (Walker). Journal of Plant Protection and Pathology, Mansoura University, 9(6): 357–361.

Bayoumy, M., Awadalla, H. S., Michaud, J. P., and Ramadan, M. M. (2018). A life table for *Liriomyza trifolii* (Diptera: Agromyzidae) in a temperate zone of Northeast Egypt with key factor analysis. Environmental Entomology, 47(4): 56–58.

Bhat, D. M., and Bhagat, R. C. (2009). Natural parasitism of leaf miner, *Chromatomyia horticola* (Goureau) (Diptera: Agromyzidae) on vegetable crops in Kashmir (India). World Journal of Agricultural Sciences, 5(S): 888–891.

Chabi-Olaye, A., Mujica, N., Lohr, B., and Kroschel, J. (2008). Role of agroecosystems in the abundance and diversity of *Liriomyza* leafmining flies and their natural enemies. In Proceedings of the XXIII International Congress of Entomology (pp. 6–12), July.

Claudio, G., and Welter, S. C. (2001). Parasitism of natural populations of *Liriomyza helianthi* Spencer and *Calycomyza platyptera* (Thomson) (Diptera: Agromyzidae). Biological Control, 22: 81–97.

Costat (2005). Statistical Software Version 6.311. Coltrat Software, Monterey, CA, USA.

Daiber, K. C. (1994). Injurious insects, spider mites, and nematodes on peas and green beans in South Africa. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz, 101(1): 99–107.

Duncan, B. D. (1955). Multiple range and multiple F tests. Biometrics, 11: 1–42.

Gencer, L. (2004). A study on the chalcidoid (Hymenoptera: Chalcidoidea) parasitoids of leafminers (Diptera: Agromyzidae) in Ankara Province. Turkish Journal of Zoology, 28: 119–122.

Eid, F. M. H. (2008). Monitoring the suitability of certain cowpea host plant varieties to infestation with serpentine leafminer *Liriomyza trifolii* (Burgess) and its hymenopterous parasitoids at El-Arish region, North Sinai, Egypt. Egyptian Journal of Biological Control, 18(1): 189–192.

Ekram, A. A., Refaei, E. A., and Taha, R. A. (2014). Field evaluation for insect pests infesting *Phaseolus vulgaris* and their natural enemies in Beheira Governorate. Journal of Plant Protection Research, 2(3): 514–525.

El-Khawas, S. A. (2012). Priming *Pisum sativum* with salicylic acid against the leafminer *Liriomyza trifolii*. African Journal of Agricultural Research, 7(34): 4731–4737.

Elkhouly, A., Mousa, H. A., and Shafsha, H. A. (2022). Population densities of the serpentine leaf miner *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) and associated parasitoids *Diglyphus isaea* and *Opius pallipes* on two weed host plants. Libyan Journal of Plant Protection, 12: 1–8.

Elkhouly, A., Alhireereeq, A., Albasha, O., and Shafsha, H. A. (2020). Population abundance of the serpentine leaf miner *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) on four winter host plants. Asian Journal of Agricultural and Horticultural Research, 6: 8–15.

Elsharkawy, G. A. (2013). Growth, yield, and chemical composition of peas (*Pisum sativum*) as affected by potassium levels and different methods of yeast application. Alexandria Science Exchange Journal, 34(4): 360–368.

Foba, C. N., Salifu, D., Lagat, Z. O., Gitonga, L. M., Akutse, K. S., and Fiaboe, K. K. M. (2015). Species composition, distribution, and seasonal abundance of *Liriomyza* leafminers (Diptera: Agromyzidae) under different vegetable production systems and agroecological zones in Kenya. Environmental Entomology, 44: 223–232.

Ibrahim, S. M. (1999). Studies on *Aphis craccivora* (Koch) and *Bemisia tabaci* (Genn.) infesting ten bean (*Phaseolus vulgaris* L.) cultivars at Menoufia Governorate, Egypt. Journal of Agricultural Science, Mansoura University, 24(9): 5111–5117.

Jyani, D. B., Patel, N. C., Jhala, R. C., and Patel, J. R. (1995). Bioefficacy of neem and synthetic insecticides on serpentine leafminer (*Liriomyza trifolii*) (Diptera: Agromyzidae) infesting pea (*Pisum sativum*). Indian Journal of Agricultural Sciences, 65(5): 373–376.

Liu, T. X., Kang, L., Heinz, K. M., and Trumble, J. T. (2009). Biological control of *Liriomyza* leafminers: Progress and perspective. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 4: 1–16.

Metwally, S. A. G. (1991). Population studies on *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) and its parasitoids. Egyptian Journal of Biological Pest Control, 1: 23–30.

Murphy, S. T., and LaSalle, J. (1999). Balancing biological control strategies in the IPM of New World invasive *Liriomyza* leafminers in field vegetable crops. Biocontrol News and Information, 20: 91–104.

Neama, A. A., and Hegazi, E. M. (2014). Parasitoids of the leaf miners *Liriomyza* spp. (Diptera: Agromyzidae) attacking faba bean in Alexandria, Egypt. Egyptian Journal of Biological Pest Control, 24(2): 301–305.

Ode, P. J., and Heinz, K. M. (2002). Host-size-dependent sex ratio theory and improving mass-reared parasitoid sex ratios. Biological Control, 24: 31–41.

Saleh, M. R. A., Guirguis, M. W., Tantawy, M. A., and Alattar, N. (1983). Population dynamics of *Liriomyza congesta* larvae and their parasites on broad bean. Annals of Agricultural Science, 28: 1735–1745.

SAS Institute. (1994). *SAS/STAT User's Guide: Statistics*, Version 6.04, 4th Edition. SAS Institute, Inc., Cary, NC, USA.

Shoaib, A. A. M., Youssif, M. A. I., and Helaly, S. M. Y. (2020). The leaf miner *Liriomyza trifolii* (Burgess) and its parasitoids on faba bean. Plant Archives, 20(1): 1669–1680.

Sunil Kumar Yadav, S. K., and Patel, S. (2015). Insect pest complex on *Pisum sativum* L. and natural enemies at Pantnagar. Journal of Plant Development Sciences, 7(11): 839–841.