Entomology

# Insect pests, snails and spider mite associated with cultivated field peas, and *Liriomyza* spp parasitoids

**Aneesa Saber Sadek**

Department of Vegetables Crop Pests Research, Plant Protection Research Institute, Agricultural Research Center, Egypt

Correspondence Author: Aneesa S. Sadek

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**Abstract**

Field pea (*Pisum sativum* L.) is one of the most popular foods having a high nutritional value for human consumption. This important vegetable crop is liable to infestations of several insect pests that negatively affect the yield quantitatively and qualitatively. The current investigation was carried out at the experimental farm of Sakha Agricultural Research Station, during 2019/2020 and 2021 seasons. The objectives were to monitor the population dynamics of some insect pests, as well as two-spotted spider mite and snail. Also, the parasitoids attacking *Liriomyza* spp were recorded and monitored. In the first plantation (sown on October 10$^{th}$), *Liriomyza* spp, *Bemisia tabaci*, *Empoasca* spp, as well as *Tetranychus urticae* and the snail, *Monacha cantiana* were found in considerable higher population densities; compared to *Lampides boeticus*, *Thrips tabaci* or *Pieris rapae*. In the second plantation (sown on January 15$^{th}$), the infestations of field peas by *Lampides boeticus* and *Thrips tabaci* were higher than these of the first plantation. Four hymenopterous parasitoids were recorded, as emerging from *Liriomyza* spp pupae: *Opius dissitus* Muesebeck (Braconidae), *Diglyphus isaea* Waker (Eulophidae), *D. crassinervis* Erdos (Eulophidae) and *Pediobius* spp (Eulophidae). The total parasitism of the four species, during both seasons of study, ranged between 22.18 and 49.76% *Liriomyza* spp parasitism by *Opius dissitus* ranged between 3.60 and 5.31%, *Diglyphus isaea* between 12.99 and 33.33%, *D. crassinervis* between 2.04 and 8.85%, while that of *Pediobius* sp. ranged between 2.77 and 4.56%. The obtained results, from the current study, show that parasitoids of *Liriomyza* spp may contribute effectively in managing the leafminers attacking field peas. Accordingly, application of insecticides to control the dominant insects should be seriously minimized, particularly that *P. sativum* is mostly consumed as fresh vegetable, as well as the infestations by monitored pests were low in both seasons of study.

**Keywords:** *Pisum sativum*, population dynamics, insects, *Tetranychus* sp., *Monacha cantiana*, parasitoids

## Introduction

Field pea, *Pisum sativum* L. is one of the most important popular foods, having a high nutritional value for human consumption, as both fresh and dry seeds. The seeds contain about 18-30 % protein, 35-50% starch and 4-7% fiber (Ibrahim *et al*., 2020) [9]. In addition, inclusion of peas in crop rotation is agronomically very beneficial to the soil.

Unfortunately, this crop is attacked by several pests, Damaging the yield from early growth stages up to harvest. Pea leaf miner, *Liriomyza huidobrensis* (Blanchard), is an important pest and highly polyphagous leaf miner and has too many hosts in at least 15 plant families (Foba *et al.* 2015) [6]. Piercing sucking insects are one of pests attacking *P. sativum* throughout the growth stages. El-Serafi *et al* (2000) [5] and Shalaby *et al* (2021) [15] reported the aphid, *Acyrthosiphon pisum* (Koch), *Empoasca* spp, *Nezara viridula*, *Bemisia tabaci* (Genn.) and *Lygus hesperus* (Knight) as insects reducing the quantity and quality of the crop. In addition, Ibrahim *et al* (2020) [9] pointed out that *Etiella zinckenella* (Treitshke), *Tetranychus urticae* (Koch), *Caliothrips* spp, as well as the mammals, *Rattus* spp are of great threat to the *Pisum sativum*. The spider mite, *T. urticae*, despite widespread allover climates, is more infesting to the crops at warm regions, particularly inside the greenhouses (Capinera, 2008) [2]. Kamel *et al* (2014) [10] indicated into positive correlations between *T. urticae* population and each of total carbohydrates and total proteins, but negative correlation with the total phenols in field peas plants. Molluscs are serious pests attacking agricultural crops in most areas of the world. They were recorded with relatively high population density on major economic crops (Abd El-Wahed 2014) [1]. *Monacha cartusiana* (Muller) (Gastropoda: Hygromiidae) is the most important terrestrial hygromnidae widely distributed at all localities of Sharkia Governorate (Abou Senna *et al* 2016 and Ismail *et al* 2017) [17, 18] For the control of pea blue butterfly, *Lampides boeticus* (Linnaeus), Okamoto (2018) [12] recommended apply one of four insecticides as safe compounds; cartap, malathion, etofenprox and permethrin, as the toxicities of these chemicals are very low to human, and their traces in pods are allowable.

Fortunately, leaf miners are vulnerable to attacks of several parasitoid species, which efficiently manage their populations on plants. Gencer (2004) [7] found that *Diglyphus isaea* is the most common parasitoid of leaf miner. Ekram *et al.* (2019) [3] recorded *Diglyphus* sp. (Eulophidae: Hymenoptera) and *Opius* sp. (Braconidae: Hymenoptera) as the most parasitoids of leaf miner larvae. Also, Mujica and Kroschel (2011) [11] found that *Diglyphus* sp. and *Opius* sp. are important biological control agents against the agromyzid, *Liriomyza huidobrensis* on vegetable crops in Peru.

The objectives of the current study were to monitor the population fluctuations of piercing sucking insects, leafminers, *Liriomyza* spp., blue butterfly, *Lampides boeticus* as well as the mollusc; *Monacha cantiana*. In addition, the population fluctuations of the coccinellid; *Scymnus* spp and parasitoids attacking *Liriomyza* spp were investigated.

## Materials and methods

The present study was carried out at the experimental farm of Sakha Agricultural Research station, Kafr El-sheikh during 2019/20 and 2020/21 seasons. An area of about 200 $m^2$, in each season, was divided into four equal replicates (50 $m^2$ each). In both seasons, the first plantation of field pea was sown on October 10th, while the second one was sown on January 15th. Sampling started one month after sowing and continued weekly until harvest.

From each plot, 30 leaflets (10 plants×3 leaflets each) were examined or picked up to record the immature and/ or mature stages of insects and/ or mites. The leaflets were taken as one leaflet from lower, middle, and upper levels of peas plants. The samples were examined directly in the field to count numbers of *Bemisia tabaci* adults, *Thrips tabaci* larvae and adults, *Empoasca* spp and *Aphis gossypii* nymphs and adults in each plot. In the laboratory, the leaflets were examined visually or under binocular microscope to count larvae of *Liriomyza* spp in the mines, and number of *Tetranychus urticae* eggs and adults on both sides of leaflets. Numbers of pea pod butterfly, *Lampides boeticus* larvae were recorded in the field per 100 pea pods. The numbers of the snails, *Monacha cantiana* juveniles and adults were recorded in an area of 1$m^2$ per plot. Adults of *pieris rapae* (Linnaeus) and the coccinellid, *Scymnus interruptus* (Goez) were recorded as for 10 plants.

## Results

### 1. Population dynamics of arthropod pests and snails infesting field peas and their associated predators

### 1.1. Fir1st plantation (sown on October 10th)

Population densities of pests, snails and associated predators were weekly monitored, throughout 2019/2020 (Table 1) and 2020/ 2021 (Table 2) seasons.

**Table 1:** Population dynamics of piercing-sucking pests, snails, pod borer, cabbage butterfly and *Scymnus interruptus* on field peas (first plantation) at Sakha Agricultural Research Station farm, in 2019/2020 season

| Examination date | Per 30 leaflets | | | | | | *Monacha cantiana* /1$m^2$ | *Lampides boeticus* /100 pods | Per 10 plants | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Liriomyza* spp | *Bemisia tabaci* | *Empoasca* spp | *Aphis gossypii* | *Tetranychus urticae* | | | | *Pieris rapae* | *Scymnus interruptus* |
| | L | N+A | N+A | N+A | A | E | J+A | L | A | A |
| Nov. 3,2019 | 56.00 | 9.00 | 2.00 | 0.00 | 1.00 | 13.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 121.25 | 21.25 | 5.00 | 1.00 | 3.25 | 94.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17 | 72.00 | 11.00 | 3.50 | 8.50 | 9.25 | 101.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24 | 85.75 | 9.50 | 16.25 | 15.50 | 10.25 | 267.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec,1 | 63.50 | 17.00 | 21.50 | 43.00 | 17.50 | 315.25 | 0.00 | 0.00 | 1.50 | 2.00 |
| 8 | 45.50 | 14.75 | 19.00 | 10.50 | 56.75 | 905.00 | 3.00 | 0.00 | 1.50 | 1.00 |
| 15 | 57.00 | 10.25 | 10.00 | 0.00 | 9.25 | 695.00 | 20.25 | 0.00 | 0.00 | 1.00 |
| 22 | 48.25 | 7.50 | 8.25 | 0.00 | 73.50 | 256.25 | 35.25 | 0.00 | 2.75 | 0.00 |
| 29 | 50.75 | 8.00 | 9.50 | 0.00 | 19.50 | 168.50 | 56.50 | 0.00 | 1.25 | 0.00 |
| Jan,5,2020 | 48.00 | 3.00 | 6.00 | 5.00 | 8.25 | 33.50 | 185.00 | 0.00 | 0.00 | 1.25 |
| 12 | 31.25 | 2.25 | 4.25 | 8.00 | 2.00 | 9.50 | 354.50 | 0.00 | 0.00 | 2.50 |
| 14 | 25.50 | 1.50 | 9.00 | 0.00 | 1.00 | 2.25 | 149.00 | 0.00 | 0.00 | 0.00 |
| 26 | 10.75 | 3.75 | 16.75 | 0.00 | 0.00 | 1.00 | 220.25 | 1.00 | 1.25 | 2.75 |
| Feb,2 | 3.00 | 2.00 | 11.25 | 0.00 | 0.00 | 0.00 | 268.50 | 1.25 | 0.00 | 1.00 |
| Average± SE | 51.32±8.06 | 8.63±1.60 | 10.16±1.63 | 6.54±3.11 | 15.11±5.96 | 204.38±74.22 | 92.30±32.16 | 0.16±0.11 | 0.59±0.24 | 0.82±0.27 |

E: egg, L: larva, N: nymph, A: adult, J: juvenile

### 1.1.1. *Liriomyza* spp. larvae

In the first season (Table 1), leaf miner infestation started on November 3rd with 56.00 larvae/30 pea leaflets, and quickly formed a peak one week later, on November 10th, with 121.25 larvae/30 leaflets. The second peak (85.75 larvae) was attained on November 24th, while the third one (57.00 larvae/30 leaflets) was detected on December 15th. In 2020/2021 season (Table 2), the population density of *Liriomyza* spp was higher compared to the first season, despite only two peaks were recorded, but they were higher compared to those of the first one, exhibiting values of 240.25 and 390.75 larvae/30 leaflets on November 10th and December 22nd, respectively. Seasonal average of the second season (137.04 ± 30.82) was higher than that of the first season (51.32 ± 8.06 larvae/30 leaflets).

**Table 2:** Population dynamics of piercing-sucking pests, snails, pod borer, cabbage butterfly and *Scymnus interruptus* on field peas (first plantation) at Sakha Agricultural Research Station farm in 2020/2021 season

| Examination date | Per 30 leaflets | | | | | | *Monacha cantiana* /1$m^2$ | *Lampides boeticus* /100 pods | Per 10 plants | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Liriomyza spp* | *Bemisia tabaci* | *Empoasca* spp | *Aphis gossypii* | *Tetranuchus uriticae* | | | | *Pieris rapae* | *Scymnus interruptus* |
| | L | N+A | N+A | N+A | A | E | J+A | L | A | A |
| Nov. 3, 2020 | 180.00 | 15.75 | 0.00 | 2.25 | 3.00 | 75.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 240.25 | 12.00 | 3.50 | 1.75 | 4.00 | 186.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17 | 95.75 | 9.00 | 1.00 | 0.00 | 21.25 | 123.75 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24 | 135.00 | 12.25 | 2.00 | 0.00 | 43.50 | 341.25 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec, 1 | 136.00 | 6.50 | 7.25 | 0.00 | 70.00 | 514.25 | 0.00 | 0.00 | 0.00 | 1.00 |
| 8 | 150.50 | 4.00 | 15.00 | 0.00 | 23.25 | 348.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| 15 | 195.25 | 9.00 | 18.75 | 0.00 | 128.75 | 1064.00 | 0.00 | 0.00 | 0.00 | 2.25 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 22 | 390.75 | 2.75 | 6.50 | 10.00 | 46.00 | 515.00 | 10.00 | 0.00 | 0.00 | 0.00 |
| 29 | 288.00 | 1.25 | 3.00 | 6.25 | 27.00 | 127.25 | 13.25 | 0.00 | 0.00 | 0.00 |
| Jan. 5, 2021 | 43.75 | 0.00 | 1.00 | 0.00 | 18.75 | 96.25 | 21.75 | 0.00 | 0.00 | 1.50 |
| 12 | 33.50 | 0.00 | 2.25 | 9.50 | 0.00 | 8.50 | 30.00 | 1.00 | 1.50 | 1.50 |
| 14 | 16.75 | 1.75 | 9.00 | 0.00 | 0.00 | 3.00 | 96.00 | 1.50 | 1.50 | 2.25 |
| 26 | 9.00 | 5.50 | 10.50 | 0.00 | 0.00 | 0.00 | 135.25 | 2.00 | 2.75 | 0.00 |
| Feb, 2 | 4.00 | 8.00 | 12.00 | 0.00 | 0.00 | 0.00 | 123.75 | 5.00 | 5.00 | 0.00 |
| Average ± SE | 137.04±30.82 | 6.27±1.32 | 6.55±1.55 | 2.13±0.98 | 27.54±9.66 | 243.02±79.61 | 30.71±13.11 | 0.68±0.38 | 0.77±0.40 | 0.68±0.24 |

E: egg, L: larva, N: nymph, A: adult, J: juvenile

#### 1.1.2. *Bemisia tabaci* nymphs and adults

Population densities of *B. tabaci* were low in both seasons of study, with seasonal average of 8.63 and 6.27 nymphs and adults /30 leaflets in the first and second seasons, respectively (Tables 1 and 2). This whitefly was mainly occurring during November up to early December. Seasonal averages of *B. tabaci* population densities were almost low and similar in both seasons.

#### 1.1.3. *Empoasca* spp nymphs and adults

*Empoasca* spp nymphs and adults exhibited only one peak of occurrence in 2019/2020 season with 21.50 nymphs and adults/30 leaflets on December 1st and one in 2020/2021 season, with 18.75 nymphs and adults /30 leaflets on December 15th. Low seasonal means were recorded in both first (10.16 ± 1.63) and second season (6.55 ± 1.55 nymphs and adults/30 leaflets).

#### 1.1.4. *Aphis gossypii* Glover nymphs and adults

Low population densities of *A. gossypii* seasonal average were attained in the first season (6.54 ± 3.11) and in the second one (2.13 ± o.98 nymphs and adults/30 leaflets).

#### 1.1.5. *Tetranychus urticae* Koch eggs and adults

Adults of *T. urticae* had two peaks of existence in the first season, on December 8th (56.75/30 leaflets) and on December 22nd (73.50/30 leaflets) with a seasonal mean of 15.11 ± 5.96 adults/30 leaflets. In the second season (2020/2021), the spider mite exhibited a peak of 70.00 adults on December 1st and another peak of 128.75 adults on December 15th, with a seasonal mean of 27.54 ± 9.66 adults/30 leaflets.

The mite eggs in 2019/2020 appeared in one peak of 905.00 eggs/30 leaflets, with a seasonal mean of 204.38 ± 74.22 eggs. In 2020/2021, mite eggs exhibited two peaks: on December 1st and December 15th with 514.25 and 1064.00 eggs/30 leaflets, respectively. The seasonal average of 2020/2021 was higher (243.02 ± 79.61eggs/30 leaflets) than that of 2019/2020 season (204.38 ± 74.22).

#### 1.1.6. Blue pod butterfly, *Lampides boeticus* (Linnaeus) larvae

This insect was almost absent throughout the two seasons, with the exceptions of very few larvae during January and early February.

#### 1.1.7. Snail, *Monacha cantiana* (Montagu) juveniles and adults

Juveniles and adults of *M. cantiana* were not detected in pea fields up to early December in the first season, and up to early January in the second one. However, this snail had only one peak in each pea season, with 354.5o and 135.25 juveniles and adults on January 12th and on January 26th, in the first and second seasons, respectively. The seasonal means were 92.30 and 30.71 juveniles and adults in the first and second seasons, respectively.

#### 1.1.8. Cabbage butterfly, *Pieris rapae* (Linnaeus) and coccinellid, *Scymnus interruptus* (Goez)

*Scymnus interruptus* were detected in very few numbers in this plantation in both seasons of study.

### 1.2. Second plantation (sown on January 15th)

#### 1.2.1. *Liriomyza* spp larvae

In the first season, the infestation by *Liriomyza* spp was recorded (Table 3) on February 15th (64.00 larvae/30 leaflets), with the highest peak on February 22nd (105.00 larvae/3o leaflets). The population decreased gradually until March 29th, then disappeared in the last week of March. The infestation recorded a small peak on April 5th (8.75 larvae/30 leaflets) and disappeared in the remaining examinations.

In 2021 season (Table 4), the infestation by *Liriomyza* spp. was recorded on February 22nd, and peaked on March 8th with 112.00 larvae/30 leaflets. Then, the population density of leaf miner larvae decreased till April 5th, to completely disappear till the end of experimental period.

Seasonal averages were 32.70 ± 12.26 and 31.43 ± 12.22 larvae/30 leaflets in the first and second seasons, respectively.

**Table 3:** Population dynamics of piercing-sucking pests, snails, pod borer, cabbage butterfly and *Scymnus interruptus* on field peas (second plantation) at Sakha Agricultural Research Station farm, in 2020 season

| Examination date | Per 30 leaflets | | | | | | | *Monacha cantiana*/ 1m² | *Lampides boeticus* /100 pods | Per 10 plants | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Liriomyza* spp | *Bemisia tabaci* | *Empoasca* spp | *Aphis gossypii* | *Thrips tabaci* | *Tetranuchus urticae* | | | | *Pieris rapae* | *Scymnus interruptus* |
| | L | N+A | N+A | N+A | L+N | A | E | J+A | L | A | A |
| Feb. 15, 2020 | 64.00 | 0.00 | 3.00 | 5.25 | 0.00 | 1.00 | 5.00 | 2.50 | 0.00 | 0.00 | 0.00 |
| 22 | 105.00 | 14.25 | 2.50 | 0.00 | 0.00 | 3.00 | 15.25 | 9.00 | 0.00 | 1.00 | 0.00 |
| Mar. 1 | 84.50 | 10.00 | 8.25 | 0.00 | 0.00 | 14.75 | 60.75 | 12.25 | 0.00 | 1.25 | 0.00 |
| 8 | 34.50 | 9.75 | 11.00 | 3.75 | 4.25 | 21.25 | 130.00 | 8.25 | 0.00 | 2.00 | 0.00 |
| 15 | 26.00 | 3.50 | 9.00 | 0.00 | 3.75 | 27.00 | 198.25 | 10.00 | 0.00 | 0.00 | 0.00 |
| 22 | 4.25 | 2.00 | 10.75 | 2.00 | 5.00 | 19.00 | 140.00 | 9.00 | 3.00 | 3.25 | 0.00 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 0.00 | 4.00 | 6.25 | 3.50 | 9.25 | 3.50 | 81.25 | 7.00 | 11.25 | 1.00 | 0.00 |
| Apr. 5 | 8.75 | 2.25 | 1.00 | 7.50 | 34.25 | 3.25 | 10.50 | 3.25 | 11.75 | 1.00 | 0.00 |
| 12 | 0.00 | 6.75 | 3.00 | 0.00 | 8.00 | 22.25 | 70.25 | 1.75 | 13.00 | 0.00 | 0.00 |
| 19 | 0.00 | 0.00 | 0.00 | 0.00 | 1.50 | 17.00 | 42.00 | 0.00 | 10.50 | 0.00 | 0.00 |
| Average± SE | 32.70±12.26 | 5.25±1.51 | 5.48±1.29 | 2.20±0.85 | 6.60±3.24 | 13.20±3.04 | 75.33±20.12 | 6.30±1.30 | 4.95±1.85 | 0.95±0.33 | 0.00 |

E: egg, L: larva, N: nymph, A: adult, J: juvenile

### 1.2.2. *Bemisia tabaci* nymphs and adults

In the first season (Table 3), *B. tabaci* adults were detected on February 22nd (14.25 nymphs and adults/30 leaflets), decreased until April 5th and then recorded a small peak of 6.75 nymphs and adults/ 30 leaflets on April 12th. In the second season (Table 4), the infestation also started on February 22nd with a low population density; 3.25 nymphs and adults/30 leaflets and recorded a peak on March 1st (15.75). Then, the infestation decreased towards the end of the season. Seasonal averages were 5.25 ± 1.51 and 5.30 ± 1.44 nymphs and adults/30 leaflets in the first and second seasons, respectively.

**Table 4:** Population dynamics of piercing-sucking pests, snails, pod borer, cabbage butterfly and *Scymnus interruptus* on field peas (second plantation), at Sakha Agricultural Research Station farm, in 2021 season

| Examination date | Per 30 leaflets | | | | | | | *Monacha cantiana* /1m² | *Lampides boeticus* /100 pods | Per 10 plants | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Liriomyza* spp | *Bemisia tabaci* | *Empoasca* spp | *Aphis gossypii* | *Thrips tabaci* | *Tetranuchus urticae* | | | | *Pieris rapae* | *Scymnus interruptus* |
| | L | N+A | N+A | N+A | L+A | A | E | J+A | L | A | A |
| Feb. 15 2021 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.25 | 0.00 | 0.00 | 0.00 |
| 22 | 20.25 | 3.25 | 2.00 | 0.00 | 1.00 | 5.75 | 23.00 | 3.75 | 0.00 | 0.00 | 0.00 |
| Mar. 1 | 74.00 | 15.75 | 4.50 | 0.00 | 1.50 | 18.00 | 75.50 | 8.00 | 0.00 | 0.00 | 0.00 |
| 8 | 112.00 | 10.00 | 3.00 | 25.00 | 2.25 | 10.25 | 68.25 | 2.50 | 0.00 | 0.00 | 0.00 |
| 15 | 64.75 | 2.50 | 8.75 | 6.25 | 4.00 | 27.25 | 222.75 | 5.25 | 0.00 | 0.00 | 0.00 |
| 22 | 20.75 | 5.50 | 6.25 | 0.00 | 3.75 | 29.75 | 198.00 | 4.75 | 8.00 | 1.25 | 0.00 |
| 29 | 12.50 | 3.75 | 4.00 | 5.25 | 79.25 | 13.00 | 110.25 | 1.00 | 12.25 | 0.00 | 0.00 |
| Apr. 5 | 10.00 | 6.25 | 1.00 | 47.00 | 52.00 | 6.00 | 40.25 | 0.00 | 14.75 | 1.50 | 0.00 |
| 12 | 0.00 | 4.00 | 3.50 | 7.00 | 34.00 | 22.75 | 70.00 | 0.00 | 9.00 | 0.00 | 0.00 |
| 19 | 0.00 | 2.00 | 1.00 | 0.00 | 11.50 | 5.00 | 28.50 | 0.00 | 2.50 | 0.00 | 0.00 |
| Average ± SE | 31.43±12.22 | 5.30±1.44 | 4.00±0.78 | 9.05±4.87 | 18.93±8.65 | 13.78±3.23 | 83.65±23.39 | 3.05±0.88 | 4.65±1.83 | 0.28±0.18 | 0.00 |

E: egg, L: larva, N: nymph, A: adult, J: juvenile

### 1.2.3. *Empoasc*a spp nymphs and adults

In the first season (Table 3), the infestation by *Empoasca* spp appeared on February 15th with a low number (3.00 nymphs and adults/30 leaflets). This leafhopper recorded two peaks on March 8th and 22nd (11.00 and 10.75 individuals/30 leaflets, respectively). Then, the infestation decreased till the end of the season, with a seasonal average of 5.48 ±1.29 nymphs and adults/30 leaflets.

In the second season (Table 4), *Empoasc*a spp. was attained in the first examination (6.00 nymphs and adults), then the population recorded a small peak on March 15th (8.75 individuals/30 leaflets). After that, the population decreased towards the end of the season. Seasonal infestation average was 4.00 ± 0.78 individuals/30 leaflets.

### 1.2.4. *Aphis gossypii* nymphs and adults

*A. gossypii* nymphs and adults appeared in two small peaks in the first season (Table 3); 3.75 and 7.50 individuals /30 leaflets on March 8th and April 5th, with a seasonal average of 2.2 0 ± 0.85 individuals /30 leaflets. In the second season (Table 4), aphid nymphs and adults recorded higher considerable population densities with 25.00 and 47.00 nymphs and adults /30 leaflets on March 8th and April 5th, respectively. Seasonal averages were 2.20 ± 0.85 and 9.05 ± 4.87 nymphs and adults in the first and second seasons, respectively.

### 1.2.5. *Thrips tabaci* larvae and adults

In the first season (Table3). infestation by *T. tabaci* was recorded late, on March 8th (4.25 larvae and adults /30 leaflets) and increased gradually to reach one peak on April 5th (34.25 larvae and adults /30 leaflets). The population decreased till the end of the season. Seasonal average infestation was 6.60 ± 3.24 larvae and adults/30 leaflets.

In the second season (Table 4), the first *T. tabaci* infestation was recorded on February 22nd with a very low average number (1.00 larvae and adults /30 leaflets). The population increased gradually to reach only one peak on March 29th (79.25 larvae and adults /30 leaflets), then, the infestation decreased towards the end of the season. Seasonal average infestation was 18.93± 8.65 nymphs and adults/30 leaflets.

### 1.2.6. *Tetranychus urticae*

In the first season (Table3), population of *T. urticae* was recorded at the first week with low numbers for adults and eggs. Then, the population increased gradually to reach the first peak of adults and eggs on March 15th (27.00 and 198.25 /30leaflets respectively). The second peak was recorded on April 12th for adults and eggs (22.25 and 70.25 individuals/30 leaflets, respectively). Seasonal average infestations were 13.20 ± 3.04 and 75.33± 20.12 for adults and eggs, respectively.

In the second season (Table 4), infestation by *T. urtica* adults and eggs were recorded in the third week of February (5.75 and 23.00 individuals/30 leaflets). The infestation recorded three peaks, the first on March 1st (18.00 and 75.50 adults and eggs, respectively), the second of adults on March 22nd (29.75 individuals/30 leaflets) while the second peak of eggs on March 15th (222.75 egg/30 leaflets). The third peak of adults and eggs was recorded on April 12th (22.75 and 70.00 adults and eggs

/30 leaflets respectively). Seasonal average infestations were 13.78 ±3.23 and 83.65 ± 23.39 for adults and eggs, respectively.

### 1.2.7. *Monacha cantiana* juveniles and adults

In the first season (Table 3), infestation by the snail, *M. cantiana* juveniles and adults was recorded on mid-February with low number (2.50 individuals /$m^2$), and then recorded two peaks. The first peak on March 1st (12.25 individual /$m^2$) while the second one occurred on March 15th (10.00 individuals /$m^2$). Then, the population decreased until the end of season. Seasonal average infestation was 6.30 ± 1.30 individuals / $m^2$.

In the second season (Table 4), the snail was recorded on February 15th (5.25 individuals / m2) and recorded one peak on March 1st (8.00 individuals / m2). The population decreased gradually and disappeared in the last three examinations. The seasonal average infestation was 3.05 ± 0. 88 juveniles and adults /m².

### 1.2.8. *Lampides boeticus* larvae

In the first season (Table 3), infestation by *L. boeticus* was recorded by late March (3.00 larvae/ 100 pods). The population increased gradually to reach a peak on April 12th (13.00 larvae/100 pods). Seasonal average infestation was 4.95 ±1.85 larvae/100 pods.

In the second season (Table 4), the population of *L. boeticus* was recorded late; on March 22nd (8.00 larvae / 100 pods), and more increased to reach another peak on April 5th (14.75 larvae /100 pods). The population decreased until the end of the season. Seasonal average infestation was 4.65 ±1.83 larvae /100 pods.

### 1.2.9. *Pieris rapae* adults

Adults of *P. rapae* were captured in very few numbers in both seasons. However, the seasonal averages were 0.95 ± 0.33 and 0.28 ± 0.18 in the first and second seasons, respectively.

### 1.2.10. *Scymnus interruptus* was not detected in all samples of both seasons.

## 2. Parasitism of *Liriomyza* spp

### 2.1. First plantation (sown on October 10th)

### 2.1.1. 2019/2020 season

Mined leaflets of field pea (*Pisum sativum*) were collected and kept at room temperature (27 ± 2°C) inside jars, till the larvae turn into pupae. Weekly collected pupae were kept into Petri dishes and monitored to record the numbers of emerging parasitoids.

*Liriomyza* spp pupae (Table 5) exhibited three peaks of occurrence on November 17th, December 22nd and January 12th with numbers of 23, 68 and 87 pupae/100 field peas leaflets, respectively.

*Opius dissitus* emerged from all larval samples, except those collected on November 3rd, January 26th and February 2nd (Table5). Two distinct peaks were recorded for the parasitoid on December 1st (21.74%) and December 29th (15.38%). Overall parasitism throughout 2019/2020 season in the first plantation was 5.31%.

**Table 5:** Parasitism of *Liriomyza* spp pupae in the first plantation of field peas at Sakha Agricultural Research Station, 2019/2020 season

| Date of Sampling | No. of *Liromyza* pupae /100 leaflets | *Opius dissitus* | | *Diglyphus isaea* | | *Diglyphus crassinervis* | | *Pediobius* sp. | | Total parasitism |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % | No. | % | % |
| Nov. 3,2019 | 0 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | - |
| 10 | 17 | 2 | 11.76 | 5 | 29.41 | 0 | 0.00 | 1 | 5.88 | - |
| 17 | 23 | 1 | 4.35 | 8 | 34.78 | 1 | 4.35 | 0 | 0.00 | - |
| 24 | 19 | 3 | 15.79 | 2 | 10.53 | 2 | 10.53 | 1 | 5.26 | - |
| Dec. 1 | 23 | 5 | 21.74 | 12 | 52.17 | 0 | 0.00 | 2 | 8.70 | - |
| 8 | 45 | 3 | 6.67 | 14 | 31.11 | 0 | 0.00 | 3 | 6.67 | - |
| 15 | 57 | 2 | 3.51 | 10 | 17.54 | 1 | 1.75 | 2 | 3.51 | - |
| 22 | 68 | 1 | 1.47 | 15 | 22.06 | 4 | 5.88 | 4 | 5.88 | - |
| 29 | 26 | 4 | 15.38 | 5 | 19.23 | 3 | 11.54 | 1 | 3.85 | - |
| Jan 5, 2020 | 63 | 2 | 3.17 | 7 | 11.11 | 3 | 4.76 | 0 | 0.00 | - |
| 12 | 87 | 1 | 1.15 | 13 | 14.94 | 1 | 1.15 | 2 | 2.3 | - |
| 19 | 23 | 1 | 4.35 | 7 | 30.43 | 0 | 0.00 | 1 | 4.35 | - |
| 26 | 11 | 0 | 0.00 | 2 | 18.18 | 0 | 0.00 | 0 | 0.00 | - |
| Feb. 2 | 9 | 0 | 0.00 | 3 | 33.33 | 0 | 0.00 | 0 | 0.00 | - |
| Total | 471 | 25 | | 103 | - | 15 | - | 17 | - | - |
| Overall parasitism | - | - | 5.31 | - | 21.87 | - | 3.18 | - | 3.61 | 33.97 |

*Diglyphus isaea* emerged from all *Liriomyza* spp pupae throughout the season, except those collected on November 3rd (Table 5). This parasitoid appeared in high numbers compared to the other collected parasitoids. Three high peaks were attained on November 17th, December 1st and January 19th with values of 34.78, 52.17 and 30.43%, respectively. Overall parasitism, throughout the season, was 21.87%.

The two parasitoids; *Diglyphus crassinervis* and *Pediobius* sp appeared in relatively lower numbers compared to other parasitoids (Table 5). Two small peaks of *D. crassinervis* were found with 10.53 and 11.54% on November 24th and December 29th, respectively, with an overall parasitism of 3.18% throughout 2019/2020 season.

*Pediobius* sp exhibited only one peak with 8.70% parasitism on December 1st, and an overall parasitism with 3.61%.

From the abovementioned results, it could be concluded that the highest parasitism of *Liriomyza* spp pupae occurred by *Diglyphus isaea* (21.87%), followed by *Opius dissitus* (5.31%),

while parasitism was lower by *D. crassinervis* (3.18%) and *Pediobius* sp (3.61%).

Total *Liriomyza* spp parasitism by the four abovementioned parasitoids was 33.97%, which means that about one third of insect host pupae died by these parasitoids. Thus, it is very important to conserve these natural control agents, by different techniques in the frame of Integrated Pest Management (IPM).

### 2.1.2. 2020/2021 season

*Liriomyza* spp pupae were obtained from field peas leaflets beginning from November 3rd up to February 2nd (Table 6). Two peaks of pupae were recorded:139 and 74/100 leaflets on November 17th and December 15th, respectively.

*Opius dissitus* was detected in two peaks with 7.50 and 16.00% parasitism on December 22nd and January 5th, respectively.

**Table 6:** Parasitism of *Liriomyza* spp pupae in the first plantation of peas at Sakha Agricultural Research Station, 2020/2021 season

| Date of Sampling | No. of Liromyza pupae /100 leaflets | *Opius dissitus* | | *Diglyphus isaea* | | *Diglyphus crassinervis* | | *Pediobius* sp. | | Total parasitism |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % | No. | % | % |
| Nov. 3,2020 | 8 | 0 | 0.00 | 2 | 25.00 | 0 | 0.00 | 0 | 0.00 | - |
| 10 | 120 | 1 | 0.83 | 6 | 5.00 | 0 | 0.00 | 2 | 1.67 | - |
| 17 | 139 | 3 | 2.16 | 12 | 8.63 | 3 | 2.16 | 1 | 0.72 | - |
| 24 | 86 | 2 | 2.33 | 15 | 17.44 | 2 | 2.32 | 4 | 4.65 | - |
| Dec.1 | 71 | 4 | 5.63 | 9 | 12.68 | 2 | 2.82 | 2 | 2.82 | - |
| 8 | 59 | 3 | 5.08 | 6 | 10.17 | 3 | 5.08 | 3 | 5.08 | - |
| 15 | 74 | 2 | 2.70 | 7 | 9.46 | 1 | 1.35 | 1 | 1.35 | - |
| 22 | 40 | 3 | 7.50 | 11 | 27.50 | 1 | 2.50 | 1 | 2.50 | - |
| 29 | 28 | 1 | 3.57 | 9 | 32.14 | 0 | 0.00 | 3 | 10.71 | - |
| Jan 5,2021 | 25 | 4 | 16.00 | 5 | 20.00 | 0 | 0.00 | 1 | 4.00 | - |
| 12 | 20 | 3 | 15.00 | 3 | 15.00 | 1 | 5.00 | 1 | 5.00 | - |
| 19 | 7 | 1 | 14.29 | 2 | 28.57 | 1 | 14.29 | 0 | 0.00 | - |
| 26 | 3 | 0 | 0.00 | 1 | 33.33 | 0 | 0.00 | 0 | 0.00 | - |
| Feb.2 | 5 | 2 | 40.00 | 1 | 20.00 | 0 | 0.00 | 0 | 0.00 | - |
| Total | 685 | 29 | - | 89 | - | 14 | - | 19 | - | - |
| Overall parasitism | - | - | 4.23 | - | 12.99 | - | 2.04 | - | 2.77 | 22.03 |

*Dglyphus isaea* exhibited the highest levels of parasitism on *Liriomyza* spp pupae, with three peaks:17.44, 32.14 and 33.33% on November 24th, December 29th and January 26th, respectively.

Both *Diglyphus crsssinervis* and *Pediobius* sp parasitoids were recorded in few numbers throughout 2020/2021 season. However, the overall averages of the four parasitoids, throughout the season, were 4.23,12.99, 2.04 and 2.77% for the four abovementioned parasitoids, respectively. Total parasitism of *Liriomyza* spp pupae, throughout 2020/2021 season was 22.03%.

## 2.2. Second plantation (sown on January 15th)

### 2.2.1. 2020 season

Seasonal average parasitism of *Liriomyza* spp were 3.60, 33.33, 8.78 and 4.05% for *Opius dissitus*, *Diglyphus isaea*, *D. crassinervis* and *Pediobius* sp, respectively (Table 7). Thus, the total parasitism of the leaf miners, *Liriomyza* spp was 49.76%. This means that about one half of *Liriomyza* spp population was managed by these four natural enemies. However, no distinct peaks were observed for both *Opius dissitus* and *Pediobius* sp throughout the season, while *D. isaea* appeared in a high population density during March. *D. crassinervis* appeared in high densities from the second week of March till the last week of same month.

**Table 7:** Parasitism of *Liriomyza* spp pupae in the second plantation of peas at Sakha Agricultural Research Station, 2020 season

| Date of Sampling | No. of *Liromyza* pupae /100 leaflets | *Opius dissitus* | | *Diglyphus isaea* | | *Diglyphus crassinervis* | | *Pediobius* sp. | | Total parasitism |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % | No. | % | % |
| Feb. 15,2020 | 5 | 1 | 20.00 | 3 | 60.00 | 0 | 0.00 | 0 | 0.00 | - |
| 22 | 18 | 1 | 5.56 | 10 | 55.56 | 2 | 11.11 | 1 | 5.56 | - |
| Mar. 1 | 52 | 3 | 5.77 | 22 | 42.31 | 4 | 7.69 | 2 | 3.85 | - |
| 8 | 98 | 2 | 2.04 | 33 | 33.67 | 8 | 8.16 | 4 | 4.08 | - |
| 15 | 115 | 4 | 3.48 | 45 | 39.13 | 12 | 10.43 | 3 | 2.61 | - |
| 22 | 88 | 2 | 2.27 | 15 | 17.05 | 7 | 7.95 | 2 | 2.27 | - |
| 29 | 45 | 2 | 4.44 | 10 | 22.22 | 5 | 11.11 | 4 | 8.89 | - |
| Apr.5 | 13 | 1 | 7.69 | 5 | 38.46 | 1 | 7.69 | 0 | 0.00 | - |
| 12 | 8 | 0 | 0.00 | 4 | 50.00 | 0 | 0.00 | 2 | 25.00 | - |
| 19 | 2 | 0 | 0.00 | 1 | 50.00 | 0 | 0.00 | 0 | 0.00 | - |
| Total | 444 | 16 | - | 148 | - | 39 | - | 18 | - | - |
| Overall parasitism% | - | - | 3.60 | - | 33.33 | - | 8.78 | - | 4.05 | 49.76 |

### 2.2.2. 2021 season

Like in the previous season, *Opius dissitus* had no distinguished peaks, with a seasonal average of 4.02% on *Liriomyza* spp (Table 8). *Diglyphus isaea* was also detected with high population densities throughout the season, particularly during March and April, followed by *D. crassinervis* that appeared in high population densities during March. However, *Pediobius* sp was detected in low densities.

The four parasitoids recorded seasonal averages of 4.02, 30.03, 8.85 and 4.56% for, *Opius dissitus*, *D. isaea*, *D. crassinervis* and *Pediopus* sp. Total calculated parasitism of the four considered parasitoids was 47.46%

**Table 8:** Parasitism of *Liriomyza* spp pupae in the second plantation of peas at Sakha Agricultural Research Station, 2021season

| Date of Sampling | No. of Liromyza pupae /100 leaflets | *Opius dissitus* | | *Diglyphus isaea* | | *Diglyphus crassinervis* | | *Pediobius* sp. | | Total parasitism |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % | No. | % | % |
| Feb. 15,2021 | 12 | 0 | 0.00 | 3 | 25.00 | 1 | 8.33 | 1 | 8.33 | - |
| 22 | 20 | 1 | 5.00 | 8 | 40.00 | 3 | 15.00 | 1 | 5.00 | - |
| Mar. 1 | 65 | 4 | 6.15 | 15 | 23.08 | 8 | 12.31 | 2 | 3.08 | - |
| 8 | 112 | 3 | 2.68 | 28 | 25.00 | 6 | 5.36 | 5 | 4.46 | - |
| 15 | 80 | 2 | 2.50 | 30 | 37.50 | 5 | 6.25 | 4 | 5.00 | - |
| 22 | 58 | 1 | 1.72 | 13 | 22.41 | 7 | 12.07 | 2 | 3.45 | - |
| 29 | 20 | 2 | 10.00 | 8 | 40.00 | 2 | 10.00 | 1 | 5.00 | - |
| Apr.5 | 10 | 1 | 10.00 | 4 | 40.00 | 1 | 10.00 | 1 | 10.00 | - |
| 12 | 6 | 1 | 16.67 | 3 | 50.00 | 0 | 0.00 | 0 | 0.00 | - |
| 19 | 0 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | - |
| Total | 373 | 15 | - | 112 | - | 33 | - | 17 | - | - |
| Overall parasitism% | - | - | 4.02 | - | 30.03 | - | 8.85 | - | 4.56 | 47.46 |

## Discussion

In the current research, population fluctuations of several insect pests, mites and snails were monitored. The abovementioned targets had more one generation in a study on peas. At Dakahlia Governorate, Shalaby *et al* (2021) [15] recorded two peaks for *Myzus persicae* by late November, while each of *Aphis craccivora* and *Acyrthosiphon pisum* had only one peak on sweet peas. In the same study, they found that the leafhopper, *Empoasca decipiens* had only one peak by mid-March but each of *E. decipiens* and *Nezara viridula* had two peaks. In Morocco, El-Fakhouri *et al* (2021) [4] reported that the population dynamics of the aphid, *Acyrthosiphon pisum* on lentil, as a leguminous crop, increased rapidly between March and April because of warm weather which encourages aphid development.

In the current investigation, average aphid, *Aphis gossypii*, population density ranged between 2.13 and 9.05 nymphs and adults /30 leaflets of peas. Similar results were obtained by Pal *et al* (2020) [14] who recorded population density of *Aphis craccivora* of 0.24-2.08 nymphs and adults/pea plant. They also recorded the pods damaged by the gram pod borer, *Helicoverpa armigera* as 0.29-31.17%. The pod borer, in the current investigation exhibited very low population densities of 0.16–4.95 larvae/100 pods.

Golawska *et al* (2008) [8] indicated that some chemical compounds negatively affect aphid infestation to *Pisum sativum* l., from which is phenolics, and they considered these compounds are good factors for control of several insect pests. In the current study, the blue pod borer, *Lampides boeticus* was recorded in very few numbers, particularly in the first field peas plantation. In Nigeria, Ibrahim *et al* (2020) [9] considered another pod borer, *Etiella zinckenella* as an important insect pest, among other pests. They observed that *Tetranychus* spp and thrips continued to infect the peas from early stages up to pudding stage. On the other hand, they advised the growers to practice control procedures against mice, *Rattus* spp as a great threat to the crops.

Four parasitoid species were attained as infesting larvae of *Liriomyza* spp and emerging from the leaf miner pupae. *Diglyphus isaea* was the most dominant parasitoid, followed by *D. crassinervis*, particularly in the second plantation of field pea. Both *Opius dissitus* and *Pediobius* sp were obtained in low percentages.

Olivera and Bordat (1996) [13] concluded that the parasitoid, *Opius dissitus* females preferred *Liriomyza trifolii* larvae over these of *L. huidobrensis*. However, the parasitoid was more attracted to larvae of both species when they were present on squash rather than when present on tomato or lettuce.

In Indonesia, Shepard and Braun (1998) [16] collected the leaf miner, *L. huidobrensis* from several crops; including, scallions and potato, with highest infestation on potato.The parasitoid, *Hemipterscenus varicornis* (Hymenoptera: Eulophidae) was collected as emerging from *L. huidobrensis* pupae in Java and Sumatra islands, Indonesia (Shepard and Braun 1998) [16].

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