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Occurrence of natural enemies of serpentine leaf miner, *Liriomyza trifolii* in tomato

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Abstract
Study on occurrence of serpentine leaf miner was carried out during 2019, *Rabi* at KVK farm, Shivamogga. Three parasitoids species namely *Opius dissitus* Muesebeck, *Neochrysocharis formosa* Westwood and *Neochrysocharis* sp. have emerged from reared larvae and pupae of leaf miner with an average per cent parasitization of 8.48%, 3.04% and 1.56%, respectively. Total per cent parasitization by the three parasitoids ranged from 0.00 to 44.28. Highest parasitization (44.28%) was noticed during 1st week of January *i.e.*, 13 weeks after transplanting (1st standard week). Total average parasitization by the three parasitoids was 13.02 per cent. The highest (44.28%) parasitization rate coincided with highest leaf miner infestation during 1st week of January. The per cent parasitization by *O. dissitus* showed a significant negative correlation with minimum temperature (^{0}C), morning relative humidity (%) and evening relative humidity (%) with correlation co-efficient 'r' value of -0.709*, -0.596* and -0.664*, respectively. It had a significant positive correlation with sunshine hours (hours/day) and wind speed (kilometers/hour) with correlation co-efficient 'r' value of 0.512* and 0.507*, respectively.

Keywords: Parasitoids, leaf miner, natural enemies, tomato, parasitization

Introduction
Leaf miners of family Agromyzidae are economically important pests of vegetable crops (Murphy and La Salle, 1999) [7]. There are more than 3000 known species of vegetable leaf miners in the world (Gencer, 2004; Shahreki *et al*., 2012) [2, 9]. Damage due to leaf miner is caused by larval mining into the mesophyll layer of the leaf and by feeding on it. The adult females makes oviposition punctures on leaves. This damage due to larval mining and oviposition punctures results in reduced photosynthesis and decreased tissue conductance (Rauf *et al*., 2000) [8]. There is rich natural enemy community of leaf miners. The hymenopteran parasitoids of leaf miners play an important role in biological control of this pest (Johnson, 1993; Murphy and LaSalle, 1999) [4, 7]. More than 140 species of natural enemies of *Liriomyza* have been recorded. Among these the parasitoids belonged to Braconidae, Eulophidae and Pteromalidae of hymenoptera (Waterhouse and Norries, 1987; Gratton and Welter, 2001; Liu *et al*., 2009) [12, 3, 5]. The present aimed at collection and identification of larval and pupal parasitoids of *Liriomyza trifolii*.

Materials and Methods
The tomato leaves infested with leaf miner (live mines) were collected from the field that was free from insecticides application. The collection was made when there was high leaf miner infestation in the field. These leaves containing live mines were kept (Plate 1) by placing them in petri plates provided with wet cotton to provide moisture and holes on lid for aeration. Observations for number of larval parasitoids emerged were taken (Asadi *et al*., 2006) [1]. Pupae of the leaf miner were collected from the field that was free from insecticides application and placed in petri plates. The pupae kept in petri plates (Plate 2) were observed for emergence of pupal parasitoids. The collection was made when there was high leaf miner infestation in the field. The parasitoids emerged from larvae and pupae of leaf miner were sent for identification. A total of 25 larvae and pupae were collected at weekly intervals. The mean number of parasitoids emerged were counted and per cent parasitization was calculated for 25 larvae and pupae with following formula.

$$\text{Per cent parasitization} = \frac{\text{Number of parasitoids emerged}}{\text{Total number of host larvae/pupae}} \times 100$$

Plate 1: Rearing of leaf miner larvae in petriplates

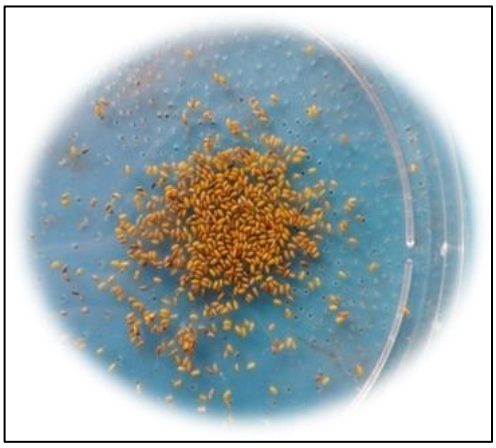

Plate 2: Leaf miner pupae in petriplates

Plate 3: Larval-pupal parasitoid, *Opius dissitus*

Plate 4: Larval parasitoid, *Neochrysocharis formosa*

Plate 5: Larval parasitoid, *Neochrysocharis* sp

Results and Discussion

As presented in the Table 1, three parasitoids species namely *Opius dissitus* Muesebeck (Plate 3), *Neochrysocharis formosa* Westwood (Plate 4) and *Neochrysocharis* sp. (Plate 5) have emerged from larvae and pupae of leaf miner. The species *O. dissitus* Muesebeck is a larval pupal parasitoid and a solitary endoparasitoid belonging to family Braconidae of order Hymenoptera. The species *N. formosa* Westwood and *N.* sp. were identified as larval parasitoids belonging to family Eulophidae of order Hymenoptera. These are also solitary endoparasitoids. A total mean number of 38.16 *O. dissitus* Muesebeck, 13.68 *N. formosa* Westwood and 7.02 number of *N.* sp. have emerged from reared larvae and pupae.

Table 1: Occurrence of parasitoids of serpentine leaf miner, *L. trifolii*in tomato

Type of parasitoid	Species	Family	Order	Mean no. of individuals emerged/450 host larvae and pupae
Larval – pupal parasitoid	*Opius dissitus*	Braconidae	Hymenoptera	38.16
Larval parasitoid	*Neochrysocharis formosa*	Eulophidae	Hymenoptera	13.68
Larval parasitoid	*Neochrysocharis* sp.	Eulophidae	Hymenoptera	7.02

The periodical data on per cent parasitization by these parasitoids is given in Table 2. The parasitization by the species *O. dissitus* Muesebeck ranged from 8.42 to 25.64 with an average of 8.48%. Its paratisation was noticed from second week of December *i. e.*, 9 weeks after transplanting (49th standard week) to first week of February *i. e.*, 17 weeks after transplanting (5th standard week). Highest peak (25.64%) in its parasitism was noticed during 1st week of January *i. e.*, 13 weeks after transplanting (1st standard week). The parasitization by the species *N. formosa* Westwood ranged from 1.00 to 13.43 per cent with an average of 3.04%. Its paratisation was noticed from third week of December *i. e.*, 10 weeks after transplanting (50th standard week) to first week of February *i. e.*, 17 weeks after transplanting (5th standard week). Highest peak (13.43%) in its parasitism was noticed during second week of January *i. e.*, 14 weeks after transplanting (2nd standard week). The parasitization by the species *Neochrysocharis* sp. ranged from 4.84 to 8.83 per cent with an average of 1.56%. Its paratisation was noticed from fifth week of December *i. e.*, 12 weeks after transplanting

(52nd standard week) to 3rd week of January *i. e.,* 15 weeks after transplanting (3rd standard week). Highest peak (8.83%) in its parasitism was noticed during first week of January *i. e.,* 13 weeks after transplanting (1st standard week). Highest peak (8.83%) in its parasitism was noticed during first week of January *i. e.,* 13 weeks after transplanting (1st standard week). Overall, the occurrence of the three parasitoid species was highest during first and second weeks of January.

Total per cent parasitization by the three parasitoids ranged from 8.42 to 44.28. Highest parasitization (44.28%) was noticed during 1st week of January *i. e.,* 13 weeks after transplanting (1st standard week). Total average parasitization by the three parasitoids was 13.02%.

Table 2: Per cent parasitization by natural enemies in tomato

Months and weeks	Weeks after transplanting	Standard week	Per cent parasitization by			
			Opius dissitus	*Neochrysocharis formosa*	*Neochrysocharis* sp.	Total (%)
October II	1	41	0.00	0.00	0.00	0
III	2	42	0.00	0.00	0.00	0
IV	3	43	0.00	0.00	0.00	0
November I	4	44	0.00	0.00	0.00	0
II	5	45	0.00	0.00	0.00	0
III	6	46	0.00	0.00	0.00	0
IV	7	47	0.00	0.00	0.00	0
December I	8	48	0.00	0.00	0.00	0
II	9	49	8.42	0.00	0.00	8.42
III	10	50	11.61	1.00	0.00	12.61
IV	11	51	13.63	1.64	0.00	15.27
V	12	52	18.42	3.12	6.12	27.66
January I	13	1	25.64	9.81	8.83	44.28
II	14	2	22.41	13.43	6.81	41.65
III	15	3	16.96	10.62	4.84	33.42
IV	16	4	14.24	7.41	0.00	21.65
February I	17	5	12.83	4.63	0.00	17.46
Mean	-	-	8.48	3.04	1.56	13.02

The correlation study between the per cent parasitization by natural enemies of leaf miner and different weather parameters is presented in Table 3. The parasitoid *O. dissitus* showed a significant negative correlation with minimum temperature (^{0}C), morning relative humidity (%) and evening relative humidity (%) with correlation co-efficient 'r' value of -0.709**, -0.596** and -0.664**, respectively. It had a significant positive correlation with sunshine hours (hr/day) and wind speed (km/hr) with correlation co-efficient 'r' value of 0.512** and 0.507**, respectively. The maximum temperature (^{0}C) had a positive non - significant relation (r = 0.043) and rainfall (mm) showed a negative non- significant (r = -0.364) effect on the parasitization.

The parasitoid *N. formosa* had significant negative correlation with minimum temperature (^{0}C), morning relative humidity (%) and evening relative humidity (%)with correlation co-efficient 'r' value of -0.787**, -0.597** and -0.631**, respectively. A positive non-significant correlation existed with maximum temperature and bright sunshine hours (hr/day) with correlation co-efficient 'r' value of 0.206 and 0.446, respectively. A significant positive correlation between parasitoid parasitization and wind speed (km/hr) was noticed with correlation co-efficient 'r' value of 0.556**.

The parasitoid *N.* sp. showed a significant negative correlation with minimum temperature (^{0}C), morning relative humidity (%) and evening relative humidity (%) with correlation co-efficient 'r' value of -0.619**, -0.602** and -0.589**, respectively. It had a non-significant positive correlation with maximum temperature (^{0}C), bright sunshine hours (hr/day) and wind speed (km/hr) with correlation co-efficient 'r' value of 0.288, 0.288 and 0.439, respectively. The rainfall (mm) showed a negative but non- significant (r = -0.210) effect on the per cent parasitization.

Table 3: Relationship between parasitization by natural enemies of *Liriomyza trifolii* with weather parameters in tomato

Weather parameters	Correlation Coefficients (r)		
	Opius dissitus	*Neochrysocharis formosa*	*Neochrysocharis* sp.
Sunshine hours (hr/day)	0.5124*	0.4462	0.2281
Maximum temperature (^{0}C)	0.0432	0.2061	0.2284
Minimum temperature (^{0}C)	-0.7094*	-0.7871*	-0.6192*
Morning relative humidity (%)	-0.5962*	-0.5973*	-0.6023*
Afternoon relative humidity (%)	-0.6641*	-0.6310*	-0.5894*
Wind speed (km/hr)	0.5072*	0.5564*	0.4392
Rainfall (mm)	-0.3644	-0.2731	-0.2100

*Correlation is significant at 0.05% level of significance

The regression equation fitted between per cent parasitization by leaf miner parasitoids and different weather parameters are presented in Table 4. The regression equation fitted between per cent parasitization of *O. dissitus* and different weather parameters was $Y= -127.047+ 4.430X_1 - 1.952X_2 - 0.012X_3 - 0.072X_4 +0.033X_5 + 4.264X_6 + 0.665X_7$. The influence of weather parameters on the *O. dissitus* parasitization was 69.9% (R^2= 0.699). The regression equation fitted between per cent parasitization of *N. formosa* and *N.* sp. with different weather parameters are presented in Table 5. The regression

equation fitted was Y= -131.343+ 4.072X_1 – 1.780X_2 +0.132X_3 + 0.058X_4 +0.080X_5 + 2.239X_6 + 1.023X_7 and Y= -44.828+ 1.905X_1 – 0.444X_2 -0.074X_3 - 0.068X_4 +0.049X_5 + 0.177X_6 + 0.309X_7,, respectively. The influence of weather parameters on per cent parasitization of these species was to the extent of 89.4% (R^2= 0.894) and 60.7% (R^2= 0.607), respectively.

Table 4: Regression equation fitted for parasitization by natural enemies of *L. trifolii* with weather parameters in tomato

Per cent parasitization	Regression equation	R^2
Opius dissitus	Y= -127.047+ 4.430X_1 - 1.952X_2 - 0.012X_3 - 0.072X_4 +0.033X_5 + 4.264X_6 + 0.665X_7	0.661
Neochrysocharis formosa	Y= -131.343+ 4.072X_1 – 1.780X_2 +0.132X_3 + 0.058X_4 +0.080X_5 + 2.239X_6 + 1.023X_7	0.894
Neochrysocharis sp.	Y= -44.828+ 1.905X_1 – 0.444X_2 -0.074X_3 - 0.068X_4 +0.049X_5 + 0.177X_6 + 0.309X_7	0.607

X_1 – Maximum temperature (^{0}C), X_2 – Minimum temperature (^{0}C), X_3 – Morning relative humidity (%), X_4 – Evening relative humidity (%), X_5 – Rainfall (mm), X_6 –Sunshine hours (hr/day), X_7 – Wind speed (km/hr)

This shows that the number and abundance of individual parasitoids species of leaf miner was very poor. But the total parasitization rate three species together reached to 44.28% when the host population was abundant. So the host population also had a very significant effect on abundance of its parasitoids. The three weather parameters *viz*., minimum temperature (^{0}C), morning relative humidity (%) and evening relative humidity (%) had a strong negative effect on these natural enemies. As this experiment was conducted during winter season the maximum temperature did not show any significant correlation but minimum temperature had a significant negative correlation with both leaf miner and its natural enemy populations.

Sharma *et al.* (2011) [10] reported the activity of larval parasitoid *Neochrysocharis formosa* of family Eulophidae and *Opius* sp. belonged to family Braconidae that is a larval-pupal parasitoid was noticed throughout the cropping season with maximum activity of 20.1-28.6%. Mazumdar and Bhuiya (2016) [6] recorded parasitoid species *viz*., *Neochrysocharis formosa* of family Eulophidae and *Opius* sp. of family Braconidae. Wahyuni *et al.* (2017) [11] reported the rate of parasitism of Neochrysocharis *formosa between* 8.20% and 32.58%.

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