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THE LEAF MINER, *LIRIOMYZA TRIFOLII* (BURGESS) AND ITS PARASITOIDS ON FABA BEAN PLANTS

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Abstract

Survey and relative densities of *L. trifolii* and its parasitoids were studied on three faba bean cultivars in newly reclaimed sandy land at El-Salhia district, Sharkia Governorate Egypt during 2015 / 16 and 2016/17 growing seasons.

The obtained results were summarized as follows:

1. The faba bean leafminer infestation on faba bean cultivars started in the 3rd week of November in the first and second seasons. It continued till the end of both seasons.
2. Two tested cultivars; Giza 716 and Giza 3 were highly susceptible to the pest infestation while, Giza 843 cultivar was less susceptible to the pest infestation. The mean numbers of larvae / sample for the three cultivars were 140.45, 127.23 and 110.77 & 147.57, 123.24 and 115.33 in the first and second seasons, respectively. Statistical analysis revealed that the differences between three cultivars were significant and highly significant (F = 7.537* and 16.607**) during 2015 / 16 and 2016/17 seasons, respectively.
3. The mean percentages of infestation in the first season were 77.95, 76.36 and 67.91% on Giza 716, Giza 3 and Giza 843, respectively. They were 75.05, 74.19 and 67.05% in the second season, respectively.
4. In the first season, means of mines/sample for Giza 716, Giza 3 and Giza 843 were 202.59, 188.77 and 181.86, respectively. While in the second season 214.19, 181.38 and 177.57 were recorded, consecutively.
5. Eleven hymenopterous parasitoid species, of *L. trifolii* belonging to Eulophidae, Braconidae and Pteromalidae were recorded. They included four ecto-larval, three endo-larval and four endo-larval –pupal parasitoids.
6. Generally, the most dominant ecto-larval parasitoid was *Diglyphus isaea* (Walk.), accounting for 24.65 and 30.10% of the total recorded parasitoids in the first and second seasons, successively. It was followed by endo-larval parasitoids, *Neochrysocharis formosa* (West.) Which composed 21.42 and 17.35% of parasitoids in the first and second seasons, respectively. *Opius basalis* Fischer was the most abundant endo-larval - pupal species which parasitized 11.02 and 10.90 % of the pest larvae in the first and second seasons, consecutively.
7. The parasitoids of *L. trifolii* on faba bean cultivars had four to six peaks annually. The mean parasitism percentages of the host larvae were 66.38, 63.24 and 57.78 & 61.97, 65.39 and 54.30% on Giza 716, Giza 3 and Giza 843 in the first and second seasons, respectively.
8. Temperature and relative humidity affected infestation percentages by 22.29, 31.37 and 22.41% & 23.12, 15.75 and 17.09% during 2015/16 and 2016/17 seasons, respectively. While their influences on percentages of parasitism were 15.89, 15.76 and 6.28% & 16.84, 42.06 and 14.66% during two seasons, respectively.
9. The chemical contents affected on the infestation percentages by *L. trifolii* infested three faba bean cultivars.

Key words: *Liriomyza trifolii*, Faba bean, Relative densities, Parasitoids, Parasitism, Biological control.

Introduction

Faba bean, *Vicia faba* L. is one of the most important leguminous crops in Egypt. It is one of the promising pulse crops, which can play an important role in increasing legume production in Egypt. Seeds are used for human nutrition as seeds have 28% protein, 58% carbohydrate and 2% fat (Kopke and Nemecek 2010).

The faba bean leafminer, *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) is a polyphagous herbivorous species of field, ornamentls and vegetable crops

throughout the world (Kang *et al.*, 2009, Hernandez *et al.*, 2011, Li *et al.*, 2012, Sawsan *et al.*, 2014, Eva, 2016, Hassan *et al.*, 2016 and Bayoumy *et al.*, 2018). It was reported as a pest of many plant species belonging to different families including faba bean (Li *et al.*, 2012 and Bayoumy *et al.*, 2018), field bean (Li *et al.*, 2012), field pea (Hassan *et al.*, 2016) and field tomato (Eva, 2016).

This insect pest is one of the most destructive pests of faba bean. It has a short developmental period, a high egg–laying capacity and rapidly develops insecticides resistance (Reitz and Trumble, 2002 and Neama and Hegazi 2014).

Larvae of this pest cause serious damage of the leaves of plants and kills small seedling, reduces photosynthetic capacity of the plant and yield (Neintraub and Horowitz, 1995). Also, the formation of punctures in the leaves by the adult females cause significant damage (Abd El-Megid 1986).

Also, indirect damage, by transmitting plant diseases (Zitter and Tsai, 1977), reducing quality of ornamental crops and creating quarantine tissues (Parrella *et al.*, 1985). The incidence of the pest and its parasitoids on faba bean plants in the valley region have been recently studied by Bayoumy *et al.*, (2018). Extensive investigations of natural enemies of *Liriomyza* have been conducted worldwide and more than 150 species of parasitoids are known to attack *Liriomyza* species (Claudio and Welter, 2001).

The preset work was carried out to contribute and provide information concerning the following points in the newly reclaimed sandy area:

1. Infestation percentages of three faba bean cultivars by *L. trifolii*.

2. Survey and seasonal abundance of the insect parasitoids and their relative densities.

3. Percentages of parasitism of the pest on different cultivars of faba bean.

4. Effect of prevailing temperatures and relative humidities on the pest population and its parasitoids.

Effect of chemical contents of leaves faba bean cultivars on the population density of leaf miner, *L. trifolii*.

Materials and methods

Experimental site and design:

Field experimental were carried out during two successive growing seasons of (2015/16) and (2016/17) in newly reclaimed sandy land at El-Salhia district, Sharkia Governorate, Egypt.

Three faba bean (*Vicia faba* L.) cultivars namely, Giza 716, Giza 3 and Giza 843 were tested. An area of about one feddan was prepared and divided into 15 plots (5 plots for each cultivar). The cultivars were sown at random design on 12th and 19th October during the two seasons (2015/16 and 2016/17), respectively.

Normal agricultural practices were followed and no chemical control was applied.

In the 3rd week after sowing, the leaf miners infestation was first occurred and observed weekly thereafter. Then, sampling began and continued once a week until the plant leaves became dry. For each cultivar, 100 leaflets were collected randomly (20 leaflets of each plot) and placed in a polyethylene bag. These samples were examined in the laboratory by means of a binocular microscope. Where number of each infested leaflets, mines and the larvae of pest were recorded.

The faba bean leaflets containing larvae of the pest, *L. trifolii* were placed in glass jars, provided with filter papers on their bottoms. About 10% of these leaflets were confined singly in glass vials (7 × 2cm). Jars and vials were covered with muslin secured by rubber bands and kept under laboratory conditions. They were examined twice weekly, where the emerged parasitoids were collected and the host pupated larvae were separated.

Pupated larvae were placed in test tube (15 × 1cm) (100 pupae in each tube), covered with pieces of cotton wool, kept under laboratory conditions and were observed till emergence of the flies or the parasitoids adults. To confirm the ectoparasitoids, 30 infested leaflets were taken randomly at weekly intervals from each cultivar (from the fifth plot) and pest larvae were examined under a binocular microscope. All emerged parasitoids, either from glass jars, vials and test tubes were collected, counted and identified.

The daily degrees of temperature as well as the relative humidity during the seasons of study were taken from the Meteorological Station at Zagazig. The obtained data was statistically analyzed the proper F, simple correlation, partial regression and explained variance values were calculated according to COSTAT Computer Program (2005).

Effect of chemical contents of leaves of faba bean cultivars on the population density of leaf miner, *L. trifolii* infesting certain faba bean cultivars

Plant leaves were taken at random from each replicate of Giza 716, Giza 3 and Giza 843 cultivars during 2016/17 season to determine protein, carbohydrates, calcium fat, fiber, ash and moistures percentages in the

central laboratory, Faculty Agriculture, Zagazig University, according to Bremner and Mulvaney (1982) and Dubois *et al.,* (1956).

Results and Discussion

Seasonal abundance of leaf miner, *Liriomyza trifolii* (Burgess) on different faba bean cultivars

As shown in Tables 1 and 2, the seasonal abundance of the *L. trifolii* on Giza 716, Giza 3 and Giza 843 faba bean cultivars during 2015/16 and 2016/17 seasons was evaluated considering percentages of infestation as well as numbers of larvae and mines.

Infestation percentages

In the first season (Table 1), the infestation began to appear in the 3rd week of November at means of 22.3ºC and 63.5% R.H. recording 18, 31 and 20% on Giza 716, Giza 3 and Giza 843, respectively. Then, the infestation was increased gradually. It attained the highest levels of 96, 95 and 95% during the 5th , 4th and 3rd week of March (21.6-21.8ºC and (43.0-43.8% RH) on the three cultivars, respectively. The mean percentages of infestation in all season were 77.95, 76.36 and 67.91% on Giza 716, Giza 3 and Giza 843, consecutively.

In the second season (Table 2), the initial infestation was recorded in the 3rd week of November (23.2ºC and 60.7%RH) recording 18, 20 and 21% on Giza 716, Giza 3 and Giza 843 respectively. Then the infestation fluctuated with a general tendency to reach maximum values of 92% in the 2nd week of February (15.3 ºC and 63.2% RH), 91 % in the 3rd week of February (16.3 ºC and 63.7% RH) and 90% in the 2nd week of March (19.9ºC and 63.3% RH) on the previously mentioned cultivars, consecutively. The mean percentages of infestation during the whole season on Giza 716, Giza 3 and Giza 843 were 75.05, 74.19 and 67.05%, successively.

These findings agree with those of Hammad (2000) who reported that the mean percentages of infestation during the whole season on Giza 3, Giza 674 and Giza 714 were 70.6, 69.0 and 68.9%, successively.

Numbers of larvae per sample:

Data presented in Table 1, indicate that in the first

Table 1: Seasonal abundance of the leaf miners *Liriomyza trifolii* (Burgess) on different faba bean cultivars during 2015/16 season in newly reclaimed sandy area of El-Salhia district, Sharkia Governorate, Egypt.

Sampling date	Giza 716			Giza 3			Giza 843			Corresponding means of	
	% inf.	Total / sample		% inf.	Total / sample		% inf.	Total / sample			
		Larvae	Mines		Larvae	Mines		Larvae	Mines	Temp.ºC	R.H.%
Nov., 3rd	18	30	61	31	62	90	20	22	40	22.3	63.5
4th	40	123	180	50	130	181	21	100	130	20.4	62.3
5th	48	163	190	55	141	200	33	113	205	19.7	66.2
Dec., 1st	62	168	200	71	152	241	41	122	221	20.7	61.7
2nd	70	173	190	75	160	253	63	133	221	19.9	60.6
3rd	75	160	210	81	100	131	60	81	113	18.2	59.6
4th	77	100	183	80	93	140	51	80	161	18.9	59.6
Jan., 1st	78	120	160	83	130	175	65	69	124	14.4	60.0
2nd	80	132	155	82	141	171	63	100	190	15.7	60.0
3rd	85	160	210	73	171	200	71	130	189	14.3	53.4
4th	89	167	198	71	170	201	83	143	200	11.7	66.7
Feb., 1st	90	200	253	75	211	247	51	195	200	13.0	67.5
2nd	93	215	231	81	100	133	79	191	211	14.9	57.2
3rd	90	230	270	71	112	123	90	131	180	20.3	46.4
4th	83	200	275	80	113	200	85	132	185	19.5	51.0
Mar., 1st	81	192	218	73	121	215	60	145	195	22.4	49.5
2nd	90	130	200	90	151	233	93	138	175	20.5	48.7
3rd	95	100	233	91	155	165	95	83	183	21.8	43.0
4th	92	86	289	95	100	200	90	71	190	20.0	47.7
5th	96	80	280	91	95	220	90	76	205	21.6	43.8
Apr., 1st	90	93	130	91	100	201	95	92	212	22.7	53.7
2nd	93	68	141	90	91	233	95	90	271	26.4	40.7
General total	1715	3090	4457	1680	2799	4153	1494	2437	4001		
Mean	77.95	140.45	202.59	76.36	127.23	188.77	67.91	110.77	181.80		

season, the numbers of larvae per sample occurred three peaks in case of Giza 716 recording 173, 230 and 93 larvae / sample in the 2nd week of December (19.9ºC and 60.60% RH), 3rd week of February (20.3ºC and 46.4% RH) and first week of April (22.7ºC and 53.7% RH), respectively. The numbers of larvae / sample showed five peaks on Giza 3 were represented by 160, 171, 211, 155 and 100 larvae / sample in the 2nd week of December (19.9ºC and 60.6% RH), 3rd week of January (14.3ºC and 53.4% RH), 1st week of February (13.0ºC and 67.5% RH), 3rd week of March (21.8ºC and 43.0% RH) and first week of April 22.7ºC and 53.7% RH), respectively. On Giza 843, the numbers of larvae / sample recorded four peaks, the peaks amounting 133, 195, 145 and 92 larvae / sample in the 2nd week of December, 1st week of February, 1st week of March and 1st week of April , consecutively.

The corresponding means of temperatures were 19.9-22.7ºC and these of relative humidites were 60.6 -53.7%. The mean numbers of larvae/ sample of Giza 716, Giza 3 and Giza 843 in the season was 140.45, 127.23 and 110.77, successively.

During the second season (Table 2), the larval population appeared three peaks on Giza 716 and three peaks on Giza 3 and two peaks on Giza 843.

On Giza 716, the larvae attained their peaks of 259, 265 and 100 larvae / sample in the 4th week of December (18.0ºC and 59.5% RH), 3rd week of February (16.3ºC and 63.7% RH) and 1st week of April (20.3ºC and 59.2% RH), respectively. The peaks of larvae on Giza 3 were 295, 153 and 80 larvae/ sample obtained in the 3rd week of December (18.2ºC and 59.3% R H), 3rd week of February (16.3ºC and 63.7 % RH), and 2nd week of April (20.0 ºC and 53.9 % RH), respectively.

On Giza 843, the larvae reached their peaks in the 4th week of December (18.0ºC and 59.5% RH) and 4th week of February (18.5 ºC and 59.3% RH), showing 235 and 190 larvae/ sample, successively. The mean numbers of larvae / sample of Giza 716, Giza 3 and Giza 843 during the season were 147.57, 123.24 and 115.33, respectively.

The obtained results disagree with findings of Hassan *et al.*, (2016) who reported that the mean number of larvae / sample was 2 larvae /45 leaves in the end of

Table 2: Seasonal abundance of the leaf miners, *Liriomyza trifolii* (Burgess) on different faba bean cultivars during 2016/17 season in newly reclaimed sandy area of El-Salhia district, Sharkia Governorate, Egypt.

Sampling date	Giza 716			Giza 3			Giza 843			Corresponding means of	
	% inf.	Total / sample		% inf.	Total / sample		% inf.	Total / sample			
		Larvae	Mines		Larvae	Mines		Larvae	Mines	Temp.ºC	R.H.%
Nov., 3rd	18	21	40	20	41	53	21	18	31	23.2	60.7
4th	65	153	195	63	165	190	33	141	182	19.9	59.7
Dec., 1st	71	191	215	69	210	283	35	170	200	20.1	62.3
2nd	75	200	348	71	235	295	72	185	235	19.2	63.7
3rd	83	220	336	72	295	370	60	220	280	18.2	59.3
4th	46	259	420	81	281	325	60	235	310	18.0	59.5
Jan., 1st	53	198	240	89	170	220	40	163	201	18.3	61.5
2nd	59	100	159	65	120	150	40	95	131	17.2	60.2
3rd	63	87	113	60	99	88	50	81	120	17.7	60.0
4th	73	160	186	49	60	80	70	65	100	16.7	63.2
5th	82	179	210	67	52	100	80	100	130	16.3	60.1
Feb., 1st	90	195	233	83	100	130	83	131	210	18.5	59.3
2nd	92	215	225	90	115	171	81	153	220	15.3	63.2
3rd	90	265	290	91	153	200	80	180	270	16.3	63.7
4th	90	153	195	87	100	190	83	190	215	18.5	59.3
Mar., 1st	79	100	193	80	95	200	88	90	200	21.3	58.2
2nd	87	83	122	90	81	100	90	77	180	19.9	63.3
3rd	90	70	188	83	30	133	87	50	171	19.2	62.1
4th	88	55	200	87	40	141	90	48	100	18.3	60.3
Apr., 1st	90	100	210	80	66	200	83	20	125	20.3	59.2
2nd	92	95	180	81	80	190	82	10	118	20.0	53.9
General total	1576	3099	4498	1558	2588	3809	1408	2422	3729		
Mean	75.05	147.57	214.19	74.19	123.24	181.38	67.05	115.33	177.57		

December.

Numbers of mines per sample

In the first season (Table 1), the numbers of mines / sample of Giza 716, Giza 3 and Giza 843 showed six, five and six peaks, respectively. On Giza 716, the numbers of mines / sample for these peaks were 200, 210, 210, 253, 275 and 289 in the 1st and 3rd week of December (20.7ºC and 61.7% RH and 18.2ºC and 59.6% RH), 3rd week of January (14.3ºC and 53.4% RH), 1st and 4th week of February (13.0ºC and 67.5% RH and 19.5ºC and 51% RH) and 4th week of March (20.0ºC and 47.7% RH), successively.

On Giza 3, they were 253, 175, 247, 233 and 220 mines/ sample in the 2nd week of December (19.9ºC and 60.6% RH), 1st week of January (14.4ºC and 60.0 % RH), 1st week of February (13.0ºC and 67.5% RH), 2nd and 5th week of March (20.5ºC and 48.7% RH) and 21.6ºC and 43.8 % RH), respectively.

The mines on Giza 843 peaked in the 1st and 4th week of December, 2nd week of January, 2nd week of February and 1st week of March and 2nd week of April, showing 221, 161, 190, 211, 195 and 271 mines/ sample, respectively.

The corresponding means of temperatures and relative humidity were 20.7-26.4ºC and 61.7- 40.7% RH, respectively. The mean numbers of means / sample of Giza 716, Giza 3 and Giza 843 were , 202.59,188.77 and 181.86, respectively.

In the second season (Table 2), the numbers of mines / sample showed five peaks on Giza 716, four peaks on Giza 3 and three peaks on Giza 843. On Giza 716, the mines peaked on the 2nd week of December (19.2ºC and 63.7% RH), 4th week of December (18.0ºC and 59.5% RH), 1st week of February (18.5ºC and 59.3% RH), 3rd week of February (16.3ºC and 63.7% RH and 1st week of April (20.3ºC and 59.2% RH) recording 348, 420, 233, 290 and 210 mines / sample, respectively.

On Giza 3, the peaks were recorded in the 3rd week of December (18.2ºC and 59.3% RH), 3rd week of February (16.3ºC and 63.7% RH), 1st week of March (21.3ºC and 58.2% RH) and 1st week of April (20.3ºC and 59.2% RH), showing 370, 200, 200 and 200 mines / sample, successively.

On Giza 843, the mines peaked in the 4th week of December, 3rd week of February and 1st week of April representing 310, 270 and 125 mines/ sample, respectively. The corresponding means of temperatures were 18.0 and 20.3ºC and these of relative humidities were 59.5 and 59.2%.

The mean numbers of mines/ sample of Giza 716, Giza 3 and Giza 843 during the season were 214.19, 181.38 and 177.57, respectively.

The obtained results disagree with findings of Hassan *et al.,* (2016) who mentioned that the mean number of mines / sample was 64 with a range of (60-69) mines / 45 leaves in the beginning of April.

Survey and relative densities of *L. trifolii* parasitoids

Eleven species of hymenopterous parasitoids, belonging to three families Pteromalidae, Braconidae and Eulophidae, were recorded from collected leaf miners, *L. trifolii* larvae infesting faba bean plants during 2015-16 and 2016-17 growing seasons (Tables 3 and 4).

Diglyphus isaea (Walker), *Diglyphus* sp., *Hemiptarsenus zilahisebessi* (Erods) and Zagrammosoma sp. (Eulophidae) are ecto- larval parasitoids, while the eulophids *Neochrysocharis*

Table 3: Survey and relative densities of *L. trifolii* parasitoids on different faba bean cultivars during 2015-16 growing seasons at El-Salhia district, Sharkia Governorate Egypt.

Family	Species	Giza 716		Giza 3		Giza 843		Total	
		Number	%	Number	%	Number	%	Number	%
Braconidae	*Diglyphus isaea (*Walker*)*	530	25.65	463	25.09	315	22.56	1308	24.65
	Opius basalis Fischer	213	10.31	195	10.57	177	12.68	585	11.02
	Diglyphus sp.	311	15.05	291	15.77	187	13.40	789	14.87
	Opius sp.	209	10.12	175	9.49	163	11.68	547	10.31
Eulophidae	*Neochrysocharis formosa (*Westood*)*	451	21.83	398	21.57	288	20.63	1137	21.42
	*Neochrysocharis pentheus (*Walker*)*	175	8.47	210	11.38	197	14.11	582	10.97
	*Chrysocharis pentheus (*Walker*)*	75	3.63	53	2.87	33	2.36	161	3.03
Pteromalidae	*Hemiptarsenus zilahisebessi (*Erods*)*	45	2.18	35	1.90	18	1.29	98	1.85
	Zagrammosoma sp.	25	1.21	18	0.98	11	0.79	54	1.02
	*Halticoptera circulus (*Walker*)*	17	0.82	4	0.22	4	0.29	25	0.47
	Halticoptera sp.	15	0.73	3	0.16	3	0.21	21	0.39
Total		2066	100.00	1845	100.00	1396	100.00	5307	100.00

formosa (Westood), *Neochrysocharis* sp., and *Chrysocharis pentheus* Walker (Eulophidae) are endo-larval ones.

Opius basalis Fischer and Opius sp. (Braconidae), *Halticoptera circulus* (Walker) and Halticoptera sp. (Pteromalidae) are solitary endo-larval pupal parasitoids.

Nine hymenopterous parasitoid species of *L. trifolii* were recorded by Hammad (2000) in nearly reclaimed sandy land at El-Khattara district in Egypt seven hymenopterous parasitoids species of *L. trifolii* were surveyed by Neama and Hegazi (2014).

Hammad (2000) and Neama and Hegazi (2014) who mentioned that the parasitoid, *D. isaea* was the predominant parasitoids reared from the host larvae.

- Diglyphus isaea

The predominant parasitoid species was emerged from the larvae of *L. trifolii* (Tables 3 and 4). It composed 22.56-25.65% and 27.45-31.70% of all surveyed parasitoids during the first and second seasons. Successively. Its general relative density was 24.65% in the first season and 30.10% during the second season. These results are in agreement with the findings of Cabello *et al.*, (1994), Hammad (2000), Noyes (2004) and Neama and Hegazi (2014) who mentioned that *D. isaea* is an ecto- larval parasitoid of leaf miners. *L. trifolii* infested faba bean plants. Also, the results agree with those of Zhu *et al.*, (2000), Hammad (2000), Noyes (2004) and Neama and Hegazi (2014) who stated that the *D. isaea* is the predominant parasitoid of the leaf miners, *L. trifolii*.

On the other hand, different *Diglyphus* species were surveyed by several workers, *viz.*, *D. intermedius* (Chandler *et al.*, 1988), *D. chabria* (Cabello *et al.*, 1994), *D. begini* (Sher and Parrella, 1996).

Mujica and Kroschel (2011), Li *et al.*, (2012), Sawsan *et al.*, (2014), Eva (2016) and Hassan *et al.*, (2016) and Bayoumy *et al.*, (2018) who reported that the *D. isaea* is an ecto larval parasitoid of *L. trifolii* infested faba bean plants.

- Neochrysocharis formosa

This species was the most dominant endo – larval parasitoid, a counting for 20.63-21.83% of the total parasitoids emerged during the first season and 15.09-20.36% during the second one (Tables 3 and 4). The parasitoid showed relative densities of 21.42 and 17.35% in the first and second season, respectively. These findings are in accordance with those obtained by Eid (1998), Hammad (2000), Sawsan *et al.*, (2014), Eva (2016) and Bayoumy *et al.*, (2018) who mentioned that *N. formosa* is an endo- larval parasitoid of the leaf miners, *L. trifolii*.

These results agree with those of Sharaf El-Din *et al.*, (1997), Hammad (2000), Sawsan *et al.*, (2014), Eva (2016) and Bayoumy *et al.*, (2018) who stated that *N. formosa* being one of the most dominant parasitoid species and disagree with the findings of Lynch and Johnson (1987) who reported that this parasitoid composed 0.9-2.6% of all parasitoids.

- Opius basalis:

O. basalis is an endo-larval pupal parasitoid, the percentages of the *L. trifolii* larvae parasitized by this parasitoid ranged between 10.31-12.68% with a mean of 11.02% during the first season and 9.43-12.69%, with a mean of 10.90% in the second season (Tables 3 and 4). These results agree with those of Hammad (2000), Neama and Hegazi (2014), Eva (2016) and Bayoumy *et al.*, (2018), who reported that *O. basalis* is an endo larval – pupal parasitoid. *O. basalis* recorded by Neama and Hegazi (2014) who mentioned that the percentages of

Table 4: Survey and relative densities of *L. trifolii* parasitoids on different faba bean cultivars during 2016/17 growing seasons at El-Salhia district, Sharkia Governorate Egypt.

Family	Species	Giza 716		Giza 3		Giza 843		Total	
		Number	%	Number	%	Number	%	Number	%
Braconidae	*Diglyphus isaea* (Walker)	615	31.70	515	27.45	410	31.51	1540	30.10
	Opius basalis Fischer	183	9.43	210	11.19	165	12.69	558	10.90
	Diglyphus sp.	216	11.13	310	16.52	205	15.76	731	14.29
	Opius sp.	183	9.43	192	10.23	115	8.84	490	9.58
Eulophidae	*Neochrysocharis formosa* (Westood)	395	20.36	283	15.09	210	16.14	888	17.35
	Neochrysocharis pentheus (Walker)	200	10.31	221	11.78	100	7.69	521	10.18
	Chrysocharis pentheus (Walker)	62	3.20	81	4.32	61	4.69	204	3.99
Pteromalidae	*Hemiptarsenus zilahisebessi* (Erods)	53	2.73	41	2.19	19	1.46	113	2.21
	Zagrammosoma sp.	18	0.93	11	0.59	8	0.61	37	0.72
	Halticoptera circulus (Walker)	11	0.57	5	0.27	3	0.23	19	0.37
	Halticoptera sp.	4	0.21	7	0.37	5	0.38	16	0.31
Total		1940	100.00	1876	100.00	1301	100.00	5117	100.00

the pest larvae parasitized by this parasitoid showed a relative densities of 5.90 and 23.50% in the first and second seasons, successively.

- *Diglyphus* sp.

This parasitoid is an ecto-larval parasitoid of the pest. It comprised 13.40- 15.77% and 11.13-16.52% of all parasitoid during the first and second seasons, respectively. Tables (3 and 4). It showed general relative densities of 14.87 and 14.29% during the first and second seasons successively. These findings are in agree with those obtained by Palumbo *et al*., (1994), Hammad (2000), Neama and Hegazi (2014), Eva (2016) and Bayoumy *et al.,* (2018) who mentioned that Diglyphus sp. is an ecto –larval parasitoid of the leaf miners, *L. trifolii* infested faba bean plants. Hammad (2000) in Egypt reported that this parasitoid composed 15.49-19.13% and 17.45-23.21% of all parasitoids in the first and second seasons, consecutively.

The obtained results disagree with findings of Mujica and Kroschel (2011) who stated that the mean percentage of parasitism by this parasitoid was 8.7% during the whole season.

- *Opius* sp.

Opius sp. is an endo-larval – pupal parasitoid , accounting for 9.49-11.68% of the total parasitoids emerged during the first season and 8.84-10.23% in the second one (Tables 3 and 4). The parasitoid showed relative densities of 10.31 and 9.58% in the first and second seasons, respectively.

Opius sp. as endo-larval – pupal parasitoid was recorded by Eid (1998), Hammad (2000), Neama and Hegazi (2014), Eva (2016) and Bayoumy *et al.,* (2018).

- *Neochrysocharis* sp.

This parasitoid is an endo-larval parasitoid. The percentages of the insect larvae parasitized by this parasitoid ranged between 8.47-14.11% with a mean of 10.97% in the first season and 7.69-11.78% with a mean of 10.18% during the second season (Tables 3 and 4).

The results are in agreement with the findings of Eid

Table 5: Parasitism percentages of *Liriomyza trifolii* (Burgess) on Giza 716, Giza 3 and Giza 843 faba bean cultivars in newly reclaimed sandy land during 2015/16 season at El-Salhia district, Sharkia Governorate, Egypt.

Sampling date	Giza 716			Giza 3			Giza 843			Corresponding	
	Colle-cted larvae	Emerged para-sitiods	Para-sitism %	Colle-cted larvae	Emerged para-sitiods	Para sitism %	Colle-cted larvae	Emerged para-sitiods	Para-sitism %	Temp. ^{0}C	R.H. %
Nov., 3rd	30	10	33.33	62	3	4.84	22	2	9.09	22.3	63.5
4th	123	95	77.24	130	52	40.0	100	19	19.00	20.4	62.3
5th	163	97	59.51	141	100	70.92	113	65	57.52	19.7	66.2
Dec., 1st	168	93	55.36	152	112	73.68	122	71	58.20	20.7	61.7
2nd	173	130	75.14	160	103	64.38	133	92	69.17	19.9	60.6
3rd	160	125	78.13	100	57	57.0	81	66	81.48	18.2	59.6
4th	100	81	81.00	93	80	86.02	80	41	51.25	18.9	59.6
Jan., 1st	120	99	82.50	130	83	63.85	69	50	72.46	14.4	60.0
2nd	132	95	71.97	141	113	80.14	100	74	74.00	15.7	60.0
3rd	160	140	87.50	171	133	77.78	130	100	76.92	14.3	53.4
4th	167	120	71.86	170	95	55.88	143	120	83.91	11.7	66.7
Feb., 1st	200	181	90.50	211	171	81.04	195	83	42.56	13.0	67.5
2nd	215	92	42.79	100	53	53.00	191	41	21.47	14.9	57.2
3rd	230	110	47.83	112	61	54.46	131	16	12.21	20.3	46.4
4th	200	103	51.50	113	60	53.10	132	18	13.64	19.5	51.0
Mar., 1st	192	117	60.94	121	73	60.33	145	130	89.66	22.4	49.5
2nd	130	110	84.62	151	121	80.13	138	125	90.58	20.5	48.7
3rd	100	81	81.00	155	133	85.81	83	60	72.29	21.8	43.0
4th	86	50	58.14	100	77	77.00	71	55	77.46	20.0	47.7
5th	80	33	41.25	95	51	53.68	76	56	86.84	21.6	43.8
Apr., 1st	93	63	67.74	100	71	71.00	92	80	86.96	22.7	53.7
2nd	68	41	60.29	91	43	47.25	90	22	24.44	26.4	40.7
Total	3090	2066		2799	1845		2437	1386			
Mean	140.45	93.91	66.38	127.23	83.86	63.24	110.77	63.0	57.78		

(1998), Hammad (2000), Neama and Hegazi (2014), Eva (2016) and Bayoumy *et al.*, (2018). Who stated that *Neochrysocharis* sp. is an endo- larval parasitoid of the pest.

- *Chrysocharis pentheus*

The percentages of the pest larvae parasitized by this parasitoid comprised 2.36-3.63% and 3.20-4.69% of all parasitoids in the first and second seasons, respectively (Tables 3 and 4).

This parasitoid showed general relative densities of 3.03 and 3.99% during the first and second season, respectively.

The results are in agreement with the findings of Neama and Hegazi (2014) and Bayoumy *et al.*, (2018) who stated that this parasitoid is an endo- larval parasitoid of the pest.

Mujica and Kroschel (2011) who reported that the mean percentage of parasitism by this parasitoid during the season was 19.5%.

- *Hemiptarsenus zilahisebessi*

H. zilahisebessi is an ecto-larval parasitoid, parasitized the pest larvae with a range of 1.29 -2.18 % with a mean of 1.85% in the first season and 1.46-2.73% with general relative density was 2.21% in the second season. This parasitoid was surveyed by Cabello *et al.*, (1994), Hammad (2000), Eva (2016) and Bayoumy *et al.*, (2018), Eva (2016) reported that the mean percentages of parasitism by this parasitoid was 23.56%.

- *Zagrammosoma* sp.

This parasitoid is an ecto-larval parasitoid of the leaf miners, *L. trifolii*. The percentages of the pest larvae parasitized by this parasitoid ranged between 0.79-1.21 and 0.59-0.93% of the total parasitoids reared in the first and second seasons, successively (Tables 3 and 4).

This parasitoid showed general relative densities of 1.02 and 0.72% in the first and second seasons respectively. These results agree with those of Hannou (1992), Hammad (2000), Neama and Hegazi (2014) who stated that the parasitoid, *Zagrammosoma* sp. is an ecto-larval parasitoid of the leaf miners, *L. trifolii* infested faba bean plants. Neama and Hegazi (2014) who reported that the parasitoid, *Zagrammosoma* sp. parasitized the insect larvae with general relative density of 9.9%.

- *Halticoptera circulus* and *Halticoptera* sp.

These parasitoids were recorded in very low numbers during the two seasons of study. In the first season (Table 3), the relative densities of *H. circulus* and *Halticoptera* sp. ranged between 0.22-0.82% and 0.16-0.73 % with general relative densities of 0.47 and 0.39% respectively.

In the second season (Table 4) , they composed 0.23-0.57% and 0.21-0.38% with general relative densities of 0.37 and 0.31% , respectively. These results are in agreement with those of Hammad (2000) , Neama and Hegazi (2014) who stated that *H. circulus* and *Halticoptera* sp. are endo- larval – pupal parasitoids of the leaf miners, *L. trifolii*. Neama and Hegazi (2014) recorded seven hymenopterous parasitoid species of *L. trifolii* , *H. circulus* and *Halticoptera* sp. were recorded by very low numbers during the two seasons of study with general relative densities of 3.5 and 0.9% , respectively.

Bayoumy *et al.*, (2018) who stated that Halticoptera sp. is an endo-larval – pupal parasitoid of *L. trifolii* infested faba bean plants in Egypt.

Percentages of parasitism

On Giza 716

In the first season Table 5 the parasitism occurred during the whole period of the leaf miners, *L. trifolii* infestation. The parasitism percentages were fluctuated to record six peaks, occurred on 4th week of November, first and 3rd week of January, first week of February, 2nd week of March and first week of April. The percentages of parasitism in these dates were 77.24, 82.50, 87.50, 90.50, 84.62 and 67.74% , respectively.

The corresponding means of temperatures and relative humdidities were 20.4-22.7ºC and 62.3-53.7% R.H.

The mean percentage of parasitism during the whole season was 66.38% (Table 5). In the second season the same trend was noticed, where the parasitism was fluctuated, but recording only four peaks of population density. They were 86.36, 86.59, 79.0 and 85.0% during the 3rd week of December (18.2ºC and 59.3% RH), 5th week of January (16.3ºC and 61.1%RH), first week of March (21.3ºC and 58.2% RH) and first week of April (20.3ºC and 59.2%RH), successively. The mean percentage of parasitism in the season was 61.97% (Table 6).

On Giza 3

During the first season, the parasitism occurred all over the season, fluctuated and achieved six peaks. The percentages of parasitism of the insect larvae throughout these peaks were 73.68, 86.02, 80.14, 81.04, 85.81 and 71.00% during the first and 4th week of December, 2nd week of January, first week of February, 3rd week of March and first week of April, consecutively. The corresponding means of temperatures were ranged

between 20.7 and 22.7ºC and these of relative humidities were 61.7-53.7% R.H. the mean percentage of parasitism during the whole season was 65.9% (Table 5).

In the second season (Table 6), the parasitism was recorded all- around the period of the *L. trifolii* infestation. The parasitism percentages were fluctuated to show four peaks. There were in the 2nd week of December (89.36%), 2nd week of January (87.50), first week of February (81.00) and 2nd week of March (87.65%). The corresponding means of temperatures were 19.2-19.9ºC and those of relative humidites were 63.7-63.3%. Generally, the mean percentage of parasitism during the whole season was 72.5%.

On Giza 843

During the first season (Table 5), the parasitism occurred all over the season, fluctuated and achieved four peaks. The first one, 81.48% was found in the 3rd week of December at means of 18.2ºC and 59.6% RH. The second peak, 83.91%, took place in the 4th week of January at means of 11.7ºC and 66.7% RH. The third and highest peak, 90.58% , was recorded in the 2nd week of March at means of 22.4ºC and 49.5% RH. The fourth one, 86.96% occurred in the first week of April at means of 22.7ºC and 53.7% RH. The mean percentage of parasitism during the whole season was 57.78%. In the second season, the similar trend was recorded, where the insect larvae were parasitized all round the season. The parasitism peaked in the 3rd week of December (63.69%), 2nd week of January (73.68%), 2nd week of March (84.42%) and first week of April (75.00%). The means of temperatures at the above mentioned dates ranged between 18.2 and 20.3ºC these of relative humidities ranged between 59.3 and 59.2%. The mean percentage of parasitism in this season was 54.30% (Table 6).

Generally, it could be concluded that the parasitoids of leaf miners, *L. trifolii* showed active all over the faba bean growing season. They were recorded in considerable numbers as the percentage of parasitism at many dates exceeded 70% and some times reached to 90%. The parasitism percentages on faba bean cultivars had 4-6 peaks annually. The mean percentages of parasitism during the two seasons of study varied from

Table 6: Parasitism percentages of *Liriomyza trifolii* (Burgess) on Giza 716, Giza 3 and Giza 843 faba bean cultivars in newly reclaimed sandy land during 2016/17 season at El-Salhia district, Sharkia Governorate, Egypt.

Sampling date	Giza 716			Giza 3			Giza 843			Corresponding	
	Colle-cted larvae	Emerged para-sitiods	Para-sitism %	Colle-cted larvae	Emerged para-sitiods	Para sitism %	Colle-cted larvae	Emerged para-sitiods	Para-sitism %	Temp. ºC	R.H. %
Nov., 3rd	21	2	9.52	41	1	2.44	18	2	11.11	23.2	60.7
4th	153	100	65.30	165	100	60.61	141	40	28.37	19.9	59.7
Dec., 1st	191	130	68.06	210	150	71.43	170	100	58.82	20.1	62.3
2nd	200	170	85.00	235	210	89.36	185	110	59.46	19.2	63.7
3rd	220	190	86.36	295	260	88.14	220	140	63.69	18.2	59.3
4th	259	200	77.22	281	240	85.41	235	100	42.55	18.0	59.5
Jan., 1st	198	160	80.81	170	130	76.47	163	110	67.48	18.3	61.5
2nd	100	81	81.00	120	105	87.50	95	70	73.68	17.2	60.2
3rd	87	72	82.76	99	70	70.71	81	52	64.20	17.7	60.0
4th	160	133	83.13	60	40	66.67	65	40	61.54	16.7	63.2
5th	179	155	86.59	52	31	59.62	100	59	59.00	16.3	60.1
Feb., 1st	195	113	57.95	100	81	81.00	131	70	53.34	18.5	59.3
2nd	215	20	9.3	115	85	77.91	153	80	52.29	15.3	63.2
3rd	265	30	11.32	153	102	66.67	180	82	45.56	16.3	63.7
4th	153	80	52.29	100	63	63.00	190	70	36.84	18.5	59.3
Mar., 1st	100	79	79.00	95	45	47.37	90	35	38.89	21.3	58.2
2nd	83	50	60.24	81	71	87.65	77	65	84.42	19.9	63.3
3rd	70	40	57.14	30	20	66.67	50	31	62.00	19.2	62.1
4th	55	40	72.73	40	21	52.50	48	25	52.08	18.3	60.3
Apr., 1st	100	85	85.00	66	31	46.97	20	15	75.00	20.3	59.2
2nd	95	10	10.52	80	20	25.00	10	5	50.00	20.0	53.9
Total	3099	1940		2588	1876		2422	1301			
mean	147.57	92.38	61.97	123.24	89.33	65.39	115.33	61.95	54.30		

Table 7: Mean percentages of parasitism of *Liriomyza trifolii* larvae on Giza 716, Giza 3 and Giza 843 faba bean cultivars during 2015/16 and 2016/17 growing seasons at El-Salhia district, Sharkia Governorate.

Seasons	Cultivar	Mean number of		% parasitism
		Collected host larvae	Parasitized host larvae	
2015/16	Giza 716	140.45[a]	93.91[a]	66.37[a]
	Giza 3	127.23[ab]	83.86[ab]	63.24[a]
	Giza 843	110.77[b]	63.00[b]	57.78[a]
	F. value	7.537*	6.619*	2.5679[NS]
	L.S.D. 0.05	18.742	21.206	9.989
2016/17	Giza716	147.57[a]	92.38[a]	61.97[ab]
	Giza 3	123.24[b]	89.33[a]	65.39[a]
	Giza 843	115.33[b]	65.76[b]	54.30[b]
	F. value	16.607**	24.808**	4.2686[NS]
	L.S.D. 0.05	14..268	10.1218	9.5118

54.30 to 72.5%. Generally, the parasitoids of the leaf miners, *L. trifolii* had an important role as biological control agents for suppression the leaf miners, *L. trifolii* population number the newly reclaimed sandy land, which must not be neglected and must be protected from the usage of pesticides. The obtained results agree with findings of Hammad (2000) who mentioned that parasitism of *L. trifolii* larvae and pupae had 3-6 peaks and the peaks differed in their numbers and times of appearance owing to the growing season and faba bean cultivars.

Also, the given results agree with the findings of Neama and Hegazi (2014) who stated the mean percentages of parasitism during the two seasons of study at many dates exceeded 70% and sometimes achieved 90%.

Mujica and Kroschel (2011) reported that the mean percentage of parasitism during the whole season was 90.1% Bayoumy *et al.*, (2018) who mentioned that the parasitism level of *L. trifolii* on faba bean plants reached about 41% in late January – early March.

Susceptibility of certain faba bean cultivars to the infestation with *L. trifolii*

Data given in Table 7 revealed that the differences between average numbers of larvae on the three tested faba bean cultivars were statistically significant for the tow season of the study, where mean larvae recorded 140.45, 127.23 and 110.77 on Giza 716, Giza 3 and Giza 843 respectively, F. = 7.537* in the first season , while in the second season recorded 147.57, 123.24 and 115.33 on the three cultivars respectively, (F. = 16.607**).

The same trend in the parasitized host larvae were highly significant between the three faba bean cultivars where recorded 93.91, 83.86 and 63.00 in Giza 716, Giza 3 and Giza 843 respectively (F. = 6.619*). In the second season were highly significant between the three cultivars (F. = 24.808**).

Effect of temperature and relative humidity on the infestation percentages and percentages of

Table 8: Simple correlation (r) partial regression (b) and explained variance (E. V.) for the infestation percentage of different faba bean cultivars by *L. trifolii* under periodic mean temperature and relative humidity during 2015/16 and 2016/17 growing seasons in newly reclaimed sandy land at El-Salhia district, Sharkia Governorate, Egypt.

Season	Considered climatic factors	r			b			E.V. %		
		Giza 716	Giza 3	Giza 843	Giza 716	Giza 3	Giza 843	Giza 716	Giza 3	Giza 843
2015/16	Periodic mean Temp.	-0.466*	-0.5598**	-0.4563*	0.286*	0.0067**	0.0328*	21.767	31.339	20.822
	Periodic mean R.H.	0.215	0.341	0.164	0.3366	0.1194	0.4645	4.621	11.686	2.705
	Interaction Temp. R. H.							22.29	31.367	22.44
2016/17	Periodic mean Temp.	-0.5704**	-0.123	-0.3816	0.0069**	0.5967	0.0878	32.546	1.501	14.565
	Periodic mean R.H.	-0.271	0.090	0.273	0.2349	0.6995	0.2312	7.338	0.802	7.451
	Interaction Temp. R. H.							33.412	15.75	17.09

Table 9: Simple correlation (r), partial regression (b) and explained variance (E. V.) for the percentage of parasitism of *L. trifolii* larvae on different faba bean cultivars under periodic mean temperature and relative humidity during 2015/16 and 2016/17 growing seasons in newly reclaimed sandy land at El-Salhia district, Sharkia Governorate, Egypt.

Season	Considered climatic factors	r			b			E.V. %		
		Giza 716	Giza 3	Giza 843	Giza 716	Giza 3	Giza 843	Giza 716	Giza 3	Giza 843
2015/16	Periodic mean Temp.	-0.3977	-0.264	-0.142	0.0668	0.2340	0.5281	21.767	31.542	20.822
	Periodic mean R.H.	0.211	-0.085	-0.084	0.3448	0.7080	0.7100	4.621	11.773	2.705
	Interaction Temp. R. H.							15.819	15.76	6.280
2016/17	Periodic mean Temp.	0.082	-0.583**	-0.362	0.7230	0.0055**	0.1065	32.546	1.501	14.565
	Periodic mean R.H.	0.035	0.456*	0.234	0.8804	0.378*	0.3081	7.338	0.8017	7.451
	Interaction Temp. R. H.							16.84	42.060	14.660

Table 10: Effect of leafminer larvae infestation on the chemical content of different faba bean cultivars.

Cultivars	Mean larvae	The chemical components in the cultivar leaves						
	L. trifolii	Protein	Carbohydrates	Calcium	Fat	Fibre	Ash	Moistures
Giza 716	147.57a	4.16c	22.19b	0.189b	3.12c	2.18b	2.15c	66.2a
Giza 3	123.24b	4.50b	25.05b	1.102a	3.80b	2.38b	2.97b	61.63a
Giza 843	115.33b	5.12a	29.09a	1.113a	4.81a	6.91a	8.57a	45.5b
F. value	6.248*	60.925***	12.3116**	883.369**	123.96**	615.685***	2561.149***	53.6423***

parasitism of *L. trifolii* larva on different faba bean cultivars in newly reclaimed sandy land at El-Salhia district, Sharkia Governorate, Egypt, during 2015/16 and 2016/17 growing seasons

Statistical analysis of the results in Table (8) revealed that there is a negative high significant correlation between mean temperature and infestation percentage in the first season, where (r) values were -0.466*,-0.559** and -0.456* of Giza 716, Giza 3 and Giza 843, respectively.

In the second season, this correlation was negative, being significant on both Giza 716 (r = 0.570**), insignificant on Giza 3 (r = -0.123) and Giza 843 (r-0.382). The correlation coefficient values between mean relative humidity and percentage of infestation were insignificant.

In both seasons, where they were 0.215, 0.341 and 0.164 & 0.271, 0.090 and 0.273 of Giza 716, Giza 3 and Giza 843 during the first & second seasons, respectively.

Temperature and relative humidity affected infestation percentage in the first season by 22.29, 31.37 and 22.44% on Giza 716, Giza 3 and Giza 843, Successively. In the second season, there influences were 23.12, 15.75 and 17.09 on the previously mentioned cultivars consecutively.

Data given in Table 9 showed that there was an insignificant negative correlation between the percentage of parasitism of the pest larva and mean temperature on all cultivars in both seasons without Giza 3 cultivar in the second season was highly significant negative correlation (r = -0.583**). Relative humidity had insignificant correlation r = 0.211, -0.085 and -0.084 & 0.035, 0.456 and 0.234 of Giza 716, Giza 3 and Giza 843, during the first & second seasons, respectively.

Temperature and relative humidity affected percentage of parasitism by 15.819, 15.76 and 6.28% and 16.84, 42.06 and 14.66% in the first and second seasons, respectively.

Effect of chemical contents of leaves faba bean cultivars on the population density of leafminer, *L. trifolii*.

The highly infestation of leaf miner 141.86 larvae in the first cultivar, was effected on the chemical content of leaf, and decreased of carbohydrate (22.19), calcium (0.189), ash (2.15), total protein (4.16), fibre (2.18) and fat (3.12), while the moderate infestation 123.24 larvae on the second cultivar, was less effected on the chemical content of leaf were carbohydrate (25.05), calcium (1.102), ash (2.97), total protein (4.50), fibre (2.38) and fat (3.8), on the other hand the third cultivar was low infestation 115.33 larvae was less effected on chemical content of leaf where recorded carbohydrate (29.09), calcium (1.113), ash (8.57) total protein (5.12), fibre (6.91) and fat (4.81).

Data presented in Table 10, indicated that the differences between values of moistures, fat, fibre, total protein, ach, calcium and carbohydrate in three, faba bean cultivars were highly significant during 2016/17 season The intensity of leaf miner larvae infestation in 2016/17 measured as total numbers of leaf miner larvae arranged in descending order as follows Giza 716 (141.86), Giza 3 (123.24) and Giza 843 (115.33) larvae.

Conclusion

There are eleven hymenopterous parasitoid species that attack *L. trifolii* belonging to Eulophidae, Braconidae and Preromalidae were recorded. They included four ecto- larval, three endo- larval and four endo-larval pupal parasitoids. In general, the most dominant ecto-larval parasitoid was *Diglyphus isaea* (Walk.). The parasitoids of *L. trifolii* on faba bean cultivar had 4-6 peaks annually. The mean percentages of parasitism during the two seasons of study varied from 54.30 to 72.5%.

Generally, the parasitoids of the leaf miners, *L. trifolii* had an important role as biological control agents for suppression the pest population.

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