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Parasitoids of *Liriomyza sativae* Blanchard (Diptera: Agromyzidae) in the Mid Country of Sri Lanka

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ABSTRACT. *Parasitoids of vegetable leaf miner, Liriomyza sativae (Diptera: Agromyzidae) was investigated from August 2006 to May 2007 in the mid country region of Sri Lanka. Five parasitoid species were collected and identified as Neochrysocharis sp. (Hymenoptera: Eulophidae), Diglyphus isaea.(Hymenoptera: Eulophidae), Hemiptarsenus varicornis (Hymenoptera: Eulophidae), Closterocerus sp., (Hymenoptera: Eulophidae) and Opius sp. (Hymenoptera: Braconidae). Two new parasitoid species; Closterocerus sp. and Neochrysocharis sp. to the mid-country region of Sri Lanka was also recorded. Neochrysocharis sp. with the total parasitism of 18.34% was recorded as the dominant parasitoid followed by D. isaea, H. varicornis and Opius sp., with the total percent parasitism of 3.32, 1.27 and 0.35, respectively. The intensity of parasitism varied from crop to crop. Further more organically grown crops recorded a higher parasitism over conventionally grown crops. This indicates the negative effects of pesticides on parasitoids and highlights the importance of their conservation. The morphological characters of all the species found in this study are given in brief.*

INTRODUCTION

Leaf mining flies in the family Agromyzidae are economically important pests of vegetables and floricultural crops (Murphy and La Salle, 1999). The larva of the leaf miners feed within the leaves of the host plants and at high densities, severely reduce yields or kill the plants (Spencer, 1990).

Three species of Agromyzid flies, *Liriomyza sativae* Blanchard, *L. huidobrensis* and *L.trifolii* cause damage to vegetable crops in Sri Lanka (Niranjana *et al*., 2005; Nugalliyadda *et al*., 2001; Wijesekara, 2001and 1997). Agromyzid leaf miners are known to have rich natural enemy communities. Several leaf miner parasitoids have been reported in the world (Edwards and La Salle, 2004; La Salle and Parrella, 1991; Stegmaier, 1966). Therefore, there is a high potential for utilizing these parasitoids in the management of vegetable leaf miners. However, there have been only a few studies on parasitoids of leaf miners in Sri Lanka (Niranjana *et al*., 2005; Nugalliyadda *et al*., 2001; Wijesekara, 2001).

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The objectives of this study were to investigate the parasitoids of vegetable leaf miner *L. sativae* and to determine the level of parasitization in the mid country region of Sri Lanka.

MATERIALS AND METHODS

This study was carried out during August 2006 - May 2007 at the Department of Agricultural Biology, Faculty of Agriculture, University of Peradeniya. Study was implemented in two phases (a) Field collection of host insects and subsequent rearing them until adult emergence and (b) Identification of emerged parasitoids using taxonomic keys.

The field survey was carried out in selected areas of the mid country including Matale, Kundasale, Peradeniya, Thalathuoya, Naranwita, Gannoruwa and Galaha. Samples were collected from both organically and conventionally managed vegetable fields.

Leaf miner infested leaves of different vegetables such as tomato (*Lycopersicum esculentum*), cabbage (*Brassicae oleraceae*), cucumber (*Cucumis sativa*), wing bean (*Psophocarpus tetragonolobus*.), brinjal (*Solanum melongena*), snake gourd (*Tricosanthes* sp.), raddish (*Raphanus sativus*) and long bean (*Phaseolus vulgaris*) were collected at two week intervals. The collected host insects together with plant leaves were individually placed in plastic containers (2.0 cm diameter and 7.5 cm height) and covered with cotton plugs. The petioles of the infested leaves were wrapped with moistened cotton wool to delay drying of leaves in order to keep the parasitic larva alive. The vials were kept in the laboratory at 25 ± 2^0C and 80% RH until the adult emergence and examined weekly. Emerging adults were either preserved as dry mounts or placed in 70% alcohol in glass vials (11 mm diameter and 5 cm height) for identification. The unemerged larvae were discarded after four weeks following a thorough examination of vials under the dissecting microscope.

The emerged parasitoids were identified using taxonomic keys and related literatures (Sharkey and Wharton, 2007; Fisher and La Salle, 2005; Belokobylskij *et al*., 2004; Edwards and La Salle, 2004; Noyes, 2004; Burks, 2003; Zhu *et al.*, 2000; La Salle and Parrella; 1991). Representative samples of parasitoids were sent to the taxonomic expert, Professor Chao-Dong Zhu, of the Institute of Zoology, Chinese Academy of Sciences for confirmation of identity.

Representative specimens of each parasitoids and host species were deposited in the Insect Museum, Department of Agricultural Biology, Faculty of Agriculture, University of Peradeniya. The illustrations were prepared using a stereomicroscope (Nikon Japan SMZ-U) under the magnification of (30×4.5).

Intensity of parasitism

The intensity of parasitism of host species was presented as percentages using the formula given by Van Driesche (1983). The dead insects during the rearing were excluded in the calculation.

$$\textit{Percent parasitism} = \frac{\text{No. of adult parasitoids}}{\text{No. of adult parasitoids + No. of adult hosts}} \text{ X } 100$$

The data was analyzed using contingency tables and logit regression using Systat 11 SPSS software.

RESULTS AND DISCUSSION

Five species of parasitoids namely *Neochrysocharis* sp., *H. varicornis*, *Opius* sp., *D. isaea* and *Colesterocerus* sp. were identified during the study. Other parasitoids from the family Eulophidae and Braconidae were also collected, however their identities yet to be confirmed.

The parasitism among the crops varied significantly (Likely Hood (L.H) Chi-Square = 124.77 df= 7 P<0.01) (Table 1).

Table 1. Percentage of parasitism and host plants of parasitoids of *L. sativae*

Name of parasitoid	Host plants	Parasitism (%)	Total Parasitism (%)
Neochrysocharis sp.	Tomato	10.79	18.34
	Cabbage	6.35	
	Bean	0.12	
	Cucumber	0.71	
	Brinjal	0.34	
Hemiptarsenus varicornis	Tomato	0.55	1.27
	Cabbage	0.72	
Diglyphus sp.	Tomato	1.94	3.32
	Cabbage	1.20	
	Bean	0.18	
Opius sp.	Tomato	0.07	0.35
	Cabbage	0.28	
Closterocerous sp.	Wing Bean	Obtained once	-

Neochrysocharis sp., was the most common parasitoid (18.34%) found in almost all sampling sites. However, the percentage of parasitism of *Neochrysocharis* sp., significantly varied among the crops sampled (L.H Chi-square= 90.51 df = 7 p<0.01) (Table 1).

Murphy and La Salle (1999) stated that parasitoids that exceed 10% parasitism can be considered as potential biological control agents. Therefore, *Neochrysocharis* sp., can be considered as a potential biological control agent for controlling tomato leaf miners in the mid country region of Sri Lanka.

There was no significant difference in the parasitism by *Neochrysocharis* sp., with the crop management system, but a higher number of parasitoids were obtained in the organically grown crops than in the conventionally managed crops (Table2). However in Tomato, there is a significant difference in the parasitism by *Neochrysocharis* sp. among the organic and conventional management systems (L.H Chi-square= 83.436 df= 1 $p<0.01$).

D. isaea, an introduced larval parasitoid reported to be the dominant parasitoid associated with the leaf miner pests in Sri Lanka. This was the second dominant species with a total parasitism of 3.32. Parasitism by *D. isaea* was significantly different among crops (L.H Chi-square= 24.961 df= 7 $p<0.01$) (Table 1). There was a significant difference observed with the crop management in cabbage and tomato (L.H Chi-square= 0.635 df= 1 $p<0.05$ and L.H Chi-square= 9.356 df= 1 $p<0.01$, respectively) (Table 2).

Table 2. Total parasitism in cabbage and tomato crops with the crop management method

Parasitoid	Crop	Total parasitism (%)	
		Organic	Conventional
Neochrysocharis sp.	Tomato	10.47 (26.49)	0.31 (3.00)
Diglyphus isaea	Tomato	1.69 (13.33)	0.25 (1.94)
	Cabbage	1.20 (10.13)	0.00
Hemiptarsenus varicornis	Tomato	0.49 (1.17)	0.06 (0.15)
	Cabbage	0.72 (10.15)	0.00
Opius sp.	Tomato	0.03 (0.10)	0.04 (0.09)
	Cabbage	0.15 (1.14)	0.13 (1.26)

Note: Percentage parasitism are given in parenthesis

The total parasitism by *H. varicornis* was found to be 1.27% (Table 1). There was a significant difference in parasitism of this species among the different crops sampled (L.H Chi-square = 41.61 df= 7 $p<0.01$). There was a significant difference observed with crop management in Cabbage and Tomato host plants (L.H Chi-square= 0.635 df= 1 $p<0.05$ and L.H Chi-square= 4.205 df= 1 $p<0.05$, respectively) (Table 2). Kettipearachchi (2002) had reported *H. varicornis* attacking *L. sativa* from bean host plants (*P. vulgaris*) in the Aralaganwilla area of Sri Lanka but this was not observed in this study.

Opius sp., was found in the samples with the total parasitism of 0.35. There was no significant difference observed among the crops sampled and among the system of crop management (Table 2).

Closterocerus sp., was found only once in sampling of wing bean host plants. The reason for the occurrence of this parasitoid only in the wing bean plant may be associated with the host plant characters, which attract this specific parasitoid. Further intensive study is necessary to confirm this result.

Crops such as snake gourd and raddish had zero parasitism and this condition may be related to the host plant characteristics and management system. An intensive study needs to be carried out further on these crops to confirm this result.

Relative parasitism of *L. sativae* in organically managed crops (76.3) was three times higher than in the conventionally managed fields (23.70). Lower relative parasitism found in the conventionally managed farms may be due to the toxic effect of broad-spectrum insecticides on leaf miner parasitoids.

Descriptions of different parasitoid species collected during the study are given below.

1. *Neochrysocharis* sp. Kurdjumov (Hymenoptera: Eulophidae: Entedoninae)

Neochrysocharis sp., larval parasitoids of leaf miners, has been reported in several regions of the world (Murphy and La Salle, 1999). This genus has been reported on *L. sativae* from the Batticaloa region (low country) of Sri Lanka (Niranjana *et al.*, 2005). The present finding reveals the occurrence of this species in the mid country region of Sri Lanka.

Description

Body length varies from 0.8 to 1.4 mm in the females and from 0.7 to 1.1 mm in the males. Body metallic blue green in colour. Antennae dark brown, scape cylindrical in lateral view, funicle two segmented and clava three segmented. Funicular segments about sub equal in length and width (Figure 1a). No branches in the funicular segments of both sexes. Post marginal vein of the forewing is shorter than the stigmal vein. Fore wing with out markings or rows of hairs from the stigmal vein. (Figure 1b) Notaulus not reaching to posterior margin of mesoscutum. No grooves found on the mesoscutellum (Figure 1c). Propodeum with out carina. Tarsus of legs 4 segmented. Fore, mid and hind femora white to yellowish white, some times with a blackish marking (Figure 1d) (Fisher and La Salle, 2005; Noyes, 2004; Burks, 2003).

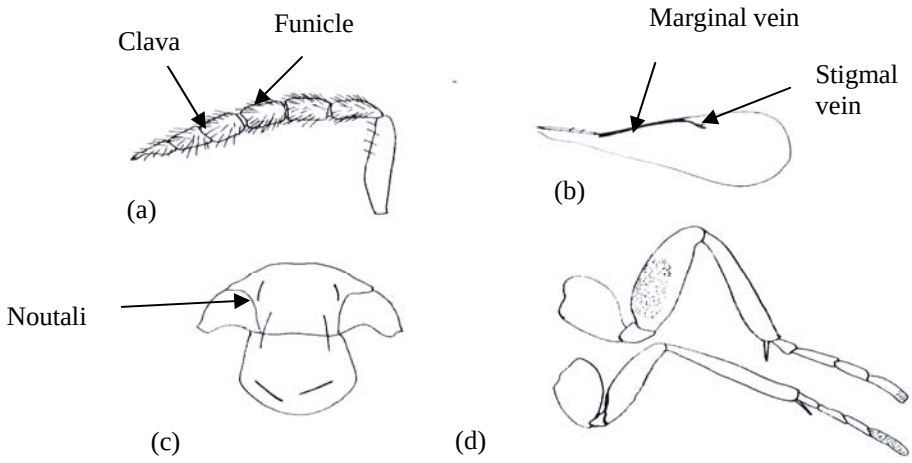

Figure 1. Taxonomically important morphological features of *Neochrysocharis* sp.
(a) Antennae (b) Fore wing (c) Mesoscutum and Scutellum (d) Hind Leg

Hemiptarsenus Westwood, 1833 a moderate size genus in the family Eulophidae. It includes more than 23 species worldwide. The hosts of this genus include various species of Agromyzid leaf miners. In Sri Lanka it has been recorded from *L. trifoli* and *L. huidobrensis* (Nugaliyadda *et al*., 2001; Wijesekara, 1997). In the present study this parasitoid species has been recovered from *L. sativae* infested cabbage and tomato crops from Matale, Peradeniya and Thalatuoya areas.

Description

Body length varies between 1.5 to 1.6 mm in females and 0.9 to 1.0 mm in males. Scutellum metallic green. Head and mid lobe of mesoscutum metalic green. Rest of the body is shiny metallic brown in colour Antennae inserted high on face and scape far extending beyond vertex; funicle 4 segmented, basal 3 segments of funicle branched in males. Flagellum of female antennae brown in colour dark basally and apical portion yellow in colour (Figure 2a). Lateral margin of funicular branches saw toothed, without hairs (Figure 2b). Fore wings long and narrow. Post marginal vein longer than the stigmal vein (Figure 2c). Mesosoma elongated and dorso ventrally flattened. Scutellum without sub median or sub lateral grooves (Asadi *et al*., 2006; Noyes, 2004; Burks, 2003; Zhu *et al*., 2000).

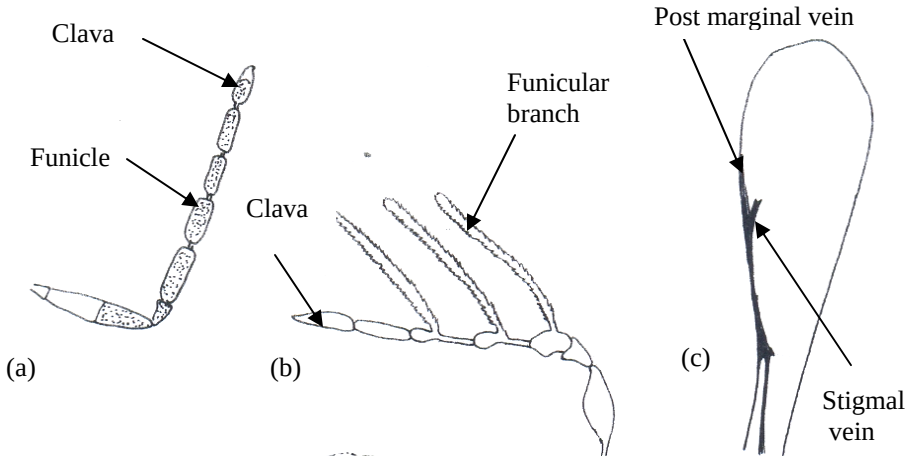

Figure 2. Taxonomically important morphological features of *Hemitarsenus varicornis.*
(a) Female antennae (b) Male antennae (c) Fore wing

3. *Opius* sp., Wesmael (Hymenoptera : Braconidae : Opinae)

It is a larval parasitoid of leaf miner reported to be attacking *Liriomyza* species in Sri Lanka (Niranjana *et al*., 2005; Nugalliyadde *et al*., 2001). This species is widely distributed in the temperate regions of the world and over 400 species have been recorded. (Sharkey and Wharton, 2007) This species parasitize the pests of families Agromyzidae, Anthomyiidae, Chloropidae, Drosophilidae, Ephydridae and Tephritidae (Sharkey and Wharton, 2007). However in this study, *Opius* sp. was obtained only from tomato and cabbage collected from Matale, Peradeniya and Thalatuoya.

Description

Body is bright orange in colour. Body length varies between 1.8 to 2.2 mm. Antennae are long, brown and filiform with more than 16 segments (Figure 3a). Occipital carina absent laterally and dorsally. Fore wing vein RS reaching wing margin as a tubular vein. Fore wing vein 2RS shorter than vein 3RSa. Fore wing cross vein r not arising from extreme base of stigma. Fore wing vein (RS+M) b not thickened. Fore wing vein 2RS shorter than vein 3RSa. Fore wing vein m-cu entering second sub marginal cell and thus make the second submarginal cell 5 sided. Fore wing vein (RS+M) not thickened (Figure 3b). Notauli, epicnemial carina and mid pit on mesonotum absent (Figure 3c). Hind wing m-cu absent. Stigma not long, narrow and weakly expanded apically (Figure 3d). Hind tibia with out sharp dorsal-medial carina basally. Mandibles over lapping when closed. Vertex smooth (Sharkey and Wharton, 2007; Belokobylskij, 2004)

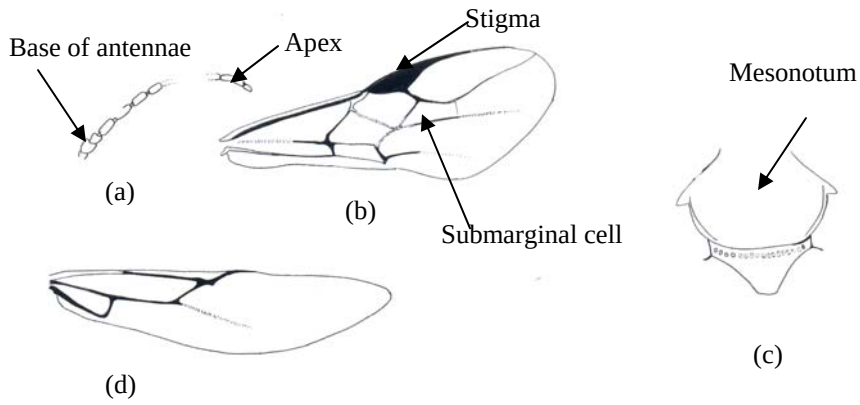

Figure 3. Taxonomically important morphological features of *Opius* sp.
(a) Antennae (b) Fore wing (c) Mesonotum (d) Hind wing

4. *Closterocerus* sp. Westwood (Hymenoptera: Eulophidae)

This genus has been reported as a parasitoid of several leaf mining species belonging to the Diptera, Coleoptera and Lepidoptera (Asadi *et al*., 2006). In the present study this species was found for the first time attacking leaf miners in wing bean plants. Complete identification of this parasitoid yet to be carried out.

Description

Length of the body is 1.35 mm. Head and mesosoma dark metallic blue green. Gaster dark brown to black, with only slight metallic reflections dorsally. Antennae black (Figure 4a). Notauli incomplete and straight. Legs: coxae, all femora and hind tibia dark brown to black. Tarsal segments 1-3 yellow to orange 4th tarsal segment brown. Fore wing with three markings, with a row of hairs from stigmal vein, stigmal vein longer than the post marginal vein. (Figure 4b). Pronotum, mesonotum and scutellum reticulate. Mesoscutellum with out grooves. Scutellum with 2 setae (Edwards and La Salle, 2004; Burks, 2003).

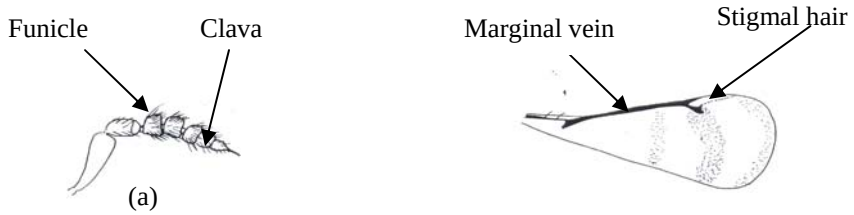

Figure 4. Taxonomically important morphological features of *Closterocerus* sp.
(a) Antennae (b) Fore wing

5. *Diglyphus isaea* (Walker) (Hymenoptera: Eulophidae: Eulophinae)

This is a larval ectoparasitoid of various species of leaf miners, especially the Agromyzidae. *Diglyphus isaea* widely distributed in tropical, Pacific, Oriental and Palearctic regions. *D. isaea* had been reported as a parasitoid of *L. sativae, L. trifoli* and *L. cinerina* (Asadi *et al*., 2006). In this study it was reared from *L. sativae* on vegetable crops such as tomato, cabbage and beans.

Description

Body length varies between 1.5 to 1.7 mm in the females and 1.3 to 1.5 mm in the males. Antennae dark brown, scape cylindrical in lateral view, funicle two segmented and clava three segmented (Figure 5a). Pronotum triangular shaped in dorsal view, mesoscutum with incomplete notauli, scutellum with parallel submedian grooves (Figure 5c) and post marginal vein as long as stigmal vein, cubital vein strongly curved at base. Speculum rather narrow some times effaced (Figure 5b) (Asadi *et al*., 2006, La Salle and Parrella, 2001).

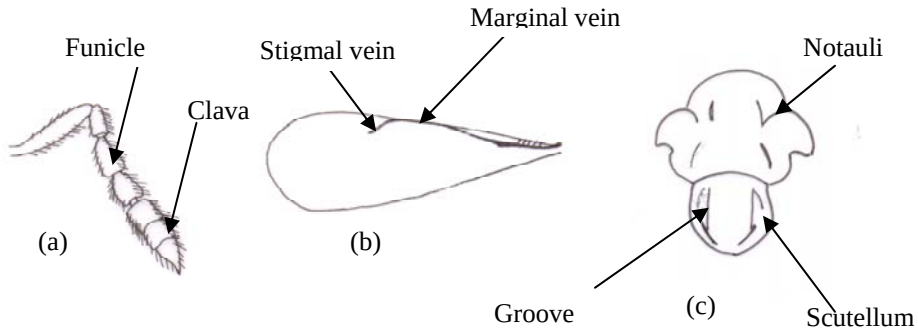

Figure 5. Taxonomically important morphological features of *Diglyphus isaea*
(a) Antennae (b) Fore wing (c) Mesoscutum and scutellum

CONCLUSIONS

Five parasitoid species of *L. sativa* were recorded in the mid-country region of Sri Lanka and identified as *Neochrysocharis* sp., (Hymenoptera: Eulophidae), *H. varicornis* (Hymenoptera: Eulophidae), *Closterocerus* sp., (Hymenoptera: Eulophidae) *D. isaea*. (Hymenoptera: Eulophidae) and *Opius* sp., (Hymenoptera: Braconidae). *Neochrysocharis* sp., was found as the dominant parasitoid of the pest and this is the first record of *Closterocerous* sp., as a leaf miner parasitoid in Sri Lanka. The intensity of parasitism was varying from crop to crop and organically grown vegetable crops showed higher percentage of parasitism than the conventionally managed fields. As the natural parasitism of *L. sativa* is high in vegetable crops the usage of pesticides should be discouraged and conservation methods of the parasitoids should be encouraged.

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