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Identification of Parasitoids and Seasonal Parasitism of the Agromyzid Leafminers Genus *Liriomyza* (Dip.: Agromyzidae) in Varamin, Iran

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ABSTRACT

The agromyzid leafminers, *Liriomyza sativae* Blanchard and *L. trifolii* (Burgess) (Diptera: Agromyzidae) are major pests that attack vegetables in Varamin, Tehran Province. The parasitoids (Hymenoptera: Eulophidae) of these pests were investigated during 2003. The leafminer infested leaves were collected from different host plants, in particular cucumber (*Cucumis sativus* L.,) and preserved under laboratory conditions until the parasitoids emerged. The vegetable leafminer were parasitized by an expected range of parasitoids. The parasitoid species included *Cirrospilus vittatus* Walker, *Hemiptarsenus zilahisebessi* Erdös, *Closterocerus formosus* Westwood, *Diglyphus isaea* (Walker), *Diglyphus crassinervis* Erdös. and *Pnigalio* sp. nr. *pectinicornis*. The most common species was *D. isaea*, followed by *C. formosus* and *D. crassinervis*. Although insecticides were applied continuously for control of leafminers, the mean seasonal percentage of parasitism was 51.12%. The morphological characteristics of each species are given in brief.

Keywords: Eulophidae, Leafminer, *Liriomyza*, , Parasitoid, Varamin(Iran).

INTRODUCTION

The genus *Liriomyza* contains more than 300 species which are widely distributed in the New and Old Worlds, but most occur naturally in temperate regions (Parrella, 1987). The agromyzid leafminers, *Liriomyza sativae* and *L. trifolii* cause direct and indirect damage to a wide variety of vegetable crops and ornamentals (Murphy and LaSalle, 1999). The damage caused to their host plants is very similar for both species. The larval stages feed within the leaves of the host plants and, at high densities, severely reduce yields or kill the plants (Spencer, 1990). The biology of *L. sativae* is not well studied in Iran because, until fairly recently, it was confused with other similar species such as *L. trifolii* (Burgess) and *L. congesta* (Becker). *Liriomyza sativae* had first been reported in Khoozestan (Kalantar-Hormozi *et al.*, 2000). It also has a wide distribution in the New World, but is a more recent invader of the Old World, where a rapid range expansion is currently occurring in Eastern Asia (Murphy and LaSalle, 1999). *Liriomyza sativae* has the potential to spread in any suitable habitat with a warm temperature, especially in glasshouses where temperatures are more suitable for its reproduction and viability. The application of insecticides for control of agromyzid leafminers is disruptive to biological control agents and outbreaks are sometimes reported following chemical treatments (Johnson *et al.*, 1980). Several studies have shown that problems with *L. sativae* and *L. trifolii* can result from the overuse of pesticides, with the resultant decimation of effective natural enemies and the development of pesticide resistance (Keil *et al.*, 1985).

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Many species of the families Braconidae and Eulophidae are important parasitoids of agromyzid leafminers. Noyes (2004) listed over 300 species of agromyzid parasitoids, and over 80 species that are known to attack various *Liriomyza* species. In Asia, there are several regional reviews of leafminer parasitoids (Petcharat *et al*., 2002; Xu *et al*., 1999; Zhu *et al*., 2000, 2002 and 2003). Sheng *et al*. (1999) studied the chalcidoid parasitoids of *Liriomyza sativae*. The precise identification of the parasitoids is an essential part of biological control programs. Agromyzid leafminers have never been investigated for their associated parasitoids in Iran. The objective of this study was to identify the parasitoids and level of parasitization of the *L. trifolii* and *L. sativae* in Varamin (Tehran Province).

MATERIALS AND METHODS

The survey on parasitoids of the vegetable leafminer was carried out during August to December 2003 in Varamin. The infested leaves of different host plants consisting of bean, *Phaseulus vulgaris* L., cucumber, *Cucumis sativus* L., tomato, *Lycopersicon esculentum* Mill. and watermelon, *Citrullus lanatus* (Thunb.) were collected at two-week intervals from glasshouses and fields and transferred in plastic bags to the laboratory. The materials were then placed in petridishes and covered with a layer of filter paper. The petridishes were placed inside the incubator under constant conditions (temperature of 25±1°C, relative humidity 0±5% and under 16 Light: 8 Dark photoperiod). The wasps that emerged were collected daily using an aspirator and stored in 75% ethyl alcohol for future work. In the case of cucumber, the numbers of adult parasitoids that emerged from 20 infested leaves were counted separately for each species. All of the cucumber-growing fields were commercial and were treated with chemical pesticides frequently. The parasitoids were identified according to the reliable keys (Gates *et al*, 2002; LaSalle and Parella, 1991; Zhu *et al*., 2000, 2002 and 2003). Specialists in agromyzid and chalcidoid taxonomy also identified all species of leafminers and parasitoids. The illustrations were prepared using a stereomicroscope with a drawing tube. Some of the specimens from each species were deposited in the collection of the Department of Entomology, Collage of Agriculture, Tarbiat Modares University.

RESULTS AND DISCUSSION

In Varamin, the vegetables were attacked by two important agromyzid species, *L. sativae* and *L. trifolii*. The adults of *L. sativae* are principally yellow and black in color, but the shiny black mesonotum of *L. sativae* is used to distinguish this fly from the closely related species serpentine leafminer, *L. trifolii,* which has a grayish black mesonotum. Also, the black hind margin of the eyes serves to distinguish this insect from *L. trifolii*, which has eyes with yellow hind margins. These agromyzid leafminer were attacked by a number of parasitoids that included *Cirrospilus vittatus* Walker, *Hemiptarsenus zilahisebessi* Erdös, *Closterocerus formosus* Westwood, *Diglyphus isaea* (Walker), *Diglyphus crassinervis* Erdös and *Pnigalio* sp. nr. *pectinicornis*. All known parasitoids belong to the family Eulophidae. The populations of both agromyzid leafminer species were most abundant in the autumn. *Liriomyza sativae* was the major agromyzid species infesting vegetable crops in the Varamin area. However, *L. trifolii* was found in lower numbers. These were the only agromyzid species reared from the infested crops. The percentage of parasitism of each parasitoid species during the growing season is given in Figure 1. *Diglyphus isaea* was the most common species and included 30.62% of the total adult parasitoids reared from infested leaves. It was active throughout the growing season and increased in number as the leafminer populations increased. *Closterocerus formosus* was the next most abundant species and made up 28.91% of total parasitoids. *Diglyphus*

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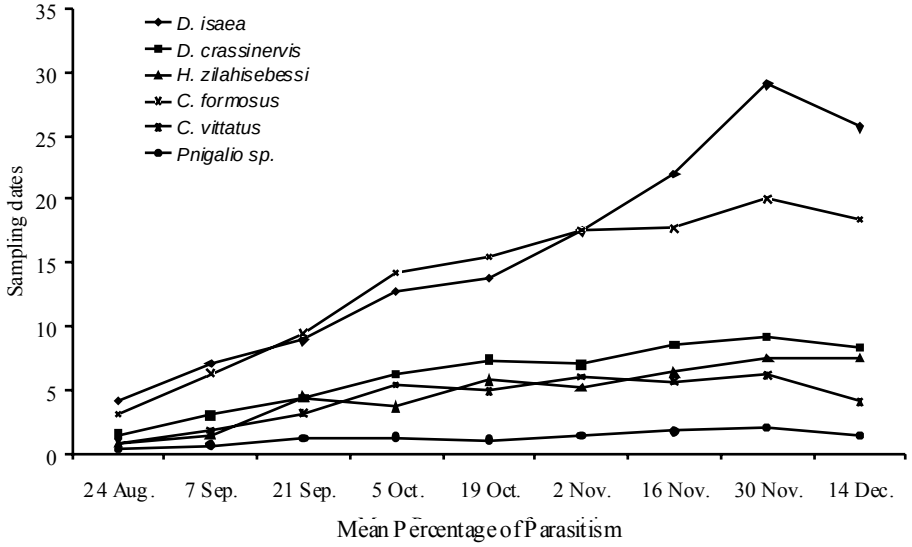

Figure 1. Percentage of parasitism in *Liriomyza* leafminers during August–December 2003 in Varamin, Tehran Province.

crassinervis, *H. zilahisebessi* and *C. vittatus* were found in low numbers. The percentage of parasitism caused by all parasitoids ranged seasonally from 17.54% in mid summer to 73.08% in late autumn. The mean seasonal percentage of parasitism in *Liriomyza* leafminers by all parasitoids was 51.12%. However, insecticides were applied continuously for leafminer control. Our findings on the percentage of parasitism agree with those reported by Johanson (1987) for natural parasitism of *L. sativae* and *L. trifolii* on watermelon in Hawaii and was higher than those reported by Cheol *et al.* (2002) for *L. trifolii* on tomato in South Korea.

Notes on the Species:

***Diglyphus isaea* (Walker)**

Diagnosis: Body length 1.5 to 1.7 mm. in the female and 1.3 to 1.5 mm. in the male (Figure 5 d); antenna dark brown, scape cylindrical in lateral view, funicle 2 segmented, clava 3 segmented (Figure 2c); pronotum triangle shaped in dorsal view, mesoscutum with incomplete notauli, scutellum with parallel submedian grooves (Figure 4c); postmarginal vein as long as stigmal vein, cubital vein strongly curved at base, speculum rather narrow, sometime effaced (Figure 3c).

Hosts and Distribution: *Diglyphus isaea* had been reported for the first time from Tehran and West Azerbayjan as a parasitoid of *Liriomyza cicerina* Rondani (Adldoost, 1995). However, in this research, it was reared from *L. sativae* and *L. trifolii* in Varamin as a new host records. This species is a larval ectoparasitoid of various species of the leafminers, especially Agromyzidae. It has also been recorded on *Lyonetia clerckella* (L.)(Lep.: Lyonetidae) and Tephritidae (Boucek and Askew, 1968; Zhu *et al.*, 2000; LaSalle and Parrella, 1991).

Diglyphus isaea is widely distributed in Afrotropical, Pacific, Oriental (Zhu *et al.*, 2000) and Palearctic regions (LaSalle and Parrella, 1991) and can be considered as a cosmopolitan species because introductory releases have been carried out in the United States, Canada and New Zealand (Noyes, 2004).

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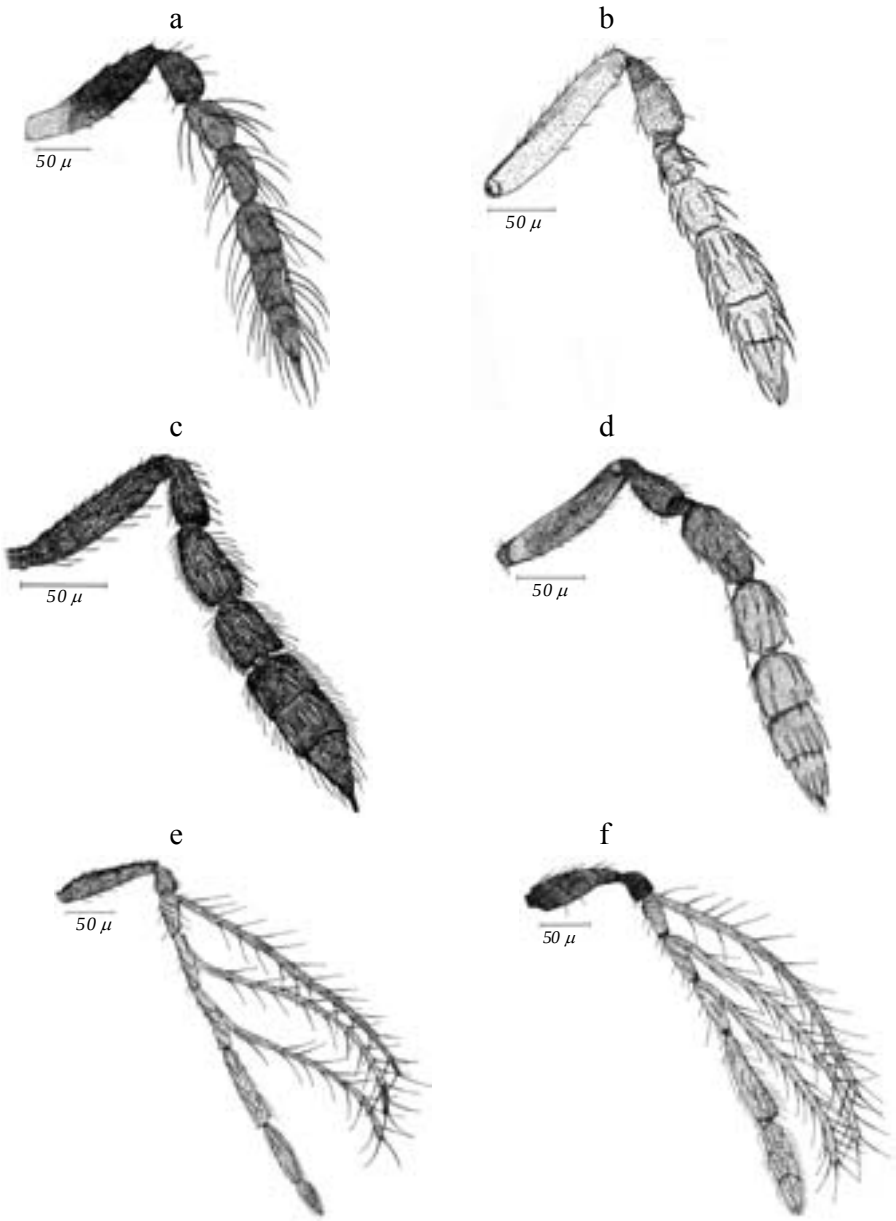

Figure 2. Antennae, (a) *Closterocerus formosus* (♂), (b) *Cirrospilus vittatus* (♂), (c) *Diglyphus isaea* (♀), (d) *D. crassinervis* (♀) (e) *Hemiptarsenus zilahisbessi* (♂) (f) *Pnigalio* sp. (♂).

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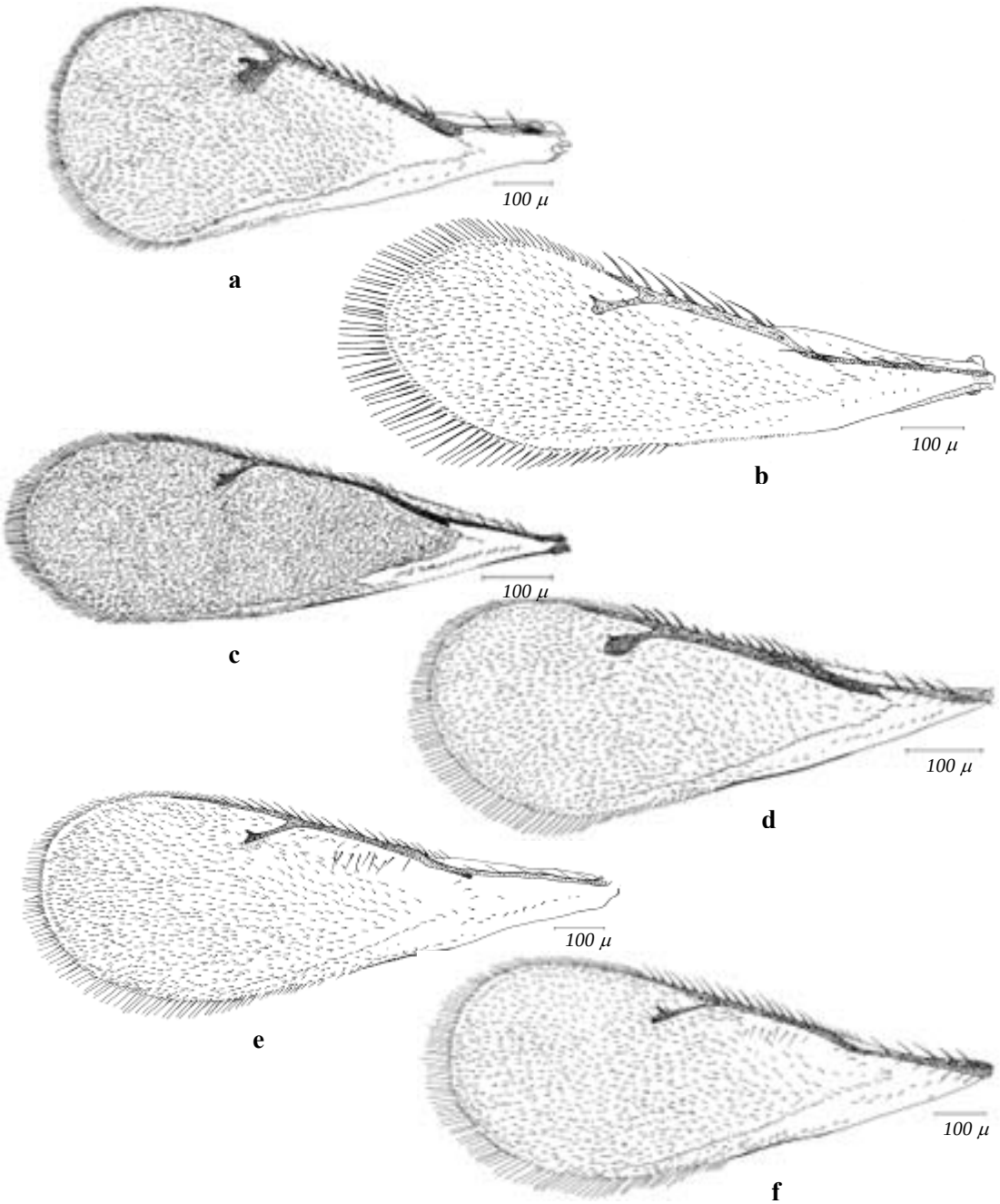

Figure 3. Forwing, (a) *Closterocerus formosus*, (b) *Cirrospilus vittatus*, (c) *Diglyphus isaea*, (d) *D. crassinervis*, (e) *Hemiptarsenus zilahisbessi*, (f) *Pnigalio* sp.

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Diglyphus crassinervis (Erdös, 1958)

Diagnosis: Body length 1.7 to 1.9 mm. in the female and 1.6 to 1.8 mm. in the male; body metallic dark brown (Figure 5c); antenna dark brown with scape metallic, first funicular segment longer than pedicel (Figure 2d); postmarginal vein longer than stigmal vein, forewing veins swollen, stigmal vein knob-like (Figure 3d).

Hosts and Distribution: *D. crassinervis* is recorded here for the first time from Iran. No data are available on this species from *L. sativae* in other areas of the world. The host range of this parasitoid is limited to the species of Agromyzidae such as *Liriomyza huidobrensis* (Blanchard), *L. trifolii*, *Paraphytomyza populi* (Kltb.), *Phytomyza atricornis* Meigen and *Chromatomyia horticola* (Goureau), (Zhu *et al*., 2000; Noyes, 2004).

Diglyphus crassinervis has been reported from Iraq, Egypt (Anonymous, 1971), England, France (Boucek and Askew, 1968); Turkey (Bulut and Gocman, 2000) and Germany (Noyes, 2004).

***Cirrospilus vittatus* (Walker)**

Diagnosis: Body length 1.3 to 1.5 mm. in the female and 1 to 1.2 mm. in the male; body mainly yellow, with dark metallic strips on head and thorax, nutauli complete and weakly curved, reaching scutellar margin, scutellum flat, with parallel submedian grooves that may be difficult to discern, dorsellum as long as propodeum medially (Figures 4b and 5a); scape cylindrical in lateral view, pedicel longer than 1st funicular segment (Figure 2b); forewing without fuscous markings, cubital line strongly curved at base, postmarginal vein shorter than stigmal vein (Figure 3b).

Hosts and Distribution: *Cirrospilus vittatus* was reported for the first time from Iran (West Azerbayjan) as a parasitoid of *Stigmella malella* (Stainton) (Radjabi, 1986) but, in this research, it was reared from leafminers *L. sativae* and *L. trifolii* in Varamin. It is a common primary parasitoid of Cosmopterigidae, Elachistidae, Gracillaridae, Heliozelidae, Lyonetiidae, Phyllocnistidae and Stigmellidae (Lepidoptera); *Liriomyza trifolii* and *Liriomyza huidobrensis* (Blanchard) (Diptera: Agromyzidae); Cimbicidae and Tenthredinidae (Hymenoptera) (Zhu *et al.*, 2002; Noyes, 2004).

This species is known from the Palearctic (Zhu *et al.*, 2002), Canada (Huber and Moreau, 2003), Germany and the United States (LaSalle and Parrella, 1991).

***Hemiptarsenus zilahisebessi* (Erdös)**

Diagnosis: Body length 1.7 to 1.9 mm. in the female and 1.5 to 1.7 in the male; body brown with shiny metallic colouring (Figure 5e); torulus situated above the lower margins of eyes and the scape extends beyond level of vertex, scape completely dark, funicle 4 segmented, basal 3 segments of funicle branched in males (Figure 2e); forewing long and narrow, postmarginal vein longer than stigmal vein (Figure 3e); mesosoma elongated and dorso-ventrally flattened, scutellum without submedian or sublateral grooves (Figure 4d), dark parts of metasoma non-metallic (Figure 5e).

Hosts and Distribution: *H. zilahisebessi* has been recorded on *L. bryoniae* (Kaltenbach), *L. congesta* and *L. trifolii* (Agromyzidae: Diptera); *Hypurus* sp. (Curculionidae: Coleoptera) and *Stigmella* sp. (Nepticulidae: Lepidoptera) (Noyes, 2004).

This species has been recorded from Bulgaria, China (Zhu *et al.*, 2000), Egypt (Trjapitzin, 1978), France, Poland, Turkey (Boucek and Askew, 1968) and South Korea (Yefremova, 2002).

***Closterocerus formosus* (Westwood)**

Diagnosis: Body length 1.2-1.4 mm in the female and 1-1.2 mm in the male; body dark brown (Figure 5b); funicle 2 segmented; clava 4 segmented and apical segment very small and narrow (Figure 2a); mesoscutal midlobe with 4 setae, notauli straight and incomplete (Figure 4a); submarginal vein

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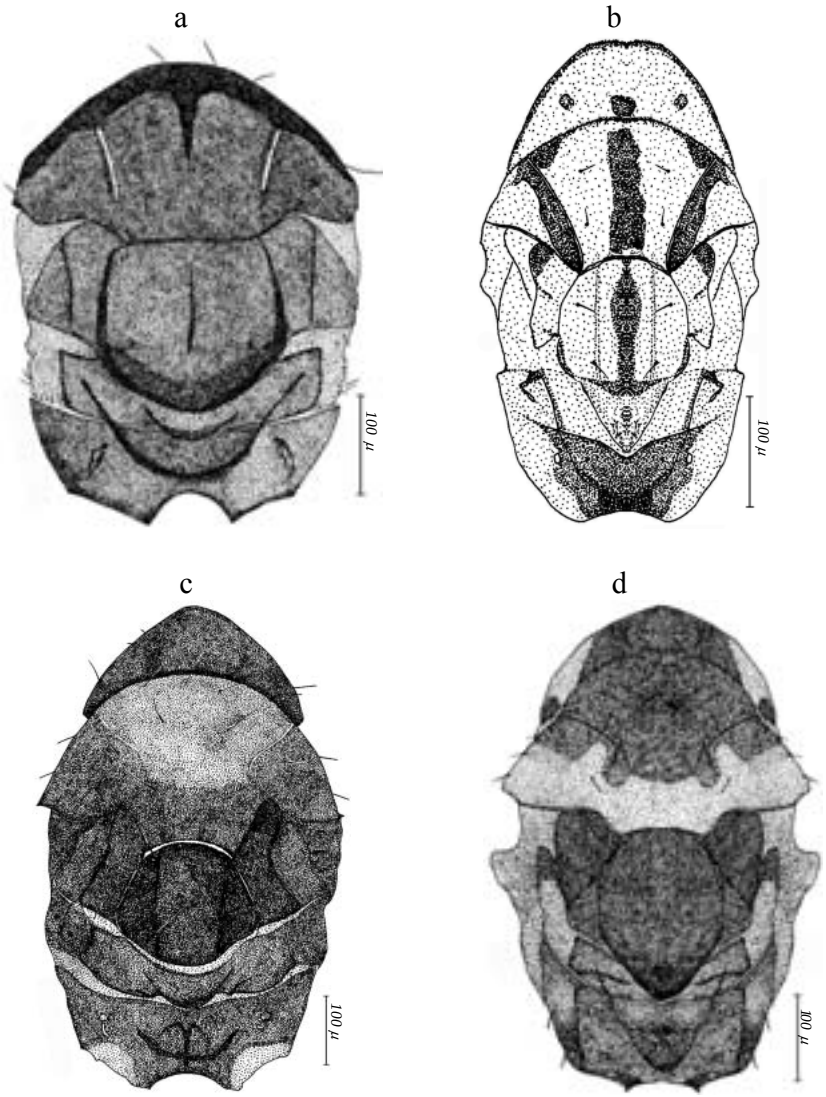

Figure 4. Thorax, (a) *Closterocerus formosus*, (b) *Cirrospilus vittatus*, (c) *Diglyphus isaea*,

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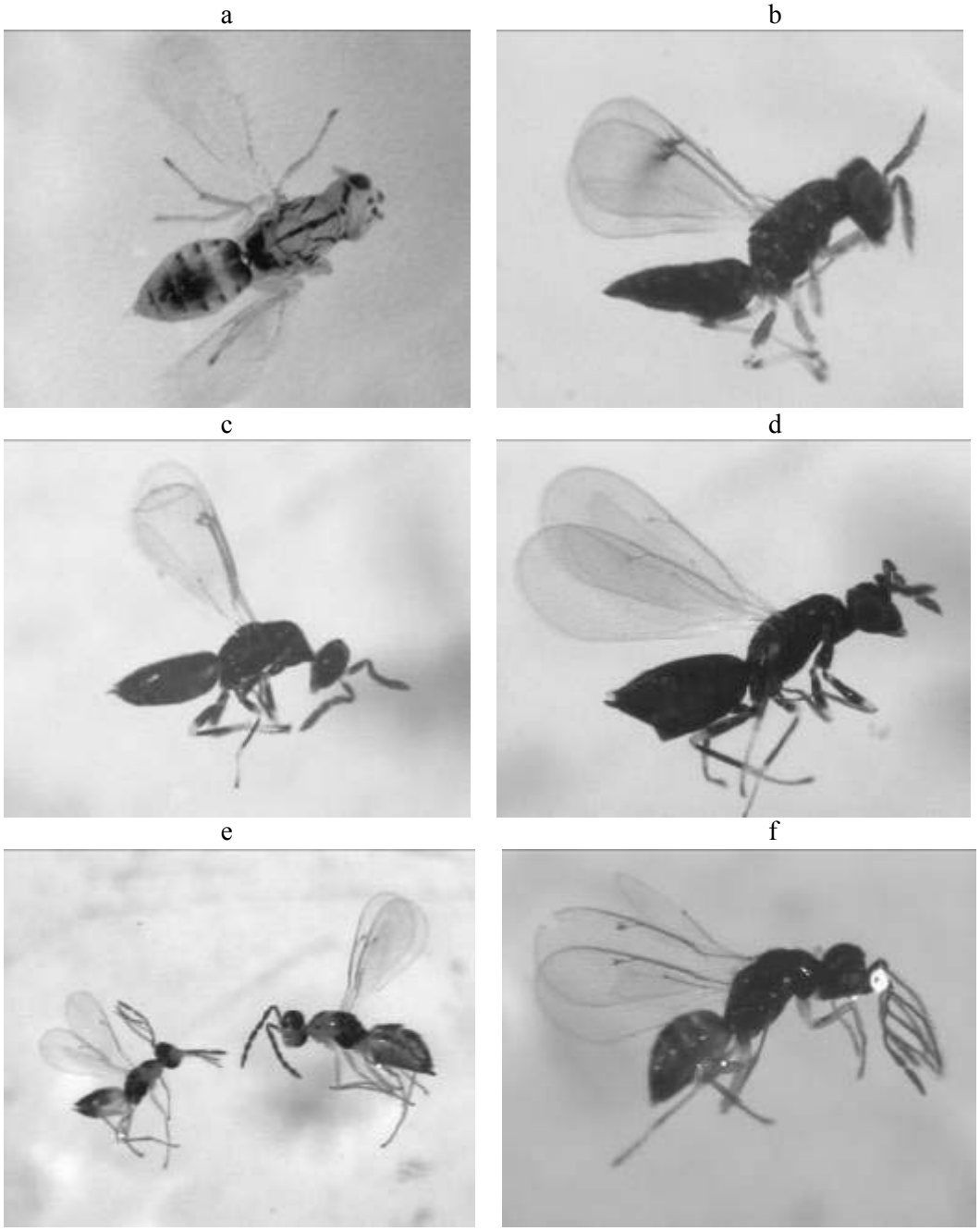

Figure 5. Adults (a) *Cirrospilus vittatus* ♀, (b) *Closterocerus formosus* ♂, (c) *Diglyphus crassinervis* ♂, (d) *D. isaea* ♀, (e) *Hemiptarsenus zilahisbessi* ♂♀, (f) and *Pnigalio* sp. ♂.

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with 2 dorsal setae, postmarginal vein subequal or a little shorter than stigmal vein (Figure 3a).

Hosts and Distribution: This species is regarded as larval parasitoid of Chrysomelidae and Curculionidae (Coleoptera), Cimbicidae, Diprionidae, Pamphilidae and Tenthredinidae (Hymenoptera), Pyralidae, Gelechidae, Gracillaridae, Heliozelidae, Lasiocampidae and Lyonetiidae (Lepidoptera) and many species of Agromyzidae such as *Agromyza* sp., *Liriomyza* sp., *Napomyza lonicerella* Hend., *Ophiomyia phaseoli* (Tryon), *Phytomyza* sp. and *Pseudonapomyza dianthicola* Venturi (Noyes, 2004).

Closterocerus formosus is known from Canada (Herting, 1975), Switzerland (Boucek and Askew, 1968), China (Chen *et al.*, 2000), the Canary Islands (Baez and Askew, 1999), Germany (Boucek and Askew, 1968), Denmark and North Africa (Hansson, 1990), France (Herting, 1978), the United Kingdom (Boucek and Askew, 1968), Iran (Anonymous, 1971), Turkey (Bulut and Gocmen, 2000) and the United States (Tyron, 1980).

Pnigalio sp.

Diagnosis: Body length 1.7 to 1.9 in females and 1.5 to 1.7 mm. in males; color of body dark brown, gaster lighter (Figure 5f); notauli incomplete, scutellum without submedian or sublateral grooves, mesoscutal midlobe setose; flagellum with 4 funicular segments, basal 3 funicular segments of the male antenna with long lateral branches (Figures 2f and 5f); postmarginal vein longer than stigmal vein (Figure 3f).

Hosts and Distribution: This species was identified as *Pnigalio* sp. nr. *pectinicornis* by Alex V. Gomuvsky (Schmalhausen Institute of Zoology, Kiev, Ukraine). It is a common parasitoid of Anobiidae, Chrysomelidae, Curculionidae (Coleoptera); *Agromyza* sp., *Phytomyza* sp. (Agromyzidae), *Dacus oleae* (Gmelin) and *Trypeta artemisiae* (Fabricius) (Tephritidae) (Diptera); Tenthredinidae (Hymenoptera) and Elachistidae, Eriocranidae, Gelechidae, Gracillaridae (Lepidoptera) (Noyes, 2004).

P. pectinicornis has been reported from Bulgaria (Tomov, 2002), the Canary Islands (Baez and Askew, 1999), the United Kingdom (Askew and Shaw, 1979), Iran (Haeselbarth, 1989), New Zealand (Yefremova, 2002) and Russia (Boucek and Askew, 1968).

At least 23 species of parasoitoids have been used in biological control programs against *L. trifolii* and *L. sativae* throughout the world (Greathead and Greathead, 1992). In Varamin, the most common parasitoid of *L. trifolii* and *L. sativae* was *D. isaea*. This species appears to be one of the major agents for biological control programs against *L. trifolii* and *L. sativae*. Therefore, further biological and ecological studies are necessary to better understand the influences of *D. isaea* on the population dynamics of these agromyzid leafminers.

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شناسایی پارازیتوییدها و پارازیتیسم فصلی مینوزهای جنس *Liriomyza* (Dip.: Agromyzidae) در ورامین، ایران

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چکیده

مگس‌های مینوز *Liriomyza sativae* Blanchard و *L. trifolii* (Burgess) (Diptera: Agromyzidae) از مهمترین آفات سبزیجات در منطقه ورامین (استان تهران) محسوب می‌شوند. پارازیتوئیدهای این آفات در سال ۱۳۸۲ مورد بررسی قرار گرفت. نمونه‌های برگ‌های آلوده به مینوز از روی میزبان‌های مختلف به ویژه لوبیا (*Phaseolus vulgaris* L.) جمع‌آوری و تا خروج حشرات کامل پارازیتوئید در شرایط آزمایشگاه نگهداری شدند. پارازیتوئیدهای شناسایی شده شامل *Cirrospilus vittatus* Walker، *Hemiptarsenus zilahisebessi* Erdos، *Clesterocerus formosus* Westwood، *Diglyphus isaea* (Walker)، *Diglyphus crassinervis* Erdos و *Pectinicornis* sp. nr. *Pnigalio* بودند. فراوان‌ترین گونه *D. isaea* بود و پس از آن زنبورهای *C. formosus* و *D. crassinervis* از فراوانی بیشتری برخوردار بودند. اگرچه در منطقه ورامین حشره‌کشها به صورت مداوم بکار می‌روند ولی میانگین پارازیتیسم فصلی لارو مینوزها ۵۱/۱۲ درصد تعیین شد. ویژگی‌های مرفولوژیک هر گونه به طور مختصر بیان گردیده است.

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