Species Diversity of *Liriomyza sativae* Parasitoid on Vegetables and Weeds in South Sumatra

Triani Adam[1)], Siti Herlinda[1)], Komarudin[2)], Rosdah Thalib[1)], and Yulia Pujiastuti[1)]
[1)]Department of Plant Pest and Disease, Faculty of Agriculture, Sriwijaya University, Kampus Inderalaya, Jl. Raya Palembang-Prabumulih, km 32, Ogan Ilir, Inderalaya 30662, South Sumatra, Indonesia, Email: trianiadam@yahoo.com
[2)]Agriculture Quarantine Service, Palembang, South Sumatra

Abstract

Parasitoids that associate with *L. sativae* found on lowland vegetables ecosystem in Indonesia have very sparse information. The objective of this research was to identify species of *L. sativae* parasitoids and to analyze their species diversity on various cultivated and non-cultivated plants (weeds). Survey of *L. sativae* parasitoids was conducted on lowland vegetable centers on South Sumatra, such as Gelumbang, Tanjung Raja, Inderalaya, and Talang Kelapa. The adult parasitoids and the apparent parasitism of *L. sativae* were obtained by rearing from infested leaves in the laboratory. Fourteen species of the hymenopterous parasitoids found in the vegetable crops and weeds were *Opius dissitus, Hemiptarsenus varicornis, Asecodes* sp., *Diglyphus albiscapus, Diglyphus* sp., *Neochrysocharis okazakii, Neochrysocharis* sp., *Quadrasticus liriomyzae, Quadrasticus* sp. *Gronotoma micromorpha, Diphoropria kushell, Diphoropria* sp., *Chrysonotomyia* sp., and a mymarid wasp, unidentified species (Mymaridae). The highest apparent parasitism of *L. sativae* was found on cucumber (18.75%), whereas it could achieve up to 100% on weeds. However, *L. sativae* parasitoid abundance was significantly higher for vegetables than that of weeds. *N. okazakii* was parasitoid species that always found at various host plants on South Sumatra. Species diversity index of *L. sativae* parasitoid on cucumber, squash, cowpea, and tomato was higher than that of weeds.

Keywords: Species Diversity, *Liriomyza sativae* Parasitoid, South Sumatra

Introduction

The leafminer fly, *Liriomyza sativae* (Blanchard) (Diptera: Agromyzidae) had spread at various parts of the world, including Indonesia. Currently, *L. sativae* had spread toward lowland vegetables centers in South Sumatra (Herlinda 2003). *L. sativae* is polyphagous insect pest which attacks several vegetables. Several plants which are attacked by this pest for instance are Cucurbitaceae, Solanaceae, and Leguminosae families (Rauf *et al*. 2000). In South Sumatra, plants that are used to be attacked by *L. sativae* consisted of cucumber, tomato, current tomato, eggplant, squash, and several weeds (Herlinda *et al*. 2005a,b).

Plants attacked by *L. sativae* have shown a symptom of white spots due to ovipositor puncture and mines having specific properties that are characterized by linear form, serpentine, and wider mine than that of other species (Murphy & LaSalle 1999). As a consequence, leaves are dry and having brown color with burned appearance. The

attack on high population could result in harvesting failure or death of the plants. The attack of *L. sativae* on cucumber crops at West Java had result in losses up to 60% (Rauf *et al*. 2000).

In order to solve the leafminer problem on vegetable crops, control measure is currently more focused on the utilization of natural enemies from parasitoid guild because it is more effective, but *L. sativae* is chemically more resistant to synthetic insecticides. There are more than 20 parasitoid species found in Indonesia that parasite on *Liriomyza* spp. (Rauf *et al*. 2000). Most of *Liriomyza* parasitoids are belong to *Eulophidae*, *Eucoilidae*, and *Braconidae* families (Susilawati 2002; Cikman *et al*. 2006). The dominant parasitoids that parasite *Liriomyza* spp. at various vegetable crops in Indonesia are *Hemiptarsenus varicornis*, *Opius* sp., and *Asecodes* sp. (Rauf *et al*. 2000). Parasitoids that associate with *L. sativae* found on lowland vegetables ecosystem have very sparse information. The objective of this paper was to identify species of *L. sativae* parasitoids and to analyze their species diversity on various host plants in lowland vegetables center on South Sumatra.

MATERIALS AND METHODS

Survey of *L. sativae* Parasitoid. Survey of *L. sativae* parasitoids was conducted at various altitudes on lowland vegetable centers on South Sumatra area, such as Gelumbang (Muara Enim District), Tanjung Raja (Ogan Komering Ilir District), Inderalaya (Ogan Ilir District), and Talang Kelapa (Banyuasin District). It was carried out from March to August 2005. Synthetic insecticides were not applied to sample crops in this study. The leaves of host plants consisting of cowpea (*Vigna sinensis*), tomato (*Lycopersicum pimpeneliifolium*), squash (*Luffa cylindrica*), and cucumber (*Cucumis sativus*) showing a symptom of mines by the pest were pruned. Leaves from the same species were subsequently put into plastic pouch (size of 5 L) provided with label of location, sampling time, and crop types. The leaves sample from the same crops were put into plastic containers (diameter of 20 cm and height of 25 cm) supported by wire ram to provide space between leaves and container base in laboratory. Glass tube (2 cm in diameter and 12 cm in height) was placed on plastic container lid to accommodate the emergence of leafminer adult and parasitoids. *L. sativae* adult and parasitoids that emerge were daily recorded and subsequently put into vial bottle containing 70% alcohol. Sampling of leaves attacked by *L. sativae* larva was conducted regularly for every 2 weeks during 20 weeks period, or in other words the survey was conducted 10 times per location.

L. sativae parasitoid identification was carried out at Entomology Laboratory, Plant Pest and Disease Department, Faculty of Agriculture, Sriwijaya University by using standard from Konishi (1998). Identification results were subsequently confirmed to Zoology Museum, Biological Research and Development Center, Indonesia Scientific Council, Cibinong, Bogor.

Data Analysis. Tabulation of *L. sativae* fly number as well as the emergence of parasitoid types and number was made for each collection date. Species abundance was determined based on species diversity index which was measured by using Shannon index, Berger-Parker index, and Pielou index (Magurran 1991).

Results and Discussion

Parasitoid Species. Survey results at lowland vegetable centers on South Sumatra has found 14 species of *L. sativae* larva parasitoid that associate with cowpea, tomato, squash, cucumber, ciplukan (*Physalis angulata*), spiny pigweed (*Amaranthus spinosus*), krokot (*Portulaca oleraceae*), letah ayam (*Borreria alata*), dan sembung rambat (*Mikania micrantha*) (Table 1 and 2). Those parasitoid species were *Opius dissitus* (Hymenoptera: Braconidae), *H. varicornis* (Hymenoptera: Eulophidae), *Asecodes sp.* (Hymenoptera: Eulophidae), *Diglyphus albiscapus* (Hymenoptera: Eulophidae), *Diglyphus sp., Neochrysocharis okazakii* (Hymenoptera: Eulophidae), *Quadrasticus* sp., *Gronotoma micromorpha* (Hymenoptera: Eulophidae), *Diphoropria kushell* (Hymenoptera: Diapriidae), *Diphoropria* sp*., Chrysonotomyia* sp*.* (Hymenoptera: Braconidae), and one unidentified species from Myramidae family.

Survey results showed for the first time in Indonesia of seven species and one family that has never been reported before which parasite *Liriomyza* spp., consisting of *D. albiscapus*, *Diglyphus* sp., *D. kushell*, *Diphoropria* sp., *N. okazakii*, *Chrysonotomyia* sp., and Mymaridae family. All of these newly-found species were larval parasitoid, except the last species from Mymaridae family that was an egg parasitoid which parasite *L. sativae* eggs. Out of 14 species found in this study, nine species are belong to Eulophidae family. These parasitoid families were reported as cosmopolitan parasitoid that capable to parasite *Liriomyza* sp. at various parts of the world (Waterhouse & Norris 1987). Rauf *et al.* (2000) has reported that from 13 species of *L. huidobrensis* parasitoid found in Indonesia, 10 species are belong to Eulophidae family (*Asecodes* sp., *Chrysocharis* sp., *Cirrospillus ambiguous*, *Closterocerus* sp., *H. varicornis*, *Neochrysocharis formosa*, *Neochrysocharis* sp., *Pnigalio* sp., *Quadrastichus* sp., and *Zagrammosoma* sp.) and one species of Eucoilidae (*Gronotoma* sp.), *Braconidae* (*Opius* sp.), and Pteromalidae

(*Sphegigaster* sp.) families, respectively. Murphy and LaSalle (1999) found a new phenomenon in which from 37 species of *Liriomyza* spp. parasitoid in Asia, 26 species belong to Eulophidea family, 4 species belong to Pteromalidae family, and 4 species belong to Eucolidae family.

Table 1. Parasitism of *Liriomyza sativae* larvae on four vegetable species in South Sumatra

Spesies Parasitoid	Parasitism of *Liriomyza sativae* (%)			
	Cowpea	Tomato	Squash	Cucumber
Opius dissitus	8.42	8.97	10.61	10.16
Hemiptarsenus varicornis	7.34	7.99	10.87	12.00
Asecodes sp.	7,05	8.85	12.53	8.20
Diglyphus albiscapus	9.77	10.19	13.58	9.24
Diglyphus sp.	8.20	8.17	6.89	9.96
Neochrysocharis okazakii	11.21	10.74	10.25	12.99
Neochrysocharis sp.	9.60	9.24	7.25	10.23
Quadrasticus liriomyzae	11.03	9.00	10.32	10.73
Quadrasticus sp.	7.58	9.11	9.63	8.48
Gronotoma micromorpha	9.24	9.52	11.28	18.57
Diphoropria kushell	0	0	10.28	15,38
Diphoropria sp.	0	5.00	10.63	8.70
Chrysonotomyia sp.	0	0	0	10.00
Unidentified species (Mymaridae)	0	0	4,16	6.66

Based on their life pattern, parasitoids found at this study could be classified into two groups, namely ectoparasitoid and endoparasitoid. The results of direct observation in laboratory and findings from previous studies showed that *Asecodes* sp. and *Crysonotomyia* sp. were endoparasitoid larva, whereas *D. albiscapus* and *Diglyphus* sp. were ectoparasitoid larva. *O. dissitus* is larva-pupa parasitoid on *L. huidobrensis* (Rustam 2002). *H. varicornis* was ectoparasitoid larva on *L. sativae* (Hidrayani 2003). Chin and Ku (1998) stated that *N. Okazakii*, *Neochrysocharis* sp., *Q. liriomyzae*, and *Quadrastichus* sp. are larva endoparasitoid on *L. trifolii*. It is known for the first time that parasitoid do parasite on *L. sativae* egg.

Apparent Parasitism and Parasitoid Abundance. Apparent parasitism or parasitism of *L. sativae* was vary amongst different host plants. The highest apparent parasitism was found on cucumber (18.75%, Table 1), whereas it could achieve up to 100% on weeds. However, based on their abundances, *L. sativae* parasitoid abundance was significantly higher for vegetables than that of weeds (Table 3-7). *L. sativae* population on weeds was very low, sometimes only one larvae was found or even no attack was found on weeds, but parasitoid was still found on weeds in spite of low host larva. *N. okazakii* was parasitoid species that always found at various host plants on South Sumatra (Table 2). *N. okazakii* was still capable to find the host plant on condition of low population which imply that this parasitoid has high searching capacity. According to Quicke (1997), parasitoid having this property was an effective parasitoid in biological control.

Table 2. Parasitism of *Liriomyza sativae* larvae on five weed species in South Sumatra

Parasitoid species	Parasitism of *Liriomyza sativae* larvae (%)				
	Ciplukan	Spiny pigweed	Krokot	Letah Ayam	Sembung Rambat
Opius dissitus	0	0	0	0	0
Hemiptarsenus varicornis	0	0	0	0	0
Asecodes sp.	0	0	0	0	0
Diglyphus albiscapus	41.67	27.78	0	0	0
Diglyphus sp.	100.00	37.50	25.00	0	33.33
Neochrysocharis okazakii	49.00	29.17	41.67	36.46	47.62
Neochrysocharis sp.	37.33	52.08	33.33	0	0
Quadrasticus liriomyzae	0	0	0	0	0
Quadrasticus sp.	0	0	0	0	0
Gronotoma micromorpha	0	0	0	0	0
Diphoropria kushell	0	0	0	0	0
Diphoropria sp.	0	0	0	0	20.00
Chrysonotomyia sp.	0	0	0	0	0
Unidentified species (Mymaridae)	50.00	0	0	0	0

The most dominant parasitoid found in various host plants and locations on South Sumatra were *N. okazakii* and *H. varicornis*. Dominant *N. okazakii* was generally found on all of surveyed host plants (nine species), but dominant *H. varicornis* was only found on tomato, cucumber, squash, and cowpea. There was a trend that parasitoid was in favor of its specific host plant. This phenomenon for instance was found on *H. varicornis*.

Field or laboratory observation showed that this parasitoid tended to be abundance on cucumber and squash compared to other host plants (Table 3-7). This imply that *H. varicornis* was more attracted to Cucurbitaceae family than that of Solanaceae and Leguminosae families. Attractiveness of parasitoid to adhere toward certain host plants was due to the role of chemical compounds or plant allelochemicals. Olivera and Bordat (1996) demonstrated *O*. *dissitus* parasitoid capability to parasite host plant of *Cucurbita pepo* in higher level than *Lectuna sativae* and *Lycopersicum esculentum* plants as the host of *L. trifolii* and *L*. *huidobrensis*. This was due to *C. pepo* plant leaves that contain volatile attractant which attract *O. dissitus* to adhere and to find its host insect.

Table 3. Community characteristic of *Liriomyza sativae* parasitoid on vegetable and weed in Gelumbang

Host plants	Parasitoid specimen number (adults)	Parasitoid species number	Shannon index	Berger-Parker index	Pielou index
Cowpea	54	8	1.90	0.31	0.91
Tomato	74	8	1.84	0.30	0.88
Squash	55	9	1.87	0.33	0.85
Cucumber	43	9	2.01	0.23	0.91
Ciplukan	4	2	0.56	0.75	0.81
Spiny pigweed	3	3	1.10	0.33	1.00
Krokot	2	1	0	1.00	0
Letah Ayam	3	1	0	1.00	0
Sembung Rambat	5	2	0.50	0.80	0.72

In addition to host plants, parasitoid abundance at a habitat was also affected by competition and hyper parasitism. Parasitoid that has less competition capability tended to be removed by strong species, whereas higher parasitism could decrease the primary parasitoid abundance. Takada and Kamijo (1979) reported that *Chrysocharis pentheus* (Walker) has a role as hyper parasite in decreasing parasitism by ectoparasitoid *Diglyphus isae* (Walker).

In addition to two dominant parasitoids above, there was one very interesting species, i.e. *G. micromorpha*. Although its parasitism and abundance was not too high, but this parasitoid has advantages compared to 13 other species found in this study. *G. micromorpha* has thelytoky reproduction type, whereas other species have arrhenotoky type. Abe (2001) stated that thelytoky reproduction type has parthenogenesis properties which produce all female off-springs. This species in general is very useful in biological control because its generation would continue to develop in absence of male parent.

Species Diversity of Parasitoid. Species number of *L. sativae* parasitoid found on plant of Cucurbitaceae family at several locations on South Sumatra was higher (14 species on cucumber and 13 species on squash) than Leguminosae (cowpea) and Solanaceae (tomato), but the least species number of parasitoid was found on five weeds type (Table 3-7). High species number followed by homogenous individual distribution on each species would also produce high species diversity index. Species diversity index of *L. sativae* parasitoid on cucumber, squash, cowpea, and tomato was also higher than that of weeds.

Table 4. Community characteristic of *Liriomyza sativae* parasitoid on vegetable and weed in Tanjung Raja

Host plants	Parasitoid specimen number (adults)	Parasitoid species number	Shannon index	Berger-Parker index	Pielou index
Cowpea	65	9	1.98	0.26	0.90
Tomato	55	9	1.97	0.35	0.90
Squash	47	11	2.20	0.23	0.92
Cucumber	53	10	2.15	0.23	0.93
Ciplukan	5	4	1.33	0.40	0.96
Spiny pigweed	0	0	0.00	0.00	0.00
Krokot	1	1	0	1	0
Letah Ayam	1	1	0	1	0
Sembung Rambat	4	1	0	1	0

Table 5. Community characteristic of *Liriomyza sativae* parasitoid on vegetable and weed in Inderalaya

Host plants	Parasitoid specimen number (adults)	Parasitoid species number	Shannon index	Berger-Parker index	Pielou index
Cowpea	54	9	1.91	0.33	0.87
Tomato	79	9	1.86	0.35	0.85
Squash	59	10	2.16	0.20	0.94
Cucumber	58	9	1.94	0.28	0.88
Ciplukan	2	2	0.69	0.50	1.00
Spiny pigweed	1	1	0.00	1.00	0.00
Krokot	2	2	0.69	0.50	1.00
Letah Ayam	1	1	0	1.00	0
Sembung Rambat	3	2	0.64	0.67	0.92

Table 6. Community characteristic of *Liriomyza sativae* parasitoid on vegetable and weed in Palembang

Host plants	Parasitoid specimen number (adults)	Parasitoid species number	Shannon index	Berger-Parker index	Pielou index
Cowpea	51	8	1.80	0.37	0.87
Tomato	55	9	2.03	0.20	0.92
Squash	49	9	1.91	0.33	0.87
Cucumber	44	8	1.84	0.25	0.89
Ciplukan	3	2	0.64	0.67	0.92
Spiny pigweed	2	2	0.35	0.50	0.50
Krokot	1	1	0	1,00	0.00
Letah Ayam	1	1	0	1,00	0.00
Sembung Rambat	3	2	0.64	0.67	0.92

Table 7. Community characteristic of *Liriomyza sativae* parasitoid on vegetable and weed in Talang Kelapa

Host plants	Parasitoid specimen number (adults)	Parasitoid species number	Shannon index	Berger-Parker index	Pielou index
Cowpea	55	9	1.87	0.29	0.85
Tomato	75	9	1.96	0.28	0.89
Squash	52	10	2.22	0.15	0.96
Cucumber	52	11	2.12	0.25	0.88
Ciplukan	0	0	0.00	0.00	0.00
Spiny pigweed	8	3	0.97	0.50	0.89
Krokot	2	1	0	1.00	0
Letah Ayam	2	2	0	1.00	0
Sembung Rambat	8	2	0.38	0.88	0.55

The difference in *L. sativae* parasitoid species diversity on various host plants was due to differences in niche of those plants. Higher parasitoid species diversity on cucumber, squash, cowpea, and tomato than that of weeds is due to more complex structure of those host plants than that of weeds. The complex structure is manifested from leaf width, number of leaves, trunk height and branches, and more flower number of host plants which provide more recess availability for parasitoid due to denser host plants population that can be accommodated on that recesses. Rusell (1989) stated that more complex structure of plants and vegetations tend to be followed by more diverse of fauna associate with them.

Species diversity of *L. sativae* parasitoid on weeds was low, but information concerning the parasitoid existence on weeds is very important because it has a role as parasitoid colony source if new crop ecosystem would be established. Therefore, weed can be function as natural predator source for subsequent vegetable crops season (*sink*). Moreover, weed can also be function as parasitoid shelter if vegetable crops becoming unsuitable place to live, for instance due to pesticides application. Rodenhouse *et al.* (1992) stated that seasonal weeds existence with an area of 12.5% from cropping area can significantly increase the abundance of natural predators as well as to decrease population and pest attack.

Acknowledgements

Financial support of this research was provided by the 13th Competitive Research Grant, General Directorate of Higher Education, Department of National Education (Budget Year 2005, Contract Number: 021/SPPP/PP/DP3M/IV/2005, April 11th 2005). We thank to Dr. Chandra Irsan for his assistance in identifying parasitoid species.

References

Abe Y. 2001. Egg-pupal and larval-pupal parasitism in the parasitoid *Gronotoma micromorpha* (Hymenoptera: Eucoilidae). *Appl. Entomol. Zool.* 36:479-482.

Chien CC, Ku SC. 1998. The occurrence of *Liriomyza trifolii* (Diptera: Agromyzidae) and its parasitoids on fields of *Gerbera jamesonii*. *Chinese J. Entomol.* 18:187-197.

Cikman E, Beyarslan A, Cuvelek HS. 2006. Parasitoids of leafminers (Diptera: Agromyzidae) from Southeast Turkey with 3 new records. *Turk. J. Zool.* 30:167-173.

Herlinda S, Oktarika CD, Pujiastuti Y, Sodikin E, Rauf A. 2005a. Pengaruh tanaman ketimun dan tomat pada perkembangan lalat pengorok daun, *Liriomyza sativae* (Blanchard) (Diptera: Agromyzidae). *Jurnal Tanaman Tropika* 8:82-94.

Herlinda S, Rosalina LP, Pujiastuti Y, Sodikin E, Rauf A. 2005b. Populasi dan serangan *Liriomyza sativae* (Blanchard) (Diptera: Agromyzidae) pada pertanaman ketimun. *Jurnal HPTT.* 5:73-81.

Herlinda S. 2003. Ecology of *Liriomyza* spp. (Diptera: Agromyzidae) in field vegetables in South Sumatera, p. 60-66. *In*: Organic Farming and Sustainable Agriculture in the Tropics and Subtropics. Proceedings of an International Seminar, Palembang Oktober 8-9, 2003. Sriwijaya University Publishers, Inc. Palembang.

Hidrayani. 2003. *Hemiptarsenus varicornis* (Girault) (Hymenoptera: Eulopidae), parasitoid *Liriomyza huidobrensis* (Blanchard) (Diptera: Agromyzidae): Biologi dan tanggap fungsional, serta pengaruh jenis tumbuhan inang dan aplikasi insektisida [Disertasi]. Bogor: Program Pascasarjana, Institut Pertanian Bogor.

Konishi K. 1998. *An Illustrated key to the Hymenopterous Parasitoids of Liriomyza trifolii in Japan*. Reprinted from The Miscellaneous Publication of the National. Institute of Agronomic Environmental Sciences. No. 22. March. 1998, Japan.

Magurran AE. 1988. *Ecological Diversity and Its Measurement.* Princeton University Press. New Jersey. 179 p.

Olivera CR, Bordat D. 1996. Influence of *Liriomyza* species (Diptera: Agromyzidae) and their host plants, in oviposition by *Opius dissitus* females (Hymenoptera: Braconidae). *J. App. Ent.* 13: 399-404.

Quicke DLJ. 1997. *Parasitic Wasps*. London: Chapman & Hall.

Murphy ST, LaSalle J. 1999. Balancing biological control strategies in the IPM of new world invasive *Liriomyza* leafminer in field vegetables crops. *Biocontrol News Inform* 20:91-104.

Rauf A, Shepard BM, Johnson MW. 2000. Leafminers in vegetables, ornamental plants and weed in Indonesia: surveys of host crops, spesies composition and parasitoids. *Int J. Pest. Manage.* 46:257-266.

Rodenhouse NL, Barrett GW, Zimmerman DM, Kemp JC. 1992. Effects of uncultivated corridors on arthropod abundances and crop yields in soybean agroecosystems. *Agric. Ecosyst. Environ.* 38:179-191.

Russell EP. 1989. Enemies hypothesis: A review of the effect of vegetational diversity on predatory insect and parasitoids. *Environ. Entomol.* 18:590-599.

Rustam R. 2002. Biologi *Opius* sp. (Hymenoptera: Braconidae), parasitoid lalat pengorok daun kentang. Thesis: Graduate Program, Bogor Agricultural Institute, Bogor.

Susilawati. 2002. Komposisi dan kelimpahan parasitoid lalat penggorok daun, *Liriomyza sativae* (Blanchard) (Diptera: Agromyzidae). Thesis: Graduate Program, Bogor Agricultural Institute, Bogor.

Takada H, Kamijo K. 1979. Parasite complex of the garden pea leafminer, *Phytomyza horticola* Gourea in Japan. *Kontyu* 47:18-37.

Waterhouse DF, KR Norris. 1987. *Biological Control: Pacific Prospects.* Melbourne. Inkata Press. 454pp.