Journal of Sustainable Development Science
Vol. 7, No. 1, June 2025, pp. 1-9
e-ISSN: 2715-9140 | p-ISSN: 2722-919X

Interaction of Parasitoids with Leaf Miner Fly (Diptera: Agromyzidae) on Potato and Tomato Plants in Bali

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ABSTRACT

The leafminer fly, *Liriomyza* spp. is one of the important pests that attack the leaves of potato and tomato plants in Bali. The research aims to determine the diversity, abundance, dominance, and parasitization level of parasitoid species associated with *Liriomyza* spp. Which attacked potato and tomato plants in Bali in September 2021-February 2022 using a survey method ranging from mediumlands of 700-1000 masl and highlands >1000 masl. The research used a purposive sampling method by taking 150-250 plant leaves that showed symptoms of larval excretion at the study site. The results showed that parasitoids associated with Liriomyza spp. in September 2021-February 2022 has moderate (1.62 -1.69) diversity (H) index values, abundance (R1) is low (0.84 -1.12), and dominance (D) is low (0.18-0.22). *Opius dissitus* was the most highly associated parasitoid with Liriomyza spp. from September 2021-February 2022. At an altitude of 700-1000 masl and >1000 masl the diversity index (H) of the parasitoids associated with *Liriomyza* spp. has moderate values (1.56 and 1.72), abundance (R1) is low (0.83 and 0.74), and dominance (D) is low (0.26 and 0.19). *Opius chromatomyiae* was a parastioid that has the highest parasitization rate of 26.27% on potato plants at an altitude of > 1000 masl.

Keywords: *Liriomyza* spp., Parasitoids, Potato and Tomato Plants.

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1. INTRODUCTION

Plant potatoes and plants tomato is example plant horticulture which includes in family Solanaceae in abundance planted in Indonesia. Potato plants are a horticultural commodity that is quite strategic in providing food ingredients to support food security (Karjadi, 2016). Tomato plants are one of the multi-purpose commodities, in addition to being used as vegetables and fruits, tomatoes are also often used as a complement to cooking spices, fresh drinks, sources of vitamins and minerals, and natural dyes, even tomatoes can be used as basic ingredients for cosmetics or medicines (Purwati and Khairunisa, 2007).

In the period 2016-2020 (the last five years), potato and tomato production in Bali has decreased. In 2016, Bali Province was able to produce 671 tons of potatoes and 24,806 tons of tomatoes, but in 2020 Bali Province was only able to produce 376 tons of potatoes and 13,811 tons of tomatoes (Bali Provincial Statistics Center, 2020). The decrease in potato and tomato production is due to limiting factors, namely climate factors and OPT (Plant Pest Organisms). One of the OPTs that can

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Vol. 7, No. 1, June 2025, pp. 1-9
e-ISSN: 2715-9140 **|** p-ISSN: 2722-919X

reduce the productivity of potato and tomato plants in the field is the leafminer fly pest *Liriomyza* spp. Sarjan *et al*., (2021), reported the intensity of damage to potato plant leaves by *Liriomyza* spp. of 21 - 74% depending on the potato plant variety. While the intensity of damage to tomato plants by *Liriomyza* spp. is at least 10.12% (Mohan and Anitha, 2018). Types of vegetable plants attacked by *Liriomyza* spp. is from the Cucurbitaceae family (cucumbers), Leguminosae (beans), Solanaceae (tomatoes and potatoes), Asteraceae (asters), Liliaceae (onions), and Brassicaceae (cabbages) (Utama, 2020). To control plant damage due to *Liriomyza* spp attacks until now farmers still use insecticides. However, these control efforts have not been able to suppress the population or damage that occurs to plants (Baliadi, 2009). Integrated Pest Management (IPM) by utilizing natural enemies, especially parasitoids, is a strategy to reduce the negative impacts of using insecticide.

Parasitoids are insects that have the potential to control insect pests. This has been proven by research conducted in the laboratory, greenhouse and in the field with the conclusion that parasitoids are able to significantly suppress the population of leafminer flies (Bader *et al*., 2006).

Supartha (2003) reported that up to 2002 in Bali, seven species of parasitoids were found associated with *Liriomyza* spp. namely *Hemiptarsenus varicornis*, *Opius chromatomiyae*, *Neochrysocharis okazakii* , *N. formosa*, *Asecodes deluchii*, *Pnigalio* sp., and *Quadrastichus liriomyzae* . Research by Susila *et al*., (2005) found eight parasitoids associated with *Liriomyza* spp. in legume plants, namely *N. okazakii*, *A. deluchii*, *H. varicornis*, *Pnigalio katonis*, *Q. liriomyzae*, *Sphegigaster* sp., *Closterocerus* sp., and *O. chromatomiyae*. Meanwhile, Utama (2020) reported that seven species were found, namely *H. varicornis*, *N. okazakii*, *O. dissitus*, *O. chromatomyiae*, *Gronotoma micromorpha*, *Pnigalio* sp., and *Closterocerus* sp. This study aims to determine the community structure, namely species abundance, species diversity, and dominance of parasitoid species associated with *Liriomyza* spp. and the level of parasitoid parasitization on potato and tomato plants in.

2. METHODS

2.1 Time and Place

The research was conducted from September 2021 to February 2022. The research was conducted on potato and tomato plants in Tabanan, Buleleng, Badung, and Bangli districts in Bali. Maintenance and identification of samples were carried out at the Integrated Management of Plant Pests and Diseases Laboratory and Plant Pests Laboratory, Agroecotechnology Study Program, Faculty of Agriculture, Udayana University.

2.2 Materials and tools

The tools used in the study were a binocular stereo microscope, scissors, a 7 cc collection bottle, a brush, a petri dish (to place the specimen to be identified), plastic, plastic cups, gauze, rubber bands, label paper, an altimeter, a pen, a book, a spite / syringe (to take alcohol in the bottle) and a camera. The materials used in the study were samples of potato and tomato plant leaves that had symptoms of *Liriomyza*

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spp. attack and 80% alcohol used to preserve the specimen.

2.3 Methods and Data Analysis

Sampling locations were conducted in several districts in Bali at potato and tomato plant centers with an altitude of 500–1400 meters above sea level (masl). Sampling was conducted at 5–10 locations in several districts in Bali. Leaf sampling in the field was conducted using the Information:

$$H' = -\sum Pi \ln Pi = -\sum \frac{ni}{N} \ln \frac{ni}{N}$$

H' = Diversity index
Pi = ni/N (number of individuals of type I divided by the total number of individuals)
ni = Number of individuals of type I
N = Total number of individuals
Index Value:
< 1.5 : diversity index is classified as low
1.5 – 3.5 : diversity index is classified as moderate
> 3.5 : diversity index is classified as high

The parasitoid abundance index uses the Margalef index (Magurran, 2005). The population abundance index can be formulated:

$$RI = \frac{S-1}{Ln(N)}$$

Information:
RI = abundance index
S = Total species found
N = Total individuals
Index value:
< 2.5 : low species richness
2.5 - 4.0 : medium type of wealth
< 4.0 : high species richness

The dominance index is calculated using the Monheinik index formula, (Magurran, 2005):

"purposive" method, namely by taking leaves that showed symptoms of *Liriomyza* spp. attack. The number of leaf samples taken per location was 150–250 leaves, according to the availability of leaves that had symptoms of attack in each location. The diversity of parasitoids associated with *Liriomyza* was analyzed using the Shannon-Wienner diversity index. The Shannon–Winner diversity index formula (Magguran, 2005) is as follows:

$$D = \sum \frac{ni(ni-1)}{N(N-1)}$$

Information:
D = Dominance index
ni = Total type I individual
N = Total individuals
Index Value:
0.00 < D< 0.30 : low dominance index
0.30 < D < 0.60 :moderate dominance index
0.60 < D < 1.00 : high dominance index

The parasitization rate of parasitoids associated with *Liriomyza* spp. was calculated using the formula (Magurran, 2005):

$$TP = \frac{\sum \text{imago parasitoid A}}{\sum \text{imago Liriomyza} + \sum \text{imago parasitoid A}} \times 100\%$$

Information:
TP = Parasitization rate (%)
∑ parasitoid imago = Number of imago of one of the parasitoids that appear
∑ Liriomyza imago = Total number of *Liromyza* spp. imago that appear

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3. RESULTS AND DISCUSSION

3.1 Results of Parasitoids Identification Associated with Liriomyza spp. on Potato and Tomato Plants in Bali

Based on results identification associated parasitoids with *Liriomyza* spp. namely *Opius disitus* Muesebeck (Hymenoptera: Braconidae), *Opius chromatomyiae* Belokobylskij & Wharthon (Hymenoptera: Braconidae), *Hemiptarsenus varicornis* Girault (Hymenoptera: Eulophidae), *Neochrysocharis okazakii* Kamijo (Hymenoptera: Eulophidae), *Neochrysocharis Formosa* Westwood (Hymenoptera: Eulophidae), and *Pnigalio sp*. (Hymenoptera: Eulophidae). Morphological characteristics are as follows:

3.1.1 Opius dissitus Muesebeck (Hymenoptera: Braconidae)

Based on the identification results, the imago of *O. dissitus* has a black color, legs or femurs are brownish yellow, and has transparent wings with clear veins. On the female abdomen there is an ovipositor or looks pointed while the male imago does not have an ovipositor or looks blunt. According to Schuster and Wharton (1993) the antenna segments of the female imago are 21 segments while the segments of the male imago are 20 segments.

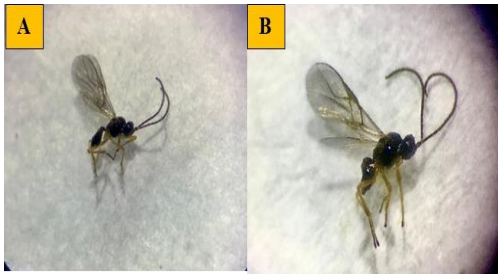

Figure 1. The entire body of the imago parasitoid *O. dissitus Male* (A) and Female (B) at 300x magnification

3.1.2 Opius chromatomyiae Belokobylskij & Wharthon (Hymenoptera : Braconidae)

Based on the identification results of the *O. chromatomyiae* imago, it has a blackish brown color and the legs are brownish yellow but the tarsus is blackish brown. According to Berryman (1981) the antenna segments of the female imago are 25 segments while the male imago has 23 segments.

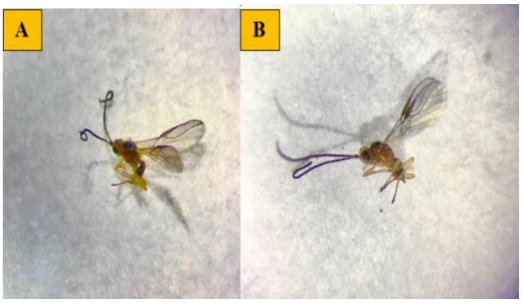

Figure 2. The whole body of the male parasitoid *O. chromatomyiae* imago (A) and female (B) with 300x magnification

3.1.3 Hemiptarsenus varicornis Girault (Hymenoptera: Eulophidae)

Based on the identification results, the imago of *H. varicornis* has a black color and white legs but the tips are blackish. The female imago has an elbow-shaped antenna, straight, long, and at the tip of the antenna is white while in the male imago the antenna is branched like a comb.

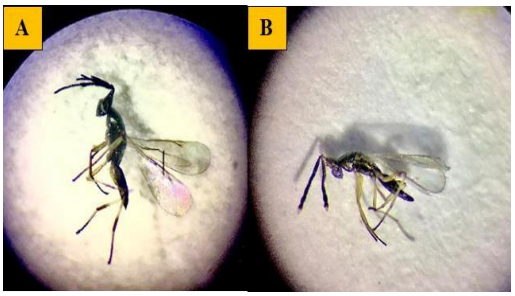

Figure 3 . The whole body of the male (A) and female (B) imago parasitoid H. varicornis with 300x magnification.

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3.1.4 Hemiptarsenus varicornis Girault (Hymenoptera: Eulophidae)

Based on the identification results, *N. formosa* has a metallic green color and its antennae are elbowed and crossed. The femur is white but has black spots.

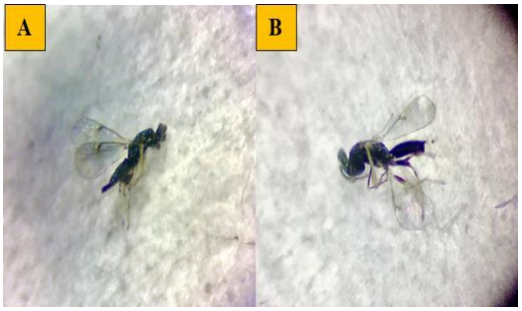

Figure 4. Overall imago body of parasitoid *N. formosa* male (A) and female (B) with 300x magnification

3.1.5 Pnigalio sp. (Hymenoptera: Eulophidae)

Based on the identification results, *Pnigalio sp*. has a blackish metallic blue color. The femur of the leg is white but there are black spots and the tarsus is blackish brown. The abdomen has white spots. The difference between female and male imago lies in the shape of the antenna. The female antenna is elbow-shaped, straight, and long. While the male imago has a branched antenna shape like a comb.

Figure 5. Overall body of the parasitoid *Pnigalio sp* . with 300x magnification

3.2 Identification Associated Parasitoids With Liriomyza spp . In Plants Potatoes and Tomatoes in Bali

Table 1.
Index Diversity, Index Abundance , and Index Dominance of Associated Parasitoids with *Liriomyza* spp. on Plants Potatoes and Tomatoes in September 2021- February 2022

Spesies	Month					
	September	October	November	December	January	February
Opius dissitus	98	126	44	62	40	32
Opius chromatomyiae	58	89	40	33	33	16
Hemiptarsenus varicornis	46	53	36	26	26	12
Neochrysocharis okazakii	42	30	25	20	24	13
Neochrysocharis formosa	30	44	12	13	16	12
Pnigalio sp.	25	32	15	17	15	3
S Parasitoid	6	6	6	6	6	6
N Parasitoid	299	374	172	171	154	88
H	1,68	1,65	1,69	1,65	1,67	1,62
R1	0,88	0,84	0,97	0,97	0,99	1,12
D	0,20	0,22	0,19	0,22	0,18	0,21
L. sativae	182	291	189	206	146	85
L. huidobrensis	106	117	131	104	93	29
L. trifolii	123	194	137	94	82	37

Description: H = Diversity Index, R1 = Abundance Index, D = Dominance Index, S = Number of species found, N = Total Number of Individuals

The results of the analysis showed that the values of the species diversity index (H), species abundance index (R1), and dominance index (D) of the parasitoid *Liriomyza* spp. varied in each month. The diversity index value in each month had a moderate value (1.5 - 3.5), where the diversity index value was 1.62 -1.69 with the lowest index value occurring in February, which was 1.62, while the highest index value was 1.69 in November.

The abundance index value (R1) of Hymenoptera parasitoids against *Liriomyza* spp. on potato and tomato plants that occurred from September 2021 to February 2022 had a low value (<2.5), where the lowest abundance index value occurred in October, namely 0.84, while the highest index value was 1.12 which occurred in February.

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According to Supartha (1998), the high and low diversity and abundance of host insects and parasitoids in the field are influenced by two factors, namely intrinsic and extrinsic factors. Intrinsic factors are genetic resistance, where *Liriomyza* spp. insects are able to create resistance naturally so that they can adapt to changes in the physiology of host plants and their food. While extrinsic factors are environmental factors such as the amount of food resources, climate, competition space, natural enemies, and the influence of pesticides. In addition, intercropping patterns also affect the increasing role of parasitoids in dealing with their hosts (Wahyuni *et. al*., 2017). Mixed cropping systems also increase the stability of parasitoids, through increasing the role of natural enemies caused by the availability of nutritional sources such as nectar for parasitoids (Alteri, 1999).

The dominance index value (D) of *Liriomyza* spp. parasitoids on potato and tomato plants from September 2021 to February 2022 had a low value (<0.30), where the highest Hymenoptera parasitoid index value occurred in October and December, each with a value of 0.22, while the lowest value, namely 0.18, occurred in January (Table 1).

The dominance of species in an ecosystem is influenced by the population abundance value. The dominance value is highly dependent on host availability and ecological conditions. Ecological conditions such as good weather and temperature will affect parasitoid activity in finding hosts (Soegianto, 1994).

3.3 Diversity Index, Abundance Index, and Dominance Index of Parasitoids Associated with Liriomyza spp. on Potato and Tomato Plants at High Altitudes in Bali

The results of the study showed that at an altitude of 700-1000 meters above sea level (masl) parasitoids associated with *Liriomyza* spp. found six types of parasitoids with the highest population were *O. dissitus (*184 individuals), *O. chromatomyiae* (79 individuals), *N. okazakii (* 54 individuals), *H. varicornis* (46 individuals), *N. formosa* (40 individuals), and *Pnigalio sp.* (25 individuals) with a moderate diversity index (1.56), low abundance index (0.83), and low dominance index (0.26). At an altitude of >1000 meters above sea level (masl) also found six species of parasitoids with the highest population were *O. dissitus* (216 individuals*), O. chromatomyiae* (190 individuals), *H. varicornis* (151 individuals), *N. okazakii* (106 individuals), *N. formosa* (85 individuals), and *Pnigalio sp* (82 individuals) with a moderate diversity index (1.72), low abundance index (0.74), and low dominance index (0.19). Differences in altitude affect the diversity and abundance *of Liriomyza* spp. and its parasitoids due to plant maintenance and environmental factors that affect the abundance and diversity *of Liriomyza* spp. According to Supartha *et al*., 2005, the dominance of *Liriomyza* spp. species and their parasitoids is closely related to the types of host plants that are usually abundant at each altitude. When the altitude changes, there will be an increase or decrease in the population of *Liriomyza* spp. which also affects the number of parasitoids. Migration or movement of *Liriomyza* spp. species is related to temperature, altitude and host adaptation at that location. (Kang *et al* ., 2009).

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Table 2.
Diversity Index, Abundance Index, and Dominance Index of Parasitoids Associated with *Liriomyza* spp. on Potato and Tomato Plants at Several Altitudes in Bali

Parasitoid Species	Height	
	700-1000 meters above sea level	>1000 meters above sea level
O. dissitus	184	216
O. chromatomyiae	79	190
H. varicornis	46	151
N. okazakii	54	106
N. formosa	40	85
Pnigalio sp.	25	82
S Parasitoid	6	6
N Parasitoid	428	830
H	1,56	1,72
R1	0,83	0,74
D	0,26	0,19
L. sativae	860	266
L. huidobrensis	303	223
L. trifolii	487	173

3.4 Parasitization Level of Hymenoptera Parasitoids Associated with Liriomyza spp. on Potato and Tomato Plants at High Altitude in Bali

The results of the analysis showed that the parasitization level of each parasitoid found was different in potato and tomato plants at altitudes of 700-1000 masl and >1000 masl. In potato plants at altitudes >1000 masl, the highest parasitization level of parasitoid species occurred in *O. chromatomyiae* (26,27), followed by *H. varicornis* (18,16), *O. dissite* (13.75), *Pnigalio sp* (11.85), *N. okazakii* (9.60), and *N . formosa* (8.05).
Masl, the highest species parasitization rate occurred in *O.* dissitus (22.06), followed by *O. chromatomyiae* (10.84), *N. okazakii* (7.67), *H. varicornis* (6.61), *N. formosa* (5.80), and *Pnigalio sp. (3.70).* At an altitude of >1000 masl, the highest species parasitization rate occurred in O. *dissitus* (10.69) , followed by *H. varicornis (5.48*), *O. chromatomyiae* (5.22), *N. okazakii* (4.96), *N. formosa* (3.97), and *Pnigalio sp* (2.75). The high level of parasitization of *O. dissitus* on tomato plants is thought to be caused by tomato plants in the field generally being cultivated annually by farmers, so that their abundance is maintained throughout the year, making it easier for *Liriomyza* spp. to find these plants. Imago *Liriomyza* spp. tend to choose the same host when they were larvae to lay their eggs, this theory is explained in the Hopkins Host Selection Principle (Hopkins, 1916).

Table 3.
Parasitization Level of Hymenoptera Parasitoids Against *Liriomyza* spp. on Plants Potatoes and Tomatoes at High Altitude Places in Bali

Height	Parasitoid species *Liriomyza* spp.	Parasitoid Parasitization Rate (%) On Host Plants	
		Tomato	Potato
700-1000	*O. dissitus*	22,06	0,00
	O. chromatomyiae	10,84	0,00
	H. varicornis	6,61	0,00
	N. okazakii	7,67	0,00
	N. Formosa	5,80	0,00
	Pnigalio sp.	3,70	0,00
>1000	*O. divided*	10,69	13,75
	O. chromatomiiae	5,22	26,27
	H. varicornis	5,48	18,16
	N. okazakii	4,96	9,60
	N. Formosa	3,97	8,05
	Pnigalio sp.	2,75	11,85

The results of the analysis showed that in potato plants the parasitoid with the highest parasitization rate was *O. dissitus* (26.27) at an altitude of >1000 masl, while in tomato plants the parasitoid *O. chromatomyiae* had the highest parasitization rate (22.06) at an altitude of 700-1000 masl. The high and low levels of parasiticity of parasitoids associated with *Liriomyza* spp. were influenced by the type of host plant and altitude.

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e-ISSN: 2715-9140 **|** p-ISSN: 2722-919X

4 CONCLUSION

Results identification associated parasitoids with *Liriomyza* spp. namely *O. dissitus* Muesebeck, *O. chromatomyiae* Belokobylskij & Wharthon , *H. varicornis* Girault, *N. okazakii* Kamijo, *N. formosa* Westwood , and *Pnigalio sp* . in September 2021-February 2022 had moderate diversity index (H) values (1.62 -1.69), low abundance (R1) (0.84 -1.12), and low dominance (D) (0.18-0.22). *O. dissitus* was the parasitoid most associated with *Liriomyza* spp. from September 2021-February 2022. At altitudes of 700-1000 masl and >1000 masl, the diversity index (H) of parasitoids associated with Liriomyza spp. have moderate values (1.56 and 1.72), low abundance (R1) (0.83 and 0.74), and low dominance (D) (0.26 and 0.19). *Opius chromatomyiae* is a parasitoid that has the highest value, namely 26.27% in potato plants at an altitude of > 1000 masl.

ACKNOWLEDGMENT

The author would like to thank I Made Wahyu Widia Putra as a colleague who has contributed to the implementation of the research, writing the research results and being a fellow typist in writing this journal.

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Vol. 7, No. 1, June 2025, pp. 1-9
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