

Parasitoid Quality of *Gronotoma micromorpha* Parasitizing *Liriomyza huidobrensis* on Chinese Cabbage and Soybean

LA DAHA

Department of Plant Pests and Diseases, Faculty of Agriculture, Hasanuddin University,
Jalan Perintis Kemerdekaan Km. 10, Makassar 90245, Indonesia
Phone/Fax: +62-411-587100, E-mail: drladaha@yahoo.com

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A study with the aim to investigate the quality of *Gronotoma micromorpha* which attack the immature developmental stages of *Liriomyza huidobrensis* has been carried out. Such variables as body length measured from caput to the tip of abdomen, wing span and the length of tibia of hind leg were measured to represent parasitoid quality. The immature developmental stage period of the parasitoid was also recorded. The result indicated that a better quality *Gronotoma* was obtained when it was developed in the *Liriomyza* larvae fed on chinese cabbage with the average of 123.85 μm for body length, 253.45 μm for wing span, and 42.85 μm for the length of hind tibia, respectively. When *Gronotoma* was developed in the *Liriomyza* larvae fed on soy bean, its size became smaller with the average of 97.7 μm for body length, 214.3 μm for wing span, and 37.2 μm for the hind tibia. When it is developed in the *Liriomyza* on chinese cabbage host plant the immature developmental period of *Gronotoma* is slightly shorter with the average of 18.4 and 17.3 days for which developed in the larvae and pupa respectively and on soy bean it become longer with the average of 19.2 days for in eggs, 19.9 days for that in the larvae. On chinese cabbage, *Liriomyza* tend to have bigger size for both flies and pupae.

Key words: *Gronotoma micromorpha*; quality, *Liriomyza huidobrensis*

INTRODUCTION

Liriomyza huidobrensis is one of the most important pest attacking various vegetable crops. The pest invaded Indonesia in 1994 (Rauf *et al.* 1995). In the following years then the pest seemed to spread out over the country in the central of vegetable production areas and in 1998 it was recorded to attack potato plant in Malino (one of major production area in South Sulawesi) (La Daha, unpublished data).

Up to the present time the population of *L. huidobrensis* still high and cause a significant yield reduction especially on potato. No control method available that can be used by the farmers other than the use of insecticide. It is realized that the use of insecticide will bring about the pest to be resistant as reported by Abe and Tahara (2003) in Japan. Insecticide application also cause a negative impact on the such natural enemy as parasitoid (Weintraub 2001; Bjorksten & Robinson 2005; Hossain & Poehling 2006).

In 1999, Australian Government through Department of Horticulture organized a collaborative research to help Indonesia to develop an effective integrated pest managment. The research was focused on identifying of the inportant and dominant parasitoids. During the period of collaboration, the researchers documented 13 parasitoid species attacking *Liriomyza* in Indonesia (Rauf *et al.* 2000). Ten species i.e. *Asecodes* sp., *Chrysocharis formosa*, *Cirrospillus ambiguus*, *Closterocerus* sp., *Hemiptarsenus varicornis*, *Neochrysocharis formosa*, *Neochrysocharis*

sp., *Pnigalio* sp., *Quadrastichus* sp., and *Zagrammosoma* sp., belong to Eulophidae and *Gronotoma* sp., *Opius* sp., and *Sphegigaster* sp. each of which belong to Eucolidae, Braconidae, and Pteromalidae, respectively. Other observation in the Dieng mountainous area of Central Java recorded 12 parasitoid species: *H. varicornis*, *C. ambiguus*, *N. formosa*, *A. delucchii*, *N. beasleyi*, *Chrysocharis* sp., *A. erxias*, *N. okazakii*, *Q. liriomyzae*, *Closterocerus* sp., *G. micromorpha*, and *Opius* sp. (Tantowijoyo & Hoffmann 2010).

In South Sulawesi four parasitoid species (*H. varicornis*, *Gronotoma micromorpha*, *Pnigalio* sp., and *Opius* sp.) were recorded attacking *L. huidobrensis* (La Daha 2002) with *H. varicornis* and *G. micromorpha* seemed to be the dominant or abundant species. *H. varicornis* was found attacking *Liriomyza* in all over centers of vegetable productions in the province while *G. micromorpha* on the other hand was found only in some areas. *Gronotoma* was recorded to be dominant parasitoid of *L. trifolii* in Japan (Konishi 1998) and in Guan, United State of America (Johnson 1993).

Gronotoma is expected to be a more potential parasitoid since it is a thelytoky parasitoid (Arakaki *et al.* 2001) in which all individuals are females and could attack egg and larval developmental stages (Abe 2001; Abe & Tahara 2003). *Hemiptarsenus*, on the other hand, might consist more males than females. Another advantage of *Gronotoma* is an endoparasitoid compared to ectoparasitoid for *Hemiptarsenus*. Stouthamer (1993) argued that in mass rearing, a such thelytokous parasitoid

as *Gronotoma* is more efficient compared to such arrhenotokous parasitoid as *Hemiptarsenus*. It is believed that *Gronotoma* could keep the *Liriomyza* population in such away that the pest would not cause a significant damage. An effort has to be done to establish the parasitoid in the vegetable production areas where it is not found. The question is whether *Gronotoma* could establish in a new area? The answer is that it might depend on the such various factors as host plant and parasitoid quality released as argued by Smith (1996). The altitudinal factor representing the different temperature might also be contributed in the establishment of the parasitoid introduced as reported by Tantowijoyo and Hoffmann (2010). Parasitoids as *N. beasley*, *A. delucchii*, *N. formosa* were restricted at low altitudes, *H. varicornis* and *Opius* sp. were common at high altitudes. Hondo, Koike and Sugimoto (2006) also reported that *N. Formosa* and *H. varicornis* are more tolerant to high temperatures while *P. katonis*, *D. isaea*, *D. minoews*, *D. pusztensis*, and *C. pentheus* are more tolerant to low temperatures.

La Daha (2008) studied the movement of *Gronotoma* in the field that the parasitoid could move as far as seven meters away from the release point after two days of release. The movement ability is considered to be one of the parasitoid quality variables as suggested by Smith (1996).

Smith (1996) mentioned such other quality variables as body length, wing span, and the length of hind tibia. These parasitoid parameters might be associated with the parasitoid size. The bigger parasitoid would have longer body, wing span and hind tibia. It expected that the bigger parasitoid will also produce more offsprings. The wing span might be associated with the movement ability from field to field or from plant to plant and hind tibia might be associated with the ability of the parasitoid in finding host (*Liriomyza*) in a plant. Therefore, the bigger parasitoid would find more hosts and attack or kill them as in the case of parasitoid wasp *Aphidius colemani* Viereck killing of it hosts (*Aphis gossypii*) (Lykouressis *et al.* 2009). For pest insect, there is a positive correlation between body size and fitness (e.g. Tammaru *et al.* 2002; Berger *et al.* 2008). But fitness of the bigger female might be reduced due to thermal induced time limitation during oviposition as reported by Gotthard *et al.* (2007) for the butterfly *Pararge aegeria*.

The objectives of this study were mainly to investigate: (i) the body size of *Gronotoma* as an important component of its quality by measuring its body length, wing span, and tibia length; (ii) the period of its immature developmental stages.

MATERIALS AND METHODS

Preparasiton. The seeds of host plants (chinese cabbage and soy bean) were planted in a medium (a mixture of soil and compost) in a polybag. Five to seven polybags were made in every three days in order to provide the need of host plants during the experiment. To obtain leafminer, *L. huidobrensis*, a number of chinese cabbage

leaves showing leafminer attack were collected from Malino in South Sulawesi with no *Gronotoma* in the area. The leaf samples then placed on a newspaper on the table. The leaves were arranged in such away that not overlapping each other to overcome leaf damage from leaf blight. The daily inspection was made for pupal emergence. The emerged pupae were then collected and placed in a plastic cap. When *Liriomyza* adults emerged, they then were placed in a cage of 0.5 x 0.3 x 0.3 m size and at the same 3 polybags of 2-3-week-old soy bean were placed in the cage for mass rearing as host plants.

To obtain *Gronotoma* for the experiment, a number of chinese cabbage leaves with leafminer attack were collected from Malakaji area (other vegetable production area in the province) in which *Gronotoma* is the common and dominant leaf miner parasitoid. The emerged *Gronotoma* then was mass reared in the laboratory.

The *Gronotoma* Body Size Study. A polybag of soy bean containing *Liriomyza* eggs was placed in a cage and at the same time a number of *Gronotoma* were also placed in to attack the eggs. A 10% honey solution was made available in the cage for the parasitoid. After 24 hours, the soy bean plant was taken out and substituted with a new one. This was done every day until all *Gronotoma* died. The date of plant exposure to *Gronotoma* was recorded. The plant host then was inspected daily for pupal emergence. The emerged pupae then were collected and placed in a plastic cap and daily inspection was made for adult emergence. The emerged *Gronotoma* were then collected for the measurement of quality variables (body length, wing span, and the length of hind tibia). The immature developmental stage period of *Gronotoma* (from date exposure to adult emergence) was also recorded. The same procedure was done for larval or pupal developmental stage of *Liriomyza* fed on chinese cabbage host plant and attacked by the parasitoid. An one way analysis of variance then constructed to compare the data (*Gronotoma* or *Liriomyza*) obtained from the two host plants.

***Liriomyza* Size Observation.** The size of *Liriomyza* could be represented by the size of either pupae or adult flies or by both. But in this trial the size measurement was made on both pupae and adult flies. This trial was carried out to obtain data on *Liriomyza* associated with the *Gronotoma* quality variables. For this purpose, the size of *Liriomyza* developed on both soy bean and chinese cabbage was observed. A number of polybag of the bean of two to three weeks were placed in a cage and offered to a number of leafminer flies to deposit eggs. The plants in the cage were replaced every 24 hours with a new one. This was done until all flies died.

The egg infested plants were daily inspected for pupal emergence. The all emerged pupae were then collected and a number of pupae were sampled randomly. The pupal samples then placed under binocular microscope and with micrometer device the length and diameter of pupae were measured. The remaining pupae were reared for adult emergence. The emerged adults were collected for measurement of body length and wing span.

RESULTS

Quality Variables and the Immature Developmental Stages Period of *Gronotoma*. Based on the availability of samples, the such parasitoid quality variables as body length, wing span and tibia length were only recorded from the *Gronotoma* which attacking or parasitizing the host larvae on both the bean and the cabbage. The immature developmental stage period of *Gronotoma*, on the other hand, was only recorded from the parasitoid parasitizing egg and larval host fed on the bean and parasitizing larval and pupal host fed on cabbage.

The results indicated that the adult of *Gronotoma* developed on *Liriomyza* larvae fed on the cabbage has a significant bigger body size compared to that fed on the bean, i.e. 123.9 μm compared to only 97.7 μm ($P = 0.05$) (Table 1). The same tendency was recorded for wing span and the length of hind tibia with the mean of 253.5 and 42.9 μm respectively on the cabbage compared to that of 214.3 and 37.2 μm on the bean host plants (Table 1). These means showed also a significantly different between different host plants ($P = 0.05$).

The results indicated that, in general, the immature developmental stage period is slightly longer when *Gronotoma* developed in *Liriomyza* fed on the bean plant with the mean of 19.2 and 19.9 days when it was developed from the *Liriomyza* eggs and larvae, respectively (Table 2). Meanwhile the means of the parasitoid developmental stage period were 18.4 and 17.3 days when *Gronotoma* was developed from larvae and pupae of *Liriomyza* fed on cabbage, respectively (Table 2).

The Size of *Liriomyza*. The results indicated that the size of flies and pupae that fed on the cabbage tend to be bigger than that fed on the bean. The mean of body length of the flies fed on the cabbage is 163.3 μm compared to 111.7 μm fed on the bean and these means are significantly different ($P = 0.05$) (Table 3). The significantly different is also recorded for wing span with the mean of 282.7 and 255.7 μm for that fed on the cabbage and on the bean, respectively ($P = 0.05$) (Table 3).

The pupa of *Liriomyza* fed on the cabbage tend to have bigger size with the mean length and diameter are

198.9 and 78 μm compared to 133.5 and 65.3 μm fed on the bean (Table 3).

DISCUSSION

In general, a better quality of *Gronotoma* adults was obtained if the parasitoid developed on *Liriomyza* attacking Chinese cabbage compared to that of from *Liriomyza* attacking the bean. Plant as a host, herbivore, and parasitoid are the first, second and third trophic levels in a ecological food chain. The plant as the first component will produce a great impact on the development of the other components.

L. huidobrensis is a polyphagous herbivore attacking various such vegetable crops as Chinese cabbage, soy bean, potato, tomato, cabbage, and green onion. These host plants might contain different nutrition in both quantity and quality that in turn it will affect the development of *Liriomyza* fed on them. The two vegetable host plants (Chinese cabbage and soy bean) used in this study are different especially in leaf size and also the quality. The cabbage has a larger or wider leaves compared to the bean. A single leaf of the cabbage might be equivalent to seven up to 10 leaves of the bean and that the cabbage assumed to contain more abundant herbivore nutrition over the bean. Consequently, it is not surprising that the leaf miner (*Liriomyza*) attacking the cabbage produced adult flies with a bigger size and a longer wing span as well as producing a bigger pupa (Table 3).

Gronotoma on the other hand will take an advantage. A better quality of *Gronotoma* will be produced when the

Table 2. The means of immature developmental stage period (days) of *Gronotoma micromorpha* on different developmental stages of *Liriomyza*

Host plant	Stage development of <i>Liriomyza</i>	Developmental stage period of <i>Gronotoma</i> (days)
Soy bean	Egg	19.2 \pm 0.6 (n = 11)
	Larva	19.9 \pm 1.9 (n = 12)
Chinese cabbage	Larva	18.4 \pm 1.3 (n = 74)
	Pupa	17.3 \pm 3.9 (n = 6)

n = the number of samples measured.

Table 1. The means of different quality variables of *G. micromorpha* developed from *Liriomyza* larvae on two different host plants

Host plants	No. samples	Size of quality variables (μm)		
		Body length	Wing span	Length of tibia
Chinese cabbage	20	123.9 \pm 14.9a	253.5 \pm 30.1a	42.9 \pm 4.6a
Soy bean	10	97.7 \pm 9.5b	214.3 \pm 30.2b	37.2 \pm 4.5b

Means within a column followed by the different letters are significantly different ($P < 0.05$) by one tail *F*-test.

Table 3. The means of body length and wing span of fly and of pupal length and diameter (μm) of *Liriomyza* developing on two different host plants

<i>Liriomyza</i> developmental stages	Size variables	Host plants	
		Chinese cabbage	Soy bean
Adult flies	Body length	163.3 \pm 35.8a (n = 3)	111.7 \pm 18.7b (n = 14)
	Wing span	282.7 \pm 49.0a (n = 3)	255.7 \pm 37.5b (n = 14)
Pupae	Length	198.9 \pm 41.8a (n = 12)	133.5 \pm 15.3b (n = 4)
	Diameter	78.0 \pm 13.1a (n = 12)	65.3 \pm 8.0b (n = 4)

Means within each row followed by the different letter are significantly different ($P < 0.05$) by one tail *F*-test. n = the number of samples measured.

parasitoid attacks the immature stages of the host (*Liriomyza*) developing on the cabbage. It is represented by body length, wing span and the length of hind tibia which expected to play an important role in seeking and finding host (*Liriomyza*) in the vegetable ecosystem as argued by Smith (1996) for *Trichogramma*. An adult parasitoid with a longer wing span will be able to fly and move faster to long distance from place to place or from one plant to other plant to seek and find host. As the parasitoid lands on a plant, the such other quality variable as tibia length will determine the movement on leaf surface. An adult parasitoid with longer hind tibia will walk and move faster and then seeking and finding more host (eggs and larvae of *Liriomyza*) on the leaves. As a consequence, a such parasitoid as *Gronotoma* with a better quality is expected to find and attack more host population and as a result the parasitoid will much reduce and control the pest population. In addition, a bigger body size of the parasitoid might produce more offsprings compared to the small one. Although this needs to be proved or studied especially for *Gronotoma* but some authors concluded that a bigger female usually has a higher potential fecundity (Tammaru, Esperk, and Castellanos 2002; Berger, Walters, and Gotthard 2008; Gotthard, Berger, and Walters 2007). However, the number of offsprings produced by a female might be finally determined by the environmental microclimates, since for example temperature limits time during oviposition as reported by Gotthard *et al.* (2007) for butterfly *Pararge aegeria*. The developmental stage period of the parasitoid might also be contributed to parasitoid quality. Such parasitoid attributes as the number of offspring and developmental period might give an advantage especially in mass rearing for parasitoid release purposes. A parasitoid with a larger number of offspring and a faster developmental stage period will save time and food materials in the mass rearing program.

Such potential parasitoid as *Gronotoma* can be mass reared and then released in the vegetable area where this parasitoid is not found or uncommon. It seems that *Gronotoma* is one of among parasitoids that commonly adapted only at high altitudes as found in South Sulawesi. *Gronotoma* were commonly found on Chinese cabbage leaves planted above 1000 m ASL. Another study also indicated that *G. micromorpha* was found at 1200 m ASL from snap bean (Tantowijpyo & Hoffmann 2010). However, this parasitoid is not present in Kanreapia (Malino) District with an altitude of 1500 m ASL that we surveyed, one of the main vegetable areas in the province (South Sulawesi). The more abundant or dominant parasitoid in this area is *H. varicornis*. The questions are what factors might restrict the presence or distribution of *Gronotoma* in such area as Kanreapia District and can this parasitoid be established if it is released in both high and low land representing low and high temperature? To answer these questions a number of studies are needed to investigate in detail such factors as environmental microclimates (temperature and relative humidity). They might affect the fitness of the insect as reported by Larsson and Kustvall (1990) for Cerambycid beetle. The ability of

Gronotoma to compete with the native such parasitoid as *Hemiptarsenus* which is commonly found in both high and low altitude is also important to be studied as argued by Smith (1996). He suggested that the native parasitoid had been well adapted to all existing environmental factors of the ecosystems and the native parasitoid might perform a better performance (fitness) compared to the introduced species. Based on this research finding, for release purposes, *Gronotoma* can be mass reared by using Chinese cabbage as host plant since this crop might housing *Liriomyza* with a bigger size in which *Gronotoma* with a bigger size and faster developmental period (a better quality) can be developed in to produce a parasitoid with a better quality.

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