



Research Article

The Diversity and Abundance of Egg Parasitoids in Brown Planthopper, *Nilaparvata lugens* Stål. (Hemiptera: Delphacidae) at Different Rice Growth Phases in Saketi, Pandeglang, Banten

Nurullah Asep Abdilah^{1)*} & Hadi Susilo¹⁾

¹⁾Department of Biology, Faculty of Science and Pharmacy, University of Mathla'ul Anwar
Jln. Raya Labuan KM. 23, Cikaliung, Saketi, Pandeglang - Banten 42273 Indonesia

*Corresponding author. E-mail: nurullah.asep@gmail.com

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ABSTRACT

An extensive study about egg parasitoid biodiversity in different plant growth stages is an important need. This study was aimed to determine the diversity and abundance of egg parasitoids *Nilaparvata lugens* on different rice growth stages in Saketi, Pandeglang, Banten. The parasitoids sample was collected three times with two days interval sampling in three villages, i.e. Sodong (location I), Sindanghayu (location II), and Sukalangu (location III) from February to September 2018. Ten plants (as bait: rice that infected by *N. lugens* eggs) were put during two days along the transect line (100 meters) with 10 m space in between. The findings revealed that the abundance richness (S), the diversity index (H'), and similarity (J') of egg parasitoids of *N. lugens* were higher in the location I than those in the locations II and III. The study indicated that the diversity and abundance of egg parasitoids of *N. lugens* decreased in the generative phase of rice growth.

Keywords: biodiversity; biological control; natural enemy; parasitoid

INTRODUCTION

The existence of egg parasitoids is often overlooked by farmers because of their tiny size (Abdilah, 2015). The egg parasitoids are the natural enemy that control herbivorous insect populations in the ecosystem, thus affecting the dynamics of pest populations. The egg parasitoid of brown planthopper could be used as biological control agents (Meilin, 2012). Brown planthopper, *Nilaparvata lugens* Stal (Hemiptera: Delphacidae), is an important pest of rice that is difficult to be controlled because it has high genetic plasticity that often threatens national rice productivity (Baehaki, 2012). The use of egg parasitoids as biological control agents is considered capable of replacing the previous control techniques of *N. lugens*, such as the use of conventional insecticides and resistant varieties that do still not effective, efficient, and safe for the environment yet (Kartohardjono, 2011). Biological control using egg parasitoids is considered an effective effort because it parasitizes pests in the early phases, so pests do not develop into larvae/nymphs which can cause damage to crops. Egg parasitoids

also have no negative impacts on consumers and the environment; do not cause resistance and resurgence of pests; able to find their host, multiply and spread; the control can run by itself; and relatively easy for rearing (Wilyus *et al.*, 2012). Control of *N. lugens* which is done by the use of resistant varieties and the application of insecticides leads to the emergence of new biotypes of *N. lugens* that are more resistant (Baehaki & Mejaya, 2014) and the disrupt of biodiversity in the paddy ecosystem that leads to the outbreak (resurgence) (Effendi, 2009). The lack of research on *N. lugens* egg parasitoids has been an obstacle in efforts to use it as a control agent of *N. lugens*.

The research on the parasitoid of *N. lugens* egg is currently conducted in laboratories and only in one particular type (Yaherwandi & Syam, 2007). Studies on the diversity and abundance of *N. lugens* egg parasitoids have been conducted in several areas, namely West Sumatra, Bantul Yogyakarta, and Dramaga Bogor. Diversity and abundance of *N. lugens* egg parasitoids show differences between one area and another (Yaherwandi & Syam, 2007;

Meilin, 2012; Abdilah, 2015). Yaherwandi & Syam (2007) reported that 8 species of egg parasitoids could potentially be used as *N. lugens* biological control agents in West Sumatra. Meilin (2012) succeeded in collecting 3 species of egg parasitoids which were potentially used as biological agents of *N. lugens* in Bantul, Yogyakarta. Abdilah (2015) reported 6 species of egg parasitoids have the potential as biological agents controlling *N. lugens* in Dramaga, Bogor. Different ecological conditions might cause the potency of the egg parasitoids to control *N. lugens* are different for each region.

Research on the *N. lugens* egg parasitoid has not been carried out in rice cultivation in Pandeglang District, Banten. Research on the diversity and abundance of *N. lugens* egg parasitoids associated with the plant growth phase needs to be done to determine the ecological conditions in rice fields at different growth phases. The description of ecological conditions, such as the *N. lugens* egg parasitoid species that are present in each phase of rice plant growth is important to be identified in planning and implementing biological control of *N. lugens* in the future, especially in obtaining potential biological agents (Meilin, 2012). This study aimed to determine the diversity and abundance of *N. lugens* egg parasitoids on the different rice growth stages in Saketi District, Pandeglang Regency, Banten.

MATERIALS AND METHODS

Research Implementation

The *N. lugens* egg parasitoids were collected three times with two days interval sampling at the rice fields in three villages, in Saketi, Pandeglang-Banten, i.e. Sodong (location I), Sindanghayu (location II) and Sukalangu (location III). The study was conducted over 8 months, starting February–September 2018 at the Integrated Laboratory, Faculty of Science and Pharmacy, University of Mathla'ul Anwar, Banten.

Description of Sampling Location

Locations I, II, and III are rice fields aged 1.5 months after planting (vegetative phase), 2.5 months after planting (generative initial phase), and 3.5 months after planting (final generative phase). The location I and III were planted by Ciherang variety while location II by IR-64 variety. The three locations

use a monoculture planting system (Figures 1, 2, and 3). The coordinates and altitudes of the three locations are at 6° 23.902'S 105° 58.628' T and 142 meters above sea level (masl), 6° 23.508'S 105° 57.658' T and 113 masl, and 6° 26.942'S 105° 55.569' T and 8 masal for location I, II, and III, respectively.

Experimental Design

This study used a survey method and quantitative descriptive analysis to describe the diversity and abundance of *N. lugens* egg parasitoids. The sampling of *N. lugens* egg parasitoids was carried out using a purposive sampling technique using baited plants.

Population and Sample

The population in this study were *N. lugens* egg parasitoid species found in rice fields in Saketi, Pandeglang, Banten. The sample in this study was all species of *N. lugens* eggs parasitoid collected from rice fields in Saketi, Pandeglang, Banten in 3 villages, i.e. Sodong, Sindanghayu, and Sukalangu. The sample unit in this study was the *N. lugens* egg parasitoid species that emerged from baited plants

Provision of Seeds and Rice Plants

The rice seeds used were 7 days after sowing (das) by soaking 200 grams of Ciherang variety seeds in water over 24 hours. The rice seeds were then rinsed and sown hydroponically in plastic jars (30 cm in top diameter, 25 cm in bottom diameter, 27 cm in height) covered with organdy cloth using a rubber band. Rice seeds were grown into seeds 2–3 das, then maintained daily until the seeds aged 7 das by adding water until humid using a hand sprayer.

The rice plants used were 1 month after sowing by soaking 5 grams of Ciherang variety seeds in water over 24 hours, rinsed and sowing in the planting media in a plastic bucket (21 cm in top diameter, 17 cm in bottom diameter, 19 cm in height). Growing media consists of compost and garden soil in a ratio of 1:1. During seeding, the seeds were watered by a hand sprayer until the planting media becomes moist. Four of the rice seedlings aged 7 days were transferred into new planting media and maintained by adding water every 2 days. Maintenance of rice seeds was also done by pull out the weeds grow on planting media. Seedlings were maintained until they grow into rice plants 1 month after seedling (Abdilah *et al.*, 2016).

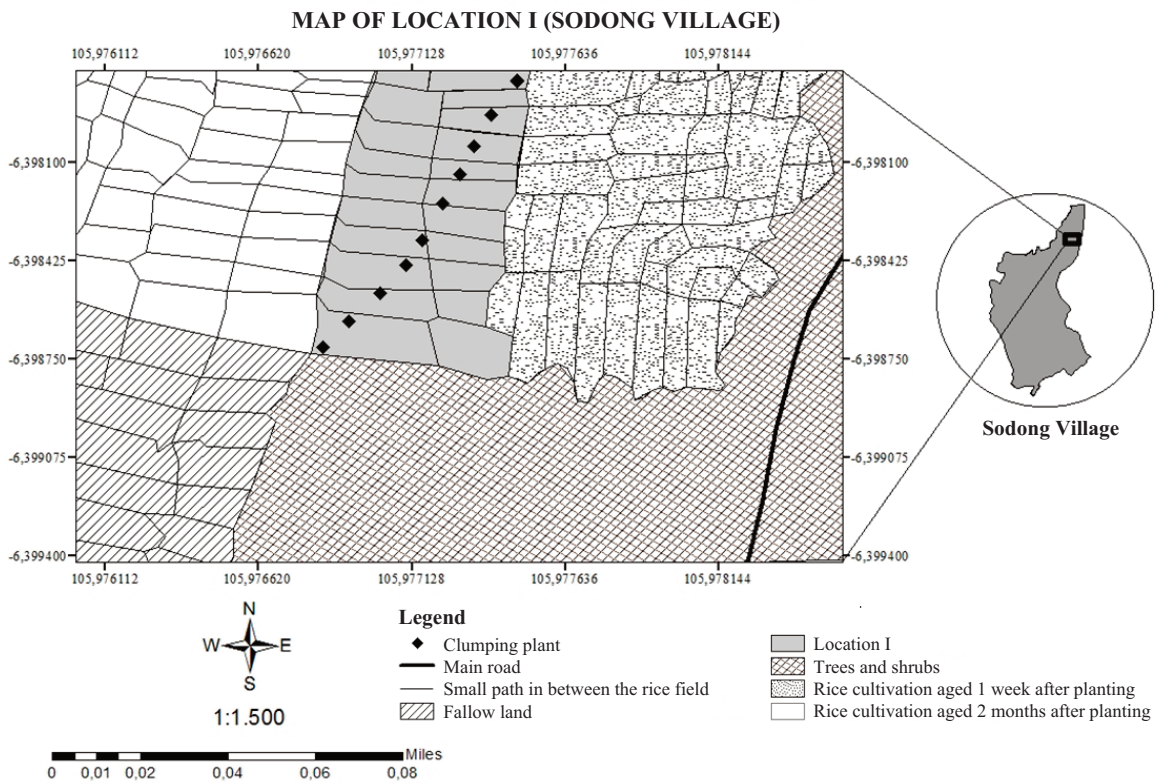


Figure 1. The landscape of the agricultural area in the Sodong Village, Saketi, Pandeglang-Banten (location I)

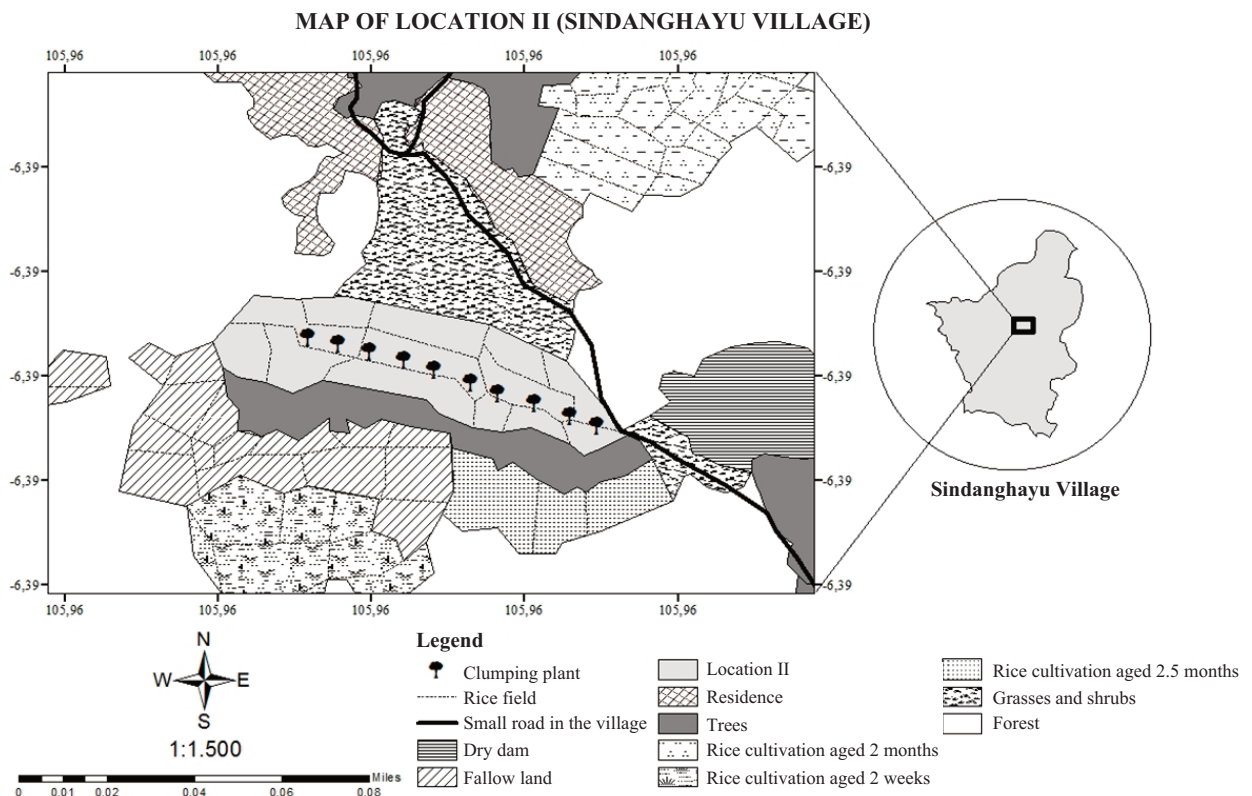


Figure 2. The landscape of the agricultural area in Sindanghayu Village, Saketi, Pandeglang-Banten (location II)

MAP OF LOCATION III (SUKALANGU VILLAGE)

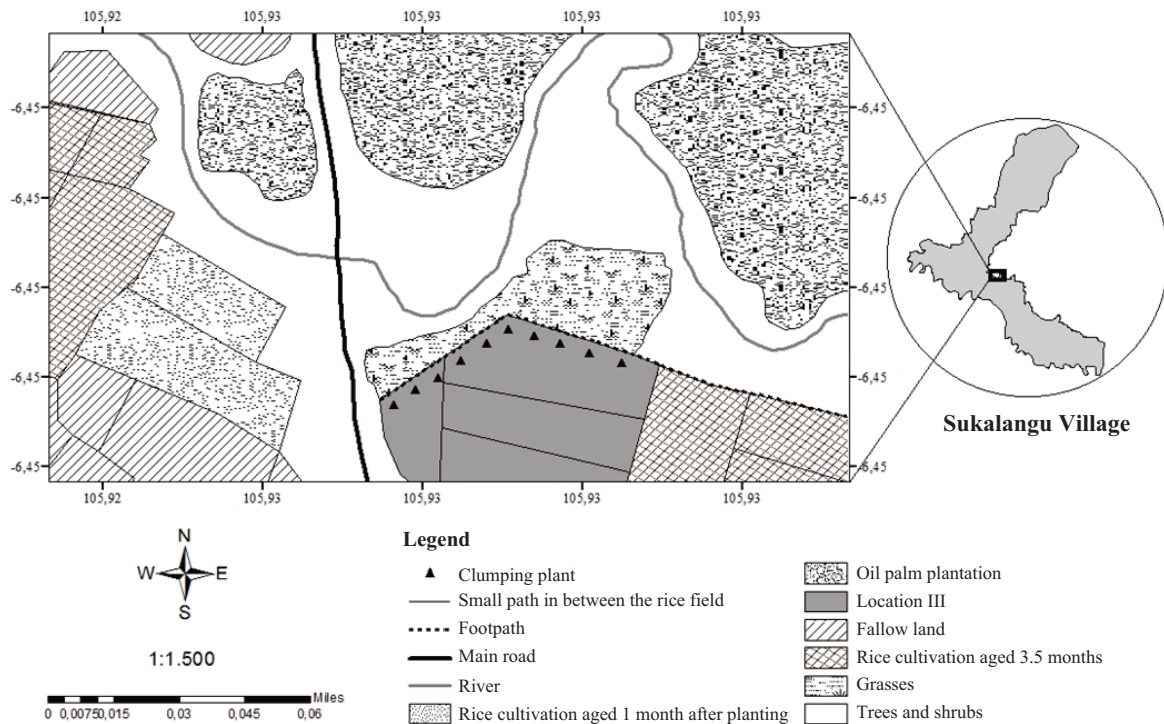


Figure 3. The landscape of the agricultural area in Sukalangu Village, Saketi, Pandeglang - Banten (location III)

Mass Rearing of *N. lugens*

Fifty male and female adults of *N. lugens* were infested using aspirator into rice seedlings aged 7 days were kept hydroponically in plastic jars (30 cm in top diameter, 25 cm in bottom diameter, 27 cm in height). *N. lugens* were reared until a sufficient population of *N. lugens* gravid (sex maturity) was obtained. The rice seedlings were watered by spray bottles every 2 days and removal of *N. lugens* if the rice seedlings became yellow. The transfer of *N. lugens* was done by placing yellowed rice seeds (old media) on 7-day-old rice seeds (new media) supported by rope wire. *N. lugens* would migrate to new media and then the old media would be removed after two days (Meilin, 2012).

Baited Plants Preparation

Rice aged 1 month after the seedlings were transferred to the planting media in plastic cups (10 cm in top diameter, 14 cm in height). Rice was covered with a cylindrical cage (10 cm in diameter, 60 cm in height) of rigid plastic (0.17 mm thick) with the sides and top of the cage covered by organdy cloth as aeration. Rice was infested with 8 gravid

females of *N. lugens* to lay eggs for 2 days. Rice plants that have been infested with *N. lugens* eggs were used as baited plants (Abdilah *et al.*, 2016) then planted to the field in all three locations and placed in rice fields on the specified transect lines.

Specimens Collection of *N. lugens* Egg Parasitoid

Ten baited plants were placed for 2 days along the 100 m transect line with 10 m space in between. Baited plants were brought back to the laboratory, removed the leaves, and then covered with cylindrical confinement (10 cm in diameter, 60 cm in height) of rigid plastic (0.17 mm thick). Baited plants were maintained until the parasitoid adult of *N. lugens* emerged on days 8–14 since the baited plants were planted. The emerged parasitoids were transferred to 96% alcohol in a 5 ml vial bottle using a small brush. Parasitoid specimens were identified up to morphospecies level according to Viggiani & Rao (1978), Triapitsyn (2002), Triapitsyn & Berezovskiy (2004), and Huber & Islam (2017). The identification of the parasitoids were verified at the Laboratory of Entomology, Zoology, Research Center for Biology, LIPI, Cibinong.

Data Analysis

Data on species abundance and evenness from the three locations were analyzed by One-Way ANOVA and then followed by the Tukey test if the results were significantly different ($\alpha = 0.05$). Data of richness, diversity, and dominance of species that did not fit the normal distribution, were analyzed by the Kruskal-Wallis test followed by the Mann-Whitney test ($\alpha = 0.05$). SPSS 16 program was used to perform the analysis.

RESULTS AND DISCUSSIONS

N. lugens egg parasitoids collected from three locations were 5,606 individuals, 5 species in 2 families, i.e. *Anagrus nilaparvatae* (Mymaridae), *Anagrus* sp. (Mymaridae), *Gonatocerus* sp. (Mymaridae), *Mymar* sp. (Mymaridae), and *Oligosita* sp. (Trichogrammatidae) (Table 1). *N. lugens* egg parasitoids collected from this study were more diverse than those reported by Haryati *et al.* (2015) which collected 2 species from 2 families, i.e. *Oligosita* sp. (Trichogrammatidae) and *Anagrus* sp. (Mymaridae) in Bantul, Yogyakarta. Other researchers (Abdilah, 2015) reported that there were 6 species from 3 families of *N. lugens* parasitoid eggs in the Dramaga area, Bogor, i.e. *A. nilaparvatae* (Mymaridae), *Anagrus* sp. (Mymaridae), *Gonatocerus* sp. (Mymaridae), *Tetrastichus formosanus* (Eulophidae), *Oligosita* sp. (Trichogrammatidae), and *Cyrtogaster near vulgaris* (Pteromalidae). In West Sumatra, was found 8 species from 3 families of *N. lugens* egg parasitoids, including *Anagrus* sp. (Mymaridae), *Gonatocerus* sp.A (Mymaridae), *Gonatocerus* sp.B (Mymaridae), *Gonatocerus* sp.C (Mymaridae), *Mymar* sp. (Mymaridae), *Oligosita* sp. (Trichogrammatidae), Trichogrammatidae (sp-2) and Eulophidae (spi-1) (Yaherwandi & Syam, 2007). Different locations

might have different biotic and abiotic conditions that affect the parasitoids in adapting and developing. Parasitoid species with the same host have different adaptability hence the number and composition of species might differ from one region to another (Hamid, 2002; Yaherwandi *et al.*, 2008; Herlina *et al.*, 2011; Abdilah, 2015). One of the biotic conditions is the growth phase of rice. The collection of *N. lugens* egg parasitoids in this study was conducted at different growth stages of rice, whereas Haryati *et al.* (2015) and Abdilah (2015) in the same growth phase of rice thus they showed the number and composition of different species of *N. lugens* egg parasitoids.

The composition and number of families of *N. lugens* egg parasitoids collected from this study were lower than Yaherwandi & Syam (2007) and Abdilah (2015), but similar to Meilin (2012) and Haryati *et al.* (2015) (Table 1). Habitat composition at collection locations by Yaherwandi & Syam (2007) and Abdilah (2015) was a polyculture rice planting area consisting of rice, secondary crops, and wild plants (complex agricultural landscapes). Habitat composition at the collection site of this study, Meilin (2012) and Haryati *et al.* (2015), which is monoculture system (simple agricultural landscapes) might cause similarities in the composition and number of families of the collected *N. lugens* egg parasitoids (Figures 1, 2, and 3). Habitat in simple agricultural landscapes consists of less diverse vegetation than complex agricultural landscapes (Herlinda, 2007), so it does not support the availability of resources such as alternative hosts, adult feed (pollen and nectar), shelter, sustainable availability of feed, and suitable microclimate for survivability of the parasitoid (Yaherwandi, 2009). Therefore, the composition and number of families of *N. lugens* egg parasitoids collected from this study were low.

Table 1. Richness and abundance of *Nilaparvata lugens* egg parasitoids at different collection times and locations

Parasitoid species	Family	Location and collection time								
		Sodong			Sindanghayu			Sukalangu		
		I	II	III	I	II	III	I	II	III
<i>Anagrus nilaparvatae</i>	Mymaridae	30	31	32	19	14	8	3	4	4
<i>Anagrus</i> sp.	Mymaridae	9	7	2	20	2	2	0	3	0
<i>Gonatocerus</i> sp.	Mymaridae	6	0	0	0	0	0	0	0	0
<i>Mymar</i> sp.	Mymaridae	0	3	0	0	0	0	0	0	0
<i>Oligosita</i> sp.	Trichogrammatidae	1104	336	678	1097	478	289	755	404	256
Total individual		1149	377	712	1136	494	299	768	411	260
Total species		4	4	3	3	3	3	2	3	2

Rice plantations in the three locations consisted of different growth phases, but they showed a low diversity index ($H' < 1$) (Figure 4) hence it was possible that the growth phase of rice did not cause the low diversity index. The low diversity index value in the three locations might be because the collection was conducted in the rainy season when the baited plants were in the collection location. High rainfall could disrupt the searching ability and activity of the parasitoids to the host, thereby resulting in the low diversity of parasitoids in a community (Hamid *et al.*, 2003). Raindrops could cause mortality of parasitoids and their host (*N. lugens*) (Herlinda *et al.*, 2012) thereby reducing the parasitoid diversity index. The low diversity index was also influenced by the evenness and dominance of *N. lugens* egg parasitoids in all three locations. The *N. lugens* egg parasitoid in the three locations is unevenly distributed and dominance by one species, i.e. *Oligosita* sp. (Figure 4). The Shannon diversity index (H') is influenced by the abundance and evenness of species in the community. Uneven distribution of species would lead to dominance and decrease the diversity index (Magurran, 1988).

N. lugens egg parasitoid collected at the three locations showed significant differences for the diversity index ($H = 7.20$; 2 d.f; $P = 0.027$), evenness ($F = 5.62$; $N = 9$; $P = 0.042$) and dominance ($H = 7.32$; 2 df; $P = 0.026$) but not significantly different for the species richness ($H = 5.33$; 2 df; $P = 0.069$) and species abundance ($F = 0.39$; $N = 9$; $P = 0.68$). The lowest number of *N. lugens* eggs was collected from location III (1,439 individuals) and more from location I (2,238 individuals) and II (1,929 individuals) (Table 1). The richness of *N. lugens* egg parasitoid species in the location I have the highest average ($S = 3.6$), followed by location II ($S = 3$) and III ($S = 2.3$). The average diversity of the highest to lowest *N. lugens* egg parasitoids was at location I ($H' = 0.27$), II ($H' = 0.16$), and III ($H' = 0.08$), respectively. The distribution of species abundance at the location I is the most evenly distributed ($J' = 0.19$) than location II ($J' = 0.14$) and location III ($J' = 0.09$). The highest species dominance was at location III ($D = 0.96$), then location II ($D = 0.93$), and I ($D = 0.87$) (Figure 4). The difference in abundance and diversity of *N. lugens* egg parasitoids from the three locations is due to the different locations and growth phases of

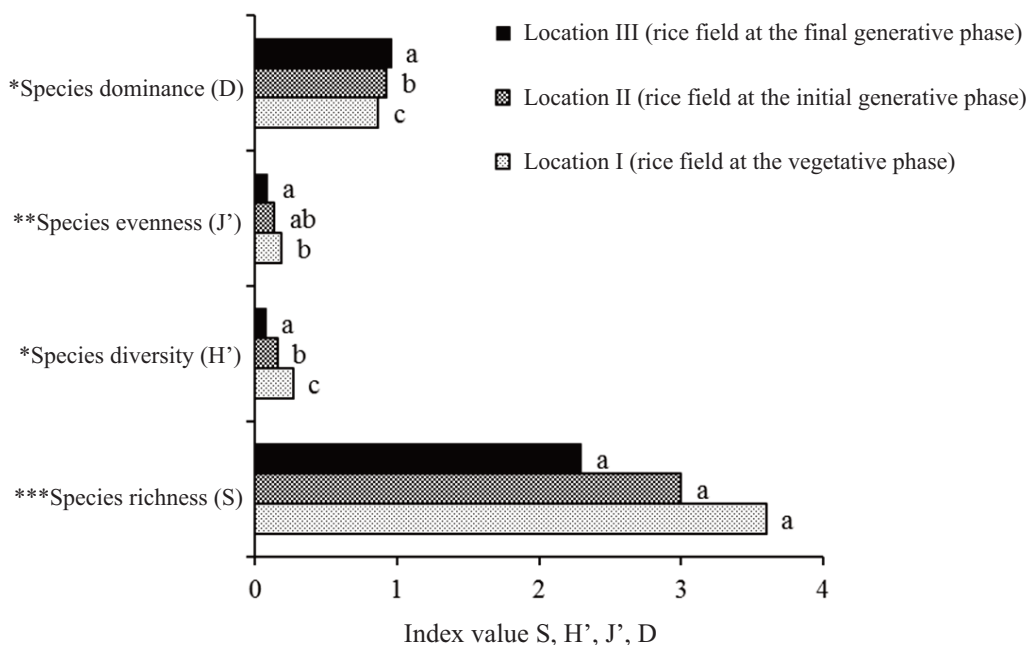


Figure 4. Richness, diversity, evenness, and dominance of the *Nilaparvata lugens* parasitoid species at each collection location; the same letters above the same group diagram were not significantly different at the 5% level (*Mann–Whitney test, **Tukey's test, ***Kruskal–Wallis test)

rice in each location. Different locations in a wide range might show different conditions, such as latitude, demographics, climate, rainfall, temperature, habitat vegetation, and landscapes that affect the composition of flora and fauna species, including parasitoids (Yaherwandi *et al.*, 2008; Herlina *et al.*, 2011). Rice plants have different numbers and diversity of host insects at each growth phase (Rizali *et al.*, 2002) causes the abundance and diversity of *N. lugens* egg parasitoids to be different in each phase of rice growth (Yaherwandi & Syam 2007; Herlina *et al.*, 2011). *N. lugens* egg parasitoids collected from the three locations have diversity of different host insects in each phase of rice plant growth that might affect the diversity of *N. lugens* egg parasitoids present in three locations. Parasitoid diversity would follow its host diversity under favorable habitat conditions (Heinrichs *et al.*, 1994). *N. lugens* egg parasitoids collected from the three locations have other hosts beside *N. lugens* eggs, i.e. *A. nilaparvatae* could parasitize eggs *N. bakeri*, *N. muiri*, *Laodelphax striatellus*, *Sogatella furcifera*, *S. panicicola*, *Toya propinqua*, and *T. tuberculosa*; *Gonatocerus* could parasitize the eggs of *Nephotettix cincticeps*, *N. nigropicta*, *N. virescens*; *S. furcifera*. *Mymar* could parasitize *N. cincticeps* and *S. furcifera* eggs; and *Oligosita* could parasitize the eggs of *S. furcifera*, *Toya* sp., *Togosodes pusanus*, *N. cincticeps*, *N. virescens*, *N. nigropicta*, and *L. striatellus* (Gurr *et al.*, 2011).

The abundance, richness, and diversity of *N. lugens* egg parasitoid species decreased in the generative phase of rice growth (Figure 4). That is because of the increasing age of rice plants, the host insect population (*N. lugens*) has decreased (Yaherwandi & Syam, 2007). The diversity and low abundance of host insects affect the higher tropics, i.e. parasitoids that use host insects as a feed to survive. The diversity and low abundance of host insects cause parasitoids to be less diverse and abundant in rice cultivation. The availability of numbers and selection of low host insects decreases parasitoid abundance and diversity index (Hamid *et al.*, 2003). The vegetative phase of rice has high nitrogen (N) content for organ formation. Nitrogen in rice plants is a good nutrition source for *N. lugens* and most herbivorous insects. The vegetative phase of rice has a morphology suitable for the habitat and place of *N. lugens* oviposition (Sianipar *et al.*, 2017). The vegetative

phase of rice at the location I showed a higher richness, abundance, and diversity index than those in locations II and III (Figure 4). The generative phase of rice absorbs more Phosphor (P) and Potassium (K) for grain formation. Therefore, adults of *N. lugens* would form wings and migrate to search the new feed when rice is in the generative phase (Sianipar *et al.*, 2017). According to Fu *et al.* (2014), pest migration in the tropics is generally due to depleted resources, such as near the harvest. Hamid *et al.* (2003) reported that the diversity of low-value host insects at the beginning of the planting period (vegetative phase) then fluctuates and decreases again at the end of the generative phase. This might be caused by habitat quality that began to decline hence host insects migrate to other habitats which can reduce the index of the diversity of parasitoids. Location II was rice field which reached the initial stage of generative phase (grain formation) while location III was rice field which reached the final stage of the generative phase (before harvest) so that the diversity index of *N. lugens* parasitoid eggs in these two locations was not much different and lower than those in the location I (Figure 4). The differences in collection locations are inseparable factors with the growth phase of rice plants in influencing the diversity and abundance of *N. lugens* egg parasitoids collected in this study. The difference in collection location affects habitat quality which is also determined by the growth phase of rice plants. Collection location with the generative phase of rice causes habitat quality to decrease thus the diversity and abundance of *N. lugens* parasitoids are lower than the collection location with vegetative phase rice cultivation.

The abundance of *N. lugens* egg parasitoids from the three locations was *A. nilaparvatae* (155 individuals), *Anagrus* sp. (45 individuals), *Gonatocerus* sp. (6 individuals), *Mymar* sp. (3 individuals), and *Oligosita* sp. (5,397 individuals) (Table 2). *Oligosita* sp. was more abundant than other *N. lugens* egg parasitoids at each location (Figure 5). Similar results were reported by Meilin (2012), Haryati *et al.* (2015), and Abdilah (2015). The difference in abundance between the *N. lugens* parasitoid species is due to competition in getting the same host (Abdilah, 2015). Bogran *et al.* (2002) reported that interspecific parasitoid competition might occur in the field related to the

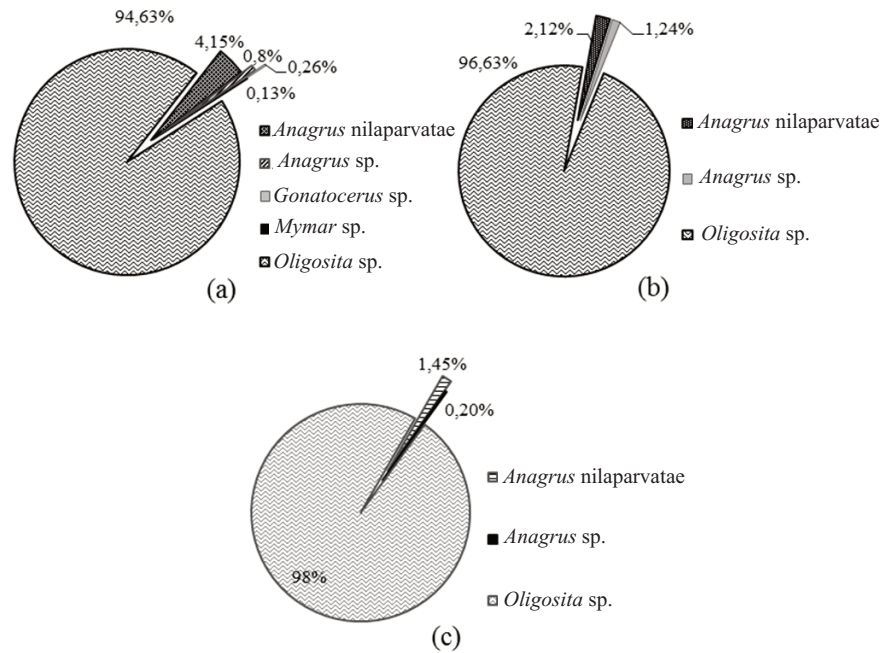


Figure 5. The relative abundance of *Nilaparvata lugens* egg parasitoids: location I (a), location II (b), location III (c)

Table 2. The relative abundance of *Nilaparvata lugens* egg parasitoids at the overall time and location of the collection

Egg Parasitoids Species	Relative Abundance (%)
<i>Anagrus nilaparvatae</i>	2.76
<i>Anagrus sp.</i>	0.8
<i>Gonatocerus sp.</i>	0.1
<i>Mymar sp.</i>	0.05
<i>Oligosita sp.</i>	96.27

same host. Parasitoid species have high searching ability to find a host are more successful in their reproduction (Abdilah, 2015). The difference in abundance between *N. lugens* parasitoid species is also influenced by the level of local adaptation and dispersal ability of each species (Susiawan & Yuliarti, 2006). The results of this study strengthen the indications that *Oligosita sp.* is a parasitoid of *N. lugens* eggs that could spread, adapt, and reproduce well. The abundance and diversity of *N. lugens* egg parasitoids of this study could be used to determine the potential of species as biological agents. *Oligosita sp.* is considered to be a superior biological agent to control the population of *N. lugens*, especially in the rice fields in Saketi, Pandeglang, Banten. The diversity of *N. lugens* egg parasitoids might vary from one region to another hence allowing the use of location-specific biological

agents. Varied *N. lugens* egg parasitoids allow the use of several species as biological agents together to result in effective control.

CONCLUSIONS

The diversity and abundance of *N. lugens* egg parasitoids decreased during the generative phase of rice growth. The diversity and abundance of *N. lugens* egg parasitoids were higher in rice fields in the vegetative phase (location I) than that in the generative initial phase (location II) and the final generative phase (location III). *N. lugens* egg parasitoids collected from three locations in Pandeglang Regency, Banten was five species from two families, i.e. *A. nilaparvatae* (Mymaridae), *Anagrus sp.* (Mymaridae), *Gonatocerus sp.* (Mymaridae), *Mymar sp.* (Mymaridae), and *Oligosita sp.* (Trichogrammatidae). *Oligosita sp.* was the most dominant species among other *N. lugens* egg parasitoids in rice fields at each growth phase.

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