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RESEARCH PAPER

Vatiga illudens Drake (Hemiptera: Tingidae): Morphometry and abundance in Bogor Regency, West Java, Indonesia

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ABSTRACT

Vatiga illudens Drake (Hemiptera: Tingidae) is a newly emerging pest of cassava in Indonesia. This species has not yet been classified as a quarantine pest by the Indonesian government, allowing it to spread largely unnoticed. This study aimed to determine the abundance and morphometric characteristics of *V. illudens* in Bogor Regency, West Java. The research was conducted by collecting lace bug specimens preserved in 70% alcohol from nine cassava plantations located in two villages of Bojong Gede Subdistrict and one village of Tajurhalang Subdistrict. Lace bug abundance was analyzed using the least significant difference (LSD) test. Specimens were identified based on morphological characteristics using an Olympus SZ51 stereo microscope, and morphometric variables were measured using a Leica DFC 450 microscope. The results confirmed that the collected specimens were *V. illudens*, and their body measurements were relatively larger than those reported from Brazil and East Java. The mean body length and width were 1.01 ± 0.03 mm and 0.25 ± 0.03 mm for first-instar nymphs; 1.29 ± 0.09 mm and 0.36 ± 0.02 mm for second-instar nymphs; 1.62 ± 0.13 mm and 0.54 ± 0.04 mm for third-instar nymphs; 2.36 ± 0.08 mm and 0.72 ± 0.06 mm for fourth-instar nymphs; 3.14 ± 0.15 mm and 0.98 ± 0.09 mm for fifth-instar nymphs; and 4.44 ± 0.11 mm and 1.28 ± 0.04 mm for imagos. The highest *V. illudens* abundance was observed in Susukan Village, and populations in all observation villages were dominated by males.

Keywords: Cassava, lace bug, pest, population, size

INTRODUCTION

Vatiga illudens Drake, commonly known as the cassava lace bug (CLB), is a newly reported cassava pest in Indonesia. CLB originates from the Neotropical regions. In Indonesia, it was first discovered in East Java in 2021 and has since been reported and studied in Central Java and Bali (Puspitarini et al., 2021; Sudiarta et al., 2024; Suroto et al., 2023). The presence of CLB in Indonesia is suspected to be associated with the importation of plant materials from Neotropical regions. Therefore, CLB is considered an alien species in Indonesia and the broader Oriental region (Puspitarini et al., 2021).

Vatiga illudens is an important pest of cassava in the Neotropical region (Puspitarini et al., 2021). It is one of the most common cassava pests in Brazil and is economically significant in that country (da Silva Wengrat, 2016; Puspitarini et al., 2021). This species has also been reported in several other countries, including Cuba, Haiti, Colombia, Ecuador, and Venezuela (Froeschner, 1993). *V. illudens* is known as a cassava-specific pest due to its high host specificity (Puspitarini et al. 2021; Schuh & Weirauch, 2020). Since its initial discovery, it has spread to tropical regions of Africa and Asia, areas suitable for cassava cultivation (Cock & Connor, 2021). This pest can cause a 48–55% reduction in cassava yield and 48–50% leaf loss in Brazil, while infestation intensity in Banyumas Regency, Indonesia, ranges from 2.69% to 22.34% (da Silva Wengrat, 2016; Suroto et al., 2024). However, *V. illudens* has not been designated as a quarantine pest by the Indonesian government (Indonesian Ministry of Agriculture, 2020). As a result, it is suspected that this pest may continue to spread to other cassava production centers in Indonesia (Puspitarini et al., 2021).

The reason *V. illudens* has not been classified as a quarantine pest by the Indonesian government remains unclear. This situation may create an information gap regarding this pest among the general public and the farming community. Such an information gap could

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cause farmers to overlook the presence and significance of *V. illudens* in their pest management practices. Therefore, this study aims to determine the abundance and characteristics of *V. illudens* in order to monitor its development, particularly in Bogor Regency, West Java.

MATERIALS AND METHODS

Research Site. The study was conducted from January to June 2024 in cassava plantations located in the Bojong Gede and Tajurhalang Subdistricts, Bogor Regency. Laboratory work was carried out at the Insect Biosystematics Laboratory, Department of Plant Protection, Faculty of Agriculture, Bogor Agricultural University (IPB University), Indonesia.

Observation Plot Selection. Observation plots were selected from cassava plantations in Susukan and Cimanggis Village of Bojong Gede Subdistrict, as well as Sasak Panjang Village of Tajurhalang Subdistrict. In each village, three plots with an area of approximately 100–500 m^2 were selected. Plot coordinates were recorded using the GPS function in Google Maps. Plot selection in Tajurhalang Subdistrict was necessary due to the limited availability of cassava plantations with a minimum area of 100 m^2 in the northern part of Bojong Gede Subdistrict.

The observation plots in Susukan Village were located at 6°28′44.9″ S, 106°48′00.7″ E; 6°28′38.0″ S, 106°47′33.4″ E; and 6°28′35.9″ S, 106°47′38.2″ E. Plots in Cimanggis Village were located at 6°27′17.3″ S, 106°45′42.5″ E; 6°27′44.9″ S, 106°45′42.6″ E; and 6°27′33.4″ S, 106°45′42.6″ E. Meanwhile, plots in Sasak Panjang Village were located at 6°29′27.8″ S, 106°46′22.8″ E; 6°29′51.2″ S, 106°46′36.3″ E; and 6°29′37.8″ S, 106°46′25.7″ E.

Sample Plant Selection. Sample plants within each plot were selected using a diagonal sampling method by establishing five sampling areas. Each sampling area consisted of three plants marked with rope, resulting in a total of 15 sample plants per plot.

Insect Collection and Counting. *Vatiga illudens* specimens were collected from two infested leaves per plant, one from the lower and one from the middle part of the plant. A total of 30 leaves were collected from each plot. The leaves were placed in 25 × 40 cm ziplock bags containing cotton soaked with 70% alcohol to kill the insects. Dead lace bugs were then transferred into vials containing 70% alcohol for preservation prior to laboratory observation.

Insect collection was conducted once per plot between 9:00 AM and 12:00 PM or up to 1:30 PM, depending on plot size. The CLB population was counted in the laboratory using an Olympus SZ51 stereo microscope (Evident, Japan). Specimens were counted according to developmental stage, from nymph to imago, based on identification descriptions provided by da Silva Wengrat (2016) and Puspitarini et al. (2021).

Identification and Morphometry Measurement of Cassava Lace Bug. Species confirmation of *V. illudens* was performed using the identification key by Froeschner (1993) under an Olympus SZ51 stereo microscope. Morphometric measurements of *V. illudens* at each developmental stage were conducted using a Leica DFC 450 microscope and Leica Application Suite version 4.4.0 (Leica Microsystems, Germany). A total of 15 individuals per developmental stage were measured.

Morphometric measurements followed the method described by da Silva Wengrat (2016) for nymphs and a modified version of the method by Puspitarini et al. (2021) for adults (imago). The modification involved adding variables from da Silva Wengrat (2016) to complement total body length (TTL) and total body width (TTW), which were the only variables measured in Puspitarini et al. (2021).

Data Analysis. The experimental design used in this study was a randomized block design, with village as the treatment factor and population per plot as the replicate. *V. illudens* population data were analyzed using one-way analysis of variance (ANOVA), followed by a least significant difference (LSD) test at a 5% significance level using RStudio version 4.2.1. Population data, morphometric measurements, and LSD test results were tabulated and presented using Microsoft Excel 2016.

RESULTS AND DISCUSSION

Overview of *V. illudens*. Based on observations, the collected cassava lace bugs were identified as *V. illudens*. Froeschner (1993) reported that *V. illudens* possesses a regularly biseriate pattern on the costal area of the body (Figure 1A), a constricted mesosternum lamina (Figure 1B), and one or two anteromedian tubercles that are not located on the midline of the head (Figure 2). These characteristics were consistent with those observed in the collected specimens. The *V. illudens* population was composed of nymphs, which have five instars and a whitish-yellow body, and imagos, which have a brownish-yellow body (Figure 3). This observation is consistent with the description provided by Puspitarini et al. (2021). The sex of *V. illudens* can be determined by the presence of a channel at the abdominal apex in females, which is absent in males (Figure 4), as reported by Puspitarini et al. (2021).

Vatiga illudens was typically found on the undersides of lower and middle cassava leaves (Figure 5B), similar to observations by Puspitarini et al. (2021). This distribution may be related to higher levels of chemical defenses in younger leaves, causing lace bugs to avoid these tissues (Caldwell et al., 2016). *V. illudens*

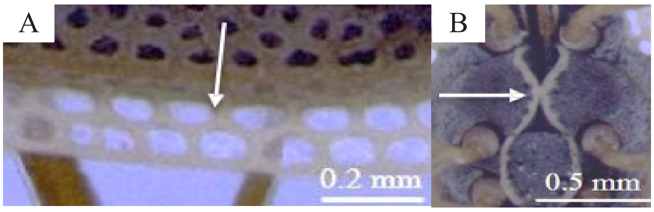

Figure 1. *Vatiga illudens* diagnostic characteristics (arrow). A. Biseriate pattern on the hemelytron; B. Constricted mesosternal lamina on the thorax.

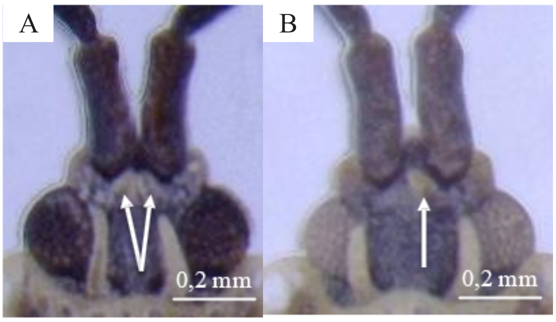

Figure 2. Variation of anteromedian tubercles on the head (arrow). A. Paired; B. Single.

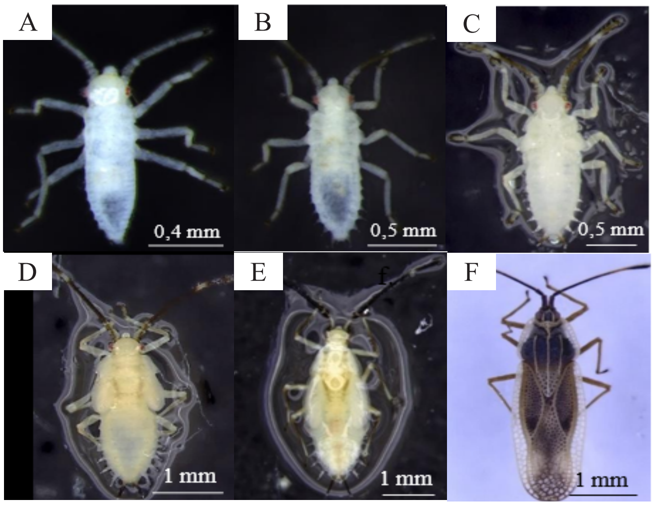

Figure 3. Developmental stages of *Vatiga illudens*. A. First-instar nymph; B. Second-instar nymph; C. Third-instar nymph; D. Fourth-instar nymph; E. Fifth-instar nymph; F. Imago.

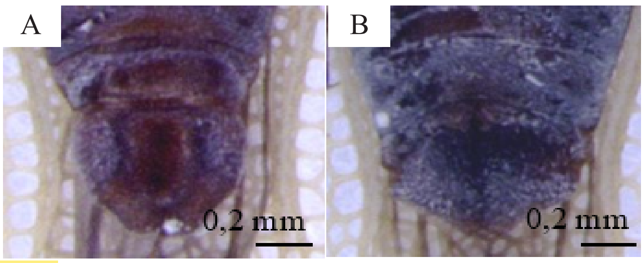

Figure 4. Abdominal differences between sexes. A. Male; B. Female.

feeds by consuming the protoplasm of parenchymal cells, leading to cell death and the formation of yellow necrotic spots on the upper leaf surface (da Silva Wengrat, 2016). As infestation intensity increased, these symptoms expanded and nearly covered the entire leaf surface (Figure 5A).

Morphometric Characteristics of *V. illudens*. *Vatiga illudens* specimens exhibited size variation across developmental stages (Table 1). Nymphs showed a gradual increase in body size with each successive instar, with the imago stage exhibiting the largest body size compared to all previous stages.

Morphometric measurements confirmed several diagnostic characteristics of *V. illudens.* Second-instar nymphs had slightly larger body sizes than first-instar nymphs despite their similar appearance. Nymphs from the third to fifth instars could be clearly distinguished by progressively increasing wing pad length. The head of *V. illudens* was consistently shorter than its width, in agreement with observations by da Silva Wengrat (2016). In addition, the second antennal segment was the shortest, while the third segment was the longest, consistent with previous descriptions (da Silva Wengrat, 2016).

Measurements also revealed that *V. illudens* specimens collected from Bojong Gede and Tajurhalang were relatively larger than those reported from Brazil (da Silva Wengrat, 2016; Table 2) and East Java, primarily Malang (Puspitarini et al., 2021; Table 3). Size differences were particularly evident in total body length (TTL) and total body width (TTW). These differences may be attributed to nutritional factors associated with cassava consumed in each location.

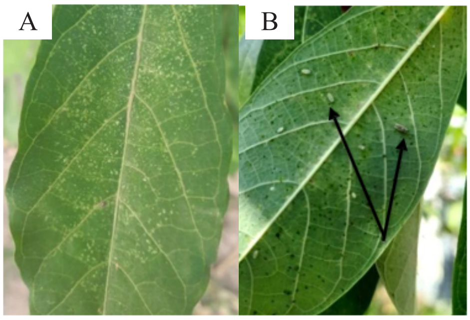

Figure 5. Infestation symptoms of *Vatiga illudens*. A. Spots on the upper surface of the leaf; B. Lace bug on the underside of the leaf (arrow).

Tabel 1. Body size of *Vatiga illudens* in Bojong Gede dan Tajurhalang Subdistrict

Variable[1)]	Size (mm) (mean ± standard deviation)					
	Nymph instar					Imago
	First	Second	Third	Fourth	Fifth	
TTL	1.01 ± 0.03	1.29 ± 0.09	1.62 ± 0.13	2.36 ± 0.08	3.14 ± 0.15	4.44 ± 0.11
TTW	0.25 ± 0.03	0.36 ± 0.02	0.54 ± 0.04	0.72 ± 0.06	0.98 ± 0.09	1.28 ± 0.04
HL	0.23 ± 0.02	0.28 ± 0.03	0.32 ± 0.06	0.40 ± 0.06	0.42 ± 0.05	0.41 ± 0.03
HW	0.25 ± 0.01	0.29 ± 0.02	0.38 ± 0.04	0.49 ± 0.03	0.53 ± 0.05	0.56 ± 0.02
ID	0.19 ± 0.02	0.21 ± 0.02	0.27 ± 0.04	0.32 ± 0.03	0.34 ± 0.04	0.24 ± 0.02
I	0.06 ± 0.01	0.08 ± 0.01	0.11 ± 0.01	0.16 ± 0.02	0.22 ± 0.02	0.31 ± 0.03
II	0.06 ± 0.01	0.08 ± 0.01	0.10 ± 0.01	0.13 ± 0.01	0.19 ± 0.01	0.21 ± 0.02
III	0.23 ± 0.01	0.37 ± 0.03	0.56 ± 0.06	0.88 ± 0.05	1.28 ± 0.07	1.45 ± 0.14
IV	0.20 ± 0.01	0.24 ± 0.03	0.34 ± 0.03	0.46 ± 0.02	0.61 ± 0.05	0.60 ± 0.10
RL	0.32 ± 0.06	0.42 ± 0.04	0.52 ± 0.07	0.67 ± 0.05	0.83 ± 0.07	1.05 ± 0.10
TL	0.30 ± 0.03	0.37 ± 0.04	0.45 ± 0.06	0.87 ± 0.09	1.13 ± 0.11	1.37 ± 0.06
TW	0.27 ± 0.02	0.39 ± 0.02	0.56 ± 0.03	0.78 ± 0.06	1.05 ± 0.08	1.33 ± 0.04
WL	–[2)]	–	0.23 ± 0.02	0.53 ± 0.04	1.27 ± 0.02	-

[1)]TTL = Total Length); TTW = Total Width; HL = Head Length; HW = Head Width; ID = Interocular Distance; I–IV = Antenna segment length; RL = Rostrum Length; TL = Thorax Length; TW = Thorax Width; WL = Wing Pad Length. [2)]An em dash (–) indicates that measurement was not conducted.

Nutrition plays a key role in insect growth and ultimately determines body size (Poças et al., 2020). Botsch et al. (2023) also reported that food quality is a major factor influencing insect body size. It is possible that cassava varieties grown in the observation areas contained higher levels of nutrients essential for *V. illudens* growth, resulting in larger body sizes.

Size variation may also be influenced by differences in food availability among locations. Areas with abundant food and resources may promote larger body size because insects expend less energy for foraging, and vice versa (Budiarsa et al., 2022). This may explain the larger body size observed in *V. illudens* populations from the study areas. Additionally, lower elevation and higher temperatures are often associated with smaller insect body size due to increased metabolic rates (Atkinson, 1994; Wonglersak et al., 2020). However, the CLB specimens in this study were collected from Bojong Gede and Tajurhalang, which are located at relatively low elevations (156–162 m above sea level; BPS-Statistics Indonesia Bogor Regency, 2015), compared to Marechal Cândido Rondon, Brazil (420 m a.s.l.), and Malang, East Java (250–500 m a.s.l) (da Silva Wengrat, 2016; BPS-Statistics Indonesia Malang Regency, 2023). This suggests that other factors, such as predation pressure and population density, may obscure the effects of altitude and temperature on insect body size (Gavini et al., 2020; Botsch et al., 2023).

Abundance of *V. illudens*. A total of 259 *V. illudens* specimens were collected from the three observation villages in Bojong Gede and Tajurhalang Subdistricts. The largest population, consisting of 115 individuals, was recorded in Susukan Village, Bojong Gede, while the smallest population was found in Sasak Panjang Village, Tajurhalang, with 70 individuals. Overall, *V. illudens* populations in all villages were dominated by nymphs compared to imagos. However, population structure varied among villages (Figure 6). For instance,

Table 2. Body size of *Vatiga illudens* in Brazil

Variable[1)]	Size (mm) (mean ± standard deviation)				
	Nymph instar				
	First	Second	Third	Fourth	Fifth
TTL	0.50 ± 0.03	0.78 ± 0.02	1.14 ± 0.03	1.20 ± 0.05	1.70 ± 0.04
TTW	–[2)]	–	–	–	–
HL	0.11 ± 0.01	0.13 ± 0.01	0.19 ± 0.01	0.21 ± 0.02	0.23 ± 0.04
HW	0.14 ± 0.02	0.20 ± 0.02	0.26 ± 0.01	0.31 ± 0.01	0.38 ± 0.01
ID	0.11 ± 0.01	0.14 ± 0.01	0.19 ± 0.02	0.21 ± 0.01	0.22 ± 0.02
I	0.02 ± 0.01	0.04 ± 0.03	0.06 ± 0.01	0.10 ± 0.01	0.11 ± 0.03
II	0.03 ± 0.00	0.03 ± 0.01	0.05 ± 0.01	0.08 ± 0.01	0.10 ± 0.01
III	0.12 ± 0.02	0.22 ± 0.01	0.38 ± 0.03	0.70 ± 0.04	0.83 ± 0.02
IV	0.10 ± 0.02	0.17 ± 0.01	0.22 ± 0.01	0.33 ± 0.02	0.36 ± 0.02
RL	0.20 ± 0.02	0.30 ± 0.01	0.36 ± 0.03	0.44 ± 0.02	0.58 ± 0.03
TL	0.09 ± 0.01	0.14 ± 0.02	0.29 ± 0.02	0.30 ± 0.02	0.53 ± 0.01
TW	0.12 ± 0.01	0.27 ± 0.02	0.94 ± 0.01	0.48 ± 0.01	0.73 ± 0.04
WL	–[2)]	–	0.11 ± 0.01	0.34 ± 0.01	0.70 ± 0.02

Source: da Silva Wengrat APG (2016). [1)]TTL = Total Length); TTW = Total Width; HL = Head Length; HW = Head Width; ID = Interocular Distance; I–IV = Antenna segment length; RL = Rostrum Length; TL = Thorax Length; TW = Thorax Width; WL = Wing Pad Length. [2)]An em dash (–) indicates that measurement was not

Table 3. Body size of *Vatiga illudens* in East Java

Variable	Size (mm) (mean ± standard deviation)					
	Nymph instar					Imago
	First	Second	Third	Fourth	Fifth	
Length	0.39 ± 0.01	0.66 ± 0.02	1.03 ± 0.05	1.28 ± 0.01	1.86 ± 0.01	2.95 ± 0.08
Width	0.16 ± 0.01	0.27 ± 0.01	0.45 ± 0.01	0.62 ± 0.01	0.76 ± 0.00	0.90 ± 0.04

Source: Puspitarini et al. (2021).

populations in Susukan and Sasak Panjang Villages were dominated by nymphs, whereas the population in Cimanggis Village was slightly dominated by imagos.

The infestation percentage (the proportion of infested sample plants relative to the total number of sample plants) also varied among villages. Susukan Village exhibited the highest infestation percentage (62.22%), followed by Sasak Panjang Village (60.00%). Cimanggis Village had the lowest infestation percentage (51.11%).

Results of the LSD test indicated that *V. illudens* populations did not differ significantly among the three villages (p-value > 0.05), although the highest mean population was observed in Susukan Village (Table 4). This suggests that village location did not significantly influence *V. illudens* population density. This pattern may be associated with the quantity and quality of cassava available to the lace bugs. Adequate food availability and suitable nutritional quality can promote population growth (Elisabeth et al., 2021). The cassava cultivated in the observation areas may belong to the same or a limited range of varieties, resulting in relatively uniform food quality and similar population growth rates. Cassava quantity may also be influenced by cultivation practices. If cultivation methods across plots were similar, food availability would likewise be similar, leading to comparable lace bug populations among villages (Snyder et al., 2020).

Vatiga illudens populations in the study areas were generally dominated by nymphs. This may be related to the presence of young cassava plants. Cassava plants aged approximately 4–5 months are known to be preferred by cassava lace bugs, as this growth stage provides optimal resources for pest development, particularly for nymphs (Bellotti et al., 2012; Kalyebi et al., 2021). In this case, young plants likely fell within this optimal age range, supporting higher nymph densities. Nymph dominance may also be influenced by cassava variety. Certain varieties possess leaf surfaces with dense trichomes, which can impede CLB attachment, particularly in nymphs (Pastório et al., 2019). This factor may also explain the relative dominance of imagos in Cimanggis Village.

Vatiga illudens populations in the observation areas were dominated by males. The highest sex ratio was observed in Cimanggis Village (1:0.75), while the lowest was recorded in Susukan Village (1:0.90). The sex ratio in Sasak Panjang Village was 1:0.76. Male-dominated populations may be influenced by cassava chemical defense mechanisms. Cassava produces defensive enzymes such as polyphenol oxidase and peroxidase, which can disrupt CLB development and affect sex ratios (da Silva Wengrat, 2016; da Silva Wengrat et al., 2020). Other secondary metabolites produced by cassava can also alter nutritional quality and influence CLB development and sex ratios. However, the composition of these compounds depends on cassava variety, as some varieties may promote female-dominated populations, while others favor male dominance (da Silva Wengrat et al., 2020).

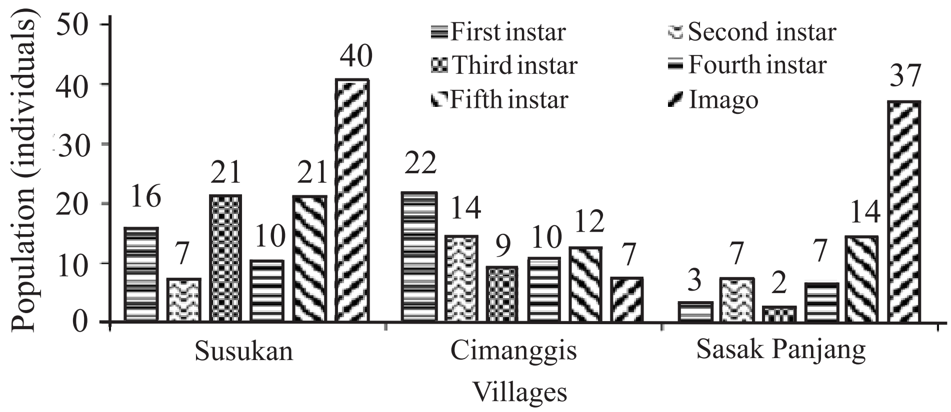

Figure 6. Population of *Vatiga illudens* in three observation villages.

Table 4. Abundance of *Vatiga illudens* in the observation villages

Village	Population average (individuals)
Susukan	38.33 a
Cimanggis	24.67 a
Sasak Panjang	23.33 a

Letters following the numbers indicate the results of mean comparisons using the LSD test at the 5% significance level.

CONCLUSION

The *Vatiga illudens* population in Bojong Gede and Tajurhalang Subdistricts varied among observation villages. The largest population was recorded in Susukan Village, with a total of 115 individuals. Overall, *V. illudens* populations in the study areas were dominated by males and consisted of both nymphs, which develop through five instars, and imagos. The largest body length and width of *V. illudens* observed were 1.07 mm and 0.23 mm for first-instar nymphs; 1.39 mm and 0.40 mm for second-instar nymphs; 1.86 mm and 0.63 mm for third-instar nymphs; 2.51 mm and 0.86 mm for fourth-instar nymphs; 3.30 mm and 1.12 mm for fifth-instar nymphs; and 4.62 mm and 1.33 mm for imagos.

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AUTHORS' CONTRIBUTIONS

MRS and NM conceptualized and designed the research. MRS conducted the preliminary field survey, insect collection, identification, abundance analysis, and morphometric measurements. MRS also performed data analysis, interpreted the abundance data, and prepared the manuscript. NM and IWW provided feedback on research progress, data analysis, and data interpretation, as well as comments on manuscript structure and content. All authors read and approved the final manuscript.

COMPETING INTEREST

The authors declare no competing interests related to this publication.

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