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Biotype Diversity of *Nilaparvata Lugens* (Stall) In Several Rice-Producing Areas in North Sumatra

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Abstract: Nilaparvata lugens is a major rice pest that causes significant losses in Asia. This study aims to identify the diversity of brown planthopper (BPH) biotypes from four rice production centers in North Sumatra, namely Asahan Regency, Batubara Regency, Deli Serdang Regency, and Langkat Regency. Morphologically, the average body length of the macroptera imago was 4.36 mm and that of the brachyptera was 3.51 mm, with antennae consisting of a scape, pedicel, and flagellum. Four samples were tested using PCR with universal primers LCO1490/HCO2198, resulting in amplification of ±700 bp. Sequence and phylogenetic analysis using MEGA 11 showed a genetic distance between samples of 0.000, indicating very close kinship. However, the genetic distance to GenBank data (biotypes 1, 2, 3, and Y) ranged from 0.578 to 0.596, indicating differences in kinship and possible gene mutations or biotype changes. The characteristics of farmers were dominated by those aged 41–50 years, high school education, and the majority being male. The most widely used variety was Inpari-32 (somewhat susceptible to WBC). Most farmers used more than three types of synthetic pesticides, especially in Batubara (96.67%) with a frequency of >3 times per planting season. The intensity of attacks ranged from 1–5%. There was a significant relationship between variety and attack rate (p=0.00). Pests and diseases were the main problems (>50%).

Keywords: Attack rate; Biomolecular; Morphology; Respondents

Introduction

Indonesia is a tropical country with a stable climate and even rainfall throughout the year. The majority of Indonesians work as farmers. Agriculture is a major industry with a wide variety of crops, one of which is rice. Rice (*Oryza sativa* L.) is one of the main food sources for Indonesians, as the majority of the population uses rice as their staple food. The demand for rice continues to increase along with the growing population, efforts to increase rice production are needed to meet these food needs (Wati, 2017).

Based on data from the Central Statistics Agency (BPS) 2023, rice consumption in Indonesia in 2022 was 30.2 million tons. With a population of 280 million people and a rice consumption rate of 124.89 kg/capita/year. Rice production in Indonesia from January to September 2023 is estimated at 45.33 million tons of milled dry grain (GKG), a decrease of around 105.09 thousand tons of GKG (0.23%) compared to January-September 2022, which amounted to 45.43 million tons of GKG.

Efforts to increase rice production are inversely proportional to the amount of land used due to land conversion. According to BPS data (2023), the area of rice fields in January-September 2023 was 8.66 million hectares, a decrease of around 33.04 thousand hectares (0.38%) compared to January-September 2022, which reached 8.69 million hectares.

In addition, productivity can also decline due to biotic and abiotic factors. One biotic factor is the presence of plant pests, in the form of insect infestations. The presence of OPT can break the resistance of plant varieties. One of the main insect pests that is most destructive to rice crops in rice-producing areas is WBC (WBC), Nilaparvata lugens (Stål) (Homoptera: Delphacidae) (Syahrawati et al., 2021).

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Brown planthoppers are one of the important factors affecting rice production. WBC pest attacks can reduce rice productivity because WBCs are vectors of grass dwarf virus and empty dwarf virus. In severe attacks, they can even cause hopperburn (Yuliani et al., 2020).

Brown planthoppers can cause rice yield losses of around 75%. Sumini et al. (2020) stated in her research that the percentage of WBC attacks reached 75% because the same rice varieties were used continuously every planting season, causing high pest populations.

The high population of WBC is influenced by the variety and age of the rice plants as well as the large population of WBC pests. According to Suwandari et al. (2023), the WBC population in the Cigeus variety is higher than in the Ciherang variety because the number of productive rice tillers is greater, resulting in a higher population and intensity.

The study by Tian et al. (2022) states that the results of the analysis of WBC population variance among rice varieties show very significant results. The WBC population in rice plants differs among varieties. The highest WBC population was found in the Inpari 32 variety, while the lowest WBC population was found in the Primas, Inpago Unsoed 1, and Mugibat varieties. Research by Darmadi et al. (2018) states that the results of WBC observations on rice plants differed for each variety. The highest WBC attacks were on the Inpari 32, Cisadane, and Pelita varieties, at 80% (very severe symptoms).

Continuous planting of superior varieties in a region will cause the emergence of new WBC biotypes. Sodiq (2009) adds that resistant varieties that are continuously planted over a long period of time can stimulate the emergence of new pest races or biotypes, as occurred in North Sulawesi, where the planting of the IR 42 variety (to combat brown planthopper biotype 2) encouraged the formation of the North Sumatra (SU) biotype. Then, to deal with WBC biotype 2, several rice varieties from IRRI were introduced, such as IR32, IR36, and IR42, which have the bph2 resistance gene.

These new varieties were able to survive in the field, but in 1981/82 it was reported that the IR42 variety in Simalungun, North Sumatra, had been attacked by a population of brown planthoppers. These new varieties were able to survive in the field, but in 1981/82 it was reported that the IR42 variety in Simalungun, North Sumatra, had been attacked by brown planthoppers. This brown planthopper population is referred to as IR42 SU (North Sumatra). Biotope testing continues and it is known that the WBC attacking IR42 in North Sumatra is biotype 3 (S. Baehaki, 2012).

In Indonesia, WBC biotypes 1, 2, and 3 appeared successively after the planting of the Pelita I/1 variety (without WBC resistance genes), the IR26 variety (with the Bph1 resistance gene), and IR42 (with the Bph2 resistance gene). The planting of the IR64 variety and its derivatives, such as Ciherang, was able to overcome WBC biotype 3 attacks in the field for a long time (25 years) until biotype 4 was detected in North Sumatra in 2006 (Effendi et al., 2015).

The prolonged existence of brown planthopper biotype 3 was due to the presence of the IR64 (Bph1+) variety, which is a durable resistance variety that acts as a buffer against the change of brown planthoppers to a higher biotype, as well as the lack of development of the IR74 (Bph3) variety, which would have triggered the formation of a new biotype. With the presence of IR64 and its derivatives, such as Ciherang, biotype 3 was able to survive for up to 25 years because by 2006, biotype 4 had already begun to appear in Asahan, North Sumatra (S. E. Baehaki et al., 2014).

The use of VUB rice is still dominated by the Ciherang and Mekongga varieties. These varieties have advantages other than high production, they are also resistant to WBC pests (Kurniawati et al., 2022). New WBC biotypes can break the resistance genes in superior varieties that were previously resistant, making them vulnerable.

Based on this background, this study was conducted to identify WBC morphologically and biomolecularly in several rice-producing districts in North Sumatra.

Method

Lowland rice fields in Asahan Regency, Batubara Regency, Langkat Regency, and Deli Serdang Regency, North Sumatra. WBC morphological identification was carried out at the Tanjungbalai Asahan Class I Agricultural Quarantine Station Laboratory, Tanjungbalai, North Sumatra, and molecular identification was carried out at the Animal, Fish, and Plant Quarantine Standards Testing Center in Jakarta. This research was conducted from January 2024 to April 2024.

Research Materials and Tools

The materials and tools used in this study included label traps, tweezers, aspirators, microscopes, magnifying glasses, collection bottles, plastic jars with lids, scissors, gauze, hand counters, and documentation tools. The materials used were alcohol, water, WBC, and rice plants.

Research Methods

This study used a survey method. The survey method was conducted with the aim of determining the characteristics of farmers' agricultural systems in relation to WBC pest management in rice cultivation. This study was conducted in Asahan Regency, Batubara Regency, Langkat Regency, and Deli Serdang Regency, North Sumatra.

The locations were selected using purposive sampling, considering that the above regencies are the regencies with the highest WBC infestation rates in North Sumatra Province. The sampling method used was simple random sampling with a sample size of 30 rice farmers in each district. The samples in this study were farmers who were members of the Farmers Group Association (Gapoktan). The survey locations were selected using purposive sampling, namely Asahan Regency, Batubara Regency, Deli Serdang Regency, and Langkat Regency.

WBC Sampling

WBC samples were taken at all stages found in the field based on the researcher's consideration that the desired elements were present in the desired sample members.

Morphological Identification

Morphological identification was performed to observe specific morphological characteristics in WBC samples found in the field using a stereo microscope.

Identification of WBC using the PCR method

DNA extraction using the Dneasy Blood and Tissue Kit. The DNA extraction process consists of cell lysis, DNA binding, DNA washing, and DNA elution. Techniques are used to obtain optimal PCR conditions. The steps performed are as follows: three leg segments are placed in a 1500 µl tube, then 30 µl of ATL buffer is added and ground with a micropastle. Next, 150 µl of ATL buffer and 5 µl of proteinase K are added to lyse the cells.

The mixture is then homogenized and incubated at 56°C for 24 hours (overnight). After lysis, 100 µl of AL buffer and 100 µl of ethanol (96%-100%) are added, and the mixture is inverted. DNA binding was performed by placing the mixed lysate into a white Spin column filter.

The Spin column was centrifuged at 8,000 rpm for 1 minute. The collection tube was removed and the Spin column was placed into a new collection tube. The next step was to wash the DNA by adding 250 µl of Wash Buffer I to the column, centrifuging at 8,000 rpm for 1 minute, the collection tube is removed and discarded, and the spin column is placed into a new collection tube. A total of 250 µl of Wash Buffer 2 is added to the spin column, then centrifuged at a speed of 14,000 rpm for 3 minutes.

Next, elute the DNA by adding 50 µl of Genomic elution buffer, incubate for 5 minutes at room temperature, then centrifuge at 8,000 rpm for 1 minute. Store the purified DNA in a refrigerator at -20°C for subsequent PCR.

Sequencing and Phylogenetic Analysis

PCR products were sequenced at the Genetics Science Laboratory, Jakarta, Indonesia. Sequencing results were analyzed using the Basic Local Alignment Search Tool (BLAST). Phylogenetic analysis was performed using Molecular Evolutionary Genetics Analysis (MEGA) software version 11.0.

Data Analysis

All data from the research results are presented in tables and figures, then analyzed using descriptive statistics

Morphological Characteristics of WBC (Brown Planthopper)

The easily recognizable morphological differences between N. and WBC imagoes are found in their wings. WBC imagoes have long wings (Long-Winged) macroptera (Figure 1a) and short wings (Short-Winged) brachyptera (Figure 1b). According to Zhang et al. (2021), insects that undergo incomplete metamorphosis (hemimetabolous), such as WBC, develop through five nymphal instars (lasting 3-5 days for each stage) and then molt into adults. The wing buds of WBC develop gradually with increasing instar stages in the nymph, but the morphology of the macroptera and brachyptera imagoes can only be distinguished externally at the imago stage.

Result and Discussion

Morphological Characteristics of WBC (Brown Planthopper)

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Morphological observations of WBC imagoes were conducted by measuring the body length of macroptera and brachyptera imagoes. The results showed that the body length of macroptera was 4.36 mm (Figure 1a) and that of brachyptera was 3.51 mm (Figure 1b). The identification and body length measurements conducted by Wilson et al. (1991) stated that male macroptera imagoes measure 3.7-4.1 mm, female macroptera imagoes measure 4.1-5.0 mm, male brachyptera imagoes measure 2.4-2.8 mm, and female brachyptera imagoes measure 2.8-3.3 mm.

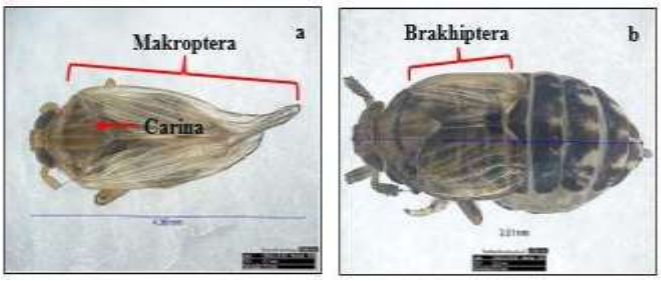

Figure 1. Morphology of the WBC imago

Wing dimorphism in WBC imagoes, which then develop into macroptera and brachyptera, plays a role in the spread of WBC, enabling WBC to exploit host plants, namely rice, and causing damage to rice production. Chaerani (2018) states that macroptera imagoes are formed when there is high population density and a decline in the carrying capacity of host plants. Macroptera adapt to fly long distances, aided by the wind, to colonize newly planted rice fields. Meanwhile, brachyptera imagoes have larger bodies with longer legs and ovipositors, making them more suitable for reproduction than macroptera imagoes.

Table 1. Image of Morphological Differences Between Macroptera and Brachyptera WBCs Under a Stereo Microscope

Morphology	Macroptera	Brakiptera
Wing		
		
	2,5x magnification	8x magnification
Leg		
	4x magnification	8 x magnification

Morphological observations of the WBC imago in Figure 1 and Table 1 show that the WBC imago has a yellowish-brown to dark brown body with dull yellow hyaline wings. According to Iamba et al. (2021), the WBC imago is blackish brown with a yellowish brown body ranging in size from 4-5 mm and has a distinct white band, known as the carina, located on the mesonotum. The mesonotum is dark in color and the outer side of the mesonotum is brown.

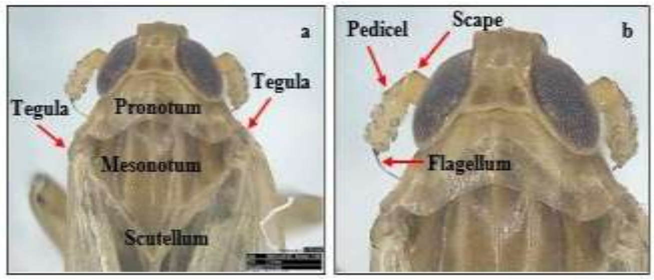

Figure 2. Morphology of the thorax and antennae of the WBC imago

Morphological observations of the thorax of WBC imago samples show the presence of tegulae on the mesonotum on both the right and left sides of the mesothorax (Figure 2a). Identification of leafhoppers based on the presence or absence of tegulae in leafhoppers was carried out by Wilson et al. (1991), who found that tegulae are almost always present on the mesothorax of insects belonging to the suborder Fulgoromorpha.

Morphological observation of the thorax in the WBC imago sample shows the presence of a pronotum and mesonotum (Figure 2a). According to (Mochida et al. (1979), the morphological characteristics of N. lugens (male macroptera) on the thorax are the presence of a pronotum, with tegula on the right and left sides, and the presence of a scutellum.

Morphological observation of the antennae of the WBC imago sample shows that the antennae consist of three parts, namely: scape, pedicel, and flagellum (Figure 2b). Antenna identification of insects in the Delphacidae family conducted by Wilson et al. (1991) indicates that the pedicels of insects belonging to the Delphacidae family are enlarged with a rough surface.

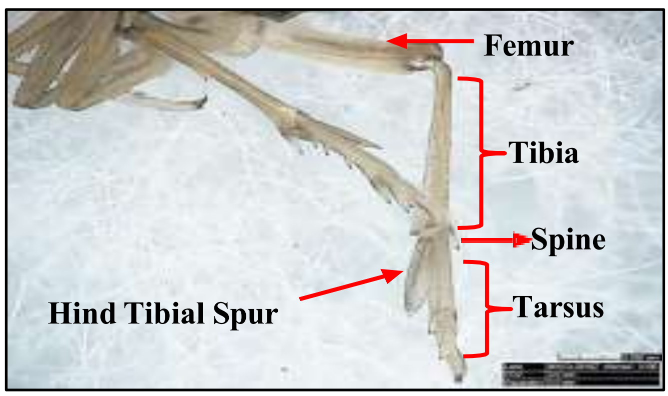

Figure 3. Morphology of the hind leg of the WBC imago

Morphological observation of the hind legs of the WBC imago sample shows that the tibia of the hind legs of the WBC imago sample has a hind tibial spur (Figure 3). The identification of the tibia on the hind legs of the Delphacidae family conducted by Wilson and Claridge (1991) shows that the hind legs of insects of the Delphacidae family have a hind tibial spur, also known as a movable spur. According to Mochida et al. (1979), the morphological characteristic that is typical of N. lugens (male macroptera) on the hind legs is the presence of a spur, also known as a calcar, on the hind tibia.

The morphology of the hind legs of the WBC imago sample shows that the legs are divided into several parts, namely: femur, tibia, and tarsus with spines located on the tibia to tarsus (Figure 3). According to Mochida et al. (1979), the morphological characteristics that are typical of N. lugens can be distinguished by the presence of spines on the basal segment of the tarsus on the hind legs.

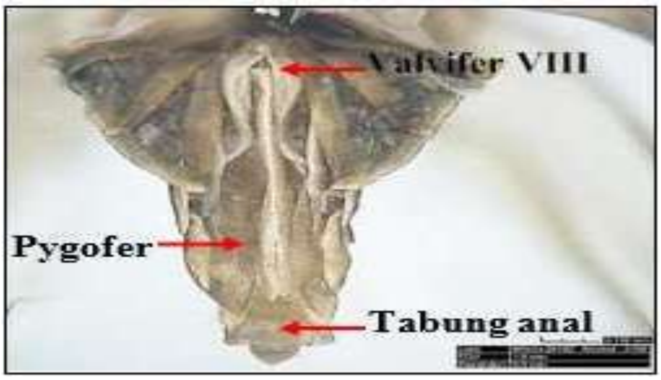

Figure 4. Morphology of female sexual organs of WBC imago

The brown planthopper (Nilaparvata lugens Stål) is one of the major pests of rice crops in Asia, including Indonesia, causing damage both directly through the sucking of plant sap and indirectly as a vector of rice viruses. According to Nilaparvata lugens, this insect exhibits two wing morphologies, or wing dimorphism: macropterous and brachyptous. The macropterous form has long wings that cover the entire abdomen, enabling it to fly and migrate long distances, whereas the brachyptous form has short wings with limited flying ability (Sōgawa, 1982).

Chaerani et al. (2017) explain that the macropterous form generally develops under conditions of high population density and an unfavorable environment, prompting the insects to migrate in search of new host plants. Conversely, the brachyptous form is more dominant under stable environmental conditions and sufficient food availability because this type focuses more on reproduction than migration. This indicates that wing dimorphism in the brown planthopper is a form of physiological adaptation to environmental conditions.

The morphology of the sexual organs of female WBC imago samples showed the presence of valvifer VIII, pygofer, and anal tube, which are specific morphological characteristics of N. lugens (Figure 4).

Sampling of WBC imagoes from the field showed that macroptera and brachyptera were found in every observation district (Asahan District, Batubara District, Deli Serdang District, and Langkat District) (Table 1). According to Xue et al. (2014), among all the characteristics of WBC, the most notable are its wing dimorphism (macroptera and brachyptera imago) and its ability to migrate long distances, which allows the WBC imago to exploit host plants, namely rice, in temperate climates and cause maximum damage to rice production in a wide geographical area. Measurement results show that WBC brachyptera in Asahan district has a body length of 3.892 mm, Batubara district 3.892 mm, Deli Serdang district 3.356 mm, and Langkat district 2.57 mm. WBC brachyptera imago is found in all districts. The WBC imago in Batubara district has a longer body length than in Asahan, Deli Serdang, and Langkat districts.

The results of WBC wing length measurements in Asahan district show a length of 2.17 mm, Batubara district 2.552 mm, Deli Serdang district 2.63 mm, and Langkat district 1.31 mm. Meanwhile, the leg length in Asahan district was 5.32 mm, Batubara district 6.016 mm, Deli Serdang district 5.286 mm, and Langkat district 2.42 mm.

Table 2. Average Comparison of Body Length, Wing Length, and Leg Length of Brachypterous Imagoes WBC in Asahan Regency, Batubara Regency, Deliserdang Regency, and Langkat Regency Observations (n=50)

Regency	Body Length (Magnification 4x)	Wingspan (Magnification 8x)	Leg Length (Magnification 8x)
Asahan	3.25 mm	2.17 mm	5.32 mm
Batubara	3.892 mm	2.552 mm	6.016 mm
Deli Serdang	3.356 mm	2.634 mm	5.286 mm
Langkat	2.57 mm	1.31 mm	2.42 mm

Measurement results show that WBC macroptera in Asahan district at 2x magnification have a body length of 2.15 mm, Batubara district 2.6 mm, Deli Serdang district 2.12 mm, and Langkat district 2.43 mm. WBC macroptera imagoes are found in all districts. The WBC imago in Batubara district has a longer body length than those in Asahan, Deli Serdang, and Langkat districts.

Measurement results of the wing length of WBC macroptera at 2.5x magnification in Asahan district show a length of 2.59 mm, Batubara district 2.56 mm, Deli Serdang district 2.67 mm, and Langkat district 2.34 mm. Meanwhile, the leg length at 4x magnification in Asahan Regency was 3.79 mm, Batubara Regency 3.43 mm, Deli Serdang Regency 3.766 mm, and Langkat Regency 3.47 mm.

Table 3. Average Comparison of Body Length, Wing Length, and Leg Length of Macroptera Imago WBC in Asahan Regency, Batubara Regency, Deliserdang Regency, and Langkat Regency Observations (n=50)

Regency	WBC Imago Makroptera		
	Body Length (Magnification 2x)	Wingspan (Magnification 2.5x)	Leg Length (Magnification 4x)
Asahan	2.15 mm	2.59 mm	3.79 mm
Batubara	2.6 mm	2.566 mm	3.43 mm
Deli Serdang	2.122 mm	2.672 mm	3.766 mm
Langkat	2.43 mm	2.34 mm	3.47 mm

WBC Biomolecular Test

After morphological identification of the WBC samples, WBC PCR detection was performed at the species level. The Polymerase Chain Reaction (PCR) method was used to examine four WBC samples obtained from four districts after DNA extraction/purification using the Dneasy Blood and Tissue extraction kit. The primers used in this study were the universal insect mitochondrial primer pair LCO 1490/HCO 2198, with amplification results at 700 bp.

Based on the electrophoresis results of the four samples tested, namely WBC samples from Asahan, Batubara, Deliserang, and Langkat districts, all four showed N. lugens DNA bands at 700 bp (Figure 5). Bahagiawati and Habib Rijzaani, 2005, conducted research on WBC using several potential primers that produced three to seven DNA bands from each RAPD reaction, ranging in size from approximately 200 bp to 1600 bp.

The sequencing results from four PCR samples (WBC Asahan Regency, Batubara Regency, Deli Serdang Regency, and Langkat Regency) were analyzed using BLAST to compare the sequence results with the data in Gene Bank. The analysis was performed using tools available on the NCBI website. The sequencing results were then aligned using Clustal W, which is part of the MEGA 11.0 software.

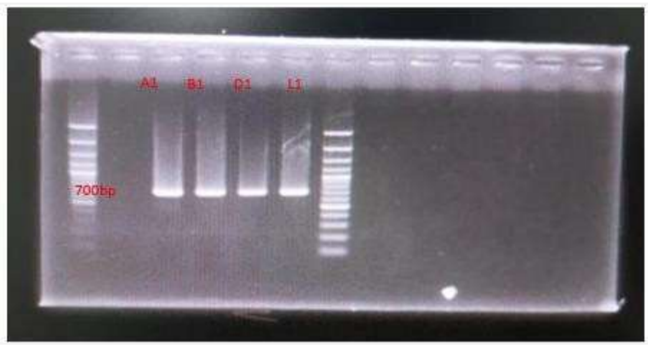

Figure 5. WBC electrophoresis results from each district with the codes marker (M), positive control (C+), A1 (Asahan District), B1 (Batubara District), D1 (Deli Serdang District), L1 (Langkat District) and negative control

Table 4. Results of Sample Sequencing Analysis Using BLAST Analysis

Sample Name (Sample Code)	GenBank	E-Value	Percent Identity (%)
Nilaparvata lugens Asahan (A1)	*Nilaparvata lugens*	0.0	100%
Nilaparvata lugens Batubara (B1)	*Nilaparvata lugens*	0.0	100%
Nilaparvata lugens Deli Serdang (D1)	*Nilaparvata lugens*	0.0	100%
Nilaparvata lugens Langkat (L1)	*Nilaparvata lugens*	0.0	100%

Based on the results of multiple alignments, genetic distances were also obtained. Genetic distance is the genetic difference between species or between populations within a particular species. Genetic distance is measured using various parameters. A small genetic distance indicates a close genetic relationship. A large genetic distance indicates a distant genetic relationship (Pinem et al., 2015). The genetic distance values of the 4 samples indicate a fairly close genetic distance, suggesting that the samples have a close genetic relationship. The genetic distance between the 4 samples and the 4 reference sequences taken from the gene bank also indicates a close genetic distance, suggesting that the samples also have a close genetic relationship with the sequences taken from the GeneBank, as shown in Table 5.

In general, there are three types of clades in phylogenetic trees: monophyletic groups, which are groups of organisms descended from the same ancestor or ancestors; paraphyletic groups, which are groups of organisms consisting of some monophyletic groups (descended from the same ancestor or ancestors); and polyphyletic groups, which are groups of organisms that are all descended from different ancestors (diverse).

The phylogenetic tree in Figure 6 shows that the analyzed mitochondrial sequences form three clades. A group is said to be monophyletic if all of the operational taxonomy units grouped together are closer to each other genealogically (sharing the same ancestor) than to other groups of different lineages (not sharing the same ancestor). A monophyletic group is also called a clade. Based on Figure 6, the genetic distance value between N. lugens in each district is 0, in other words, there is no genetic distance difference between the samples, or it can be concluded that the samples have homologous/identical sequences.

Table 5. Genetic Distance between N. lugens Sequences and Sequences Found in GeneBank

	1	2	3	4	5	6	7
JN563995.1_Nilaparvata_lugens _biotype_1_mitochondrion_complete _genome							
JN563996.1_Nilaparvata_lugens_ biotype_2_mitochondrion_complete _genome	0.578						
JN563997.1_Nilaparvata_lugens_ biotype_3_mitochondrion_complete _genome(2)	0.578	0.000					
MK301229.1_Nilaparvata_lugens_i solate_Y	0.578	0.000	0.000				
N._lugens_Asahan	0.573	0.596	0.596	0.596			
N._lugens_Batubara	0.573	0.596	0.596	0.596	0.000		
N._lugens_D._Serdang	0.573	0.596	0.596	0.596	0.000	0.000	
N._lugens_Langkat	0.574	0.598	0.598	0.598	0.002	0.002	0.002

Figure 6. Phylogenetic tree of N. Lugens

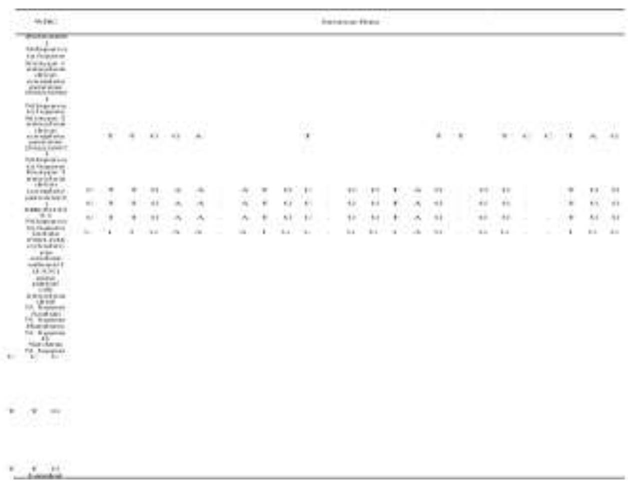
Figure 7. Base composition of WBC samples from four districts compared to the base composition of WBC biotypes in GeneBank

The results of the phylogenetic tree analysis revealed the possibility of a new biotype, as it did not fall into biotype 1, biotype 2, or biotype 3. This is likely biotype 4. In 1980, to combat WBC biotype 2, the IR42 (bph2) variety was introduced, but in 1981 an outbreak occurred in Simalungun, North Sumatra, and several other areas because the WBC population had changed from biotype 2 to biotype 3. Meanwhile, in other regions, according to Baehaki (1987, 2010, 2012), the brown stem rust populations in Klaten and Yogyakarta showed different adaptive abilities to resistant varieties and had evolved into biotype 4. To combat WBC biotype 3, IR56 (Bph3) was introduced in 1983 and IR64 (Bph1+) in 1986.

In 2006, the resistance gene for the WBC population in IR64 was damaged because the WBC population had changed to biotype 4 planthoppers (Maman, 2020). Bottrell et al. (2012) stated that WBC biotypes identified based on the International Rice Research Institute (1996) testing standards do not reflect their genetic variation.

Based on the WBC base composition of the four regions, genetic similarities between samples are shown in Figure 6, indicating the level of gene flow that occurs. Based on this, it is suspected that WBC samples in the study areas migrate or move between each other and interbreed. From an ecological perspective, there are no barriers between WBC population habitats.

Characteristics of Responding Farmers

Characteristics of rice farmers based on education, age, gender, and farming experience. The majority of farmers who responded were in the 41-50 age group, namely 33.67% in Asahan Regency, 43.33% in Batubara

Regency, 40% in Deli Serdang Regency, and 46.67% in Langkat Regency (Figure 1). According to BPS (2024), a person's economically productive age ranges from 16 to 64 years old. This shows that farmers in the four districts are still in their productive age. A person in their productive age will be able to work well in managing agricultural land and make decisions related to pest control measures on their respective farmland.

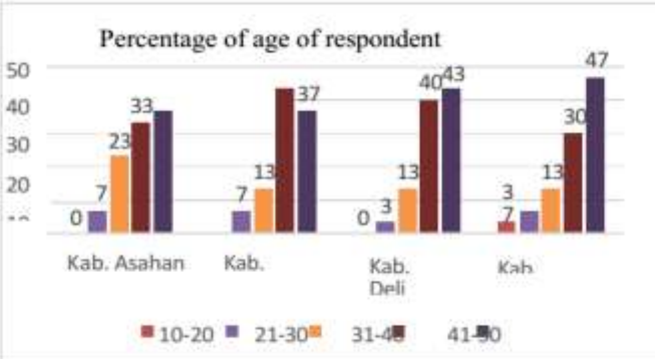

Figure 8. Percentage comparison of the ages of farmer respondents in the four observation districts

The formal education level of the farmer respondents varied from elementary school to bachelor's degree. Generally, the farmer respondents in the four districts were high school graduates, with percentages of 60%, 60%, 56%, 67%, and 53.33% in Asahan, Batubara, Deli Serdang, and Langkat being 60%, 60%, 56.67%, and 53.33% (Figure 9), respectively, while respondents with a bachelor's degree had the lowest percentage.

Based on the results of interviews with farmers in the four districts, male farmers dominated, with percentages in Asahan, Batubara, Deli Serdang, and Langkat districts being 86.6%, 80%, 90%, and 76.67%, respectively. Meanwhile, the percentage of female farmers was only 3.33%, 20%, 10%, and 23.33% (Figure 10). The majority of female farmers only do farming as a side job to help their husbands manage their farming businesses.

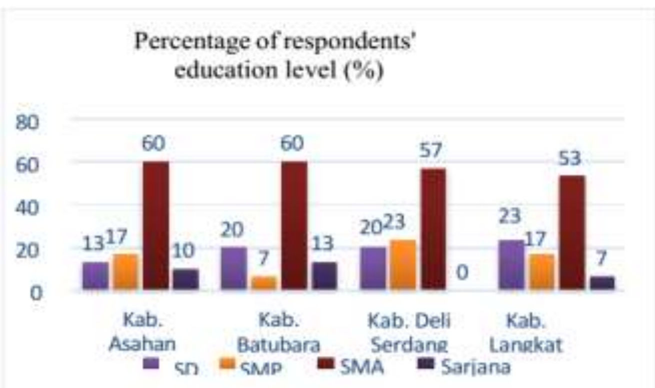

Figure 9. Comparison of the percentage of education levels of farmer respondents in 4 districts (n=30)

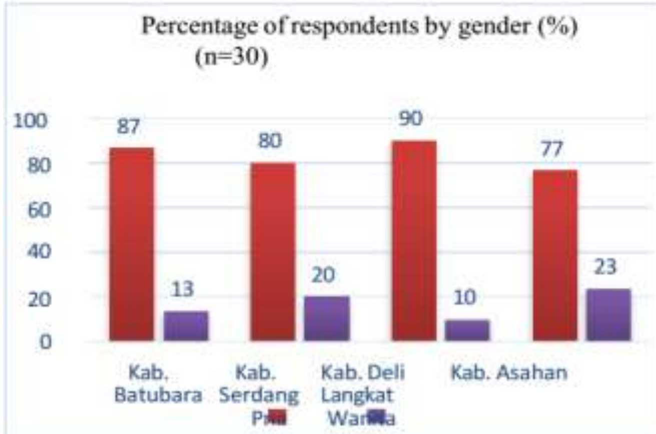

Figure 10. Comparison of the percentage of gender of farmer respondents in 4 districts (n=30)

Based on the results of field interviews, the highest percentage of respondents' farming experience was between 11 and 20 years, with the percentages in each of the districts of Asahan, Batubara, Deli Serdang, and Langkat being 36.67%, 43.33%, 36%, 67%, and 26.67% (Figure 11). According to Riadiani (2012), the longer the years of farming, the higher the level of experience that farmers will have and the better their behavior in managing the land will be.

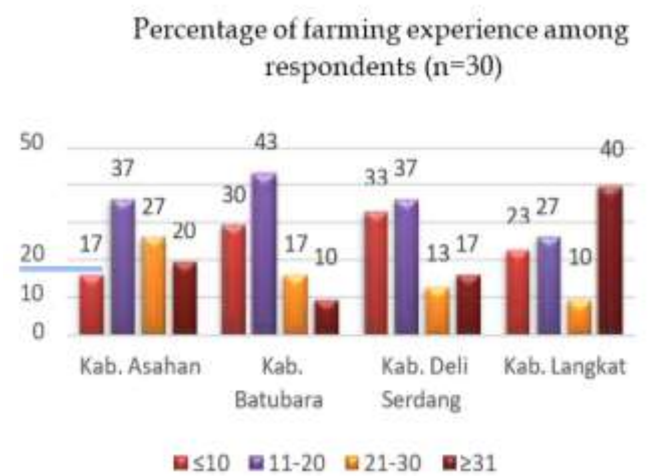

Figure 11. Comparison of the percentage of farming experience of farmer respondents in 4 districts (n=30).

Characteristics of WBC Control

The use of the Inpari-32 variety in the four districts, namely Asahan, Batubara, Deli Serdang, and Langkat, shows that the majority of farmer respondents use the Inpari-32 variety, with percentages for each district being 80%, 76%, 67%, 80%, and 63.33% (Table 4). In addition to Inpari-32, farmers also use the Ciherang, Mekongga, M70, Inpari 42, and local varieties.

Respondents' use of the Inpari-32 variety is influenced by the availability of seeds at agricultural kiosks or nurseries, the price of the seeds themselves, production yields, and personal preferences or habits.

According to the respondent farmers, seed stocks for the Inpari-32, Mekongga, and Ciherang varieties are readily available at agricultural kiosks and nurseries. However, there are still farmers who use seeds from the previous season's harvest. These factors together will affect the amount of rice seeds used in the community.

Respondent farmers use the Inpari-32 variety because it is widely available and has high productivity. This is in line with the results of research by Purba et al. (2022) that the productivity of the Inpari-32 variety is higher than Ciherang and Mekongga. Conversely, the productivity of the Inpari-32 variety is stated to reach 8-10 tons/ha in one harvest, exceeding the estimated yield potential.

The Inpari-32 variety is also somewhat susceptible to WBC, based on the results of interviews with respondents in Deli Serdang District, which had the highest incidence compared to other districts. The majority of farmers in this district use the Inpari-32 variety. Hardiansah et al (2020) stated that based on their research, the highest WBC population was found in the Inpari-32 variety.

Research Darmadi et al. (2018) stated that WBC observations on rice plants differed between varieties. The high WBC population in the Inpari 32 variety may be due to the fact that this variety is somewhat susceptible to WBC attacks. According to Litbang (2020), the Inpari 32 variety is somewhat susceptible to WBC biotypes 1, 2, and 3. According to Dianawati (2015), continuous planting of resistant varieties will not be sufficient to prevent pest attacks. This is because some pests have the ability to adapt and form new biotypes that can cause variety resistance to break down.

Respondent farmers use various types of pesticides to control WBC. The majority of respondent farmers use more than three types of pesticides, with the highest percentage in Batubara Regency at 96.67%, Asahan Regency at 90%, Deli Serdang Regency at 70%, and Langkat Regency at 53% (Figure 12A). The information obtained by the interviewer shows that the majority of farmers apply pesticides by mixing them with other pesticides and using doses that do not comply with the recommendations on the pesticide label. The use of pesticides is the main choice of farmers to suppress pest attacks, even though according to Laba et al. (2008), the use of pesticides can have a negative impact on the main pests and non-target organisms. These impacts include the emergence of resistance and resurgence of insect pests, as well as threats to natural enemies and non-target organisms.

Meilin et al. (2014) also reported that the application of insecticides can reduce the ability of parasitoids to control insect pests. Pesticide application in a single planting period for WBC control was mostly more than three times, with the highest percentage in Batubara Regency at 96.67%, Deli Serdang Regency at 83.33%, Asahan Regency at 73.33%, and Langkat Regency at 46.67% (Figure 12B). Inappropriate use of pesticides can exacerbate pest attacks. Pesticides are the main choice for farmers because of their immediate effect in suppressing pest attacks. Chai (2008) states that without the use of pesticides, crop losses reach 34% and will decrease by 35-42% if pesticides are applied (Liu et al., 2002).

WBC attacks in a single planting period, based on interviews with farmer respondents, varied from 1% to 5% per area of land owned by farmers. The group with the highest WBC attack rate ranged from 1% to 2% in each observation district (Figure 12C). The intensity of WBC attacks is still below the economic threshold, which is above 10% and in the generative phase there are 4 egg groups per clump (BPTP West Java, 2011).

A B C

Figure 12. A. Comparison of the percentage of pesticide types used by respondent farmers in 4 districts (n=30), B. Comparison of the percentage of pesticide use in one planting period to control WBC in 4 districts (n=30), C. Comparison of the percentage of WBC attacks in one planting period in 4 districts (n=30)

Based on the correlation coefficient values obtained from the analysis using SPSS, in Asahan District (0.563) with a significance value (0.001), Batubara District (0.969) with a significance value (0.000), Deli Serdang District (0.432) with a significance value (0.17), and Langkat District (0.782) with a significance value (0.000), it can be categorized that there is a degree of relationship between the rice varieties used by the respondent farmers and the level of WBC attack in the four observation districts presented in Table 6. This shows that the varieties used by the respondent farmers affect the level of WBC attack.

Table 6. Correlation Analysis Results (r) of the Relationship between Varieties and WBC Attack Levels

Asahan	Rice Varieties	Attack Level
Correlation	1.000	.563**
Person	.563**	1.000
Sig.(2-tailed)	.001	.001
N	30	
Batubara		
Correlation	1	.969**
Person	.969**	1
Sig.(2-tailed)	.000	.000
N	30	
Deli Serdang		
Correlation	1	.432*
Person	.432*	1
Sig.(2-tailed)		.017
N	30	
Langkat		
Correlation	1	.782**
Person	.782**	1
Sig.(2-tailed)	.000	
N	30	30

Note: **The correlation is highly significant at the level

The positive correlation indicates that the more often the variety is used, the higher the level of WBC attack. The rice variety frequently used by the respondent farmers is Inpari-32, which is a variety that is somewhat susceptible to WBC biotypes 1, 2, and 3. According to Dianawati and Sujitno, 2015, the presence of WBC in rice fields is influenced by biotic and abiotic factors. Biotical factors that influence the presence of WBC in fields include rice varieties and the presence of natural enemies. Rahmini, et al. 2012 also stated that the use of susceptible varieties is one of the factors causing the emergence of WBC in fields.

Cultivation Characteristics

Common problems faced by farmers include pests and diseases, price fluctuations, land suitability, marketing, and irrigation. Based on interviews with farmer respondents in four districts, the main problems that are always encountered are pests and diseases, price fluctuations, and water/irrigation. Ridwan (2009) explains that the decline in rice production is caused by many factors, including climate change, water availability, soil fertility, rice varieties, crop management systems, pests, and rice diseases.

Pests and diseases are the most common problems experienced by farmers. This is consistent with the results of interviews in the four districts, namely 93.33% of the problems complained about by farmers in Asahan District, 70% in Batubara District, 80% in Deli Serdang District, and 66.67% in Langkat District. In addition to pests and diseases, another problem frequently experienced by farmers is related to limited business capital. Business capital in agriculture plays an important role for farmers in production.

Capital plays an important role in farmers' considerations before undertaking agricultural activities (Hermanto, 1992). Capital is needed primarily for the procurement of production inputs (seeds, fertilizers, and pesticides), which farmers perceive as increasingly expensive. Indonesian farmers are generally smallholders with limited capital, and their sources of funding are often considered insufficient to finance the expansion of their farming businesses.

The area of rice fields owned by rice farmers in the four districts ranges from 1,000 to 10,000 m2, with a percentage of 70% in Asahan District, 56.67% in Batubara District, 93.33% in Deli Serdang District, and 76.67% in Langkat District (Table 7). This shows that the area of land managed by farmers is relatively small. Relatively limited land ownership affects the efficiency of farming. Farmers who own or manage small areas of land cannot produce optimally, and their income at harvest time is often less than the total cost of farming they have to bear (Handayani, 2006).

Crop rotation is only practiced by a small number of farmers in the four subdistricts, namely by planting secondary crops such as beans and corn as intercrops. A total of 100% of farmers in Asahan District do not practice crop rotation, 70% in Batubara District, 90% in Deli Serdang District, and 63.33% in Langkat District, as shown in Table 8.

Continuous rice cultivation is one of the factors contributing to the spread of WBC. This is related to food availability, as WBC is a monophagous pest (on rice plants) that attacks almost all rice varieties, causing mild to severe damage and even crop failure. The majority of farmer respondents plant rice twice a year, with 100% of farmer respondents in Asahan Regency, 90% in Batubara Regency, 90% in Deli Serdang Regency, and 70% in Langkat Regency.

Conclusion

Results from the specific morphological identification of long-winged (Macroptera) and short-winged (Brachyptera) WBC imagoes. The results of aligning WBC samples with 4 sequences in GeneBank show a fairly close genetic distance, but when analyzed using a phylogenetic tree, the 4 samples are not in the same clade, indicating that the samples form a new clade or a new biotype. The characteristics of farmers managing agricultural businesses in controlling WBC are relatively similar, namely management based on farmers' traditions passed down from generation to generation and a preference for using chemical pesticides.

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References

Baehaki, S. (2012). Perkembangan Biotipe Hama Wereng Coklat pada Tanaman Padi. *Iptek Tanaman Pangan*, *7*(1), 8–17. https://repository.pertanian.go.id/bitstreams/55880300-32ee-4313-a4dc-6f28a19d8985/download

Baehaki, S. E., & Mejaya, I. M. (2014). Wereng Cokelat sebagai Hama Global Bernilai Ekonomi Tinggi dan Strategi Pengendaliannya. *Iptek Tanaman Pangan*, *9*(1), 1–12.

Bottrell, D. G., & Schoenly, K. G. (2012). Resurrecting the ghost of green revolutions past: The brown planthopper as a recurring threat to high-yielding rice production in tropical Asia. *Journal of Asia-Pacific Entomology*, *15*(1), 122–140. https://doi.org/10.1016/j.aspen.2011.09.004

Chaerani, C. (2018). Virulensi Wereng Batang Cokelat (Nilaparvata lugens Stål) dan Strategi Pengelolaannya. *Jurnal AgroBiogen*, *13*(1), 53. https://doi.org/10.21082/jbio.v13n1.2017.p53-66

Chai, D. (2008). Understand the role of chemical pesticides and prevent misuses of pesticides. *Bulletin of Agricultural Science and Technology*, *1*, 36 38.

Darmadi, D., & Alawiyah, T. (2018). Respons Beberapa Varietas Padi (Oryza sativa L.) terhadap Wereng Batang Coklat (Nilaparvata lugens Stall) Koloni Karawang. *Agrikultura*, *29*(2), 73. https://doi.org/10.24198/agrikultura.v29i2.19249

Dianawati, M. (2015). Kajian berbagai varietas unggul terhadap serangan wereng batang coklat dan produksi padi di lahan sawah Kabupaten Garut, Jawa Barat. *Pros. Sem. Nas. Masy. Biodiv. Indon*, *1*(4), 868–873. https://doi.org/10.13057/psnmbi/m010437

Effendi, B. S., & Munawar, D. (2015). Uji ketahanan galur padi terhadap wereng coklat biotipe 3 melalui population build-up. *Jurnal Entomologi Indonesia*, *10*(1), 7. https://doi.org/10.5994/jei.10.1.7

Hardiansah, T. M., Rostaman, & Haryanto, T. A. (2020). Tingkat Serangan Wereng Batang Coklat dan Penggerek Batang Padi pada Beberapa Varietas Padi di Purbalingga. *Jurnal Pertanian Indonesia*, *1*(2), 75–82.

Iamba, K., & Dono, D. (2021). A Review on Brown Planthopper (Nilaparvata lugens Stål), a Major Pest of Rice in Asia and Pacific. *Asian Journal of Research in Crop Science*, *6*(4), 7–19. https://doi.org/10.9734/ajrcs/2021/v6i430122

Kurniawati, S., Susanti, E. Y., Noviastuti, N., Giamerti, Y., Yursak, Z., & Susilawati, P. N. (2022). Preferensi Petani dan Konsumen terhadap Gabah, Beras dan Nasi dari 10 Varietas Unggul Baru di Kabupaten Serang Provinsi Banten. *Agropross : National Conference Proceedings of Agriculture*, 102–107. https://doi.org/10.25047/agropross.2022.278

Laba, I. W., & Trisawa, I. M. (2008). Tinjauan masalah serangga hama dan pengelolaannya. *Prosiding Seminar Nasional Perhimpunan Entomologi Indonesia Cabang Palembang Dan Perhimpunan Fitopatologi Indonesia Komda Sumsel*.

Liu, C. J., Men, W. J., Liu, Y. J., & Zhang, H. (2002). The pollution of pesticides in soils and its bioremediation. *System Sciences and Comprehensive Studies in Agriculture*, *18*(4), 295–297.

Meilin, A., & Heru, R. (2014). Dampak Insektisida Deltametrin Konsentrasi Subletal pada Perilaku dan Biologi Parasitoid. *Iptek Tanaman Pangan*, *9*. Retrieved from https://www.academia.edu/download/81150951/2178.pdf

Mochida, O., & Okada, T. (1979). Taxonomy and biology of Nilaparvata lugens (Hom., Delphacidae). In *Brown Planthopper: Threat to Rice Production in Asia* (pp. 21–44). International Rice Research Institute.

Pinem, D. Y. F., Irmansyah, T., & Sitepu, F. E. (2015). Respons Pertumbuhan dan Produksi Brokoli Terhadap Pemberian Pupuk Kandang Ayam dan Jamur Pelarut Fosfat. *Jurnal Online Agroekoteknologi*, *3*(1), 198–205. https://doi.org/10.32734/jaet.v3i1.9383

Purba, T., Tarigan, K., & Supriana, T. (2022). Analisis Sikap Dan Preferensi Petani Terhadap Penggunaan Benih Padi Varietas Unggul di Kabupaten Langkat Sumatera Utara. *Jurnal Agrica*, *15*(1), 35–47. https://doi.org/10.31289/agrica.v15i1.5169

Sōgawa, K. (1982). The Rice Brown Planthopper: Feeding

Physiology and Host Plant Interactions. *Annual Review of Entomology*, *27*(1), 49–73. https://doi.org/10.1146/annurev.en.27.010182.000405

Sumini, S., & Kusdarwati, R. (2020). The Discovery of Vibrio harveyi on Litopenaeus vannamei Infected White Feces Disease in Situbondo, East Java. *Jurnal Perikanan Universitas Gadjah Mada*, *22*(1), 9. https://doi.org/10.22146/jfs.47791

Suwandari, N. L. A., Mulyantari, N. K., & Wirawati, I. A. P. (2023). Convalescent Plasma Therapy for COVID-19 with Pregnancy in Sanglah Hospital, Denpasar. *Indonesian Journal Of Clinical Pathology And Medical Laboratory*, *30*(1), 97–101. https://doi.org/10.24293/ijcpml.v30i1.1837

Syahrawati, M., Hermanda, A., Arneti, A., & Darnetty, D. (2021). Predation of Phidippus sp [Araneae: Salticidae] on Nilaparvata lugens [Hemiptera: Delphacidae] at different densities. *IOP Conference Series: Earth and Environmental Science*, *741*(1), 012013. https://doi.org/10.1088/1755-1315/741/1/012013

Tian, W., Wang, Y., Zhou, Y., Yao, Y., & Deng, Y. (2022). Effects of Prophylactic Administration of Granulocyte Colony-Stimulating Factor on Peripheral Leukocyte and Neutrophil Counts Levels After Chemotherapy in Patients With Early-Stage Breast Cancer: A Retrospective Cohort Study. *Frontiers in Oncology*, *12*. https://doi.org/10.3389/fonc.2022.777602

Wati, C. (2017). Identifikasi Hama Tanaman Padi (Oriza sativa L) Dengan Perangkap Cahaya di Kampung Desa Distrik Prafi Provinsi Papua Barat. *Jurnal Triton*, *8*(2), 81–87. Retrieved from https://jurnal.polbangtanmanokwari.ac.id/index.php/jt/article/view/25

Wilson, M. R., & Claridge, M. F. (1991). *Handbook for the identification of leafhoppers and planthoppers of rice*. CAB International.

Xue, J., Zhou, X., Zhang, C.-X., Yu, L.-L., Fan, H.-W., Wang, Z., Xu, H.-J., Xi, Y., Zhu, Z.-R., Zhou, W.-W., Pan, P.-L., Li, B.-L., Colbourne, J. K., Noda, H., Suetsugu, Y., Kobayashi, T., Zheng, Y., Liu, S., Zhang, R., … Cheng, J.-A. (2014). Genomes of the rice pest brown planthopper and its endosymbionts reveal complex complementary contributions for host adaptation. *Genome Biology*, *15*(12), 521. https://doi.org/10.1186/s13059-014-0521-0

Yuliani, & Agustian, A. P. (2020). Kepadatan Populasi Dan Intensitas Serangan Wereng Batang Coklat (Nilaparvata lugens. Stal) Pada Budidaya Padi Pandanwangi Dengan Penerapan Organik Dan Anorganik. *Pro-Stek*, *2*(1), 49–56. Retrieved from https://pdfs.semanticscholar.org/792c/671cd7ed1fce3947b8fa01f6d08a257f1330.pdf

Zhang, J. L., Fu, S. J., Chen, S. J., Chen, H. H., Liu, Y. L., Xin, Liu, Y., & Xu, H. J. (2021). Vestigial mediates the effect of insulin signaling pathway on wing-morph switching in planthoppers. *PLoS Genetics*, *17*(2), 1–19. https://doi.org/10.1371/JOURNAL.PGEN.1009312