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PREFERENSI KEHADIRAN DAN OVIPOSISI *Rhyzopertha dominica* (Fabricius) (Coleoptera: Bostrichidae) PADA BEBERAPA VARIETAS UNGGUL BARU PADI

PRESENCE AND OVIPOSITION PREFERENCES OF Rhyzopertha dominica (Fabricius) (Coleoptera: Bostrichidae) *ON SEVERAL NEW SUPERIOR VARIETIES OF RICE*

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ABSTRAK

Varietas Unggul Baru (VUB) padi merupakan hasil inovasi bidang pertanian untuk meningkatkan produktivitas padi di Indonesia. VUB padi mampu meningkatkan produktivitas (8,51 t/ha), pendapatan (65,8%), dan produksi padi dalam kisaran 1,5–33,71%. Adanya peningkatan produksi, maka diperlukan upaya penyimpanan untuk menjaga ketersediaan dan kualitas padi. Akan tetapi, terdapat kendala dalam penyimpanan, yaitu adanya serangan hama gudang, *Rhyzopertha dominica* (Fabricius) (Coleoptera: Bostrichidae). Hama *R. dominica* dapat menginfestasi gabah dan beras dalam simpanan. Oleh karena itu, penelitian ini dilakukan untuk mengetahui preferensi kehadiran dan oviposisi *R. dominica* pada beberapa gabah dan beras VUB padi (varietas Baroma, Inpara 9 Agritan, Inpari Gemah, Inpari 43 Agritan GSR, Ciherang, dan Inpari 42 Agritan GSR) menggunakan mekanisme ketahanan antixenosis. Hasil penelitian menunjukkan bahwa preferensi kehadiran dan oviposisi *R. dominica* dipengaruhi oleh faktor fisik pakan (bentuk dan kekerasan biji). Preferensi kehadiran dan oviposisi *R. dominica* lebih tinggi dan memiliki pola penyebaran mengelompok (*clumped)* pada bentuk beras dibandingkan dengan bentuk gabah. Beberapa beras VUB memiliki tingkat kekerasan biji yang lebih rendah dibandingkan dengan gabah sehingga lebih menarik serangga *R. dominica* untuk hadir dan meletakkan telur. Akan tetapi, faktor kimia pakan seperti kandungan fenol, kadar air, karbohidrat, protein, lemak, dan abu yang terkandung dalam beberapa gabah dan beras VUB padi tidak memengaruhi preferensi kehadiran dan oviposisi *R. dominica*.

ABSTRACT

New Superior Varieties (NSV) of rice is result from agricultural innovation to increase rice productivity in Indonesia. VUB of rice can increase productivity (8.51 t/ha), income (65.7%), and rice production (1.5–33.71%). With this increase in rice production, storage properties are needed to maintain the availability and quality of rice. However, the main obstacle in rice storage is the infestation of stored product pest Rhyzopertha dominica (Fabricius) (Coleoptera: Bostrichidae). R. dominica can infest unhulled rice and milled rice in storage. This study aimed to examine the presence and oviposition preferences of R. dominica on several unhulled rice and milled rice of new superior varieties (i.e., Baroma, Inpara 9 Agritan, Inpari Gemah, Inpari 43 Agritan GSR, Ciherang, and Inpari 42 Agritan GSR) using the antixenosis resistance mechanism. The results showed that the presence and oviposition preferences of R. dominica were influenced by physical factors of the diet (form and grain hardness). The presence and oviposition of R. dominica were higher and there was a clustered distribution (clumped) on the milled rice compared to the unhulled rice. Some milled rice has a lower grain hardness level than unhulled rice, so it is more attractive to R. dominica to be present and lay eggs. However, chemical factors of the diet, such as phenol content, water content, carbohydrate, protein, fat, and ash contained in several unhulled rice and milled rice, did not significantly affect the presence and oviposition preferences of R. dominica.

KEYWORDS:

Milled rice, new superior varieties of rice, presence and oviposition preferences, Rhyzopertha dominica, unhulled rice

1. INTRODUCTION

The New Superior Varieties (NSV) of rice are result from innovation in the agricultural sector, developed to increase rice productivity. NSV of rice developed in Indonesia results from the Balai Besar Pengujian Standard Instrumen (BBPSI) Padi (Thamrin *et al*., 2023). NSV of rice has advantages in high yields and adapting to location-specific conditions. NSV of rice can increase productivity (8.51 t/ha) and income (65.8%) (Susanti *et al*., 2020). Slameto and Kismanto (2018) reported that using NSV of rice can potentially increase rice production by 1.5–33.71%. With the increase in rice production, proper effort is needed to store the rice, which is usually stored in the form of unhulled rice and milled rice. Storage is carried out to maintain the availability and quality of rice, both in terms of physical, chemical, and functional properties (Kanta, 2016). However, there are obstacles to storing rice, such as the infestation of stored product pests. Stored product pest attacks on stored products can cause losses of up to 50% (Astuti, 2019). One of the stored product pests that have the potential to cause damage to stored unhulled rice and milled rice is *Rhyzopertha dominica* (Fabricius) (Coleoptera: Bostrichidae) (Rees, 2004).

R. dominica is a cosmopolitan pest with a broad host range (Hagstrum *et al*., 2013). This pest can infest various stored products, including barley, corn, millet, oats, rice, sorghum, wheat, various types of spices, and various legumes (Rees, 2004; Hagstrum and Subramanyam 2009; Hagstrum *et al*., 2013). Setiono (2011) reported that *R. dominica* can infest unhulled rice and milled rice in storage. *R. dominica* has been reported to cause 20.67% damage to unhulled rice and 12.33% to milled rice (Hendrival *et al*., 2019). Furthermore, damage to *R. dominica* infestation is caused by the feeding activity of larvae and adults. *R. dominica* larvae and adults cause direct and indirect damage (Rees, 2004). Direct damage due to *R. dominica* infestation includes holes in grain, frass, decreased quantity of stored products, and contamination (Astuti, 2019). Furthermore, indirect damage to *R. dominica* infestation is caused by changes in odor and decreased commercial value of stored products (Kumar and Kalita, 2017). The level of damage to storage products due to *R. dominica* infestation is influenced by the diet's suitability, which is determined by the physical and chemical factors of the diet (Yasin, 2009). Physical factors of diet include the size, texture, and grain hardness. Furthermore, chemical factors of the diet include nutrient content (carbohydrates, amino acids, fat, vitamins, and minerals) and volatile compounds (Chapman, 2013). Physical and chemical factors in each diet variety can vary (Budiharto, 2023). Different diet content will affect the preferences of insects.

Some studies report that physical and chemical factors of diet can affect the preferences of stored product pests (Astuti *et al*., 2013; Astuti *et al*., 2019a; Arthur *et al*., 2020). Astuti *et al*. (2013) reported that *R. dominica* was more suitable for Intani-2 rice varieties than Sembada, Cibogo, IR-64, Ciherang, and Membramo rice varieties. Fajarwati *et al*., (2019) also reported that the high-fat content in black rice (2.64%) can support the growth of *R. dominica*. In addition, Arthur *et al*., (2020) reported that the population growth of *R. dominica* was more optimal on a diet with a low hardness level. This study aims to address the lack of evaluations on the presence and oviposition preferences of *R. dominica* on several unhulled rice and milled rice of NSV under storage conditions. Such evaluations are important to clarify the interaction between rice forms and varieties with the insect's behavioral responses, with practical implications for post-harvest management and the reduction of storage losses. This study was conducted to examine the presence and oviposition preferences of *R. dominica* on several unhulled rice and milled rice of NSV in storage (Baroma, Inpara 9 Agritan, Inpari Gemah, Inpari 43 Agritan GSR, Ciherang, and Inpari 42 Agritan GSR varieties) against *R. dominica*.

2. MATERIAL AND METHOD

2.1 Insect Rearing

The insect rearing of *R. dominica* was conducted at the Plant Pest Laboratory, Department of Plant Pests and Diseases (HPT), Faculty of Agriculture, Brawijaya University (FP UB), Malang, East Java, Indonesia, at a temperature of 27 ± 2°C and relative humidity of 42 ± 9%. The insect rearing of *R. dominica* was carried out on a rolled oat diet using an insect rearing box (l= 17 cm, w= 17 cm, h= 6 cm). The *R. dominica* insects used for insect rearing were obtained from the Plant Pest Laboratory, HPT, FP UB collection. The insect rearing was identified based on their morphology: a cylindrical body, brown in color, a head concealed under the pronotum, and pointed elytral tips (Astuti, 2019; Astuti *et al*., 2022). Insect rearing was done by infesting 100 *R. dominica* adults, without distinguishing between males and females, into a rearing box containing 500 g of rolled oat diet for 14 days (Setiono, 2011). Subsequently, the rearing box was closed with modified lids. After 14 days, the adults were removed, and the diet infested with *R. dominica* eggs was left until it became a newly emerged F1 progeny. The F1 progeny used in the experiment were 7–14 days old (Bashir, 2002).

2.2 Unhulled Rice and Milled Rice of New Superior Varieties

This research used six NSV of rice: unhulled rice and milled rice. Baroma, Inpara 9 Agritan, Inpari Gemah, and Inpari 43 Agritan GSR rice varieties were obtained from BBPSI Padi, West Java. The Ciherang variety was obtained from the Biological Agent Service Post Kepanjen, Malang Regency, and Inpari 42 Agritan GSR variety from farmers in Maindu Village, Kedungpring District, Lamongan, East Java. The diet obtained from unhulled rice was processed into rice using a mobile rice milling unit (local rice huller machine), which functions to dehull and polish the grains before being used in the experiment. Subsequently, all varieties of unhulled rice and milled rice were sterilized using the cold sterilization method by Heinrichs *et al*., (1985). Each variety was prepared in a single batch of unhulled rice and a single batch of milled rice (± 1 kg each), placed separately in ziplock plastic (l= 35 cm, w= 25 cm), resulting in a total of 12 sterilized samples. After that, it was put into a freezer with a temperature of -15°C for one week to kill the organisms carried in the diet. Then, the diet was moved into a chiller (refrigerator) with a temperature of 5°C for one week to avoid further contamination. After that, the diet was moved to a room temperature of 27±2ºC for two weeks to normalize the diet temperature before being used for treatment. The moisture content of the grain was measured using the SNI 01-2891-1992 method. The measurement results showed that the grain's moisture content was 8–12%, which meets the moisture content standards for stored cereal seeds (IRRI, 2025).

2.3 Physicochemical Properties Unhulled Rice and Milled Rice Analysis

The physicochemical properties of unhulled rice and milled rice of NSV were analyzed in the testing laboratory. Grain hardness testing was conducted at the Agricultural Food Technology Laboratory, Faculty of Food Technology (FTP), Gadjah Mada University (UGM), Yogyakarta using the Universal Testing Machine (UTM). The chemical analysis included total phenol content and proximate composition (carbohydrate, protein, fat, ash, and water content). For sample preparation, 30 g of unhulled rice and milled rice from each variety were used for total phenol analysis, while 200 g were used for proximate composition analysis. The samples were taken in the form of dried whole grains (unhulled and milled rice) and analyzed directly according to the requirements of each laboratory. Total phenol analysis was conducted using UV-VIS Spectrophotometry with the Folin-Ciocalteu method at the Plant Disease Laboratory, Department of HPT, FP UB. Proximate analysis was conducted at the Food Chemistry Laboratory, Badan Standardisasi Instrumen Pertanian (BSIP) Aneka Kacang, Malang Regency. Protein content was measured using the Kjeldahl method (AOAC, 2016 No. 12.1.07), fat content was measured through Soxhlet extraction (SNI 01-2891-1992 points 8.1.1–8.1.4), ash content by gravimetric method (SNI 01-2891-1992 points 6.1.1–6.13), and water content by oven drying (SNI 01-2891-1992 points 5.1.1–5.1.3). Finally, the carbohydrate content was calculated using a different method with the following formula: 100% - water content (%) - ash (%) - fat (%) - protein (%).

2.4 Preference Test

This research was conducted at the Plant Pest Laboratory, HPT, FP UB, Malang, East Java, Indonesia, from December 2024 to February 2025. During the research, the laboratory conditions were at a temperature of 27 ± 2°C and relative humidity of 42 ± 9%. The preference test was conducted using the Free Choice Test Method (FCTM) to examine the preference for the presence and oviposition of *R. dominica*. The preference test consisted of a combination of several unhulled rice and milled rice (n=12), which was repeated four times and arranged in a Factorial Completely Randomized Design (CRD). Furthermore, a separate preference test was conducted for several unhulled rice (n= 6) and milled rice (n= 6), repeated four times and arranged in a Completely Randomized Design (CRD). The preference test used a preference cage modified by Astuti *et al*. (2021). The preference cage was a hexagonal shape, consisting of 12 chambers (d= 45 cm, h= 10 cm) (Figure 1a) for the combined unhulled rice and milled rice, and six chambers (d= 30 cm, h= 10 cm) (Figure 1b) for the preference test of unhulled rice and milled separately. Preference tests using 12 chambers and six chambers were conducted to determine the consistency of the presence and number of eggs laid by female adults of *R. dominica* when experiments were conducted on a combination of unhulled rice and milled rice as well as experiments conducted separately between unhulled rice and milled rice. In each experiment, 30 g of diet was placed into each chamber, and 60 pairs of *R. dominica* adults (aged 7–14 days) were infested in the center of the preference cage. The number of adults present and eggs laid on each diet was recorded after seven days of infestation. The placement of chambers was randomized to minimize positional bias.

Table 1. Physicochemical of Some Treatments of Unhulled Rice and Milled Rice.

Treatments	Code	Physical Factor	Chemical Factors					
		Grain hardness (N)	Moisture content (%)	Ash (%)	Fat (%)	Protein (%)	Crb (%)	Pnl (ppm)
UR. Baroma	G.BR	154.16	8.70	5.74	2.06	6.32	77.19	1.90
UR. Inpara 9 Agritan	G.I9	204.02	9.25	4.36	2.01	6.16	78.23	2.20
UR. Inpari Gemah	G.GH	240.54	8.77	5.42	1.59	5.98	78.24	2.90
UR. Inpari 43 Agritan GSR	G.I43	231.75	9.66	7.39	2.02	5.23	75.70	1.20
UR. Ciherang	G.CH	191.30	10.65	5.64	1.84	5.71	76.16	2.80
UR. Inpari 42 Agritan GSR	G.I42	160.27	12.26	3.91	2.21	6.27	75.35	1.90
MR. Baroma	B.BR	94.83	9.91	0.55	0.22	6.72	82.60	0.81
MR. Inpara 9 Agritan	B.I9	68.51	9.55	0.63	0.30	7.59	81.93	0.77
MR. Inpari Gemah	B.GH	65.66	9.33	0.54	0.20	7.39	82.57	0.88
MR. Inpari 43 Agritan GSR	B.I43	77.76	10.78	0.41	0.30	6.08	82.44	0.91
MR. Ciherang	B.CH	58.00	11.02	0.52	0.32	6.17	81.97	0.87
MR. Inpari 42 Agritan GSR	B.I42	48.51	11.62	0.46	0.20	6.35	81.36	0.79

Notes: UR= unhulled rice, MR= milled rice, Crb= carbohydrate, Pnl= phenolic.

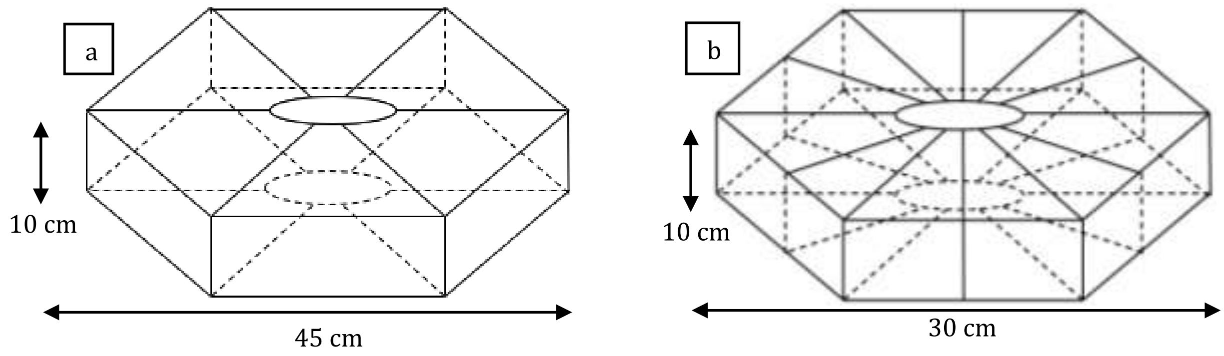

Figure 1. Preference cage (a) with twelve chambers and (b) with six chamber.

2.5 Distribution Pattern

The number of adults present and eggs laid by female adults of *R. dominica* were recorded each chamber (30 g of diet). Data from replicate chambers were then used to calculate the mean and variance for each treatment, providing the basis for determining the distribution pattern of number adult presence and eggs of *R. dominica* in the preference test. The distribution pattern calculation formula is based on the calculation of the dispersion index by Ludwig and Reynolds (1988).

$$ID = \frac{S^2}{\bar{x}} \quad (1)$$

ID is the dispersion index, S^2 is the variance estimate, and $\bar{x}$ is the sample mean. The ID shows a random pattern when (*random*) $\bar{x} = S^2$, a clumped pattern (*clumped*) when $\bar{x} > S^2$, and a uniform pattern (*uniform*) when $\bar{x} < S^2$.

2.6 Data Analysis

The data from the results of this research were tabulated using Microsoft Excel. The normality and homogeneity tests of the data were based on the Shapiro-Wilk and Levene Tests. If the assumptions of normality and homogeneity were not met, the data were transformed using a logarithmic transformation (log x) applied to count data, including the number of adults present and the number of eggs. Furthermore, the data on the number of adult presence (male+female) and the number of eggs from the combination preference experiment between unhulled rice and milled rice were analyzed using a two-way analysis of variance (ANOVA Two-Way) at a 5% error level. Meanwhile, the data on the number of adult presence (male+female) and the number of eggs from the preference test of several unhulled rice and milled rice conducted separately were analyzed using a one-way analysis of variance (ANOVA One-Way) at a 5% error level. If the analysis results showed a significant effect between treatments, it was continued with the Duncan Multiple Range Test (DMRT) at a 5% error level. In addition, the obtained data were analyzed using data on grain hardness, water content, ash, fat, protein, and total phenol. A Generalized Linear Model (GLM) was used to determine the relationship between the physical and chemical properties of the diet treatment and the observation variables. Data analysis was done using R statistical software version 4.3.2 (R Core Team, 2023) with the Agricolae package (Mendiburu, 2023).

3. RESULT AND DISCUSSION

3.1 Effect of Unhulled Rice and Milled Rice of New Superior Varieties on Adult Presence of *Rhyzopertha dominica*

The preference for the presence of *R. dominica* adults on several unhulled rice and milled rice of VUB was calculated based on the number of *R. dominica* adults present on each diet after seven days of infestation. The results of the combination preference test of unhulled rice and milled rice (n= 12) showed that the mean number of *R. dominica* imago present tended to be higher in the milled rice (9.25–19.75%) compared to the unhulled rice (2.75–7.5%) (Figure 2a). Furthermore, based on Table 2, it is known that the total number of adults present was higher in the milled rice form (3.25–23.25 individuals), which reached 23.25 individuals in the Inpari Gemah variety of milled rice compared to the unhulled rice form which was in the range of 3.00–9.00 individuals. The same applies to the preference test results between unhulled rice (n = 6) and milled rice (n = 6), which were carried out separately. The presence of *R. dominica* adult was higher in the unhulled rice Ciherang variety (GCH) (29.75%) and Inpari 42 Agritan GSR variety (GI42) (26.00%) compared to other treatments (Figure 2b). However, the preference test of several milled rice of VUB varieties showed that the total adults of *R. dominica* present in several milled rice tended to be uniform. The mean percentage of total adults present in the experiment of several milled rice ranged from 13.00–20.50% (Figure 2c).

Table 2. The Mean of Total Adults (Male+Female), Number of Male Adults, and Number of Female Adults of *Rhyzopertha dominica* in the Preference Test.

Treatments	n	Code	Total Adult		Male	Female
			Individuals (x̄ ± SD)	% (x̄ ± SD)	(Individuals) (x̄ ± SD)	(Individuals) (x̄ ± SD)
UR. Baroma	12	G.BR	3.75 ± 3.30	3.25 ± 2.87	1.00 ± 1.41	2.75 ± 2.06
UR. Inpara 9 Agritan		G.I9	3.00 ± 1.41	2.75 ± 0.95	2.50 ± 1.91	0.50 ± 0.57
UR. Inpari Gemah		G.GH	3.25 ± 2.21	2.75 ± 1.70	1.75 ± 0.95	1.50 ± 1.29
UR. Inpari 43 Agritan GSR		G.I43	4.00 ± 2.16	3.25 ± 2.70	2.00 ± 1.41	2.00 ± 1.41
UR. Ciherang		G.CH	9.00 ± 3.82	7.50 ± 3.31	4.00 ± 1.82	5.00 ± 3.55
UR. Inpari 42 Agritan GSR		G.I42	4.25 ± 1.25	3.50 ± 1.00	2.25 ± 0.50	2.00 ± 0.81
MR. Baroma		B.BR	15.25 ± 11.92	12.75 ± 10.01	6.00 ± 4.89	9.25 ± 7.08
MR. Inpara 9 Agritan		B.I9	11.25 ± 5.43	9.25 ± 4.64	6.50 ± 2.64	4.75 ± 2.87
MR. Inpari Gemah		B.GH	23.25 ± 7.27	19.50 ± 5.80	12.00 ± 5.47	11.25 ± 2.21
MR. Inpari 43 Agritan GSR		B.I43	14.00 ± 4.61	14.00 ± 4.61	7.50 ± 1.91	6.50 ± 3.00
MR. Ciherang		B.CH	19.75 ± 4.78	11.50 ± 4.04	9.75 ± 2.87	10.00 ± 2.16
MR. Inpari 42 Agritan GSR		B.I42	9.25 ± 4.78	7.75 ± 4.27	4.75 ± 2.87	4.50 ± 2.38
UR. Baroma	6	G.BR	19.25 ± 9.91	16.00 ± 8.20	10.25 ± 7.36	9.00 ± 3.36
UR. Inpara 9 Agritan		G.I9	16.50 ± 10.11	13.75 ± 8.05	8.25 ± 5.12	8.25 ± 5.12
UR. Inpari Gemah		G.GH	9.75 ± 4.1	8.00 ± 3.74	5.00 ± 2.58	4.75 ± 3.77
UR. Inpari 43 Agritan GSR		G.I43	8.00 ± 2.4	6.75 ± 2.06	5.50 ± 1.73	2.50 ± 1.00
UR. Ciherang		G.CH	35.50 ± 22.06	29.75 ± 18.31	16.25 ± 11.44	19.25 ± 10.68
UR. Inpari 42 Agritan GSR		G.I42	31.00 ± 15.38	26.00 ± 12.56	14.75 ± 7.54	16.25 ± 9.06
MR. Baroma	6	B.BR	24.25 ± 10.56	20.50 ± 8.88	13.25 ± 8.34	24.25 ± 10.56
MR. Inpara 9 Agritan		B.I9	18.50 ± 3.41	15.50 ± 2.64	8.00 ± 0.81	18.50 ± 3.41
MR. Inpari Gemah		B.GH	19.50 ± 6.24	16.25 ± 5.37	9.25 ± 4.57	19.50 ± 6.24
MR. Inpari 43 Agritan GSR		B.I43	17.00 ± 11.34	14.25 ± 9.28	8.75 ± 6.23	17.00 ± 11.34
MR. Ciherang		B.CH	25.25 ± 14.72	21.25 ± 12.31	13.25 ± 8.53	25.25 ± 14.72
MR. Inpari 42 Agritan GSR		B.I42	15.50 ± 7.85	13.00 ± 6.58	7.50 ± 2.64	15.50 ± 7.85

Notes: UR= unhulled rice, MR= milled rice, n= number of data, SD= standard deviation.

Table 3. Result of Two-Way and One-Way Anova on Total *R. dominica* Adults Present.

	Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F	P-value
Two-way ANOVA (unhulled and milled rice	Form	1	14.842	14.842	55.645	$8.27x10^{-9***}$
	Variety	5	3.221	0.644	2.416	0.0548
	Form × Variety	5	1.823	0.365	1.367	0.2597
One-way ANOVA (unhulled rice)	Unhulled rice	5	6.139	1.227	3.121	0.0335*
One-way ANOVA (milled rice)	Milled rice	5	309.5	61.90	0.652	0.664

The results of ANOVA two-way showed that the form factor (unhulled rice and milled rice) had a significant effect on the total *R. dominica* adults present (F= 55.645; P< 0.05) in the combination preference test between unhulled rice and milled rice. Furthermore, the variety factor and the interaction between form and variety did not show a significant effect (P> 0.05) (Table 3). These results show that the difference in the form of diet used consistently affects the total *R. dominica* adults present regardless of the variety used. Based on this, the effect of the form of diet is uniform across all varieties tested, so the main factor determining the total presence of *R. dominica* adult is the form of diet. The results of this research were reinforced by the preference test between unhulled rice and milled rice, which was conducted separately. ANOVA one-way showed that the variety of unhulled rice significantly affected the total *R. dominica* adults present (F= 3.121; P< 0.05). However, in the preference test of several milled rice, ANOVA one-way showed that several milled rice had no significant effect on the total *R. dominica* adults present (Table 3).

Overall, these results indicate that grain form factor affects the total preference of *R. dominica* adult presence, but differences between varieties still have an influence, especially on unhulled rice. It is suspected that there is a physical factor that is the difference in the form of diet. Based on the results of the GLM analysis in the combination preference test of unhulled rice and milled rice (n = 12), the unhulled rice has a negative relationship with the total percentage of *R. dominica* adult presence (Est= -1.57, P< 0.05) (Table 4). These results indicate that the diet (unhulled rice) affects the percentage of the presence of *R. dominica* adults to be lower than that of milled rice. These results are also supported by the results of the GLM analysis in the preference test of several unhulled rice (n= 6^). The GLM analysis shows that the hardness of the unhulled rice has a negative relationship with the total percentage of *R. dominica* adult presence (Est= -0.01, P< 0.05) (Table 4). Therefore, following the results of the grain hardness test, where the higher the level of grain hardness, the lower the percentage of *R. dominica* adults present. Furthermore, the Dispersion Index (ID) calculation results showed the distribution pattern of *R. dominica* adults. Based on these results, it is known that the ID value of the total *R. dominica* adults present in the combination preference test of unhulled rice and milled rice (ID= 6.40), several unhulled rice (ID= 11.10), and several milled rice (ID= 4.20) has an ID > 1. These results show that the distribution pattern of *R. dominica* adults in all preference tests has a clumped distribution (ID> 1).

3.2 Oviposition Preference of Rhyzopertha dominica on Unhulled Rice and Milled Rice of New Superior Varieties

The results of the oviposition preference of *R. dominica* in the combination preference test between unhulled rice and milled rice (n= 12) showed that the number of eggs laid by female *R. dominica* adults tended to be higher in the milled rice form (20.00–61.00 eggs) compared to the unhulled rice form (5.75–41.50 eggs) (Figure 3a). Meanwhile, in the variety, the number of eggs was higher in the milled rice Inpara 9 Agritan (BI9) variety (61.00 eggs) compared to the unhulled rice Inpara Agritan (GI9) (9.25 grains) and other treatments (Figure 3a). However, when the unhulled rice (n= 6) and milled rice (n= 6) were tested separately, no difference was found in the number of eggs laid by female *R. dominica* adults. The average number of eggs laid by female *R. dominica* adults in the unhulled rice and milled rice ranged between 22.75–52.75 eggs (Figure 3b) and 30.00–53.25 eggs (Figure 3c).

The results of ANOVA two-way showed that the form factor (unhulled rice and milled rice) (F= 25.667; P< 0.05), variety (F= 2.779; P< 0.05), and the interaction between unhulled rice and milled rice (F= 7.777; P< 0.05) significantly affect the oviposition preference of *R. dominica* (Table 5). These results show that the form of diet, variety of diet, and the interaction between form and variety affect the number of eggs laid by female adults. Furthermore, the interaction between the form factor and the variety of diets shows that the effect of form depends on the variety. Conversely, the effect of variety also depends on the form of diet used. Furthermore, when the form of unhulled rice (n= 6) and milled rice (n= 6) were tested separately, no significant effect of variety was found on the number of eggs laid. The results of ANOVA one-way in the preference test of several unhulled rice (F= 0.1918; P> 0.05) and several milled rice (F= 1.669; P> 0.05) showed that the variety factor did not affect the female adult of *R. dominica* in laying eggs (Table 5).

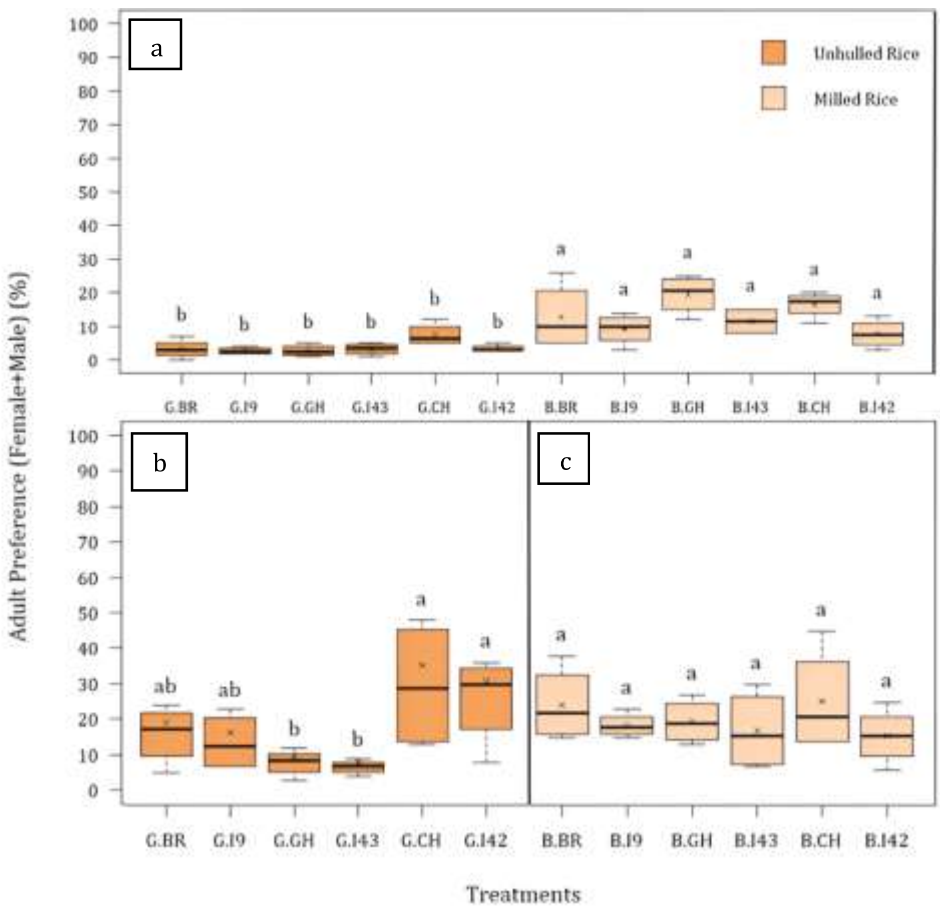

Figure 2. Total preference of Rhyzopertha dominica adult presence towards (a) combination of several unhulled rice and milled rice, (b) several unhulled rice, (c) several milled rice. Different lowercase letters at the top boxes indicate significantly different results. In contrast, the same lowercase letters at the top indicate box results that are not significantly different by the DMRT test at a 5% level. Boxplots showed marks as mean, the center line as median, the upper and lower whiskers as maximal and minimal data, and box limits as upper and lower quartiles.

Table 4. The Results of the GLM Analysis Relate the Form Factors (Unhulled Rice and Milled Rice), Physical Factors (Grain Hardness), and Chemical Factors (Phenol and Protein) of Diet to the Total Percentage of Adult Presence and the Number of Eggs of *Rhyzopertha dominica* in the Preference Test.

Variables	n	Total Adults Present (%)			Number of Eggs (Eggs)		
		Est	SE	P	Est	SE	P
Intercept	12	2.31	0.33	1.86 x 10^{8***}	6.94	1.09	1.1 x 10^{7**}
Unhulled rice		-1.57	0.61	0.014*	0.72	0.59	0.224
Grain hardness		-0.00	0.00	0.650	-0.00	0.00	0.030*
Phenolic		0.43	0.30	0.160	-0.19	0.28	0.512
Intercept	6^	1.91	1.48	0.210	10.80	3.85	0.010*
Grain hardness		-0.01	0.00	0.020*	-0.01	0.00	0.001*
Protein		-1.74	1.44	0.240	-0.78	0.48	0.110
Phenolic		0.49	0.24	0.060	0.17	0.17	0.330
Intercept	6	2.62	2.69	0.970	57.25	24.49	0.030*
Grain hardness		0.00	0.00	0.480	-0.04	0.02	0.030*
Protein		-0.03	0.19	0.860	-2.80	1.30	0.040
Phenolic		0.10	2.21	0.960	-11.4	5.50	0.050

Notes: Est= Estimate, SE= Standard Error, P= P-value, *P< 0,05; **P< 0,01; ***P< 0,001. The water content, protein, fat, carbohydrate, and ash data at n= 12 were not analyzed because there was multicollinearity. Data on water content, fat, carbohydrate, and ash at n= 6^ and n= 6 were not analyzed because multicollinearity existed. 6^ is the preference test for several unhulled rice, and n= 6 is the preference test for several milled rice.

Table 5. Result of Two-Way and One-Way ANOVA on the Number of *R. dominica* Eggs Laid.

	Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F	P-value
Two-way ANOVA (unhulled and milled rice	Form	1	11.166	11.166	25.667	$1.23x10^{-5***}$
	Variety	5	6.044	1.209	2.779	0.0319^{*}
	Form × Variety	5	16.917	3.383	7.777	$4.8x10^{-5***}$
One-way ANOVA (unhulled rice)	Unhulled rice	5	2533	506.6	0.1918	0.141
One-way ANOVA (milled rice)	Milled rice	5	1913	382.7	1.669	0.193

Based on the results of the combination preference test of several unhulled rice and milled, as well as the preference test of several unhulled rice and milled rice conducted separately, it can be seen that the diet form factor is more dominant in influencing the oviposition preference of *R. dominica* compared to the differences in diet varieties used. Milled rice tends to be preferred by female *R. dominica* adults to lay eggs compared to unhulled rice because it is suspected that *R. dominica* adults are more interested in a diet with low grain hardness.

These results are supported by the results of the GLM analysis between the number of eggs and the grain hardness of several unhulled rice and milled rice used in the combination preference test (n= 12) (Est = -0.00, P< 0.05), the preference test of several unhulled rice (Est = -0.00, P< 0.05), and of several milled rice (Est = -0.02, P< 0.05) (Table 4). The results of the GLM analysis showed that grain hardness had a negative relationship with the number of eggs laid by female *R. dominica* adults, which means that the lower the level of grain hardness, the higher the number of eggs laid by female *R. dominica* adults. In addition, based on the results of the ID value, it is known that in the combination preference test of unhulled rice and milled rice (ID= 12.55), several unhulled rice (ID= 7.92) and several milled rice (ID = 6.68) have ID> 1. Based on these results, it can be seen that the distribution pattern of female adults of *R. dominica* in laying eggs tends to have a clumped distribution (ID> 1).

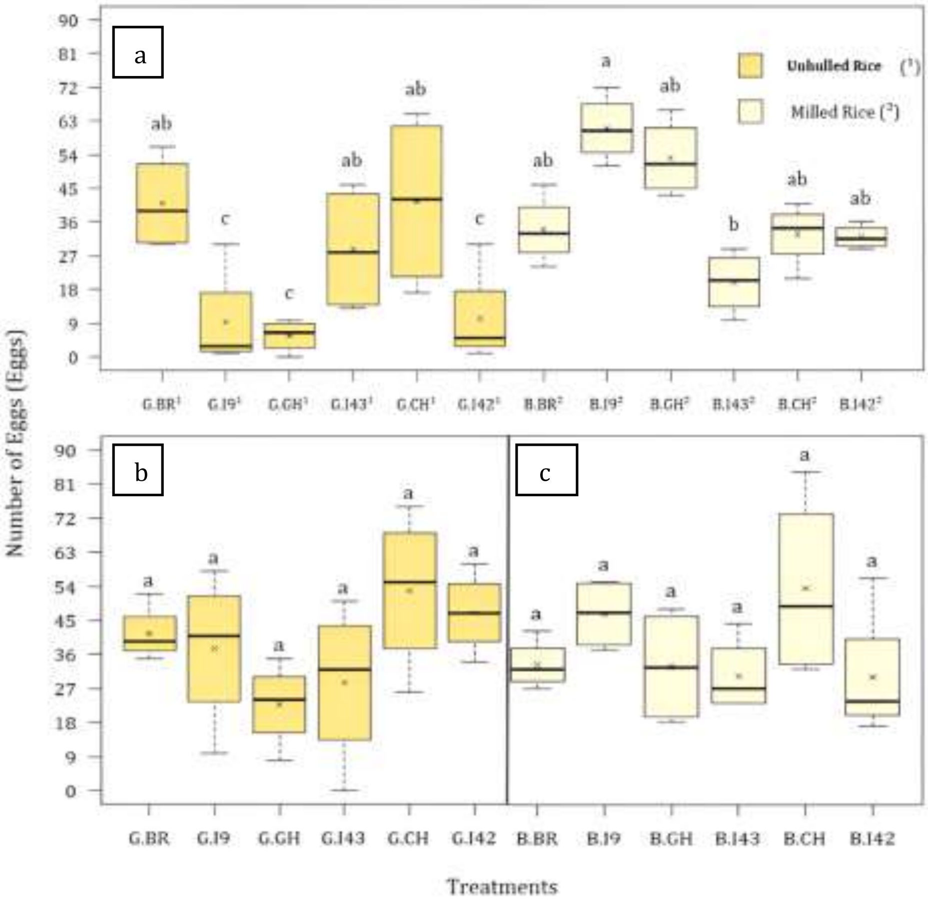

Figure 3. Oviposition preference of *Rhyzopertha dominica* towards (a) a combination of several unhulled rice and milled rice, (b) several unhulled rice, and (c) several milled rice. Different lowercase letters at the top boxes indicate significantly different results. In contrast, the same lowercase letters at the top indicate box results that are not significantly different by the DMRT test at a 5% level. Boxplots showed marks as mean, the center line as median, the upper and lower whiskers as maximal and minimal data, and box limits as upper and lower quartiles.

The presence and oviposition preferences of *R. dominica* were higher in milled rice than in unhulled rice. This difference is thought to be influenced by physical factors such as form and grain hardness, and chemical factors of unhulled rice and milled rice were tested. Astuti *et al*., (2020) reported that physical (form and hardness of diet) and chemical (nutrient content and volatile compounds) diet factors can affect the preferences of stored product pests. In this research, the number of adults present and the number of eggs laid by female *R. dominica* adults were lower in unhulled rice both in the combination preference test between unhulled rice and milled rice (n= 12) and the separate preference test between several unhulled rice (n= 6) and milled rice (n= 6). The husk layer of unhulled rice serves as a physical barrier, potentially influencing both the feeding preference and oviposition behavior of female *R. dominica* adults. Similarly, several studies have reported that the presence of husks or seed coats in grains can increase their preference for stored product pest pests, including *R. dominica, Sitophilus zeamais* (Motschulsky), and *Sitophilus oryzae* (Linnaeus) (Coleoptera: Curculionidae) (Breese, 1960; Antunes *et al*., 2016; Mario *et al*., 2025). On the other hand, the total presence of adults and the higher number of eggs in the milled rice form compared to the unhulled rice form can be associated with differences in the hardness of the milled rice and unhulled rice. Unhulled rice has a high hardness level, so it may be less attractive to female adults when choosing the diet and a place to lay eggs. The hardness of unhulled rice can hinder feeding activity because of the hard skin layer. The analysis showed a negative relationship between grain hardness in the preference test. The results of this research are supported by Chanbang *et al*., (2008) who reported that grain hardness can affect the preference of *R. dominica* on a diet. Astuti *et al*., (2021) also reported that grain hardness was negatively correlated with *R. dominica* preference, meaning that *R. dominica* was more attracted to a diet with low grain hardness. In addition, the distribution pattern of *R. dominica* presence and oviposition in preference test tended to cluster. This distribution pattern indicates a preference for a suitable condition, such as physical diet factors (Southwood and Henderson, 2000).

Furthermore, this research also found that only physical factors were the main factors influencing the presence and oviposition preferences of *R. dominica* adults. Chemical factors of the diet, including water content, phenolic compounds, carbohydrates, proteins, fats, and ash content, did not significantly influence the presence or oviposition rates of female *R. dominica* adults in the combination preference test between unhulled rice and milled rice or the preference test between unhulled rice and milled rice conducted separately. The content of water, phenol, carbohydrate, protein, fat, and ash in the diet used is thought to be within the range of levels suitable for *R. dominica*. In line with Astuti *et al*., (2021) which reported that infested *R. dominica* adults tended to be present and lay eggs on all types of diet tested in the preference test of several rice varieties with water content ranging from 10–16%. These results indicate that *R. dominica* adults can be present and lay eggs on grains at varying water content. In addition to water content, other chemical factors such as phenol, carbohydrate, protein, fat, and ash content also do not affect the number of presence and egg laying of female *R. dominica* adults. This means that the range of phenol, carbohydrate, protein, fat, and ash content in several tested unhulled rice and milled rice is still suitable with the range of nutritional content required by *R. dominica*. Astuti *et al*., (2013) support this research's results, which reported no correlation between protein, fat, and carbohydrates and the number of eggs laid by female *R. dominica* adults on several milled rice varieties. Based on the results of this research, the content of phenol, carbohydrate, protein, fat, and ash in content did not affect the presence and oviposition preference by *R. dominica.*

Based on the results, the differences in the presence and oviposition preferences of *R. dominica* on several tested unhulled rice and milled rice may be due to variations in the physicochemical properties of the grains. Understanding these grain characteristics, which can affect the preference for feeding and laying eggs, helps develop stored product pest management strategies on stored. Therefore, maintaining low moisture content in grains is not enough to prevent pest infestation because, in this study, the lowest moisture content of the grain was 8.7%, which still attracts *R. dominica* to attend and lay eggs. In addition, it should be noted that although unhulled rice is considered less preferred by *R. dominica* to attend and lay eggs due to the presence of the skin layer, the insect showed interest in the form of milled rice. Thus, when the unhulled rice is milled, it can be attractive to *R. dominica* to present and lay eggs because the husk of the rice, which acts as a physical barrier, is removed.

4. CONCLUSIONS

The presence and oviposition preferences of *R. dominica* were significantly higher and had a clumped distribution pattern in the milled rice form compared to the unhulled rice. The several milled rice of NSV with lower level grain hardness would be more attractive for *R. dominica* to be present and lay eggs. Phenol content, water content, carbohydrate, protein, fat, and ash contained in several unhulled and milled rice of VUB did not affect the presence and oviposition preferences of *R. dominica*. These finding suggest that physical properties (grain hardness) play a more critical role than chemical compositions in *R. dominica* infestation on stored rice varieties.

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