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Distribution Analysis of Asiatic Palm Weevil *Rhynchophorus vulneratus* Panzer (Coleoptera: Dryphthoridae) using GIS Technique and the Interaction with Coconut Beetle *Oryctes rhinoceros* L. (Coleoptera: Scarabaeidae)

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ABSTRACT

Asiatic palm weevil *Rhynchophorus vulneratus* Panzer is one of the key pests of coconut in Indonesia. Information regarding the spatial distribution of *R. vulneratus* is needed to support Integrated Pest Management and can be analyzed using Geographic Information System (GIS). Initial studies on the interaction between *R. vulneratus* and *Oryctes rhinoceros* were also studied in this study. This research aimed to analyze the spatial distribution of *R. vulneratus* using GIS and its interaction with the Coconut beetle *Oryctes rhinoceros*. The research was conducted in Yogyakarta as a habitat model (0-1,000 masl). *R. vulneratus* and *O. rhinoceros* were catched by installing aggregation pheromone traps hanging to coconut plants at 1.7 m above ground. The research was conducted during the rainy and dry seasons. The spatial distribution of *R. vulneratus* was analyzed by IDW interpolation using QGIS 3.22, whereas its interaction with *O. rhinoceros* was analyzed by the Pearson correlation test using SPSS 22. The results showed low number of *R. vulneratus* captured in the Yogyakarta area during the rainy season at 0-1,000 masl. However, the number of *R. vulneratus* during the dry season has increased, and the distribution rate was dominated by medium to very high levels, especially at an altitude of 0-300 masl. The study also showed that the number of *R. vulneratus* was not influenced by the number of *O. rhinoceros*, which suggested that the abundance of *O. rhinoceros* cannot accurately predict the abundance of *R. vulneratus*.

1. Introduction

Asiatic palm weevil Rhynchophorus (Coleoptera: Dryophthoridae) is one of the most destructive pests of palms (Family Arecaceae), especially in coconut plants (Wattanapongsiri 1966). Three species of Asiatic palm weevils were reported to be pests in Southeast Asia, namely *R. ferrugineus*, *R. vulneratus*, and *R. bilineatus* (EPPO 2020). *R. vulneratus* and *R. bilineatus* have been identified as harmful pests in Indonesia (Rugman-Jones *et al.* 2013; Sukirno *et al.* 2018). The distribution of *R. vulneratus* is spread in Aceh, West Java, Central Java, East Java, Yogyakarta, Central Kalimantan, and Gorontalo *R. ferrugineus* is reported not to be found in Indonesia (Rozziansha *et al.* 2021; Sukirno *et al.* 2018).

Larvae of *R. vulneratus* are known as a type of hidden stem borer (Murphy and Briscoe 1999). The presence of *R. vulneratus* larvae that attract the host plant is difficult to detect until the plant shows symptoms. The characteristics of host plants attacked by *R. vulneratus* are shown by leaf damages such as drying and collapsing crown (Abraham *et al.* 1998; Yulianto and Ernawati 2015). However, before showing those damages, it is not to know the presence of *R. vulneratus* at the stem.

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R. vulneratus has been reported to attack host plants aged 3-15 years (Abraham *et al.* 1998; El-Sabea *et al.* 2009). Yulianto and Ernawati (2015) reported that *Rhynchophorus* had caused damage and death of young coconut plants in several plantations in East Java, such as Ponorogo, Tulungagung, Jombang, and Kediri. Even the Jombang government spent a budget to carry out efforts to control these beetles. The first attack of *R. vulneratus* on an oil palm plantation was recorded in January 2018 in Central Kalimantan (Prasetyo *et al.* 2019; Priwiratama *et al.* 2019).

The coconut beetle *Oryctes rhinoceros* L. was the key pest of the coconut plant (Bedford 1980). The symptom is due to the attack of *O. rhinoceros* as in a V-shaped leave (Manjeri *et al.* 2014; Siahaya 2014). *Rhynchophorus* was reported as the secondary pest that attacked the coconut tree after an attack from *O. rhinoceros* (Kalshoven 1981; Pracaya 2007). *Rhynchophorus* utilized trunk injuries caused by *O. rhinoceros* as an entrance to attack host plants. Once inside the trunk, the female *Rhynchophorus* laid the eggs, and then the larvae would stay and eat in the stem until they became pupa (Azmi *et al.* 2013).

A geographic information system (GIS) is a computer-based information system that is used to organize, store, manage, analyze, and produce geographic (location or spatial) information, (Huisman and de By 2009). The ability of GIS can combine various data, analyze and add information to the map so that GIS can provide information in the form of locations, conditions, trends, patterns, or models (Sutton *et al.* 2009). In the digitalization era, GIS plays a very important role in human life because GIS can be used to provide spatial information such as in the field of transportation, health, tourism, agriculture, analysis of natural disaster status, and information on climate and weather growth (Chang 2007).

In recent years, GIS applications have been used in research on Integrated Pest Management (IPM) as a tool for monitoring pests on agricultural land. Research related to the monitoring of *Rhynchophorus* spp. using GIS analysis, among others, conducted by Cinnirella *et al.* (2020) in Italy, Ge *et al.* (2015) in China, and Massoud *et al.* (2011) in Saudi Arabia. The study's results using the GIS application are in the form of information maps related to the activity, abundance, and distribution of *Rhynchophorus* spp. that attacks a location in a certain area and time. GIS can even be a model to predict a certain time (Ge *et al.* 2015).

Yogyakarta has an area of 65% of its area at an altitude of 100-499 masl (Jogjaprov 2014). This geographical condition is very suitable for the growth of the coconut plant because the optimal growth at 600 masl, coconut will produce good fruit and a high content of vegetable oil (Mardiatmoko and Ariyanti 2018). This research aimed to study the distribution of *R.vulneratus* in various habitats at different altitude levels in Yogyakarta and want to see the interaction with *O. rhinoceros*. We expected that the data would provide information about the distribution of *R. vulneratus*, which is necessary for integrated pest management of these insects.

2. Materials and Methods

2.1. Time and Location of the Research

The research was done on February to May 2020 as a representative for the rainy season, and June to November 2020 as a dry season. The sampling locations were divided based on the altitude levels representing the areas of Sleman, Yogyakarta City, Bantul, and Kulonprogo Regencies. Samplings were done by using 15 locations as sampling points for trapping based on five altitude groups (0-50, 50-100, 100-300, 300-600, and 600-1,000 masl) (Figure 1).

2.2. Traps Installation

A bucket made the traps with a diameter of 23 cm and a height of 20 cm (Figure 2). To attract *R. vulneratus* and *O. rhinoceros*, the traps were filled with aggregation pheromone by ORICMAS® from PT. Anugerah Sarana Hayati IND (contained: ethyl 4 methyl octanoate, 4 methyl 5 nonanol, and octanoic acid). Four holes with a size of 2 × 5 cm each at four sides were made at the upper body of the bucket as entrances. The bucket was also filled with water and sugarcane as a food source so the insects did not get out. The traps were hung to the host plant at a height of 1.7 m from the ground (Kaakeh *et al.* 2001)

2.3. The Collection and Preservation of Insects

Sampling for each collection period was carried out weekly. Then, *R. vulneratus* and *O. rhinoceros* caught were preserved in a 50 ml conical tube that contained 96% ethanol and stored in the freezer at 4°C for further analysis (Sukirno *et al.* 2018). Each conical

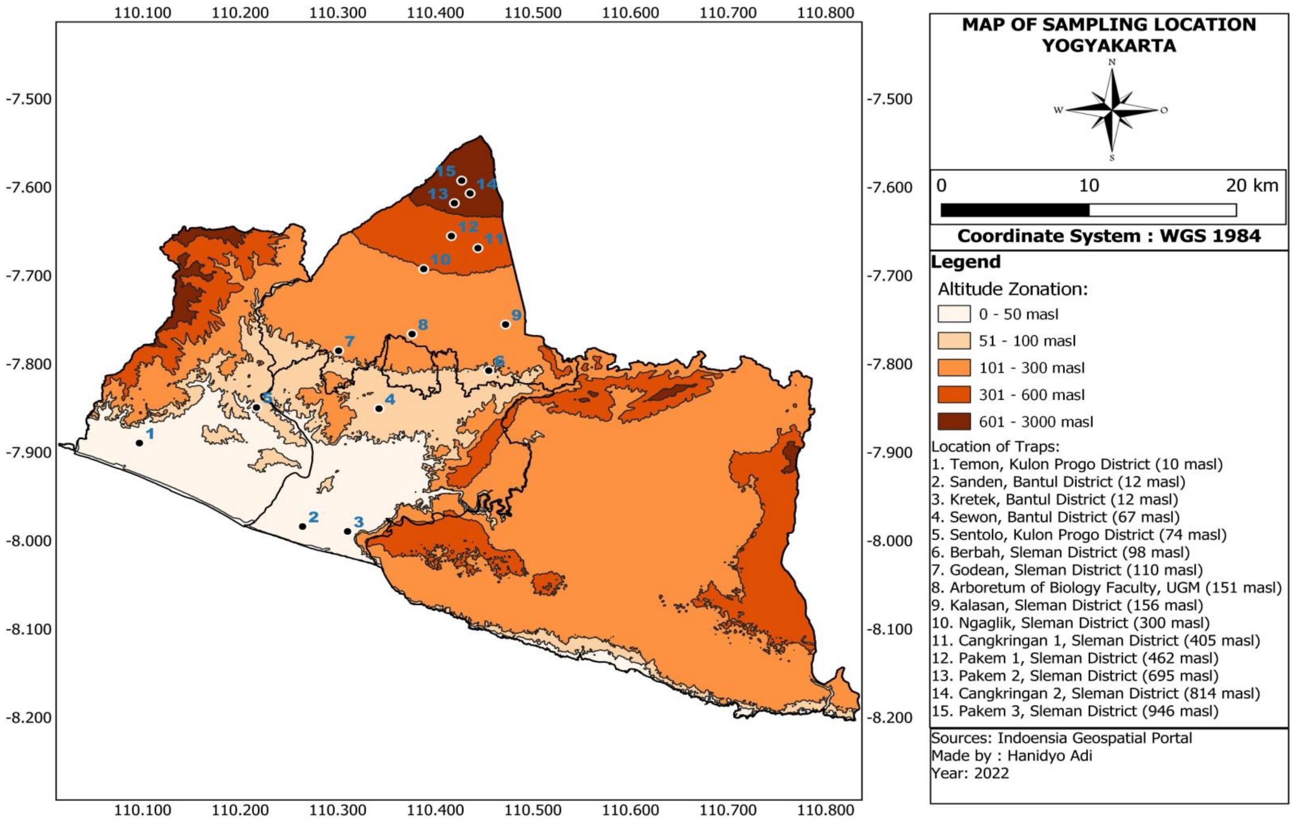

Figure 1. The Trap locations of *R. vulneratus* and *O. rhinoceros* in Yogyakarta

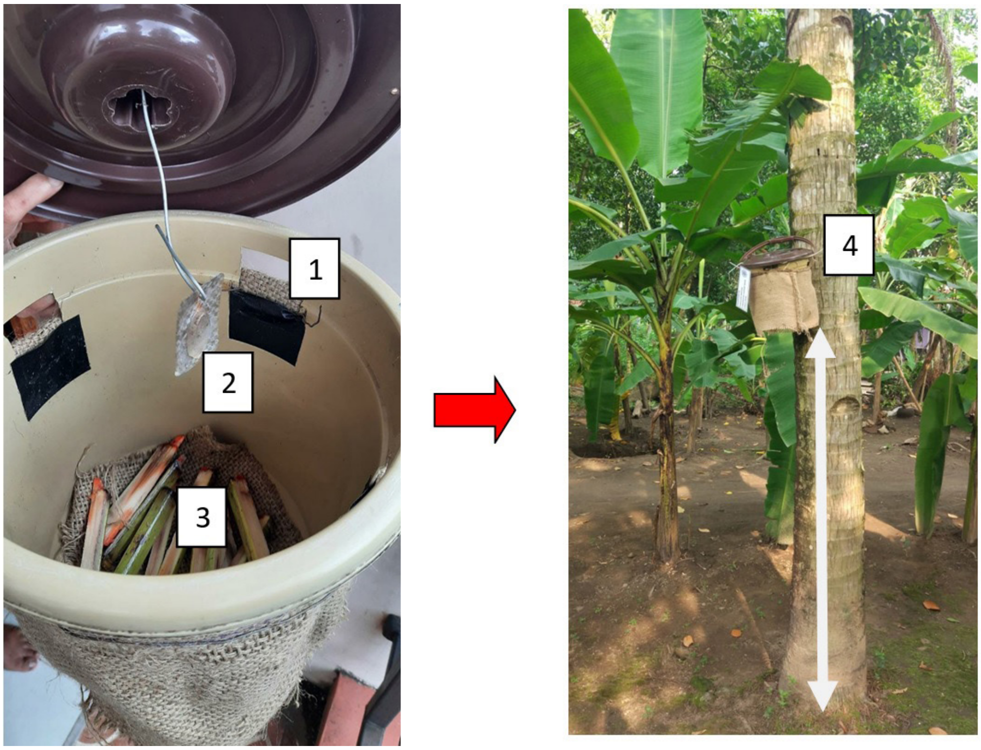

Figure 2. The bucket as aggregation pheromone traps installed at host plant: 1. Entrance hole, 2. aggregation pheromone, 3. water and sugarcane (contents), 4. height trap at 1.7 m from above ground

tube contained 5–6 individuals of *R. vulneratus* and two individuals of *O. rhinoceros*. The data of rainfall parameter measured during collection was taken from the Meteorology, Climatology, and Geophysics Agency of Yogyakarta.

2.4. Analysis Spatial Distribution of *R. vulneratus* using GIS and the Study of Interaction with *O. rhinoceros*

The Coordinate Reference System (CRS) was used EPSG:4326–WGS 84. The Inverse Distance weight (IDW) interpolation was used to analyze the spatial distribution of *R. vulneratus* during the rainy and dry seasons. The IDW interpolation was analysed by using GIS 3.22. The spatial distribution of *R. vulneratus* was depicted at four levels (Table 1). Furthermore, the number of *R. vulneratus* at each altitude level was compared with the number of *O. rhinoceros*. The interaction was analyzed by using a correlation test to study the relationship.

2.5. Statistical Analysis

The interaction population of *R. vulneratus* with *O. rhinoceros* was analyzed by the Pearson correlation test. All the statistical analysis was using SPSS 22. The interpretation of the correlation test was based on Sugiyono (2015).

3. Results

3.1. The Abundance of *R. vulneratus* During the Rainy and Dry Season

The number of *R. vulneratus* captured in each location was higher during the dry season than in the rainy season (Table 2). In Kretek, Bantul (at 12 masl) was found as the highest number of *R. vulneratus*. It has 184 individuals captured in the rainy season and 626 individuals caputed in the dry season. While in Pakem, Sleman (at 946 masl) was the lowest numbers of *R. vulneratus*, with 17 and 32 individuals captured in rainy season and dry season, respectively.

Table 1. Categories of weevil spatial distribution based on the number of individuals captured

Number of captured	Categories
0-100 weevils	Low
101-300 weevils	Medium
301-500 weevils	High
501-700 weevils	Very high

Table 2. The number of *R. vulneratus* captured in rainy and dry season during February to November 2020

Location (district)	Altitudes (masl)	Rainy season	Dry season	Total of individuals
Temon, Kulon Progo	10	23	180	203
Sanden, Bantul	12	71	557	628
Kretek, Bantul	12	184	626	810
Sewon, Bantul	67	13	78	91
Sentolo, Kulon Progo	74	122	273	395
Berbah, Sleman	98	22	238	260
Godean, Sleman	110	123	388	511
Arboretumof Biologi Faculty UGM	151	66	77	143
Kalasan, Sleman	156	117	271	388
Ngaglik, Sleman	300	49	94	143
Cangkringan, Sleman	405	44	44	88
Pakem, Sleman	462	62	101	163
Pakem, Sleman	695	37	77	114
Cangkringan, Sleman	814	34	38	72
Pakem, Sleman	946	17	32	49

3.2. The Spatial Distribution of *R. vulneratus* During the Rainy and Dry Season

The spatial distribution of *R. vulneratus* during the rainy season is shown in Figure 3. Overall, the spatial distribution of Kulon Progo, Bantul, Yogyakarta and Sleman Region showed a low level. The spatial distribution of *R. vulneratus* during the dry season was shown in Figure 4. During the dry season, there was an increase in the number of *R. vulneratus* captured. The spatial distribution of *R. vulneratus* in the Bantul region showed a significant difference. The captured weevil were gradually increased from very high captured in the southern part of Bantul to low captured in the north. The spatial distribution of *R. vulneratus* in the Kulon Progo Region showed mostly medium levels, high levels in the south, and low levels in the north. The spatial distribution of *R. vulneratus* in the Sleman region shows mostly low and high levels in the west and medium levels in the west and east, adjacent to the Kulon Progo and Bantul Regions. Only the Yogyakarta City area showed the same level as during the rainy season (low levels).

3.3. The Interaction of Asiatic Palm Weevil *R. vulneratus* and Rhinoceros beetle *O. rhinoceros*

The interaction between *R. vulneratus* and *O. rhinoceros* was seen in the symptom of damage to coconut plants. We observed that almost the coconut plants that *R. vulneratus* infested at different altitudes had symptoms of the collapsing crown and also had

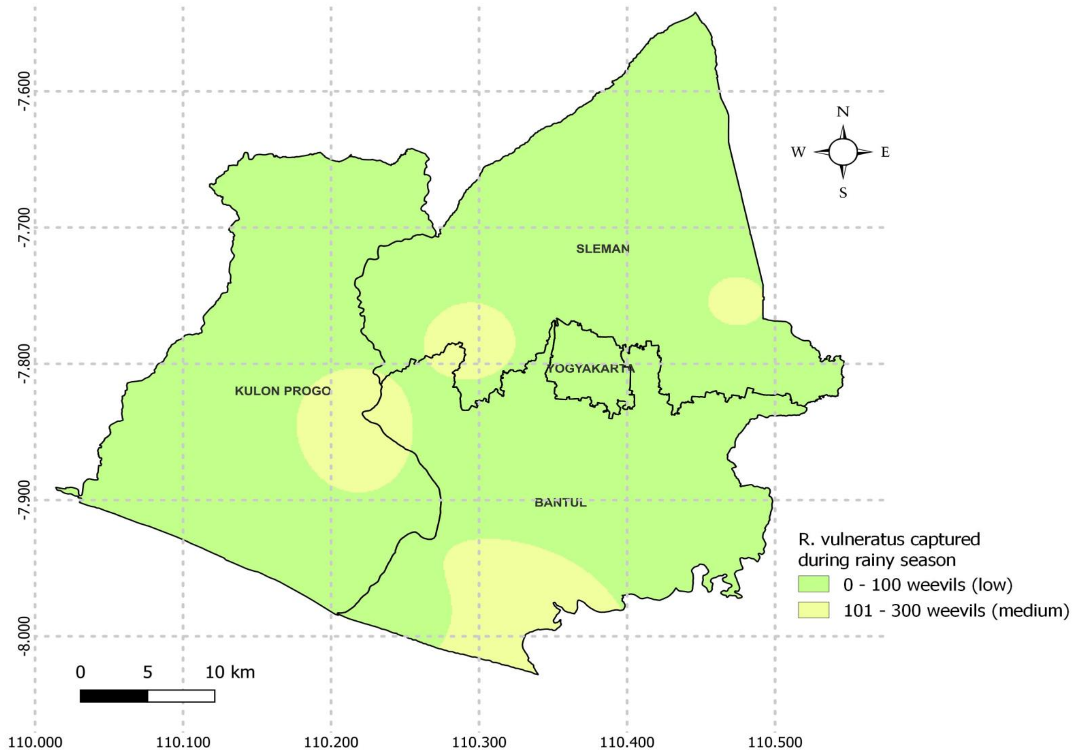

Figure 3. The spatial distribution of *R. vulneratus* during the rainy season

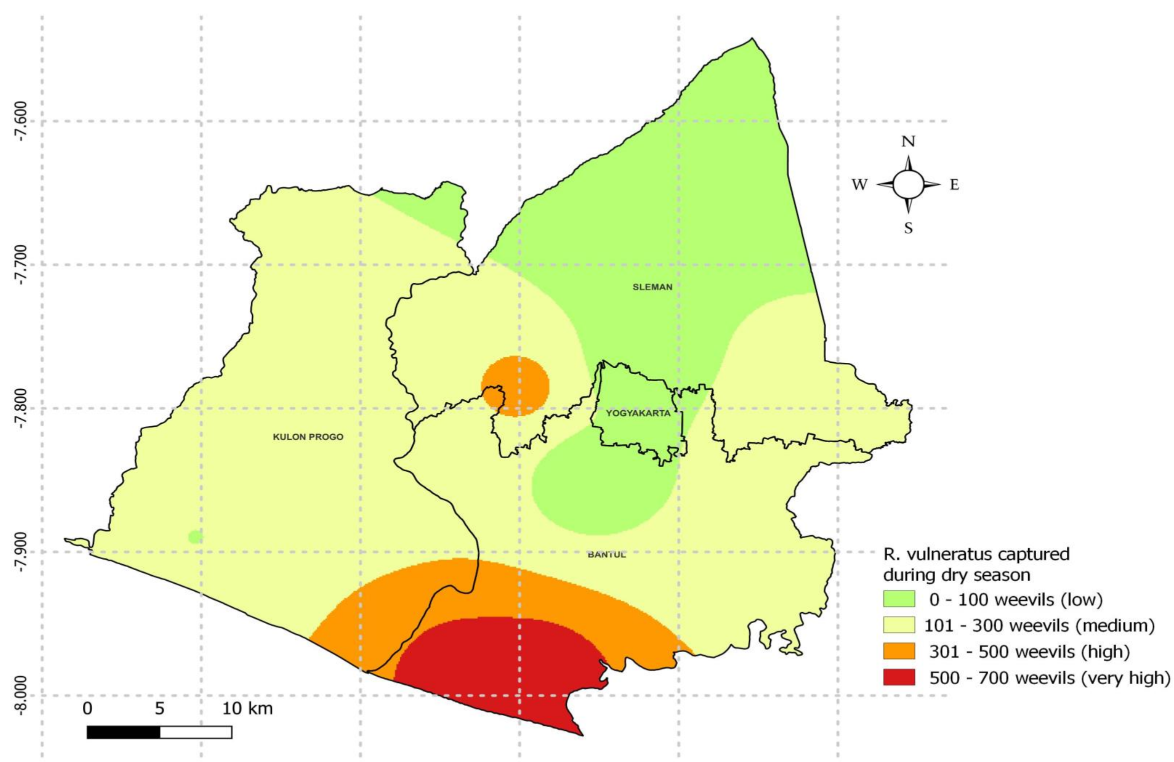

Figure 4. The spatial distribution of *R. vulneratus* during the dry season

symptoms of V-shaped leaves as the characteristic of *O. rhinoceros* attacks (Figure 5).

Based on the comparison of the abundance of the two species (Figure 6), these results indicated that initially, there was a directly proportional relationship where an increase in the number of individuals of *O. rhinoceros* and *R. vulneratus* captured up to May. However, from June to October, the number of *O. rhinoceros* individuals tended to fluctuate, while the number of individuals with *R. vulneratus* continued to increase. The results of the correlation test (Pearson correlation) showed that based on the number of individuals caught, the abundance of *R. vulneratus* was not affected by *O. rhinoceros* (p-value >0.05).

According to the Meteorology Climatology and Geophysics Council of Yogyakarta Province (Figure 6), February-April 2020 is a rainy season (maximum rainfall = 89.8 mm). May 2020 is an early dry season (maximum rainfall = 77.5 mm). June–September 2020 is a dry season (maximum rainfall = 27.2 mm). October 2020 was an early rainy season (maximum rainfall = 65.1 mm). November 2020 was the rainy season (maximum rainfall = 75 mm). Based on the rainfall data, the number of individuals with *R. vulneratus* from February to September was increasing, then tends to decrease in October. It implied that during the rainy season (February–April) the number of adults was low and tended to increase during the dry season (May–September). Whereas the number of *O. rhinoceros* fluctuated and reached its peak season in May or during the seasonal transition from rainy to dry season.

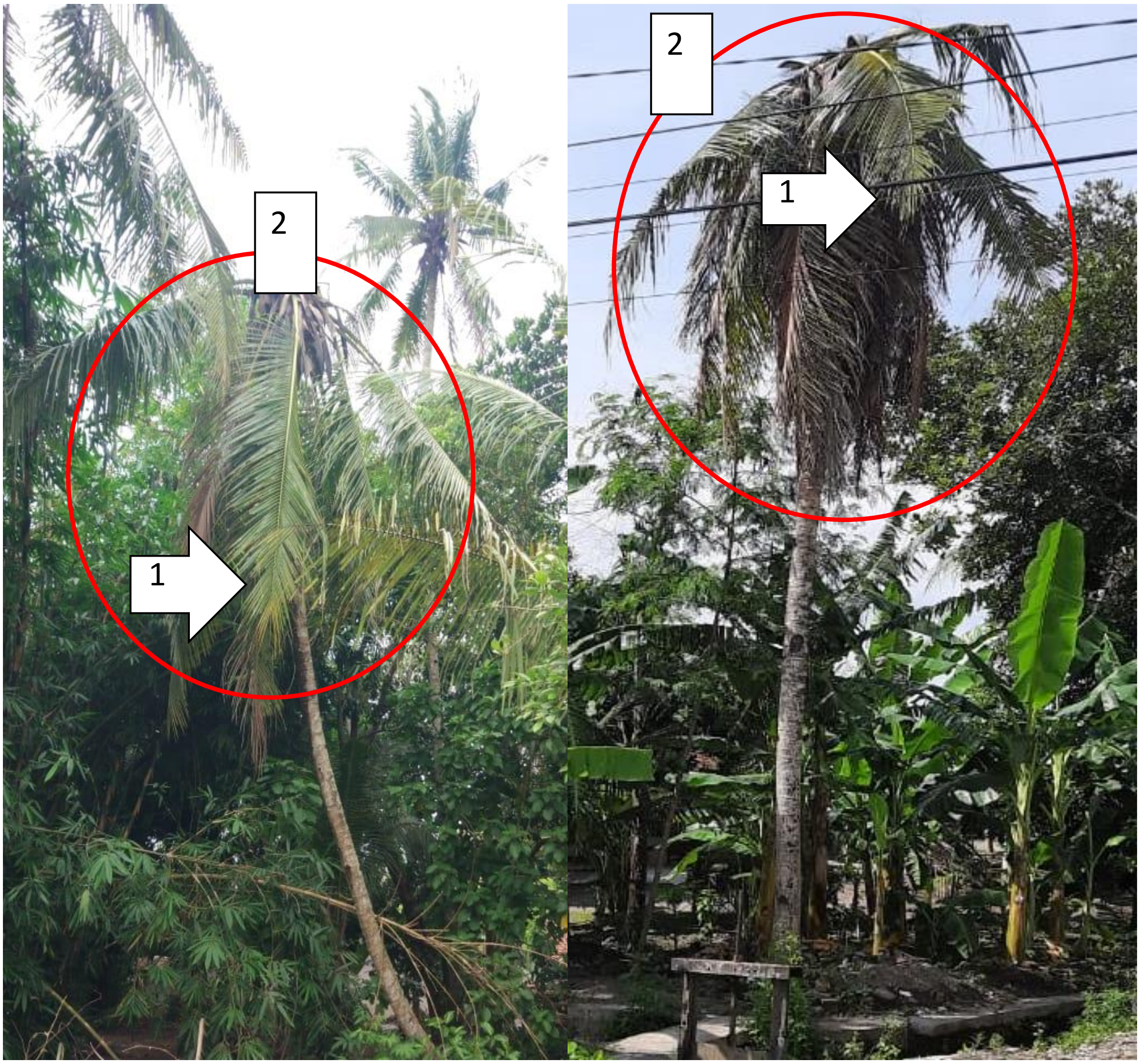

Figure 5. The coconut plants that were infested by *R. vulneratus* and *O. rhinoceros*: (1) collapsing crown and (2) V-shaped leaves

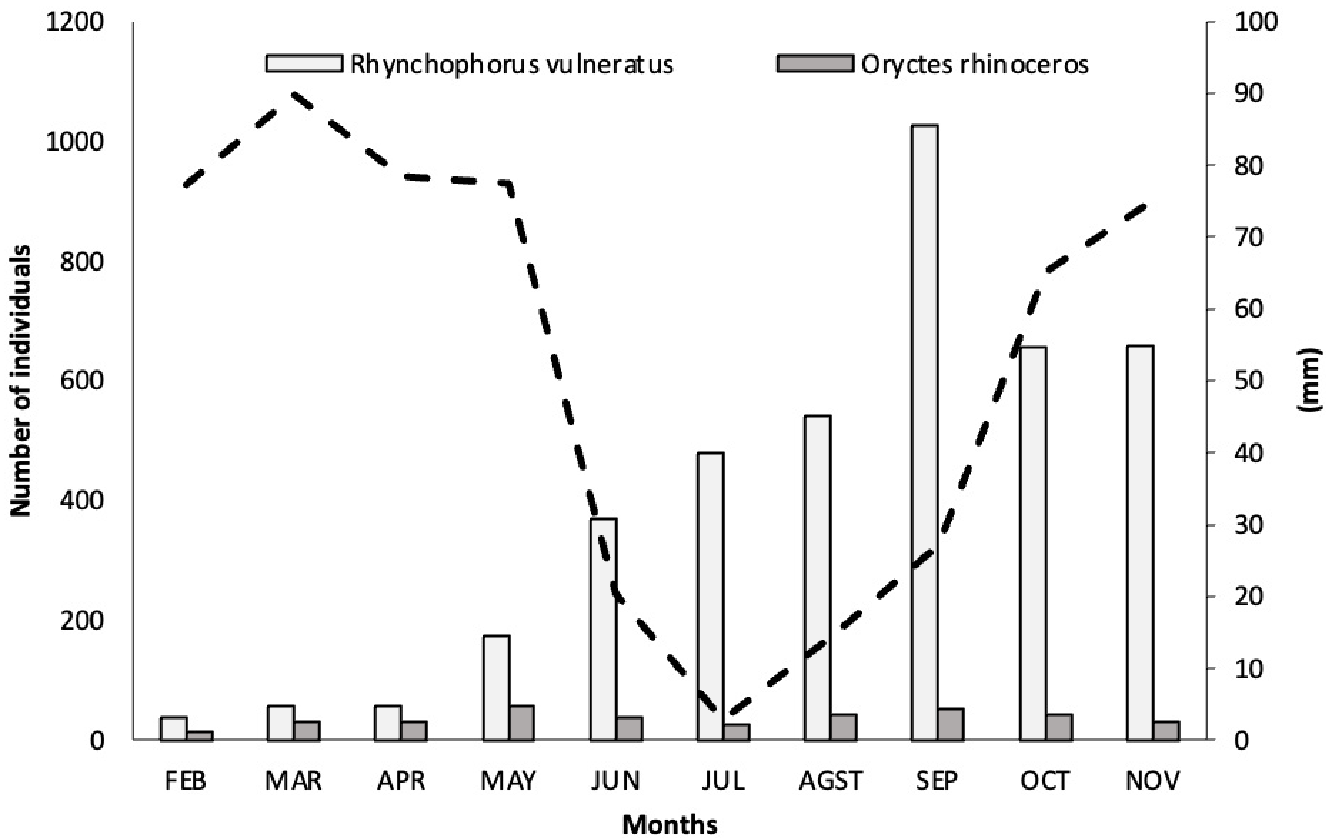

Figure 6. The number of individuals of *R. vulneratus* and *O. rhinoceros* in Yogyakarta caught with rainfall data during February-November 2020 (r = 0.552, not significant at P>0.05)

4. Discussion

Information about the abundance and distribution of pests at a particular location and time is important. Integrated pest management is greatly helped by knowing this information. For example, the abundances of *R. vulneratus* in the Yogyakarta area were different during the rainy and dry seasons (Table 2). The number of *R. vulneratus* caught was more in the dry than the rainy season. Azmi *et al.* (2014) also reported that the number of Rhynchophorus captured tended to be higher in the dry season than in the rainy season. This indicated that *R. vulneratus* tended to be more active in flying and foraging during the dry season than the rainy season.

Spatial distribution describes the presence of pests in an area. The spatial distribution of *R. vulneratus* in Yogyakarta during the rainy and dry seasons increased levels (Figure 3 and 4). The spatial distribution of *R. vulneratus* increased in level during the dry season because the number of *R. vulneratus* captured increased. The medium infestation level appears slightly low in some areas of Kulon Progo, Bantul, and Sleman. The distribution of *R. vulneratus* at the medium level in the Bantul area is the largest because the south of the Bantul area is a coastal area where there are many coconut plants around it. An integrated pest control strategy by studying the spatial distribution that can be analyzed using GIS has been widely practiced. This research used GIS to describe the spatial distribution *R. vulneratus* at level altitudes during rainy and dry seasons. Rano *et al.* (2022) reported that spatial distribution analysis using GIS can describe the distribution of pests in the past and present and predict distribution in the coming year.

In coconut plants that were attacked by *R. vulneratus*, almost all of the leaves had a V-shaped cut (Figure 5). This could be indicated that *R. vulneratus* played a role as the secondary pest because *R. vulneratus* attracted the coconut through the injury holes caused by *O. rhinoceros.* Gunawardena and Gunatilake (1993) reported that the injury holes of coconut plants secreted a liquid fermented chemical compound that attracts *Rhynchophorus*. Azmi *et al.* (2013) also reported that *Rhynchophorus* attacked coconut plants in three ways, namely (1) directly through shoots, (2) through holes in the stems or fronds made by *O. rhinoceros*, and (3) through the root system. Because the two species interacted with each other, efforts to control the populations of the two species were also related. The combination of two types of aggregate pheromones was one of the ways of pest management. This study used ORICMAS which contains a variety of aggregation pheromones from *R. vulneratus* and *O. rhinoceros*. The synergism of the two pheromones showed that they were more effective at attracting *R. vulneratus* because the number of caught *R. vulneratus* was higher than *O. rhinoceros* (Figure 6). The same results were also shown in research by Prasetyo *et al.* (2009) on oil palm plantations.

Based on Figure 6, rainfall influenced the two species' abundance. Rainfall had an impact on air temperature, air humidity, and light intensity to form a local microclimate (Price *et al.* 2011). The population of *O. rhinoceros* tended to increase, especially during the rainy season, but the population tended to decrease in the dry (Indriyanti *et al.* 2017; Nuriyanti *et al.* 2017). Information on population abundance during rainy and dry seasons was beneficial for predicting the population dynamics of *Rhynchophorus* and *O. rhinoceros* to play a role in helping to prevent and control their population. However, the correlation test (Pearson correlation) showed that the number of individuals of *R. vul* was not influenced by the number of *O. rhinoceros* (p-value >0.05). We suggested that the abundance of captured *O. rhinoceros* cannot accurately predict the abundance of *R. vulneratus*. Field Al-Ayedh and Al Dhafer (2015) also reported the same result.

In conclusion, the study concluded that GIS analysis showed the distribution spatial of *R. vulneratus* during the dry season had four levels of concern compared rainy season. Therefore, initial study about the interaction *R, vulneratus* with *O. rhinoceros* could be shown by the symptoms, not their abundance.

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