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Presence of Insect Pests and Predatory on Shallot Plants (*Allium ascalonicum* L.) Around The Flower Garden of Kedai Sawah Sembalun

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ABSTRACT

Shallot (*Allium ascalonicum* L.) is a high-value horticultural crop whose productivity is often constrained by insect pests such as *Spodoptera exigua, Liriomyza huidobrensis, Thrips tabaci*, and *Neotoxoptera formosana*. This study aimed to identify pest and predator insect communities in shallot fields surrounding the Kedai Sawah Flower Garden, Sembalun, and to examine the role of flower gardens as refugia in regulating pest populations. The study was conducted from April to June 2025 using a descriptive method at four observation sites (L1–L4) located at different distances from the flower garden. Insects were sampled during seven observation periods using sweep nets and identified to the genus level. Parameters observed included insect abundance, Shannon–Wiener diversity index (H′), dominance index (C), evenness index (E), relative abundance, and pest attack intensity. A total of 13 insect genera were recorded, comprising four pest genera and nine predator genera. Spodoptera exigua was the dominant pest, with higher populations at sites farther from the flower garden, while predators such as *Paederus, Coccinella, Lycosa*, and *Episyrphus* were more abundant at sites closer to the garden. Pest diversity was low (H′ = 0.85–0.91), whereas predator diversity was moderate to high (H′ = 1.87–2.08). Lower infestation levels of S. *exigua* near the flower garden indicate that flower gardens function effectively as refugia by supporting predator populations and naturally suppressing pest outbreaks.

INTRODUCTION

Shallot (*Allium ascalonicum* L.) is one of the most important horticultural crops widely cultivated in Indonesia due to its high nutritional value and diverse uses, both as a food ingredient and as a culinary spice. This commodity has high economic value and broad market prospects, making it one of Indonesia's leading vegetable crops (Porang, 2022). Shallot can be cultivated in both lowland and highland areas; however, optimal productivity is achieved at elevations of 600–900 m above sea level under cool environmental conditions, loose soil structure, and adequate air circulation (Purwanto et al., 2019).

Shallot production in Indonesia is dominated by six major provinces, namely Central Java, East Java, West Java, West Sumatra, South Sulawesi, and West Nusa Tenggara (NTB), which together contribute approximately 81.42% of national production (BPS, 2021). NTB is considered a potential production area; however, its productivity remains fluctuating and relatively low, ranging from 8–12 tons ha^{-1}, far below the optimal potential yield of 20–30 tons ha^{-1} (BPS NTB, 2022). Low productivity is attributed to several factors, particularly the incidence of plant pests and diseases, weeds, and the reduction of cultivated area.

Major insect pests commonly found in shallot fields include the beet armyworm (*Spodoptera exigua*), leaf miner (*Liriomyza chinensis*), thrips (*Thrips tabaci*), and aphids (*Neotoxoptera formosana*). Pest infestations damage leaves, stems, and bulbs, thereby reducing photosynthetic activity, yield, and product quality. Therefore, the implementation of Integrated Pest Management (IPM) is strongly recommended to reduce dependence on chemical pesticides through environmentally friendly and sustainable approaches (Febriani et al., 2021).

One IPM strategy involves the utilization of predatory insects as biological control agents. Predators are capable of suppressing pest populations without disrupting agroecosystem balance (Altieri & Nicholls, 2020; Amar et al., 2024). In addition, flowering plants as refugia play a crucial role by providing nectar and

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pollen as food sources, as well as shelter for predators and parasitoids, helping to maintain their populations even when pest density declines (Kurniawati & Martono, 2015).

The concept of flowering refugia can be observed in the Kedai Sawah Flower Garden, Sembalun, East Lombok, which functions not only as a tourist destination but also as a natural habitat for various pollinators and predatory insects. The proximity of this flower garden to shallot fields is expected to enhance predator populations, suppress pest attacks, and reduce pesticide use. Therefore, this study was conducted to investigate the presence of insect pests and predators in shallot cultivation around the Kedai Sawah Flower Garden, Sembalun.

MATERIALS AND METHODS

This study was conducted from April to June 2025 in farmers paddy fields surrounding Kedai Sawah, Sembalun Bumbung Village, East Lombok Regency, West Nusa Tenggara (NTB), Indonesia. The site was selected due to the presence of diverse flowering plants in the Kedai Sawah Flower Garden, while the surrounding fields were cultivated with shallot, allowing observation of interactions between insect pests and their natural enemies. Shallot plants were cultivated on raised beds 1.2 m in width with varying lengths, covered with plastic mulch and planted at a spacing of 20 × 20 cm. A basal fertilizer at a rate of 100 kg ha^{-1} and a top-dressing fertilizer at the same rate were applied following standard cultivation practices. The equipment used in this study included 15 mL Eppendorf tubes, a stereomicroscope, insect sweep nets, brushes, a smartphone camera, and stationery. The research materials consisted of 70% alcohol for specimen preservation and shallot plants as the main observed crop.

1. Data Collection Techniques

Observations were conducted at four different locations around the Kedai Sawah Flower Garden, designated as Location 1 (L1), Location 2 (L2), Location 3 (L3), and Location 4 (L4). Location 1 was the closest to the flower garden, Location 4 was the farthest, while Locations 2 and 3 were at intermediate distances. At each location, four plots measuring 3.2 m in length were established, consisting of six rows with 16 plants per row, resulting in 96 plants per plot.

Plant samples were selected using systematic random sampling by taking six plants from each plot, for a total of 96 sample plants. Data on insect pests and predators were collected using a sweep net swung 20 times alternately to the left and right. Observations were carried out seven times at weekly intervals during plant ages of 3–9 weeks after planting (WAP). Captured insects were preserved in specimen bottles containing 70% alcohol and identified to the genus level in the laboratory using a stereomicroscope and taxonomic references.

2. Research Parameters

The observed parameters included species composition and population levels of insect pests and predators, Shannon–Wiener diversity index, dominance index, evenness index, relative abundance, pest attack intensity, and regression analysis.

a) Diversity Index

Species diversity was calculated using the Shannon–Wiener diversity index (Odum, 1993):

$$H' = -\sum pi \ln pi, \rightarrow pi = \frac{ni}{N}$$

where H′ is the Shannon–Wiener diversity index, n_i is the number of individuals of species i, and N is the total number of individuals. Diversity was classified as low ($H' < 1$), moderate ($1 \le H' < 3$), or high ($H' > 3$).

b) Dominance Index

Species dominance was calculated using Simpson's dominance index (Magurran, 1988):

$$D = \sum_{i=1}^{n} \left[\frac{ni}{N}\right]^2$$

where D is the dominance index. Dominance levels were categorized as low ($0 < D \le 0.5$), moderate ($0.5 < D \le 0.75$), or high ($0.75 < D \le 1.0$).

c) Evenness Index

The evenness index was calculated using the Evenness index proposed by Odum (1998) as follows:

$$E = \frac{H'}{\ln s}$$

where E is the evenness index and S is the total number of species. Evenness was classified as depressed (0.00 < E ≤ 0.50), moderate (0.50 < E ≤ 0.75), or stable (0.75 < E ≤ 1.00).

d) Relative Abundance

Relative abundance was calculated as:

$$\text{Relative Abundance (RA)} = \frac{\text{number of individuals of species } i}{\text{total number of individuals}} \times 100\%$$

e) Pest Attack Intensity

The attack intensity of the beet armyworm was determined using the absolute damage intensity formula (Moekasan, 2011):

$$IS = \frac{n}{N} \times 100\%$$

where IS is attack intensity (%), n is the number of damaged plants or plant parts, and N is the total observed units. Damage severity was scored from 0 (no damage) to 4 (severe damage >75-100%).

Plant damage categories were determined based on the severity of pest attack assessed using a scoring system. A score of 0 indicated plants with no damage. A score of 1 represented light damage, with more than 0-25% of plant tissue affected. A score of 2 indicated moderate damage, with more than 25-50% damage. A score of 3 corresponded to severe damage, with more than 50-75% of plant tissue affected. A score of 4 indicated very severe damage, with more than 75-100% damage, classified as heavy infestation.

f) Regression Analysis

Regression analysis was used to determine the relationship between pest population and pest attack intensity at different locations of shallot cultivation, using the simple linear regression model (Sugiyono,2013):

$$Y = a + bX$$

where Y is the dependent variable, X is the independent variable, a is the constant, and b is the regression coefficient. The strength of the relationship was evaluated using the coefficient of determination (R^2), categorized from very weak (0.00-0.199) to very strong (0.80-1.00).

The strength of the relationship based on the R^2 value was classified into several coefficient intervals: values of 0.00-0.199 indicate a very weak relationship, 0.20-0.399 indicate a weak relationship, 0.40-0.599 indicate a moderate relationship, 0.60-0.799 indicate a strong relationship, and 0.80-1.00 indicate a very strong relationship.

RESULTS AND DISCUSSION

1. Diversity Index

Table 1. Number of pest and natural enemy insect individuals found in shallot fields at each observation location around the Kedai Sawah Flower Garden, Sembalun.

Role	Order	Family	Genus	Number of Individuals			
				L1	L2	L3	L4
Pest	*Lepidoptera*	*Noctuidae*	*Spodoptera*	10	18	28	38
	Hemiptera	*Scutelleridae*	*Poecilocoris*	2	2	3	4
	Coleoptera	*Coccinellidae*	*Epilachna*	3	4	5	6
		Tenebrionidae	*Tenebrio*	0	2	3	4
		Total		15	26	39	52
Natural Enemies	*Coleoptera*	*Staphylinidae*	*Paederus*	14	13	9	6
		Coccinellidae	*Coccinella*	13	10	7	5
	Odonata	*Coenagrionidae*	*Agriocnedae*	9	8	5	3

	Libellulidae	*Orthetrum*	8	7	5	3
Araneae	*Lycosidae*	*Lycosa*	10	9	6	4
	Araneidae	*Araneus*	9	8	5	3
Hymenoptera	*Formicidae*	*Camponotus*	8	8	6	4
	Vespidae	*Eumenes*	10	9	6	3
Diptera	*Syrphidae*	*Episyrphus*	10	11	6	3
	Total		91	83	55	34

Note: L1 (Location 1), L2 (Location 2), L3 (Location 3), L4 (Location 4).

Based on the results of the study, a total of 132 pest insect individuals were recorded, belonging to 3 orders, 4 families, and 4 genera, whereas 263 predator individuals were recorded, belonging to 5 orders, 9 families, and 9 genera. The pest insects identified comprised the genera *Spodoptera, Poecilocoris, Epilachna,* and *Tenebrio*.

The highest number of pest individuals was found at L4, with 52 individuals, dominated by the genus *Spodoptera* (38 individuals). The high population of *Spodoptera* at this location was associated with a decline in predator populations, resulting in relatively low predation pressure on pest larvae and eggs. This finding is consistent with Sari et al. (2023), who reported that the presence of predators is a key factor in suppressing pest populations, and that a reduction in predator abundance leads to increased pest attacks in shallot fields. In contrast, the lowest pest abundance was recorded at L1 (15 individuals), with *Spodoptera* accounting for only 10 individuals. This condition is closely related to the high predator population at this site, allowing natural control processes to function optimally. Similarly, Ginting et al. (2022) reported that high predator abundance in agricultural habitats can significantly suppress the development of major pest populations.

Within the predator group, the highest number of individuals was observed at L1 (91 individuals), dominated by the genera *Paederus* (14 individuals) and *Coccinella* (13 individuals). This condition was supported by the presence of the Kedai Sawah Flower Garden, which serves as an additional food source in the form of nectar and pollen. According to Sari et al. (2023), flowering plants surrounding crop fields play an important role in providing energy resources for predators, thereby increasing their abundance and predation effectiveness against pests. Conversely, the lowest predator population was recorded at L4 (34 individuals). The low abundance of predators at this location was likely due to limited availability of supplementary food resources and less favorable microhabitat conditions. This finding aligns with Ginting et al. (2022), who stated that vegetation diversity strongly influences predator abundance, with areas having minimal vegetation tending to support lower predator populations.

2. Dominance Index

Table 2. Diversity, evenness, and dominance indices of pest insects on shallot plants at each observation location around the Kedai Sawah Flower Garden, Sembalun

Location	H'	Criteria	E	Criteria	D	Criteria
L1	0.85	Low	0.91	High	0.38	Low
L2	0.91	Low	0.73	High	0.55	Moderate
L3	0,86	Low	0.69	High	0.45	Low
L4	0,87	Low	0.72	High	0.42	Low

Note: L1 (Location 1), L2 (Location 2), L3 (Location 3), L4 (Location 4), H' (Diversity Index), E (Evenness Index), D (Dominance Index).

The diversity index of pest insects on shallot plants at the four observation locations was classified as low. This low diversity indicates that the number of pest insect species found at each location was relatively limited and that the pest community structure was not highly complex. However, despite the low H′ values, the evenness index at all locations was classified as high. This suggests that the distribution of individuals among species was relatively even, indicating that no single species dominated the community absolutely. These findings are consistent with Sari et al. (2025), who reported that insect diversity in shallot fields with the presence of refugia plants was generally low, yet the insect community remained balanced because it was not dominated by a single pest species. This result is further supported by Baderan et al. (2021), who stated that high evenness reflects a relatively uniform distribution of individuals among species, with no species exhibiting a markedly higher population than others.

The dominance index in this study ranged from low to moderate. Locations 1, 3, and 4 exhibited low dominance, indicating that no single pest species strongly dominated the community. This condition may be influenced by the presence of predators that suppress pest population growth, thereby preventing excessive dominance by any one species. In contrast, Location 2 (L2) showed a moderate dominance index, suggesting a tendency for one or several pest species, such as Spodoptera exigua, to be more dominant than others. This condition may be attributed to several factors, including differences in microhabitat conditions that are more favorable for pest development (e.g., higher plant density or soil moisture), as well as lower predator effectiveness in that area. Ecologically, moderate dominance at L2 may also reflect an imbalance in interspecific competition among pest species, where one species is more adaptive to local environmental conditions than others. Fajarfika (2020) noted that low dominance index values are generally associated with moderate diversity indices, indicating the absence of a highly dominant species. Overall, pest insect diversity in shallot fields at the study site is influenced by complex factors such as the abundance and composition of predators, availability of food resources, and ecosystem conditions (Ginting et al., 2024).

3. Evenness Index

Table 3. Diversity, evenness, and dominance indices of predator insects on shallot plants at each observation location around the Kedai Sawah Flower Garden, Sembalun

Location	H'	Criteria	E	Criteria	D	Criteria
L1	2.08	Moderate	0.97	High	0.11	Low
L2	2.12	Moderate	0.96	High	0.12	Low
L3	2.11	Moderate	0.90	High	0.13	Low
L4	2.07	Moderate	0.93	High	0.14	Low

Note: L1 (Location 1), L2 (Location 2), L3 (Location 3), L4 (Location 4), H' (Diversity Index), E (Evenness Index), D (Dominance Index).

The predator diversity index at each observation location was classified as moderate, the evenness index was high, and the dominance index was low. A moderate diversity index indicates that a relatively high number of genera or species were present, with a total of nine predator genera recorded. This value suggests that the predator community was sufficiently diverse and likely contributed to maintaining the stability of the shallot agroecosystem. This condition is further supported by the high evenness index, which indicates that predator populations were distributed relatively evenly, with no pronounced differences in abundance among species.

Meanwhile, the dominance index was categorized as low, indicating that no single predator species dominated the community. This condition allows pest control to be carried out effectively by a variety of predator species. Low dominance also reflects a healthy ecosystem that supports the coexistence of diverse predator taxa.

These findings are consistent with those of Santosa et al. (2008) and Amrulloh et al. (2023), who reported that a moderate diversity index reflects the presence of a sufficiently diverse assemblage of predator genera or species within an ecosystem. Furthermore, a high evenness index indicates a balanced distribution of predator populations without a pronounced dominance of any single species.

4. Relative Abundance

Table 4. Relative abundance of pest insects on shallot plants at each observation location around the Kedai Sawah Flower Garden, Sembalun

Order	Family	Genus	Relative Abundance (%)			
			L1	L2	L3	L4
Lepidoptera	*Noctuidae*	*Spodoptera*	66.67	69.23	71.79	73.07
Hemiptera	*Scutelleridae*	*Poecilocoris*	13.34	7.69	7.69	7.69
Coleoptera	*Coccinellidae*	*Epilachna*	20	15.38	12.82	11.53
	Tenebrionidae	*Tenebrio*	0	7.69	7.69	7.69

Note: L1 (Location 1), L2 (Location 2), L3 (Location 3), L4 (Location 4)

The pest insect genus with the highest relative abundance was Spodoptera, with values of 66.67% (L1), 69.23% (L2), 71.79% (L3), and 73.07% (L4). The high relative abundance of the genus Spodoptera can be attributed to its high population density at the study sites. A higher number of individuals directly influences the relative abundance value of each species. These results are consistent with the findings of Asril et al. (2022) and Januarisya et al. (2023), who reported that relative abundance is strongly determined by the number of individuals recorded.

The high relative abundance of *Spodoptera* may also be influenced by favorable environmental conditions and the availability of suitable host plants that support its life cycle. According to Moekasan et al. (2012), the pest Spodoptera exigua is capable of infesting shallot crops throughout the year, both during the dry and rainy seasons.

Table 5. Relative abundance of predator insects on shallot plants at each observation location around the Kedai Sawah Flower Garden, Sembalun.

Order	Family	Genus	Relative Abundance (%)			
			L1	L2	L3	L4
Coleoptera	*Staphylinidae*	*Paederus*	15.38	15.66	16.36	17.64
	Coccinellidae	*Coccinella*	14.28	12.04	12.72	14.70
Odonata	*Coenagrionidae*	*Agriocnedae*	9.89	9.63	9.09	8.82
	Libellulidae	*Orthetrum*	8.79	8.43	9.09	8.82
Araneae	*Lycosidae*	*Lycosa*	10.98	10.84	10.90	11.76
	Araneidae	*Araneus*	9.89	9.63	9.09	8.82
Hymenoptera	*Formicidae*	*Camponotus*	8.79	9.63	10.90	11.76
	Vespidae	*Eumenes*	10.98	10.84	10.90	8.82
Diptera	*Syrphidae*	*Episyrphus*	10.98	13.25	10.90	8.82

Note: L1 (Location 1), L2 (Location 2), L3 (Location 3), L4 (Location 4).

The predator genus with the highest relative abundance at all observation locations was Paederus. The relative abundance of this genus tended to increase from L1 (15.38%) to L4 (17.64%). The high abundance of this predator is presumably due to its role as a generalist predator that actively preys on a wide range of small insects, including the eggs and larvae of Spodoptera exigua, which is the major pest of shallot. In addition, Paederus is known to have high mobility and strong adaptability to various microhabitat conditions, allowing its population to remain stable or even increase at locations farther from the center of the study area.

The abundance of the genus Paederus is also associated with the presence of the Kedai Sawah Flower Garden around the observation sites. Flowering vegetation in the garden potentially provides shelter and supplementary food resources, thereby supporting the survival of this predator. According to Winasa et al. (2020), predators such as Paederus play an important role in shallot agroecosystems by suppressing populations of defoliator pests and maintaining ecological balance. Similarly, Nelly et al. (2015) reported that Paederus is among the dominant predator genera within predator communities, together with several other predator genera. This dominance is thought to be related to its a daptability across diverse agroecosystem conditions and its high mobility in searching for prey, particularly lepidopteran larvae and sap-sucking insect pests.

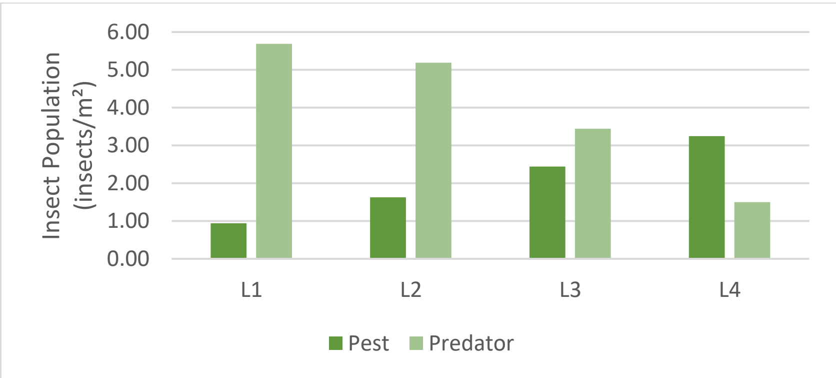

Figure 1. Pest and predator insect populations at four observation distances from the Flower Garden

The populations of pest and predator insects at the four observation locations (L1, L2, L3, and L4) showed contrasting patterns. Pest populations increased gradually from L1 to L4, whereas predator populations decreased over the same distances. Observations were conducted within an area of 16 m² at each location.

At location L1, the pest population was recorded at 0.93 individuals/m², increasing to 1.62 individuals/m² at L2, 2.43 individuals/m² at L3, and reaching the highest value of 3.25 individuals/m² at L4. This increase indicates a tendency for pest populations to rise as predator populations decline. Factors that may contribute to this pattern include reduced predation pressure due to lower predator abundance and increased food availability at locations farther from the flower garden, which are also more distant from the center of pest management activities.

In contrast, predator populations exhibited a marked decreasing trend. At L1, predator abundance was 5.68 individuals/m², declining slightly to 5.18 individuals/m² at L2, then decreasing more sharply to 3.43 individuals/m² at L3, and reaching the lowest level of 1.50 individuals/m² at L4. This decline may be attributed to reduced habitat suitability or the availability of alternative food resources, as well as possible migration of predators to other areas that better support their survival.

These findings are consistent with the study of Afifah and Sugiono (2019), who reported that predator diversity and abundance increase in areas containing flowering plants used as refugia, thereby effectively suppressing pest populations in shallot cultivation. Furthermore, the use of refugia plants around shallot fields has been shown to reduce pest populations while enhancing predator presence, supporting sustainable and environmentally friendly biological control strategies in shallot agroecosystems.

5. Pest Attack Intensity

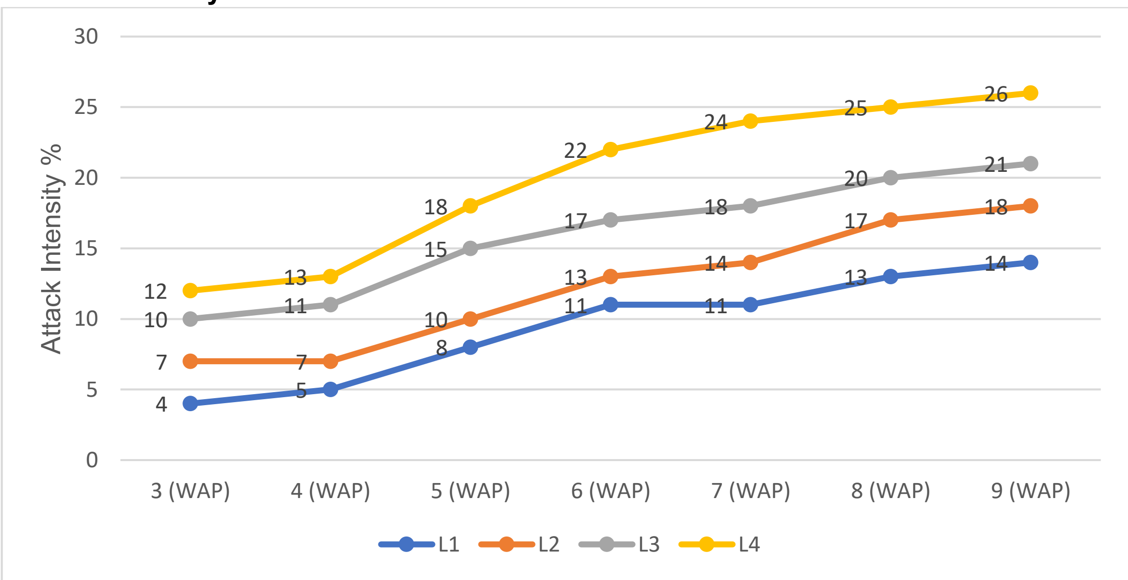

Figure 2. Figure 2. Intensity of Caterpillar Attack at Different Times in Four Observation Locations, (Weeks After Planting, WAP), Location 1 (L1), Location 2 (L2), Location 3 (L3), Location 4 (L4).

The highest attack intensity occurred at location L4, reaching 26% at 9 WAP, which is classified as moderate. The high level of infestation at this location is presumably due to its position being the farthest from the predator source, making pest populations more difficult to suppress by natural enemies. In addition, the greater availability of leaves at the late growth stage further supports larval development.

The increase in attack intensity is closely related to plant age. At 3-4 WAP, pest attack intensity was still low because the number of leaves was limited, resulting in restricted food availability for larvae. Entering 5-7 WAP, attack intensity began to increase as leaf number and leaf area expanded, making the plants more suitable for pest feeding. Furthermore, at 8–9 WAP, the attack intensity reached its highest level because the plants had entered the generative stage, while larval feeding requirements also increased prior to the pupal stage.

These findings are consistent with the study by Pratiwi et al. (2021), which reported that the attack intensity of Spodoptera exigua increases with plant age, with peak infestation occurring at the late growth stage.

6. Regression Analysis

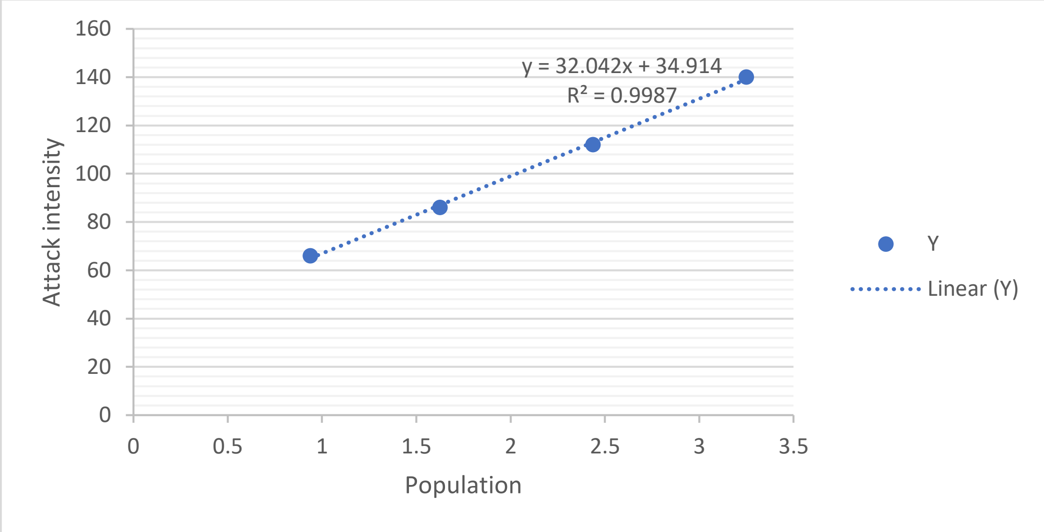

Figure 3. Relationship between Population and Attack Intensity of *Spodoptera exigua*

Regression analysis of the population and attack intensity of Spodoptera exigua indicates that there is a relationship between the population of Spodoptera exigua and the intensity of attack on shallot plants, expressed by the equation Y = 32.042x – 34.914. This equation can be interpreted to mean that for every increase of one individual of Spodoptera exigua, the attack intensity caused by this pest increases by 32%.

The coefficient of determination is 0.99, which indicates that 99% of the variation in attack intensity is influenced by the population of Spodoptera exigua. This result demonstrates that the relationship between population density and attack intensity is very strong, meaning that the population level and attack intensity of Spodoptera exigua are closely related and significantly influence each other.

CONCLUSIONS

A total of 132 pest insect individuals and 263 predator individuals were recorded. Species diversity was classified as moderate, evenness was high, and dominance was low, with pests dominated by Spodoptera and predators dominated by Paederus. The attack intensity of Spodoptera exigua varied among locations and observation periods, being highest at L4 (26%) and lowest at L1 (14%), and increased with plant age. The presence of the Kedai Sawah Sembalun Flower Garden served as a natural refugia that enhanced predator populations and suppressed pest populations and attack intensity on shallot plants.

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