Diversity and Distribution of Diurnal Predatory Insects of *Spodoptera frugiperda* J.E. Smith in Magelang Regency, Central Java

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Abstract. Predatory insects are among the natural enemies that can significantly reduce *Spodoptera frugiperda* populations. This species has been reported to spread into Magelang Regency, Central Java. Therefore, this study aimed to study the diversity and spatial distribution of diurnal predatory insects associated with *S. frugiperda* in the region. The research was conducted from December 2023 to May 2024. Sampling sites were selected using a stratified method, while maize fields within each site were chosen purposively. Insects were collected using hand-picking and sweeping net methods. Environmental data were also collected. The diversity of predatory insects found was analyzed descriptively. The relationship between predator abundance and abiotic factors was analyzed using simple correlation and regression. The results showed that 15 species of predatory insects of *S. frugiperda* were found in Magelang Regency. The predatory insects found came from three orders: Coleoptera, Hymenoptera, and Dermaptera. The most abundant species found was *Coccinella transversalis* (Coleoptera: Coccinellidae). These predatory insects were found in almost every region in Magelang Regency with varying abundances. However, most predators were found in the western and southern regions. These results provide information on the presence of local predators that can be utilized in future *S. frugiperda* management programs sustainably.

1 Introduction

Spodoptera frugiperda J.E. Smith (Lepidoptera: Noctuidae) is an invasive pest of corn plants originating from the Americas [1]. *Spodoptera frugiperda* spread from the Americas to Africa in 2016 [2, 3]. Its spread continued to the Asian continent in mid-2018, including India, Bangladesh, China, Sri Lanka, Thailand, and Indonesia. *Spodoptera frugiperda* was first found attacking corn plants in Indonesia in Pasaman Barat, West Sumatra, in 2019 [4]. *Spodoptera frugiperda* has also been found attacking corn plants in Lampung [5] and West

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Java [4]. Nurkomar, Putra, Trisnawati, Saman, Pangestu and Triyono [6] reported that *S. frugiperda* was found in the Special Region of Yogyakarta, a province directly bordering Magelang Regency, and in 2024, *S. frugiperda* was reported to have been found throughout the Yogyakarta region [7]. *Spodoptera frugiperda* was also found in Magelang Regency in 2024 (unpublished).

Spodoptera frugiperda attacks on corn plants are a serious concern for farmers since they can lower yields and cost much money. The amount of damage caused by this pest varies significantly from region to region. For example, *S. frugiperda* assaults in Tuban and Bantul Regencies caused yields to drop by 5% to 20% [8]. In fact, according to several international studies, yield reductions can reach up to 80–100% without optimal control. Estimates of corn yield losses due to *S. frugiperda* range from 22% to 67%, depending on the level of infestation and location in Africa. Therefore, control strategies need to be well-designed to prevent severe attacks. In general, *S. frugiperda* control still uses synthetic pesticides intensively. However, the use of synthetic pesticides has negative impacts, such as residual residues in the soil, pest resurgence, and impaired human health. Therefore, other efforts are needed to suppress the population of *S. frugiperda* by utilizing its natural enemies as predatory insects [9].

Numerous studies on *S. frugiperda* have been conducted since the pest was first reported in Indonesia, including studies on predators [10]. However, there has been no report on the species inventory and abundance of *S. frugiperda* predators in Magelang Regency. The presence of *S. frugiperda* in Magelang after being discovered in Yogyakarta raises the interesting question of whether the invasion of *S. frugiperda* in Magelang is followed by interactions with local natural enemies. The interaction of *S. frugiperda* with local natural enemies is important to study to determine the potential of local predators that can be used as biological agents. Therefore, this study aims to study the diversity and distribution of diurnal predatory insects associated with *S. frugiperda* in Magelang Regency. The results of this study can serve as a scientific reference in the use of diurnal predators for sustainable *S. frugiperda* control in the future.

2 Materials and Methods

2.1 Site Selection

The study was conducted from December 2023 to May 2024, covering 21 sub-districts across Magelang Regency, Central Java (Figure 1). Sampling locations were determined using a stratified sampling method [6, 7]. Three villages were selected from each sub-district, and one corn field was selected from each village as a sampling location. Each sampling location was then marked with geographic coordinates using the GPS Essentials application. These coordinates were stored in digital format (.kml) and used for location mapping using Google Earth Pro software. The elevation in sampling locations in Magelang Regency ranges from 202 to 1,378 meters above sea level (asl). Before sampling, a preliminary survey was conducted through interviews with farmers to confirm the presence of *S. frugiperda* in the field.

2.2 Insect and Environmental Sampling

Sampling of predatory insects was done twice weekly at each site (Figure 1) by visually inspecting maize plants showing signs of *S. frugiperda* damage. Insects were collected by hand (hand-picking) and using sweep nets. Captured insects were placed into 50 ml plastic bottles containing 70% alcohol for later identification.

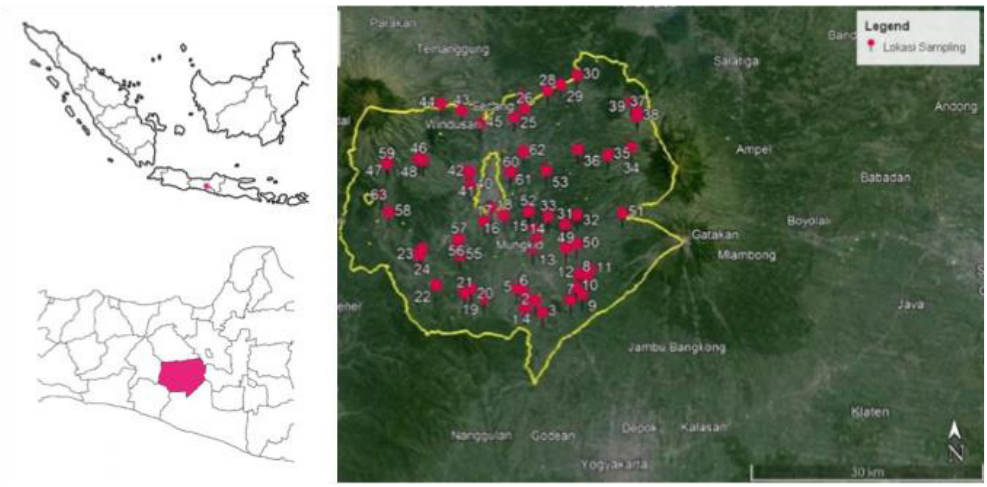

Fig. 1. Map of research sampling location in Magelang Regency

Environmental variables, including sunlight intensity, wind speed, air temperature, and humidity, were measured three times during each sampling visit: upon arrival, collection, and before leaving [20]. Light intensity was measured using a lux meter; wind speed with an anemometer; and temperature and humidity with a thermo-hygrometer.

2.3 Insect Identification

Predators were identified at the Ecology and Systematics Research Laboratory, Faculty of Applied Science and Technology, Ahmad Dahlan University, Yogyakarta. Morphological features such as mouthparts, body color, tarsus count, and wing pattern were observed and compared to identification keys [11]. Identified species were photographed, and their individuals counted to determine relative abundance.

2.4 Data Analysis

Predator diversity was analyzed descriptively. Relationships between predator abundance and abiotic factors were examined by correlation and simple linear regression tests.

3 Results and Discussion

The study found 15 species of predatory insects belonging to 3 orders and seven families in Magelang. These included species from the orders Coleoptera, Hymenoptera, and Dermaptera (Table 1). The most diverse family was Coccinellidae (7 species), followed by Formicidae (4 species). Coccinellidae species included *Verania lineata*, *Exochomus nigripennis*, *Coccinella transversalis*, *Harmonia axyridis*, *Cheilomenes politus*, and *Hippodamia octomaculata*. All are known to prey on early instar larvae of *S. frugiperda*, although some are more commonly associated with several Lepidopteran larvae [12]. Formicidae was the second most common family, with ants also known to prey on *S. frugiperda* larvae.

Table 1. Diversity of diurnal predatory insects associated with *S. frugiperda* in Magelang Regency

Order	Family	Species	Abundance (individual)
Coleoptera	Coccinellidae	*Coccinella transversalis* Fabricius, 1781	282
		Verania lineata Thunberg	92
		Harmonia axyridis (Pallas, 1773)	48
		Harmonia octomaculata (Fabricius, 1781)	4
		Exochomus nigripennis (Erichson, 1843)	3
		Chilocorus politus Mulsant, 1850	2
	Staphylinidae	*Paederus fuscipes* Curtis, 1826	3
Hymenoptera	Formicidae	*Camponotus singularis* (Smith, 1858)	74
		Polyrachis amarta (Le Guillou, 1842)	52
		Camponotus sp. (Linnaeus, 1758)	35
		Polyrhachis fuscipes Mayr, 1862	1
	Vespidae	*Polistes* sp.	1
Dermaptera	Forficulidae	*Forficula auricularia* Linnaeus, 1758	2

Coccinella transversalis was the most abundant species (282 individuals), followed by *V. lineata* (92 individuals). This result differs from results in Sleman and Gunungkidul, where *Menochilus sexmaculatus* was dominant [11]. This difference may relate to reproductive traits. *Coccinella transversalis* has higher fecundity than *M. sexmaculatus*, especially under high prey availability. Both species are important predators of *S. frugiperda* eggs and early larvae. *Polyrhachis fuscipes* and *Polistes* sp. were the least abundant species, with only one individual each. *Polyrachis fuscipes*, a Formicidae member, is typically found in lowland areas (<400 masl), whereas this study was conducted at mid-elevation (400–700 masl, avg. 502 masl). *Polistes* sp. may also have specific habitat preferences unsuitable for these elevations.

Abiotic factors also influenced predator abundance. Temperature ranged from 24.8–34.77°C, humidity 42.43–84%, and light intensity 12769.3 – 101725.5 lux (Table 2). These ranges generally support Coccinellidae development, which prefers 15–35°C and 66–85% humidity [26]. Though light intensity was higher than ideal, *C. transversalis* was still abundant, especially in areas like Tempuran (84% humidity) compared to Windusari (42%). Wind speed ranged from 0–1.1 m/s, within tolerance limits for predator movement, influencing insect survival, diversity, and spread [13].

Correlation test showed a significant relationship between predator abundance and light intensity, but not with temperature or humidity (Table 3). According to Zilahi et al. [14], light is a key abiotic factor affecting insect visitation. Coccinellidae species require optimal light conditions for daily activity and distribution [15], consistent with their dominance in this study.

Table 2. Average biotic factors measured at sampling locations in Magelang Regency

Sub-districts	Air temperatures (°C)	Air humidities (%)	Light intensity (lux)
Ngluwar	29.39	65.89	59320.4
Muntilan	26.58	73.11	12769.3
Salam	24.84	78.22	16701.3
Srumbung	26.78	61.00	26497.7
Mungkid	25.33	76.57	19572.7

Sub-districts	Air temperatures (°C)	Air humidities (%)	Light intensity (lux)
Mertoyudan	27.42	72.47	22054.7
Borobudur	29.53	55.33	60771.1
Salaman	32.67	44.00	68003.3
Secang	33.06	42.43	78249.1
Grabag	30.52	46.20	46426.1
Sawangan	26.12	69.44	47426.8
Pakis	29.28	59.00	84481.11
Ngablak	26.85	57.11	102637.8
Bandongan	27.31	84.00	101725.5
Windusari	31.93	48.99	10562.01
Kaliangkrik	34.77	48.20	18059.9
Dukun	25.25	73.77	43482.0
Candimulyo	31.82	59.66	15480.7
Tempuran	27.26	79.89	72048.2
Kajoran	30.25	54.39	9420.00
Tegalrejo	33.32	58.44	13336.4

Spatially, most predators were found in the western and southern regions of Magelang (Figure 2). These areas border Sleman and Kulon Progo (Yogyakarta), which were reported earlier as *S. frugiperda* infestations, suggesting that pest spread from Yogyakarta to Magelang may have been accompanied by the spread of their natural enemies. These findings highlight the importance of understanding local natural enemy composition and distribution as part of environmentally friendly pest management. By identifying dominant predator species in Magelang, this research offers a foundation for ecosystem-based strategies that support sustainable agriculture and reduce reliance on chemical pesticides. Furthermore, this dataset can serve as a reference for future studies on the dynamics between pests and predators under various agroecological conditions.

Table 3. Pearson correlation coefficients between predators' abundance and environmental factors (Temperature, Humidity, and Light Intensity) in Magelang Regency

Correlations					
		Num of predator	**Temperature (°C)**	**Humidity (%)**	**Light intensity (lux)**
Num of predator	*Pearson Correlation*	1	.098	-.189	.616*
	Sig.(2-tailed)		.673	.413	.003
	N	21	21	21	21
Temperature (°C)	*Pearson Correlation*	.098	1	-.817*	.616*
	Sig.(2-tailed)	.673		.000	.003
	N	21	21	21	21
Humidity (%)	*Pearson Correlation*	-.189	-.817*	1	.616*
	Sig.(2-tailed)	413	.000		.003
	N	21	21	21	21
Light intensity (lux)	*Pearson Correlation*	.616*	-.817*	-.189	1
	Sig (2-tailed)	.003	.000	413	
	N	21	21	21	21

* : significant at the 0.01 level (2-tailed)

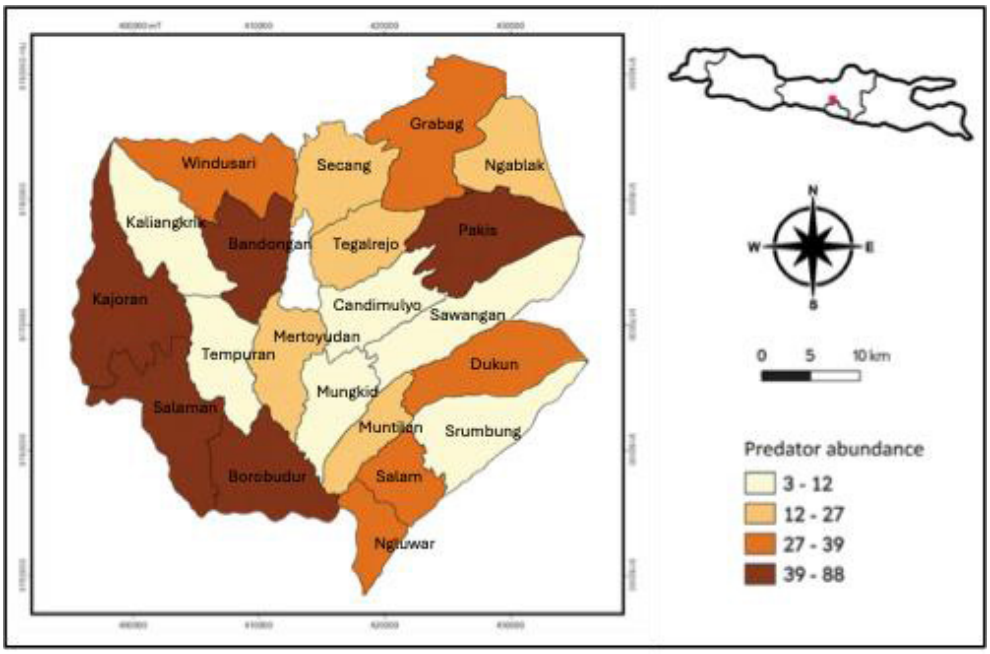

Fig. 2. Distribution of *S. frugiperda* diurnal predator in Magelang Regency. Color indicating predator abundance (see legend)

4 Conclusion

This study recorded 15 species of diurnal predatory insects associated with *S. frugiperda* in Magelang Regency, dominated by species from Coccinellidae and Formicidae. The most abundant species was *C. transversalis*, while *P. fuscipes* and *Polistes* sp. were the least abundant. Predator diversity and abundance were influenced by several factors, including maize growth stage, abiotic conditions (temperature, humidity, light, and wind), and elevation. The highest predator density occurred in Magelang's western and southern areas.

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Author Contribution. ILIP and IN designed the research, ILIP and SS collected samples, ILIP, IN and SS identified the samples, ILIP, IN and SS analysed the data, ILIP, SS and IN write the original manuscript, revise, and approve the final version of the manuscript.

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