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DIVERSITY OF PESTS AND NATURAL ENEMIES IN RICE FIELDS IN KINIAR VILLAGE, EAST TONDANO DISTRICT, NORTH SULAWESI-INDONESIA

Parluhutan Siahaan*, Saroyo, Agustina Monalisa Tangapo, Susan Marlein Mambu

Department of Biology, Faculty of Mathematics and Natural Sciences, Sam Ratulangi University, Manado, Indonesia

*Corresponding author
Email: luhut.siahaan68@unsrat.ac.id

Abstract. *A study was conducted in Kiniar Village, East Tondano District, North Sulawesi, to investigate the variety of pests and their natural adversaries in rice fields. The primary objective of this research was to ascertain the count of insect that act as pests, the number of natural enemy, diversity index, dominance index, and species relative abundance of insect pests and natural enemies in rice fields in Kiniar Village. The results showed that there are 40 insects and spider from 29 families and eight orders in local rice cultivation in Kiniar Village. These species were further categorized into two classes, consisting of 20 pests and 20 natural enemies. The diversity index calculated for all species was 2.99, with separate values of 2.36 for insect pests and 2.42 for natural enemies. Regarding the abundance index, Leptocorisa acuta emerged as the primary pest species, boasting the highest index value at 28.86%, while Tetragnatha sp. stood out as the most prominent natural enemy, with a substantial index value of 32.17%. The dominance index, on the other hand, was determined to be 0.08, indicating that no single insect species exerted dominant control over rice cultivation in Kiniar Village. The diversity of natural enemies and pests is in the medium category. There are no species that dominate the rice fields in Kiniar village, either pests or natural enemies.*
Keywords: *Diversity index; Kiniar Village; natural enemies; pest; relative abundance*

1. Introduction

The rice ecosystem is a form of artificial ecosystem where rice is the main vegetation (Oo, *et al*., 2020). The rice ecosystem is influenced by the physical, chemical, and biological conditions of the local environment (Yu *et al*., 2022), so that the rice ecosystem has its own community which is different from other agricultural ecosystems. According to Jauharlina *et al*. (2019) the main communities in the rice ecosystem are anthropod groups such as insects and spiders.

Insects and spiders in the rice ecosystem are intermediate organisms in the food chain that can act as herbivores, saprophytes, parasites, and predators (Sánchez-Bayo, 2021). All insects that have the potential to harm crop yields are classified as insect pests (Hajjar *et al*., 2023), while insects that prey on other insects are classified as predators (Williams *et al*., 2021). Spiders that live in rice ecosystems are often grouped with predatory insects as natural enemies because of their function as predators which can help the role of predatory insects in controlling insect pests (García *et al*., 2020).

Research on insect diversity in rice ecosystems was conducted by Siregar *et al*. (2017) in Lae Parira, Dairi Regency which found 37 species, 24 families, and 8 orders. Oo *et al*. (2020)

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reported that there were 71 insect species, 40 families, and 8 orders in rice fields in Taungoo, Myanmar. Numerous research findings indicate that the presence and quantity of predatory insects contribute to enhancing pest management efforts (Adhikari & Menalled, 2020). knowledge about insect and spider communities can be a determining factor for the use of biological agents in pest control so that their use is right on target and does not damage the ecosystem. Studies on the diversity of natural enemies in the rice fields of Kiniar Village have never been conducted before, this is important to obtain data on the diversity of natural enemies, which can be used as a basis for pest control efforts.

Kiniar Village, situated within the East Tondano District of Minahasa Regency, is recognized as one of the rice-producing areas. Within this region, a significant issue encountered in rice cultivation pertains to pest infestations. Insect related pest infestations pose a grave concern, leading to substantial reductions in crop yields and considerable financial setbacks for local farmers (Mendesil *et al.*, 2023). The presence of abundant natural predators can serve to reduce pest infestations (Da Silva *et al*., 2022). Hence, it is vital to investigate the relative abundance and diversity of pests in relation to the prevalence of their natural adversaries. Gathering data on the population and diversity of insect pests, as well as the presence and diversity of natural enemies within Kiniar Village, becomes a crucial factor for evaluating the most effective pest control strategies, especially those utilizing local natural enemies.

Based on this background, the aim of this research was to assess the quantity of insect pest species, natural enemy species, diversity index, dominance index, and the relative abundance of both pest insects and natural enemies in the rice fields located within Kiniar Village, situated in the East Tondano District of Minahasa Regency, North Sulawesi Province, Indonesia.

2. Methods

2.1 Study area

The study was conducted within the rice fields of Kiniar Village, Minahasan Regency, North Sulawesi Province, from April 2023 to June 2023. The sampling location is shown in Figure 1. The red dot shows the rice field sample.

2.2. Research Methods

This research is an exploratory study using a 1x1 m plot method, the location of the samples used purposive random sampling (Siahaan *et al*., 2023). Three rice fields with a total area of 750 m^2, all samples containing rice plants that were eight weeks old were taken. 10 points were selected for each rice field with a size of 10 x 10 meters which were used as sampling locations. Sampling was conducted in two ways, namely sweeping using an insect net and five insect traps at each sampling point. The insects and spiders were then transported to the laboratory for the purpose of identification. Identification was conducted using the Borror *et al.* (1996) identification book. The research was conducted three times in the period April 2023 to June 2023. Samples were taken in the morning for collection with insect nets and insect traps were installed in the morning and taken in the afternoon.

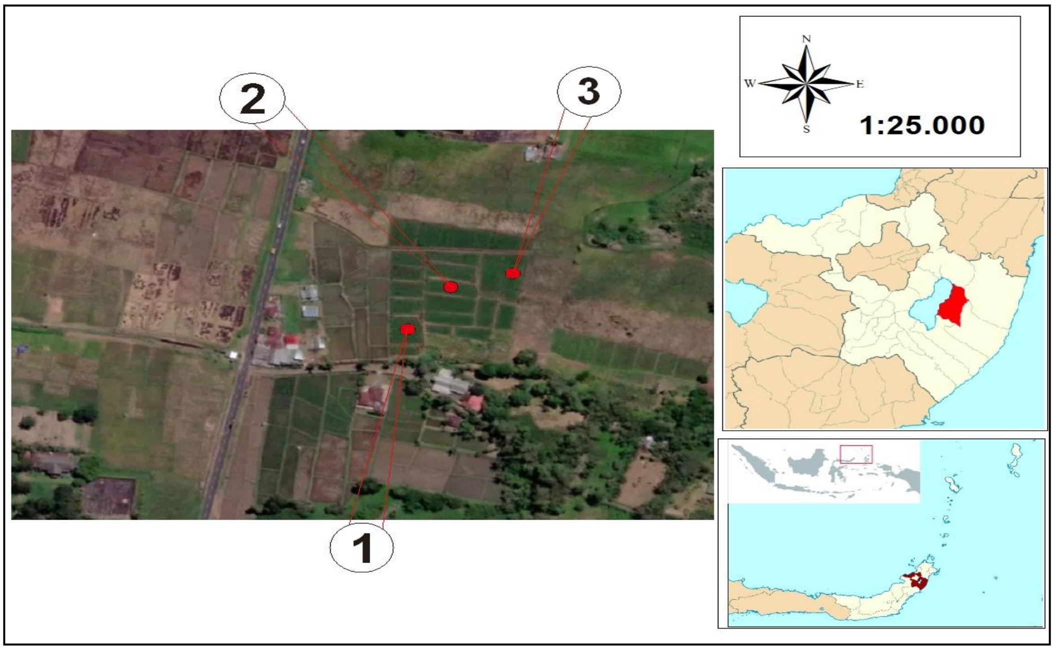

Figure 1. Sampling Location: point 1 (1°16'07.6"N 124°56'14.2"E), point 2 (1°16'09.0"N 124°56'15.2"E), point 3 (1°16'09.3"N 124°56'16.5"E).

Species diversity index is calculated using the following (1) (Bashir *et al.*, 2019):

$$H' = -\sum_{n=1}^{s} pilnpi \quad (1)$$

H'= Shannon-wiener Diversity Index

Pi= Comparing the number of individuals in a specific group with the total number of individuals in the entire population

S= Number of species i

Species relative abundance was counted using (2) (Bashir *et al.*, 2019):

$$A = \frac{\text{Total Number of Individual species}-i}{Total\ Number\ of\ Species\ Population} \quad (2)$$

The dominance index is calculated using the following (3) (Bashir *et al.*, 2019):

$$C = \sum_{i=1}^{n} (Pi)^2 \quad (3)$$

Where C= Dominance Index, Pi= The proportion of individuals, i= 1, 2…, n

Index values range from 0 - 1 by the following categories:

$0 < C < 0.5$ = Low Dominance.

$0.5 < C \leq 0.75$ = Moderate Dominance.

0.75< C ≤ 1.0 = High Dominance.

The calculation was conducted three times for the following groups (Bashir *et al.*, 2019); Calculation of the total number of insects and spiders found, calculation of insect pests, and calculation of natural enemies. Determining the status of insects as pests and as natural enemies is conducted by means of literature studies.

2. Results and Discussion

In Kiniar Village, the total count of insects and spiders found in rice fields amounted to 767 individuals, encompassing 40 different species. These species belonged to 29 families and eight orders, which were further classified into two classes. (Table 1). For insects, the order Hemiptera had the highest representation with 10 species, followed by the order Orthoptera with seven species, the order Coleoptera with six species, the order Lepidoptera with six species, the order Diptera with five species, and the orders Odonata and Hymenoptera, each having only one species. On the other hand, among the spiders, there were four species belonging to the Araneae order (Figure 2). Consequently, Hemiptera was the most encountered order, while the orders Odonata and Hymenoptera were the least frequently observed. These results are the same as research conducted by Hashim *et al.* (2017) who found that insect species from the order Hemiptera were more commonly found than other orders, where this was influenced by the composition of species from this order which had the status of pests.

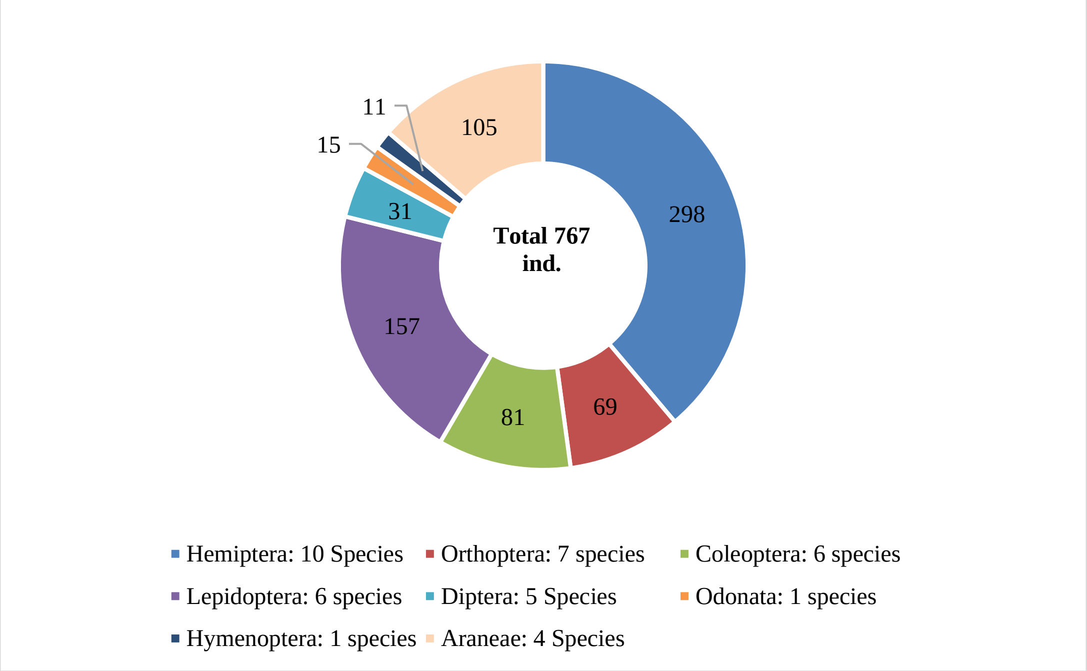

Figure 2. Number of Species in Each Order

Based on the Table 1, The species *L. oratorius* (Hemiptera: Alydidae) stands out as the most numerous, with a total of 155 individuals, resulting in a density of 5.17 individuals/m^2 and an abundance of 20.21%. Following closely, the species *N. depunctalis* (Lepidoptera: Crambidae) is the second most abundant, with 104 individuals, a density of 3.47 individuals/m^2, and an abundance of 13.56%. In contrast, both *Lygaeus* sp. and *P. seragamis* are the least common species, each with only one individual, yielding a density of 0.03 individuals/m^2 and an abundance of 0.13%.

The presence of *L. oratorius* (Alydidae) with the highest abundance aligns with its status as one of the major pests in rice cultivation. Additionally, the timing of observations also influences the insect abundance data in rice fields, as the observations were conducted just before the rice entered the milky stage. This corresponds with the statement made by Hwang *et al.* (2022), where the increase in the population of rice bugs is attributed to the sufficient availability of food for their development, particularly since rice bugs typically attack rice plants when they have reached the milky stage. Apart from that, *L. oratorius* has the potential for greater spread and damage to rice cultivation because the density of *L. oratorius* is estimated to be higher than currently, and this pest has become the dominant rice pest in Southeast Asia, including Indonesia (Litsinger *et al*., 2015).

The findings showed that the number of insect and spider species found in the rice fields of Kiniar Village was 40 types. The results of research conducted by Sulaiman *et al*. (2013) at a rice plantation in Lubok China, Malaysia found a lower number, namely 34 species. This relatively low number is thought to be influenced by the age of the rice studied and differences in other predators such as birds and frogs. Jauharlina *et al*. (2019) found total of 25 insect and spider species were discovered in the rice fields of Banda Aceh, the results were much less likely to be influenced by differences in the intensity of pesticide use in the rice fields. The pesticides used in the research area were 2-4 times during the growing period so that they had a negative impact on the rice fields. Chagnon *et al*. (2015) stated that the use of pesticides that are too frequent and too much will reduce the diversity of species in a land. Rice plants that are 8 weeks old and the pattern of pesticide application which is quite high from farmers in the sampling area, have an influence on the presence of natural enemies and pests.

Oo *et al*. (2020) found 71 insect species in agricultural lands that do not use pesticides and in agricultural locations close to forests. This condition is a supporting factor for the high number of species found. These things are in accordance with Zhang *et al*. (2013). This statement suggests that the diversity of insect species in agricultural areas is influenced by several factors, including the location, land management practices, and the methods used for sampling. In the case of the research conducted in the village of Nowar, its proximity to residential areas and its distance from the forest have an impact on the population of individuals and the variety of species that can be observed. Additionally, the sampling technique employed involves the use of insect nets, which limits the collection to insects present on the surface of rice plants and those that are active during daylight hours.

Table 1. Total Number, Average and Abundance of Insects and Spiders in Rice Fields in Kiniar Village

Class	Order	Family	Species	Number of Individual	Average/m^2	Abundance (%)
Insekta	Hemiptera	Pentatomidae	*Eurydema pulchrum*	20	0.67	2.61
			Scotinophara coarctata	43	1.43	5.61
			Nezara viridula	14	0.47	1.83
			Zicrona sp.	2	0.07	0.26
		Alydidae	*Leptocorisa oratorius*	155	5.17	20.21
		Cicadellidae	*Nephotetix virescens*	37	1.23	4.82
		Rhyparochromidae	*Pamera bilobata*	4	0.13	0.52
		Lygaeidae	*Lygaeus* sp.	1	0.03	0.13
		Reduviidae	*Rhinocoris* sp.	2	0.07	0.26
		Gerridae	*Gerris adelaidis*	20	0.67	2.61
	Orthoptera	Tettigoniidae	*Ruspolia* sp.	4	0.13	0.52
			Conocephalus longipennis	3	0.10	0.39
		Acrididae	*Locusta migratoria*	9	0.30	1.17
			Valangan nigricornis	6	0.20	0.78
			Oxya chinensis	25	0.83	3.26
		Pyrgomorphidae	*Atracomorpha crenulata*	15	0.50	1.96
		Gryllidae	*Gryllus* sp.	7	0.23	0.91
	Coleoptera	Coccinellidae	*Coccinella* sp.	24	0.80	3.13
			Cheilomenes sexmaculata	3	0.10	0.39
		Chrysomelidae	*Aulacophora dorsalis*	32	1.07	4.17
			Aulacophora similis	4	0.13	0.52
		Staphyllinidae	*Paederus fuscipes*	17	0.57	2.22
		Cerambycidae	*Pterolophia uniformis*	1	0.03	0.13
	Lepidoptera	Crambidae	*Cnaphalocrocis medinalis*	14	0.47	1.83
			Schircophaga incertulas	18	0.60	2.35
			Schircophaga inotata	15	0.50	1.96
			Nyimphula depunctalis	104	3.47	13.56
		Nymphalidae	*Melanitis leda*	4	0.13	0.52
		Lycaenidae	*Lampides boeticus*	2	0.07	0.26
	Diptera	Muscidae	*Atherigona oryzae*	15	0.50	1.96
		Syrphidae	*Episyrphus* sp.	2	0.07	0.26
		Sciomyzidae	*Sepedon* sp.	4	0.13	0.52
		Ephydridae	*Hydrellia philippina*	4	0.13	0.52
		Asilidae	*Hymenia* sp.	6	0.20	0.78
	Odonata	Agrionidae	*Agriocnemis femina oryzae*	15	0.50	1.96
	Hymenoptera	Formicidae	*Dolichoderus* sp.	11	0.37	1.43
Arachnida	Araneae	Tetragnathidae	*Tetragnatha* sp.	74	2.47	9.65
		Oxyopidae	*Oxyopes javanus*	13	0.43	1.69
		Linyphiidae	*Atypena* sp.	11	0.37	1.43
		Araneidae	*Argiope catenulata*	7	0.23	0.91
TOTAL					25.57	100.00

Table 2 illustrates the ecological roles of each insect and spider species in rice paddies. In the class insecta, there are 20 insect species from seven orders that play roles as pests, with six species from the order Lepidoptera all serving as pests. In the order Hemiptera, there are six species with pest roles, Orthoptera has four species, while Coleoptera and Diptera each have two species with pest roles. The presence and abundance of each pest species in rice fields in Kiniar Village are directly related to the availability of food resources. According to Belsky and Joshi (2019), the presence of insects in an agricultural ecosystem is closely linked to the availability of plant resources, which serve as sources of protein and sugar that support the survival of existing insect populations. The presence of insect pests itself triggers the emergence of natural enemies of these pests in rice plantings (Farina *et al*., 2023) thus forming a food chain in the ecosystem.

Table 2. Ecological Function of Insect and Arachnids in the Rice Fields of Kiniar Village

Class	Order	Family	Species	Status
Insecta	Hemiptera	Pentatomidae	*Eurydema pulchrum*	pest
			Scotinophara coarctata	pest
			Nezara viridula	pest
			Zicrona sp.	predator
		Alydidae	*Leptocorisa acuta.*	pest
		Cicadellidae	*Nephotetix virescens*	pest
		Rhyparochromidae	*Pamera bilobata*	predator
		Lygaeidae	*Lygaeus* sp.	pest
		Reduviidae	*Rhinocoris* sp.	predator
		Gerridae	*Gerris adelaidis*	predator
	Orthoptera	Tettigoniidae	*Ruspolia* sp.	predator
			Conocephalus longipennis	predator
		Acrididae	*Locusta migratoria*	pest
			Valangan nigricornis	pest
			Oxya chinensis	pest
		Pyrgomorphidae	*Atracomorpha crenulata*	pest
		Gryllidae	*Gryllus* sp.	predator
	Coleoptera	Coccinellidae	*Coccinella* sp.	predator
			Cheilomenes sexmaculata	predator
		Chrysomelidae	*Aulacophora dorsalis*	pest
			Aulacophora similis	pest
		Staphyllinidae	*Paederus fuscipes*	predator
		Cerambycidae	*Pterolophia uniformis*	predator
	Lepidoptera	Crambidae	*Cnaphalocrocis medinalis*	pest
			Schircophaga incertulas	pest
			Schircophaga inotata	pest
			Nyimphula depunctalis	pest
		Nymphalidae	*Melanitis leda*	pest
		Lycaenidae	*Lampides boeticus*	pest
	Diptera	Muscidae	*Atherigona oryzae*	pest
		Syrphidae	*Episyrphus* sp.	predator
		Sciomyzidae	*Sepedon* sp.	predator
		Ephydridae	*Hydrellia philippina*	pest
		Asilidae	*Hymenia* sp.	predator
	Odonata	Agrionidae	*Agriocnemis femina oryzae*	predator
	Hymenoptera	Formicidae	*Dolichoderus* sp.	predator
Arachnida	Araneae	Tetragnathidae	*Tetraghnata* sp.	predator
		Oxyopidae	*Oxyopes javanus*	predator
		Linyphiidae	*Atypena* sp.	predator
		Araneidae	*Argiope cetunulata*	predator
TOTAL				

Not all insects are detrimental as some of them have positive impacts, such as the presence of natural enemies that act as predators and parasitoids. Through their role as natural enemies, insects assist humans in pest control efforts. Furthermore, insects also have a crucial role in preserving the equilibrium of the food chain within agricultural ecosystems. (Kumar & Omkar, 2023). The research results revealed 16 species from six orders in the class insecta and four species from the class Arachnida that serve as predators. The orders Hemiptera and Coleoptera each have four species acting as predators, the orders Orthoptera and Diptera each have three species, while the orders Odonata and Hymenoptera each have one species. Natural enemies are efficient population regulators because their reactions are contingent on the population density (Milosavljević *et al*., 2021). When the population of pest insects rises, it results in an increase in the population of natural enemies, a phenomenon known as the "numerical response." This, in turn, leads to heightened feeding activity or an enhancement in their "functional response." (Abraços-Duarte *et al*., 2021).

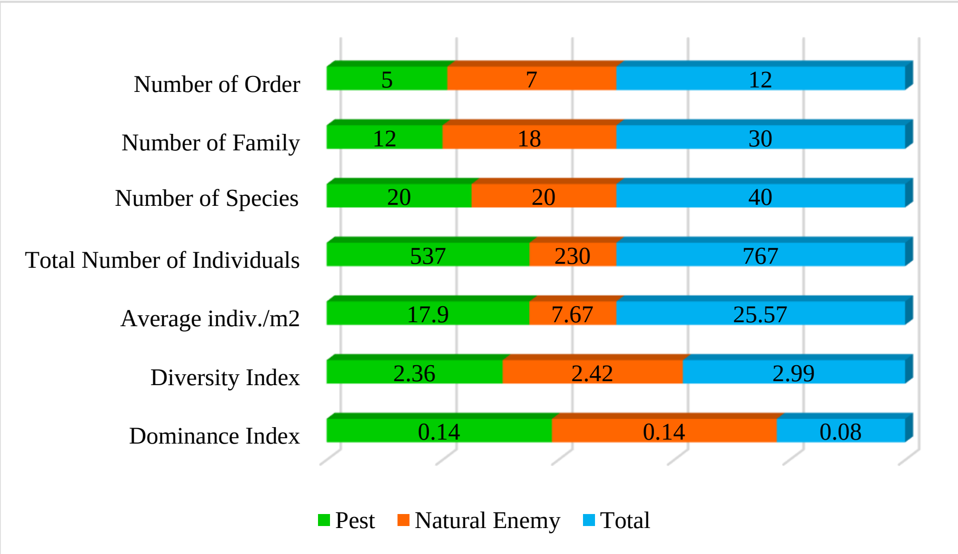

Figure 3. Comparison of Pest and Natural Enemy Community Composition

The most found natural enemy is *Tetragnatha* sp. (Tetragnathidae), accounting for 9.65% of the total abundance (Table 1). This finding aligns with the research by He *et al*. (2020), where the Tetragnathidae family (54%–66%) was reported to be the most abundant natural enemy among 12 families found in organic rice fields in China. These spiders are distributed worldwide, with over 100 other species (GBIF, 2020), often found in tropical and subtropical regions, and some of them can even walk on water. The presence of *Tetragnatha* sp. in rice ecosystems plays a crucial role in controlling pest insects due to their wide range of prey. Research conducted by Saksongmuang *et al*. (2020) indicates that *Tetragnatha* primarily preys on four orders: Diptera, Hemiptera, Odonata, and Ephemeroptera, with Diptera being the most consumed.

The value of the diversity index (H') in each calculation both in total, pest groups, and natural enemy groups showed different values, but were in the same category. The value of H' in the total calculation is 2.99, in the pest group 2.36, and in the natural enemy group 2.42. The diversity index value obtained has the same category as the research of Siregar *et al*. (2017) with a value of 2.26 and Oo *et al*. (2020) with a value of 2.55. However, the diversity index value obtained was much higher, namely 2.99. The diversity of pest insects has an impact on the diversity of their natural enemies, as noted by Pebrianti (2016). The variety of insects pest in an environment influences the diversity of existing parasitoids and predators. Some insects serve as hosts for parasitoids and as prey for predators. The greater the diversity of insects pest found in a habitat, the higher the likelihood of diversity among parasitoids and predators (Frago & Zytynska, 2023). This is associated with the presence of an ample supply of food resources for these natural enemies. The dominance index value shows that there is no dominant species in each group. In the total calculation, the dominance index value is 0.08, in the pest group and natural enemies both are 0.14 (Figure 3). Overall, based on the number of species found, the diversity index value, and the dominance index value, it shows that the condition of rice cultivation in Kiniar Village is quite diverse, the situation is balanced to support the survival of existing insects and has not too large ecological pressure.

4. Conclusions

The diversity of natural enemies and pests is in the medium category. There are no species that dominate the rice fields in Kiniar village, either pests or natural enemies, so the presence of natural enemies can still control the presence of pests.

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