

Article History

Received : May 28, 2025

Accepted : November 04, 2025

Published : November 30, 2025



Aquatic Insect Diversity as Bioindicators of Water Quality in Organic Inorganic Rice Fields, Pringsewu, Lampung

Keanekaragaman Serangga Air sebagai Indikator Kualitas Air di Sawah Organik Anorganik di Pringsewu Lampung

Rima Pramudita^{1*}, Gina Dania Pratami¹, Meidaliyantisyah², Kusuma Handayani¹

¹Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Lampung, Lampung, Indonesia

²Research Organization for Energy and Manufacture, National Research and Innovation Agency (BRIN), South Tangerang, Indonesia

*Corresponding author: rimapramudita60@gmail.com

Abstrak

Keanekaragaman serangga air merupakan indikator penting dalam menilai kualitas ekosistem pertanian, khususnya pada lahan persawahan organik dan anorganik. Pertanian organik yang memanfaatkan bahan alami cenderung mendukung peningkatan keanekaragaman hayati, sedangkan pertanian anorganik berisiko menurunkannya akibat penggunaan bahan kimia. Penelitian ini dilakukan untuk mengkaji keanekaragaman, dominansi, pemerataan, serta faktor lingkungan yang memengaruhi keberadaan serangga air di dua jenis lahan pertanian di Desa Tulung Agung, Lampung. Hasil penelitian menunjukkan bahwa lahan organik memiliki keanekaragaman serangga air lebih tinggi dengan indeks keanekaragaman (H') sebesar 2,3386, indeks dominansi (D) sebesar 0,058, dan indeks pemerataan (E) sebesar 0,9411. Sebaliknya, lahan anorganik menunjukkan nilai indeks keanekaragaman (H') sebesar 0,9743, indeks dominansi (D) sebesar 0,5188, dan indeks pemerataan (E) sebesar 0,3312. Faktor lingkungan tidak berpengaruh signifikan terhadap serangga air di lahan organik, namun menunjukkan korelasi kuat pada lahan anorganik dengan nilai korelasi (r) sebesar 0,905 dan nilai signifikansi (p) sebesar 0,035. Temuan ini menegaskan bahwa sistem pertanian organik mampu mendukung keseimbangan ekosistem perairan yang lebih stabil.

Kata kunci: serangga air, keanekaragaman, pertanian, organik, kualitas air.

How to Cite: R. Pramudita, G. Dania Pratami, Meidaliyantisyah, and K. Handayani, "Aquatic Insect Diversity as Bioindicators of Water Quality in Organic Inorganic Rice Fields, Pringsewu, Lampung", *J-BEKH*, vol. 12, no. 2, pp. 43-52, Nov. 2025. <https://doi.org/10.23960/j-bekh.v12i2.424>

Abstract

The diversity of aquatic insects serves as an important indicator for assessing the quality of agricultural ecosystems, particularly in organic and conventional (non-organic) rice fields. Organic farming, which relies on natural inputs, tends to support greater biodiversity, whereas conventional farming may reduce it due to the use of chemical substances. This study aimed to examine the diversity, dominance, evenness, and environmental factors influencing the presence of aquatic insects in two types of agricultural systems in Tulung Agung Village, Lampung. The results showed that the organic rice fields had higher aquatic insect diversity, with a diversity index (H') of 2.3386, a dominance index (D) of 0.058, and an evenness index (E) of 0.9411. In contrast, the conventional rice fields showed a diversity index (H') of 0.9743, a dominance index (D) of 0.5188, and an evenness index (E) of 0.3312. Environmental factors had no significant effect on aquatic insects in the organic fields, but showed a strong correlation in the conventional fields, with a correlation value (r) of 0.905 and a significance value (p) of 0.035. These findings highlight that organic farming systems are better able to support a more stable aquatic ecosystem balance.

Keywords: aquatic insects, diversity, agriculture, organic, water quality

INTRODUCTION

As an agricultural country, Indonesia has a significant agricultural sector that plays a crucial role in the economy, contributing more than 13% to the national Gross Domestic Product (GDP) [1]. Inorganic agriculture, which relies on synthetic fertilizers and pesticides, is increasingly being used to increase crop yields [2]. However, the use of these chemicals can degrade soil quality and pollute water, raising concerns about negative impacts on the environment [3].

As an alternative, organic farming, which uses natural materials and avoids synthetic chemicals, is believed to support ecosystem sustainability and improve environmental quality [4]. In Tulung Agung Village, Pringsewu, some farmers have begun implementing organic farming systems to mitigate adverse environmental impacts.

Aquatic insects can serve as bioindicators to assess water quality and the health of aquatic ecosystems. They are sensitive to environmental changes, and their life cycles are closely related to water conditions [5]. Therefore, the presence and diversity of aquatic insects provide essential information about the level of water pollution [6].

Several studies have demonstrated that organic land has higher aquatic insect diversity compared to inorganic land [7]. However, many studies have not linked

insect diversity data to the physical and chemical parameters of water; therefore, this study aims to fill this gap by comparing the two agricultural systems in Pringsewu.

This study aims to determine the differences in aquatic insect diversity between organic and inorganic rice fields, as well as their relationship with water quality. The results of this study are expected to provide insight into the impact of both agricultural systems on water quality and the overall ecosystem.

METHODS

This research method was designed to obtain relevant data on aquatic insect diversity as an indicator of water quality in organic and inorganic rice fields in Pringsewu, Lampung. The study was conducted from early December 2024 to February 2025, with samples taken twice: before planting in early December and after planting in late February. The research location was in Tulung Agung Village, Gading Rejo District, Pringsewu Regency, Lampung, which included organic and inorganic rice fields. The researcher carried out the identification of aquatic insects at the Zoology Laboratory, Faculty of Mathematics and Natural Sciences, Universitas Lampung.

Material and Equipment

The equipment and materials used in this study included a water net (150 mesh) to catch aquatic insects, collection bottles containing 96% alcohol to preserve samples, trays, tweezers, magnifying glasses, and

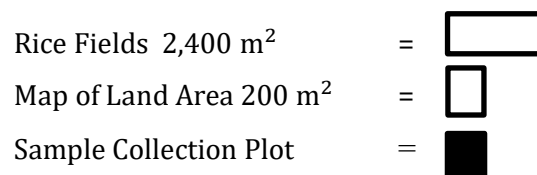
writing instruments. We used thermometers, pH meters, DO meters, and digital thermometer-hygrometers to measure the environmental parameters. All of these tools supported the process of collecting and analyzing samples in the field and in the laboratory. To measure environmental parameters, a thermometer, a pH meter, a DO meter, and a digital thermometer-hygrometer were used. All of these tools supported the process of collecting and analyzing samples in the field and in the laboratory.

Research Implementation

The activity began with a site survey to obtain an overview and determine the sampling points using purposive sampling. We divided each plot (organic and inorganic), which measured 2,400 m², into 12 sections and conducted sampling on four sections of each plot. Insect sampling was conducted in the morning using a net as we walked around the rice fields, both before and after planting. The insects caught were placed in collection bottles containing alcohol and labeled. Figure 1 illustrates the map of aquatic insect sampling in a single rice field.



Figure 1. Map of Water Insect Sampling in Rice Fields



Measurement of Environmental Factors

We measured water parameters, including pH, water temperature, dissolved oxygen (DO) content, and air temperature and humidity, to determine the physical and chemical environmental conditions. These measurements were taken directly in the field using specially prepared equipment, simultaneously with the collection of water insect samples. Table 1 presents the standards for physical and chemical environmental parameters that affect aquatic insect life.

Table 1. Environmental Physical-Chemical Parameter Standards for Aquatic Insects

Physical-Chemical Parameter	Tolerance Range	Optimum
Water pH	6,5–8,5	7,0
Water temperature (°C)	20–34	25–30
DO (mg/L)	≥ 5	≥ 6
Air temperature (°C)	15–45	25
Air humidity (%)	60–80	70

Data Identification and Analysis

Aquatic insect samples were identified to genus level using the book “Introduction to the Study of Insects” by Borror et al. (1992), with the aid of a magnifying camera and other laboratory equipment. The data were analyzed using several indices.

The Shannon-Wiener diversity index is calculated using the formula:

$$H' = -\sum P_i \ln (P_i), \text{ where } P_i = (n_i/N)$$

Description:

H' = Shannon-Wiener Diversity Index

n_i = Number of individuals type i

N = Total number of individuals of all species, Index value criteria

The results of the diversity index values obtained are presented in accordance with the benchmark values in Table 2.

Table 2. Diversity Index Benchmark Value

Diversity Index	Diversity Category
≤ 1	Low
1 < H' < 3	Moderate
≥ 3	High

The dominance index is calculated using Simpson's formula:

$$C = \sum(n_i/N)^2$$

Description:

C : Dominance Index

N_i : Number of individuals type i

N : Total number of individuals

The dominance scores obtained are in accordance with the benchmark values presented in Table 3.

Table 3. Dominance Index Benchmark Value

Dominance Index Value	Dominance Criteria
0 < C ≤ 0,5	Low
0,5 < C ≤ 0,75	Moderate
0,75 < C ≤ 1,0	High

The evenness index is calculated using the following formula: $E = \frac{H'}{\ln S}$

Description:

E = Insect Evenness Index Specific species

H' = Shannon-Wiener Diversity Index

S = Number of Insect Species

ln = Natural Logarithm

The benchmark value of the evenness index is presented in Table 4.

Table 4. Evenness Index Benchmark Value

Evenness Index Value	Evenness Criteria	Description
0 < E ≤ 0,4	Low	Stress
0,4 < E ≤ 0,6	Moderate	Unstable
0,6 < E ≤ 1	High	Stable

Pearson's correlation coefficient with the formula:

$$R = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}}$$

Description:

r = Pearson's correlation coefficient, which measures the linear relationship between two variables.

n = Number of data pairs (amount of observed data).

ΣXY = The sum of the products of each value of X and Y.

ΣX = The sum of all X values.

ΣY = The sum of all Y values.

ΣX² = The sum of the squares of each value of X.

ΣY² = The sum of the squares of each value of Y

The correlation coefficient values obtained are presented in Table 5, in accordance with the benchmark value.

Table 5. Benchmark value of the correlation coefficient

Correlation Coefficient	Degree of Association
0,00 to 0,20	No Correlation
0,21 to 0,40	Weak Correlation
0,41 to 0,60	Moderate Correlation
0,61 to 0,80	Strong Correlation
0,81 to 1,00	Perfect Correlation

RESULTS AND DISCUSSION

This study identified a total of aquatic insects, comprising 17 genera, 9 families, and originating from 5 main orders: Odonata, Coleoptera, Hemiptera, Diptera, and Ephemeroptera. Organic land showed a higher number of species and individuals compared to inorganic land. Before planting, 332 individuals were found on organic land, and 79 individuals were found on inorganic

land. After planting, organic land recorded 130 individuals, while inorganic land recorded 123 individuals. The higher number and variety of genera in organic land indicate that organic farming systems are more conducive to the survival of aquatic insects than inorganic systems.

The number of aquatic insects found in organic (O) and inorganic (I) rice fields is presented in Table 6.

Table 6. Number of aquatic insects found in organic and inorganic rice fields

Ordo	Family	Genus	Role	Number of Individuals			
				Before Planting		After Planting	
				O	I	O	I
Odonata	Libellulidae	<i>Sympetrum</i>	Predator	63	2	10	-
		<i>Pantala</i>	Predator	13	-	-	-
		<i>Leucorrhinia</i>	Predator	9	-	2	-
	Coenagrionidae	<i>Enallagma</i>	Predator	-	-	16	-
		<i>Hygrotus</i>	Predator	58	4	12	2
		<i>Dytiscus</i>	Predator	10	-	10	1
Coleoptera	Dytiscidae	<i>Agabus</i>	Predator	9	-	8	1
		<i>Eretes</i>	Predator	8	-	5	-
		<i>Thermonectus</i>	Predator	-	-	6	-
	Spercheidae	<i>Laccophilus</i>	Predator		6		9
		<i>Spercheus</i>	Detritivor	15	1	1	3
Hemiptera	Micronectidae	<i>Micronecta</i>	Omnivora	-	20	-	87
	Notonectidae	<i>Notonecta</i>	Predator	25	10	19	21

Insect Group				Number of Individuals			
				Before Planting		After Planting	
Ordo	Family	Genus	Role	O	I	O	I
	Staphylinidae	<i>Stenus</i>	Predator	13	-	7	-
Diptera	Culicidae	<i>Aedes</i>	Detritivor	7	-	3	-
		<i>Culex</i>	Detritivor	-	-	-	1
Ephemeroptera	Baetidae	<i>Baetis</i>	Detritivor	-	-	3	-
Total Number of Individuals				230	43	102	125

Table 7 shows how the ecological index values reflect this difference in the structure of aquatic insect communities. In organic land before planting, the Shannon-Wiener diversity index (H') value was 2.0592, classified as moderate, with evenness (E) of 0.8588 and dominance (C) of 0.1682, indicating a relatively stable community. After planting, the H' value increased to 2.3386, E to 0.9411, and C decreased to 0.0296. The findings suggest an improvement in both the balance and

diversity of the aquatic insect community. In contrast, the H' value in the inorganic land increased from 0.6888 before planting to 0.9743 after planting, and both values fall into the low category. The dominance value also increased from 0.3012 to 0.5188, indicating the dominance of particular species, namely *Micronecta*, as an indicator of declining water quality [8]. Table 7 presents the calculated values of the diversity index, dominance index, and evenness index of aquatic insects.

Table 7. Calculation results for the Diversity Index, Dominance Index, and Evenness Index

Time	Land System	H'	Category (H')	(C)	Category (C)	(E)	Category (E)
Before Planting	Organic Land	2,0592	Moderate	0,1682	Low	0,8588	Stable
	Inorganic Land	0,6888	Low	0,3012	Low	0,3844	Stressed
After Planting	Organic Land	2,3386	Moderate	0,0296	Low	0,9411	Stable
	Inorganic Land	0,9743	Low	0,5188	Moderate	0,3312	Stressed

Measurements of environmental, physical, and chemical quality show apparent differences between organic and inorganic rice fields. Organic fields have more stable conditions and support airborne insect life,

with pH and dissolved oxygen (DO) values within the optimal range and an increase in DO after planting, indicating good biological activity. In contrast, inorganic fields experienced a decrease in pH and DO and an

increase in air temperature that approached the tolerance limit of aquatic organisms. These conditions indicate a decline in water quality that can affect aquatic insect diversity. Air temperatures below 35°C and DO levels above 5 mg/L indicate conditions

that still support the stability of the aquatic ecosystem [9].

Table 8 presents the Measurements of environmental, physical, and chemical quality.

Table 8. Measurements of environmental, physical, and chemical quality

Physical-Chemical Parameter	Before Planting		After Planting	
	Organic	Inorganic	Organic	Inorganic
Water pH	7,9	7,4	7,6	6,9
Water temperature (°C)	29,1	32,2	29,4	32,8
DO (mg/L)	5,66	4,85	6,62	3,49
Air temperature (°C)	33,6	35,5	30,5	33,15
Air humidity (%)	73,6	75,5	74,55	62,75

Pearson's correlation analysis reveals that in organic land, there is no significant relationship between environmental factors and aquatic insect diversity, both before planting ($p = 0.915$) and after planting ($p = 0.824$) (Table 3). In contrast, in inorganic land after planting, a powerful relationship was found between environmental factors and aquatic insect diversity, with a Pearson correlation value of $r = 0.905$ and a significance value of $p = 0.035$. The findings

indicate that aquatic insect communities in inorganic land are more sensitive to changes in environmental quality, likely due to the use of chemicals such as pesticides and synthetic fertilizers [10].

Table 9 presents the correlation coefficient between the physical and chemical factors of the water and aquatic insect diversity, while Table 10 provides the Pearson correlation results.

Table 9. Significance Result

Measurement Time	Rice Fields	Significance (P)	Interpretation
Before Planting	Organic	0,915	Not Significance
	Inorganic	0,148	Not Significance
After Planting	Organic	0,824	Not Significance
	Inorganic	0,035	Significance

Table 10. Pearson Correlation Result

Measurement Time	Rice Fields	Pearson Correlation (r)	Interpretation
Before Planting	Organic	-0,085	No Correlation
	Inorganic	0,746	Strong Correlation
After Planting	Organic	-0,139	No Correlation
	Inorganic	0,905	Perfect Correlation

The *Sympetrum* and *Enallagma* genera of the Odonata order dominate the types of insects found in organic fields. The presence of these two genera indicates relatively good water quality and a stable habitat. In contrast, *Micronecta*—a species of the order Hemiptera known for tolerating polluted or degraded waters—dominates the inorganic fields. This finding is consistent with previous studies, which have shown that several species from the order Hemiptera can survive in low-quality water conditions [11]. Based on these results, the researchers conclude that organic farming systems tend to maintain the stability of aquatic insect communities. In contrast, inorganic systems exert high ecological pressure on these communities.

CONCLUSION

Research shows that organic land has higher aquatic insect diversity with a value of $H' = 2.0592$ before planting and $H' = 2.3386$ after planting. In contrast, inorganic land is classified as low with $H' = 0.6888$ before planting and $H' = 0.9743$ after planting. The analysis found no correlation between diversity and water quality in organic land; however, it identified a robust correlation in

inorganic land after planting, with a correlation coefficient of $r = 0.905$ and a p-value of 0.035. These findings indicate that chemical inputs in inorganic land directly influence water quality and decrease aquatic insect diversity. Therefore, researchers encourage the use of organic farming systems to preserve the water ecosystem and recommend further studies to evaluate long-term impacts and the diversity of other insects.

CONFLICT OF INTEREST

I hereby declare that there is no conflict of interest in the writing of this scientific paper.

REFERENCES

- [1] S. I. Kusumaningrum, "Pemanfaatan Sektor Pertanian Sebagai Penunjang Pertumbuhan Perekonomian Indonesia," 2019.
- [2] S. A. Husna, M. Hadi, and R. Rahadian, "Struktur Komunitas Mikroartropoda Tanah di Lahan Pertanian Organik dan Anorganik di Desa Batur Kecamatan Getasan Salatiga," *Bioma : Berkala Ilmiah Biologi*, vol. 18, no. 2, p.

- 157, Dec. 2016, doi: 10.14710/bioma.18.2.157-166.
- [3] A. Mallongi, A. U. Rauf, R. D. P. Astuti, and Ernyasih, *Dampak Bahan Kimia Beracun Di Perairan Pada Kesehatan Dan Sistem Ekologi : Panduan Praktis Bagi Mahasiswa, Dosen, Peneliti, Praktisi Dan Para Profesional Kualifikasi Kesehatan*. Yogyakarta: Gosyen Publishing, 2023.
- [4] H. Mayrowani, "Pengembangan Pertanian Organik di Indonesia," Dec. 2012.
- [5] R. W. Suci, "Serangga Air sebagai Indikator Biologis Cemaran Air di Sungai Cikaniki, Desa Citalahab, Tn. Gunung Halimun Salak, Jawa Barat," 2016.
- [6] I. Muslim, H. Hamid, and D. Martinius, "Keanekaragaman Serangga Air di Sawah Konvensional dan Organik di Kota Padang Diversity of Water Insects in Conventional and Organic Rice Cultivations in Padang City," vol. 1, no. 2, pp. 68–78, 2017.
- [7] M. Trianto, N. Nuraini, S. Sukmawati, and M. Dahri Kisman, "Keanekaragaman Genus Serangga Air sebagai Bioindikator Kualitas Perairan," *Justek: Jurnal Sains dan Teknologi*, vol. 3, no. 2, p. 61, Nov. 2020, doi: 10.31764/justek.v3i2.3562.
- [8] N. R. Ataluda, A. T. Ina, A. L. Makatita, and Y. M. Matulesy, "Diversitas Jenis Mangrove di Pesisir Pantai Kawangu Kabupaten Sumba Timur sebagai Sumber Belajar Bookle," *BioEksakta: Jurnal Ilmiah Biologi Unsoed*, vol. 6, no. 2, 2024.
- [9] N. P. R. Diantari, H. Ahyadi, I. S. Rohyani, and I. W. Suana, "Keanekaragaman serangga Ephemeroptera, Plecoptera, dan Trichoptera sebagai bioindikator kualitas perairan di Sungai Jangkok, Nusa Tenggara Barat," *J Entomol Indones*, vol. 14, no. 3, p. 135, May 2018, doi: 10.5994/jei.14.3.135.
- [10] N. Nurmaisah, A. Rahim, and Muh. Adiwena, "Populasi Serangga pada Lahan Budidaya Tomat yang Dikelilingi Refugia," *Perbal: Jurnal Pertanian Berkelanjutan*, vol. 13, no. 1, pp. 59–66, Feb. 2025, doi: 10.30605/perbal.v13i1.5279.
- [11] M. M. Shah and U. Sharif, *Insect Science-Diversity, Conservation and Nutrition*. InTech, 2018. doi: 10.5772/intechopen.71639.

This page is intentionally left blank.