El-Hayah

JURNAL BIOLOGI
Journal Homepage: http://ejournal.uin-malang.ac.id/index.php/bio/index
e-ISSN: 2460-7207, p-ISSN: 2086-0064

Original research article

Community Structure and Diversity of Dragonflies (Odonata) as Bioindications of Water Quality in Telaga Aqua, Tulungagung District

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DOI: 10.18860/elha.v10i2.31923

Article Info

Article history:
Received 30 December 2024
Received in revised form
07 February 2025
Accepted 11 March 2025

Key Word:
Bioindicator,
Community Structure,
Odonata,
Telaga Aqua

Abstract

Dragonflies also play a role in ecosystems as predators and bioindicators of water quality. The study aims to determine the community structure and diversity of dragonflies in Telaga Aqua. The study was conducted in April 2021. Type of qualitative descriptive research, with visual day flying method with 3 observation locations based on vegetation composition and ease of access. Sampling using insect nets, documentation and identification. Based on the results of the study, 10 species of odonata were obtained, including 5 species of dragonflies (Anisoptera) and 5 species of needle dragonflies (Zygoptera). The total number of dragonflies found in 3 locations was 337 individuals from 6 families, including Euphaea variegata, Heliocypha fenestrata, Rhinocypha heterostigma, Vestalis luctuosa, Coeliccia membranipes, Onychogomphus fruhstorferi, Orthetrum glaucum, Orthetrum pruinosum, Orthetrum sabina, and Pantala flavescens. The results of the diversity index (H') showed 2.04 medium categories, the highest abundance was found in the species Euphaea variegata which was valued at 24.9% and the lowest abundance was found in Coeliccia membranipes worth 1.2%. The evenness index of 0.9 is high and the dominance index of 0.2 is low, which means dragonflies have the same opportunity to utilize resources. The calculation of the Family Biotic Index (FBI) to 3 locations of 0.02 is included in the category of very good water quality. The higher the number of dragonflies in the ecosystem, indicating that the ecosystem is still natural and environmental sustainability is maintained. When pollution occurs in the waters, it causes the life cycle of dragonflies to be disrupted and their population to decline.

1. INTRODUCTION

Dragonflies are a group of insects that belong to the order Odonata. Odonata are characterized by having toothed jaws, on the lower lip there are sharp protrusions (spines) like the shape of teeth **[1;17]**. They vary in body size, ranging from small to large and often display colors. Most of the dragonfly's life is used for flying, with a wide range ranging from forest areas, residential areas, rice fields, gardens, lakes, swamps, rivers and ponds **[20]**. Scientifically, dragonflies are devided into two sub-orders, Anisoptera (dragonflies) and Zygoptera (damselflies). Both sub-orders have very different morphological characteristics, both in terms of body shape, eye shape, wings and flight behavior.

The Anisoptera sub-order has a relatively large body size, has a pair of compound eyes that are fused together, the wings on the front are larger than the wings on the back, and at the time of perching the position of the wings will be stretched out and has a high flight speed with a wide range. While the Zygoptera sub-order has a relatively small body size that is shaped like a needle, has a pair of separate compound eyes, has the same size front and rear wings, when perching the position of the wings will be folded over the body, and has a low flight speed (weak) with a range that is not so wide **[16]**.

Dragonflies are diurnal animals that carry out activities during the day and highly mobility in their habitats **[14]**. Dragonflies are aquatic animals, because they are easily found in areas adjacent to water or areas with open spaces **[24]**. Dragonflies are insects that are vulnerable to changes in temperature and water quality, because most of the dragonfly life phase is in the water in larval form which takes three to six years, while during the adult phase dragonflies will be in terrestrial habitats close to water sources.

Dragonflies also have distinctive characteristics when breeding, namely dragonflies will lay eggs in a clean water environment, and when there is pollution in the waters, it will disrupt the dragonfly's life cycle which causes a decrease in the dragonfly population **[5].** Dragonfly larvae have different tolerances to various environmental factors, such as temperature, pH, and pollution levels, so their presence and types can reflect environmental conditions.

Benthic macroinvertebrates can be used as bioindicators of water quality because they can provide an overview of the biological conditions of a water body **[9]**. So the presence of dragonflies will make dragonflies an organism that can be used as a bioindicator of water quality and an indicator of ecosystem balance **[15]**. Because in the ecosystem dragonflies also act as natural predators that maintain the balance of the food chain **[11; 27].** As a natural predator, dragonflies will prey on smaller insects such as mosquitoes, flies, aphids, brown leafhoppers, weevils, rice stem borers and even cannibalize their own species **[8; 20]**.

Telaga Aqua is a natural tourist attraction with a natural and beautiful environment located in Beji Hamlet, Geger Village, Sendang District, Tulungagung Regency, East Java. The composition of the vegetation in the Telaga Aqua area is still well maintained, such as the condition of the river water, which is still clear with rocky and sandy substrates, the variety of plants species around Telaga Aqua, and the presence of riparian vegetation located on the banks of the river.

Telaga Aqua is located at the foot of Mount Wilis so that the environmental conditions are still beautiful, and the air tends to be cool. In general, dragonflies like natural habitats such as forests with dense canopy cover, bushes, rice fields, grasses, open land, and very fond of areas close to water sources or waters, this is very compatible with the conditions that exist in Telaga Aqua **[19].** In addition, most dragonflies occupy special habitats according to their characteristics, supported by environmental factors such as pH, temperature, light intensity, air humidity

and availability of water and foodstuffs that are suitable for their habitat which be very supportive for dragonfly life **[20]**.

Therefore, the preservation of dragonfly's life must be carried out in conjunction with the preservation of its natural habitat to prevent extinction, especially in endemic dragonfly species. So, this research aims to determine the community structure and diversity of dragonflies (odonata) as bioindicators of water quality in Telaga Aqua, Tulungagung Regency, which is expected to become initial data as an effort to step up biodiversity conservation and to maintain water quality in Telaga Aqua.

2. MATERIALS AND METHODS

The research was conductedt from April to May 2021 in the Telaga Aqua area, Geger Village, Sendang District, Tulungagung Regency (Figure 1). Data collection in the field was carried out in the morning from 07.00 to 11.00 WIB and in the afternoon from 14.00 to 17.00 WIB **[19]**. Descriptive qualitative research using the *visual day flying* method at 3 observation locations consisting of 9 stations, which refers to composition of vegetation and ease of access during data collection. Dragonfly samples were taken using an *insect net* and then put into a sample bottle containing cotton wool that had been given *chloroform* and preserved with 70% alcohol. From these samples, data collection was carried out for each species found in the observation table.

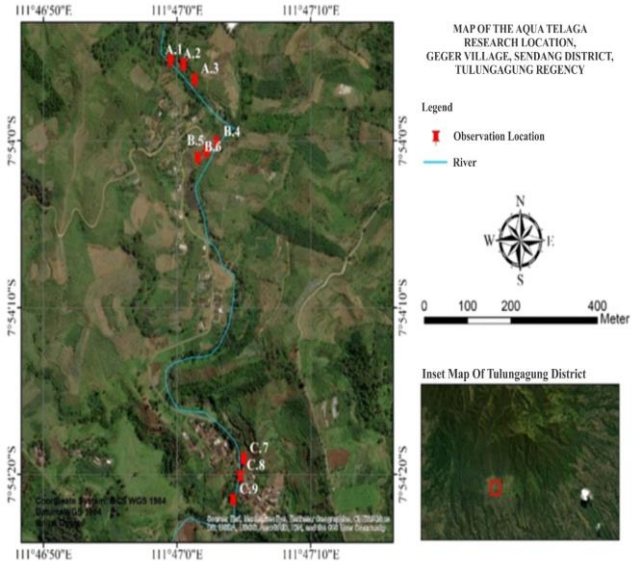

Figure 1. Map of Research location in the Telaga Aqua Area

Then data analysis was calculated using the *Shannon-Wiener* diversity index, *Odum's* (1993) relative abundance index, *Krebs'* (1989) evenness index, dominance index, and the *Family Biotic Index* (FBI).

The parameters of biotic and abiotic factors observed were vegetation structure, community structure, dragonfly diversity and abiotic factors (temperature, air humidity and light intensity). The tools and materials used in this research are insect nets, *Global Positioning System* (GPS), identification key table based on **[8; 22]**, writing tools, camera, sample container, *thermometer, lux meter, hygrometer, needles*, 70% alcohol and *chloroform*.

Data on dragonfly species obtained were then analyzed using the *Shannon – Wiener* Diversity Index (H'), Odum's relative abundance index (1993), Krebs' evenness index (1989), dominance index and *Family*

Biotic Index (FBI). By following the formula as follows:

$H' = -\sum pi \, Ln \, Pi$

Information:

' : Shannon -Wiener Diversity Index

i : explanation of the ni/N formula

i : the total number of individuals of the n species

N : total number of individuals of all species

Relative abundance= ni/N x 100%

Information:

ni : total number of individuals of the n species

N : total number of individuals of all species

E= H'/Ln S

Information:

E : evenness index

H' : diversity index

LnS : natural logarithm of the total number of species found

$C = (ni/N)^2$

Information:

C : Dominance index

ni : total number of individuals of the n species

N : total number of individuals of all species

$FBI = \sum (Xi.ti) / N$

Information:

FBI : Family Biotic Index

Xi : number of individuals in family i

Ti : tolerance value of family i (see: Table 1)

N : total number of individuals of all species

3. RESULTS and DISCUSSION

The results obtained as many as 10 species of dragonflies (odonata), which include 5 species of dragonflies sub-order Anisoptera (dragonflies) and 5 species of dragonflies sub-order Zygoptera (needle dragonflies). Accros the three observation sites, we rocorded 337 individuals from 6 families. The 10 Odonata species are presented in Figure 2.

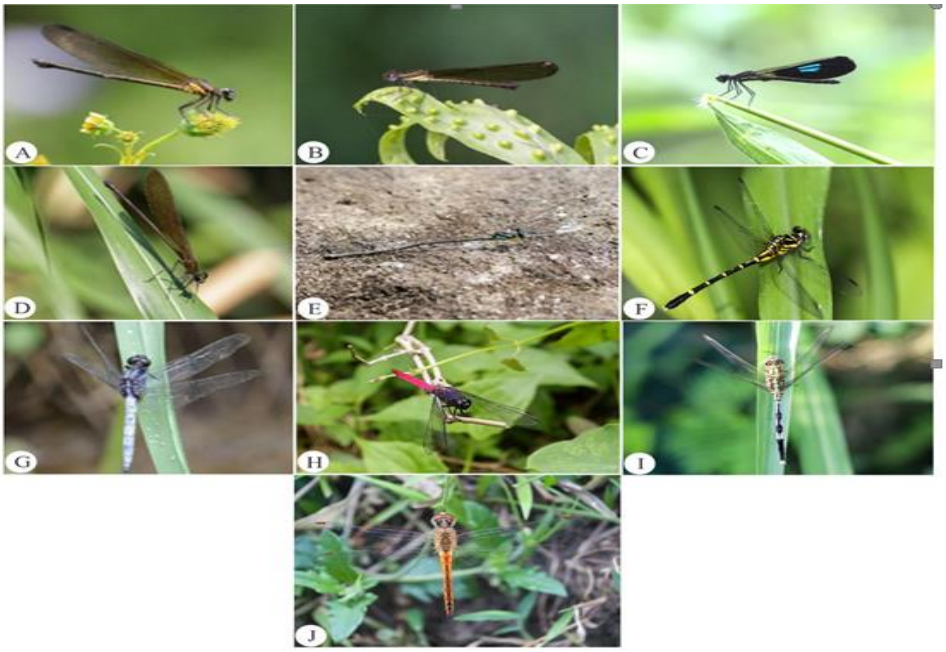

Figure 2. Type of dragonflies found in Telaga Aqua, Tulungagung. (A) *Euphae variegata,* (B) *Heliocypha fenestrata,* (C) *Rhnocypha heterostigma,* (D) *Vestalis luctoosa,* (E) *Coeliccia membranipes,* (F) *Onychogomphus frushtorferi,* (G) *Orthetrum glaucum,* (H) *Orthetrum pruinosum*, (I) *Orthetrum sabina,* (J) *Pantala flavescens.*

Based on the table of observation results (Table 1), the location with the highest dragonfly's acquisition was at location B with 120 individuals, location A with 116 individuals, and the lowest at location C with 101 individuals. Of all the species found, the species *Euphaea variegata* species had 84 individuals and ranked the highest. Then followed by the species *Vestalis luctuosa* (77 individuals), *Pantala flavescens* (36 individuals), *Orthetrum glaucum* (35 individuals), *Orthetrum pruinosum* (27 individuals), *Orthetrum sabina* (26 individuals), *Heliocypha fenestrata* (20 individuals), *Onychogomphus fruhstorferi* (19 individuals), and *Rhinocypha heterostigma* (9 individuals).

The species *Coeliccia membranipes was* the smallest population with a total of 4 individuals. Dragonfly *Euphaea variegata* occupies various types of habitat such as forest areas, near water sources, rivers with fast-flowing, clear water, perch on rocks, and perch on plants that are on the edge of the river (riparian vegetation) **[7].**

Table 1. Number of Dragonflies found at each location

No.	Types of Dragonflies (Odonata)	Local Name	Family	Conservation Status	Location			∑
					A	B	C	
1	*Euphaea variegata*	Capung Beludru Sunda	Euphaeidae	LC	42	24	18	84
2	*Heliocypha fenestrata*	Capung Kaca Patri	Chlorocyphidae	LC	11	4	5	20
3	*Rhinocypha heterostigma*	Capung Tanduk Runcing	Chlorocyphidae	NT	6	-	3	9
4	*Vestalis luctuosa*	Capung Matahari	Calopterygidae	LC	33	27	17	77
5	*Coeliccia membranipes*	Capung Jarum Hutan	Platycnemididae	LC	-	4	-	4
6	*Onychogomphus fruhstorferi*	Capung Kawis	Gomphidae	NT	12	3	4	19
7	*Orthetrum glaucum*	Capung Elang Rawa Biru	Libellulidae	LC	3	14	18	35
8	*Orthetrum pruinosum*	Capung Sambar Merah	Libellulidae	LC	2	18	7	27
9	*Orthetrum sabina*	Capung Sambar Hijau	Libellulidae	LC	3	13	10	26
10	*Pantala flavescens*	Capung Ciwet	Libellulidae	LC	4	13	19	36
	Total Number				116	120	101	337

Information,
LC (Least Concern): Low Risk & NT (Near Threatened): Almost Threatened

Habitat types and vegetation structures with different characteristics also influence the presence of dragonflies **[6]**. Figure 3 illustrates the sampling sites and their characteristics. Of the three locations, location B is the place where the most dragonflies were found. This is because location B shows the characteristics of diverse vegetation composition. So, dragonflies prefer ecosystems that tend to have abundant biological resources. In location C the number of dragonflies found was less than in B and location A, namely 101 individuals, this is because the structure or composition of the vegetation in location C tends to be homogeneous, consisting of garden areas and shrubs. So, habitats with less varied vegetation will affect the acquisition of the number of dragonfly species. The existence of different vegetation structures in Telaga Aqua can support the survival of dragonflies, both as a place to live, a food source, perch and shelter.

When dragonflies are still in the larval phase (nymph), dragonflies will live in the

water so that dragonflies make aquatic animals (microorganisms) as a food source. And when dragonflies are in the adult phase, their diet shifts to other insects that live around the vegetation, both in riparian vegetation and other vegetation **[27]**. In addition, the presence of bamboo vegetation that forms a canopy will protect dragonflies from high sun exposure, thus helping the survival of dragonflies **[27]**.

Figure 3. Location of research stations, location A (Station 1, 2, 3), location B (Station 4, 5, 6), location C (Station 7, 8, 9).

Based on the data in Figure 4, the Shannon-Wiener diversity index value (H') of dragonflies in Telaga Aqua shows the medium category, with a value of 2.04. Balance in the structure of an ecosystem can be seen from the variety of biotic components and species supported by the condition of vegetation in the environment **[2]**.

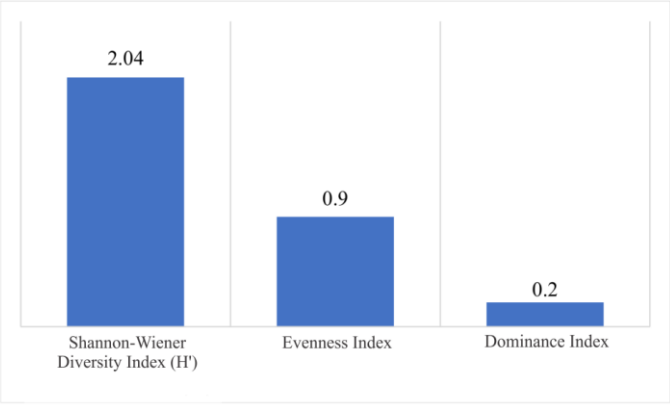

Figure 4. Calculation of the Shannon-Wiener Diversity Index (H'), Evenness Index, and Odonata Dominance Index in the Telaga Aqua Area, Tulungagung Regency

4. DISCUSSION

This indicates that the dragonfly population at Telaga Aqua exhibits stable and consistent productivity levels. Dragonfly diversity with moderate value can help in the process of balancing the ecosystem in the Telaga Aqua area, considering that dragonflies are second-level consumers at the trophic level of the food chain **[21]**. In the calculation of the evenness index, the results obtained is 0.9, which indicated that the evenness of dragonflies in the Telaga Aqua area is high. Because the species evenness index is comparable to the diversity index value, and indicates that the distribution pattern of dragonflies in the Telaga Aqua is very even and balanced.

The dragonfly dominance index calculation results indicate a low category with a value of 0.2, meaning that each organism at the observation location has equality in utilizing the resources available in the waters to the maximum. The Dominance Index and Diversity Index (H') have an inversely proportional relationship. If diversity is high then dominance tends to be low, and vice versa. If diversity is low, dominance will be high. The dominance of a species occurs when the species is able to adapt well to the surrounding habitat, including in terms of habitat space, food sources and competition with other species **[23]**. The level of dragonfly dominance in a habitat is reflected in the relative abundance of each dragonfly species. The number of species present in the habitat will affect the level of dominance. The fewer the number of species can, the higher the dominance, and vice versa. If the abundance of a dragonfly species is high, it indicates that the species can survive and adapt to existing limiting factors, and vice versa **[8].**

Based on the calculation of the *Family Biotic Index* (FBI) in Table 2, a value of 0.02 is obtained, which indicates a good water quality category **[29]**. Odonata are insects whose life phases depend on water, starting from the larval phase (nymph) to the adult phase. Odonata lay their eggs and develop into larvae (nymphs) in clean waters and avoid polluted water areas. Larvae **[26].** Odonata like water conditions that have flowing rivers, so that the distribution of odonatates does not just stop in one place.

This is in line with the conditions of the river current in Telaga Aqua, which flows so that it has good oxygen circulation for the growth of dragonfly larvae (nymphs), which will have an impact on the even distribution of dragonflies. The presence of dragonflies in Telaga Aqua can also be used as a bioindicator of water quality, which is supported by the diversity of riparian vegetation in Telaga Aqua. A healthy river ecosystem is an important component for dragonfly habitat so that the dragonfly life cycle is well maintained.

Table 2. Family Biotic Index (FBI) Calculation Results

No	Famili	Amount	Ti	*FBI* Value
1.	Gomphidae	19	3	0,17
2.	Libellulidae	124	7	2,58
3.	Platycnemididae	4	6	0,07
4.	Euphaeidae	84	6	1,50
5.	Chlorocyphidae	29	5	0,43
6.	Calopterygidae	77	5	1,14
	Jumlah	337		5,88
		FBI = 0,02		

Based on the data in figure 5, the type of dragonfly that has the highest abundance is *Euphaea variegata* with an index of 24.9%, and the lowest abundance is *Coeliccia membranipes* with an index of 1.2%. The percentage of relative abundance of *Euphaea variegata* dragonflies is very high because at each observation station there is a lot of bamboo vegetation growing around the riverbanks, so that the temperature becomes optimal and

the light intensity is sufficient for dragonflies to carry out various activities such as reproducing, sheltering, and resting. *Euphaea variegata* prefers clean, flowing water habitats with moderate sunlight intensity or under tree shade. They are often found around rivers, springs, or areas with fairly dense aquatic plants.

Just as stated by **[2]**, *Euphaea variegata* is a type of dragonfly that is commonly found in riverbank, areas. In addition, lower plants such as grass and riparian are also used by dragonflies for perching and breeding.

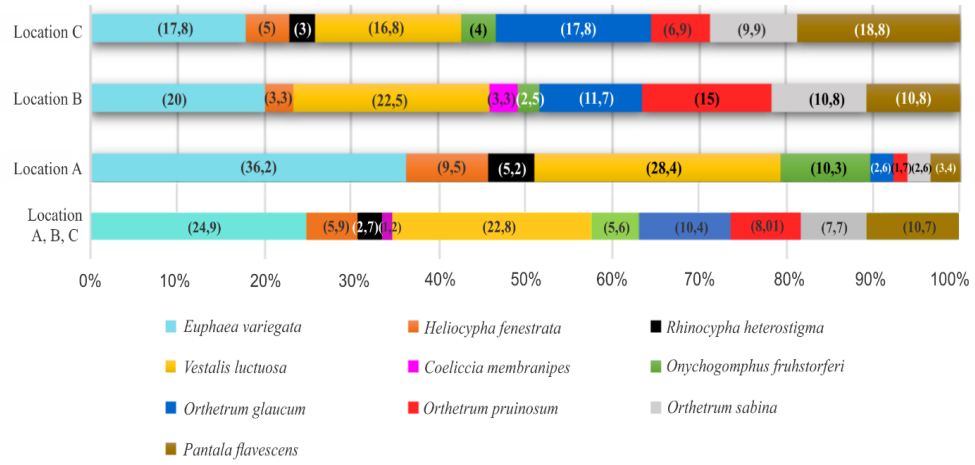

Figure 5. Results of calculating the relative abundance of dragonflies in Telaga Aqua.

Abiotic factors in Telaga Aqua are measured using three parameters, namely air temperature, air humidity, and light intensity. Based on Table 3, the results of air temperature measurements from the three locations have a range of 20.1-22.9°C. Each type of insect has a different temperature tolerance to continue to live, if it exceeds a predetermined temperature, then the insect will die. Physiology of insect when a special temperatures will have an impact on the productivity of insect activities, the productivity will be reduced if the temperature changes **[13].** The temperature at the observation site appears to be in accordance with the tolerance range of dragonflies (odonata) to carry out activities and metabolic processes, allowing dragonflies (odonata) to maintain survival. The low temperature at the site is due to its geographical position in the highlands, particulary on the slopes of Mount Wilis. In addition, there is a factor of lush trees that minimizes the distribution of direct sunlight and has an impact on the cold temperature in the area.

Table 3. Results of Observation of Abiotic Factors at the Research Location

Locations	Abiotic Factors		
	Air temperature	Air humidity	Light intensity
A	20,1 - 22,2°C	65,0 - 69,1%	5327-6855 lux
B	21,6 - 22,7°C	62,5 - 67,1%	7117-9198 lux
C	21,0 - 22,9°C	53,4 - 56,7%	6831-9626 lux

Air humidity plays an important role in the sustainability of the dragonflies (odonata) life cycle. Air humidity is a crucial factor for insect growth. Air humidity in the Telaga Aqua area has a value range of 53.4 – 69.1%. This value is considered tolerable by dragonflies and is still within normal criteria so that dragonflies can adapt well in the three observation locations.

Dragonflies are a group of insects that can tolerate air humidity values between 50% and 70%. Because if it is in a location with relatively low air humidity, it can be bad for dragonflies, because dragonflies can experience dehydration conditions **[25].**

Light intensity in the three observation locations varied between 5327 to 9626 Lux. The pattern of dragonfly distribution and activity in a place is influenced by light intensity. Dragonflies need sunlight for the thermoregulation process. Dragonflies (Odonata) that are exposed to light will carry heat into the body, so that their body temperature will increase and have an impact on their metabolic rate. Dragonflies (Odonata) need sunlight to maintain hemolymph activity throughout their wing venation. Differences in light intensity at the three locations occurred due to the number of canopies and vegetation of different trees, but the differences in light intensity values were not far apart. Light intensity and temperature can affect dragonflies' body color. Changes in body color are a common feature of thermoregulation in dragonflies **[19]**. Biodiversity in the Telaga Aqua ecosystem near the rice fields is still well maintained. Biological components such as frogs, rice field snakes, eels, various types of dragonflies, butterflies and others can live side by side in balance **[19]**.

5. CONCLUSION

The study recorded 10 Odonata species in Telaga Aqua, Tulungagung Regency, comprising: 5 Anisoptera species (true dragonflies) and 5 Zygoptera species (damselflies). The total number of dragonflies found at the 3 research locations was 337 individuals from 6 families, including the species Euphaea variegata, Heliocypha fenestrata, Rhinocypha heterostigma, Vestalis luctuosa, Coeliccia membranipes, Onychogomphus fruhstorferi, Orthetrum glaucum, Orthetrum pruinosum, Orthetrum sabina, and Pantala flavescens.

The results of the diversity index (H') showed a medium category with a value of 2.04, the results of the calculation of the highest abundance index found in Euphaea variegata which is worth 24.9% and the lowest abundance found in Coeliccia membranipes is worth 1.2%, then the results of the evenness index showed a high category with a value of 0.9, and a dominance index that showed a low category with a value of 0.2.

The data analysis which is where the state of an environment can affect the presence and distribution of dragonflies and can be used to describe the structure of the dragonfly community in the area. The higher the number of dragonflies in an ecosystem, it indicating that the ecosystem is still natural and environmental sustainability is maintained. When there is pollution in the waters, the life cycle of dragonflies is disrupted, and their population decreases.

6. ACKNOWLEDGEMENTS

The authors would like to express gratitude to the Faculty of Medicine, Diponegoro University – Faculty of Science and Mathematics, Brawijaya University - University of Muhammadiyah Semarang for facilities and support in conducting this study.

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