pISSN 2302-1616, eISSN 2580-2909
Vol 13, No. 1, June 2025, pp. 22-28
Available online http://journal.uin-alauddin.ac.id/index.php/biogenesis
DOI https://doi.org/10.24252/bio.v13i1.57495

Diversity of arboreal insects in the Tagur Tinggi Waterfall Area Lempake District, Samarinda, East Kalimantan

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ABSTRACT. The Tagur Tinggi Waterfall region is characterized by its verdant and expansive landscape, featuring diverse flora such as trees and grass. This region is optimal for arboreal insects as a habitat. Arboreal insects, which are abundant and readily seen, inhabit the upper branches of trees and travel between trees to facilitate pollination. The abundance of arboreal insects serves as a reliable measure of the overall well-being of an ecosystem. The present study aims to identify the various species of insects that inhabit the trees in the Tagur Tinggi region and calculate the diversity, evenness, and dominance measures for these arboreal insects. This study used the transect approach, wherein samples are gathered bi-daily in the morning and evening. There were a total of 44 bug species belonging to 19 different families and 8 distinct orders. The arboreal insect diversity index (H') was measured to be 3.24 in the morning and 3.14 in the afternoon. Arboreal insects have an evenness index (E) of 0.91 during the morning and 0.87 during the afternoon. Additionally, they have a dominance index (D) of 0.044 in the morning and 0.056 in the afternoon. According to the health index values obtained, it can be inferred that the Tagur Tinggi Waterfall area in Lempake Samarida Village is highly conducive to the survival of arboreal insects. This is due to the well-preserved habitat and abundant vegetation structure that supports the life of arboreal insects.

Keywords: arboreal insects; diversity; dominance; evenness; Tagur Tinggi Waterfall

Article History: Received 3 June 2025; Received in revised form 8 August 2025; Accepted 27 September 2025; Available online 30 September 2025.
How to Cite This Article: Hariani N, Fudiantoro A, Patang F, Yuliatin E, Budiman B. 2025. Diversity of arboreal insects in the Tagur Tinggi Waterfall Area Lempake District, Samarinda, East Kalimantan. Biogenesis: Jurnal Ilmiah Biologi. vol 13(1): 22–28. doi: https://doi.org/10.24252/bio.v13i1.57495.

INTRODUCTION

Insects are the most prevalent creatures on Earth, exceeding the population of all other terrestrial reptiles. There are currently 1,413,000 known insect species, and approximately 7,000 new species are found annually (Tsioumani & Tsioumanis, 2020). Although insects are commonly associated with being pests, it is important to note that the majority of insects also provide valuable benefits to the natural world. Insects play both harmful and beneficial roles in agriculture and life (Stork, 2018). A negative feature is that certain bug species may act as agricultural pests, causing harm to crops, or even serving as disease carriers for humans. However, insects serve a useful function in various aspects of the ecosystem, including pollination, decomposition, predation, bioindication, and the production of health-benefit compounds (Borror *et al*., 1992; Meilin & Nasamsir, 2016).

There are many different kinds of insects, distinguished by the environments in which they live. These include arboreal insects, soil insects, and aquatic insects. The group of insects known as arboreal insects is the most prevalent and simple to locate type of insect ever discovered (Karthik *et al*., 2022). The majority of these insects are found in the canopies of trees, and they move from one tree to another in order to assist in the process of pollination (de Souza Amorim *et al*., 2022). Generally speaking, this species can be found living in wide green spaces or in locations that have a great deal of flora (Sanjaya *et al*., 2019).

According to the East Kalimantan Provincial Government, the Tagur Tinggi Waterfall region is considered to be one of the green open places and water catchment areas that are within their jurisdiction. In the 1990s, this five-hectare region in Samarinda was a waterfall tourism destination that was quite well-known. However, in the 2000s, this location began to be abandoned by visitors, and it eventually became an abandoned place that was only covered with trees and grass. Fortunately, the water catchment area has been maintained by the local population up until the present day. This has allowed the water to be utilized for a variety of reasons, including consumption, irrigation,

washing, and other uses. In the region of Tagur Tinggi, there is a green open area that contains a variety of plants, including trees and grass. As a result, this environment is extremely supportive as a habitat for insects, including arboreal insects (Kaltimprov, 2013). It is necessary to investigate the variety of arboreal insects in this region to acquire a diversity index value. Additionally, it is necessary to determine the evenness and dominance of arboreal insects in the Tagur Tinggi region. The information obtained from this study can be used as an indicator of environmental health, a foundation for biodiversity conservation planning, and a basis for developing strategies to monitor ecological changes caused by anthropogenic activities or climate change. Furthermore, the results of this research have the potential to enrich tropical entomological studies and serve as a reference for policymakers in establishing protection zones or restoring arboreal habitats.

MATERIALS AND METHODS

Study area. Arboreal insect sampling was carried out in the Tagur Tinggi Waterfall Area, Lempake Village, Samarinda City, Indonesia (Fig. 1).

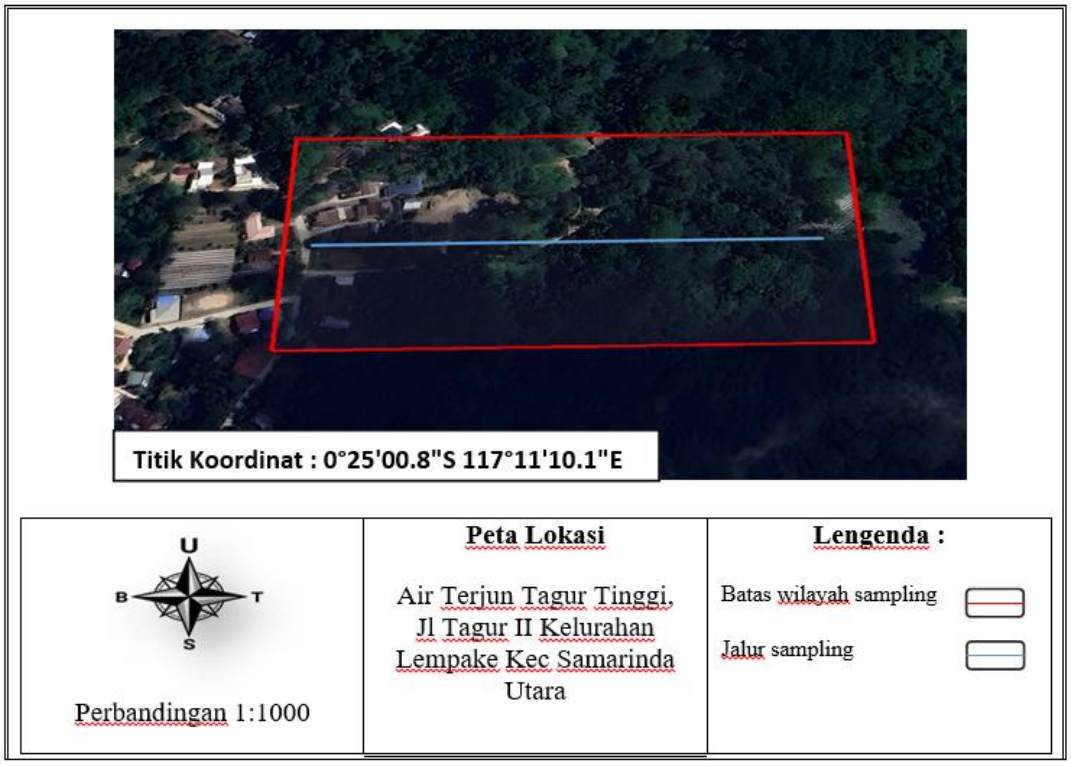

Fig. 1. Research location Tagur Tinggi Area, Lempake Village, Samarinda

Methods. The transect approach was used to sample arboreal insects with insect nets. For two months, sampling was done every two weeks in the morning (07.00-10.00 WITA) and afternoon (15.00-17.00 WITA). The captured arboreal insects are placed in a killing bottle containing 4% chloroform, labeled with the location and time of capture, and then sent to the laboratory to be formed into an insectarium and identified. To prevent damage to the samples of butterflies and dragonflies, place them in a triangle of paper.

Preparation and identification. Preparation is accomplished by creating an insect insectarium, which attempts to maintain the insects so that they are not destroyed and may be examined for a longer period of time throughout the insect identification procedure. A stretched board made of wood or modified styrofoam is used for the insectarium. The insects are placed on a stretching board and stabbed in the thorax before the wings and body parts are slowly extended. It was then recognized using literature such as Practical Guide to Butterflies in the Bogor Botanical Gardens (Peggie &

Mohammad, 2000), Butterflies (Lepidoptera: Rhopalocera) in Sumatra (Iqbal *et al*., 2021), and Introduction to Insect Lessons (Borror *et al*., 1992).

Data analysis. The collected data was used to compute the Shannon-Wiener species diversity index (H'), pielou evenness index (E), and Simpson dominance index (D) (Shehu, 2025). Microsoft Excel was used to examine the data.

RESULTS AND DISCUSSION

According to the findings of a study conducted at Kawadan Tagur Tinggi Waterfall in Lempake Village, Samarinda City, there are 8 orders of arboreal insects, 19 families, and 44 species, as indicated in (Table 1).

Table 1. Abundance of arboreal insects in the Tagur Tinggi Waterfall Area, Lempake Village, Samarinda

No	Taxon			The number of individuals captured	
	Ordo	Famili	Spesies	07.00-12.00 am	14.00-17.00 am
1	Coleoptera	Cocccinellidae	*Harmonia axyridis*	1	0
2	Diptera	Calliphoridae	*Chrysomya bezziana*	2	0
		Muscidae	*Musca domestica*	1	1
3	Hemiptera	Cicadellidae	*Bothrogonia ferugina*	11	5
			Poochara cumatilis	6	3
		Reduviidae	*Cosmolestes picticeps*	5	5
		Rhopalidae	*Leptocoris vicinus*	2	1
4	Hymenoptera	Apidae	*Xylocopa latipes*	1	0
			Xylocopa sonorina	0	1
		Ampulicidae	*Ampulex compressa*	1	1
		Pompilidae	*Hemipepsis ustulata*	0	1
5	Lepidoptera	Crambidae	*Pygospila sp.*	1	0
		Erebidae	*Asota heliconia*	0	1
		Hesperiidae	*Notocrypta paralysos*	2	1
			Telicota augias	0	1
			Udaspes folus	1	1
		Nymphalidae	*Athyma asura*	0	1
			Cupha Erymanthis	2	1
			Elymnias hypermnestra	1	0
			Euploea mulciber	1	0
			Hypolimnas bolina	3	3
			Ideopsis vulgaris	7	2
			Junonia atlites	0	1
			Junonia iphita	1	0
			Mycalesis patiana	4	0
			Neptis hylas	2	1
			Neorina lowii	0	1
		Pieridae	*Parantica aspasia*	1	0
			Ypthima fasciata	2	2
			Ypthima pandocus	1	5
			Eurema alitha	3	3
			Leptosia nina	6	9
6	Odonata	Chlorocyphidae	*Rhinocypha fenestrata*	1	0
		Libellulidae	*Crocothermis servilia*	1	2
			Neurothemis fuctuans	5	9
			Neurothemis terminata	6	7
			Orthetrum sabina	4	1
			Rhyothermis phyllis	4	2
			Tholymis tillarga	6	2
7	Orthoptera	Acrididae	*Oxya cinensis*	2	5
			Valanga iregularis	4	1
		Gryllidae	*Nisitrus vitatus*	6	11
		Tettigoniidae	*Phaneroptera brevis*	2	2

			Phaneroptera falcata	0	1	
8	Phasmatodea		Sp1	0	1	
	8 Ordo	**19 Famili**	**44 Spesies**	**109**	**95**	

The order Lepidoptera is the most prominent among other orders because the ecosystem at the research site is ideal for Lepidoptera life. The abundance of Lepidoptera in the Tagur waterfall area is due to the preservation of habitat and the availability of food sources. According to Sulistiyowati & Rahmawati, (2018), the high Lepidoptera community is sustained by a variety of causes, including biotic and abiotic ones. Food and host plant availability are examples of biotic factors. Odonata is the second most abundant order found in this location, this is common because the most suitable habitat for this order is an area with pristine waters. Koneri *et al*., (2022) reported that the Laine Waterfall area on Sangihe Island is suitable as a habitat for odonata because it is supported by several factors of temperature, humidity, light intensity and existing vegetation. Foo & Afiqah (2023) and Nisita *et al*. (2020) reported Odonata are common insects that can be found in aquatic ecosystems.

The orders Coleoptera and Phasmatodea, which comprise the Cocccinellidae family, were detected least frequently in this study. This family is found in agricultural and plantation regions, where they aid in natural pollination, prey on aphids, and occasionally eat fruit (Efendi *et al*., 2018). Fruit-bearing plants are in short supply in the Tagur Waterfall area, making insect capture challenging. There is only one type in the Phasmatodea order as well. This is because the Phasmatodea are nocturnal insects that are active at night (Oktarima, 2015). Insect sampling was done in the morning and evening, therefore very few Phasmatodea orders were acquired.

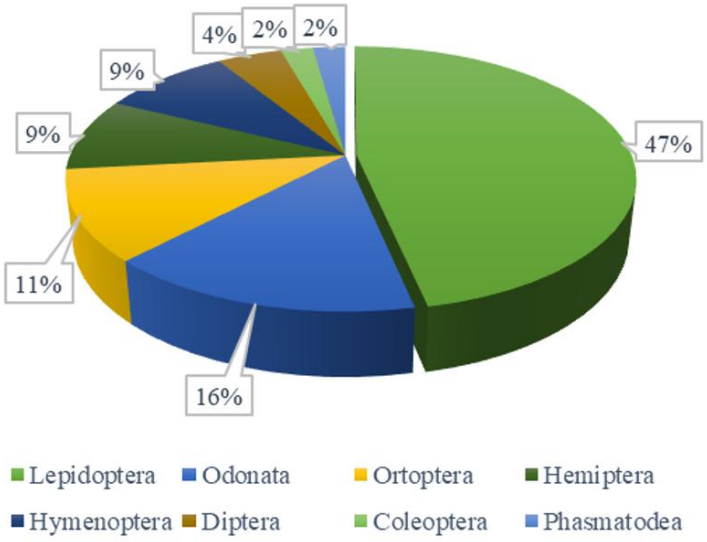

Fig. 2. The proportion of arboreal insect orders in the Tagur Waterfall area, Lempake Village, Samarinda

In the Tagur Tinggi Waterfall Area, Lempake Samarinda Village, the presence of arboreal insects is higher in the morning of the day compared to the afternoon of the same day. In the morning, there were 109 individuals of insects were observed, however in the afternoon, there were 95 individuals were observed with insects (Fig. 2). In a healthy habitat, diurnal arboreal insect groups would exhibit high community structure from the morning until late afternoon, particularly in groups of butterflies and dragonflies (Taradipha *et al*., 2018). From the morning until late afternoon, arboreal insects will be exposed to the perfect amount of light intensity and temperatures ranging from 25 to 30°C, which will cause them to become more active. According to the data presented in Table 2, the mean temperature and relative humidity for morning and afternoon sampling were 28.5°C and 82.2%, respectively. In contrast, the mean temperature and relative humidity for afternoon sampling were 32°C and 70%, respectively. Furthermore, according to Björk *et al*. (2024), habitat conditions, including temperature, humidity, etc., greatly determine the diversity of arboreal insects.

Table 2. Humidity and temperature conditions at the time of sampling

Sampling time	Date	Temperature		Humidity	
		Morning (07.00-10.00)	Evening (07.00-10.00)	Morning (07.00-10.00)	Evening (07.00-10.00)
1	05/03/23	30ºC	32,5ºC	77,30%	62%
2	19/03/23	29ºC	32ºC	81,60%	71%
3	02/04/23	28ºC	32ºC	82%	72%
4	16/04/23	27ºC	31,5ºC	87,90%	75%
Average		28,5ºC	32ºC	82,20%	70%

According to the findings of the data analysis (Table 3), the diversity index (H') value in the Tagur Tinggi Waterfall Area is 3.24 in the morning and 3.14 in the afternoon. The highest community structure of arboreal insects may be observed from the morning to the middle of the afternoon. This is the reason why the H' value is larger in the morning than it is in the afternoon. This is because the insect group receives optimal temperature and sunshine in the morning, however, in the afternoon, the opposite is true (Taradipha *et al.*, 2018).

It was also that insects will be busy from the early morning to the late afternoon, searching for food and engaging in activities. There is a correlation between insects and warm temperatures and sunshine that is not too hot (Xu *et al*., 2021; Terblanche *et al*., 2024). The smell of pollen and nectar, which is the meal of the majority of insects, attracts insects to come in the morning (Kessler *et al*., 2015). In addition to this, many flowers blossom in the morning. An exposure to the strength of the sun, which causes the nectar to evaporate, will cause the presence of insects to progressively decrease until the afternoon. This will occur because the nectar will evaporate (Kurniawan *et al*., 2020; Wong & Didham, 2024).

Table 3. The values of the diversity index (H'), the evenness index (E), and the dominance index (D) of arboreal insect species for the Tagur Tinggi waterfall area

Index	Morning	Afternoon
H'	3,24	3,14
E	0,91	0,87
D	0,044	0,056

From these results, the H' value at both times was classified as high (H' > 3), indicating that this area has a stable and diverse arboreal insect community. Evenness values close to 1 indicate that the distribution of species is relatively even, without the dominance of particular species. The community in the area is considered to be more stable when the diversity value is larger (Wirakusumah, 2003). According to Jumar (2000), the circumstances of the environment and the availability of food are two factors that determine the diversity of insects. In order for insects to continue living and growing, they require food as a source of nourishment. In line with (Elisabeth et al., 2021), there is an adequate amount of food in nature, both in terms of quality and quantity, the population of insects will swiftly rise. The availability of food in the natural environment will, on the other hand, lead to a reduction in the number of insect populations.

It is 0.91 in the morning and 0.87 in the afternoon when the evenness index (E) value is measured in the Tagur Tinggi Waterfall Area, which is located in the Lempake District of Samarinda. This number demonstrates that the distribution of arboreal insects in the Tagur Tinggi waterfall area is steady. This value also suggests that the distribution of arboreal insects in this area is even and that no species predominates. According to Yudiawati & Pertiwi (2020), the evenness index value can range anywhere from 0 to 1. This is in agreement with their findings. When determining whether or not arboreal insects are dominant, this value is taken into consideration. The evenness index value (E) will be closer to 1 if the arboreal insect community is uniformly distributed. This indicates that there are no dominant arboreal insect species in the community. The evenness index (E) value will

be closer to 0 if the arboreal insect community is distributed unevenly. This implies that there are species of arboreal insects that predominate in the community.

It can be deduced from the fact that the dominance index value in the Tagur Tinggi Waterfall region is 0.044 in the morning and 0.056 in the afternoon that there is no domination of arboreal insect species in the region. To identify the species of arboreal insect that predominates in a certain region, the dominance index (D) is utilized as an indication. According to Maesyaroh & Supriatna (2021), the dominance index (D) value can range from 0 to 1. The closer it is to 0, the more it implies that there is no dominating species in a community. On the other hand, the higher the dominance value is, the closer it gets to 1, which shows that there is species domination in a community. According to Suheryanto & Ari (2004), varied communities tend to have a dominance value that is low or close to zero. If there are kinds that have a much higher number of members than other types, then the community will be in a condition that is lacking in diversity. Kirchner *et al*. (2024) reported about their research, that that in a healthy ecosystem plus being close to a water source, the distribution of insects is very good. This will ensure that there is no dominant species so that it will give a dominance index result close to 1.

The high number of Lepidoptera found in this study is closely correlated with the environmental carrying capacity of the Tagur Waterfall area. The study area, composed of secondary forest with diverse vegetation (trees, bushes, and shrubs), combined with community plantations and natural tourism areas, creates ideal habitat conditions for pollinating insects. These factors significantly support the dominance of the Lepidoptera group as the primary pollinating insects at the study site.

CONCLUSION

In the Tagur Tinggi Waterfall Area, researchers evaluated the diversity of arboreal insects and discovered that the diversity index (H') value for arboreal insects was 3.24 in the morning and 3.14 in the afternoon. The value of the evenness index (E) for arboreal insects is 0.91 in the morning and 0.87 in the afternoon. On the other hand, the value of the dominance index (D) for arboreal insects is 0.044 in the morning and 0.056 in the afternoon. Ecologically, these index values indicate that the environment supports multiple niches for arboreal insects (maintained canopy, high host diversity, minimal disturbance), a balanced insect community, resistance to invasion/dominant species, and well-functioning pollination, decomposition, and food chains. This area could serve as a pilot project for arboreal insect conservation by establishing a 'Canopy Biodiversity Sanctuary' involving universities and NGOs.

ACKNOWLEDGEMENTS

The authors would like to thank Faculty of Mathematics and Natural Sciences, Universitas Mulawarman Indonesia for funding this research through the Higher Education Research Grant Program Hibah Riset FMIPA Pendanaan PNBP Tahun 2024.

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