Abundance and Biodiversity of Odonata (dragonflies and damselflies) at Lata Renyuk, Jeli, Kelantan

by

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DECLARATION

I therefore declare that, with the exception of the references, the study for this thesis, "Abundance of Odonata (dragonflies and damselflies) at Lata Renyuk, Jeli, Kelantan," is all my own. The thesis is not being presented concurrently for the candidature of any other degree, nor has it been accepted for any degree.

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ABSTRACT

This study focuses on analyzing the abundance and diversity of Odonata (dragonflies and damselflies) Lata Renyuk, Jeli, Kelantan. The main objectives of the study are to assess the diversity of Odonata and to provide a checklist of species present in the area. Sampling was carried out opportunistically using sweep nets along the banks of the Renyuk River at two specific sites, labeled as A and B, throughout a period of one month. A total of 11 species and 174 individuals were noted from the selected study sites. Additionally, Lata Renyuk was found to be home to 7 species and 2 families. The evaluation of the conservation status using the IUCN Red List determined that the populations are currently classified as least concern. After determining how many individuals were examined using the Shannon-Wiener diversity index, it was discovered that Site A had a maximum potential diversity of H'max = 3.97 and a low species diversity of H' = 0.931. Site B, on the other hand, showed a peak diversity value of H'max = 4.097 and a medium level of species diversity with H' = 1.410, suggesting stable environmental circumstances suitable for the evaluation of species diversity. Environmental aspects such as exposure to sunlight and water flow dynamics were identified as factors influencing the distribution of Odonata. The results emphasize the significance of habitat characteristics in shaping Odonata diversity and stress the importance of implementing conservation strategies in similar ecosystems. Further research is strongly recommended to delve into additional taxa and to evaluate the impact of human activities on Odonata populations.

Keywords: Abundance, sweep nets, IUCN Red List, Odonata, Shannon-Wiener diversity index,

Kelimpahan dan Biodiversiti Odonata (dragonflies dan damselflies) di Lata Renyuk, Jeli, Kelantan

ABSTRAK

Kajian ini memberi tumpuan kepada analisis kelimpahan dan kepelbagaian Odonata (pepatung dan pepatung kecil) di Lata Renyuk, Jeli, Kelantan. Objektif utama kajian ini adalah untuk menilai kepelbagaian Odonata dan menyediakan senarai spesies yang terdapat di kawasan tersebut. Pensampelan dilakukan secara oportunistik menggunakan jaring sapu sepanjang tebing Sungai Renyuk di dua tapak tertentu, yang dilabelkan sebagai A dan B, sepanjang tempoh satu bulan. Sebanyak 11 spesies dan 174 individu telah dicatatkan di tapak kajian yang dipilih. Selain itu, Lata Renyuk didapati mempunyai 7 spesies dan 2 keluarga. Penilaian status pemuliharaan menggunakan Senarai Merah IUCN menentukan bahawa populasi kini diklasifikasikan sebagai kurang membimbangkan. Selepas menentukan bilangan individu yang diperiksa menggunakan indeks kepelbagaian Shannon-Wiener, didapati bahawa Tapak A mempunyai kepelbagaian potensi maksimum H'max = 3.97 dan kepelbagaian spesies yang rendah iaitu H' = 0.931. Sebaliknya, Tapak B menunjukkan nilai puncak kepelbagaian H'max = 4.097 dan tahap kepelbagaian spesies sederhana dengan H' = 1.410, mencadangkan keadaan persekitaran yang stabil yang sesuai untuk penilaian kepelbagaian spesies. Aspek persekitaran seperti pendedahan kepada cahaya matahari dan dinamik aliran air dikenalpasti sebagai faktor yang mempengaruhi taburan Odonata. Hasil kajian menekankan kepentingan ciri-ciri habitat dalam membentuk kepelbagaian Odonata dan menekankan kepentingan melaksanakan strategi pemuliharaan di ekosistem yang serupa. Kajian lanjut amat disyorkan untuk menyelidiki taksa tambahan dan menilai kesan aktiviti manusia terhadap populasi Odonata.

Kata kunci: Kelimpahan, jaring sapu, Senarai Merah IUCN, Odonata, indeks kepelbagaian Shannon-Wiener

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

% - percentages

° - Degree

J - Pielou's Evenness

H' - Shannon-Wiener Index

km^2 - Square kilometer

H'max - Maximum diversity index

CHAPTER 1

INTRODUCTION

1.1 Background of study

The order Odonata includes some of the most ancient and beautiful insects, as well as some of the largest flying invertebrates ever to have lived (Barnes, 1984). Odonata consists of three groups: Anisoptera (dragonflies), Zygoptera (damselflies), and Anisozygoptera (a relict group represented by only two living species. As a subdivision of insects, the Odonata is made up of both dragonflies and damselflies. A long, slender abdomen, two pairs of transparent, membranous wings with numerous tiny veins, prehensile labium (extendible jaws beneath the head), a larval stage (nymph) that is aquatic, posterior tracheal gills, and minute antennae are just a few of the traits that set Odonata apart from other insect groups(Bos, 2000). Of all their characteristics, the easiest way to tell a dragonfly or damselfly from other insects is by the size of the eyes and shape of the abdomen. If the eyes are very large in proportion to the head and the abdomen is long and thin, then it is almost sure to be in Odonata (Peter L. Miller, 1987).

The phylogeny and categorization of odonata have been challenging to comprehend, but with the use of contemporary morphological and molecular approaches, this understanding is growing and is covered in this discussion. They are not thought to be very important economically, but they do aid people spiritually

and could have some effect as pests in agriculture and as predators of disease vectors. Furthermore, as intermediate or apex predators in many aquatic habitats, Odonata larvae play a critical role. In recent times, Odonata have been the subject of research that has produced fresh insights into the principles and regulation of insect flight. (Michael May, 2019).

Lata Renyuk is located in Kampung Renyok, is a village located in Jeli, in the state of Kelantan, which is a state in Malaysia. Kampung Renyuk was opened in the early 70s, by a land settler named Mamat Bin Kasim or better known as Pak Mat. He was accompanied by some of his friends who also explored the area. Kampung Renyuk is taken from a history of the past. A deer playing by the river with Chegal Panjang. The deer's foot tripped over the root of a sweet cane. As a result, the deer's feet got stuck between the fibers of the cane root. The deer has tried many times to wriggle its legs out of the tangle of roots. The tail of the deer twitched its legs many times. Land settler Pak Mat and his friends agreed to name this village with the name Kampung Renyut (Kelantan, K. P. S. 2012).

This Lata Renyuk is located right in Kampung Renyuk which is approximately 14 km from Jeli town. You only need to take the road leading to Kuala Balah or the Jeli - Jelawang - Gua Musang road. It results from the flow of the Renyok River which starts from the Titiwangsa range before flowing into the Pergau River. The advantage of this waterfall area is that it can be easily accessed by normal vehicles because there is also a mini hydroelectric that operates until now. Sungai Renyok is one of the sources of the river supplying water for the Pergau hydroelectric dam (MSD Digital Intelligence Sdn Bhd, 2023).

1.2 Problem statement

The correlation among anthropogenic waste, water quality, macrophyte cover, and Odonata species richness, abundance, and community composition. Because of this biphasic life cycle and the trophic cascades that connect aquatic and terrestrial systems, freshwater ecosystems depend heavily on them for regulation and function (Knight et al., 2019). They require a wide range of physical, chemical, and structural aquatic conditions for survival and development as eggs and larvae (related to temperature, salinity, pH, and dissolved solids), while adults require both aquatic and terrestrial vegetation for reproduction. They require a wide range of physical, chemical, and structural aquatic conditions for survival and development as eggs and larvae (related to temperature, salinity, pH, and dissolved solids), while adults require both aquatic and terrestrial vegetation for reproduction (Corbet, 1999). Despite their seemingly universal ecological behaviours, dragonflies and damselflies have distinct requirements when it comes to habitat selection, thermoregulation, oviposition resources, and dispersal to new locations. (Dutra and De Marco, 2015). Odonata have become part of the urbanised wildlife, yet certain species may be incurring costs and would like to remain in more protected areas. In this regard, and in the middle of our world's current biodiversity problem, where urbanisation is one of the most serious dangers, the development of sustainable cities is critical for the protection of some of the most endangered species (Fenoglio et al., 2021).

1.3 Expected outcome

Data from this research showed efforts to preserve existing habitats and restore degraded or lost habitats, particularly freshwater ecosystems. This included the creation of suitable breeding and feeding grounds for Odonata. They were important to save not only because they were unique to certain areas, but because they were important to maintain freshwater ecosystems. Efforts preserved existing habitats and restored degraded or lost habitats, particularly freshwater ecosystems. This included the creation of suitable breeding and feeding grounds for Odonata. Odonata was an order of aquatic insects with an amphibious life cycle that included an aquatic nymph phase and a terrestrial adult phase. Due to their predatory feeding habits, both nymphs and adults were at high levels in the trophic web. In addition, the life history traits of different Odonata species varied widely, such as their dispersal ability, habitat and microhabitat preferences, and tolerance to water pollution and habitat degradation (Marina, 2022).

1.4 Objective

1. To determine the diversity of odonata (dragonflies and damselflies) at Lata Renyuk, Jeli, Kelantan.
2. To provide checklist odonata (dragonflies and damselflies) at Lata Renyuk, Jeli, Kelantan.

1.5 Scope of Study

The study area was conducted in Lata Renyuk, Jeli, Kelantan. Lata Renyuk was located in Kampung Renyok, a village located in Jeli, in the state of Kelantan, which is a state in Malaysia. In the Malaysian state of Kelantan, the district of Jeli was endowed with several exquisite geological formations and landscapes, rare geological occurrences, and priceless earth elements. They were part of the region's geological legacy. This research aimed to provide insights into the diversity, abundance, and habitat preferences of the Odonata population in the Lata Renyuk area of Jeli. These insights could be critical for the conservation of the species and the management of the local environment. The Lata Renyuk region's Odonata habitats were being preserved and improved through conservation and management strategies that considered the factors that had been demonstrated to affect the species' abundance.

1.6 Significant of study

Studying Odonata (dragonflies and damselflies) held great significance in understanding the variety and abundance of Odonata in the Lata Renyuk region. These insects were essential to the ecology since they were both predators and prey, and their existence was a sign of a healthy ecosystem. To protect these species and the larger environment, conservation plans were developed with the aid of thorough research. The study's conclusions could direct habitat restoration and management initiatives in the Lata Renyuk region. Comprehending the distinct habitat inclinations of Odonata facilitated the preservation and rehabilitation of their favored settings, which was vital for their existence. The findings of the study helped local populations understand the importance of Odonata to the environment. It raised awareness of the value of protecting these insects and their habitats and involved nearby communities in conservation efforts.

CHAPTER 2

LITERATURE REVIEW

2.1 Odonata Description

The Odonata is the second biggest insect order with over 5000 known species worldwide, behind the Trichoptera, and it has an obligatory aquatic stage in its life history. The two suborders of the order Odonata, which includes dragonflies, Anisoptera and Zygoptera, go through 10 to 15 instars of larval (naiad) stages in their partial metamorphosis. Typically, the larvae hide themselves by going through the substrates in burrows, spreading out amid the fine silt and debris, or climbing on vascular plants (Westfall and Tennesen, 1996). With over 500 identified species found in Sundaland, they are particularly well-represented in the tropics, similar to many other invertebrate families. Of these, 350 species—including some of the biggest and smallest in the world for their order—are found inside Malaysia's borders (Brooks S.J., 1981). Odonates are a very old and primitive group. Existing families of fossilised wings date back to the Triassic. In the Carboniferous, giant protodonata soared. Currently, there are two recognised suborders: Zygoptera, also known as damselflies, has equal wings, while Anisoptera, often known as real dragonflies, has unequal wings. In general, the distribution and composition of aquatic insects and such as Odonata in an insect's community always change from time to time following change invironment (Che Salmah et all. 1999). The arrangement of them is excessively reliant on the make-up and arrangement of the

vegetation inside and around their microhabitats (Hawking and New, 1996). As adults or larvae, all odonates are predators. They are typically quite big insects that exist at only moderate concentrations since they are towards the top of the food chain. They don't really matter economically. It is certain that both adults and larvae feed heavily on mosquitoes, but it is unclear if this has an impact on the prevalence of arthropod-borne illnesses in human populations. Organisms of the order Odonata (dragonflies and damselflies) are highly predatory insects that are found throughout the world. Substantial data exist on the predatory nature of adult dragonflies, as well as the behavioral modifications of odonate larvae when in the presence of potential predators or other nonpredatory odonates (Strobbe et al., 2011). However, there are no reports of larval odonates using predatory luring to entice potential prey within striking distance. Here, we describe predatory luring by both dragonfly (*Aeshna palmata*) and damselfly (*Argia vivida*) larvae. This report involves organisms not previously known to lure prey (McGuffin et al., 2006).

According to earlier research, Malaysia's odonata fauna includes 342 identified species, including 161 Zygoptera species across 10 families and 181 Anisoptera species across 5 families. 239 species in all are known from 226 people are from Peninsular Malaysia (which includes Singapore), Sabah, Sarawak, and Brunei. Of the total, Peninsular Malaysia and Sabah-Sarawak share 123 species, or 36% of the total. The family compositions of the two regions are relatively similar, as would be predicted, however Borneo has far greater levels of endemicity (40%) than the peninsular region (11%), which shares most of its non-Bornean fauna with either Sumatra or Thailand (Orr et al., 2004).

Odonates can find a diverse range of natural habitat constructions in Peninsular Malaysia due to the region's irregular geographical topography. Nonetheless, the variety of odonates found in Peninsular. Up until recently, there was little information available about Malaysia, which was based mostly on sporadic accounts and descriptions (Norma-Rashid, 2010; Farizawati et al., 2014; Choong, 2014; Dow et al., 2016).

2.2 Morphology of Odonata

One of the most ancient groups of flying insects, the order Odonata includes dragonflies and damselflies, which undergo dramatic morphological changes throughout metamorphosis. After hatching from the egg, the aquatic larva, also known as nymph, goes through eight to seventeen instars of development until becoming an imago, or winged adult, and emerging from the water (Suhling et al., 2015). When an imago reaches adulthood, it features an enormous head, well-developed compound eyes, legs that allow it to grab prey in flight (usually other insects), two pairs of long, translucent wings that allow it to fly independently, and an enlarged abdomen (Hoell, et al., 1998). Although many Odonata are quite large insects, some Agriocnemis damselflies have wingspan of 17 mm, while helicopter damselflies have wingspan of 191 mm. The coerulatus megaloprepus. With a wingspan of up to 160 mm, the biggest dragonflies are far larger than any damselfly (Suhling et al., 2015).

The three ocelli on the forehead help with orientation when flying and have the ability to distinguish between light and dark. The globular compound eyes may see colour with up to 28000 ommatidia each. On each of the two short antennas are tactile sensors. The lower section of the skull is home to the mouthparts, which include the fundamental chewing mandibles. The synthorax carries the centre and back legs and both pairs of wings, whereas the prothorax, or front part of the thorax, carries two pairs of legs. Usually, there is a black line that follows the humeral suture, which runs from the base of the front wing to the middle leg. Above the humeral stripe is frequently a lighter antehumeral stripe (Paulson, 2010).

The wings are veined; they are often transparent between the veins, but they may occasionally be coloured. On the leading edge of the majority of Odonata, at the tip of the wing, is a structure called the pterostigma .This is a thickened, vein-bound, hemolymph-filled, and often colourful area. The pterostigma's functions are unknown; however, they most likely affect aerodynamics and may perhaps have a visual role (Norberg, 1972). Both dragonflies and damselflies have two pairs of long, membrane wings that are strengthened and flexible by many tiny veins that crisscross throughout the wings. A distinctive nodus, or notch, appears on the front edge of each wing of both groups. The back wings of dragonflies are bigger than the front pair and have a wider base. However, damselflies fly slower than dragonflies because their rear and front wings are similar in design. Moreover, damselflies have hinges that allow them to fold their wings together while they are at rest, whereas dragonflies do not. The primary morphological characteristic that

sets adult dragonflies apart from damselflies is this characteristic of the wings (Wiggins, 1963).

Despite their overall resemblance, there are a few clear differences between dragonflies and damselflies. Dragonflies are strong fliers that spread their wings to the side while at rest. They have moderately robust bodies and broad wings towards the base. Damselflies tend to be weaker overall and to appear weaker in flight because of their tiny wings at the base, which are frequently folded back over the abdomen while perched. Dragonflies have huge eyes that occupy a considerable amount of their head and are situated close to one another on the face. Damselflies typically have a gap between their eyes (Kalkman, 2018).

2.3 Life cycle of Odonata

Odonate life cycles start with the deposit of eggs in water; colonies of various Odonate species may be found in lakes, ponds, streams, rivers, bogs, and forest seeps. Eggs hatch into nymphs, which live and develop as aquatic insects for around a year (or more) until they are prepared to emerge as adults. Emergence is triggered by rising water temperatures in the spring and early summer. The adult emerges from the last naiad skin once the water reaches the right temperature for that species' nymphs to crawl onto adjacent plants or rocks. General adults wait a few hours for their exoskeleton to solidify and their wings to dry off before they take flight and become the often observed insects (Life Cycle and Biology, 2022).

Although an Odonata can live for more than a year, relatively little of that time is spent as an adult. The life cycle of an Odonata consists of four stages: the

egg, the nymph, pupal and the adult. The nymph stage of the Odonata life cycle is where most of it is spent (Admin, 2020). During the stage of eggs, Odonata will mate in midair when the male and female are in the air. The female Odonata will place her eggs in the water on a plant after the two mate, or she may simply drop them in if she cannot locate a suitable plant. An odonata larva's life cycle starts as a nymph once the eggs hatch. A nymph appears to be a little extraterrestrial being. It has what seems to be a crusty hump hanging onto its back and hasn't acquired wings yet (Hadley, 2020). Odonata nymphs are aquatic organisms that evolve into dragonflies or damselflies. This part of the life cycle of an Odonata can take up to four years to finish. If the nymph cycle is finished at the start of winter, it will stay under the water until spring, when the temperature is warm enough for it to emerge. Since ponds and marshlands have calmer waters than streams or rivers, Odonata nymphs reside there. They occasionally inhabit the more serene backwaters of rivers as well. Smaller Odonata nymphs may be consumed by larger nymphs as they grow. When nymphs reach adulthood, they emerge from the water and climb up on emergent plants or other structures close to the water's edge, where they change into new species. The adult with wings, called an imago, breaks through the nymph skin and appears from the exuvia (The Editors of Encyclopaedia Britannica, 2023). An important phase in the life cycle of an Odonata is the transition from a nymph to an adult. The wings of the freshly emerging adult Odonata are folded and delicate. The wings eventually dry out and grow, becoming stiff and useful for flying. Adult damselflies and dragonflies are mainly active during the day and are renowned for their amazing flying skills. They eat other insects, usually tiny, flying

ones. Depending on the species, an adult Odonata's lifespan can range from a few weeks to a few months. During this stage, their primary function is reproduction (Randy Jones, 2023).

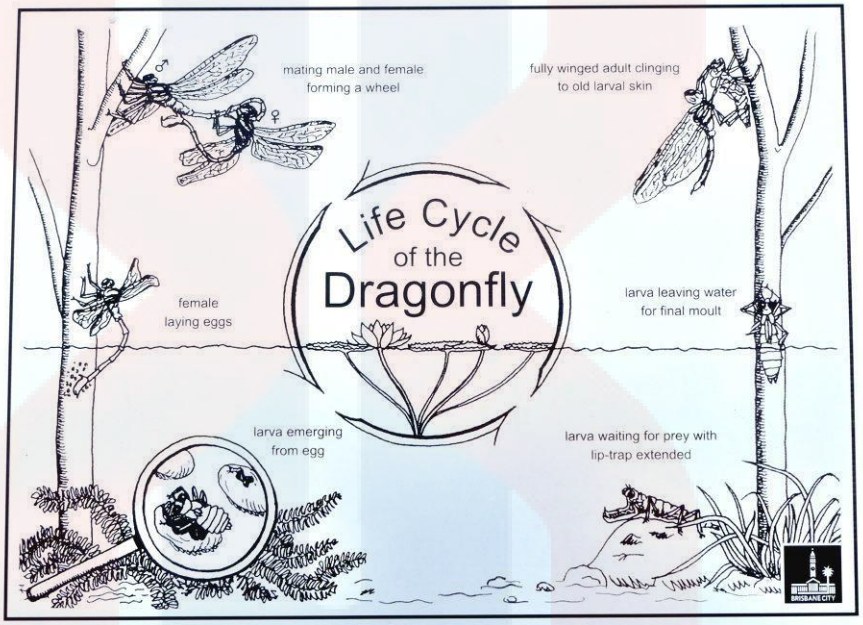

Figure 1: Life cycle of odonata (*Dragonflies and Damselflies Life Cycle*, n.d.)

2.4 Habitat Odonata

According to biotic and abiotic factors such predation, food supplies, aquatic and riparian vegetation, water temperature, oxygen content, and pH, nymphs live in a variety of freshwater environments (Vilenica et al., 2020). The main factors influencing the choice of adult habitat are shade and the composition of aquatic and riparian vegetation (Corbet and Brooks, 2008). As generalised predators that consume a variety of tiny invertebrates, both life stages are crucial for controlling the population abundances of other insects, such mosquitoes (May, 2019). Because they live in a variety of freshwater habitats, are significantly impacted by anthropogenic changes to freshwater environments, and exhibit clear

responses to habitat modification, odonata have been widely used as ecological indicators of environmental quality in aquatic ecosystems (Butler and deMaynadier, 2008). (Bried and Samways, 2015). Furthermore, because of their unique behaviour and look, Odonata are well-liked by both professional and amateur entomologists. They may be recognised rather simply in their adult stages (May, 2019).

Odonata species can be found mostly in tropical rainforests (Dow and Reels 2015). Because tropical woods contain rich ecosystems, the species diversity of dragonflies is highest there. (Manwar et al., 2012). The majority of Odonata have specific preferences for types of habitat, including riparian forests, overhanging vegetation, and riparian vegetation. Odonates have been found in the greatest number next to bodies of water, including lakes, ponds, streams, canals, and waterways, regardless of the location or habitat's size. Because they require water to deposit their eggs, dragonflies are found in a variety of wet environments. (Korkeamäki and Suhonen, 2002). The larvae form a substantial portion of aquatic food webs that include a wide range of fish, invertebrates, and other vertebrates. They also have an amazingly good diversity of aquatic environments (Ameilia et al., 2006). In addition to serving as indicators of environmental quality, dragonflies may be found in the food chain as larvae and imagoes, as well as predators. (Neog and Rajkhowa 2016). The diversity and abundance of dragonfly decrease if the environmental quality drop. Odonata demonstrate their unique habitat preferences through their distribution, which is involved primarily microhabitats (Sheldon and Walker, 1998). These insects lay their eggs in or near freshwater and thus their high

abundance in the area is a clear indicator of the freshwater quality (Acquah et al., 2013)

2.5 Diversity of Odonata

The order Odonata, which includes dragonflies and damselflies, is found almost everywhere on Earth, with the exception of the poles. At the moment, it comprises 650 genera and around 6400 species, hundreds of which are yet undiscovered. Nearly every one of the 5,680 species of dragonflies and damselflies that make up the insect order Odonata's larvae are reliant on watery environments. Predators include both adults and larvae (Olalla, 2022). The arrangement is rather extensively researched, with estimates of the true number of species approaching 7,000. Numerous species are habitat specialists with narrow distribution ranges. Examples of these species include those found in waterfalls, seepage sites in tropical rain forests, and alpine mountain bogs. They are often and effectively employed as indicators for conservation management and environmental health. The tropical rain forests with running waterways have the maximum variety, with the most specific ecosystems occurring in the Oriental and Neotropical areas (Kalkman, 2007). They are also regarded as superior bioindicators of habitat quality. Though less in number than other megadiverse groups, its place in the Pterygota phylogeny makes it an important group to comprehend insect evolution (Ricardo Koroiva, 2022).

As both prey and predators, Odonates are important biological markers of both aquatic and terrestrial ecosystems, helping to maintain the balance of the tropic levels of the food chain. They are a crucial part of freshwater habitats as well.

Odonata have been identified as possible biological indicators since they are present in nearly all types of habitats, including lakes, tiny, transitory rain puddles, and permanent flowing streams (Grimaldi and Engel, 2005). Many species, especially those found in alpine regions, are habitat specialists with narrow distributional ranges. Waterfalls, seepage regions in tropical rain forests, and alpine bogs. Tadpoles and tiny fish are among the many small creatures that larvae eat. Larvae mature over the course of a few weeks to seven years (Rehn 2003). The majority of species leave the water's edge to develop after emerging on plants or along the coast. To locate females or to mark their territory, males go back to the water. Frequently, females simply come back to mate and lay eggs. A detailed synopsis of Odonates' life cycle and behaviour is provided. (Corbet, 1999). Information on the number of species of Odonates is derived from the Global Species Database Odonata prepared for the Catalogue of Life (van Tol, 2005).

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

Study area is located at Lata Renyuk of Kampung Renyuk area with a reported Kampung Renyuk covers an area of 329,750.0 km^2 located at the central of Kelantan, latitude : 5.5810000°, longtitude : 101.8833000°. Lata Renyuk has a waterfall that results from the flow of the Renyok River, which starts in the Titiwangsa range before flowing into the Pergau River. The advantage of this waterfall area is that it can be easily accessed by normal vehicles because there is also a mini hydroelectric plant that has been operating until now. It is located at Jeli district which around 22.9 kilometers from University Kelantan Malaysia Campus Jeli.

Figure 2: The study location site at Lata Renyuk reserve from map (Google Earth, 2023)

3.2 Field Sampling

Opportunistic sampling method was employed using sweep nets for the collection of Odonata. Insect nets, had a handle that measured two feet (24 inches) in length, a net with an open mesh that allowed for little air resistance, and a weight of around 25 cm. In order to capture the flying dragonfly, it is therefore swung quickly (Orr, 2013). This sampling will go through the river and observe the side of the river where there are Odonata species and through a distance of 10 meters at each sampling location. This sampling will be carried out every 3 times in a week for 1 month and captured Odonata species will be stored in containers containing 70% ethanol so that the specimens can last a long time. This sampling will be conducted at site A and site B on a rotating basis during the same week. This sampling will be carried out at site A and site B on the same day and each point will take 2 hours to capture the specimen.

3.3 Samples Collection and Preservation the Odonata

When collecting the Odonata specimens at the sampling sites, the samples were picked from the net and put in a plastic container or box plastic containing 70% ethanol. The function of 70% ethanol is to ensure the samples were faint and died before pinning their thorax with insect pin. In order to protect the sample from damage, it was then placed in an envelope with its wings folded together over the body (Wahizatu et al., 2006). The pinned specimen was subsequently brought back to University Malaysia Kelantan for further identified, all the Odonata specimen were separated according to species Odonata. The specimen were spread on spreading board with rear margin of the front wing straight across, at right angles to the body. After set specimens at dried at room temperature then left to dry about a week before collected.

3.4 Identification of Odonata

All collected data were documented, and the samples were identified down to the species level. Samples were identified by searching "MyBis.gov.my." The acknowledged species of dragonflies were documented. Species caught during the harvest period will be recorded and labeled with time, weather and place of caught.

3.5 Data Analysis

For each sampling site, the number of species and individuals gathered were counted and analysed for the Shannon-Weiner index, Simpson's diversity indices, and Piclou's evenness or equitability.

3.5.1 Shannon -Weiner Index

$$H = -\sum_{i=1}^{s} Pi * \ln pi$$

The Shannon-Weiner index (H), which takes into account both the total number of species and the abundance of each species, was used to quantify species diversity. ni = The total number of members in the sample from each species. N is the total number of members in the sample from each species.

The total of all species that are present at various places will be used to determine the population abundance of Odonata. The variety of Odonata species in two distinct locations served as a simple indicator of species richness.

3.5.2 Simpson's Diversity Index

Diversity is measured by Simpson's Diversity Index. N = is a commonly used statistic in ecology to express how diverse an environment is. It considers both the total number of species and the relative abundance of each species.

(a) Simpson's index of dominance

$$D = \sum \frac{ni(ni-1)}{N(N-1)}$$

Where, ni = the total number of individuals of a particular species, N = the total number of individuals of all species.

(b) Simpson's index of diversity

$1 - D$

Additionally, this index has a value between 0 and 1, where a higher value indicates a more diverse sample.

3.5.3 Evenness Index

The term "species evenness" describes how closely spaced out each species is in an ecosystem.

$$J = \frac{H}{H_{max}}$$

The value of J ranges from 0 to 1. Higher values indicate higher levels of evenness. At maximum evenness, J = 1. In a community, J and D can be used as indicators of species dominance, which is the reverse of diversity. Low J denotes a dominant species or few dominant species in the community.

3.5.4 Species Accumulation Curves

The number of species in a given region is estimated using species accumulation curves (SAC; also known as species-richness curves, collector's curves, or species effort curves). They may also be used to show if a fauna survey adequately captures the species found in a given area.The predicted number of observed species or unique classes as a function of sampling effort is provided by a population's species accumulation curve, also known as the collector's curve. Researchers can analyse the advantages of increased sampling or measure and compare diversity among communities using species accumulation curves.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Overall species diversity and abundance

In this study, a total of 145 individuals of dragonflies and 29 individuals of damselflies were collected, representing 7 species and 2 families. The most abundant species was *Trithemis aurora* with 79 individuals, meanwhile the least abundant species was *Neurothemis fluctuans* with only 1 individuals recorded. All of species found in Lata Renyuk were classified as Least Concern (LC).

Table 4.1: Abundance of Odonata species encountered according to family in Lata Renyuk, Jeli, Kelantan.

Odonata	Location of specimen	IUCN Status	Abundance
Family Libellulidae			
Trithemis festiva	Site B	LC	3
Trithemis aurora	Site A, Site B	LC	79
Brachythemis contaminata	Site A, Site B	LC	11
Neurothemis fluctuans	Site B	LC	1
Orthetrum testaceum	Site A, Site B	LC	45
Orthetrum sabina	Site B	LC	6
Family Platycnemididae			
Copera marginipes	Site A, Site B	LC	29

Ecology considers species richness, defined as the total number of species or distinct classes, to be a fundamental metric in assessing population diversity (Magurran AE, 1988). However, accurately estimating species richness through surveys is frequently challenging, if not unachievable, due to the potential presence of numerous undetected rare species within the population, regardless of the number of observed species. An alternative approach involves examining the anticipated number of unique species relative to survey size, as indicated by the species accumulation curve (Colwell RK, 2004).

Comparing sampling curve both site may differ in measured species richness because of differences in underlying species richness, differences in the shape of the relative abundance distribution, or because of differences in the number of individuals counted or collected (Denslow 1995). The species curved (Figure 4.1) indicates that the estimated species richness at both study sites was asymptotic value for the cumulative species count at Site A is approximately 2.83, while the mean asymptotic value for Site B is 6.0. This indicates that, on average, Site A tends to stabilize around 2-3 species, while Site B stabilizes around 6 species over the observation period, which is suggesting that a 12 days Odonata survey at Lata Renyuk was sufficient for determining species richness with 7 total species collected in both sites.

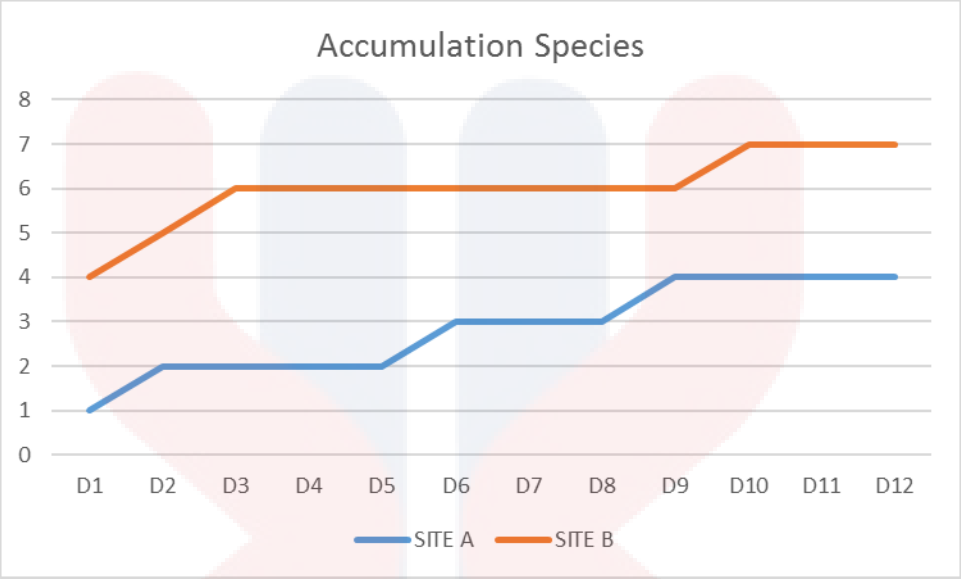

Figure 4.1: Species accumulation curve for Odonata species collected at Lata Renyuk, Jeli, Kelantan according to study sites.

4.2 Diversity index

Species richness, which refers to the number of unique species found in a specific geographical region, is a critical measure of biodiversity. The Odonata populations at both Site A and Site B demonstrate significant species richness. In Site A, there are 4 distinct species present: *Orthetrum testaceum*, *Trithemis aurora*, *Copera marginipes*, and *Brachythemis contaminata*. In contrast, Site B exhibits a more varied selection, including seven identified species: *Trithemis festiva, Trithemis aurora, Brachythemis contaminata, Copera marginipes, Orthetrum testaceum, Orthetrum sabina,* and *Neurothemis fluctuans.*

Species evenness is a crucial metric that assesses the fair and just distribution of individuals among the diverse array of species present within a particular ecological community. This metric serves as a reflection of the

equilibrium or potential lack thereof in the relative abundance of different species. Upon meticulous examination of the dataset at hand, discernible disparities in evenness become apparent when comparing Site A to Site B. At Site A, the distribution pattern tends to favor specific species, particularly *Orthetrum testaceum* and *Trithemis aurora*, which exhibit significantly higher population counts in comparison to *Copera marginipes* and *Brachythemis contaminata*. In stark contrast, Site B showcases a notably elevated level of evenness, although *Trithemis aurora* emerges as the predominant species in terms of abundance. The population counts of other species such as *Copera marginipes* and *Orthetrum testaceum* appear to be more evenly distributed relative to the dominant species, thereby indicating a more balanced and equitable apportionment of individuals among the various species present in the ecosystem.

The biodiversity differences between Site A and Site B offer important new information on the intricate ecological dynamics of Odonata populations in these specific regions. It is clear that the distribution of Site A, which is biased towards a few species, may be impacted by ecological factors that encourage the growth of *Trithemis aurora* and *Orthetrum testaceum*. Conversely, Site B has a more balanced distribution, suggesting a possibly stronger ecosystem with circumstances that support species cohabitation.

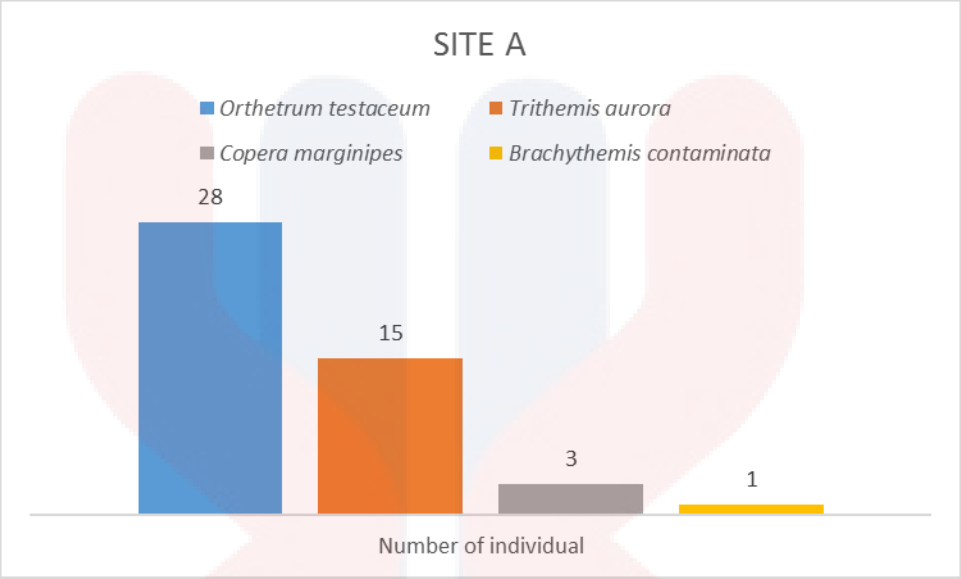

Figure 4.2: Number of individual of Odonata collected at site A in Lata Renyuk, Jeli, Kelantan.

The diversity of Odonata observed at Site A is defined by a level of species richness that can be classified as moderate, accompanied by a notable lack of species evenness. Within this ecosystem, *Orthetrum testaceum* and *Trithemis aurora* emerge as the dominant species, exerting a substantial influence on the overall population dynamics, whereas *Copera marginipes* and *Brachythemis contaminata* are represented in notably smaller proportions. The disparity in the distribution of these species serves to underscore the intricate ecological processes and resource dynamics that are at play within the confines of Site A, thereby shedding light on the potential fluctuations in ecological balances and the availability of resources at this particular site. These findings, which emphasize the uneven distribution of species, not only contribute to a deeper understanding of the ecological dynamics at Site A but also present valuable implications for conservation strategies and ecosystem management practices that are specifically

designed to uphold and potentially enhance the levels of biodiversity present in this ecosystem.

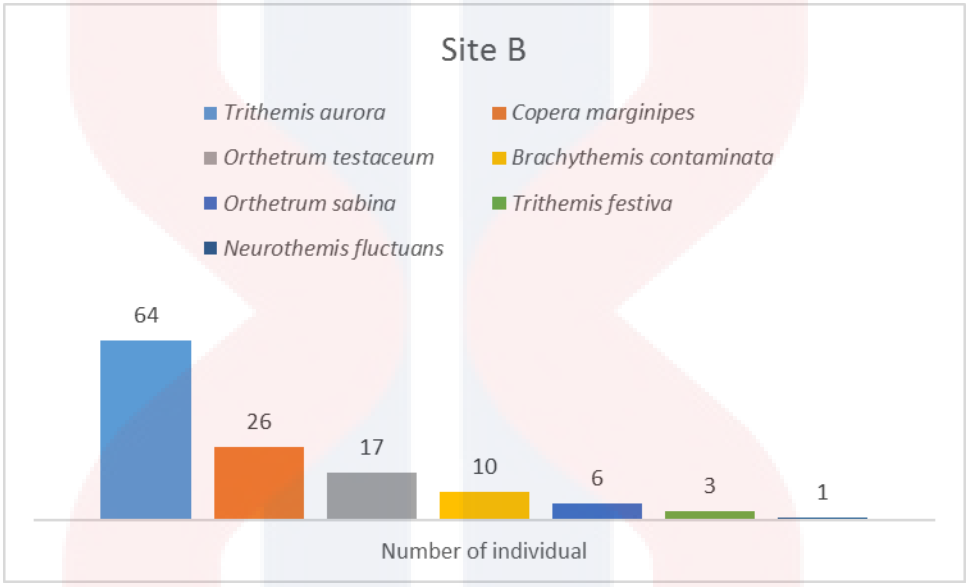

Figure 4.3: Number of individual of Odonata collected at site B in Lata Renyuk, Jeli, Kelantan.

The diversity observed in the Odonata population at Site B is characterized by a notable level of species richness combined with a comparatively low level of species evenness. The predominant species, *Trithemis aurora*, exerts a significant influence on the overall population dynamics, with *Copera marginipes* and *Orthetrum testaceum* also displaying moderate population counts. In contrast, the remaining species are present in substantially lower numbers, illustrating a distinct lack of uniformity in their distribution across the site. This uneven distribution pattern serves to underscore the intricate ecological dynamics and the varying levels of resource availability present at Site B. Such insights provide valuable information for conservation initiatives and ecosystem management strategies, both

of which are designed to uphold and potentially enhance the existing levels of biodiversity and ecological equilibrium within the site.

Table 4.2: Shannon-Wiener Diversity Index Site A and Site B

Formula	Site A	Site B
H’	0.931	1.410
H’max	2.536	4.097

The number of individuals that were subjected to analysis using the Shannon-Wiener diversity index was determined in the study. The Shannon-Wiener diversity index, as described by Shannon and Wiener, establishes specific criteria for assessing species diversity, wherein a value of H greater than 3 signifies a high level of species diversity. On the other hand, if the calculated value of H falls within the range of 1 to 3 inclusive, it indicates a medium level of diversity, while a value of H less than 1 suggests a low level of diversity within the studied population (Odum, 1999). In the present investigation, the Shannon-Wiener index at Site A is reported as H’ = 0.931, indicating a level of environmental stability deemed sufficient for the assessment of diversity index, with the maximum value reaching H’max = 3.97. Conversely, Site B exhibits a Shannon-Wiener index of H’ = 1.410, signifying a stable environmental condition suitable for the evaluation of diversity index falling within the medium category, achieving a peak value at H’max = 4.097.

4.3 Abundance

The quantification of the number of species present at a specific site, also known as richness, stands out as one of the most straightforward biodiversity variables to assess. Richness, in isolation, has often served as a primary metric in determining the comparative conservation worth of various locations (Wilsey et al. 2005). Nonetheless, it is crucial to note that relying solely on species richness as an indicator of biological diversity may lead to potentially erroneous conclusions if this metric lacks correlation or exhibits a negative correlation with other crucial characteristics of species assemblages. These attributes include, but are not limited to, evenness and the population densities of species that hold significant conservation importance (Stirling and Wilsey 2001).

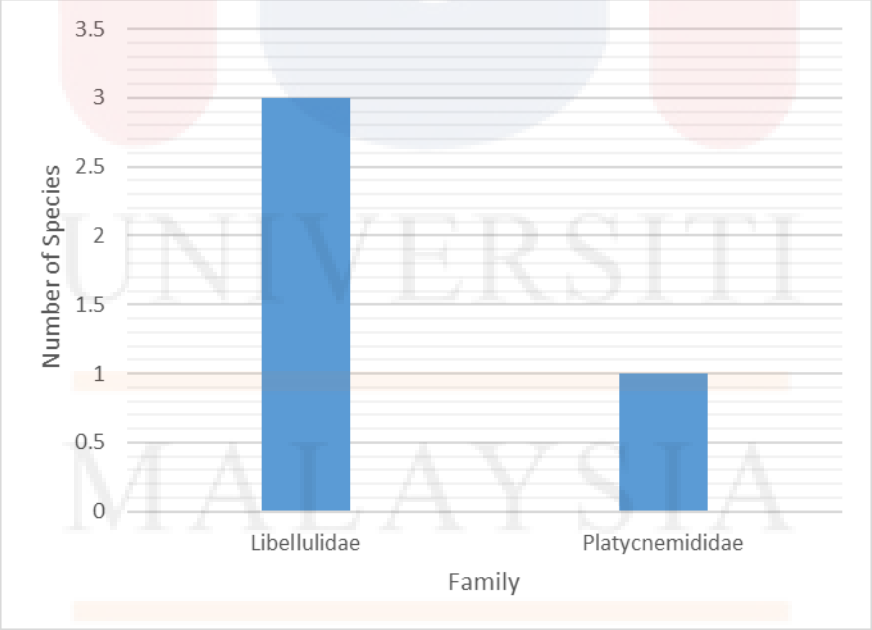

Figure 4.4: Number of species of odonata collected at site A in Lata Renyuk, Jeli, Kelantan.

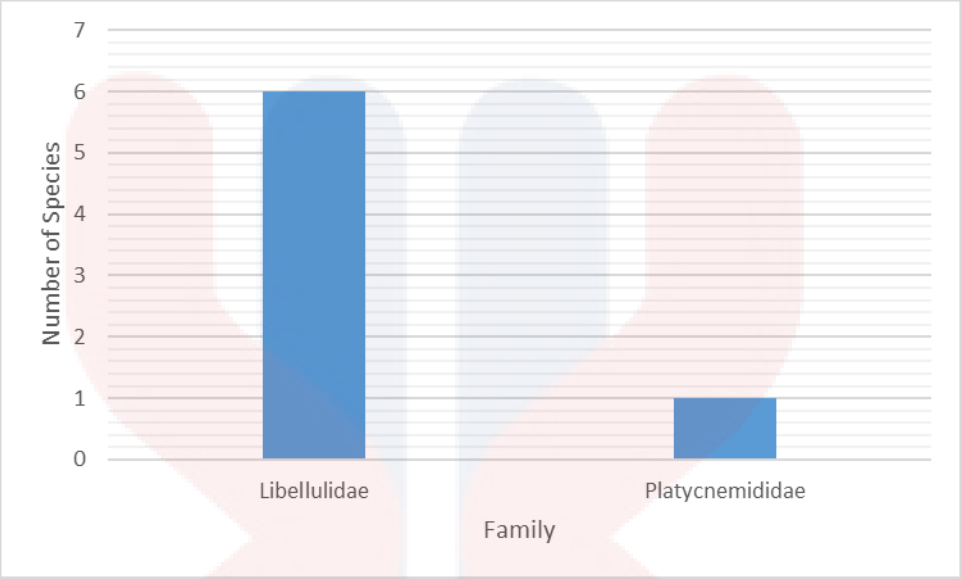

Figure 4.5: Number of species of odonata collected at site B in Lata Renyuk, Jeli, Kelantan.

The Family Libellulidae, known for its remarkable diversity, exhibits the highest number of Odonata specimens at both site A and site B, totaling 6 and 3 species respectively as illustrated in Figure 4.4 and Figure 4.5. Contrarily, the family Platycnemididae presents the least number of Odonata specimens, with only one species documented at each site.

Upon closer examination, it becomes apparent that *Orthetrum testaceum* (Libellulidae) emerges as the most prevalent species in this ecosystem, with a total of 28 individuals observed in site A, surpassing all other species in abundance. Conversely, in site B, the spotlight is on *Trithemis aurora*, which boasts a count of 64 individuals, making it the most abundant species in that location.

Examining the abundance aspect yields some interesting findings, especially for site A where a reduced abundance of Odonata species was observed.

This occurrence can be explained by the fact that only a small number of individuals belong to several species in this area. The primary cause is the environmental preferences of Odonata larvae, which frequently need firm surfaces for anchoring, such as mud, sand, or vegetation.. The rapid water flow in site A presents a problem since the tumultuous flows have the potential to uproot the necessary substrates, making it more difficult for the larvae to hold their places. Even while swift-moving rivers have the benefit of well-oxygenated water, the turbulence in these settings might prevent larvae from breathing easily. The mismatch between the circumstances in site A and the habitat requirements of Odonata larvae is highlighted by the fact that these animals have specialised systems, including gills, that are suited to steady water conditions (Corbet, 1999).

4.4 Evenness

Table 4.3: Pielou's Evenness Index

Formula	Site A	Site B
J	0.367	0.344

The range of the evenness index is 0 to 1. Pielou's Evenness Index values for this study are J = 0.367 at site A and J = 0.344 at site B. This suggests that the individuals within odonata groups are dispersed equally throughout the various species. The reason could be that the study area's disturbed sites, which offer

suitable habitats for a variety of species that depend on standing or slow-moving waters, typically have higher nutrient concentrations. This encourages the growth of aquatic plants and algae, which in turn supports higher densities of prey species for both adults and larvae (Berg, 2008).

4.5 Overall both site

This study centered on the gathering and examination of Odonata species (dragonflies and damselflies) at Lata Renyuk, Jeli, Kelantan. A sum of 145 dragonflies and 29 damselflies, representing 7 species and 2 families, were documented. *Trithemis aurora* emerged as the most prevalent species with 79 individuals, while *Neurothemis fluctuans* was the least abundant, with only one individual observed. All identified species were categorized as Least Concern (LC) in accordance with the IUCN. Odonata species have been distributed among two families which are Libellulidae and Platycnemididae.

The family Libellulidae demonstrated a higher level of diversity with a total of 6 species, in contrast to Platycnemididae, which was represented by a single species, *Copera marginipes*, identified in both sites. An analysis comparing the richness of species at Site A and Site B was conducted through the utilization of species accumulation curves. At Site A, the estimated species richness reached a plateau at approximately 2-3 species, whereas Site B stabilized at 6 species. These results suggest that the survey conducted over a period of 12 days was effective in capturing the species richness at the specified locations. The evaluation of biodiversity was based on measures of species richness and evenness.

Site A was able to catch 4 species namely *Orthetrum testaceum*, *Trithemis aurora*, *Copera marginipes* and *Brachythemis contaminata*, while Site B caught 7 species including all from Site A plus *Trithemis festiva*, *Orthetrum sabina* and *Neurothemis fluctuans*.The Shannon-Wiener diversity index (H') was computed, uncovering a higher diversity at Site B (H' = 1.410) in comparison to Site A (H' = 0.931). Both locations displayed moderate to low species evenness, with Site B demonstrating a marginally more balanced distribution of species. The abundance of Odonata species exhibited notable variations between the sites. Site A had fewer individuals due to its swift water flow, which disrupts the larvae's anchoring substrates. Conversely, Site B, characterized by slower-moving waters, sustained higher densities of Odonata. Pielou's Evenness Index suggested that Site A showcased a slightly superior evenness (J = 0.367) relative to Site B (J = 0.344), implying a more equitable distribution of individuals among species at Site A.

The importance of habitat factors in determining Odonata variety and abundance is shown by this study. The findings provide insightful information for conservation plans meant to preserve and enhance the biodiversity of these environments. This study adds to our knowledge of the biological dynamics of the Odonata population in Lata Renyuk and emphasizes the need for targeted conservation measures to preserve this rare species.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The investigation culminates by presenting the findings of the research conducted on the abundance of Odonata at Lata Renyuk, Jeli, Kelantan. The results indicate that this particular area along the river exhibits a moderate level of diversity in Odonata species with a fairly even distribution. The analysis from this particular study emphasizes the significance of species richness and evenness as crucial metrics for assessing biodiversity within the ecosystem. Specifically, Site A was observed to host four distinct species, namely *Orthetrum testaceum, Trithemis aurora, Copera marginipes,* and *Brachythemis contaminata*. In contrast, Site B displayed a more diverse selection of seven different species. On the whole, the diversity observed at Site A can be classified as moderate, with a noteworthy dominance of *Orthetrum testaceum* and *Trithemis aurora.* Conversely, while *Trithemis aurora* remains prevalent at Site B, there is a more balanced distribution among the other species present. The study indicates that the population of Odonata at Site A is influenced by factors such as the shaded environment and human activities taking place in the area. On the other hand, Site B's open and sunny habitat caters to the physiological needs of Odonata, thereby

contributing to their survival and reproductive success. These research findings shed light on the intricate ecological dynamics that impact odonata diversity at Lata Renyuk, offering valuable insights for the development of conservation strategies and ecosystem management practices. The study effectively evaluated the diversity, abundance, and evenness of Odonata populations at two distinct sites within Lata Renyuk. It was observed that Site B showcased a higher species richness and a more equitable distribution, indicating the presence of more favorable ecological conditions in that particular habitat. These outcomes underscore the critical role played by habitat characteristics in shaping odonata diversity and lay a solid groundwork for future conservation initiatives in similar ecosystems.

5.2 Recommendations

Freshwater ecosystems heavily rely on Odonata owing to their biphasic life cycle and trophic cascades that establish crucial connections between aquatic and terrestrial systems, as highlighted by Knight et al. (2019). Dragonflies and damselflies demonstrate distinctive habitat requirements, playing pivotal roles in habitat selection, thermoregulation, oviposition resources, and dispersal, as outlined by Dutra and De Marco (2015).

Further exploration could be undertaken in Lata Renyuk, Jeli, Kelantan, particularly focusing on comprehensive studies involving avian species, moths, and various plant species to thoroughly examine and assess the inherent diversity within these specific taxa. Conversely, additional investigations are imperative within freshwater environments to scrutinize the array of habitats both pre and post disturbances in free-flowing water bodies, given the existing deficit in knowledge, particularly in regions designated as recreational hubs for the general public. The ongoing use of these riverine leisure areas might have negative effects on the variety of Odonata populations as a whole, which is why conservation concerns should be raised. It is clear that this river system is unique in that it serves as a crucial hub for Odonata variety, which means that in order to properly solve thi s issue, the people of Malaysia must act swiftly and decisively. To protect the current natural habitats and lessen the negative impacts on secondary habitats, strict measures must be put into place, such as large-scale awareness campaigns and the creation of new laws and regulations.

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APPENDIX

Images of study location site A at Lata Renyuk.

APPENDIX

Images of study location site B at Lata Renyuk.

APPENDIX

Images of selected Odonata collected from the Lata Renyuk, Jeli, Kelantan