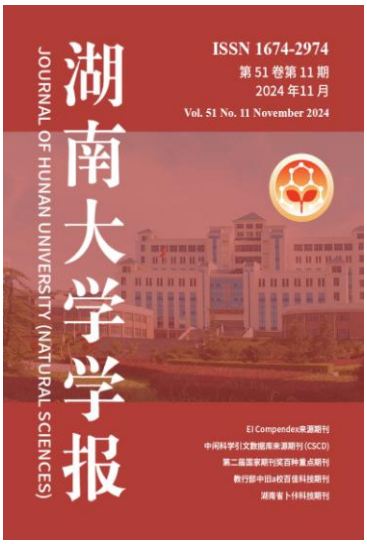

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Biodiversity Monitoring of Odonata in Peramun Hill Natural Reserve, Belitung Island, Indonesia: Future Conservation Program

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Abstract: Odonata species, including Anisoptera (dragonflies) and Zygoptera (damselflies), are well-established bioindicators of environmental quality owing to their sensitivity to water quality. This study provides a novel assessment by examining the biodiversity of Odonata across multiple habitat types—ponds, streams, and grasslands—within the Peramun Hill Natural Reserve, Belitung Island, which has not been extensively explored in previous studies. Field surveys conducted in February 2024 recorded 279 individuals, predominantly from

Libellulidae and *Platycnemididae* families. Pond habitats demonstrated the highest species richness and diversity, with a Shannon-Wiener diversity index (H') of 2.48 and a low dominance index (D = 0.09), indicating a stable and diverse community. Grassland areas, although less species-rich, supported adaptable species such as *Pantala flavescens*, whereas stream habitats, characterized by higher evenness (J = 0.95), were preferred by species sensitive to water quality, such as *Prodasineura collaris*. Notably, *Tetrathemis flavescens*, classified as Near Threatened, suggests the potential of this species to serve as a bioindicator for future biodiversity monitoring. The unique focus of this study on habitat-specific matrices highlights the importance of habitat diversity in maintaining ecological stability and species richness. Conservation efforts should prioritize collaborative management, habitat restoration, and ongoing biodiversity assessments to safeguard odonata populations and their ecosystems.

Keywords: biodiversity; Peramun hills; conservation; odonata

印度尼西亚勿里洞岛佩拉蒙山自然保护区蜻蜓生物多样性监测：未来保护计划

摘要：蜻蜓目物种，包括差翅目（蜻蜓）和豆娘，由于对水质敏感，是公认的环境质量生物指标。本研究通过研究勿里洞岛佩拉蒙山自然保护区内多种栖息地类型（池塘、溪流和草地）中蜻蜓目的生物多样性，提供了一种新颖的评估方法，此前的研究尚未对该区域进行广泛探索。2024 年 2 月进行的实地调查记录了 279 只蜻蜓，主要来自蜻蜓科和扁蜻蜓科。池塘栖息地的物种丰富度和多样性最高，香农-维纳多样性指数 (H') 为 2.48，优势度指数较低（D = 0.09），表明群落稳定且多样化。草原地区虽然物种丰富度较低，但适合 Pantala flavescens 等适应性强的物种，而溪流栖息地的特点是均匀度更高（J = 0.95），对水质敏感的物种则更青睐 Prodasineura neckis。值得注意的是，被列为近危物种的 Tetrathemis flavescens 表明该物种有可能成为未来生物多样性监测的生物指标。本研究对特定栖息地基质的独特关注凸显了栖息地多样性在维持生态稳定和物种丰富度方面的重要性。保护工作应优先考虑协作管理、栖息地恢复和持续的生物多样性评估，以保护蜻蜓种群及其生态系统。

关键词：生物多样性；佩拉门山；保护；蜻蜓目

1. Introduction

Unpredictable climatic change significantly affects the distribution of animal and plant species. For example, rising temperatures lead to a poleward shift in the distribution of animals, which consequently alters the overall composition of species communities [1, 2]. Significant alterations were mostly noted in the behavior of insects and other groups, including Odonata. Research has indicated that Odonata larvae exhibit a strong dependence on aquatic habitats, whereas the adult stages are more affected by the adjacent riparian flora [3, 4]. Therefore, various hypotheses and studies have emerged to explain the patterns of odonata community structure and their associations with resources and the environment [5, 6]. Approaches such as the ecological niche theory and neutral theory have been employed to uncover how they interact with their environment, reproduce, and survive [7]. For example, members of the suborder Zygoptera exhibit a lower dispersal capacity and are more closely associated with and dependent on specific environmental characteristics and limited spatial factors [8]. In contrast, Anisoptera includes the most common or widespread species and demonstrates a greater tolerance to variations in environmental conditions [9].

The varying physiological requirements at each developmental stage of odonata elucidate how certain environmental conditions affect the distribution of larval and adult species. During the larval stage, the hydrodynamic structure and physicochemical properties of the water substantially influence their growth [10]; in contrast, adult Odonata exhibit a stronger relationship with their aerial-terrestrial environment, such as solar radiation, temperature, and air humidity [11]. Vegetation abundance is one of the key factors supporting odonata development, where their distribution declines in parallel with the

degradation of vegetation quality, along with environmental integrity and canopy cover [12]. Therefore, investigating the ecology of riverine waters or habitats favored by Odonata, such as grasslands and open areas with sparse vegetation, is crucial, particularly regarding the impact of spatiotemporal modifications caused by anthropogenic activities [13].

In recent years, significant conservation activities have been carried out in the Peramun hills, Belitung Island, and Bangka-Belitung. This area is located 129 m above sea level, covering a total area of 115 ha [14]. The lowland forest of the Peramun Hills is a geo-site within the Belitong Geopark. As a geo-site, the area is uniquely characterized by giant granitic stones and a diverse floral landscape. Water springs flow through the lush forest, creating small streams and ponds that support the growth of aquatic organisms. This environment is highly suitable for the growth and development of Odonata, making it an ideal observation site. However, to date, no research has been conducted on the biodiversity of insects in Peramun Hills, particularly regarding dragonflies and damselflies, which are highly dependent on water quality.

This study aimed to investigate both the biodiversity and habitat-specific distribution of Odonata species within the Peramun Hills Natural Reserve across various habitats, such as grasslands, streams, and ponds. This is essential, as habitat conditions often directly influence the survival of Odonata. The analysis of odonata biodiversity in this study will be conducted by considering multiple diversity indices, including the Dominance Index, Simpson's index, Shannon-Wiener Diversity index, and evenness index. Future programs are also outlined to support sustainable conservation in this area.

2. Methods and Materials

2.1. Sampling Location and Time

This study was conducted in the Peramun hills geo-site in Belitung Regency, Bangka-Belitung Province, Indonesia (lat: - 2° 36' 55.7″, long: 107° 44' 9.06″) (Figure 1). The observation habitat was divided into three types: grasslands with few trees, small streams inside the forest interior, and ponds with few reeds at the edge of the forest.

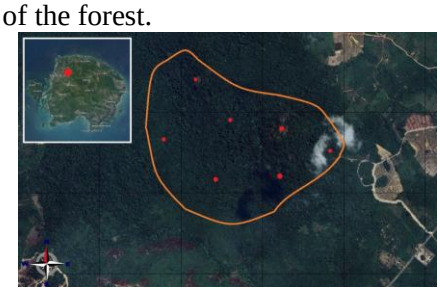

Figure 1. Peramun Hill Location in Belitung Island, Sumatra, Indonesia (authors' photo)

Data collection was conducted in February 2024, during sunny conditions with low precipitation. The majority of the islands experience strong winds throughout the month, with few heavy rains. Observation time carried out from 08.00 a.m to 11.30 a.m and continue from 01.00 p.m to 05.30 p.m.

2.2. Data Collection

Dragonfly observations were carried out by exploring all observation locations while identifying and counting the number of observed dragonfly species and their surroundings. This study utilized the visual encounter survey (VES) technique for data collection method [15]. Sweep net is also used to capture flying and perching dragonflies. The captured dragonflies were photographed in detail using a digital camera and identified based on several related books and article sources [15]. The documentation process also focuses on the habits of dragonflies to show their natural behavior in the wild. Each captured or documented individual was identified to the genus or species level. Morphological features, such as body size, color, pattern, wing venation, and tuft shape, are crucial for identifying dragonflies. The conservation status of all dragonfly and damselfly species was based on the IUCN Red List [16].

2.2. Data Collection

The analysis of odonata biodiversity in the Peramun hills area was conducted using multiple diversity indices, beginning with the Shannon-Wiener diversity index (H'). The Shannon-Wiener index is a biodiversity index that measures uncertainty in sampling outcomes [17]. The dominance index (D) values range between 0 and 1, with higher values indicating greater dominance. Specifically, a D value between 0.75 and 1 signifies a high level of dominance, while values between 0.5 and 0.75 reflect a moderate level of dominance. Lower dominance was indicated by values ranging from 0–0.5. The formula for the Shannon-Wiener diversity index is shown in Eq.1.

$$H' = -\sum_{i=1}^{n} Pi \ln Pi \quad (1)$$

H' = Shannon-Wiener diversity index

Pi = ni/N is the ratio between the number of individuals of species i (ni) and the total number of individuals of all species (N).

Ni = the number of individuals of a species

N = the total number of observed individuals

Simpson's Dominance Index was used to determine the concentration or dominance of plant species within a specific plant community. According to Simpson's Dominance Index criteria (Krebs, 1978), species with Di values of 5% or higher are considered dominant. Species with Di values between 2% and 4.99% were

classified as sub-dominant, whereas those with Di values of 2% or lower were regarded as non-dominant. The mathematical equation is as follows [18].

$$D = \sum \left(\frac{n_i}{N}\right)^2 \quad (2)$$

Di = Simpson's Dominance Index
Ni = the number of individuals of species i
N = the total number of individuals of all species

Pielou's Evenness Index (J) was used to determine the distribution of individuals within a species in a given community. When the J-value approaches 1, it indicates a higher level of evenness, meaning that no species dominates the community. According to Pielou's Evenness Index criteria [19], a J value greater than 0.6 indicates a high level of evenness within the community. Values between 0.3 and 0.6 represent moderate evenness, while values below 0.3 indicate a low level of evenness. The Pielou's Evenness Index was calculated using the following formula:

$$J = \frac{H'}{\ln(S)} \quad (3)$$

J = Pielou's Evenness Index
H' = Shannon-Wiener diversity index value
S = Total number of species

Finally, the Margalef Richness Index (R) was used to assess species richness. This index helps determine species richness within each observed community by comparing the number of individuals of a single species to the total number of species present. According to the Margalef Richness Index criteria [19], an R value greater than 5.0 indicates high species richness. Values between 3.5 and 5.0 represent moderate species richness, while values below 3.5 suggest low species richness. The formula for calculating the Margalef Richness Index was as follows:

$$R = \frac{S-1}{\log N} \quad (4)$$

R = Margalef Richness Index
S = number of species
N = total number of individuals

3. Results and Discussion

3.1. Habitat condition

Peramun hills are well-preserved forest areas, with the central region of the hill still harboring large tree species, such as *Hopea bilitonensis* and *Eusyderoxylon zwageri*, which represent the second generation of native plants in this area [20]. In addition, species such as *Heritiera littoralis*, *Syzygium pycanthum*, and *Castanopsis argentea* were also present in smaller quantities. Few Odonata species are found in environments such as the central region because Odonata is closely associated with aquatic habitats and areas with low vegetation density [21]. Under such conditions, moist and aquatic vegetation provide critical breeding, egg-laying, resting, and foraging sites for Odonata. This is evidenced by the high abundance of Odonata observed in areas with sparse tree cover, semi-aquatic habitats, and water bodies in this study. A previous study revealed that vegetation is a significant factor influencing the presence and diversity of dragonfly species [22].

Figure 2a shows semi-aquatic areas, such as streams that are dominated by vegetation, including *Colocasia* sp., *Sphaerostephanos* sp., and *Dicranopteris* sp., as well as some groups of *Nepenthes ampullaria*, which creates favorable conditions for the proliferation of various Odonata species. In addition, microscopic microorganisms that serve as the primary food source for Odonata are extensively present and offer shelter until the larvae mature [23]. The most diverse Odonata species were observed in areas with lentic water, such as ponds (Figure 2b). This area is heavily dominated by ferns, such as *Dicranopteris sp.*, surrounded by light vegetation. Similarly. grassland region, a substantial area populated by numerous Odonata, where these environments facilitate microclimates through a blend of solar exposure and wind protection, which assists in conserving the necessary warmth for ectothermic insects, enabling them to regulate their body temperature [24]. It can be concluded that vegetation diversity significantly influences the variation in Odonata species in the Peramun Hills.

Figure 2. Riparian habitat in Peramun hills natural reserve such as (a) stream and (b) pond area (picture were taken during survey) (authors' photos)

3.2. Diversity of odonata in their respective habitation

The mapping and recording of Odonata species in the Peramun Hill area during the investigation period are illustrated in Figure 3. These species are classified into two suborders: *Anisoptera* and *Zygoptera*. Four families were identified within the suborder *Zygoptera* (*Calopterygidae*, *Platycne-mididae*, *Coenagrionidae*, and *Chlorocyphidae*). The *Platycnemididae* family was the most frequently recorded, accounting for approximately 67% of the total species in the suborder *Zygoptera*. Conversely, only two families were identified as suborders of *Anisoptera* (*Chlorocyphidae* and *Libellulidae*), with the *Libellulidae* family being the most abundant for approximately 11 species, yet

only one species from the *Chlorocyphidae* family was recorded.

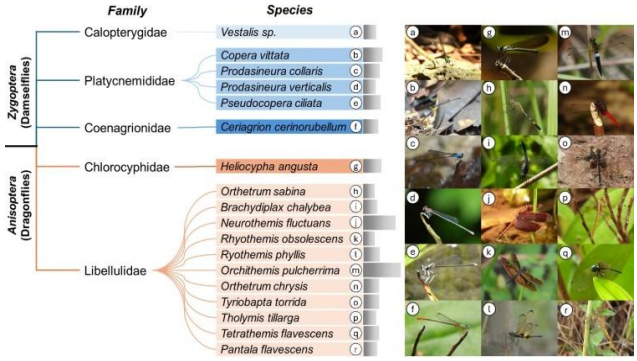

Figure 3. Phylogenetic tree of dragonflies and damselflies by family and species at Peramun Hill as well as several photograph of corresponding species (Phylogenetic tree developed by author, while odonata figures were taken during survey)

The statistical study in Table 1 indicates that *Anisoptera* comprised almost 70% of the entire Odonata population, with a total of 279 individuals. The *Libellulidae* family was the most prevalent, with 179 documented members. In contrast, the *Zygoptera* suborder consisted of approximately 89 individuals, predominantly from the *Platycnemididae* family, which accounted for 59 individuals. This distribution demonstrates the predominance of *Anisoptera*, especially the *Libellulidae* family, in the study area. According to the IUCN Red List [16], nearly all species identified in this study were categorized as Least Concern (LC). Only one species was classified as Near Threatened (NT), namely *Tetrathemis flavescens*, with a relative abundance of 5.38% among the other species. *Tetrathemis flavescens* has been recorded from Borneo, Sumatra, Belitung Island, and Cambodia [25].

Table 1. Dragonfly species composition and conservation status in Peramun hills natural reserve (compiled by the authors)

No	Species	Family	Number of Individual			Total		Status	Relative Abundance
			Gr	St	Po				
Zygoptera (damselflies) (n: 83)									
1	*Vestalis* sp.	Calopterygidae	0	11	0	11	11	LC	3.94%
2	*Ceriagrion cerinorubellum*	Coenagrionidae	0	0	13	13	13	LC	4.66%
3	*Copera vittata*	Platycnemididae	0	7	11	18	59	LC	6.45%
4	*Prodasineura collaris*	Platycnemididae	0	14	0	14		LC	5.02%
5	*Prodasineura verticalis*	Platycnemididae	0	3	8	11		LC	3.94%
6	*Pseudocopera ciliata*	Platycnemididae	0	9	7	16		LC	5.73%
Anisoptera (dragonflies) (n: 196)									
7	*Heliocypha angusta*	Chlorocyphidae	0	17	0	17	17	LC	6.09%
8	*Brachydiplax chalybea*	Libellulidae	0	0	12	12	179	LC	4.30%
9	*Neurothemis fluctuans*	Libellulidae	4	8	18	30		LC	10.75%
10	*Orchithemis pulcherrima*	Libellulidae	24	0	11	35		LC	12.54%
11	*Orthetrum chrysis*	Libellulidae	0	5	10	15		LC	5.38%
12	*Orthetrum sabina*	Libellulidae	10	0	0	10		LC	3.58%
13	*Pantala flavescens*	Libellulidae	10	0	2	12		LC	4.30%
14	*Rhyothemis obsolescens*	Libellulidae	7	0	3	10		LC	3.58%
15	*Rhyothemis phyllis*	Libellulidae	11	0	3	14		LC	5.02%
16	*Tetrathemis flavescens*	Libellulidae	10	0	5	15		**NT**	5.38%
17	*Tholymis tillarga*	Libellulidae	8	0	3	11		LC	3.94%
18	*Tyriobapta torrida*	Libellulidae	5	0	10	15		LC	5.38%
Total Abundance			**89**	**74**	**116**	**279**			

Similarly, *Tetrathemis hyalina* features bluish-green eyes, black synthorax with yellow stripes, and yellow-tinted wings. It is under-recorded, very localized, and uncommon, with only 12 known locations, two of which in Sarawak are likely to be lost to development within two decades [26]. The area of occupancy (AOO) was inferred to decline owing to lowland forest loss. Although severely fragmented, the species is assessed as being near-threatened [26].

Species of Anisoptera, especially from the *Libellulidae* family (*Brachydiplax chalybea* and *Heliocypha angusta*), are found in aquatic habitats such as ponds and streams. This abundance is associated with their life cycle features, since *Libellulidae* species, such as stagnant or slow-moving water sources, offer ideal breeding conditions and sufficient food [27]. A previous study explained that pond habitats, characterized by their generally constant water bodies, are essential for the development of dragonfly larvae [28]. Among the dragonfly and damselfly species found, only *Neurothemis fluctuans*, commonly known in Indonesia as “capung jala kecil” or “red grasshawk,” was present in all habitat types (Figure 3j). This species exhibits the highest environmental tolerance, with

advantageous morphological traits and behavioral flexibility compared with other species. It can also be found widely across Southeast Asia, including countries such as Malaysia, Indonesia, the Philippines, Thailand, and Singapore.

The Platycnemididae family (Zygoptera) shows a marked preference for stream habitats, such as *Prodasineura collaris* and *Pseudocopera ciliata* species, which largely occupy stream areas. This reflects the need for flowing water, which supplies higher oxygen levels that are essential for larval survival. Prior studies, such as [3], indicate that Zygoptera species are particularly sensitive to water quality and flow, which explains their preference for streams over ponds or grasslands. Interestingly, some Zygoptera species, such as *Copera vittata*, were found in both streams and ponds, suggesting some degree of habitat flexibility, potentially as an adaptive response to environmental change. Regardless, Zygoptera has heightened sensitivity to environmental changes; as previously discussed, unfavorable habitat conditions might reduce the Zygoptera population. [29]

Except for the Libellulidae family (i.e., *Orthetrum sabina*), the occurrence of Odonata in grasslands is limited because of the prevailing notion that non-aquatic environments offer less supplies for Odonata, especially during their larval phases. Species inhabiting grasslands, such as *Pantala flavescens*, are recognized as migratory organisms with significant dispersion capabilities, allowing them to exploit ephemeral environments [22]. This phenomenon suggests that although grasslands are not essential for odonata conservation, this area still functions as a temporary sanctuary for highly adaptable species [30]. In summary, the environment plays a crucial role in the life cycle of odonata. As shown in Figure 4, the *Libellulidae* family can thrive in environments with limited water availability, such as grasslands, demonstrating its adaptability and environmental versatility. In contrast, the *Platycnemididae* family exhibits strong dependence on water for larval development.

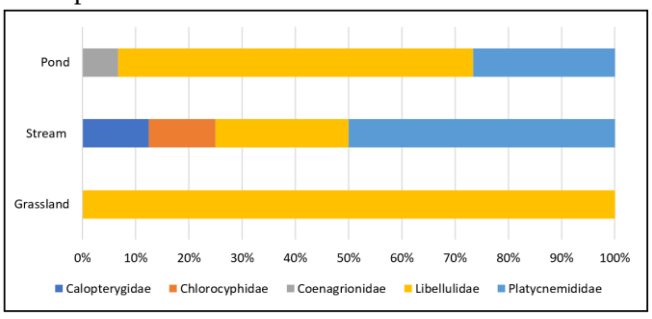

Figure 4. The total number of Odonata individuals found across various habitat types (pond, stream, and grassland areas) (calculated by the authors from the survey data)

3.3. Dominance Index (D), Simpson's Index (D'), Shannon Wiener Diversity Index (H'), and Index of Evenness (E)

Figure 5 illustrates various biodiversity indices, including the diversity index (H'), evenness index (J), dominance index (D), and richness index (R) for odonata species in Peramun Hills across three different habitats (ponds, streams, and grasslands). The diversity index serves as a quantitative measure of the biotic richness and ecosystem health. Figure 5a shows that pond habitats have a high diversity of approximately 2.48. Under such conditions, this habitat could support odonata living as *Libellulidae* and *Platycnemididae* species owing to the availability of water, vegetation, and minimal disturbances. This aligns with a previous study that revealed that a high diversity index for complex and stable ecosystems with less impact from external disturbances could promote the coexistence of multiple species [18]. In grassland areas, the diversity index was moderate, at approximately 2.07. This level is primarily attributed to the adaptability of *Libellulidae* species, such as *Pantala flavescens*, which thrives in less aquatic environments. In contrast, stream areas showed the lowest diversity index (as low as 1.97). This phenomenon occurs because of the dynamic nature of flowing water, which restricts the habitat to a smaller range of species, particularly those dependent on water flow, such as *Platycnemididae* [31].

The evenness index measures the distribution of species within habitats (Figure 5b). This indicates that stream habitats exhibit the highest evenness (0.95), meaning that species are more evenly distributed without one species dominating. Ecosystems with high evenness typically show a balanced species composition, which helps reduce the ecological pressure from dominant species. This even distribution is attributed to the presence of species from the *Libellulidae* and *Platycnemididae* families. However, the slightly lower evenness index in ponds and grasslands (both 0.94) suggests that certain species, particularly from the *Libellulidae* family, dominate these habitats, likely because of their adaptability to the environmental conditions in these areas [22].

The pond area showed the lowest dominance index (as low as 0.09 (Figure 5c). This indicates minimal species supremacy and supports the high biodiversity recorded in this habitat. A previous study implied that a low dominance level reflects a stable community with no overwhelming species dominance, leading to overall ecosystem health (citation). Conversely, stream areas (0.15) and grassland areas (0.14) showed slightly higher dominance, implying that a few species dominate these habitats. In grasslands, species like *Pantala flavescens* likely dominate because of their ability to thrive in non-aquatic environments, whereas in streams, *Platycnemididae* species, which depend on

flowing water for larval development, are more prevalent.

Based on the richness index presented in Figure 5d, ponds showed the most species-rich habitat, with an index of 2.73, reflecting a greater number of species in this environment. Richness is a key indicator of the variety of species present in a habitat and is often correlated with favorable environmental conditions. The presence of both *Libellulidae* and *Platycnemididae* species in ponds, along with ample prey and breeding sites, explains their high species richness. In contrast, grasslands (1.78) and streams (1.63) exhibited lower richness, which can be attributed to the limited water availability in grasslands and the dynamic conditions of streams, which restrict the number of thriving species. It can be concluded that diverse habitats, especially ponds, are crucial for conserving the rich biodiversity of Odonata species in Peramun Hills, as they provide the necessary conditions for species survival and proliferation across different ecological niches.

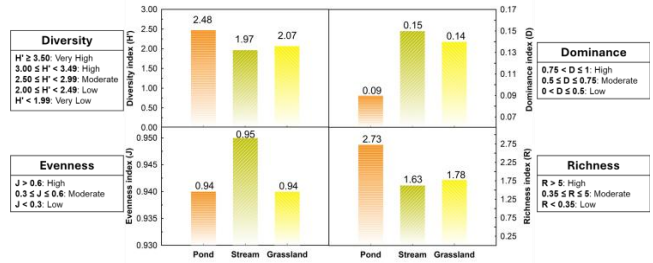

Figure 5. Variation in (a) biodiversity, (b) evenness, (c) dominance, and (d) richness index of odonata in Peramun hills (calculated by the authors from the survey data)

3.4 Conservation Program and Environmental Implications

The conservation program implemented in Peramun Hills, designated as a natural reserve, is a crucial approach to safeguard and serve as the last refuge for species within this area against human-induced threats, such as Odonata [32]. If conservation area management is inadequate, these regions may fail to sustain the species they are meant to protect [33]. There are at least four actionable steps that can be implemented to improve the quality of conservation efforts: integrating odonata species into existing management strategies, strategically designating new protected areas for key odonata species, designing broader odonata species conservation initiatives, and investing in monitoring and research efforts [34]. As a natural reserve, Peramun Hills are protected by various stakeholders, including the government, local communities, and national corporations. Each stakeholder plays a vital role in this process. For instance, the Belitung Regency government regulates and creates policies related to the management of the Peramun Hills area, while the local Air Selumar (ARSEL) community works on habitat preservation. National corporations such as PT PJB UBJOM PLTU Suge Belitung can support these efforts through funding and direct conservation actions. For example, by 2023, a tree-planting program was implemented, with a total of 5,634 individual trees planted in the Peramun Hills area. Under such conditions, *Dillenia suffruticosa* is commonly found near wetlands and water bodies. Its ability to thrive in moist environments helps maintain water quality and ecosystem balance. *Casuarina equisetifolia* has a well-developed root system that helps prevent soil erosion around water bodies, thereby reducing sedimentation in water habitats. Less sedimentation leads to clearer water, which is essential for the development of odonata larvae. In addition, this action could protect the habitat of *Belitung Tarsius*.

4. Conclusion

4.1. Main Findings of the Present Study

This study highlights the vital role of varied habitats in sustaining the biodiversity of Odonata species within the Peramun Hills Natural Reserve, Belitung Island. Pond habitats demonstrated the highest species richness and diversity, with a Shannon-Wiener diversity index (H') of 2.48 and a low dominance index (D = 0.09). Grasslands supported adaptable species such as *Pantala flavescens*, while streams exhibited higher evenness (J = 0.95), favoring species sensitive to water quality, such as *Prodasineura collaris*. Importantly, the detection of *Tetrathemis flavescens*, a near-threatened species, underscores its potential as a bioindicator for future monitoring.

4.2. Comparison with Other Studies

Unlike previous studies, which primarily focused on specific habitat types, this study explored the impact of various habitat matrices on the abundance of Odonata species. By comparing ponds, grasslands, and streams, this research highlights habitat-specific preferences and adaptability, such as the widespread presence of *Neurothemis fluctuans*. Additionally, the role of *Tetrathemis flavescens* as a bioindicator provides a unique contributes to the understanding of species-environment interactions, complementing findings from other studies on tropical odonata diversity.

4.3. Implications of the Study

This study emphasizes the importance of conserving both aquatic and semi-aquatic ecosystems to ensure the survival of diverse odonata species. The presence of near-threatened species, such as *Tetrathemis flavescens* provides an opportunity to integrate bioindicators into conservation strategies. Furthermore, biodiversity indices suggest that habitat preservation efforts should focus on maintaining the ecological stability and species richness through collaborative management.

4.4 Recommendations and Future Research

Effective conservation programs should prioritize habitat restoration and protection, particularly for ponds and streams. Collaborative initiatives involving local communities, government agencies, and private stakeholders can enhance habitat preservation. Consistent biodiversity monitoring using robust indices is recommended for tracking ecological changes and species populations. Future research should focus on the impacts of environmental fluctuations and anthropogenic activities on odonata distribution, as well as the long-term benefits of incorporating bioindicators in conservation planning.

Declarations

Author Contributions

Conceptualization, P.I.P. and T.T.K; methodology, P.I.P.; software, P.I.P. and F.S.; validation, P.I.P., T.T.K., D.I.S. and A.E.; formal analysis, F.S. and Y.A.S.; investigation, P.I.P., T.T.K., D.I.S., F.S. and A.E.; resources, P.I.P., T.T.K., D.I.S. and A.E.; data curation, F.S. and Y.A.S.; writing—original draft preparation, all authors contributed equally; writing—review and editing, F.S., A.E. and Y.A.S.; visualization, P.I.P. and F.S.; supervision, P.I.P. and A.E.; project administration, T.T.K. and D.I.S.; funding acquisition, P.I.P., T.T.K., D.I.S. and A.E. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

No new data were created or analyzed in this study. Data sharing is not applicable to this article.

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Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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