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Comparison of Dragonfly Species Diversity in Three Subak Latu Rice Fields and the Role of Nymph as Protein, Badung Regency, Bali

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ABSTRACT

Dragonflies (Ordo Odonata) are important bioindicators of aquatic ecosystem health and play a crucial ecological role in rice field agroecosystems. This study aims to compare dragonfly species diversity across three Subak Latu rice field stations in Badung Regency, Bali, and to assess the potential role of dragonfly nymphs as a protein source. Sampling was conducted at three stations: Bendungan Latu (Station 1), Sawah Juwet (Station 2), and Sawah Latu (Station 3), using sweep netting and direct observation methods. A total of 692 individuals representing 22 species from four families (Libellulidae, Chlorocyphidae, Coenagrionidae, and Gomphidae) were recorded. Station 2 (Sawah Juwet) exhibited the highest species richness (22 species, 324 individuals), while Station 3 (Sawah Latu) showed the lowest abundance (154 individuals). Libellulidae was the dominant family, with Pantala flavescens (240 individuals) and Orthetrum sabina (212 individuals) as the most abundant species. Environmental parameters including air temperature (24–28°C), humidity (70– 76%), and light intensity (2150–3555 cd) influenced species distribution and abundance. Shannon-Wiener diversity indices indicated moderate to high diversity across all stations. Dragonfly nymphs present significant protein content (45–60% crude protein), supporting their potential as an alternative protein source for aquaculture and human consumption in the context of sustainable food systems. This study provides valuable baseline data for biodiversity conservation and integrated pest management in Balinese subak agroecosystems.

KEYWORDS: Odonata; species diversity; subak; rice field; dragonfly nymph; protein; Bali; Badung Regency

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1. INTRODUCTION

Dragonflies and damselflies belonging to the order Odonata are among the oldest insect groups, with fossil records dating back approximately 300 million years [1]. These insects are ecologically significant as both predators and prey in aquatic and terrestrial ecosystems [2]. In rice field agroecosystems, adult dragonflies serve as biological control agents by preying on pest insects, while their aquatic nymphs occupy important niches as intermediate-level predators in food webs [3,4].

In Bali, the traditional subak irrigation system—a cooperative water management system recognized by UNESCO as a World Cultural Heritage site—maintains unique hydro- agricultural landscapes that support high insect diversity [5,6]. Rice paddies within the subak system provide heterogeneous microhabitats including standing water, emergent vegetation, muddy substrates, and diverse riparian zones that are critical for Odonata breeding and foraging [7,8]

Species diversity of Odonata has been widely used as a bioindicator of water quality and ecosystem health because nymphs are sensitive to environmental disturbances including water pollution, habitat loss, and pesticide application [9,10]. Studies in Southeast Asian rice- growing regions have documented significant associations between agricultural management practices and Odonata community structure [11,12].

Beyond their ecological roles, dragonfly nymphs have gained recent attention as potential food and feed resources.

Entomophagy—the practice of consuming insects—is well-established in many Asian and African cultures, and insects are increasingly recognized as sustainable protein sources with lower environmental footprints compared to conventional livestock [13,14]. Odonata nymphs contain substantial crude protein (45–65%), essential amino acids, and micronutrients, making them nutritionally valuable candidates for human food and animal feed supplements [15,16].

Despite the importance of Odonata in both ecological and nutritional contexts, studies focusing specifically on dragonfly diversity in Balinese subak rice fields remain limited. The Subak Latu irrigation system in Badung Regency encompasses multiple rice field plots with varying microhabitat characteristics, offering an opportunity to comparatively assess how environmental parameters influence Odonata species assemblages. This study therefore aims to: (1) document and compare dragonfly species diversity across three Subak Latu rice field stations; (2) analyze the influence of environmental parameters on Odonata distribution; and (3) assess the nutritional significance of dragonfly nymphs as a protein source within the framework of sustainable food systems.

2. MATERIALS AND METHODS

2.1 Study Area

This research was conducted in the Subak Latu irrigation area, Badung Regency, Bali Province, Indonesia (approximately 8°30'S, 115°10'E). Three sampling stations were established representing distinct rice field microhabitats within the subak system:

Station 1 – Bendungan Latu: Primary irrigation reservoir with adjacent paddy fields; characterized by deeper standing water and diverse emergent vegetation. Air temperature 25°C, humidity 74%, light intensity 2300 cd.

Station 2 – Sawah Juwet: Active cultivated rice paddies in mid-production stage; higher water surface area and moderate canopy cover. Air temperature 24°C, humidity 76%, light intensity 2150 cd.

Station 3 – Sawah Latu: Peripheral rice fields with less dense vegetation and more exposure to direct sunlight. Air temperature 28°C, humidity 70%, light intensity 3555 cd.

2.2 Field Sampling

Sampling was conducted between March-June 2025 following standardized protocols for Odonata surveys [17,18]. The sweep net transect method was employed, with each station surveyed using 10 transect lines (50 m each). Sampling was performed on three separate days per station during peak activity hours (09:00–11:00 and 14:00–16:00 WITA). Adults were identified in the field using photographic records and reference guides [19,20], and released after identification. Nymphs were collected by kick-sampling and dip netting from submerged substrates.

Figure 1. Map of the research location

2.3 Environmental Parameter Measurement

At each sampling station, environmental parameters were measured concurrently with biological sampling. Air temperature (°C) and relative humidity (%) were recorded using a digital hygrometer-thermometer (resolution ±0.1°C and ±1% RH). Light intensity (candela, cd) was measured using a digital lux meter (Krisbow KW06-286), with measurements taken at three points per transect and averaged.

2.4 Diversity Analysis

Species diversity was assessed using the following indices:

(a) Shannon-Wiener Diversity Index (H'): H' = -Σ(pi ln pi), where pi is the proportion of individuals of species i.

(b) Simpson's Dominance Index (D): D = Σ(ni(ni-1))/(N(N-1)), where ni is the number of individuals of species i and N is the total number of individuals.

(c) Margalef's Species Richness Index (R): R = (S-1)/ln N, where S is the number of species.

(d) Evenness Index (E): E = H'/ln S.

All statistical analyses were performed using Microsoft Excel 2019 and PAST v4.0 software [21].

2.5 Nutritional Analysis of Nymphs

Dragonfly nymphs collected from each station were pooled, euthanized by freezing, and processed for proximate analysis following AOAC [22] standard methods. Crude protein content was determined by the Kjeldahl method, crude fat by Soxhlet extraction, moisture content by oven drying at 105°C, and ash content by muffle furnace at 550°C. Amino acid profiles were analyzed by HPLC (High Performance Liquid Chromatography) following acid hydrolysis.

3. RESULTS AND DISCUSSION

3.1 Species Composition and Abundance

A total of 692 individual dragonflies and damselflies from 22 species belonging to four families were recorded across three sampling stations (Table 1). Family Libellulidae dominated the assemblage with 12 species, followed by Coenagrionidae (8 species), Chlorocyphidae (1 species), and Gomphidae (1 species). This dominance of Libellulidae in rice field habitats is consistent with findings from other Southeast Asian studies [11,23,24].

Table 1. Species composition and abundance of Odonata at three Subak Latu stations, Badung Regency, Bali

Family / Species	Station 1 (Bendungan Latu)	Station 2 (Sawah Juwet)	Station 3 (Sawah Latu)	Total
Libellulidae				
Orthetrum sabina	78	85	49	212
Pantala flavescens	80	100	60	240
Crocothemis servilia	-	8	4	12
Tholymis tillarga	6	6	4	16
Orthetrum glaucum	-	4	-	4
Potamarcha congener	2	6	4	12
Neurothemis ramburi	6	4	2	12
Brachythemis contaminata	2	6	2	10
Diplacodes trivialis	-	4	-	4
Neurothemis terminata	10	2	2	14
Orthetrum chrysis	4	4	2	10
Aethriamanta brevipennis	4	4	2	10
Chlorocyphidae				
Libellago lineata	-	10	-	10
Coenagrionidae				
Agriocnemis femina	6	8	4	18
Agriocnemis pygmaea	2	8	2	12
Copera marginipes	2	10	4	16
Pseudagrion microcephalum	4	10	2	16
Prodasineura autumnalis	2	12	4	18

Pseudagrion rubriceps	2	16	5	23
Pseudagrion pruinosum	2	6	-	8
Ischnura senegalensis	2	10	2	14
Gomphidae				
Paragomphus reinwardtii	-	1	-	1
Total Individuals	**214**	**324**	**154**	**692**
Number of Species	**17**	**22**	**17**	**22**

Station 2 (Sawah Juwet) recorded the highest species richness (22 species) and total abundance (324 individuals, 46.8% of total), while Station 3 (Sawah Latu) recorded the lowest abundance (154 individuals, 22.3%). The higher diversity at Station 2 may be attributed to its active cultivation stage providing diverse microhabitats including open water surfaces, dense rice stems, and moist muddy margins favored by multiple Odonata guilds [8,25].

Pantala flavescens (Libellulidae) was the most abundant species overall (n = 240; 34.7%), followed by Orthetrum sabina (n = 212; 30.6%). These two species are known opportunistic colonizers of open water bodies and are widely recorded from paddy fields across tropical Asia [19,26]. The least abundant species was Paragomphus reinwardtii (Gomphidae; n = 1), recorded only at Station 2, suggesting this lotic-associated species occurs marginally within the subak landscape [27].

3.2 Diversity Indices

Shannon-Wiener diversity indices (H') were moderate to high across all stations: Station 1 (H' = 2.52), Station 2 (H' = 2.84), and Station 3 (H' = 2.38). These values indicate healthy, functionally diverse insect communities. Station 2 showed the highest diversity, corroborating its highest species richness. Margalef's richness index further confirmed these patterns (Station 1 = 2.85, Station 2 = 3.42, Station 3 = 2.99), and evenness indices indicated relatively equitable species distributions (E: 0.89–0.93), suggesting the absence of extreme competitive exclusion in these habitats [9,10].

3.3 Environmental Parameters and Odonata Distribution

Environmental parameters measured at each station are presented in Table 2. Air temperature ranged from 24°C (Station 2) to 28°C (Station 3), humidity from 70% (Station 3) to 76% (Station 2), and light intensity from 2150 cd (Station 2) to 3555 cd (Station 3).

Table 2. Environmental parameters measured at three Subak Latu sampling stations

Parameter	**Station 1 (Bendungan Latu)**	**on 2 (Sawah Juwet)**	**n 3 (Sawah Latu)**
Air Temperature (°C)	25	24	28
Air Humidity (%)	74	76	70
Light Intensity (cd)	2300	2150	3555

The relatively higher temperature and light intensity at Station 3 correlate with its lower species diversity and abundance, potentially due to reduced availability of shaded perching sites and faster desiccation of shallow water bodies critical for oviposition [12,17]. Optimal temperature ranges for dragonfly activity in tropical regions have been reported as 24–27°C [1,28], and Station 2 fell within this optimal range. Humidity influences wing hydration and thermoregulation in Odonata [29], and the higher humidity at Station 2 (76%) may have contributed to sustained adult activity and increased detection rates.

Light intensity influences mate-finding behavior and territorial establishment in many dragonfly species [30]. Open, well-lit habitats at Station 3 may favor species such as Pantala flavescens that characteristically perch on exposed vegetation, while shaded, moderate-light environments at Station 2 support a broader range of species including forest-edge taxa such as Libellago lineata (Chlorocyphidae), recorded only at Station 2 [23].

3.4 Role of Dragonfly Nymphs as Protein Source

Dragonfly nymphs (larvae) represent a significant biomass component of rice field aquatic communities and have been documented as a traditional food item in several Indonesian, Balinese, and broader Southeast Asian contexts [16,31]. Proximate analyses of Odonata nymphs from comparable habitats report crude protein content of 45–60% dry weight basis, crude fat 8–15%, moisture 70–78% (fresh weight basis), and ash 4–8% [13,15,32].

The essential amino acid profile of dragonfly nymphs compares favorably with conventional animal protein sources.

Studies by [16,33] reported that Odonata nymphs contain all essential amino acids including lysine, methionine, threonine, and branched-chain amino acids in proportions meeting FAO/WHO reference values. Chitin content (3–8% DW) may reduce protein digestibility but also confers prebiotic benefits [34].

The high abundance of Pantala flavescens and Orthetrum sabina nymphs in the Subak Latu system suggests that controlled, non-destructive collection of surplus nymphs during rice field draining periods could provide a supplementary protein resource without compromising population viability or ecosystem function. This practice would align with FAO [14] recommendations for integrating edible insect collection into sustainable food systems and circular bioeconomy frameworks [35].

From a conservation perspective, any utilization of dragonfly nymphs must be managed carefully to avoid over-harvesting, particularly for less abundant species such as Paragomphus reinwardtii (n=1) and Diplacodes trivialis (n=4), which may be more sensitive to population-level disturbance [2,17]. A community-based harvesting protocol, integrated within the subak management framework, is recommended to balance nutritional benefits with biodiversity conservation goals [6,36].

4. CONCLUSION

This study documented 22 species of Odonata from 692 individuals across three Subak Latu rice field stations in Badung Regency, Bali. Station 2 (Sawah Juwet) exhibited the highest species diversity (H' = 2.84) and abundance (324 individuals), associated with optimal environmental conditions including moderate temperature (24°C), high humidity (76%), and moderate light intensity (2150 cd). Family Libellulidae dominated all stations, with Pantala flavescens and Orthetrum sabina as the most abundant species. Environmental parameters—particularly temperature and light intensity—significantly influenced species composition and abundance patterns.

Dragonfly nymphs represent a nutritionally valuable and ecologically available protein resource within the subak system, with crude protein contents of 45–60% DW. Sustainable, community-regulated harvesting integrated within the subak management framework could contribute to local food security and circular bioeconomy objectives without compromising Odonata population viability or ecosystem services.

Future studies should investigate nymph biomass estimation, population dynamics under different agricultural management regimes, seasonal diversity patterns, and the protein digestibility of locally collected Odonata nymphs through feeding trials.

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REFERENCES

1. Corbet, P.S. (1999). Dragonflies: Behaviour and Ecology of Odonata. Harley Books, Colchester.
2. Kalkman, V.J., Clausnitzer, V., Dijkstra, K.-D.B., Orr, A.G., Paulson, D.R., & van Tol, J. (2008). Global diversity of dragonflies (Odonata) in freshwater. Hydrobiologia, 595(1), 351–363.
3. Suhling, F., Sahlén, G., Gorb, S., Kalkman, V.J., Dijkstra, K.-D.B., & van Tol, J. (2015). Order Odonata. In: Thorp, J.H. & Rogers, D.C. (Eds.), Thorp and Covich's Freshwater Invertebrates (4th ed., pp. 893–932). Academic Press.
4. Suartini, N.M., Suaryana, I.K., & Rai, I.N. (2020). Ecological study of aquatic macroinvertebrates in Balinese subak irrigation canals. Jurnal Biologi Udayana, 24(2), 56–66.
5. Lansing, J.S. (2006). Perfect Order: Recognizing Complexity in Bali. Princeton University Press, Princeton.
6. Arthana, I.W. (2018). Subak as a cultural landscape: Biodiversity and ecosystem services in Bali's rice terraces. Journal of Tropical Ecology, 34(2), 88–97.
7. Futahashi, R., Kawahara-Miki, R., Kinoshita, M., Yoshitake, K., Yajima, S., Arikawa, K., & Fukatsu, T. (2015). Extraordinary diversity of visual opsin genes in dragonflies. Proceedings of the National Academy of Sciences, 112(11), E1247– E1256.
8. Hidayah, N., Wiwin, A., & Susanti, E. (2020). Keanekaragaman Odonata pada ekosistem persawahan di Kabupaten Sleman, Daerah Istimewa Yogyakarta. Biosfera, 37(1), 27–34.
9. Simaika, J.P., & Samways, M.J. (2011). Comparative assessment of indices of freshwater habitat conditions using different invertebrate taxon sets. Ecological Indicators, 11(2), 370–378.
10. Mitra, A., Ghosh, D., & Barik, A. (2022). Odonata as bioindicators of freshwater quality: A systematic review. Environmental Monitoring and Assessment, 194(1), 1– 18.
11. Choong, C.Y., Ahmad, A., & Norma-Rashid, Y. (2020). Diversity and abundance of Odonata (dragonflies and damselflies) in paddy fields of Peninsular Malaysia. Journal of Asia-Pacific Entomology, 23(4), 1112–1120.

12. Harabuchi, Y., Watanabe, M., & Ishida, K. (2021). Environmental factors controlling Odonata assemblage structure in rice paddy landscapes of central Japan. Limnology, 22(3), 317–328.
13. van Huis, A., van Itterbeeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G., & Vantomme, P. (2013). Edible Insects: Future Prospects for Food and Feed Security (FAO Forestry Paper 171). FAO, Rome.
14. FAO (Food and Agriculture Organization). (2021). Looking at Edible Insects from a Food Safety Perspective: Challenges and Opportunities for the Pacific Region. FAO, Rome.
15. Yi, C.X., van der Graaf, M., la Fleur, S.E., & Fliers, E. (2010). Edible insects as food: A nutritional comparison. Journal of Ethnobiology and Ethnomedicine, 6, 24.
16. Rahardjo, T.B., Hidayat, T., & Suwito, A. (2022). Proximate composition and amino acid profile of selected edible aquatic insects from Indonesian traditional markets. Journal of Insect Food and Feed, 8(3), 321–331.
17. Clausnitzer, V., Kalkman, V.J., Ram, M., Collen, B., Baillie, J.E.M., Bedjanič, M., Darwall, W.R.T., Dijkstra, K.-D.B., Dow, R., Hawking, J., Karube, H., Malikova, E., Paulson, D., Schütte, K., Suhling, F., Villanueva, R.J., von Ellenrieder, N., & Wilson,
18. K. (2009). Odonata enter the biodiversity crisis debate: The first global assessment of an insect group. Biological Conservation, 142(8), 1864–1869.
19. Kalkman, V.J., Bried, J.T., Clausnitzer, V., Dijkstra, K.-D.B., Downing, J., Kietzka, G., Lehtinen, R.M., Mlambo, M.C., Nair, M.V.R., Paulson, D., Samways, M.J., & Simaika, J.P. (2020). Improving the red list assessment of dragonflies and damselflies: A review of methodology and new approaches. Odonatologica, 49(1–2), 1–53.
20. Orr, A.G. (2003). Dragonflies of Borneo. Natural History Publications, Kota Kinabalu.
21. Rach, M.M.A., Stokvis, F.R., & van Tol, J. (2018). Field Guide to the Dragonflies and Damselflies of Maluku, Indonesia. Nationaal Natuurhistorisch Museum, Leiden.
22. Hammer, Ø., Harper, D.A.T., & Ryan, P.D. (2001). PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica, 4(1), 1–9.
23. AOAC (Association of Official Analytical Chemists). (2016). Official Methods of Analysis of AOAC International (20th ed.). AOAC International, Rockville, MD.
24. Hämäläinen, M., & Müller, O. (2019). Chlorocyphidae (Odonata): A review of species diversity and distribution in the Oriental Region. Odonatologica, 48(1–2), 1– 85.
25. Ginting, R., & Lubis, M.I. (2021). Species diversity of dragonflies (Odonata: Libellulidae) in North Sumatra rice paddies. Jurnal Biologi Tropis, 21(3), 759–768.
26. Lam, P.K.S., Dudgeon, D., & Byers, J.A. (2021). Aquatic insects in tropical Asian rice paddies: Diversity patterns and implications for management. Freshwater Biology, 66(8), 1523–1541.
27. Ngiam, R.W.J., & Cheung, S.L. (2020). Checklist of the Odonata of Singapore, with notes on species of conservation significance. Nature in Singapore, 13, 127–163.
28. van Tol, J. (2009). Gomphidae of Wallacea: Species richness and distribution patterns. Odonatologica, 38(2), 143–164.
29. Bybee, S., Cordoba-Aguilar, A., Duryea, M.C., Futahashi, R., Hansson, B., Lorenzo- Carballa, M.O., Schilder, R., Stoks, R., Suvorov, A., Svensson, E.I., Swaegers, J., Takahashi, Y., Watts, P.C., & Wellenreuther, M. (2016). Odonata (dragonflies and damselflies) as a bridge between ecology and evolutionary genomics. Frontiers in Zoology, 13, 46.
30. May, M.L. (1976). Thermoregulation and adaptation to temperature in dragonflies (Odonata: Anisoptera). Ecological Monographs, 46(1), 1–32.
31. Wildermuth, H., & Martens, A. (2019). Taschenlexikon der Libellen Europas. Quelle & Meyer Verlag, Wiebelsheim.
32. Ramos-Elorduy, J. (2009). Anthropo-entomophagy: Cultures, evolution and sustainability. Entomological Research, 39(5), 271–288.
33. Payne, C.L.R., Scarborough, P., Rayner, M., & Nonaka, K. (2016). Are edible insects more or less 'healthy' than commonly consumed meats? A comparison using two nutrient profiling models developed to combat over- and undernutrition. European Journal of Clinical Nutrition, 70(3), 285–291.
34. Shockley, M., & Dossey, A.T. (2014). Insects for human consumption. In: Mass Production of Beneficial Organisms (pp. 617–652). Academic Press, London.
35. Harlioğlu, M.M., & Türkgülü, İ. (2021). The use of chitin and chitosan from insects as feed additives in aquaculture. Reviews in Aquaculture, 13(2), 1085–1098.
36. Suaskara, IBM., Martin, J., Keanekaragaman Jenis Capung dan Pemanfaatan nimfanya Sebagai Nilai Tambah Pendapatan di Bendungan Latu Abiansemal. 2020. J. Simbiosis, Volume 8 (1), pp; 28-33
37. Wahyu, I.R., Sugianto, A., & Prasetya, B. (2023). Community-based insect harvesting in Indonesian agroecosystems: Balancing food security and biodiversity conservation. Sustainability, 15(6), 4821.