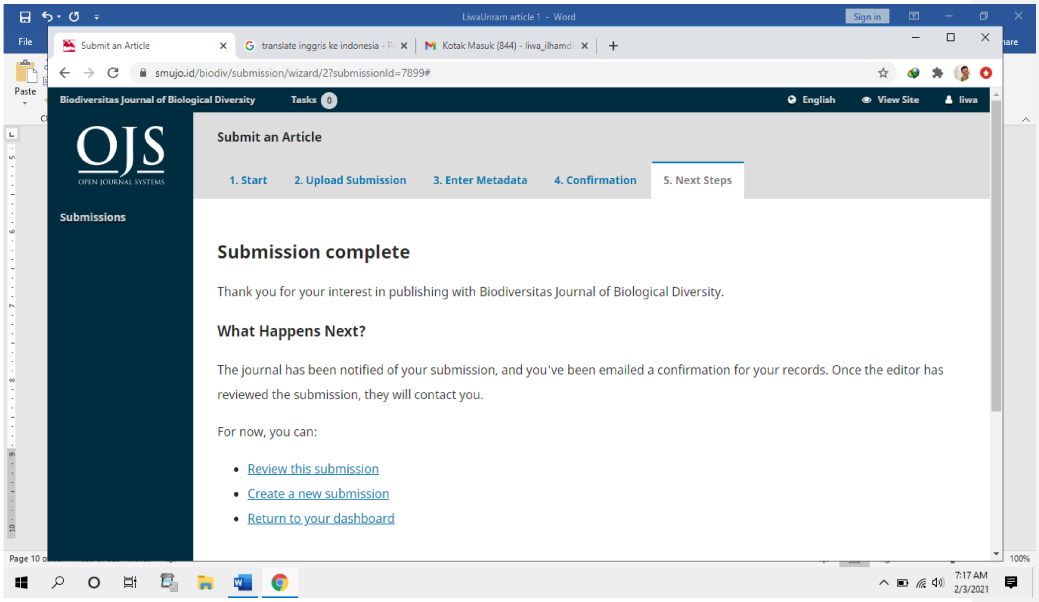
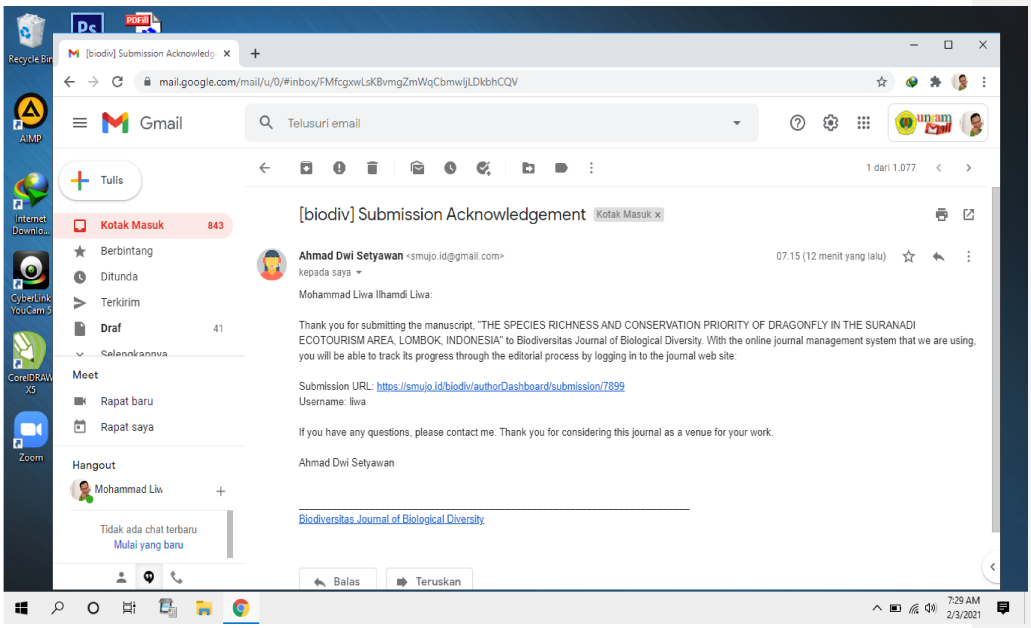
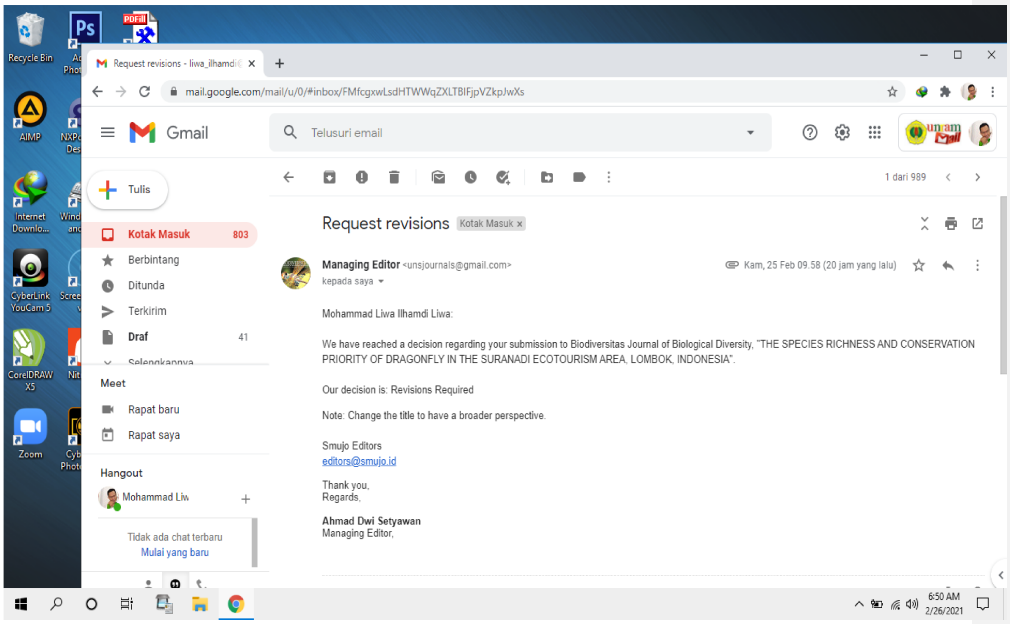
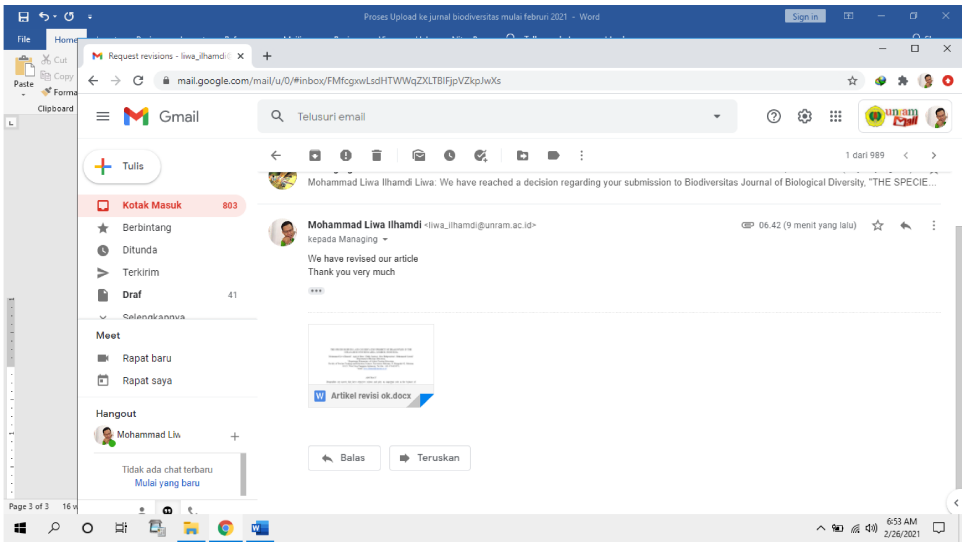
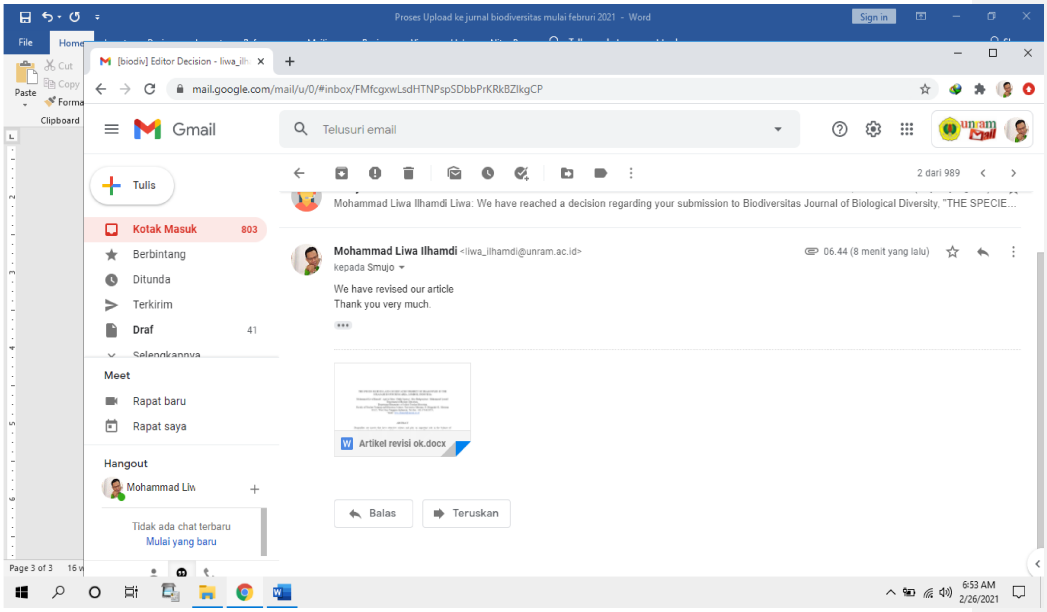
Biodiversitas Journal
2021



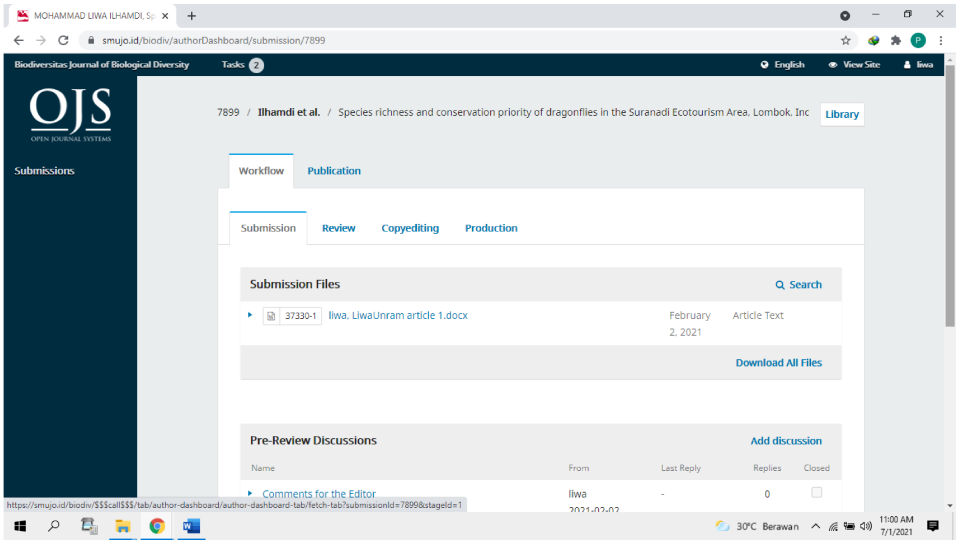



Request revisions - liwa_ilhamdi
mail.google.com/mail/u/0/#inbox/FMfcgxwLsdHTWWqZXLTBlFjpVZkpJwXs
Gmail
Telusuri email
Tulis
Kotak Masuk 803
Berbintang
Ditunda
Terkirim
Draf 41
Meet
Rapat baru
Rapat saya
Hangout
Mohammad Liw
Tidak ada chat terbaru
Mulai yang baru
1 dari 989
Request revisions
Kotak Masuk
Managing Editor <unsjournals@gmail.com>
kepada saya
Kam, 25 Feb 09.58 (20 jam yang lalu)
Mohammad Liwa Ilhamdi Liwa:
We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "THE SPECIES RICHNESS AND CONSERVATION PRIORITY OF DRAGONFLY IN THE SURANADI ECOTOURISM AREA, LOMBOK, INDONESIA".
Our decision is: Revisions Required
Note: Change the title to have a broader perspective.
Smujo Editors
editors@smujo.id
Thank you,
Regards,
Ahmad Dwi Setyawan
Managing Editor,
6:50 AM
2/26/2021

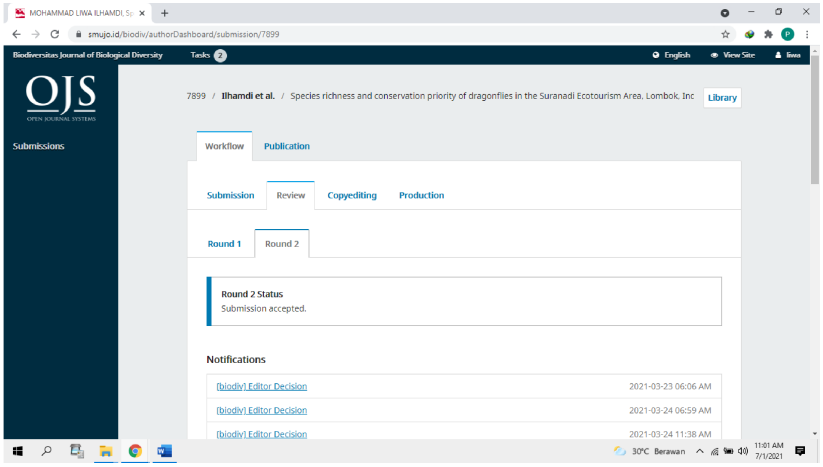

Proses Upload ke jurnal biodiversitas mulai Februri 2021 - Word
Request revisions - liwa_ilhamdi
mail.google.com/mail/u/0/#inbox/FMfcgxwLsdHTWWqZXLTBlFjpVZkpJwXs
Gmail
Telusuri email
Tulis
Kotak Masuk 803
Berbintang
Ditunda
Terkirim
Draf 41
Meet
Rapat baru
Rapat saya
Hangout
Mohammad Liw
Tidak ada chat terbaru
Mulai yang baru
1 dari 989
Mohammad Liwa Ilhamdi Liwa: We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "THE SPECIE...
Mohammad Liwa Ilhamdi <liwa_ilhamdi@unram.ac.id>
kepada Managing
06.42 (9 menit yang lalu)
We have revised our article
Thank you very much
Artikel revisi ok.docx
Balas
Teruskan
6:53 AM
2/26/2021

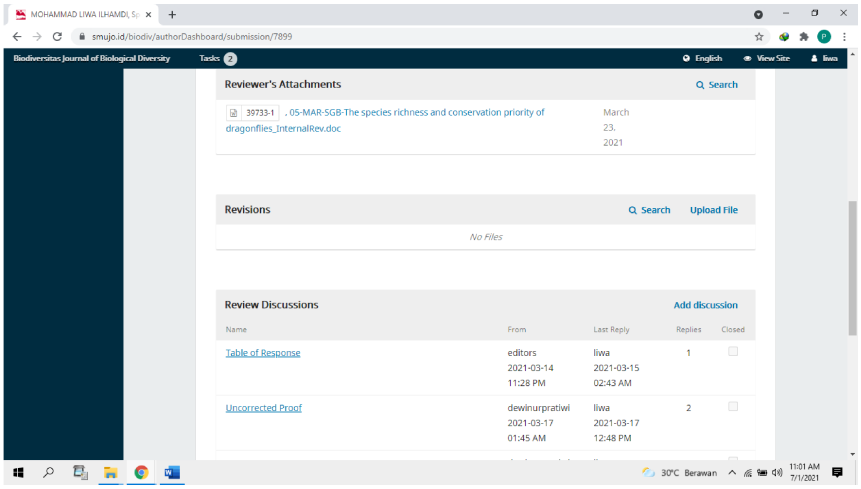

Proses Upload ke jurnal biodiversitas mulai februri 2021 - Word
Sign in
[biodiv] Editor Decision - liwa_ilh
mail.google.com/mail/u/0/#inbox/FMfcgxwLsdHTNPspSDbbPrKRkBZlkgCP
Gmail
Telusuri email
Tulis
Kotak Masuk 803
Berbintang
Ditunda
Terkirim
Draf 41
Meet
Rapat baru
Rapat saya
Hangout
Mohammad Liw
Tidak ada chat terbaru
Mulai yang baru
2 dari 989
Mohammad Liwa Ilhamdi Liwa: We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "THE SPECIE...
Mohammad Liwa Ilhamdi <liwa_ilhamdi@unram.ac.id>
kepada Smujo
06.44 (8 menit yang lalu)
We have revised our article
Thank you very much.
Artikel revisi ok.docx
Balas
Teruskan
6:53 AM
2/26/2021

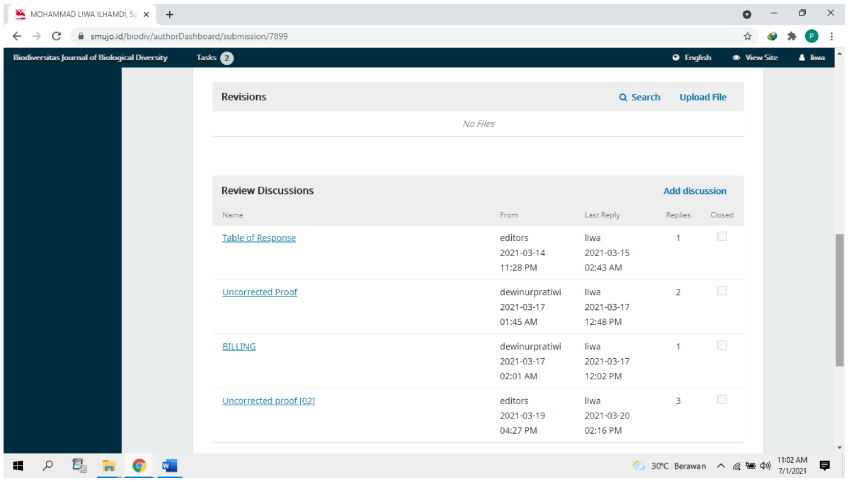
SUBMISSION



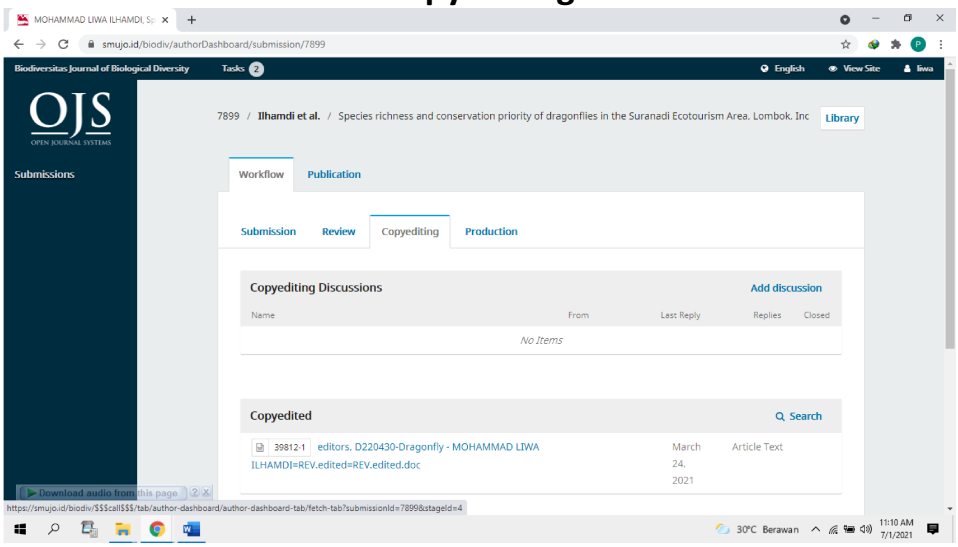
review



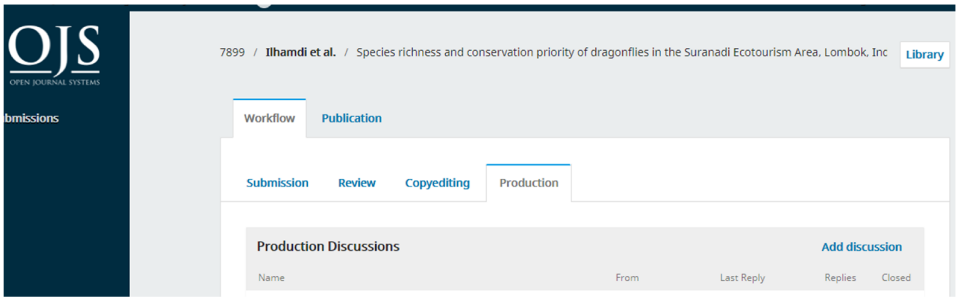

MOHAMMAD LIWA ILHAMDI, Sp
smujo.id/biodiv/authorDashboard/submission/7899
Biodiversitas Journal of Biological Diversity
Tasks 2
English
View Site
liwa
Reviewer's Attachments
Search
39733-1 . 05-MAR-SGB-The species richness and conservation priority of dragonflies_InternalRev.doc
March 23, 2021
Revisions
Search
Upload File
No Files
Review Discussions
Add discussion
Name
From
Last Reply
Replies
Closed
Table of Response
editors 2021-03-14 11:28 PM
liwa 2021-03-15 02:43 AM
1
Uncorrected Proof
dewinurpratiwi 2021-03-17 01:45 AM
liwa 2021-03-17 12:48 PM
2
30°C Berawan
11:01 AM 7/1/2021


MOHAMMAD LIWA ILHAMDI, Sp
smujo.id/biodiv/authorDashboard/submission/7899
Biodiversitas Journal of Biological Diversity
Tasks 2
English
View Site
liwa
Revisions
Search
Upload File
No Files
Review Discussions
Add discussion
Name
From
Last Reply
Replies
Closed
Table of Response
editors 2021-03-14 11:28 PM
liwa 2021-03-15 02:43 AM
1
Uncorrected Proof
dewinurpratiwi 2021-03-17 01:45 AM
liwa 2021-03-17 12:48 PM
2
BILLING
dewinurpratiwi 2021-03-17 02:01 AM
liwa 2021-03-17 12:02 PM
1
Uncorrected proof [02]
editors 2021-03-19 04:27 PM
liwa 2021-03-20 02:16 PM
3
30°C Berawan
11:02 AM 7/1/2021

Copyediting



Production



REVISI 1

The species richness and conservation priority of dragonfly in the Suranadi Ecotourism Area, Lombok, Indonesia

Commented [A1]: Only one priority? I think that different species requires different priorities.

Abstract. Dragonflies are insects that have attractive colorful wings that play an important role in the balance of ecosystems and bioindicators of the aquatic environment. As an effort to conserve and support ecotourism, this research needs to be done. The purpose of this study was to analyze the species richness and conservation priorities of dragonflies in the Suranadi ecotourism area. The research was conducted in August - December 2020 with the survey method through transect lines in 9 types of habitat. Species richness is determined based on the number of species found during observation and conservation priority refers to the PP. No. 57 / Menhut-II / 2008. The number of dragonfly species found was 18 species from 2 suborders (Zygoptera and Anisoptera) 5 families (Chlorocyphidae, Coenagrionidae, Platycnemididae, Aeshnidae and Libellulidae). The habitat type that has the highest species richness is the waterway (16 species), while the lowest species richness is found in the middle forest habitat (2 species). The species that had the highest conservation priority index scores were *Libellago lineata*, *Gynacantha subinterrupta* and *Acisoma panorphoides*. These three species are conservation priority species in the ecotourism area of Suranadi, Lombok, Indonesia.
Keywords: Species richness, conservation priority, dragonfly

INTRODUCTION

The Suranadi Ecotourism Area is one of the tourist areas based on Lombok Barat Regent Regulation No. 41 of 2016. This area consists of various habitats suitable for supporting dragonfly life. Water, which is a very important environmental component for dragonflies (Mafuwe & Moyo, 2020), is available in high volume, scattered in many points and available almost all year round. This area is known as "the city of water", and the main attraction that is used as a tourist is water. Water with suitable characteristics can be used by adult terrestrial dragonflies as spawning grounds and habitat for larvae (Luke et al., 2017). Because of their life cycle in these two habitats, dragonflies have a very important role in terrestrial and aquatic ecosystems.

The important role of dragonflies can be observed in their function as trophic components. As predators and prey, dragonflies become a medium in the process of transferring matter and energy from the trophic component organisms below to other organisms from the trophic above. Adult dragonflies are prey of larger dragonflies, spiders, and various types of vertebrate animals such as frogs (Rüppell et al., 2020). To obtain nutrition, adult dragonflies prey on various types of small animals, especially insects such as bees (Arbeiter et al., 2014). Some species are cannibals by preying on members of the same species. The larval phase that lives in the waters becomes a predator of various other smaller animals. For example, anura larvae (Weterings et al., 2015), and mosquito larvae (Weterings et al., 2015). Linares et al. (2016) found that dragonfly larvae prey on adult anura.

The important role of dragonflies can also be viewed from the aspect of environmental biology. The living conditions that require specific ecological niches make it an environmental bio-indicator, especially aquatic conditions (Nasirian & Irvine, 2017). Some special conditions that make dragonflies as bioindicators are (1) presence or absence of species (Ting et al., 2018), (2) abundance ratio of Anisoptera and Zygoptera (Oliveira-Junior & Juen, 2019), and (3) Ratio of the Libellulidae family against other families in Anisoptera and the ratio of the Coenagrionodae family to other families in Zygoptera (Šigutováa et al., 2019). Their prey, which consists of several types of harmful insects - insect pests and disease vectors - makes dragonflies act as biopesticides (May, 2019). Dragonflies can also become tourist objects because of their attractive and varied colors, both at the level of genes and species.

Its very important role indicates that dragonflies need to be a biodiversity that receives conservation efforts. This effort requires data, one of which is related to species richness. Each species has a different endemicity, population status and threat. Likewise with habitat conditions and management status. Based on these situations and conditions, we conducted research in several types of habitat in the Suranadi Ecotourism Area

with the aim of analyzing species richness and dragonfly conservation priorities. The data from this research can support dragonfly conservation and ecotourism efforts.

MATERIALS AND METHODS

Study area

The research was conducted in the Suranadi Ecotourism Area, Lombok Indonesia. This area is divided into 9 types of habitat, namely forest edges (FE), middle forest (MF), waterways (WW), roads (RO), irrigation (Iri), fields (FD), rice fields (RF), Parks (PR), and the pool (PO). Habitat types FR, MF, RO, FD, PO are terrestrial habitats, while habitat types JA, Iri, FD, and PO are aquatic habitats. The characteristics of each habitat type can be seen in Table 1.

Table 1. Characteristics of habitat types in the Suranadi Ecotourism Area

Habitat Type	Environmental factor						
	Light intensity	Humidity	Air temperature	Tree canopy	Herbaceous plantceous plant cover	Altitude (asl)	Number of plant species
PR	657	75%	29,4	90%	25%	258	20
PO	2903	73%	31	52%	30%	256	22
FD	5958	68%	33,4	30%	60%	256	25
RO	2648	57%	34,3	40%	15%	256	9
Iri	4667	63%	32,2	10%	30%	256	10
RF	7500	61%	34,8	0%	95%	256	5
RD	2800	64%	34,3	80%	91%	256	35
MF	110	69%	29,3	125%	50%	257	30
FE	4490	73%	31,8	25%	80%	256	15

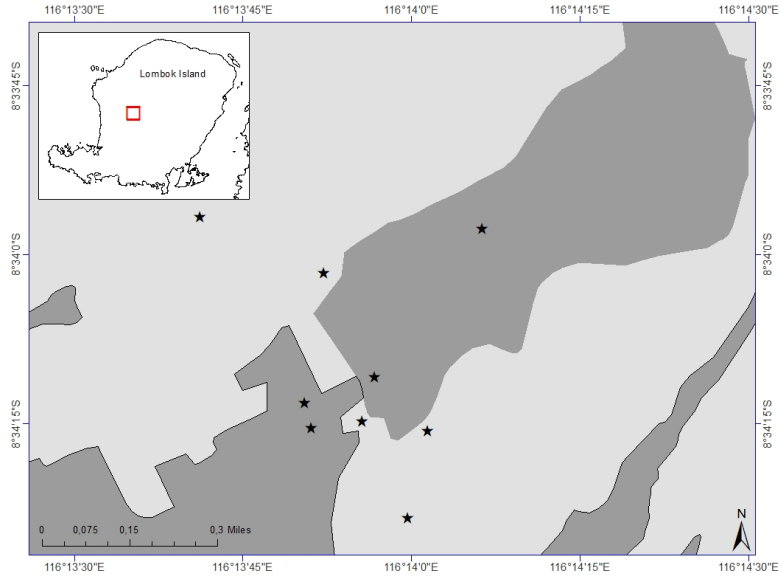


Figure 1. Map of the research location

Research method

Data were collected during August - December 2020 in 9 types of habitat (Figure 1) using direct observation methods. Adult dragonfly samples were captured using insect nets at each observation, with 5 replications. Catching dragonflies is carried out in 2 time periods for each replication, namely morning at 09.00 - 11.00 h, and afternoon at 14.00 - 16.00 h Central Indonesian Time (Wita). The number of dragonfly samples was determined based on the average of all sampled. The sample of the dragonfly was put in a plastic bag, and preserved using 70% alcohol. Identification was carried out at the Basic Biology Laboratory, Mataram

Commented [A2]: What are coordinates? Put other data about of the your study area: e.g. more important species of plants.

Commented [A3]: Why is important the character touristic of this area?

Commented [A4]: Which one is this type of habitat?

Commented [A5]: Which one is this type of habitat?

Commented [A6]: Which one is this type of habitat?

Commented [A7]: How were obtained these data?

Commented [A8]: Abstract says about of transects used to sample. How many transects? What was the length of them?

University. The naming of species refers to the book "A guide to the dragonflies of Borneo their identification and biology" (Orr & Hamalainen, 2003).

Data analysis

Species richness was determined based on the number of species found during observation in the study area. Butterfly conservation priority in the Suranadi ecotourism areas is done by using priority species. Determination of the priority species of Butterflys found during the study was assessed using criteria that describe the level of importance for conservation. The general criteria used include (1) endemicity, with indicators of the spread coverage of local, regional, national, and non-endemic; (2) threatened, with indicator species suffered serious damage due to hunting, trade, culture, and agriculture; (3) the status of species management, the management indicator is the presence or absence of management activities or management plan for the species; (4) the status of the population, with a population size indicator that consists of a small natural population, which declines drasticall, and vulnerable. Any species found in the observation will be given a total score base on criteria refer to Annex 1 of Regulation No. P.57/Menhut-II/2008.

Commented [A9]: The information in this section is very poor and lacks of precision. Analyses to obtain species richness and categorization of conservation priorities will be carefully explained.

Commented [A10]: Dragonflies? Damselflies? Odonates?

Commented [A11]: Where is the basis of this information? Publications with population size? International Union of Conservation of Nature´s (IUCN) Red Lost of Threatened Species? Populatiom stimated were obtained with marking recaptured analyses or Cormack - Jolly – Seber models?

RESULTS AND DISCUSSION

Species richness

The total species of dragonflies found in the Suranadi Ecotourism Area are 18 species from 2 suborders, namely Anisoptera and Zygoptera. The suborder Anisoptera is represented by 2 families, namely Aeshnidae and Libellulidae. The suborder Zygoptera is represented by 3 families, namely Chlorocyphidae, Coanagrionidae and Platycnemididae. Although represented by more families, the species richness of the suborder Anisoptera is higher than that of the suborder Zygoptera. Among the Anisoptera, the Libellulidae family consists of 12 species, while the Aeshnidae family has only 1 species (Figure 2a). In Zygoptera, the family with the highest species richness is Coenagrioniddae with a total of 3 out of 5 species from this suborder (Figure 2b).

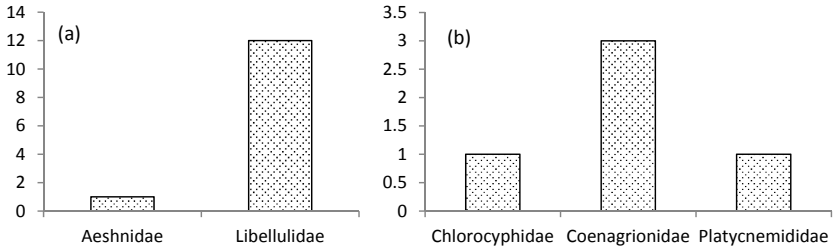


Figure 2. Species richness of Dragonflies by suborder and family.

Based on habitat type, the highest species richness was found in waterways within the forest (17 species), while the middle forest habitat type had the lowest species richness (2 species). Species richness in other habitat types ranges from 5 to 16 species (Figure 3). Two species, namely *Diplacodes trivialis* and *Orthetrum sabina* from the Libellulidae family, are found in all habitat types. The species *Libellago lineata* from the Chlorocyphidae family, and *Gynacantha subinterrupta* from the Aeshnidae family were only found in 1 type of habitat, namely waterways in the forest.

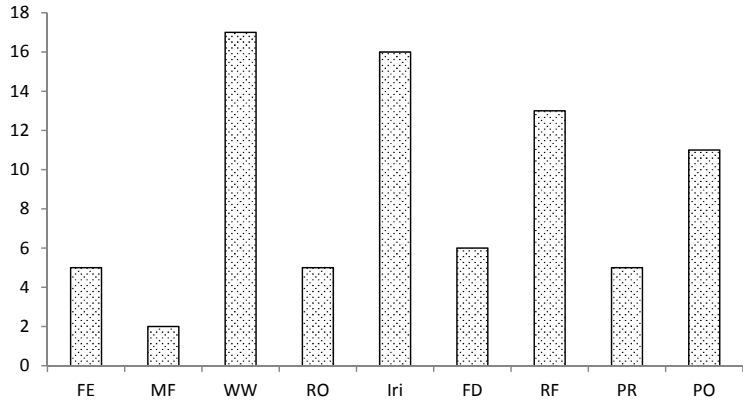


Figure 3. Species richness of dragonflies in each habitat type

During the observation, 764 specimens were recorded, with details of 573 specimens from the Anisoptera suborder and 191 specimens from the Zygoptera suborder. Among the suborder Anisoptera, the family Libellulidae is predominant with a total of 570 specimens. In the suborder Zygoptera, the family Coenagrionidae is predominant with a total of 149 specimens. The most abundant species was *Orthetrum sabina* with a total of 201 specimens, followed by *Neurothemis ramburii* with 108 specimens and *Pantala plafescens* with 101 specimens. Despite having lower species richness compared to waterways, the irrigated habitat type had the most abundant dragonflies with a total of 204 specimens. More complete information can be seen in Table 2.

Table 2. Average number of Odonata in Suranadi Ecotourism Area

Suborder	Familly	Species Name	Average Number of Dragonflies in Each Habitat									Σ
			FE	MF	RO	ROl	Iri	FD	RF	PR	PO	
Zygoptera	Chlorocyphidae	*Libellago lineata*	0	0	2	0	0	0	0	0	0	2
	Coenagrionidae	*Pseudagrion pilidorsum*	0	0	21	0	38	0	5	0	2	66
		Pseudagrion pruinosum	0	0	25	0	26	0	4	0	2	57
		Agriocnemis femina	0	0	12	0	7	0	2	0	4	25
	Platycnemididae	*Copera marginipes*	0	0	17	0	19	0	3	0	2	41
	Aeshnidae	*Gynacantha subinterrupta*	0	0	3	0	0	0	0	0	0	3
	Libellulidae	*Diplacodes trivialis*	6	1	2	5	4	7	5	6	5	41
		Lathrecista asiatica	0	0	5	0	4	0	0	0	0	9
		Neurothemis fluctuans	0	0	4	0	3	0	0	0	0	7
		Neurothemis ramburii	2	0	31	2	52	2	7	4	8	108
Anisoptera		*Orthetrum chrysis*	3	0	23	3	14	2	5	1	3	54
		Orthetrum sabina	51	2	17	15	20	53	23	9	11	201
		Pantala flavescens	3	0	4	7	2	15	56	8	6	101
		Trithemis festiva	0	0	4	0	7	0	0	0	2	13
		Zyxomma obtusum	0	0	5	0	1	0	3	0	0	9
		Zyxomma petiolatum	0	0	2	0	2	0	2	0	0	6
		Crocothermis servilia	0	0	0	0	4	0	8	0	2	4
		Acisoma panorphoides	0	0	0	0	1	1	2	0	3	7
	Σ		65	3	177	32	204	80	130	28	50	764

Where: FE (forest edges), MF (middle forest), RO (roads), Iri (irrigation), FD (fields), RF (rice fields), PR (Parks) , and PO (pool).

Conservation priorities

All dragonfly species found in the Suranadi Ecotourism Area have low endemicity, or no species are endemic. However, all species have not received adequate attention from the management aspect. There are three species, namely *Libellago lineata*, *Gynacantha subinterrupta* and *Acisoma panorphoides* which are distributed in several countries but the largest population is found in Indonesia, and their natural habitat has decreased. They have the highest score (Table 3) and therefore need priority conservation efforts.

Table 3. Priority for dragonfly conservation in the Suranadi Ecotourism Area

Spesies	Criterion value					Σ
	E	PS	HC	R	SSM	
Libellago lineata	5	20	10	10	10	55
Pseudagrion pilidorsum	5	5	10	5	10	35
Pseudagrion pruinosum	5	5	10	5	10	35
Agriocnemis femina	5	5	10	5	10	35
Copera marginipes	5	5	10	5	10	35
Gynacantha subinterrupta	5	20	10	10	10	55
Diplacodes trivialis	5	5	5	5	10	30
Lathrecista asiatica	5	15	10	10	10	50
Neurothemis fluctuans	5	5	10	5	10	35
Neurothemis ramburii	5	5	10	5	10	35
Orthetrum chrysis	5	5	10	5	10	35
Orthetrum sabina	5	5	5	5	10	30
Pantala flavescens	5	5	5	5	10	30
Trithemis festiva	5	15	10	10	10	50
Zyxomma obtusum	5	5	10	5	10	35
Zyxomma petiolatum	5	5	10	5	10	35
Crocothermis servilia	5	5	10	5	10	35
Acisoma panorphoides	5	20	10	10	10	55

Commented [A12]: What is the minning of these abreviations?

Commented [A13]: Which analyses were used to obtain these results? Is it bibliographic information? Explain

Commented [A14]: Discussion is too long. It is necessary reduce it, with explicitly information.

Discussion

The species richness of dragonflies in the Suranadi Ecotourism Area are 18 species from the Anisoptera and Zygoptera suborders. This amount is around 46.15% of the total 39 species richness found in Lombok Island based on observations in February 2014 (Kosterin, 2018). When compared with several studies conducted in Bali, an island in West Lombok, the species richness of dragonflies in the Suranadi Ecotourism Area is higher than those found in rice fields around Denpasar (Suartini & Sudatri, 2019). However, this species richness is lower than that found in the West Bali National Park with 26 species (Wijayanto et al., 2016). In several locations on the island of Flores, the island east of Lombok found dragonflies with a total of 46 species (Potapov et al., 2020).

Dragonfly species richness outside the Lesser Sunda Island tends to be higher. Sugiman et al. (2020) found a total of 25 dragonfly species from 2 families representing the Anisoptera suborder and 6 families representing the Zygoptera suborder in lowland tropical forests, Ujung Kulon National Park. In the Bawean Nature Park there are 23 species with details of 13 species from the Libellulidae family, 1 species from the Aeshnidae family, 6 species from the Coenagrionidae family, and 2 species from the Platycnemididae family (Rohman et al., 2020). At Tunan Waterfall, Minahasa, North Sulawesi, there were found 20 dragonfly species from 7 families and 2 suborders. Ten species belong to the Libellulidae family, 5 species from the Coenagrionidae family, as well as one species each from the Calopterygidae, Chlorocyphidae, Platycnemididae, Argiolestidae, and Lestidae families (Koneri et al., 2020).

The difference in species richness between Oodnata in the Suranadi Ecotourism Area and other areas in the Lesser Sunda Island and other areas outside the Lesser Sunda is at least caused by two factors. First the area. The impact of the area observed in dragonfly species found in TWA Suranadi was smaller, namely 16 species (Ilhamdi et al., 2020) compared to the results of this study. This research area covers all points that make up the Suranadi Ecotourism area including TWA Suranadi. Two additional species that were found in this study were Crocothermis servilia and Acisoma panorphoides. The islands of Bali and Flores, which have a larger area, have also greater species richness. A total of 55 species of dragonflies in Bali (Kosterin, 2018), and 46 species in Flores (Potapov et al., 2020).

The second factor is the number of habitat types available at the observation site. Suartini & Sudatri (2019) found a total of 8 species in rice paddy fields. We found a total of 18 dragonfly species in 9 habitat types including rice fields in the Suranadi Ecotourism Area. Habitat variation is directly proportional to species richness of dragonflies. This is because each dragonfly species has its own habitat preferences (Choi et al., 2020). In the Suranadi Ecotourism Area, the impacts / effects of habitat type were observed on the distribution of species. *Agriocnemis femina, Pseudagrion pilidorsum* and *Pseudagrion pruinosum* only survived in four habitat types namely JA, Iri, Saw, and Pem. Likewise, other species are distributed only in certain habitat types. The species of Anisoptera are scattered in more habitats than Zygoptera which cannot be far from water, thus impacting on species richness.

The species richness of the Anisoptera suborder is higher (13 species) than that of the Zygoptera suborder (5 species). This data shows that the carrying capacity of the environment in the Suranadi Ecotourism Area is more suitable for Anisoptera. This also means that Anisoptera is more adaptive than Zygoptera to modified habitats and is directly influenced by human activities. The advantage of the Anisoptera suborder compared to the Zygoptera suborder is the relatively larger adult body size. Ecologically, this size difference is more favorable for Anisoptera because they are predators in terrestrial ecosystems (May, 2019). The muscle mass in the chest or thorax of Anisoptera is also greater than that of Zygoptera. More muscle mass can provide greater opportunities for hunting and avoiding predators.

Libellulidae and Coenagrionidae are the families with the highest species richness compared to other families in their suborder (Figure 2). This fact indicates that the environmental conditions in the Suranadi Ecotourism Area are more suitable for the Libellulidae family between Anisoptera and Coenagrionidae among Zygoptera. This also means that the adaptability of the Libellulidae family is higher than that of other families in Anisoptera and the Coenagrionidae family in Zygoptera. The success of the Libellulidae and Coenagrionidae families to survive in their habitat is also due to their advantages in utilizing feed resources. They are relatively not picky about prey as nutrition (Folsom and Collins, 1984 in Ilhamdi et al., 2020). Some of them like Orthetrum sabina are even cannibals. These advantages give him the opportunity to survive in a wider variety of habitat types.

Commented [A15]: Which conditions? Which analysis support this results?

Based on Figure 3, the habitat type that has the highest species richness is the waterway. The existence of water resources in this type of habitat is a key factor because it is a spawning ground and habitat for dragonfly larvae (Luke et al., 2017). Three other habitat types that are classified as aquatic habitats, namely irrigation, rice fields and pool, have higher species richness compared to other types of terrestrial habitats. Second order is irrigated habitat type, followed by rice fields and fourth is pool. All dragonfly species in the Suranadi Ecotourism Area are found in this aquatic habitat. As the habitat type with the highest species richness, a total of 16 species were found in the waterway. Two other species, namely *Crocothermis servilia* and *Acisoma panorphoides*, were found in irrigation, rice fields and pool.

The higher species richness in waterway habitat types compared to other types of habitats classified as aquatic is due to the relatively better quality of water resources. The water resource comes from springs, and is better preserved because it is in a conservation area. Water in the types of irrigation habitats, rice fields and pool is contaminated by foreign substances such as organic and inorganic waste, chlorine and detergents. These foreign substances have a negative impact on dragonflies (Ann et al., 2020; Gómez-anaya et al., 2017; Mansoor, 2017). Only two of the 18 species were not found in the waterway habitat type, namely *Crocothermis servilia* and *Acisoma panorphoides*. *Crocothermis servilia* is only found in the type of habitat for irrigation, rice fields and pool. *Acisoma panorphoides* has a wider distribution because apart from the three habitat types, this species is also found in the field habitat type. However, the number of individuals is smaller than *Crocothermis servilia*.

Environmental conditions and resource availability have an impact not only on species richness, but also on the number of individuals. Dragonflies are most commonly found in irrigation, waterways, and rice field habitats (Table 2). Three species that contribute to the high number of dragonflies in this habitat type, and become the predominant species are *Orthetrum sabina*, *Neurothemis ramburii*, and *Pantala flavescens*. The habitat types in the Suranadi Ecotourism Area are more suitable for them than the other 15 species. Koneri et al. (2020) found that the number of individuals of the *Orthetrum sabina* and *Pantala flavescens* species increased along with reduced canopy. These two species are generally found to be abundant in open areas despite disturbances in the form of human activity (Leksono et al., 2017; Perez & Bautista, 2020; Rohman et al., 2020). This proves that they are habituated to these anthropogenic factors. *Neurothemis ramburii* was found in almost all habitat types but the highest number of individuals was in irrigation where the tree canopy was small.

Based on the highest score out of 5 criteria, there are 3 dragonfly species that are priority for conservation, namely *Libellago lineata*, *Gynacantha subinterrupta*, and *Acisoma panorphoides* (Table 3). In the Suranadi Ecotourism Area, they are scattered in a limited habitat type and a small number of individuals. *Libellago lineata* and *Gynacantha subinterrupta* were even found only in waterway habitat types with a low frequency. During the on-site observation, they were only found once. Respectively, the numbers of individuals from *Libellago lineata, Gynacantha subinterrupta, and Acisoma panorphoides* were 2, 3 and 7 individuals. Physical,

chemical and biological conditions of the habitat where *Libellago lineata and Gynacantha subinterrupta* were found were light intensity 2800 Cd, humidity 64%, air temperature 34.3 °C, tree canopy 80%, herbaceous plant cover 91%, altitude 256 masl, and the highest number of plant species, namely 35 species. *Acisoma panorphoides* was found in more varied habitat conditions.

Habitat conditions where *Acisoma panorphoides* were found are light intensity ranging from 2903 Cd - 7500 Cd, humidity 61% - 73%, air temperature 31 °C - 34.8 °C, tree canopy 0% - 52%, herbaceous plant cover 30% - 95%, altitude 256 masl, and plant species richness of 5-25 species. *Acisoma panorphoides* can also be found in temperature conditions ranging from 25.6 - 29.4 °C and a humidity range of 72% to 91% (Hermawan & Fitriana, 2015). From the height factor, this species can also survive in lower areas because it is found in coastal areas (Purwanto et al., 2019). This species is closely associated with water resources (Manwar et al., 2012), so that it can only be found in ponds, lakes and rivers (Baruah & Saikia, 2015). However, from this study we found this species in the type of field habitat which is quite far (> 30 meters) from water sources such as river flow, baths, rice fields and irrigation. This shows that *Acisoma panorphoides* has a wider area of circulation than previously known.

Libellago lineata, unlike *Acisoma panorphoides*, are scattered in various types of habitats. These two species are only found in the waterway habitat type in the Suranadi forest. The discovery of this species in bodies of water at the end of the dam bordering the highway. Its activity is perching on a floating banana stem. This species can also be found perching on shrubs, grass with tree vegetation (Zada et al., 2016). In the Mahaka river of South Sulawesi, *Libellago lineata* can survive in habitats with temperature conditions of 32.59 °C and humidity of 46.14% (Nuraeni et al., 2019). This temperature is lower than the temperature measured in the waterway habitat type. From the water quality factor, this species is adaptive to the inferior water quality level (Jacob & Manju, 2016). *Libellago lineata* can also habituate to anthropogenic factors because it is found in parks (Hermawan & Fitriana, 2015).

Like *Libellago lineata, Gynacantha subinterrupta* is a species found only in waterway habitat types. This species is the only dragonfly from the Aeshnidae family in the Suranadi Ecotourism Area. Morphologically, this species has the largest size compared to 17 other dragonfly species. Abdillah et al. (2019) found *Gynacantha subinterrupta* in Sumber Mangli Kediri in river habitats with temperature conditions above 25 °C and humidity above 80%. This species is able to habituate anthropgenic factors because it is found in parks, namely pond habitats and wetlands (Ngiam & Davison, 2016). Other habitat characteristics that can support the survival of *Gynacantha subinterrupta* are a pond with a high enough depth, and a ditch with a shallow muddy bottom. On the edge of ponds and trenches there is high herbaceous plant cover and dense trees (Kosterin, 2018).

The three species - *Libellago lineata, Gynacantha subinterrupta, and Acisoma panorphoides* - which are conservation priorities in the Suranadi Ecotourism Area have different ecological niches and habitat types, but some are in scope. Conservation efforts need to consider these factors. Conservation of the three priority species and odonata in general in this area is important because ecologically they play an important role in preserving nature which is the area's tourist destination. Preserved nature has a positive impact on the sustainability of the economy of people who depend on tourism activities. From an educational aspect, odonata can be a source of learning at both the primary, secondary and higher education levels. This research itself contributes in providing important information for developing conservation and ecotourism strategies in Suranadi.

In conclusion, the species richnes of dragonfly in the Suranadi Ecotourism Area of Lombok Indonesia, there are 18 species from 5 families (Chlorocyphidae, Coanagrionidae, Platycnemididae, Aeshnidae and Libellulidae) suborder Anisoptera and Zygoptera with three conservation priority species namely *Libellago lineata, Gynacantha subinterrupta, and Acisoma panorphoides.*

ACKNOWLEDGMENT

Thank you to the Directorate General of Higher Education (Dirjen Dikti) for research funding. We also express our gratitude to the BON Team for their contribution during data collection in the field.

REFERENCES

Abdillah M, Prakarsa TBP, Tyastirin E. 2019. Odonata diversity at Sumber Clangap and Sumber Mangli Puncu village sub district of Puncu district of Kediri. Jurnal Biodjati 4: 236–243.

Ann M, Perron C, & Pick FR. 2020. Water quality effects on dragon fl y and damselfly nymph communities: A comparison of urban and natural ponds. Environmental Pollution 263: 1–13.

Arbeiter S, Schnepel H, Uhlenhaut K, Bloege Y, Schulze M, Hahn S. 2014. Seasonal shift in the diet composition of european bee-eaters merops apiaster at the northern edge of distribution. Ardeola 61: 161–170.

Baruah C, Saikia PK. 2015. Abundance and diversity of Odonates in different habitats of Barpeta District, Assam, India. International Research Journal of Biological Sciences 4: 17–27.
Choi JY, Kim SK, Kim JC, Kwon SJ. 2020. Habitat preferences and trophic position of Brachydiplax chalybea flavovittata Ris, 1911 (insecta: Odonata) larvae in Youngsan River Wetlands of South Korea. International Perspectives on Psychotherapy 273: 139–157.
Gómez-anaya JA, Novelo-gutiérrez R, Astudillo-Aldana MR. 2017. Efecto de las descargas domésticas y de beneficio de café sobre la calidad del agua y la diversidad de larvas de Odonata (Insecta) en un arroyo de bosque mesófilo de monta˜na en Veracruz, México. Revista Mexicana de Biodiversidad 88: 372–380.
Hermawan AS, Fitriana N. 2015. Diversity and fluctuations of Odonates in BSD City Park, South Tangerang, Banten. Seminar Nasional Masyarakat Biodiversitas Indonesia 8: 1795–1801.
Ilhamdi ML, Idrus AAL, Santoso D, Hadiprayitno G. 2020. Short Communication: Community structure and diversity of Odonata in Suranadi Natural Park, West Lombok Indonesia. Biodiversitas 21: 718–723.
Jacob S, Manju EK. 2016. Potential of Odonate (dragonflies and damselflies) diversity as a bioindicator of water quality. International Journal of Science and Research 5: 2033–2036.
Koneri R, Nangoy M, Maabuat PV. 2020. Composition and Diversity of Dragonflies (Insecta: Odonata) in Tunan Waterfall Area, North Minahasa, North Sulawesi, Indonesia. Pakistan Journal of Zoology 1–10.
Kosterin OE. 2018. Odonata briefly observed on the islands of Bali and Lombok, Lesser Sundas, Indonesia, in the late February 2014. International Dragonfly Fund - Report 74: 1–48.
Leksono AS, Feriwibisono B, Arifianto T, Pratama AF. 2017. The abundance and diversity of Odonata along an altitudinal gradient in East Java, Indonesia. Entomological Research 1–8.
Linares AM, Maciel-Júnior JAH, de Mello HES, Leite FSF. 2016. First report on predation of adult anurans by Odonata larvae. Salamandra 52: 42–44.
Luke SH, Dow RA, Butler S, Vun Khen C, Aldridge DC, Foster WA, Turner EC. 2017. The impacts of habitat disturbance on adult and larval dragonflies (Odonata) in rainforest streams in Sabah, Malaysian Borneo. Freshwater Biology 62: 491–506.
Mafuwe K, Moyo S. 2020. Dragonfly (Odonata) community structure in the Eastern Highlands Biodiversity Hotspot of Zimbabwe: potential threats of land use changes on freshwater invertebrates. International Journal of Odonatology.
Mansoor R. 2017. *Do herbaceous planticide effects on Odonata larvae, depend on their location of origin? An ecotoxicological study using Glyphosate*.
Manwar NA, Rathod PP, Raja IA. 2012. Diversity and abundance of Dragonflies and Damselflies Of Chatri Lake Region, in Pohara – Malkhed Reserve Forest, Amravati, Maharashtra (India). International Journal of Engineering Research and Applications 2: 521–523.
May ML. 2019. Odonata: who they are and what they have done for us lately: classification and ecosystem services of dragonflies. Insects 62: 1–17.
Nasirian H, & Irvine KN. 2017. Odonata larvae as a bioindicator of metal contamination in aquatic environments: application to ecologically important wetlands in Iran. Environmental Monitoring and Assessment 189: 189:436.
Ngiam RWJ, Davison GWH. 2016. A checklist of dragonflies in Singapore Parks (Odonata: Anisoptera, Zygoptera). Nature Singapore 4: 349–353.
Nuraeni S, Budiaman, & Yaspeta S. 2019. Identification of dragonfly and damselfly species around Mahaka river, Hasanuddin university teaching forest. IOP Conf. Series: Earth and Environmental Science 343: 1–9.
Oliveira-Junior J, & Juen L. 2019. The Zygoptera/Anisoptera ratio (insecta: odonata): A new tool for habitat alterations assessment in Amazonian streams. Neotrop Entomol 48: 552–560.
Orr A, Hamalainen M. 2003. *A guide to the dragonflies of Borneo their identification and biology*. Kinabalu: Natural History Publications (Borneo).
Peraturan Bupati Lombok Barat *No. 41 tentang Kawasan Desa Wisata*. 2016. Gerung: Pemerintah Daerah Kabupaten Lombok Barat.
Perez ESN, Bautista MG. 2020. Dragonflies in the city: Diversity of Odonates in urban Davao, Philippines. Journal of Agricultural Science and Technology 10: 12–19.
Potapov GS, Kolosova YS, Gofarov MY, Bolotov IN. 2020. Dragonflies and damselflies (Odonata) from Flores Island, Lesser Sunda Archipelago: New occurrences in extreme environments and an island-level checklist of this group. Ecologica Montenegrina 25: 5–25.
Purwanto PB, Zaman MN, Ike PA, Akbar M, Arief M. 2019. Study of odonata diversity in Kerangas Forest Sukadamai Village and Punai Beach Simpang Pesak, Belitung Timur. Internat. Confer. Sci. Engin. 2: 133–136.
Rohman A, Sulistyono S, Nuryati W, Arifandy A, Setiyanto A. 2020. Dragonflies in Bawean Island Nature Reserve, Indonesia. Borneo Journal of Resource Science and Technology 10: 45–50.
Rüppell G, Hilfert-Rüppell D, Schneider B, Dedenbach H. 2020. On the firing line–interactions between hunting frogs and Odonata. International Journal of Odonatology 23: 199–217.
Šigutováa H, Šipoš J, Dolný A. 2019. A novel approach involving the use of Odonata as indicators of tropical forest degradation: When family matters. Ecological Indicators 104: 229–236.
Suartini NM, Sudatri NW. 2019. Species of dragonflies (Odonata order) for rice plantations in some rice field around Denpasar, Bali. Simbiosis 7: 23–28.
Sugiman U, Atmowidi T, Priawandiputra W. 2020. Community structure and habitat characteristics of dragonflies (Odonata) in tropical lowland forest of Ujung Kulon National Park. Journal of Entomology and Zoology Studies 8: 251–258.
Ting D, Huai-jian L, Lei S. 2018. Odonata aquatic insects as bioindicators in water quality evaluation of Dianchi Lake riparian wetland. Forest Research 31: 145–152.
Weterings R, Umponstira C, Buckley HL. 2015. Predation rates of mixed instar Odonata naiads feeding on Aedes aegypti and Armigeres moultoni (Diptera: Culicidae) larvae. Journal of Asia-Pacific Entomology 18: 1–8.
Wijayanto AG, Nafisah NA, Laily Z, Zaman MN. 2016. Inventarisasi capung (insecta: Odonata) dan variasi habitatnya di Resort Tegal Bunder dan Teluk Terima Taman Nasional Bali Barat (TNBB). Seminar Nasional Pendidikan Dan Saintek 427–434.
Zada N, Farid A, Zia A, Saeed M, Khan SM, Khan A, Khan IA, Fazlullah & Badshah T. 2016. Damselflies (Odonata: Zygoptera) fauna of District Buner, Khyber Pakhtunkhwa, Pakistan. Journal of Entomology and Zoology Studies 4: 491–495.

REVISI 2

THE SPECIES RICHNESS AND CONSERVATION PRIORITY OF DRAGONFLIES IN THE SURANADI ECOTOURISM AREA, LOMBOK, INDONESIA

Mohammad Liwa Ilhamdi[1*], Agil Al Idrus[1], Didik Santoso[1], Gito Hadiprayitno[1], Muhammad Syazali[2]
[1]Department of Biology Education,
[2] Department Elementary of School Teacher Education,
Faculty of Teacher Training and Education Science, Universitas Mataram. Jl. Majapahit 62, Mataram 83125, West Nusa Tenggara, Indonesia. Tel./fax.: +62-370-623873,
*email: liwa_ilhamdi@unram.ac.id

ABSTRACT

Dragonflies are insects that have attractive colours and play an important role in the balance of ecosystems and act as bioindicators of the aquatic environment. As an effort to conserve and support ecotourism, this research needs to be done. The purpose of this study was to analyze the species richness and conservation priorities of dragonflies in the Suranadi ecotourism area, with the aim to use dragonflies as charismatic species to support ecotourism. The research was conducted in August - December 2020 with the survey method through transect lines in 9 types of habitat. Species richness was determined based on the number of species found during observation and conservation priority refers to the PP. No. 57 / Menhut-II / 2008. The score was determined through a Focus Group Disscusion (FGD) with five experts related to the scoring criteria. The score for each species is determined based on the percentage of the opinion from the experts. The number of dragonfly species found was 18 species from 2 suborders (Zygoptera and Anisoptera) 5 families (Chlorocyphidae, Coenagrionidae, Platycnemididae, Aeshnidae and Libellulidae). The habitat type that supports the highest species richness is the waterway and irrigation (16 species), while the lowest species richness was found in the areas inside the forest habitat (2 species). The species that had the highest conservation priority index scores were *Pseudagrion pilidorsum declaratum*, *Libellago lineata*, and *Gynacantha subinterrupta*. These three species are conservation priority species in the ecotourism area of Suranadi, Lombok, Indonesia.

Key words: Species richness, conservation priority, dragonflies

INTRODUCTION

The Suranadi Ecotourism Area is one of the tourist areas based on Lombok Barat Regent, Indonesia Regulation No. 41 of 2016. This area consists of various habitats suitable for supporting dragonfly life. Water, which is a very important environmental component for dragonflies (Mafuwe & Moyo, 2020), is available in abundance, scattered in many points and available almost all year round. This area is known as "the city of water", and the main attraction that is used as a tourist resource is water. Water with suitable characteristics can be used by adult dragonflies for oviposition and as habitat for larval development (Luke et al., 2017). Because of their life cycle in these two habitats, dragonflies have a very important role in terrestrial and aquatic ecosystems.

The important role of dragonflies can be observed in their function as trophic components. As predators and prey, dragonflies are key elements in the process of transferring matter and energy along the trophic web. Adult dragonflies are prey of larger dragonflies, spiders, and various types of vertebrate animals such as frogs and bird (Rüppell et al., 2020). To obtain nutrition, adult dragonflies prey on various types of small animals, especially insects such as bees (Arbeiter et al., 2014). Some species are cannibals by preying on members of the same species. The larval phase that lives in the waters becomes a predator of various other smaller animals. For example, anura larvae (Weterings et al., 2015), and mosquito larvae (Weterings et al., 2015). Linares et al. (2016) found that dragonfly larvae prey on adult anura.

The important role of dragonflies can also be viewed from the aspect of environmental biology. The living conditions that require specific ecological niches make it an environmental bio-indicator, especially for aquatic conditions (Nasirian & Irvine, 2017). Some special conditions that make dragonflies as bioindicators are (1) presence or absence of species (Ting et al., 2018), (2) abundance ratio of Anisoptera and Zygoptera (Oliveira-Junior & Juen, 2019), and (3) Ratio of the Libellulidae family against other families in Anisoptera and the ratio of the Coenagrionodae family to other families in Zygoptera (Šigutováa et al., 2019). Their prey, which consists of several types of harmful insects - insect pests and disease vectors - makes dragonflies act as biological control agents (May, 2019). Dragonflies can also become tourist objects because of their attractive and varied colors, and conspicuous behaviours.

Their very important roles justify indicates that dragonflies need to be a biodiversity that receives conservation efforts. These efforts require data in particular about species richness. Each species has a different endemicity, population status and threat. Likewise with habitat conditions and management status. Based on these situations and conditions, we conducted research in several types of habitat in the Suranadi Ecotourism Area with the aim to determine the local and

regional species richness and propose conservation priorities for dragonflies. The collected data from our research can support dragonfly conservation and contribute to ecotourism efforts.

MATERIALS AND METHODS

Study Area

The research was conducted in the Suranadi Ecotourism Area, Lombok Indonesia. The investigated area was split up into 9 sampling stations, each presenting a different habitat type, namely forest edges (FE), middle forest (MF), waterways (WW), roads (RO), irrigation (IR), fields (FD), rice fields (RF), Parks (PR) , and the pool (PO). Habitat types FE, MF, RO, FD and PR are terrestrial habitats, while habitat types WW, IR, RF, and PO are aquatic habitats. For each of the nine different habitat types we present some characteristics in table 1. The Waterways is a place for water flows in Suranadi Ecotourism Area. The water comes from a spring located in Suranadi Ecotourism Area. This waterway is like a tributary whose water flows continuously throughout the year.

Table 1. Characteristics of the nine different habitat types present in the Suranadi Ecotourism Area, Lombok

Habitat Type	Environmental factor						
	Light intensity (Cd)	Humidity (%)	Air temperature (ºC)	Tree canopy (%)	Herbaceous plant cover (%)	Altitude (asl)	Number of plant (species)
PR	657	75	29,4	90	25	258	20
PO	2903	73	31	52	30	256	22
FD	5958	68	33,4	30	60	256	25
RO	2648	57	34,3	40	15	256	9
IR	4667	63	32,2	10	30	256	10
RF	7500	61	34,8	0	95	256	5
WW	2800	64	34,3	80	91	256	35
MF	110	69	29,3	125	50	257	30
FE	4490	73	31,8	25	80	256	15

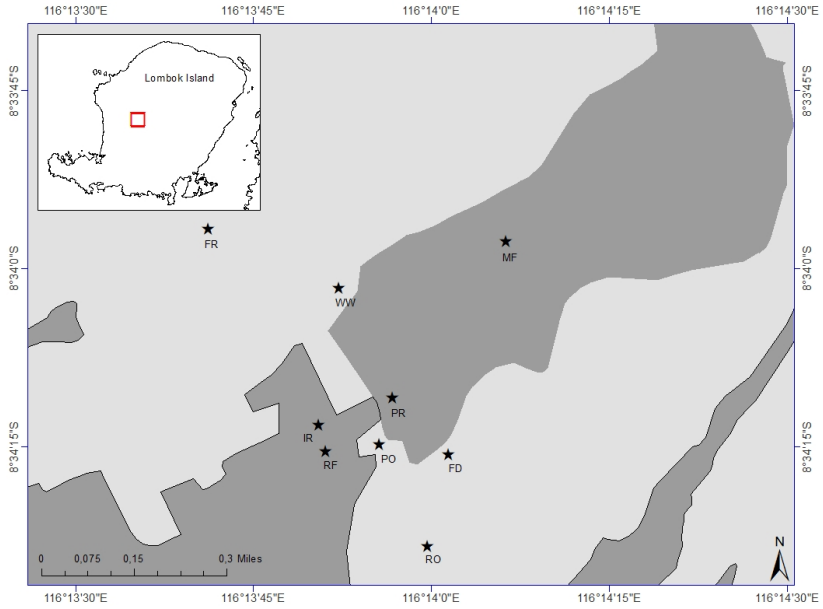


Figure 1. Map of the research location

Research Method

Data were collected during August - December 2020 in 9 types of habitat (Figure 1) using direct visual observation methods. Prior to data collection, a preliminary study was conducted with seven observations, until no additional species were found. In the second and third observations, it was found that each addition of one species was found. Furthermore,

on the fourth, five, six and seven observation, no new species were found. Adult dragonfly were captured using insect nets at each observation, with 5 replications. Catching dragonflies was carried out in 2 time periods at each replication, namely morning from 09.00 – to 11.00 am, and afternoon from 14.00 – to 16.00 pm Central Indonesian Time (Wita). The number of dragonfly samples was determined based on the average of all observations. The sample of the dragonfly was put in a plastic bag, and preserved using 70% alcohol. Identification was carried out at the Basic Biology Laboratory, Mataram University, Lombok. Species identifications was based on the book "A guide to the dragonflies of Borneo their identification and biology" (Orr & Hamalainen, 2003), and an article of result study with tittle Odonata briefly observed on the islands of Bali and Lombok, Lesser Sundas, Indonesia, in the late February 2014 (Kosterin, 2014).

Data Analysis

Species richness was determined based on the number of species found in the study area (Quisil, 2013). Dragonfly conservation priority in the Suranadi ecotourism areas is done by using priority species. Determination of the priority species of dragonfly found during the study was assessed using criteria that describe the level of importance for conservation. The general criteria used include (1) species endemicity (SE), with indicators of the spread coverage of local, regional, national, and non-endemic; (2) population status (PS), with a population size indicator that consists of a small natural population, which declines drasticall, and vulnerable; (3) habitat condition (HC), with the suitable habitat indicator running low, suitable habitat is decreasing and suitable habitat is sufficiently available and stable; (4) threat (T), with indicator species suffered serious damage due to hunting, trade, culture, and agriculture; (5) the status of species management (SSM), the management indicator is the presence or absence of management activities or management plan for the species. Any species found in the observation will be given a total score base on criteria refering to Annex 1 of Regulation No. P.57/Menhut-II/2008 for the insect group. Species that have the highest number of scores out of the 5 criteria are designated as conservation priority species. The score was determined through a Focus Group Disscusion (FGD) with five experts related to the scoring criteria. The score for each species is determined based on the percentage of the opinion from the experts.

RESULTS AND DISCUSSION

Species richness

The total species of dragonflies found in the Suranadi Ecotourism Area are 18 species from 2 suborders, namely Anisoptera and Zygoptera. Satu spesies – *Pseudagrion pilidorsum declaratum* - termasuk spesies endemik. The suborder Anisoptera is represented by 2 families, namely Aeshnidae and Libellulidae. The suborder Zygoptera is represented by 3 families, namely Chlorocyphidae, Coanagrionidae and Platycnemididae. Although represented by more families, the species richness of the suborder Anisoptera is higher than that of the suborder Zygoptera. Among the Anisoptera, the Libellulidae family consists of 12 species, while the Aeshnidae family has only 1 species (Figure 2a). In Zygoptera, the family with the highest species richness is Coenagrioniddae with a total of 3 out of 5 species from this suborder (Figure 2b).

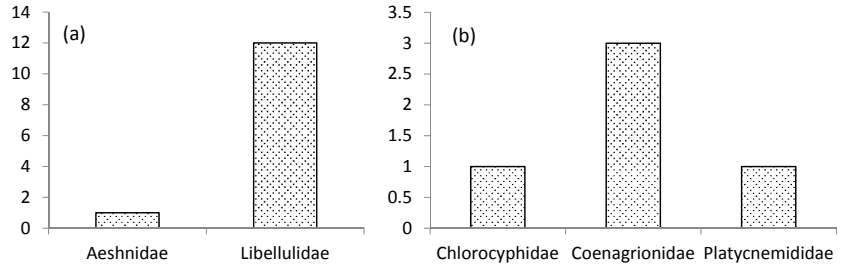


Figure 2. Species richness of dragonflies by family in suborder Anisoptera (a) and Zygoptera (b).

Based on habitat type, the highest species richness was found in waterways within the forest (17 species), while the middle forest habitat type had the lowest species richness (2 species). Species richness in other habitat types ranges from 5 to 16 species (Figure 3). Two species, namely *Diplacodes trivialis* and *Orthetrum sabina* from the Libellulidae family, were found in all habitat types. The species *Libellago lineata* from the Chlorocyphidae family, and *Gynacantha subinterrupta* from the Aeshnidae family were only found in 1 type of habitat, namely waterways in the forest.

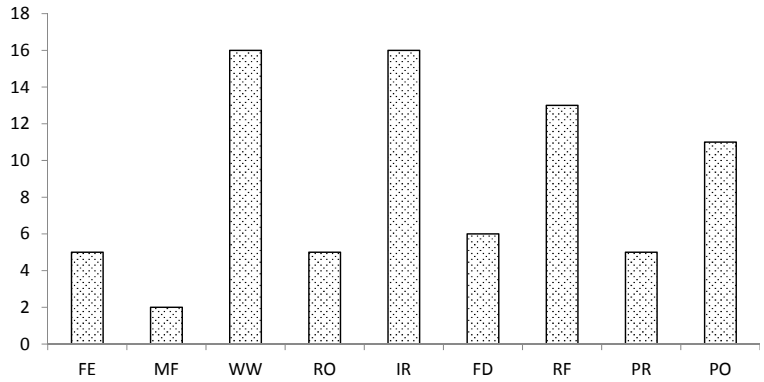


Figure 3. Species richness of dragonflies in each habitat type

During the observation, 764 specimens were recorded, with details of 573 specimens from the Anisoptera suborder and 191 specimens from the Zygoptera suborder. Among the suborder Anisoptera, the family Libellulidae is predominant with a total of 570 specimens. In the suborder Zygoptera, the family Coenagrionidae is predominant with a total of 149 specimens. The most abundant species was *Orthetrum sabina* with a total of 201 specimens, followed by *Neurothemis ramburii* with 108 specimens and *Pantala flavescens* with 101 specimens. Despite having lower species richness compared to waterways, the irrigated habitat type had the most abundant dragonflies with a total of 204 specimens. More complete information can be seen in Table 2.

Table 2. Average number of Odonata in Suranadi Ecotourism Area

Sub-order	Familly	Species Name	Average Number of Dragonflies in Each Habitat								Σ
			FE	MF	WW	RO	IR	FD	RF	PR	PO	
Zygoptera	Chlorocyphidae	*Libellago lineata*	0	0	2	0	0	0	0	0	0	2
	Coenagrionidae	*Pseudagrion pilidorsum declaratum*	0	0	21	0	38	0	5	0	2	66
		Pseudagrion pruinosum	0	0	25	0	26	0	4	0	2	57
		Agriocnemis femina	0	0	12	0	7	0	2	0	4	25
	Platycnemididae	*Copera marginipes*	0	0	17	0	19	0	3	0	2	41
Anisoptera	Aeshnidae	*Gynacantha subinterrupta*	0	0	3	0	0	0	0	0	0	3
	Libellulidae	*Diplacodes trivialis*	6	1	2	5	4	7	5	6	5	41
		Lathrecista asiatica	0	0	5	0	4	0	0	0	0	9
		Neurothemisterminata	0	0	4	0	3	0	0	0	0	7
		Neurothemis ramburii	2	0	31	2	52	2	7	4	8	108
		Orthetrum chrysis	3	0	23	3	14	2	5	1	3	54
		Orthetrum sabina	51	2	17	15	20	53	23	9	11	201
		Pantala flavescens	3	0	4	7	2	15	56	8	6	101
		Trithemis festiva	0	0	4	0	7	0	0	0	2	13
		Zyxomma obtusum	0	0	5	0	1	0	3	0	0	9
		Zyxomma petiolatum	0	0	2	0	2	0	2	0	0	6
		Crocothermis servilia	0	0	0	0	4	0	8	0	2	14
		Acisoma panorpoides	0	0	0	0	1	1	2	0	3	7
Σ			65	3	177	32	204	80	130	28	50	764

Where: FE (forest edges), MF (middle forest), WW (water way), RO (roads), IR (irrigation), FD (fields), RF (rice fields), PR (Parks) , and PO (pool).

Conservation Priorities

All dragonfly species found in the Suranadi Ecotourism Area have wide distribution and none is endemic except *Pseudagrion pilidorsum declaratum*. This species only found in East Java area and Lesser Sunda Island (https://inaturalist.laji.fi/taxa/843602-Pseudagrion-pilidorsum-declaratum). Based on criteria of Annex 1 of Regulation No. P.57/Menhut-II/2008, this species is regional endemic, and it score is 20 in SE criteria. All species have not received adequate attention from the management aspect. Based on the total score from 18 species found in the Suranadi Ecotourism Area, there are 3 species, namely *Pseudagrion pilidorsum declaratum, Libellago lineata*, and *Gynacantha subinterrupta* had the highest total scores (Table 3) so they are designated as conservation priority species.

Table 3. Priority for dragonfly conservation in the Suranadi Ecotourism Area

No	Spesies	Criterion value					Σ
		SE	PS	HC	T	SSM	
1	*Libellago lineata*	5	15	10	10	10	50
2	*Pseudagrion pilidorsum declaratum*	20	5	10	10	10	55
3	*Pseudagrion pruinosum*	5	5	10	5	10	35
4	*Agriocnemis femina*	5	5	10	5	10	35
5	*Copera marginipes*	5	5	10	5	10	35
6	*Gynacantha subinterrupta*	5	15	5	10	10	45
7	*Diplacodes trivialis*	5	5	5	5	10	30
8	*Lathrecista asiatica*	5	10	10	5	10	40
9	*Neurothemis terminata*	5	5	10	5	10	35
10	*Neurothemis ramburii*	5	5	10	5	10	35
11	*Orthetrum chrysis*	5	5	10	5	10	35
12	*Orthetrum sabina*	5	5	5	5	10	30
13	*Pantala flavescens*	5	5	5	5	10	30
14	*Trithemis festiva*	5	10	10	5	10	40
15	*Zyxomma obtusum*	5	5	10	5	10	35
16	*Zyxomma petiolatum*	5	5	10	5	10	35
17	*Crocothermis servilia*	5	5	10	5	10	35
18	*Acisoma panorphoides*	5	15	5	5	10	40

Discussion

The species richness of dragonflies in the Suranadi Ecotourism Area includes 18 species predominated by the Libellulidae and Coenagrionidae families (Figure 2). This number is around 46.15% of the total of 39 species richness found in Lombok Island based on observations in late February 2014 (Kosterin, 2014). When compared with several studies conducted in Bali, an island in West Lombok, the species richness of dragonflies in the Suranadi Ecotourism Area is higher than those found in rice fields around Denpasar (Suartini & Sudatri, 2019). However, this species richness is lower than that found in the West Bali National Park with 26 species (Wijayanto et al., 2016). In several locations on the island of Flores, the island east of Lombok, 46 spesies of dragonflies were found (Potapov et al., 2020). Several research results dragonfly species richness outside the Lesser Sunda Island tends to be higher (Sugiman et al., 2020; Rohman et al., 2020; Koneri et al., 2020).

Based on Figure 3, the habitat type that has the highest species richness is the waterway and irrigation. The existence of water resources in this type of habitat is a key factor because it is a oviposition site and larval habitat (Luke et al., 2017). Two other habitat types that are classified as aquatic habitats, namely rice fields and pool, have higher species richness compared to other types of terrestrial habitats. Second order is rice fields and fourth is pool. All dragonfly species in the Suranadi Ecotourism Area are found in this aquatic habitat. As the habitat type with the highest species richness, a total of 16 species were found in the waterway. Two other species, namely *Crocothermis servilia* and *Acisoma panorphoides*, were found in irrigation, rice fields and pool.

The higher species richness in waterway habitat types compared to other types of habitats classified as aquatic is due to the relatively better quality of water resources. The water resource comes from springs, and is better preserved because it is in a conservation area. Water in the types of irrigation habitats, rice fields and pool is contaminated by organic and inorganic waste, chlorine and detergents. These foreign substances have a negative impact on dragonflies (Ann et al., 2020; Gómez-Anaya et al., 2017; Mansoor, 2017). Only two of the 18 species were not found in the waterway habitat type, namely *Crocothermis servilia* and *Acisoma panorphoides*. *Crocothermis servilia* is only found in the type of habitat for irrigation, rice fields and pool. *Acisoma panorphoides* has a wider distribution because apart from the three habitat types, this species is also found in the field habitat type. However, the number of individuals is smaller than *Crocothermis servilia*.

Environmental conditions and resource availability have an impact not only on species richness, but also on the number of individuals. Dragonflies are most commonly found in irrigation, waterways, and rice field habitats (Table 2). Three species that contribute to the high number of dragonflies in this habitat type, and become the predominant species are *Orthetrum sabina*, *Neurothemis ramburii*, and *Pantala flavescens*. The habitat types in the Suranadi Ecotourism Area are more suitable for them than the other 15 species. Koneri et al. (2020) found that the number of individuals of the *Orthetrum sabina* and *Pantala flavescens* species increased along with reduced canopy. These two species are generally found to be

abundant in open areas despite disturbances in the form of human activity (Leksono et al., 2017; Perez & Bautista, 2020; Rohman et al., 2020). This proves that they are habituated to these anthropogenic factors. *Neurothemis ramburii* was found in almost all habitat types but the highest number of individuals was in irrigation where the tree canopy was small.

Based on the highest score out of 5 criteria, there are 3 dragonfly species that are priority for conservation, namely *Pseudagrion pilidorsoum declaratum, Libellago lineata* and *Gynacantha subinterrupta* (Table 3). In the Suranadi Ecotourism Area, they are scattered in a limited habitat type and a small number of individuals. *Libellago lineata* and *Gynacantha subinterrupta* were even only once found during the on site observation in the waterway habitat respectively 2, 3 and 7 individuals. Physical, chemical and biological conditions of the habitat where *Libellago lineata and Gynacantha subinterrupta* were found were light intensity 2800 Cd, humidity 64%, air temperature 34.3 ºC, tree canopy 80%, herbaceous plant cover 91%, altitude 256 masl, and the highest number of plant species, namely 35 species. *Pseudagrion pilidorsoum declaratum* was found in more varied habitat conditions.

Pseudagrion pilidorsoum declaratum was found in four type of aquatic habitat, namely waterways, irigation, rice fields and ponds. This species can survive in a variety of habitat conditions. During observations in the Suranadi Ecotourism Area, this species was found in conditions of humidity ranging from 61% - 73%, air temperature 31 ° C - 34.8 ° C, tree canopy 0% - 80%, herb cover 30% - 95%, altitude 256 asl. and the number of plants 5 species - 35 species. Its activities are carried out around water bodies, flying low around herbaceous plants or perching on branches or leaves with a height of less than 1 meter. This species can also be found in small river estuary habitats with edges of gravel or sand and trees, and rivers in gardens and forests with rocky bottoms (Kosterin, 2014).

Libellago lineata, unlike *Pseudagrion pilidorsoum declaratum*, appears scattered in various types of habitats. This species is only found in the waterway habitat type in the Suranadi forest. We found this species in bodies of water at the end of the dam bordering the highway, commonly perching on a floating banana stem. This species can also be found perching on shrubs, grass with tree vegetation (Zada et al., 2016). In the Mahaka river of South Sulawesi, *Libellago lineata* can survive in habitats with temperature conditions of 32.59 ºC and humidity of 46.14% (Nuraeni et al., 2019). This temperature is lower than the temperature measured in the waterway habitat type. From the water quality factor, this species is adaptive to the inferior water quality level (Jacob & Manju, 2016). *Libellago lineata* can also habituate to anthropogenic factors because it is found in parks (Hermawan & Fitriana, 2015).

Like *Libellago lineata, Gynacantha subinterrupta* is a species found only in waterway habitat types. This species is the only dragonfly from the Aeshnidae family in the Suranadi Ecotourism Area. Abdillah et al. (2019) found *Gynacantha subinterrupta* in Sumber Mangli Kediri in river habitats with temperature conditions above 25 ºC and humidity above 80%. This species is able to habituate to anthropgenic factors because it is found in parks, namely pond habitats and wetlands (Ngiam & Davison, 2016). Other habitat characteristics that can support the survival of *Gynacantha subinterrupta* are a pond with a high enough depth, and a ditch with a shallow muddy bottom. On the edge of ponds and trenches there is high herbaceous plant cover and dense trees (Kosterin, 2014).

The four species - *Libellago lineata, Pseudagrion pilidorsoum declaratum*, and *Gynacantha subinterrupta* - which are conservation priorities in the Suranadi Ecotourism Area have different ecological niches and habitat types, but some are in scope. Conservation efforts need to consider these factors. Conservation of the three priority species and odonate in general in this area is important because ecologically they play an important role in preserving nature which is the area's tourist destination. Preserved nature has a positive impact on the sustainability of the economy of people who depend on tourism activities. From an educational aspect, Odonata can be a source of learning at both the primary, secondary and higher education levels. This research itself contributes in providing important information for developing conservation and ecotourism strategies in Suranadi.

In conclusion, the species richness of dragonfly in the Suranadi Ecotourism Area of Lombok Indonesia, includes 18 species from 5 families (Chlorocyphidae, Coanagrionidae, Platycnemididae, Aeshnidae and Libellulidae) suborder Anisoptera and Zygoptera with three conservation priority species namely *Pseudagrion pilidorsoum declaratum, Libellago lineata,* and *Gynacantha subinterrupta.*

ACKNOWLEDGEMENT

Thank you to the Directorate General of Higher Education (Dirjen Dikti) for research funding. We also express our gratitude to the BON Team for their contribution during data collection in the field.

BIBLIOGRAPHY

Abdillah M, Prakarsa TBP, Tyastirin E. 2019. Odonata diversity at Sumber Clangap and Sumber Mangli Puncu village sub district of Puncu district of Kediri. Jurnal Biodjati 4: 236–243.

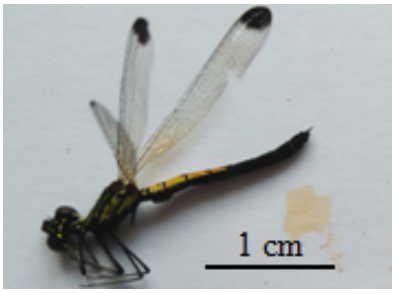
Ann M, Perron C, & Pick FR. 2020. Water quality effects on dragon fl y and damselfly nymph communities: A comparison of urban and natural ponds. Environmental Pollution 263: 1–13.

Arbeiter S, Schnepel H, Uhlenhaut K, Bloege Y, Schulze M, Hahn S. 2014. Seasonal shift in the diet composition of european bee-eaters merops apiaster at the northern edge of distribution. Ardeola 61: 161–170.

Gómez-anaya JA, Novelo-gutiérrez R, Astudillo-Aldana MR. 2017. Efecto de las descargas domésticas y de beneficio de café sobre la calidad del agua y la diversidad de larvas de Odonata (Insecta) en un arroyo de bosque mesófilo de monta˜na en

Veracruz, México. Revista Mexicana de Biodiversidad 88: 372–380.
Hermawan AS, Fitriana N. 2015. Diversity and fluctuations of Odonates in BSD City Park, South Tangerang, Banten. Seminar Nasional Masyarakat Biodiversitas Indonesia 8: 1795–1801.
Jacob S, Manju EK. 2016. Potential of Odonate (dragonflies and damselflies) diversity as a bioindicator of water quality. International Journal of Science and Research 5: 2033–2036.
Koneri R, Nangoy M, Maabuat PV. 2020. Composition and Diversity of Dragonflies (Insecta: Odonata) in Tunan Waterfall Area, North Minahasa, North Sulawesi, Indonesia. Pakistan Journal of Zoology 1–10.
Kosterin OE. 2014. Odonata briefly observed on the islands of Bali and Lombok, Lesser Sundas, Indonesia, in the late February 2014. International Dragonfly Fund - Report 74: 1–48.
Leksono AS, Feriwibisono B, Arifianto T, Pratama AF. 2017. The abundance and diversity of Odonata along an altitudinal gradient in East Java, Indonesia. Entomological Research 1–8.
Linares AM, Maciel-Júnior JAH, de Mello HES, Leite FSF. 2016. First report on predation of adult anurans by Odonata larvae. Salamandra 52: 42–44.
Luke SH, Dow RA, Butler S, Vun Khen C, Aldridge DC, Foster WA, Turner EC. 2017. The impacts of habitat disturbance on adult and larval dragonflies (Odonata) in rainforest streams in Sabah, Malaysian Borneo. Freshwater Biology 62: 491–506.
Mafuwe K, Moyo S. 2020. Dragonfly (Odonata) community structure in the Eastern Highlands Biodiversity Hotspot of Zimbabwe: potential threats of land use changes on freshwater invertebrates. International Journal of Odonatology.
Mansoor R. 2017. *Do herbaceous planticide effects on Odonata larvae, depend on their location of origin? An ecotoxicological study using Glyphosate*.
May ML. 2019. Odonata: who they are and what they have done for us lately: classification and ecosystem services of dragonflies. Insects 62: 1–17.
Nasirian H, & Irvine KN. 2017. Odonata larvae as a bioindicator of metal contamination in aquatic environments: application to ecologically important wetlands in Iran. Environmental Monitoring and Assessment 189: 189:436.
Ngiam RWJ, Davison GWH. 2016. A checklist of dragonflies in Singapore Parks (Odonata: Anisoptera, Zygoptera). Nature Singapore 4: 349–353.
Nuraeni S, Budiaman, & Yaspeta S. 2019. Identification of dragonfly and damselfly species around Mahaka river, Hasanuddin university teaching forest. IOP Conf. Series: Earth and Environmental Science 343: 1–9.
Oliveira-Junior J, & Juen L. 2019. The Zygoptera/Anisoptera ratio (insecta: odonata): A new tool for habitat alterations assessment in Amazonian streams. Neotrop Entomol 48: 552–560.
Orr A, Hamalainen M. 2003. *A guide to the dragonflies of Borneo their identification and biology*. Kinabalu: Natural History Publications (Borneo).
Peraturan Bupati Lombok Barat *No. 41 tentang Kawasan Desa Wisata*. 2016. Gerung: Pemerintah Daerah Kabupaten Lombok Barat.
Perez ESN, & Bautista MG. 2020. Dragonflies in the city: Diversity of Odonates in urban Davao, Philippines. Journal of Agricultural Science and Technology 10: 12–19.
Potapov GS, Kolosova YS, Gofarov MY, Bolotov IN. 2020. Dragonflies and damselflies (Odonata) from Flores Island, Lesser Sunda Archipelago: New occurrences in extreme environments and an island-level checklist of this group. Ecologica Montenegrina 25: 5–25.
Quisil SJC, Arreza JDE, Nuneza OM, Villanueva R. J. T., 2013 Species richness of Odonata in Lanuza and San Agustin, Surigao del Sur, Philippines. AES Bioflux 5(3):245-260.
Rohman A, Sulistyono S, Nuryati W, Arifandy A, Setiyanto A. 2020. Dragonflies in Bawean Island Nature Reserve, Indonesia. Borneo Journal of Resource Science and Technology 10: 45–50.
Rüppell G, Hilfert-Rüppell D, Schneider B, Dedenbach H. 2020. On the firing line–interactions between hunting frogs and Odonata. International Journal of Odonatology 23: 199–217.
Šigutováa H, Šipoš J, Dolný A. 2019. A novel approach involving the use of Odonata as indicators of tropical forest degradation: When family matters. Ecological Indicators 104: 229–236.
Suartini NM, Sudatri NW. 2019. Species of dragonflies (Odonata order) for rice plantations in some rice field around Denpasar, Bali. Simbiosis 7: 23–28.
Sugiman U, Atmowidi T, Priawandiputra W. 2020. Community structure and habitat characteristics of dragonflies (Odonata) in tropical lowland forest of Ujung Kulon National Park. Journal of Entomology and Zoology Studies 8: 251–258.
Ting D, Huai-jian L, Lei S. 2018. Odonata aquatic insects as bioindicators in water quality evaluation of Dianchi Lake riparian wetland. Forest Research 31: 145–152.
Weterings R, Umponstira C, Buckley HL. 2015. Predation rates of mixed instar Odonata naiads feeding on Aedes aegypti and Armigeres moultoni (Diptera: Culicidae) larvae. Journal of Asia-Pacific Entomology 18: 1–8.
Wijayanto AG, Nafisah NA, Laily Z, Zaman MN. 2016. Inventarisasi capung (insecta: Odonata) dan variasi habitatnya di Resort Tegal Bunder dan Teluk Terima Taman Nasional Bali Barat (TNBB). Seminar Nasional Pendidikan Dan Saintek 427–434.
Zada N, Farid A, Zia A, Saeed M, Khan SM, Khan A, Khan IA, Fazlullah & Badshah T. 2016. Damselflies (Odonata: Zygoptera) fauna of District Buner, Khyber Pakhtunkhwa, Pakistan. Journal of Entomology and Zoology Studies 4: 491–495.

LAMPIRAN



Libellago lineata

Neurothermis terminata

Neurothermis ramburii

Zyxomma petiolatum

REVISI 3

Species richness and conservation priority of dragonflies in the Suranadi Ecotourism Area, Lombok, Indonesia

Mohammad Liwa Ilhamdi1,♥, Agil Al Idrus1, Didik Santoso1, Gito Hadiprayitno1, Muhammad Syazali2

1Department of Biology Education, Faculty of Teacher Training and Education Science, Universitas Mataram. Jl. Majapahit 62, Mataram 83125, West Nusa Tenggara, Indonesia. Tel./fax.: +62-370-623873. ♥email: liwa_ilhamdi@unram.ac.id

2Department Elementary of School Teacher Education, Faculty of Teacher Training and Education Science, Universitas Mataram. Jl. Majapahit 62, Mataram 83125, West Nusa Tenggara, Indonesia .

Manuscript received: 2 February 2021. Revision accepted: 16 March 2021.

Abstract. Ilhamdi ML, Idrus AA, Santoso D, Hadiprayitno G, Syazali M. 2021. The species richness and conservation priority of dragonflies in the Suranadi Ecotourism Area, Lombok, Indonesia. Biodiversitas 22: 1783-1789. Dragonflies are insects that have attractive colors and play an important role to balance ecosystems. They also act as bioindicators of the aquatic environment. The purpose of this study was to investigate the species richness and conservation priorities of dragonflies in the Suranadi Ecotourism Area, Lombok, Indonesia, expecting that the dragonflies will be used as charismatic species to support ecotourism. The research was conducted in August-December 2020 by surveying transect lines across 9 types of habitat. For each species found, we then determined the conservation priority by referring to the Government Regulation using scoring method through a Focus Group Discussion (FGD) involving five experts. The score for each species was determined based on the percentage of the opinion from the experts. We found 18 dragonfly species from 2 suborders (Zygoptera and Anisoptera) and 5 families (Chlorocyphidae, Coenagrionidae, Platycnemididae, Aeshnidae and Libellulidae). The habitat type that supports the highest species richness was the waterway and irrigation (16 species), while the lowest species richness was found in

the areas inside the forest habitat (2 species). The species that had the highest conservation priority scores were Pseudagrion pilidorsum declaratum, Libellago lineata, and Gynacantha subinterrupta. These three species can be used as conservation priority species in the ecotourism area of Suranadi, Lombok, Indonesia.
Keywords: Species richness, conservation priority, dragonflies

Introduction

Dragonflies play an important role as trophic components in ecosystems. As predators and prey, dragonflies are key elements in the process of transferring matter and energy along with the trophic web. Adult dragonflies prey on larger dragonflies, spiders, and various types of vertebrate animals such as frogs and bird (Rüppell et al. 2020). Also, adult dragonflies prey on various types of small animals, especially insects such as bees (Arbeiter et al. 2014). Some dragonfly species are cannibals by preying on members of the same species. In several cases, the larval phase that lives in waters becomes predator of various other smaller animals, for example Anura larvae and mosquito larvae (Weterings et al. 2015; Linares et al. (2016). Their prey, which consists of several types of harmful insects - insect pests and disease vectors - makes dragonflies act as agents of biological control (May 2019).

Commented [A16]: I would suggest to talk about a more general issue when starting the paper instead of a specific context such as the location of the study. As such I would suggest to move the subsequent paragraphs earlier here.

The important role of dragonflies can also be viewed from the aspect of environmental biology. The biotic and abiotic conditions required by dragonflies make it possible to use them as bio-indicator of environmental conditions of habitat, especially for aquatic ecosystems (Nasirian and Irvine 2017). Several parameters have been used when employing dragonflies as bioindicators, such as: the presence or absence of dragonfly species (Ting et al. 2018), the abundance ratio of Anisoptera and Zygoptera (Oliveira-Junior and Juen 2019), and the ratio of the Libellulidae family against other families in Anisoptera and the ratio of the Coenagrionodae family to other families in Zygoptera (Šigutováa et al. 2019). Dragonflies can also become tourist objects because of their attractive and varied colors, and conspicuous behaviors.

Because of the important roles of dragonflies in ecosystems, there is a need to conserve the diversity and population of dragonfly. The first step toward dragonfly conservation efforts and what species to be prioritized is the availability of data about species richness. This information is essential because each species has a different endemicity, population status, and threat. Likewise, each dragonfly species has specific habitat conditions, making it requires unique management interventions.

The Suranadi Ecotourism Area is one of tourist areas located in West Lombok District, Indonesia established through the Regulation No. 41 of 2016. This area consists of various habitats suitable for dragonfly. Water, which is a very important environmental component for dragonflies (Mafuwe and Moyo 2020), is available in abundance, scattered in many points and available almost all year round. Due to this condition, this area is known as "the city of water", and this is considered as the main tourist attraction of the area. Water with suitable characteristics can be used by adult dragonflies for oviposition and as habitat for larval development (Luke et al. 2017). Because of the life cycle that occur in terrestrial and aquatic ecosystems, dragonflies have a very important role in these two habitats. Based on these situations and conditions, we conducted research in several types of habitat in the Suranadi Ecotourism Area with the aim to determine species richness of dragonflies and propose conservation priorities according several considerations. We expect, the collected data can be used as baseline information for developing dragonfly conservation strategies as well as contributing to ecotourism activities in the Suranadi Ecotourism Area.

MATERIALS AND METHODS

Study period and area

The research was conducted from August to December 2020 in the Suranadi Ecotourism Area, Lombok, Indonesia (Figure 1). The investigated area consisted nine sampling stations, each presenting a different habitat type, namely forest edges (FE), middle forest (MF), waterways (WW), roads (RO), irrigation (IR), fields (FD), rice fields (RF), parks (PR), and pond (PO). The waterway is referred to area for water flows in Suranadi Ecotourism Area in which the water is originated from a spring and is a tributary of a river which flows continuously throughout the year. Habitat type of FE, MF, RO, FD and PR is terrestrial habitat, while habitat type of WW, IR, RF, and PO is aquatic habitat. The characteristics of each sampling location are presented in Table 1.

Commented [A17]: Please add information about the period of the study since the temporal context is important for study like this.

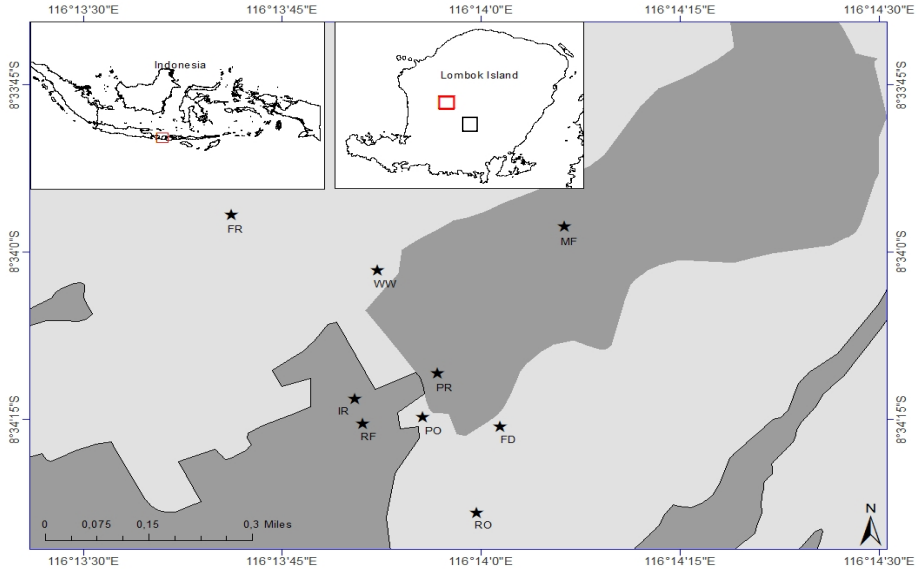


Figure 1. Map of the research location in the Suranadi Ecotourism Area, Lombok, West Nusa Tenggara, Indonesia

Table 1. The characteristics of nine habitat types in the Suranadi Ecotourism Area, Lombok, West Nusa Tenggara, Indonesia

Habitat Type	Environmental factor						
	Light intensity (Cd)	Humidity (%)	Air temperature (oC)	Tree canopy (%)	Herbaceous plant cover (%)	Altitude (m asl)	Number of plant (species)
PR	657	75	29,4	90	25	258	20
PO	2903	73	31	52	30	256	22
FD	5958	68	33,4	30	60	256	25
RO	2648	57	34,3	40	15	256	9
IR	4667	63	32,2	10	30	256	10
RF	7500	61	34,8	0	95	256	5
WW	2800	64	34,3	80	91	256	35
MF	110	69	29,3	100	50	257	30
FE	4490	73	31,8	25	80	256	15

Data collection

Data were collected using direct visual observation methods. A preliminary study was conducted with seven observations until no additional species were found. In the second and third observations, it was found that each addition of observation one species was found. Conversely, on the fourth, fifth, sixth, and seventh observation, no new species were found.

Adult dragonflies were captured using insect nets at each observation with 5 replications. Catching dragonflies was carried out at two time periods of each replication, namely morning from 09.00–11.00 AM, and afternoon from 14.00–16.00 PM Central Indonesian Time (+ 8 GMT). The number of dragonfly samples was determined based on the average of all observations. The sample of dragonfly was put in a plastic bag, and preserved

using 70% alcohol. Identification was carried out at the Biology Laboratory, Mataram University, Indonesia. Species identification was based on Orr and Hamalainen (2003), and Kosterin (2014).

Data analysis

Species richness was determined based on the number of species found in the study area (Quisil 2013). The assessment of conservation priority of dragonfly species was determined using the following criteria: (1) species endemicity (SE), using the indicator of the geographical distribution only in local, regional or national; (2) population status (PS), using the indicator of population size that consists of a small natural population, which declines drastically, and vulnerable; (3) habitat condition (HC), using the indicator of the suitable habitat that running low in extent, suitable habitat is decreasing, or the suitable habitat is sufficiently available and stable; (4) threat (T), using the indicator of the species suffers serious damage due to hunting, trade, culture, and agriculture; (5) the status of species management (SSM), using the indicator of the presence or absence of management plan and activities for the species. Any species found in the observation will be scored base on criteria referring to Annex 1 of Regulation No. P.57/Menhut-II/2008 for the insect group. Species that have the highest number of score out of the five criteria will be assigned as conservation priority species. The score was determined through a Focus Group Discussion (FGD) with five experts related to the scoring criteria. The score for each species was determined based on the percentage of the opinion from the experts.

RESULTS AND DISCUSSION

Results

Commented [A18]: In the Results, I would suggest to add photo(s) of some species, especially species with particular interest (e.g. the endemic, species of conservation priority, the most abundant, etc.).

Species richness

There were 18 species of dragonflies found in the Suranadi Ecotourism Area, belonging to 2 suborders, namely Anisoptera and Zygoptera. One species, Pseudagrion pilidorsum declaratum, is an endemic species. The suborder Anisoptera was represented by two families, namely Aeshnidae and Libellulidae. The suborder Zygoptera was represented by three families, namely Chlorocyphidae, Coanagrionidae and Platycnemididae. Although represented by more families, the number of species from the suborder of Anisoptera was higher than that of the suborder of Zygoptera. Among the Anisoptera, the Libellulidae family consisted of 12 species, while the Aeshnidae family had only only species (Figure 2a). In Zygoptera, the family with the highest species richness was Coenagrioniddae with a total of 3 out of 5 species from this suborder (Figure 2b).

Based on habitat type, the highest species richness was found in waterways with 17 species, while the middle forest habitat had the lowest species richness with two 2 species. Species richness in other habitats ranged from 5 to 16 species (Figure 3). Two species, namely Diplacodes trivialis and Orthetrum sabina from the Libellulidae family, were found in all habitat types. The species Libellago lineata from the Chlorocyphidae family, and Gynacantha subinterrupta from the Aeshnidae family were only found in one type of habitat, namely waterways.

During the observation, 764 specimens were recorded with 573 specimens belonged to the Anisoptera suborder and 191 specimens from the Zygoptera suborder. Among the suborder Anisoptera, the family Libellulidae was the most dominant with a total of 570 specimens. In the suborder Zygoptera, the family Coenagrionidae was the most dominant with a total of 149 specimens. The most abundant species was O. sabina with a total of 201 specimens, followed by Neurothemis ramburii with 108 specimens and Pantala flavescens with 101 specimens. Despite having lower species richness compared to waterways, the irrigation habitat had the most abundant dragonflies with a total of 204 specimens. The detailed information is presented in Table 2.

Conservation priorities

All dragonfly species found in the Suranadi Ecotourism Area have wide geographical distribution and none is endemic except P. pilidorsum declaratum. This species is only recorded to occur in East Java area and Lesser Sunda Islands (https://inaturalist.laji.fi/taxa/843602-Pseudagrion-pilidorsum-declaratum). Based on the Annex 1 of Regulation No. P.57/Menhut-II/2008, this species is categorized regional endemic with the calculated score of 20 in SE criteria. All species have not received adequate attention from the management aspect. Based on the total score from 18 species found in the Suranadi Ecotourism Area, there are 3 species,

namely P. pilidorsum declaratum, L. lineata, and G. subinterrupta had the highest total scores (Table 3) so they are assigned as priority species for conservation (Figure 4).

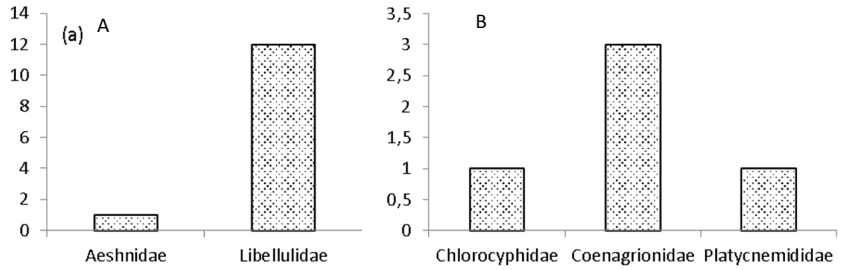


Figure 2. Species richness of dragonflies by family in suborders of Anisoptera (A) and Zygoptera (B)

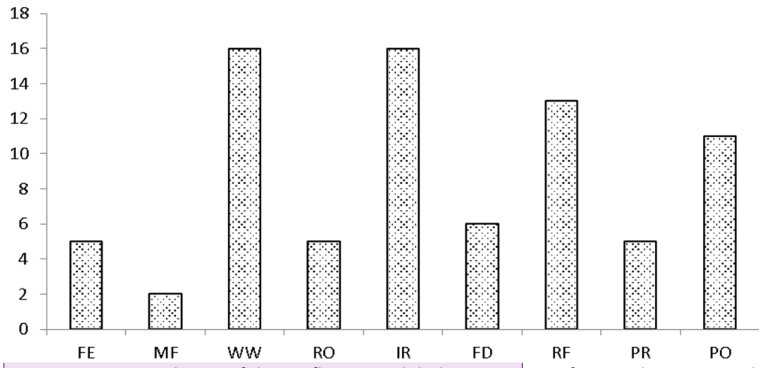


Figure 3. Species richness of dragonflies in each habitat type : FE: forest edges, MF: middle forest, WW: waterway, RO: roads, IR: irrigation, FD: fields, RF: rice fields, PR: Parks, and PO: pond

Commented [A19]: Please add note/information regarding each code used in figure 3 as you did in Table 2 (e.g. WW: waterways, etc).

Table 2. The average number of dragonfly individuals across species and habitat types in the Suranadi Ecotourism Area, Lombok

Suborder	Familly	Species name	Average number of dragonflies in each habitat									Σ
			FE	MF	WW	RO	IR	FD	RF	PR	PO	
Zygoptera	Chlorocyphidae	Libellago lineata	0	0	2	0	0	0	0	0	0	2
	Coenagrionidae	Pseudagrion pilidorsum declaratum	0	0	21	0	38	0	5	0	2	66
		Pseudagrion pruinosum	0	0	25	0	26	0	4	0	2	57
		Agriocnemis femina	0	0	12	0	7	0	2	0	4	25
	Platycnemididae	Copera marginipes	0	0	17	0	19	0	3	0	2	41
	Aeshnidae	Gynacantha subinterrupta	0	0	3	0	0	0	0	0	0	3

Anisoptera	Libellulidae	Diplacodes trivialis	6	1	2	5	4	7	5	6	5	41
		Lathrecista asiatica	0	0	5	0	4	0	0	0	0	9
		Neurothemis terminata	0	0	4	0	3	0	0	0	0	7
		Neurothemis ramburii	2	0	31	2	52	2	7	4	8	108
		Orthetrum chrysis	3	0	23	3	14	2	5	1	3	54
		Orthetrum sabina	51	2	17	15	20	53	23	9	11	201
		Pantala flavescens	3	0	4	7	2	15	56	8	6	101
		Trithemis festiva	0	0	4	0	7	0	0	0	2	13
		Zyxomma obtusum	0	0	5	0	1	0	3	0	0	9
		Zyxomma petiolatum	0	0	2	0	2	0	2	0	0	6
		Crocothermis servilia	0	0	0	0	4	0	8	0	2	14
		Acisoma panorpoides	0	0	0	0	1	1	2	0	3	7
Σ			65	3	17	32	20	80	13	28	50	764

Note: FE: forest edges, MF: middle forest, WW: waterway, RO: roads, IR: irrigation, FD: fields, RF: rice fields, PR: Parks, and PO: pond

Table 3. Dragonfly species for conservation priority in the Suranadi Ecotourism Area, Lombok

Species	Criterion value					Total (Σ)
	SE	PS	HC	T	SSM	
Libellago lineata	5	15	10	10	10	50
Pseudagrion pilidorsum declaratum	20	5	10	10	10	55
Pseudagrion pruinosum	5	5	10	5	10	35
Agriocnemis femina	5	5	10	5	10	35
Copera marginipes	5	5	10	5	10	35
Gynacantha subinterrupta	5	15	5	10	10	45
Diplacodes trivialis	5	5	5	5	10	30
Lathrecista asiatica	5	10	10	5	10	40
Neurothemis terminata	5	5	10	5	10	35
Neurothemis ramburii	5	5	10	5	10	35
Orthetrum chrysis	5	5	10	5	10	35
Orthetrum sabina	5	5	5	5	10	30
Pantala flavescens	5	5	5	5	10	30
Trithemis festiva	5	10	10	5	10	40
Zyxomma obtusum	5	5	10	5	10	35
Zyxomma petiolatum	5	5	10	5	10	35
Crocothermis servilia	5	5	10	5	10	35
Acisoma panorpoides	5	15	5	5	10	40

Note : SE: Species Endemicity, PS : population status, HC : Habitat Condition, T : Threat, SSM : Status of Species Management

A B C

Figure 4. Conservation priority dragonflies species in Suranadi ecotourism area. Indonesia. A. Pseudagrion pilidorsum declaratum B. Libellago lineata C. Gynacantha subinterrupta

Discussion

The richness of dragonfly species in the Suranadi Ecotourism Area consisted of 18 species which was dominated by the Libellulidae and Coenagrionidae families (Figure 2). This number is around 46.15% of the total of 39 species richness found in Lombok Island based on observations in late February 2014 (Kosterin 2014). At a local scale, the species richness of dragonflies in the Suranadi Ecotourism Area is higher than that found in rice fields around Denpasar (Suartini and Sudatri 2019). However, this species richness is lower than that found in the West Bali National Park with 26 species (Wijayanto et al. 2016). In several locations in Flores Island, there were 46 species of dragonflies found (Potapov et al. 2020). In general, the species richness of dragonfly in the Lesser Sunda Islands (including Lombok) tends to be lower than other regions (Koneri et al. 2020; Rohman et al. 2020; Sugiman et al. 2020).

Based on Figure 3, the habitat type that had the highest species richness is the waterway and irrigation. The presence of water in these habitats is the key factor because water is an ideal place of oviposition and larval habitat (Luke et al. 2017). Two other habitat types that are classified as aquatic habitats, namely rice fields and pond, had higher species richness compared to terrestrial habitats. Cumulatively, all dragonfly species in the Suranadi Ecotourism Area were found in the aquatic habitats. As the habitat type with the highest species richness, a total of 16 species was found in the waterway. On the other hand, two species that were absent in the waterway, namely Crocothermis servilia and Acisoma panorpoides, were found in irrigation, rice fields and pond. A. panorpoides had a wider distribution because apart from the three aquatic habitats, this species was also found in the terrestrial habitats. However, the number of individuals of A. panorpoides was smaller than C. servilia.

The higher species richness in waterway compared to three other aquatic habitats is due to the relatively better quality of water resources. The water in waterways is originated from springs, and is better preserved because it is located in a conservation area. Conversely, water in irrigation, rice fields and pond is contaminated by organic and inorganic waste, chlorine and detergents. These chemical substances have negative impacts on dragonflies (Gómez-Anaya et al. 2017; Mansoor 2017; Ann et al. 2020).

Environmental conditions and resource availability have impacts not only on species richness, but also on the number of individuals. Dragonfly individuals were most commonly found in irrigation, waterways and rice field habitats (Table 2). Three species that contributed the most on the number of individuals and became the dominant species were O. sabina, N. ramburii, and P. flavescens. This finding suggests that the habitat types in the Suranadi Ecotourism Area are more suitable for the three species than for the other 15 species. Koneri et al. (2020) found that the number of individuals of the O. sabina and P. flavescens species increased along with reduced canopy. These two species are generally found to be abundant in open areas despite disturbances in

the form of human activity (Leksono et al. 2017; Perez and Bautista 2020; Rohman et al. 2020). This proves that they are habituated to these anthropogenic environments. N. ramburii was found in almost all habitat types but the highest number of individuals was in irrigation where the tree canopy was limited.

Based on the highest score of 5 criteria of conservation priority, there were three dragonfly species considered to have conservation priority, namely P. pilidorsum declaratum, L. lineata and G. subinterrupta (Table 3). In the Suranadi Ecotourism Area, they were found in few habitat types in a small number of individuals. Even, L. lineata and G. subinterrupta were only found in the waterway habitat with only 2 and 3 individuals, respectively. The physical, chemical and biological conditions of the habitat where L. lineata and G. subinterrupta found had light intensity of 2800 Cd, humidity 64%, air temperature 34.3oC, tree canopy 80%, herbaceous plant cover 91%, altitude 256 m asl, and the highest number of plant species, namely 35 species. P. pilidorsum declaratum was found in several habitats with varying conditions.

Despite having the highest score for conservation priority, Pseudagrion pilidorsum declaratum was found in four types of aquatic habitat, namely waterways, irrigation, rice fields and ponds. This species can survive in a variety of habitat conditions. During observations in the Suranadi Ecotourism Area, this species was found in habitats with humidity ranging from 61%-73%, air temperature 31-34.8°C, tree canopy 0-80%, herbaceous plant cover 30-95%, altitude 256 m asl. and the number of plants 5-35 species. Its activities were around water bodies, flying low around herbaceous plants or perching on branches or leaves with a height of less than 1 meter. This species can also be found in small river estuary habitats with edges of gravel or sand and trees, and rivers in gardens and forests with rocky ground (Kosterin 2014).

Unlike P. pilidorsum declaratum, Libellago lineata was only found in the waterway. We found this species water bodies at the end of the dam bordering the road, commonly perching on a floating banana stem. This species can also be found perching on shrubs, grass with tree vegetation (Zada et al. 2016). In the Mahaka River, South Sulawesi, L. lineata can survive in habitats with temperature conditions of 32.59oC and humidity of 46.14% (Nuraeni et al. 2019). This temperature is lower than that in the waterway in our study. Viewed from water quality, this species is adaptive to low quality of water (Jacob and Manju 2016). L. lineata can also habituate to anthropogenic factors because it is found in parks (Hermawan and Fitriana 2015).

Like L. lineata, G. subinterrupta was found only in waterway. This species is the only dragonfly from the Aeshnidae family in the Suranadi Ecotourism Area. Abdillah et al. (2019) found G. subinterrupta in Sumber Mangli, Kediri, East Java in river habitats with temperature conditions above 25oC and humidity above 80%. This species is able to habituate to anthropogenic factors because it is found in parks, namely pond habitats and wetlands (Ngiam and Davison 2016). Other habitat characteristics that can support G. subinterrupta are pond with a high depth, and a ditch with a shallow muddy bottom. On the edge of ponds and trenches, there is high herbaceous plant cover and dense trees (Kosterin 2014).

The three species of conservation priorities, i.e. L. lineata, P. pilidorsum declaratum, and G. subinterrupta, have different ecological niches and habitat types, but some are in scope. Conservation efforts need to consider these factors. The conservation of the three priority species and dragonflies in general in this area is important because ecologically they play an important role in preserving nature which is the area for tourist destination. Preserved nature has a positive impact on the sustainability of the economy of people who depend on tourism activities. From an educational aspect, dragonflies can be a source of learning at both the primary, secondary and higher education levels. This research itself contributes to provide an important information for developing conservation and ecotourism strategies in Suranadi.

In conclusion, the species richness of dragonfly in the Suranadi Ecotourism Area of Lombok, Indonesia consisted 18 species from 5 families (Chlorocyphidae, Coanagrionidae, Platycnemididae, Aeshnidae and Libellulidae) suborder Anisoptera and Zygoptera with three conservation priority species namely P. pilidorsum declaratum, L. lineata, and G. subinterrupta.

ACKNOWLEDGEMENT

We thank the Directorate General of Higher Education (Dirjen Dikti), Ministry of Education and Culture, Indonesia for research funding. We also express our gratitude to the BON Team for their contribution during data collection in the field.

REFERENCES

Abdillah M, Prakarsa TBP, Tyastirin E. 2019. Odonata diversity at Sumber Clangap and Sumber Mangli Puncu Village Subdistrict of Puncu District of Kediri. Biodjati 4: 236-243. DOI: 10.15575/biodjati.v4i2.4823. [Indonesian]
Ann M, Perron C, Pick FR. 2020. Water quality effects on dragonfly and damselfly nymph communities: A comparison of urban and natural ponds. Environ Pollut 263: 1-13. DOI: 10.1016/j.envpol.2020.114472.
Arbeiter S, Schnepel H, Uhlenhaut K, Bloege Y, Schulze M, Hahn S. 2014. Seasonal shift in the diet composition of european bee-eaters merops apiaster at the northern edge of distribution. Ardeola 61: 161-170. DOI: 10.13157/arla.61.1.2014.161.
Gómez-anaya JA, Novelo-gutiérrez R, Astudillo-Aldana MR. 2017. Effect of domestic and coffee mill discharges on the water quality and the Odonata (Insecta) larval diversity in a mountain cloud forest stream in Veracruz, Mexico. Rev Mex Biodivers 88: 372-380. DOI: 10.1016/j.rmb.2017.03.004.
Hermawan AS, Fitriana N. 2015. Diversity and fluctuations of Odonates in BSD City Park, South Tangerang, Banten. Pros Sem Nas Masy Biodiv Indon 8: 1795-1801. DOI: 10.13057/psnmbi/m010808.
Jacob S, Manju EK. 2016. Potential of Odonate (dragonflies and damselflies) diversity as a bioindicator of water quality. Intl J Sci Res 5: 2033-2036.
Koneri R, Nangoy M, Maabuat PV. 2020. Composition and diversity of dragonflies (Insecta: Odonata) in Tunan Waterfall Area, North Minahasa, North Sulawesi, Indonesia. Pak J Zool 52(6): 1-10. DOI: 10.17582/journal.pjz/20181214071225.
Kosterin OE. 2014. Odonata briefly observed on the islands of Bali and Lombok, Lesser Sundas, Indonesia, in the late February 2014. International Dragonfly Fund (IDF)- Report 74: 1-48.
Leksono AS, Feriwibisono B, Arifianto T, Pratama AF. 2017. The abundance and diversity of Odonata along an altitudinal gradient in East Java, Indonesia. Entomol Res 47 (4): 1-8. DOI: 10.1111/1748-5967.12216.
Linares AM, Maciel-Júnior JAH, de Mello HES, Leite FSF. 2016. First report on predation of adult anurans by Odonata larvae. Salamandra 52: 42-44.
Luke SH, Dow RA, Butler S, Vun Khen C, Aldridge DC, Foster WA, Turner EC. 2017. The impacts of habitat disturbance on adult and larval dragonflies (Odonata) in rainforest streams in Sabah, Malaysian Borneo. Freshw Biol 62: 491-506. DOI: 10.1111/fwb.12880.
Mafuwe K, Moyo S. 2020. Dragonfly (Odonata) community structure in the Eastern Highlands Biodiversity Hotspot of Zimbabwe: Potential threats of land use changes on freshwater invertebrates. Int J Odonatol 23(3): 1-14. . DOI: 10.1080/13887890.2020.1768156.
Mansoor R. 2017. Do herbaceous planticide effects on Odonata larvae, depend on their location of origin? An ecotoxicological study using Glyphosate. [Thesis]. Halmstad University, Halmstad. [Sweden].
May ML. 2019. Odonata: Who they are and what they have done for us lately: Classification and ecosystem services of dragonflies. Insects 62: 1-17. DOI: 10.3390/insects10030062.
Nasirian H, Irvine KN. 2017. Odonata larvae as a bioindicator of metal contamination in aquatic environments: Application to ecologically important wetlands in Iran. Environ Monit Assess 189: 189:436. DOI: 10.1007/s10661-017-6145-6.
Ngiam RWJ, Davison GWH. 2016. A checklist of dragonflies in Singapore Parks (Odonata: Anisoptera, Zygoptera). Nat Sing 4: 349-353.
Nuraeni S, Budiaman, Yaspeta S. 2019. Identification of dragonfly and damselfly species around Mahaka river, Hasanuddin university teaching forest. IOP Conf Ser: Earth Environ Sci 343: 1-9. DOI: 10.1088/1755-1315/343/1/012052.
Oliveira-Junior J, Juen L. 2019. The Zygoptera/Anisoptera ratio (Insecta: Odonata): A new tool for habitat alterations assessment in Amazonian streams. Neotrop Entomol 48: 552-560. DOI: 10.1007/s13744-019-00672-x
Orr A, Hamalainen M. 2003. A Guide to the Dragonflies of Borneo Their Identification and Biology. Natural History Publications, Kinabalu (Borneo).
Peraturan Bupati Lombok Barat No. 41 tentang Kawasan Desa Wisata. 2016. Pemerintah Daerah Kabupaten Lombok Barat, Gerung. [Indonesian]
Perez ESN, Bautista MG. 2020. Dragonflies in the city: Diversity of Odonates in urban Davao, Philippines. J Agric Sci Technol 10: 12-19. DOI: 10.17265/2161-6256/2020.01.002.

Potapov GS, Kolosova YS, Gofarov MY, Bolotov IN. 2020. Dragonflies and damselflies (Odonata) from Flores Island, Lesser Sunda Archipelago: New occurrences in extreme environments and an island-level checklist of this group. Ecol Montenegrina 25: 5-25. DOI: 10.37828/em.2020.35.2.
Quisil SJC, Arreza JDE, Nuneza OM, Villanueva RJT. 2013 Species richness of Odonata in Lanuza and San Agustin, Surigao del Sur, Philippines. AES Bioflux 5(3):245-260.
Rohman A, Sulistyono S, Nuryati W, Arifandy A, Setiyanto A. 2020. Dragonflies in Bawean Island Nature Reserve, Indonesia. Borneo J Res Sci Technol 10: 45-50. DOI: 10.33736/bjrst.2022.2020.
Rüppell G, Hilfert-Rüppell D, Schneider B, Dedenbach H. 2020. On the firing line–interactions between hunting frogs and Odonata. Int J Odonatol 23: 199-217. DOI: 10.1080/13887890.2020.1733328.
Šigutováa H, Šipoš J, Dolný A. 2019. A novel approach involving the use of Odonata as indicators of tropical forest degradation: When family matters. Ecol Indic 104: 229-236. DOI: 10.1016/j.ecolind.2019.05.001.
Suartini NM, Sudatri NW. 2019. Species of dragonflies (Odonata order) for rice plantations in some rice field around Denpasar, Bali. Simbiosis 7: 23-28. DOI: 10.24843/JSIMBIOSIS.2019.v07.i01.p05.
Sugiman U, Atmowidi T, Priawandiputra W. 2020. Community structure and habitat characteristics of dragonflies (Odonata) in tropical lowland forest of Ujung Kulon National Park J Entomol Zool Stud 8: 251-258. www.entomoljournal.com.
Ting D, Huai-jian L, Lei S. 2018. Odonata aquatic insects as bioindicators in water quality evaluation of Dianchi Lake riparian wetland. J For Res 31: 145-152. DOI: 10.13275/j.cnki.lykxyj.2018.05.020.
Weterings R, Umponstira C, Buckley HL. 2015. Predation rates of mixed instar Odonata naiads feeding on Aedes aegypti and Armigeres moultoni (Diptera: Culicidae) larvae. J Asia-Pacific Entomol 18: 1-8. DOI: 10.1016/j.aspen.2014.10.008.
Wijayanto AG, Nafisah NA, Laily Z, Zaman MN. 2016. Inventarisasi capung (insecta: Odonata) dan variasi habitatnya di Resort Tegal Bunder dan Teluk Terima Taman Nasional Bali Barat (TNBB). Seminar Nasional Pendidikan dan Saintek 2016: 427-434.
Zada N, Farid A, Zia A, Saeed M, Khan SM, Khan A, Khan IA, Fazlullah, Badshah T. 2016. Damselflies (Odonata: Zygoptera) fauna of District Buner, Khyber Pakhtunkhwa, Pakistan. J Entomol Zool Stud 4: 491-495.

REVISI 4

The species richness and conservation priority of dragonflies in the Suranadi Ecotourism Area, Lombok, Indonesia

Mohammad Liwa Ilhamdi1,♥, Agil Al Idrus1, Didik Santoso1, Gito Hadiprayitno1, Muhammad Syazali2

1Department of Biology Education, Faculty of Teacher Training and Education Science, Universitas Mataram. Jl. Majapahit 62, Mataram 83125, West Nusa Tenggara, Indonesia. Tel./fax.: +62-370-623873. ♥email: liwa_ilhamdi@unram.ac.id

2Department Elementary of School Teacher Education, Faculty of Teacher Training and Education Science, Universitas Mataram. Jl. Majapahit 62, Mataram 83125, West Nusa Tenggara, Indonesia .

Manuscript received: 2 February 2021. Revision accepted: 16 March 2021.

Abstract. Ilhamdi ML, Idrus AA, Santoso D, Hadiprayitno G, Syazali M. 2021. The species richness and conservation priority of dragonflies in the Suranadi Ecotourism Area, Lombok, Indonesia. Biodiversitas 22: 1783-1789. Dragonflies are insects that have attractive colors and play an important role in the balance of ecosystems and act as bioindicators of the aquatic environment. As an effort to conserve and support ecotourism, this research needs to be done. The purpose of this study was to analyze the species richness and conservation priorities of dragonflies in the Suranadi ecotourism area, with the aim to use dragonflies as charismatic species to support ecotourism. The research was conducted in August - December 2020 with the

survey method through transect lines in 9 types of habitat. Species richness was determined based on the number of species found during observation and conservation priority refers to the PP. No. 57 / Menhut-II / 2008. The score was determined through a Focus Group Discussion (FGD) with five experts related to the scoring criteria. The score for each species is determined based on the percentage of the opinion from the experts. The number of dragonfly species found was 18 species from 2 suborders (Zygoptera and Anisoptera) 5 families (Chlorocyphidae, Coenagrionidae, Platycnemididae, Aeshnidae and Libellulidae). The habitat type that supports the highest species richness is the waterway and irrigation (16 species), while the lowest species richness was found in the areas inside the forest habitat (2 species). The species that had the highest conservation priority index scores were Pseudagrion pilidorsum declaratum, Libellago lineata, and Gynacantha subinterrupta. These three species are conservation priority species in the ecotourism area of Suranadi, Lombok, Indonesia.

Keywords: Species richness, conservation priority, dragonflies

Introduction

The Suranadi Ecotourism Area is one of the tourist areas based on Lombok Barat Regent, Indonesia Regulation No. 41 of 2016. This area consists of various habitats suitable for supporting dragonfly life. Water, which is a very important environmental component for dragonflies (Mafuwe and Moyo 2020), is available in abundance, scattered in many points and available almost all year round. This area is known as "the city of water", and the main attraction that is used as a tourist resource is water. Water with suitable characteristics can be used by adult dragonflies for oviposition and as habitat for larval development (Luke et al. 2017). Because of their life cycle in these two habitats, dragonflies have a very important role in terrestrial and aquatic ecosystems.

The important role of dragonflies can be observed in their function as trophic components. As predators and prey, dragonflies are key elements in the process of transferring matter and energy along with the trophic web. Adult dragonflies prey on larger dragonflies, spiders, and various types of vertebrate animals such as frogs and bird (Rüppell et al. 2020). To obtain nutrition, adult dragonflies prey on various types of small animals, especially insects such as bees (Arbeiter et al. 2014). Some species are cannibals by preying on members of the same species. The larval phase that lives in the waters becomes a predator of various other smaller animals. For example, Anura larvae and mosquito larvae (Weterings et al. 2015). Linares et al. (2016) found that dragonfly larvae prey on adult Anura.

The important role of dragonflies can also be viewed from the aspect of environmental biology. The living conditions that require specific ecological niches make it an environmental bio-indicator, especially for aquatic conditions (Nasirian and Irvine 2017). Some special conditions that make dragonflies as bioindicators are (1) presence or absence of species (Ting et al. 2018), (2) abundance ratio of Anisoptera and Zygoptera (Oliveira-Junior and Juen 2019), and (3) Ratio of the Libellulidae family against other families in Anisoptera and the ratio of the Coenagrionodae family to other families in Zygoptera (Šigutováa et al. 2019). Their prey, which consists of several types of harmful insects - insect pests and disease vectors - makes dragonflies act as biological control agents (May 2019). Dragonflies can also become tourist objects because of their attractive and varied colors, and conspicuous behaviors.

Their very important roles justify indicates that dragonflies need to be biodiversity that receives conservation efforts. These efforts require data in particular about species richness. Each species has a different endemicity, population status, and threat. Likewise with habitat conditions and management status. Based on these situations and conditions, we conducted research in several types of habitat in the Suranadi Ecotourism Area with the aim to determine the local and regional species richness and propose conservation priorities for dragonflies. The collected

data from our research can support dragonfly conservation and contribute to ecotourism efforts.

MATERIALS AND METHODS

Study Area

The research was conducted in the Suranadi Ecotourism Area, Lombok Indonesia. The investigated area was split up into 9 sampling stations, each presenting a different habitat type, namely forest edges (FE), middle forest (MF), waterways (WW), roads (RO), irrigation (IR), fields (FD), rice fields (RF), Parks (PR), and the pool (PO). Habitat types FE, MF, RO, FD and PR are terrestrial habitats, while habitat types WW, IR, RF, and PO are aquatic habitats. For each of the nine different habitat types, we present some characteristics in Table 1. A waterway is a place for water flows in Suranadi Ecotourism Area. The water comes from a spring located in Suranadi Ecotourism Area. This waterway is like a tributary whose water flows continuously throughout the year.

Research method

Data were collected during August - December 2020 in 9 types of habitat (Figure 1) using direct visual observation methods. Prior to data collection, a preliminary study was conducted with seven observations, until no additional species were found. In the second and third observations, it was found that each addition of one species was found. Furthermore, on the fourth, five, six, and seven observation, no new species were found. Adult dragonflies were captured using insect nets at each observation, with 5 replications. Catching dragonflies was carried out in 2 time periods at each replication, namely morning from 09.00 – to 11.00 am, and afternoon from 14.00 – to 16.00 pm Central Indonesian Time (Wita). The number of dragonfly samples was determined based on the average of all observations. The sample of the dragonfly was put in a plastic bag, and preserved using 70% alcohol. Identification was carried out at the Basic Biology Laboratory, Mataram University, Indonesia. Species identifications were based on Orr and Hamalainen (2003), and Kosterin (2014).

Data analysis

Species richness was determined based on the number of species found in the study area (Quisil 2013). Dragonfly conservation priority in the Suranadi ecotourism areas is done by using priority species. Determination of the priority species of dragonfly found during the study was assessed using criteria that describe the level of importance for conservation. The general criteria used include (1) species endemicity (SE), with indicators of the spread coverage of local, regional, national, and non-endemic; (2) population status (PS), with a population size indicator that consists of a small natural population, which declines drastically, and vulnerable; (3) habitat condition (HC), with the suitable habitat indicator running low, suitable habitat is decreasing and suitable habitat is sufficiently available and stable; (4) threat (T), with indicator species, suffered serious damage due to hunting, trade, culture, and agriculture; (5) the status of species management (SSM), the management indicator is the presence or absence of management activities or management plan for the species. Any species found in the observation will be given a total score base on criteria referring to Annex 1 of Regulation No. P.57/Menhut-II/2008 for the insect group. Species that have the highest number of scores out of the 5 criteria are designated as conservation priority species. The score was determined through a Focus Group Discussion (FGD) with five experts related to the scoring criteria. The score for each species is determined based on the percentage of the opinion from the experts.

Table 1. Characteristics of the nine different habitat types present in the Suranadi Ecotourism Area, Lombok, West Nusa Tenggara, Indonesia

Habitat Type	Environmental factor						
	Light intensity (Cd)	Humidity (%)	Air temperature (oC)	Tree canopy (%)	Herbaceous plant cover (%)	Altitude (asl)	Number of plant (species)
PR	657	75	29,4	90	25	258	20
PO	2903	73	31	52	30	256	22
FD	5958	68	33,4	30	60	256	25
RO	2648	57	34,3	40	15	256	9
IR	4667	63	32,2	10	30	256	10
RF	7500	61	34,8	0	95	256	5
WW	2800	64	34,3	80	91	256	35
MF	110	69	29,3	125	50	257	30
FE	4490	73	31,8	25	80	256	15

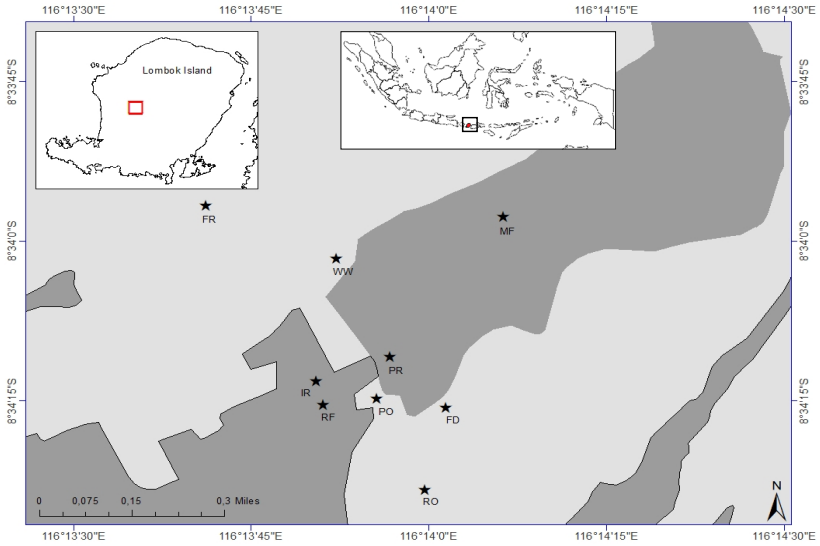


Figure 1. Map of the research location in the Suranadi Ecotourism Area, Lombok, West Nusa Tenggara, Indonesia

RESULTS AND DISCUSSION

Species richness

The total species of dragonflies found in the Suranadi Ecotourism Area are 18 species from 2 suborders, namely Anisoptera and Zygoptera. Satu spesies – Pseudagrion pilidorsum declaratum - termasuk spesies endemik. The suborder Anisoptera is represented by 2 families, namely Aeshnidae and Libellulidae. The suborder Zygoptera is represented by 3 families, namely Chlorocyphidae, Coanagrionidae and Platycnemididae. Although represented by more families, the species richness of the suborder Anisoptera is higher than that of the suborder Zygoptera. Among the Anisoptera, the Libellulidae family consists of 12 species, while the Aeshnidae family has only 1 species (Figure 2a). In Zygoptera, the family with the highest species richness is Coenagrioniddae with a total of 3 out of 5 species from this suborder (Figure 2b).

Based on habitat type, the highest species richness was found in waterways within the forest (17 species), while the middle forest habitat type had the lowest species richness (2 species). Species richness in other habitat types ranges from 5 to 16 species (Figure 3). Two species, namely Diplacodes trivialis and Orthetrum sabina from the Libellulidae family, were found in all habitat types. The species Libellago lineata from the Chlorocyphidae family, and Gynacantha subinterrupta from the Aeshnidae family were only found in 1 type of habitat, namely waterways in the forest.

During the observation, 764 specimens were recorded, with details of 573 specimens from the Anisoptera suborder and 191 specimens from the Zygoptera suborder. Among the suborder Anisoptera, the family Libellulidae is predominant with a total of 570 specimens. In the suborder Zygoptera, the family Coenagrionidae is predominant with a total of 149 specimens. The most abundant species was O. sabina with a total of 201 specimens, followed by Neurothemis ramburii with 108 specimens and Pantala flavescens with 101 specimens. Despite having lower species richness compared to waterways, the irrigated habitat type had the most abundant dragonflies with a total of 204 specimens. More complete information can be seen in Table 2.

Conservation priorities

All dragonfly species found in the Suranadi Ecotourism Area have wide distribution and none is endemic except P. pilidorsum declaratum. This species only found in East Java area and Lesser Sunda Island (https://inaturalist.laji.fi/taxa/843602-Pseudagrion-pilidorsum-declaratum). Based on criteria of Annex 1 of Regulation No. P.57/Menhut-II/2008, this species is regional endemic, and its score is 20 in SE criteria. All species have not received adequate attention from the management aspect. Based on the total score from 18 species found in the Suranadi Ecotourism Area, there are 3 species, namely P. pilidorsum declaratum, L. lineata, and G. subinterrupta had the highest total scores (Table 3) so they are designated as conservation priority species.

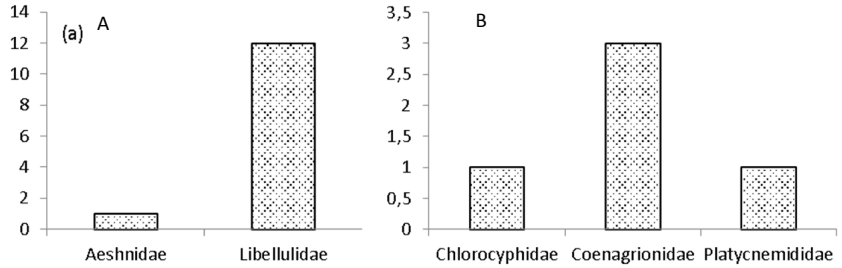


Figure 2. Species richness of dragonflies by family in suborder Anisoptera (A) and Zygoptera (B)

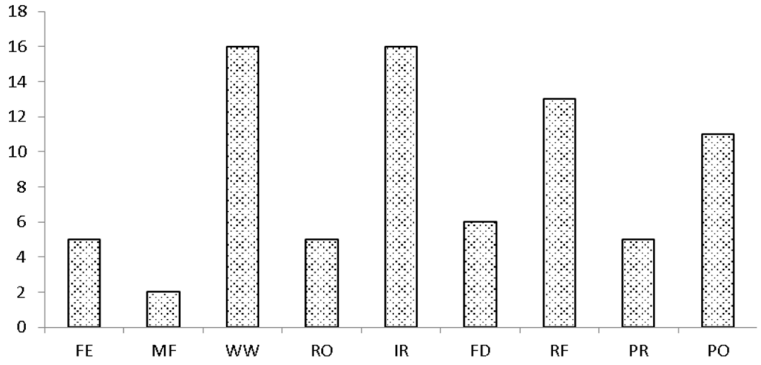


Figure 3. Species richness of dragonflies in each habitat type

Table 2. Average number of Odonata in the Suranadi Ecotourism Area, Lombok, West Nusa Tenggara, Indonesia

Suborder	Familly	Species name	Average number of dragonflies in each habitat									Σ
			FE	MF	WW	RO	IR	FD	RF	PR	PO	
Zygoptera	Chlorocyphidae	Libellago lineata	0	0	2	0	0	0	0	0	0	2
	Coenagrionidae	Pseudagrion pilidorsum declaratum	0	0	21	0	38	0	5	0	2	66

		Pseudagrion pruinosum	0	0	25	0	26	0	4	0	2	57
		Agriocnemis femina	0	0	12	0	7	0	2	0	4	25
	Platycnemididae	Copera marginipes	0	0	17	0	19	0	3	0	2	41
Anisoptera	Aeshnidae	Gynacantha subinterrupta	0	0	3	0	0	0	0	0	0	3
	Libellulidae	Diplacodes trivialis	6	1	2	5	4	7	5	6	5	41
		Lathrecista asiatica	0	0	5	0	4	0	0	0	0	9
		Neurothemis terminata	0	0	4	0	3	0	0	0	0	7
		Neurothemis ramburii	2	0	31	2	52	2	7	4	8	108
		Orthetrum chrysis	3	0	23	3	14	2	5	1	3	54
		Orthetrum sabina	51	2	17	15	20	53	23	9	11	201
		Pantala flavescens	3	0	4	7	2	15	56	8	6	101
		Trithemis festiva	0	0	4	0	7	0	0	0	2	13
		Zyxomma obtusum	0	0	5	0	1	0	3	0	0	9
		Zyxomma petiolatum	0	0	2	0	2	0	2	0	0	6
		Crocothermis servilia	0	0	0	0	4	0	8	0	2	14
		Acisoma panorpoides	0	0	0	0	1	1	2	0	3	7
Σ			65	3	177	32	204	80	130	28	50	764

Note: FE: forest edges, MF: middle forest, WW: waterway, RO: roads, IR: irrigation, FD: fields, RF: rice fields, PR: Parks, and PO: pool

Table 3. Priority for dragonfly conservation in the Suranadi Ecotourism Area, Lombok, West Nusa Tenggara, Indonesia

Species	Criterion value					Σ
	SE	PS	HC	T	SSM	
Libellago lineata	5	15	10	10	10	50
Pseudagrion pilidorsum declaratum	20	5	10	10	10	55
Pseudagrion pruinosum	5	5	10	5	10	35
Agriocnemis femina	5	5	10	5	10	35

Copera marginipes	5	5	10	5	10	35
Gynacantha subinterrupta	5	15	5	10	10	45
Diplacodes trivialis	5	5	5	5	10	30
Lathrecista asiatica	5	10	10	5	10	40
Neurothemis terminata	5	5	10	5	10	35
Neurothemis ramburii	5	5	10	5	10	35
Orthetrum chrysis	5	5	10	5	10	35
Orthetrum sabina	5	5	5	5	10	30
Pantala flavescens	5	5	5	5	10	30
Trithemis festiva	5	10	10	5	10	40
Zyxomma obtusum	5	5	10	5	10	35
Zyxomma petiolatum	5	5	10	5	10	35
Crocothermis servilia	5	5	10	5	10	35
Acisoma panorpoides	5	15	5	5	10	40

Discussion

The species richness of dragonflies in the Suranadi Ecotourism Area includes 18 species predominated by the Libellulidae and Coenagrionidae families (Figure 2). This number is around 46.15% of the total of 39 species richness found in Lombok Island based on observations in late February 2014 (Kosterin 2014). When compared with several studies conducted in Bali, an island in West Lombok, the species richness of dragonflies in the Suranadi Ecotourism Area is higher than those found in rice fields around Denpasar (Suartini and Sudatri 2019). However, this species richness is lower than that found in the West Bali National Park with 26 species (Wijayanto et al. 2016). In several locations on the island of Flores, the island east of Lombok, 46 species of dragonflies were found (Potapov et al. 2020). Several research results dragonfly species richness outside the Lesser Sunda Island tends to be higher (Koneri et al. 2020; Rohman et al. 2020; Sugiman et al. 2020).

Based on Figure 3, the habitat type that has the highest species richness is the waterway and irrigation. The existence of water resources in this type of habitat is a key factor because it is an oviposition site and larval habitat (Luke et al. 2017). Two other habitat types that are classified as aquatic habitats, namely rice fields, and pool, have higher species richness compared to other types of terrestrial habitats. Second order is rice fields and fourth is pool. All dragonfly species in the Suranadi Ecotourism Area are found in this aquatic habitat. As the habitat type with the highest species richness, a total of 16 species were found in the waterway. Two other species, namely Crocothermis servilia and Acisoma panorpoides, were found in irrigation, rice fields and pool.

The higher species richness in waterway habitat types compared to other types of habitats classified as aquatic is due to the relatively better quality of water resources. The water resource comes from springs, and is better preserved because it is in a

conservation area. Water in the types of irrigation habitats, rice fields and pool is contaminated by organic and inorganic waste, chlorine and detergents. These foreign substances have a negative impact on dragonflies (Gómez-Anaya et al. 2017; Mansoor 2017; Ann et al. 2020). Only two of the 18 species were not found in the waterway habitat type, namely C. servilia and A. panorpoides. C. servilia is only found in the type of habitat for irrigation, rice fields and pool. A. panorpoides has a wider distribution because apart from the three habitat types, this species is also found in the field habitat type. However, the number of individuals is smaller than C. servilia.

Environmental conditions and resource availability have an impact not only on species richness, but also on the number of individuals. Dragonflies are most commonly found in irrigation, waterways, and rice field habitats (Table 2). Three species that contribute to the high number of dragonflies in this habitat type, and become the predominant species are O. sabina, N. ramburii, and P. flavescens. The habitat types in the Suranadi Ecotourism Area are more suitable for them than the other 15 species. Koneri et al. (2020) found that the number of individuals of the O. sabina and P. flavescens species increased along with reduced canopy. These two species are generally found to be abundant in open areas despite disturbances in the form of human activity (Leksono et al. 2017; Perez and Bautista 2020; Rohman et al. 2020). This proves that they are habituated to these anthropogenic factors. N. ramburii was found in almost all habitat types but the highest number of individuals was in irrigation where the tree canopy was small.

Based on the highest score out of 5 criteria, there are 3 dragonfly species that are priority for conservation, namely P. pilidorsum declaratum, L. lineata and G. subinterrupta (Table 3). In the Suranadi Ecotourism Area, they are scattered in a limited habitat type and a small number of individuals. L. lineata and G. subinterrupta were even only once found during the on site observation in the waterway habitat respectively 2, 3, and 7 individuals. Physical, chemical and biological conditions of the habitat where L. lineata and G. subinterrupta were found were light intensity 2800 Cd, humidity 64%, air temperature 34.3 oC, tree canopy 80%, herbaceous plant cover 91%, altitude 256 masl, and the highest number of plant species, namely 35 species. P. pilidorsum declaratum was found in more varied habitat conditions.

Pseudagrion pilidorsum declaratum was found in four types of aquatic habitat, namely waterways, irrigation, rice fields and ponds. This species can survive in a variety of habitat conditions. During observations in the Suranadi Ecotourism Area, this species was found in conditions of humidity ranging from 61% - 73%, air temperature 31 ° C - 34.8 ° C, tree canopy 0% - 80%, herb cover 30% - 95%, altitude 256 asl. and the number of plants 5 species - 35 species. Its activities are carried out around water bodies, flying low around herbaceous plants or perching on branches or leaves with a height of less than 1 meter. This species can also be found in small river estuary habitats with edges of gravel or sand and trees, and rivers in gardens and forests with rocky bottoms (Kosterin 2014).

Libellago lineata, unlike P. pilidorsum declaratum, appears scattered in various types of habitats. This species is only found in the waterway habitat type in the Suranadi forest. We found this species in bodies of water at the end of the dam bordering the highway, commonly perching on a floating banana stem. This species can also be found perching on shrubs, grass with tree vegetation (Zada et al. 2016). In the Mahaka river of South Sulawesi, L. lineata can survive in habitats with temperature conditions of 32.59 oC and humidity of 46.14% (Nuraeni et al. 2019). This temperature is lower than the temperature measured in the waterway habitat type. From the water quality factor, this species is adaptive to the inferior water quality level (Jacob and Manju 2016). L. lineata can also habituate to anthropogenic factors because it is found in parks (Hermawan and Fitriana 2015).

Like L. lineata, G. subinterrupta is a species found only in waterway habitat types. This species is the only dragonfly from the Aeshnidae family in the Suranadi Ecotourism Area. Abdillah et al. (2019) found G. subinterrupta in Sumber Mangli Kediri in

river habitats with temperature conditions above 25 oC and humidity above 80%. This species is able to habituate to anthropogenic factors because it is found in parks, namely pond habitats and wetlands (Ngiam and Davison 2016). Other habitat characteristics that can support the survival of G. subinterrupta are a pond with a high enough depth, and a ditch with a shallow muddy bottom. On the edge of ponds and trenches, there is high herbaceous plant cover and dense trees (Kosterin 2014).

The four species, i.e. L. lineata, P. pilidorsum declaratum, and G. subinterrupta, which are conservation priorities in the Suranadi Ecotourism Area have different ecological niches and habitat types, but some are in scope. Conservation efforts need to consider these factors. Conservation of the three priority species and odonate in general in this area is important because ecologically they play an important role in preserving nature which is the area's tourist destination. Preserved nature has a positive impact on the sustainability of the economy of people who depend on tourism activities. From an educational aspect, Odonata can be a source of learning at both the primary, secondary and higher education levels. This research itself contributes to provide important information for developing conservation and ecotourism strategies in Suranadi.

In conclusion, the species richness of dragonfly in the Suranadi Ecotourism Area of Lombok, Indonesia, includes 18 species from 5 families (Chlorocyphidae, Coanagrionidae, Platycnemididae, Aeshnidae and Libellulidae) suborder Anisoptera and Zygoptera with three conservation priority species namely P. pilidorsum declaratum, L. lineata, and G. subinterrupta.

ACKNOWLEDGEMENT

Thank you to the Directorate General of Higher Education (Dirjen Dikti), Ministry of Education and Culture, Indonesia for research funding. We also express our gratitude to the BON Team for their contribution during data collection in the field.

REFERENCES

Abdillah M, Prakarsa TBP, Tyastirin E. 2019. Odonata diversity at Sumber Clangap and Sumber Mangli Puncu Village Subdistrict of Puncu District of Kediri. Biodjati 4: 236-243. DOI: 10.15575/biodjati.v4i2.4823. [Indonesian]

Ann M, Perron C, Pick FR. 2020. Water quality effects on dragonfly and damselfly nymph communities: A comparison of urban and natural ponds. Environ Pollut 263: 1-13. DOI: 10.1016/j.envpol.2020.114472.

Arbeiter S, Schnepel H, Uhlenhaut K, Bloege Y, Schulze M, Hahn S. 2014. Seasonal shift in the diet composition of european bee-eaters merops apiaster at the northern edge of distribution. Ardeola 61: 161-170. DOI: 10.13157/arla.61.1.2014.161.

Gómez-anaya JA, Novelo-gutiérrez R, Astudillo-Aldana MR. 2017. Effect of domestic and coffee mill discharges on the water quality and the Odonata (Insecta) larval diversity in a mountain cloud forest stream in Veracruz, Mexico. Rev Mex Biodivers 88: 372-380. DOI: 10.1016/j.rmb.2017.03.004.

Hermawan AS, Fitriana N. 2015. Diversity and fluctuations of Odonates in BSD City Park, South Tangerang, Banten. Pros Sem Nas Masy Biodiv Indon 8: 1795-1801. DOI: 10.13057/psnmbi/m010808.

Jacob S, Manju EK. 2016. Potential of Odonate (dragonflies and damselflies) diversity as a bioindicator of water quality. Intl J Sci Res 5: 2033-2036.

Koneri R, Nangoy M, Maabuat PV. 2020. Composition and diversity of dragonflies (Insecta: Odonata) in Tunan Waterfall Area, North Minahasa, North Sulawesi, Indonesia. Pak J Zool 52(6): 1-10. DOI: 10.17582/journal.pjz/20181214071225.

Kosterin OE. 2014. Odonata briefly observed on the islands of Bali and Lombok, Lesser Sundas, Indonesia, in the late February 2014. International Dragonfly Fund (IDF)- Report 74: 1-48.

Leksono AS, Feriwibisono B, Arifianto T, Pratama AF. 2017. The abundance and diversity of Odonata along an altitudinal gradient in East Java, Indonesia. Entomol Res 47 (4): 1-8. DOI: 10.1111/1748-5967.12216.

Linares AM, Maciel-Júnior JAH, de Mello HES, Leite FSF. 2016. First report on predation of adult anurans by Odonata larvae. Salamandra 52: 42-44.

Luke SH, Dow RA, Butler S, Vun Khen C, Aldridge DC, Foster WA, Turner EC. 2017. The impacts of habitat disturbance on adult and larval dragonflies (Odonata) in rainforest streams in Sabah, Malaysian Borneo. Freshw Biol 62: 491-506. DOI: 10.1111/fwb.12880.

Mafuwe K, Moyo S. 2020. Dragonfly (Odonata) community structure in the Eastern Highlands Biodiversity Hotspot of Zimbabwe: Potential threats of land use changes on freshwater invertebrates. Int J Odonatol 23(3): 1-14. . DOI: 10.1080/13887890.2020.1768156.

Mansoor R. 2017. Do herbaceous planticide effects on Odonata larvae, depend on their location of origin? An ecotoxicological study using Glyphosate. [Thesis]. Halmstad University, Halmstad. [Sweden].

May ML. 2019. Odonata: Who they are and what they have done for us lately: Classification and ecosystem services of dragonflies. Insects 62: 1-17. DOI: 10.3390/insects10030062.

Nasirian H, Irvine KN. 2017. Odonata larvae as a bioindicator of metal contamination in aquatic environments: Application to ecologically important wetlands in Iran. Environ Monit Assess 189: 189:436. DOI: 10.1007/s10661-017-6145-6.

Ngiam RWJ, Davison GWH. 2016. A checklist of dragonflies in Singapore Parks (Odonata: Anisoptera, Zygoptera). Nat Sing 4: 349-353.

Nuraeni S, Budiaman, Yaspeta S. 2019. Identification of dragonfly and damselfly species around Mahaka river, Hasanuddin university teaching forest. IOP Conf Ser: Earth Environ Sci 343: 1-9. DOI: 10.1088/1755-1315/343/1/012052.

Oliveira-Junior J, Juen L. 2019. The Zygoptera/Anisoptera ratio (Insecta: Odonata): A new tool for habitat alterations assessment in Amazonian streams. Neotrop Entomol 48: 552-560. DOI: 10.1007/s13744-019-00672-x

Orr A, Hamalainen M. 2003. A Guide to the Dragonflies of Borneo Their Identification and Biology. Natural History Publications, Kinabalu (Borneo).

Peraturan Bupati Lombok Barat No. 41 tentang Kawasan Desa Wisata. 2016. Pemerintah Daerah Kabupaten Lombok Barat, Gerung. [Indonesian]

Perez ESN, Bautista MG. 2020. Dragonflies in the city: Diversity of Odonates in urban Davao, Philippines. J Agric Sci Technol 10: 12-19. DOI: 10.17265/2161-6256/2020.01.002.

Potapov GS, Kolosova YS, Gofarov MY, Bolotov IN. 2020. Dragonflies and damselflies (Odonata) from Flores Island, Lesser Sunda Archipelago: New occurrences in extreme environments and an island-level checklist of this group. Ecol Montenegrina 25: 5-25. DOI: 10.37828/em.2020.35.2.

Quisil SJC, Arreza JDE, Nuneza OM, Villanueva RJT. 2013 Species richness of Odonata in Lanuza and San Agustin, Surigao del Sur, Philippines. AES Bioflux 5(3):245-260.

Rohman A, Sulistyono S, Nuryati W, Arifandy A, Setiyanto A. 2020. Dragonflies in Bawean Island Nature Reserve, Indonesia. Borneo J Res Sci Technol 10: 45-50. DOI: 10.33736/bjrst.2022.2020.

Rüppell G, Hilfert-Rüppell D, Schneider B, Dedenbach H. 2020. On the firing line–interactions between hunting frogs and Odonata. Int J Odonatol 23: 199-217. DOI: 10.1080/13887890.2020.1733328.

Šigutováa H, Šipoš J, Dolný A. 2019. A novel approach involving the use of Odonata as indicators of tropical forest degradation: When family matters. Ecol Indic 104: 229-236. DOI: 10.1016/j.ecolind.2019.05.001.

Suartini NM, Sudatri NW. 2019. Species of dragonflies (Odonata order) for rice plantations in some rice field around Denpasar, Bali. Simbiosis 7: 23-28. DOI: 10.24843/JSIMBIOSIS.2019.v07.i01.p05.

Sugiman U, Atmowidi T, Priawandiputra W. 2020. Community structure and habitat characteristics of dragonflies (Odonata) in tropical lowland forest of Ujung Kulon National Park J Entomol Zool Stud 8: 251-258. www.entomoljournal.com.

Ting D, Huai-jian L, Lei S. 2018. Odonata aquatic insects as bioindicators in water quality evaluation of Dianchi Lake riparian wetland. J For Res 31: 145-152. DOI: 10.13275/j.cnki.lykxyj.2018.05.020.

Weterings R, Umponstira C, Buckley HL. 2015. Predation rates of mixed instar Odonata naiads feeding on Aedes aegypti and Armigeres moultoni (Diptera: Culicidae) larvae. J Asia-Pacific Entomol 18: 1-8. DOI: 10.1016/j.aspen.2014.10.008.

Wijayanto AG, Nafisah NA, Laily Z, Zaman MN. 2016. Inventarisasi capung (insecta: Odonata) dan variasi habitatnya di Resort Tegal Bunder dan Teluk Terima Taman Nasional Bali Barat (TNBB). Seminar Nasional Pendidikan dan Saintek 2016: 427-434.

Zada N, Farid A, Zia A, Saeed M, Khan SM, Khan A, Khan IA, Fazlullah, Badshah T. 2016. Damselflies (Odonata: Zygoptera) fauna of District Buner, Khyber Pakhtunkhwa, Pakistan. J Entomol Zool Stud 4: 491-495.