

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

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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: 1846-1852.* 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. We then determined the conservation priority for each species found 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: Conservation priority, dragonflies, species richness

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 birds (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 a predator of various other smaller animals, such as 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).

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 Coenagrionidae family to other families in Zygoptera (Šigutová 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 Regulation No. 41 of 2016. This area consists of various habitats suitable for dragonflies. 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", which is considered 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 occurs 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 to 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 as an area for water flows in Suranadi Ecotourism Area. The water originates from a spring and is a tributary of a river that 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.

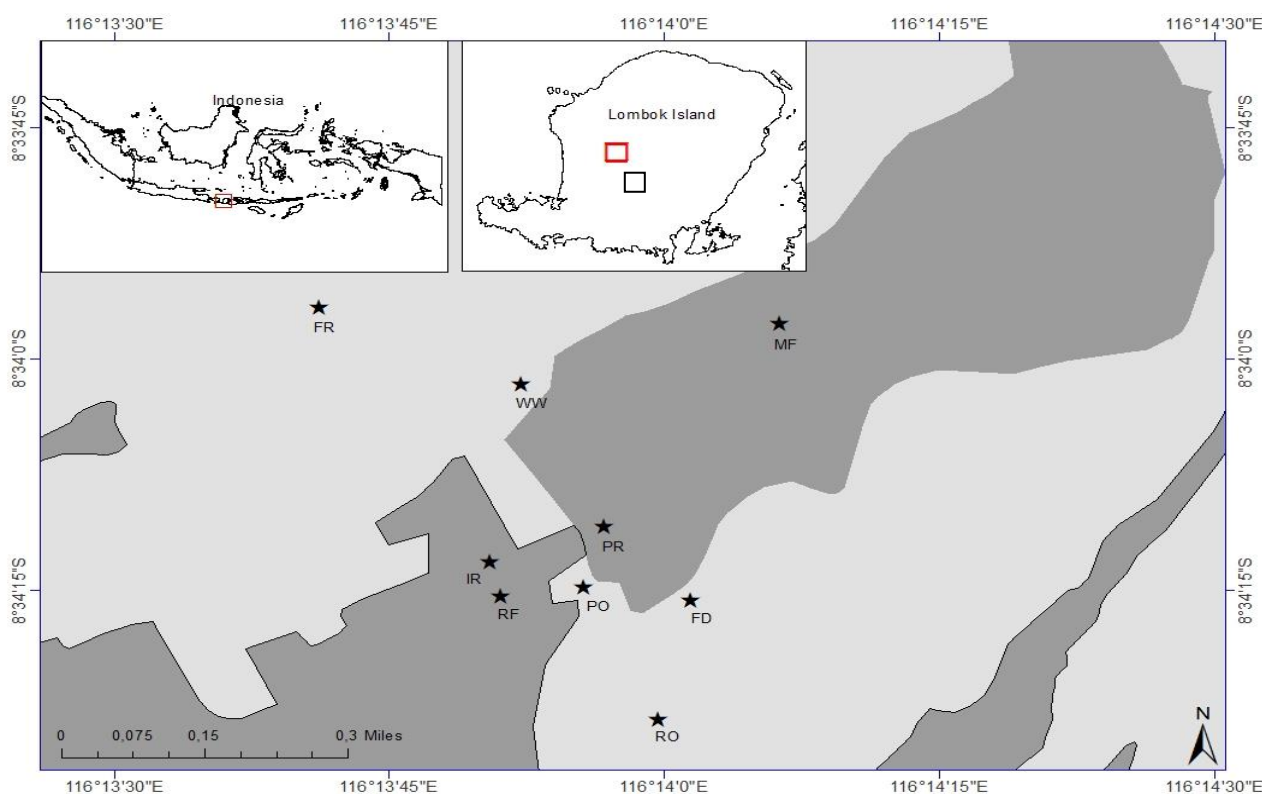


Figure 1. Map of the research location in the Suranadi Ecotourism Area, Lombok, West Nusa Tenggara, Indonesia

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 temp. (°C)	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: (i) species endemicity (SE), using the indicator of the geographical distribution only in local, regional or national; (ii) population status (PS), using the indicator of population size that consists of a small natural population, which declines drastically, and vulnerable; (iii) 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; (iv) threat (T), using the indicator of the species suffers serious damage due to hunting, trade, culture, and agriculture; (v) 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 scores 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

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, Coenagrionidae 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 species (Figure 2.A). In Zygoptera, the family with the highest species richness was Coenagrionidae with a total of 3 out of 5 species from this suborder (Figure 2.B).

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 than waterways, the irrigation habitat had the most abundant dragonflies with 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 Annex 1 of Regulation No. P.57/Menhut-II/2008, this species is categorized regional endemic with a 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).

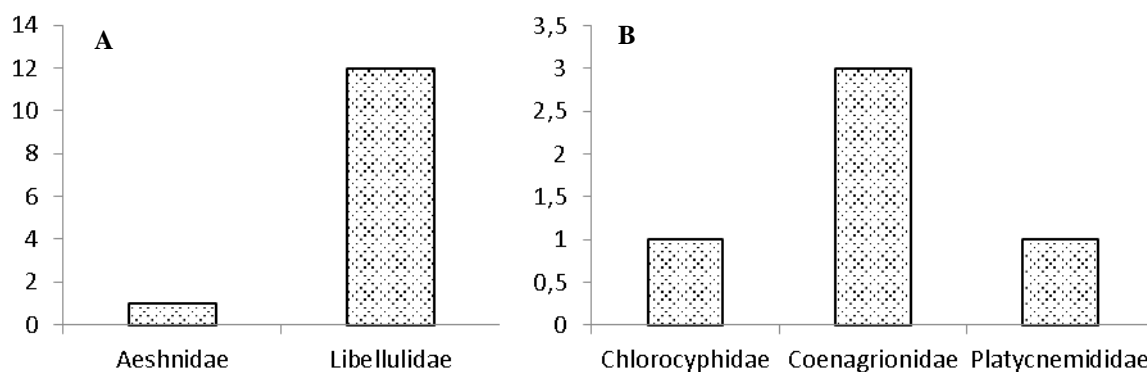


Figure 2. Species richness of dragonflies by family in suborders of Anisoptera (A) and Zygoptera (B) in the Suranadi Ecotourism Area, Lombok, Indonesia

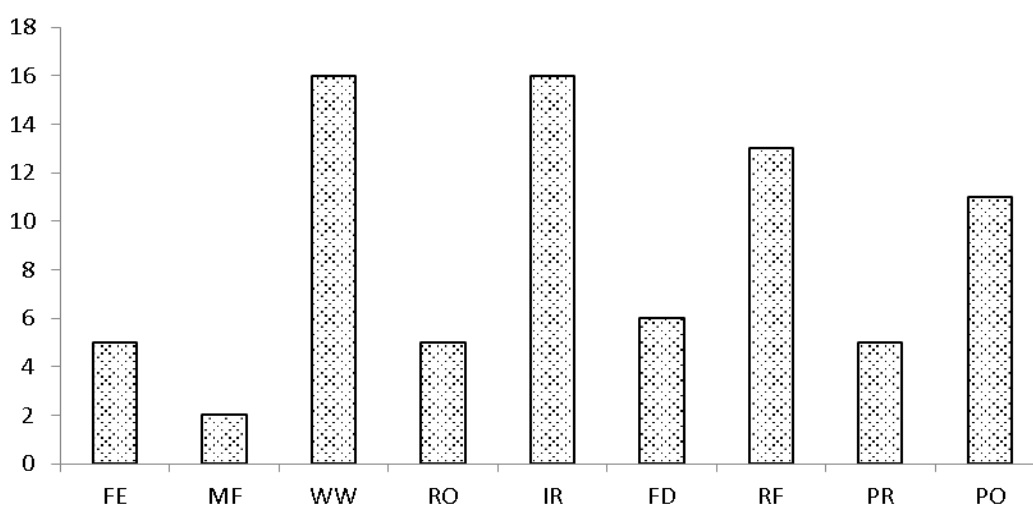


Figure 3. Species richness of dragonflies in each habitat types in the Suranadi Ecotourism Area, Lombok, Indonesia: FE: forest edges, MF: middle forest, WW: waterway, RO: roads, IR: irrigation, FD: fields, RF: rice fields, PR: Parks, and PO: pond

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

Suborder	Family	Species name	Average number of dragonflies in each habitat							Σ		
			FE	MF	WW	RO	IR	FD	RF		PR	PO
Zygoptera	Chlorocyphidae	<i>Libellago lineata</i>	0	0	2	0	0	0	0	0	0	2
	Coenagrionidae	<i>Pseudagrion pilidorsum declaratum</i>	0	0	21	0	38	0	5	0	2	66
Anisoptera	Coenagrionidae	<i>Pseudagrion pruinosum</i>	0	0	25	0	26	0	4	0	2	57
		<i>Agriocnemis femina</i>	0	0	12	0	7	0	2	0	4	25
	Platycnemididae	<i>Copera marginipes</i>	0	0	17	0	19	0	3	0	2	41
		Aeshnidae	<i>Gynacantha subinterrupta</i>	0	0	3	0	0	0	0	0	3
	Libellulidae	<i>Diplacodes trivialis</i>	6	1	2	5	4	7	5	6	5	41
		<i>Lathrecista asiatica</i>	0	0	5	0	4	0	0	0	0	9
		<i>Neurothemis terminata</i>	0	0	4	0	3	0	0	0	0	7
		<i>Neurothemis ramburii</i>	2	0	31	2	52	2	7	4	8	108
		<i>Orthetrum chrysis</i>	3	0	23	3	14	2	5	1	3	54
		<i>Orthetrum sabina</i>	51	2	17	15	20	53	23	9	11	201
		<i>Pantala flavescens</i>	3	0	4	7	2	15	56	8	6	101
		<i>Trithemis festiva</i>	0	0	4	0	7	0	0	0	2	13
		<i>Zyomma obtusum</i>	0	0	5	0	1	0	3	0	0	9
		<i>Zyomma petiolatum</i>	0	0	2	0	2	0	2	0	0	6
<i>Crocothemis servilia</i>		0	0	0	0	4	0	8	0	2	14	
<i>Acisoma panorpoides</i>		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: pond

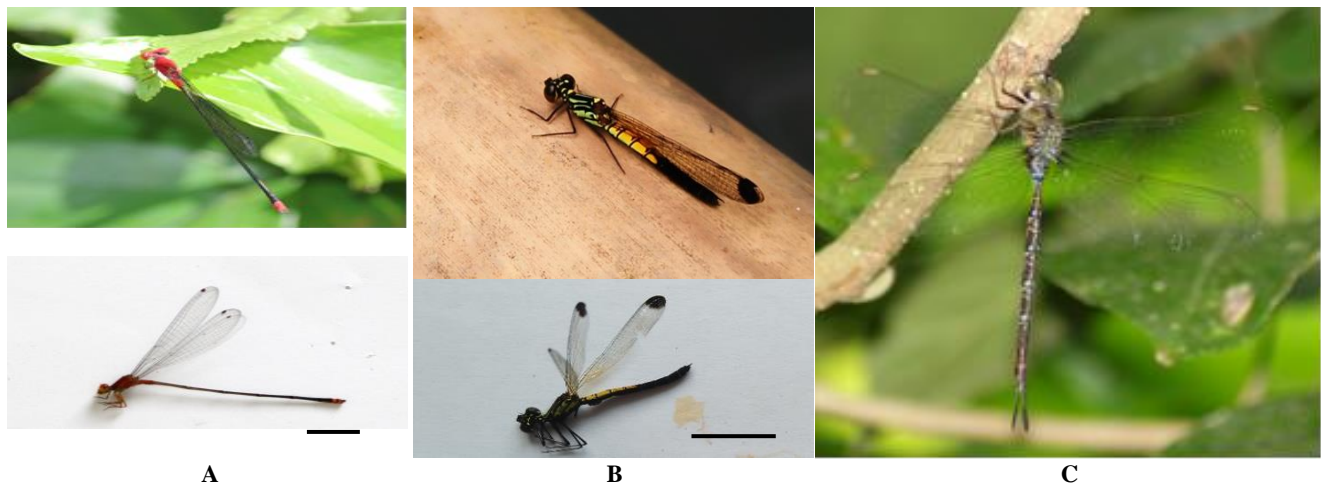


Figure 4. Conservation priority dragonflies species in Suranadi Ecotourism Area, Lombok, Indonesia. A. *Pseudagrion pilidorsum declaratum* B. *Libellago lineata* C. *Gynacantha subinterrupta*. Bar = 1 cm

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

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

Note: SE: Species endemicity, PS: Population status, HC: Habitat condition, T: Threat, SSM: Status of species management

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). There were 46 species of dragonflies found

(Potapov et al. 2020). In general, the species richness of dragonflies in the Lesser Sunda Islands (including Lombok) tends to be lower than in 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 for oviposition and larval habitat (Luke et al. 2017). Two other habitat types classified as aquatic habitats, namely rice fields and pond, had higher species richness than 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 were found in the waterway. On the other hand, two species that were absent in the waterway, namely *Crocothemis 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 are 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 impacted not only species richness, but also 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 to 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 34.3°C, 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 aquatic habitat types, 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 water bodies species 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 32.59°C 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 water (Jacob and Manju 2016). *L. lineata* can also habituate 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 25°C and humidity above 80%. This species can 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 destinations. 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 important information for developing conservation and ecotourism strategies in Suranadi.

In conclusion, the species richness of dragonflies in the Suranadi Ecotourism Area of Lombok, Indonesia consisted of 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*.

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