The Diversity of Diurnal Birds in Panua Sanctuary Conservation Area in Pohuwato District, Gorontalo Province, Indonesia

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Abstract

Panua Sanctuary is a conservation area, known as a habitat for birds, particularly the diurnal birds. The objectives of this research are as follows to figure out the species of diurnal birds, and to know the diversity, diversity numbers, evenness, and dominance index of the diurnal birds in Panua Sanctuary. The research was conducted from February until March 2021. The point count method was employed in four observation stations. The research result revealed 10 ordos, 27 families, 50 species, and 321 total of individuals. The diversity index in station I was 0.15, station II 2.10, station III 2.34, and station IV 2.70. The diversity numbers in station I was 0.15, station II 0.36, station 0.22, and station IV 0.14. The evenness index in station I was 0.87, station II 0.79, and station III 0.8. Station I was dominated by Yellow-sided Flowerpecker with Di = 15.44% which was considered as a dominating type while station II was dominated by Yellow-breasted Racquet-tail with Di = 35.71%. Station III and IV were dominated by Cattle Egret with Di value respectively 21.62% and 14.49%.

Introduction

Sulawesi is an island with diverse potential in Indonesia with an area of 187,882 Km^2 (Whitten et al., 2012). It is also a bio-geography area of Wallacea with the highest endemic proportion after Irian Jaya Province in terms of reptiles and endemic birds. Located in the northern part of Sulawesi, Gorontalo Province has some Wallacean endemic bird species. It consists of six conservation areas, i.e. Bogani Nani Wartabone National Park, Nantu Wildlife Reserve, Tangale Sanctuary, TanjungPanjang Sanctuary, Mas Popaya Raja Island Sanctuary, and Panua Sanctuary (Natural Resources Conservation Bureau of North Sulawesi, 2019).

Birds, or the so-called *aves*, are the members of vertebrae which can be used as an indicator of biodiversity, the revolution of a quality environment, and conservation area (Safanah et al., 2017) as they are highly sensitive and easily offended (Callaghan et al., 2018). Birds and animals are classified into two groups based on their activity patterns: diurnal and nocturnal (active during the days). Most birds are active during the days yet

they take a rest at different times. Families of *Strigiformes*, *Podargidae*, and *Caprimulgidae* are the only nocturnals (active at night) (Saman et al., 2019).

The existence of a bird species basically adjusts to a chosen certain environment where they can easily obtain resources to fulfill their life in that area (Indra et al., 2020). The presence of birds can also affect an ecosystem. Panua Sanctuary has several ecosystems, such as beach forest, mangrove forest, lowland, and mountains (Natural Resources Conservation Bureau of North Sulawesi, 2019). A variety of ecosystems can create various habitats for birds. Wibowo et al (2017) claimed that some considerations of a habitat such as the availability of food, breeding, nesting, and self-protecting from preys affect the diversity of bird species. Different habitats provide decent spaces for birds (Iswandaru et al., 2020). Study about birds is very engaging due to their dynamic natures and functions as the predictor of environmental changes of where they live. Birds can also be found almost everywhere (Hadinoto et al., 2012).

Based on the background of the study, considering the urgency of the information related to the species of the diurnal birds in the area of Panua Sanctuary, including its diversity, diversity numbers, evenness, and dominance index, this study is needed to be conducted to support the attempts in preserving and protecting the diurnal birds.

Materials and Methods

Research Site

The research was conducted in the area of Panua Sanctuary in Pohuwatu Regency, an area with a rich species of birds especially the endemic ones as supported by Natural Resources Conservation Bureau of North Sulawesi (2019). The research took place in four observation stations, i.e. (1) primary area, (2) secondary area, (3) transition area, and (4) distracted area (Figure 1).
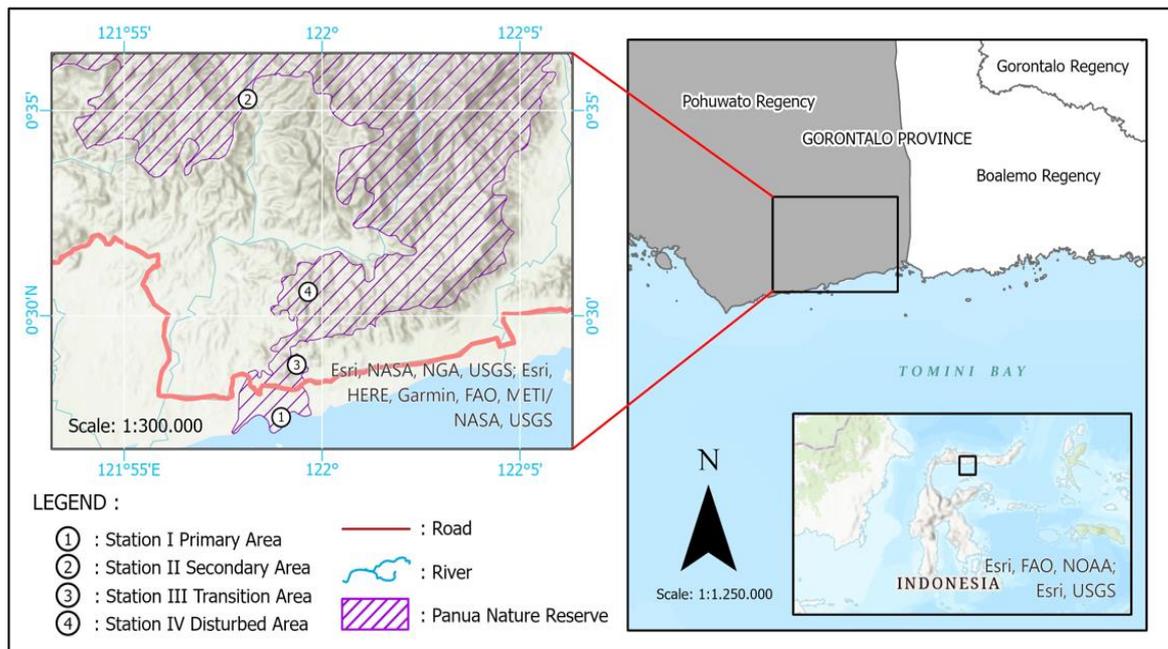
Figure 1. Location of the research on the structure of diurnal birds community in Panua Sanctuary, Gorontalo Province, Indonesia

The observation was determined by birds habitats namely: Station 1 in a primary forest, Station 2 in a secondary forest, Station 3 in a transition area and station 4 in a disturbed area.

Station I: Primary Forest

It is a natural forest area which has never been exploited. The area of beach forest located in Panua Sanctuary was determined as the location for observing the birds as part of the primary forest.

Station II: Secondary Forest

It is a regeneration forest of the primary forest. It was initially damaged due to natural disaster or the arranged logging to fulfill humans' needs. This area is located in the Northern part of the sanctuary.

Station III: Transition Area

It is a transitional area between a sanctuary and production forest, limited production forest, protection forest, and converted production forest. In this research, several transition areas between the sanctuary and the converted production forest were chosen, in this case plantation.

Station IV: Disturbed Area

The disturbed is where the plantation lies in the area of Panua sanctuary.

Research Method
Diurnal Birds Data Collection Stage

The data were collected by using *stratified systematic sampling* in each observation station. Point count method was implemented in the location where the birds were observed and where the researcher stood on a certain place for a certain period of time while noting and counting all of the birds seen in each station (Colin et al., 2000). Observations were conducted from 06:00-09:00 in the morning and from 15:00-18:00 in the afternoon.. Birds with the most active moves can be seen in the morning and afternoon (John et al., 2020). The duration of the observation lasted for 20 minutes in each observation point. After 20 minutes, the observation moved to the next location which included several activities such as noting the date and time of the observation, bird activities, species, as well as the numbers of birds seen in the observation position, and taking the photographs of the invisible birds by using digital camera. Data collection in each station consists of four observational points, the observation in each observation station lasted for 180 minutes. The observation was repeated for two times. Determining the observational station was based on the birds' habitats such as (1) primary forest, (2) secondary forest, (3) transitional forest, and (4) the distracted area.

Data analysis
Identification Stage

The collected data of the birds were identified based on its morphological characteristics by referring to a book entitled *Field Guide of Birds in Wallacea Area and the List of Indonesian Birds* (Sukmantoro, 2007), a book about birds in Wallacea area: Sulawesi, Maluku, and Nusa Tenggara (Coates & Bishop, 2000) and a book entitled Birds of Indonesia

Archipelago to figure out their English names. Next, the data of the species and numbers of the species were analyzed by using descriptive statistics.

Diversity (H')

It measures the diversity index of birds by using Shannon-Winner formula (1949).

$$H' = -\sum_{i=1}^{s} \frac{ni}{N} \log \frac{ni}{N}$$

Description:

H' = Diversity index of bird species

Ni = Total individuals of bird

N = Total individuals of all birds

Diversity Number (Pi)

Diversity number is a total number of the bird individuals found during the observation. To reveal the diversity numbers of each kind of bird, the following formula is applied:

$$Pi = \frac{\sum Burung\ spesies\ i}{\sum total\ burung}$$

Evenness (E)

Index of evenness can be calculated by using a formula as described in the following:

$$E = \frac{H'}{ln(S)}$$

Description:

E = Evenness index

S = Number of species

H' = The diversity of Shannon-Wienner

Dominance (Di)

It determines the value of dominance which further benefits in determining or setting which species of birds which are dominant, sub-dominant, or not dominant in an observation track.

$$Di = \frac{ni}{N} \times 100\%$$

Description:

Di = Dominance index of a bird species

ni = Number of individuals of a bird species

N = Number of individuals of all bird species

Results and Discussion

Results

General Description of The Research Site

Research on diurnal birds in the Panua Nature Reserve Area was carried out at 4 observation stations with different habitat types, namely primary forest, secondary forest,

transition areas, and disturbed areas. A description of each station is shown in Table 1 and a map of the research sites is presented in Figure 1.

Table 1. General description of diurnal bird research sites in the Panua Nature Reserve area

Station I	Station II	Station III	Station IV
Located on the coordinate of 121º58'58.1"E and 0º27'31.7"N	Located on coordinate of 121º58'07.3"E and 0º35'16.4"N.	Located on coordinate of 121º59'38.9"E and 0º2844,3"N	Located on coordinate of 121º59'21.5"E and 0º28'48.6"N.
Primary forest	Secondary forest	Transition areas	Disturbed areas

Primary area (Station I) is a beach forest. It is located in the southern part of Panua with an altitude of 73.90 AMSL and located on the coordinate of 121º58'58.1"E and 0º27'31.7"N. According to the real condition of the area, the primary field has a heterogeneous vegetation. The flora consists of beach she-oak and mangrove.

The secondary (Station II) area is the secondary forest located in the northern part of Panua sanctuary exactly in Marisa Sub-District. This area is located on the steep slope land (15%-25%) with coordinate of 121º58'07.3"E and 0º35'16.4"N.

The tertiary (Station III) area is the transition area between the sanctuary and the farm area located in the northern part of the area with coordinate of 121º59'38.9"E and 0º2844.3"N. According to the condition of the farm field, it is considered as dry farm land which is combined with bushes. The land cover of the forest is also degraded and a little bit cover in the form of young bushes remains on a relatively flat land and old bushes on the rocky steep slope. Meanwhile, the sanctuary area is actually a primary dry forest land with diverse vegetations with tight header cover.

The distracted area (Station IV) is located in the north. It is the area of plantation owned by the people living inside Panua Sanctuary which is located in the coordinate of 121º59'21.5"E and 0º28'48.6"N. According to the condition of the field, this area is dominated with corns and cashew crops, as well as growing grass which are used for the people to feed their farm animal that is cow. This plantation area is more-less 4 hectares.

Types of Diurnal Birds in Panua Sanctuary

The existence of a bird species is affected by the habitat. Panua sanctuary is a habitat for birds, particularly the diurnal birds. Based on the field reference book about birds in Wallacea area: Sulawesi, Maluku, and Nusa Tenggara (Coates and Bishop, 2000) and Birds of the Indonesian Archipelago: Greater Sundas and Wallacea (Eaton et al., 2016), 10 Ordos were collected namely Charadiiformes, Columbiformes, Coraciiformes, Cuculiformes, Galliformes, Passeriformes, Pelecaniformes, Piciformes, Psittaciformes, and Sulformes. In addition to that, 27 families and 50 species were also collected with the numbers of observed individuals as big as 321 (Table 2).

Table 2. Diurnal birds in Panua Sanctuary Area in Pohuwato District

| Family | Species | | Total Individuals | | | | IUCN Cites |
	Scientific Names	English Names	ST I	ST II	ST III	ST IV	
Alcedinidae	*Pelargopsis melanorhyncha*	Great-billed Kingfisher	2	1			LC
	Ceyx fallax	Sulawesi Dwarf Kingfisher		1			LC
Anhingidae	*Anhinga melanogaster*	Oriental Darter	1				NT
Ardeidae	*Butorides striatus*	Striated Heron		1			LC
	Bubulcus ibis	Cattle Egret	1		16	10	LC
Artamidae	*Artamus leucorhynchus*	White-breasted Woodswallow	4				LC
	Artamus moachus	Ivory-backed Woodswallow	3				LC
Bucerotidae	*Rhabdotorrhinus exarhatus*	Sulawesi Hornbill		4			VU
	Rhyticeros cassidix	Knobbed Hornbill	1	2		1	VU
Campephagidae	*Curacina leucopygia*	White-rumped Cuckooshrike	3		1		LC
Columbidae	*Ptilinopus melanospilus*	Black-naped Fruit-Dove	3				LC
	Ducula radiata	Gray Imperial-Pigeon		1			LC
	Chalcophap sindica	Asian Emerald Dove	3	1		1	LC
	Macropygia amboninensis	Ruddy Cuckoo-Dove	1				LC
	Treronvernans	Pink-necked Green-Pigeon	6				LC
	Geopelia striata	Zebra Dove	3				LC
	Duculaaenea	Green Imperial-Pigeon	4	1	2	7	NT
	Turacoena manadensis	White-faced Cuckoo-Dove	1				LC
	Duulaluctuosa	Silver-tipped Imperial-Pigeon			5	5	LC
	Streptopelia chinensi	Spotted Dove			1		LC
	Treron griseicauda	Gray-cheeked Green-Pigeon			8		LC
	Streptopelia tranquebarica	Red Collared-Dove	1		1		LC
Corvidae	*Corvusenca*	Slender-billed Crow	2	2	6	2	LC
Cuculidae	*Rhamphococcyx calyorhynchus*	Yellow-billed Malkoha			1	2	LC
	Centropus bengalensis	Lesser Coucal			3	2	LC
Dicaeidae	*Dicaeum celebium*	Gray-sided Flowerpecker	10				LC
	Dicaeum aureolimatum	Yellow-sided Flowerpecker	21				LC
Dicruridae	*Dicrurus hottentottus*	Hair-crested Drongo	4	9	14	3	LC
Estrildidae	*Lonchura attricapilla*	Tricolored Munia				3	LC
	Lonchura molucca	Black-faced Munia				5	LC
Hirundinidae	*Hirundo tahitica*	Pacifis Swallow	8				LC

Family	Species	Common Name					Status
Megapodiidae	*Macrocephalon male*	Maleo	2				CR
	Megapodiuseumingii	Dusky Scrubfowl	1	4			LC
Meropidae	*Meropogonforsteni*	Purple-bearded Bee-eater	2				LC
Monarchidae	*Hypothymispuella*	Pale-blue Monarch	7		4		LC
Motacillidae	*Motacilla cierea*	Gray Wagtail	1	1			LC
Muscicapidae	*Eumyias panayensis*	Turquoise Flycatcher	2				LC
Nectariniidae	*Anthreptes malacensis*	Brown-throated Sunbird	17				LC
	Cinnyris jugularis	Olive-backed Sunbird	6		7		LC
Oriolidae	*Excalfactor chinenesis*	Black-naped Oriole			3		LC
Phanasianidae	*Synoicuschinennsis*	King quail		2	1		LC
Picidae	*Mulleripicus fulvus*	Ashy Woodpecker	1				LC
Psittaculidae	*Loriulus stigmatus*	Sulawesi Hanging-Parrot	3		1		LC
	Prioniturus flavicans	Yellow-breasted Racquet-tail		15	3		NT
Pycnonotidae	*Pycnonotus aurigaster*	Sooty-headed Bulbul	4		7	8	LC
Scolopacidae	*Actits hypoleucos*	Common Sandpiper		1			LC
Sturidae	*Aplonis panayensis*	Short-tailed Starling	1				LC
Timaliidae	*Pellorneum celebense*	Sulawesi Babbler	1				LC
27	**50**		**136**	**42**	**74**	**69**	

Note : ST (Station)

Figure 2. Bird species in Panua Sanctuary: A) *Macrocephalon maleo*; **B)** *Coracina leucopygia*; **C)** *Dicaeum aureolimatum*; **D)** *Ceyx fallax.*

Based on the data (Table 1), in station I (the primary forest) there were 35 species of birds obtained out of the total individuals of the observed diurnal which was as big as 136 birds. In station II (the secondary forest), there were 14 species of birds obtained and the total individual of the observed birds as big as 39 birds. In station III (transition area), there were 15 bird species obtained with the total of the observed individuals as big as 74 birds.

While in station IV (the distracted area), there were 19 species of diurnal birds collected with total observed individuals as big as 69 birds.
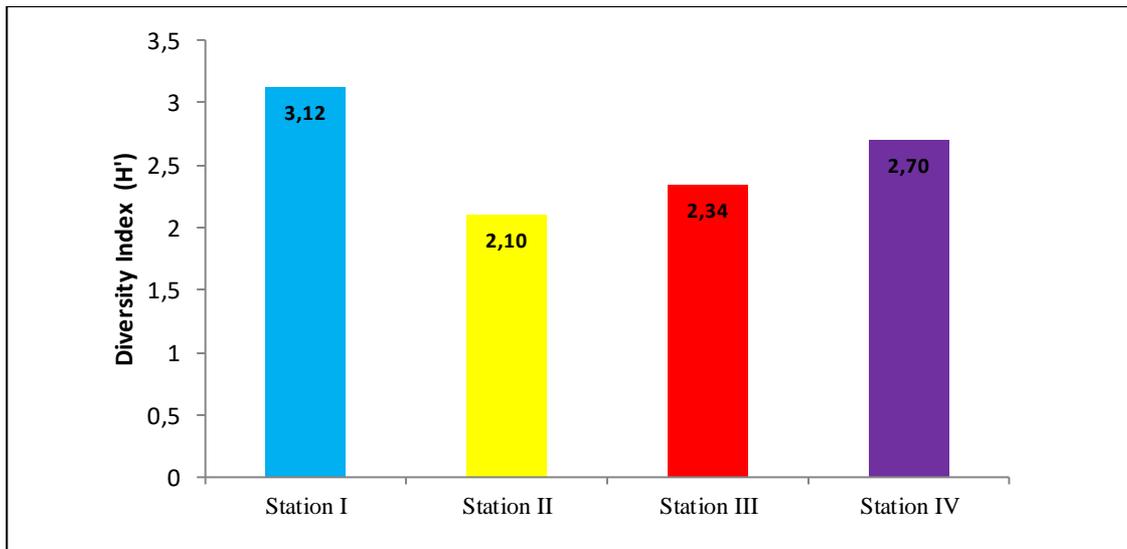

Figure 3. Diversity index of diurnal birds in Panua Sanctuary Area

It is evident that there were several differences among each observational station based on the diversity index calculated by Shannon Wienner (H') formula. The highest diversity index was on station I with H'= 3.1198 while the lowest diversity index is on station II with H'= 2.0975.
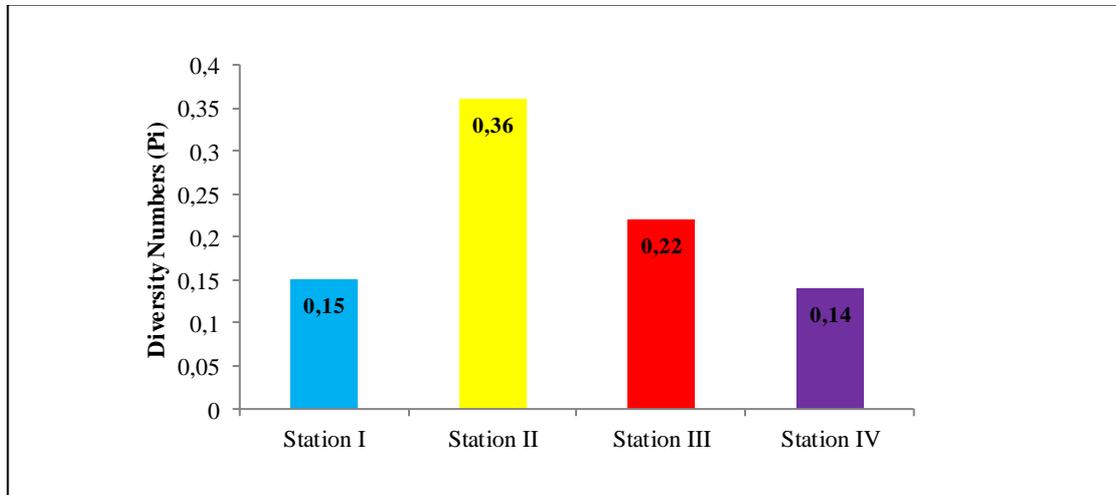

Figure 4. Index of diversity numbers of diurnal birds in Panua Sanctuary Area

The diversity numbers (Pi) in station I was as big as 0.15 dominated by Yellow-sided Flowerpecker (*Dicaeumaureolimatum*). In station II, the Pi value of the Yellow-breasted Racquet-tailis was as big as 0.36. Meanwhile, in station III and IV, the diversity numbers was dominated by Cattle Egretwith with Pi value respectively 0.22 and 0.14.
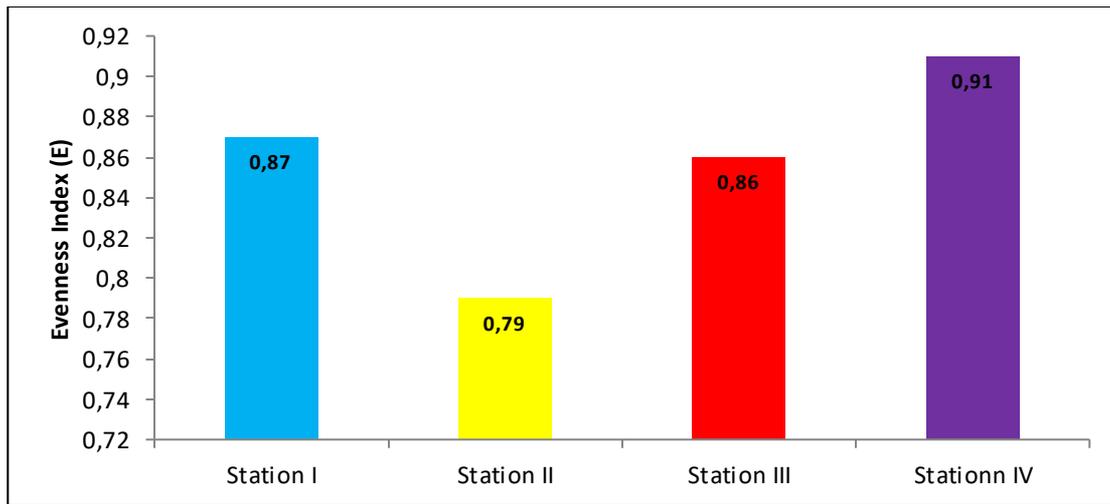
Figure 5. Evenness index of diurnal birds in Panua Sanctuary Area

The evenness index of the diurnal birds in Panua Sanctuary of station I to station IV generated the evenness index which was categorized as almost even.
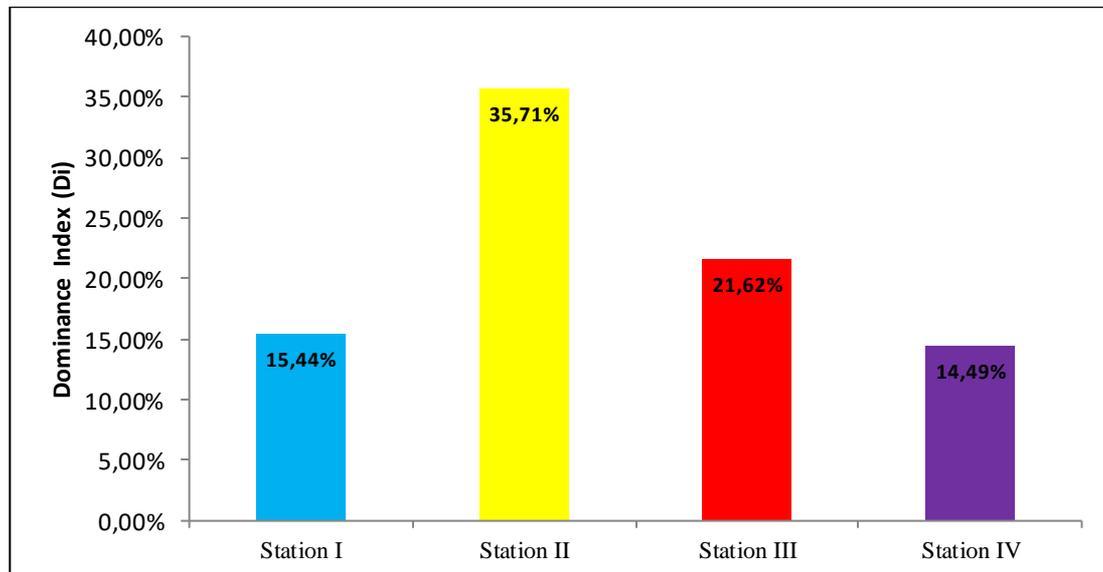

Figure 6. Dominance index of diurnal birds in Panua Sanctuary Area

Station I was dominated by Yellow-sided Flowerpecker with Di = 15.44%. Station II was dominated by Yellow-breasted Racquet-tail with Di = 35.71%. In Station III and IV, there were Cattle Egret dominated the area with Di value respectively 21.62% and 14.49%.

Discussion

Panua sanctuary has various types of ecosystems starting from beach forest, mangrove forest, swamp, lowland, to mountains (Natural Resource Conservation, 2019). The types of this various ecosystems create various habitats for birds. This was proven by the discovery of 50 species of diurnal birds and 4 species which were the endemic of Sulawesi. According to Anugrah, et al (2017), the bigger the animal diversity, the more diverse the structure of their habitats (the diversity of plants and its vegetation structure). Birds use their habitats as the source for food, water, and shelter (Kurnia et al., 2021). According to the research result, it was revealed that the value of diversity index from four

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stations was different. Station one has H' = 3.12 which was categorized high, station two has H' = 2.10 which was categorized moderate, station three has H' = 2.34 which was categorized medium, and station four has H' = 2.70 which was categorized moderate. This is relevant to a criteria by Fachrul (2012) which claimed if the value of H' 1 ≤ H' ≤ 3m, the level of diversity is considered moderate.

Station 1 provided a natural habitat and sources of food from tight trees and heterogeneous vegetation. Besides, the absence of humans makes many types of birds live in this area so that the diversity index in this station was considered high. Baderan and Utina (2021) in their research explained that a community was considered high in terms of diversity index if many species exist in that community. According to Adelina, et al (2016) the combination of vegetation, appropriate habitats, and the existence of various kinds of food source contributed to the existence of variety of bids. Putri (2015) and Khan and Pant (2016) stated that the availability of food significantly affected the diversity of birds. This appeared differently from station II, III, and IV with moderate category. This was because the trees are considered rare thus the availability of source of food for birds is limited. In addition to that, humans' activities in this transition area create distraction as well as pressure towards the natural ecosystem of the birds. Gardening activities in the distracted area creates changes on vegetation land cover so that it also impacts to the birds' habitats. Humans' activity would also likely to decrease the diversity of birds and increase distraction towards the existence of birds in a certain area (Naithani et al., 2018; Issa, 2019). Baderan (2016) further claimed that the availability of species components and changes of plants growth in the research location was considered as the consequence of community activities that generated moderate diversity in an ecosystem.

The value of H' is the calculation result of diversity index which determines a certain species diversity in a certain area. If the value of H' is bigger or equal to 1, an area is considered moderate in diversity. If the value of H' is bigger than 3, the diversity of that area is considered high or abundant. If the value of H' is bigger than 0 yet lesser than 1, the community in that area has a low dive (Krebs, 1989; Fachrul, 2012). Station I with high diversity signifies a tendency of stable condition of an ecosystem in the beach forest.

The calculation result of diversity numbers demonstrated differences in each observation station. Different vegetation affects the diversity numbers of the birds (Khan & Pant, 2016). Station I, with typical habitat of primary forest, had the highest diversity numbers that was 0.15, particularly Yellow-sided Flowerpecker (*Dicaeum aureolimatum*). This bird is the type of songbird and rain eater. Morning movement of this bird is higher than the afternoon movement. It is because the diurnal birds start their activities in the morning. The availability of the food influences the diversity numbers of Yellow-sided Flowerpecker. This is relevant to the condition of beach forest where the trees-beach she-oak (*Casuarinae quisetifolia*), mangrove, and tropical almond-massively grow,. According to the observation result, these birds eat the mangrove grains. Yellow-sided Flowerpecker is the endemic bird of Sulawesi.

Station II had the highest diversity numbers of Yellow-breasted Racquet-tailbirds with Pi = 0.36%. This bird is an endemic bird in Sulawesi. According to the Natural Resources Conservation Bureau of North Sulawesi (2019), primary and secondary beach which is high, bushy, and farm land is the common habitat of this bird. In contrast with station I and II, station III and station IV had Pi index respectively 0.22 and 0.14. The migrated birds are called Cattle Egret(*Bubulcus ibis*). The existence of this abundant animals in the distracted and transition areas is due to the availability of food source in this area. Cattle Egret usually

hunts for food in dry and open areas such as the distracted and transition areas which have open land-cover. This bird tends to hunt for flies or lice living on cows and other kinds of insects and small animal. The abundant numbers of Cattle Egretbird were affected by group activity of Cattle Egretwhen hunting for meals.

The evenness index describes the stability of a community which depicts the even species and shapes the community (Daget, 1976). In each observation station, the value of evenness index was almost complete. E = 0.87 is for station I, 0.79 for station II, 0.86 for station III, and 0.91 for station IV. According to Putu (2017), evenness index is used to measure how stable a species in maintaining their skills to survive. By measuring the evenness index, the spread of diurnal bird species in Panua Sanctuary was considered almost even. Referring to a research by Putu (2017), the higher the value of evenness index, the more the stability of the species diversity of that community.The lower the value of evenness, the lower the stability of the diversity of that community.

Considering the value of evenness index from community perspective, the requirement is as follows: the oppressed community is 0 < e ≤ 0.5; unstable community is 0,5< e ≤ 0.75; and the stable community is 0.75 < e ≤ 1 (Krebs, 1989). Panua sanctuary whose evenness is almost even is included as the stable community based on the community research.

Kinds of birds dominating each station has different observation result. Putu (2017) in his research explained that the dominance index describes the availability and unavailability of a genus or dominant species in constructing a community in an ecosystem. Station I located in the primary forest habitat was dominated by Yellow-sided Flowerpecker birds with index value *Di* = 15.44%. The dominance of this bird was influenced by the availability of food source that is the grains on mangrove. Nugroho (2016) reported that vegetation plays important role as a factor supporting the life of birds. The existence of group activity also affects the level of dominance of Yellow-sided Flowerpecker birds. According to Wibowo et al (2017), high diversity numbers of bird is caused by their habits in doing group activity thus the dominance value is high. Station II was dominated by Yellow-breasted Racquet-tailbird with index value *Di* = 35.71. Station III and IV were dominated by Cattle Egretbirds with *Di* respectively 21.62 and 14.49 which were categorized dominant. The dominance of these birds was affected by the source of food in the transition and distracted areas.

Conclusions

The research result revealed 10 ordos, 27 families, 50 species, and the total of individuals were as big as 321. The Divercity Index of station one was in the high category while stations II, III, and IV were in the medium category. The evenness index of diurnal birds in Panua Nature Reserve from station I to IV was in almost-even category. The dominance index of Station I was dominated by Yellow-sided Flowerpecker, Station II was dominated by Yellow-breasted Racquet-tail, while Station III and IV were dominated by Cattle Egret dominated.

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