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Avifaunal diversity of Bega Watershed, Prosperidad, Agusan del Sur, Philippines

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Abstract

Birds are an integral part of the ecosystem – they pollinate plants, disperse seeds, scavenge carcasses, and recycle nutrients back into the earth. This study was conducted in three sites in Bega Watershed, Prosperidad, Agusan del Sur to document species diversity, richness, and endemism of birds as there is still no available avifaunal record in the area. Methods used were a combination of mist netting for a total of 100 net days and a 2-km transect walk, for a total of 48 hours. . Eighty-three bird species comprising 35 (42.17%) endemic species, 44 (53.01%) resident species, and 4 (4.82%) migrant species, were recorded. Five globally threatened species (four vulnerable, one endangered) were documented. A high species diversity (H'=3.781) with a more or less even distribution was recorded. Results showed that Site 3, the least disturbed area with more or less intact vegetation, had the highest species richness with 71 species present. Sites 2 and 3 had the highest similarity percentage (46.40%) as shown by the Bray-Curtis cluster analysis. Individual rarefaction analysis showed that a more rigorous sampling in Site 1 is likely to yield additional species. Canonical correspondence analysis showed that five species of birds are distinctly affected by the slope, elevation, and on-site disturbances. Conversion of forested areas for agricultural use was observed as one of the major threats to the endemic and threatened avifaunal species in Bega Watershed. Results imply the need to conserve the avifauna of Bega Watershed and environs through the conservation of habitats.

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Introduction

Birds or class Aves, are the best-known class of vertebrate animals that occur worldwide in nearly all habitats (Wenny *et al.*, 2011). Most of the birds are useful to mankind. They play useful role in the control of insect pests of agricultural crops, as predators of rodents, as scavengers, as seed dispersers, and as pollinating agents. The diversity of these organisms is one of the most important ecological indicators to evaluate the quality of habitats (Manjunath and Joshi, 2012).

According to IUCN (2014), there are 10,425 species of birds. Of these, 1,373 species are considered threatened with extinction, 959 species are near threatened, 7,886 species are considered to be of least concern, 62 species lack the data to determine their status, and 145 species are recorded as extinct. The Philippines has 682 species of birds comprising 89 species that are globally threatened (52 vulnerable, 21 endangered, and 16 critically endangered). Moreover, 235 endemic species and 6 introduced species are recorded (Wild Bird Club of the Philippines, 2015).

The Philippine archipelago holds a concentration of species diversity for both flora and fauna, and endemism of global importance but human activities, such as deforestation, that causes habitat loss affect the wildlife and their habitat that is why the Philippines has been listed as one of the countries that is high on the list of priority for wildlife conservation (Abantas and Nuñeza, 2014; Sucaldito-Salibad and Nuñeza, 2014). Peterson *et al.* (2000) documented an intense concentration of endemic species in Mindanao and Luzon hinting to design reserve systems within islands to represent complete island avifaunas. Mindanao, one of the major islands that can be found in the Philippine archipelago, is situated in the southern part of the country. It is highly considered as one of the richest islands in the country due to high avifaunal biodiversity (Alviola *et al.*, 2010). The island has a record of 399 species of birds that consist of 32 endemic species and 31 species are globally threatened (Avibase, 2015). The diversity, distribution and community structure of most avian species on small forest fragments, which are important and reckoned to be needed for conservation, remain poorly studied (Flaspohler *et al.*, 2010; Cintra and Naka, 2012). Thus, it is of great importance to conduct an assessment on the composition of avian species in order to know the right measures of conservation that should be done (BirdLife International, 2014).

Published studies on birds in Mindanao such that of Paguntalan *et al.* (2011) reported a notable record of birds in the Zamboanga Peninsula where they encountered a total of 142 bird species including the critically endangered Philippine Eagle (*Pithecophaga jefferyi*). Paz *et al.* (2013) also recorded Philippine-endemic and Mindanao-endemic bird communities in Agusan del Norte where results suggested the need for conservation attention to prevent endangerment of the threatened endemics. The recent published study on birds of Agusan del Sur was that of Sucaldito-Salibad and Nuñeza (2014) who reported significant records of birds in Agusan Marsh. Cagod and Nuñeza (2012) also recorded 88 bird species in oil palm plantation in Agusan del Sur. However, no avifaunal record is available for the Bega Watershed in Agusan del Sur. Thus, this study determined the species composition, distribution, abundance, endemism, species richness, species diversity, conservation status, and the existing threats to the avifauna in Bega Watershed, Agusan del Sur.

Materials and methods

Study Area

Bega Watershed is located in barangay Mabuhay, municipality of Prosperidad, province of Agusan del Sur, CARAGA region (Fig. 1). The study was conducted from 8 May 2014 to 14 May 2014. Three sampling sites were selected – the Bega Falls, Enchanted Falls and Tiger Falls. The camp site was located at 8°69'38"N and 125°97'49", 258 meters above sea level (masl).

Fig. 1. Map of the Philippines (A) (http://en.wikipedia.org, 2015) showing the sampling area, Prosperidad, Agusan del Sur (B) (http://en.wikipedia.org, 2014).

Sampling Sites

Sampling site 1 was located in the riparian area of Bega Falls. The site has a mountainous slope (20-30°) with a secondary type of vegetation, which was observed to be diverse because of fewer disturbances. The site was dominated by *Ficus* sp., *Musa* sp., *Pandanus* sp., rattan, ground orchids, and grasses. Exposed rocks were abundant and about 1.5 km from the site is a landslide-prone area and a passage way for vehicles. Three net sites were established in selected areas. Net site 1 was situated at 8°69'95.6"N and 125°97'40.9"E, 225 masl. Net site 2 was in 8°69'76.2"N and 125°97'39.1"E, 250 masl while net site 3 was in 8°69'96.0"N and 125°97'51.9"E, 288 masl.

Sampling site 2 was located about 10 m away from the Enchanted Falls. The site has a flat to undulating slope with a secondary type of vegetation. "Tugop" and *Shorea* sp. ("Lauan") are the dominant emergent and canopy trees, respectively. Ferns, mosses and liana are the canopy epiphytes and vines present. The ground plants observed were giant ferns, *Alocasia* sp., and grasses. Palms and *Musa* sp. were present in the area. *Ficus* sp. was found to be abundant along the side of the stream. Fruit-bearing trees were also observed in the area such as *Canarium* sp. and *Clausena* sp. About 15 m from the Enchanted Falls is a degraded area and about 25 m from the falls is a slash-and-burn area. Four net sites were established in selected areas. Net site 1 was situated at 8°70'20.1"N and 125°98'28.9"E, 291 masl. Net site 2 was in 8°70'19.9"N and 125°98'29.2"E, 281 masl. Net site 3 was in 8°70'19.0"N and 125° 98'31.6"E, 294 masl while net site 4 was in 8°70'22.3"N and 125°98'34.9"E, 297 masl.

Sampling site 3 was located about 20 m from the Tiger Falls. The site has a flat to undulating slope with a secondary type of vegetation. Ferns, mosses,

and orchids were the canopy epiphytes observed. Grasses, and few *Pandanus* sp. and *Ficus* sp. were present and even exposed rocks were abundant in the site. Four net sites were established in selected areas. Net site 1 was situated at 8°70'41.8"N and 125°98'38.2"E, 316 masl. Net site 2 was in 8°70'45.1"N and 125°98'30.7"E, 312 masl. Net site 3 was in 8°70'42.7"N and 125°98'29.1"E, 320 masl, and net site 4 was in 8°70'41.7"N and 125°98'30.1"E, 312 masl.

Sampling Techniques

The assessment of birds in Bega Watershed was done from 8 May 2014 to 14 May 2014. Mist netting and transect walk methods were employed in the collection and observation of birds, respectively. Fifteen mist nets, which have a length of 6-12 meters with a mesh size of 36 mm and 3 shelves, were installed as ground nets randomly in three sampling sites in Bega Watershed – across waterways, where birds are most likely found, preferred routes of flights and near places where they forage such as fruit-bearing trees. The nets were left open during day and night to capture both diurnal and nocturnal bird species. The birds were retrieved early morning and late afternoon, which are the peak hours of birds in the wild. A total of 100 net days were spent to sample the avifauna with 40 net days in site 1 (Bega Falls), 30 net days in site 2 (Enchanted Falls) and 30 net days in site 3 (Tiger Falls).

Upon the retrieval of samples, the nets were inspected carefully as to which side the bird entered in order to prevent damage to the net and to make the retrieval of the bird easier. The captured birds were then placed temporarily in cloth bags, and were processed instantly to avoid mortality and impairment to their body parts. Identification of birds was confirmed using the book of Kennedy *et al.* (2000) and Fisher and Hicks (2000). The nomenclature, taxonomic listing, and conservation status of the avifauna was determined based on the IUCN Red List of Threatened Species (2014).

Transect walk method was used to supplement the capture results. A standard two kilometer transect line was established along man-made trails in the study area. Data were recorded such as the locality, elevation, location, date, weather, habitat type, species, the number of times a bird was observed during the walk, stratum or the location of the bird during observation, how the bird was observed, and the transect point where the bird was observed. Binoculars were used to see the birds easier even at longer distance and photographs of birds that were observed were taken. Transect walks were done early in the morning at 0530 hours and in the afternoon at 1600 hours. Other field efforts were also done such as listening to the bird calls or songs and key informant interviews.

The determination of the existing threats to the avifauna in the Bega Watershed was done by direct observations and key informant interviews of the local residents of Bega Watershed. Questions like what birds are usually hunted for food, or any anthropogenic activities that are being done in the area were asked.

Since 1990, morphological measurements have been recorded such as total length, tail length, wing length, bill length and tarsus length; to the nearest mm and body mass to the nearest 0.1 g (Hedenstrom, 2004). Vernier caliper and ruler were used to measure the morphometrics, and a pesola spring balance was used to measure the weight of the bird specimens. After the collection of morphometric data, the birds were freed immediately and to avoid the duplication of captured specimen, each captured bird specimen was marked with a nail polish on its claw or tarsus.

Habitat assessment was done in the three sampling sites in order to note the prominent vegetation in the different sites and a Global Positioning System (GPS) device was used to take the coordinates and elevation of the different sampling sites. Paleontological Statistics (PAST) Software version 2.17c was used in analyzing biodiversity indices, Bray-Curtis cluster

analysis, Individual Rarefaction analysis, and Canonical Correspondence analysis. It is a free statistical software package for paleontological data analysis which enables measures of diversity to be calculated (Hammer, 2012).

Results and discussion

Species composition

Eighty-three bird species in 13 orders, 35 families and 63 genera were recorded in Bega Watershed comprising 11 species in site 1 (Bega Falls), 44 species in site 2 (Enchanted Falls) and 71 species in site 3 (Tiger Falls). Eleven species (13.25%) and 37 species (44.58%) were found to be restricted to site 2 and site 3, respectively (Table 1). Order Passeriformes was the dominant order comprising 60.24% of the total number of species and 62.75% of the total number of individuals. The total number of species includes 4 (4.82%) migrants, 44 (53.01%) residents and 35 (42.17%) endemics. According to Kennedy *et al.* (2000), the distribution of birds is classified as migrant, resident, and endemic. Migrant birds are those that breed outside the Philippines and migrate to the country. Resident birds are those that breed or are suspected of breeding in the Philippines and normally reside in the country throughout the year while endemic birds are those that are found only in the Philippines.

Eight species (9.64%) were present in all sampling sites of which 6 (75%) are endemic, and the Philippine bulbul (*Ixos philippinus*) was the most dominant. It was also found out that this bird was the most abundant species in sites 1 and 3, comprising 22.22% and 9.14%, respectively. It usually feeds on the ripe fruits of *Ficus* sp. (Paguntalan and Jakosalem, 2008), which was present in all sites. It is from the family Pycnonotidae which is known to be adaptable to the seasonal availability of fruits. Its members are crucial in the forest ecosystem because of their role in both seed dispersal and pollination (Azman *et al.*, 2011; Sekercioglu, 2012). In addition, the Pygmy swiftlet (*Collocalia troglodytes*), an endemic species, was found to be the most abundant species in site 2 (Enchanted Falls), comprising 12%. This shows that site 2 has an abundant food source for this bird species and that it prefers feeding in the site (Rogers and Heath-Coss, 2003).

Table 1. Bird species found in Bega Watershed, Agusan del Sur, Philippines.

Order (Family)	Species (Old Name) (CN)	D	CS (LCS) IUCN 2014	Site 1	Site 2	Site 3
Accipitriformes	*Accipiter soloensis*	M	LC	0	0	1
(Accipitridae)	(Chinese Goshawk)					(0.25)
	Haliastur indus	R	LC	0	0	2
	(Brahminy Kite)					(0.51)
	Nisaetus philippensis	E	EN	0	0	1
	(*Spizaetus philippensis*)					(0.25)
	(Philippine hawk-eagle)					
	Spilornis cheela	R	LC	0	1	1
	(Crested serpent-eagle)				(0.57)	(0.25)
Bucerotiformes	*Penelopides affinis*	E	LC	0	1	5
(Bucerotidae)	(Mindanao Hornbill)				(0.57)	(1.27)
Caprimulgiformes	*Collocalia esculenta*	R	LC	3 (11.11)	12	22
(Apodidae)	(Glossy Swiftlet)				(6.86)	(5.58)
	Collocalia troglodytes	E	LC	0	**21**	17
	(Pygmy Swiftlet)				**(12.00)**	(4.31)
	Mearnsia picina	E	NT	0	1	0

Order (Family)	Species (Old Name) (CN)	D	CS (LCS) IUCN 2014	Site 1	Site 2	Site 3
	(Philippine Needletail)				(0.57)	
(Caprimulgidae)	*Caprimulgus affinus*	R	LC	0	0	1
	(Savanna Nightjar)					(0.25)
Columbiformes	*Chalcophaps indica*	R	LC	0	2	1
(Columbidae)	(Common Emerald Dove)				(1.14)	(0.25)
	Ducula aenea	R	LC	0	0	2
	(Green imperial-pigeon)					(0.51)
	Gallicolumba criniger	E	V	0	0	1
	(Mindanao bleeding-heart)					(0.25)
	Macropygia phasianella	R	LC	0	0	1
	(Brown cuckoo-dove)					(0.25)
	Phapitreron leucotis	E	LC (LT*)	0	16	14
	(White-eared brown-dove)				(9.14)	(3.55)
	Ramphiculus leclancheri	R	LC	0	1	0
	(*Ptilinopus leclancheri*)				(0.57)	
	(Black-chinned fruit-dove)					
	Ramphiculus occipitalis	R	LC	0	6	3
	(*Ptilinopus occipitalis*)				(3.43)	(0.76)
	(Yellow-breasted fruit-dove)					
	Streptopelia chinensis	R	LC	0	0	1
	(Spotted Dove)					(0.25)
	Treron vernans	R	LC	0	0	2
	(Pink-necked green-pigeon)					(0.51)
Coraciiformes	*Alcedo argentata*	E	V	5	3	0
(Alcedinidae)	(Silvery Kingfisher)			(18.52)	(1.71)	
	Todiramphus chloris	R	LC	0	0	1
	(*Halcyon chloris*)					(0.25)
	(White-collared Kingfisher)					
Cuculiformes	*Cacomantis merulinus*	R	LC	0	1	2
(Cuculidae)	(Plaintive Cuckoo)				(0.57)	(0.51)
	Cacomantis variolosus	R	LC	0	1	4
	(Brush Cuckoo)				(0.57)	(1.02)
	Centropus bengalensis	E	LC	0	0	9
	(Lesser Coucal)					(2.28)
	Centropus melanops	E	LC	0	4	2
	(Black-faced Coucal)				(2.29)	(0.51)
	Centropus viridis	R	LC	0	1	7
	(Philippine Coucal)				(0.57)	(1.78)
	Eudynamys scolopacea	R	LC	0	6	7
	(Asian Koel)				(3.43)	(1.78)
Falconiformes	*Microhierax erythrogenys*	E	LC	0	0	2
(Falconidae)	(Philippine Falconet)					(0.51)

Order (Family)	Species (Old Name) (CN)	D	CS (LCS) IUCN 2014	Site 1	Site 2	Site 3
Galliformes	*Gallus gallus*	R	LC	0	2	0
(Phasianidae)	(Red Junglefowl)				(1.14)	
Gruiformes	*Hypotaenidia torquata*	R	LC	0	0	1
(Rallidae)	(Barred Rail)					(0.25)
Passeriformes	*Coracina striata*	R	LC	0	0	2
(Campephagidae)	(Bar-bellied Cuckooshrike)					(0.51)
	Lalage nigra	R	LC	0	0	1
	(Pied Triller)					(0.25)
(Corvidae)	*Corvus enca*	R	LC	0	2	0
	(Slender-billed Crow)				(1.14)	
	Corvus macrorhynchos	R	LC	0	0	1
	(Jungle Crow)					(0.25)
(Dicaeidae)	*Dicaeum aeruginosum*	E	LC	0	1	0
	(Striped Flowerpecker)				(0.57)	
	Dicaeum australe	E	LC	4 (14.81)	10	11
	(Red-striped Flowerpecker)				(5.71)	(2.79)
	Dicaeum bicolor	E	LC	1	1	2
	(Bicolored Flowerpecker)			(3.70)	(0.57)	(0.51)
	Dicaeum pygmaeum	E	LC	0	3	3
	(Pygmy Flowerpecker)				(1.71)	(0.76)
	Dicaeum trigonostigma	R	LC	0	0	1
	(Orange-bellied Flowerpecker)					(0.25)
	Prionochilus olivaceus	E	LC	0	1	1
	(Olive-backed Flowerpecker)				(0.57)	(0.25)
(Dicruridae)	*Dicrurus bracteatus*	R	LC	0	0	3
	(Spangled Drongo)					(0.76)
	Dicrurus hottentottus	R	LC	1	10	3
	(Hair-crested Drongo)			(3.70)	(5.71)	(0.76)
(Estrildidae)	*Lonchura leucogastra*	R	LC	0	0	8
	(White-bellied Munia)					(2.03)
(Eurylaimidae)	*Eurylaimus steerii*	E	V	0	1	0
	(Mindanao Wattled-broadbill)				(0.57)	
(Irenidae)	*Irena cyanogaster*	E	NT	0	3	0
	(Philippine Fairy-bluebird)				(1.71)	
(Laniidae)	*Lanius cristatus*	M	LC	0	0	4
	(Brown Shrike)					(1.02)
	Lanius tigrinus	M	LC	0	1	0
	(Tiger Shrike)				(0.57)	
(Monarchidae)	*Hypothymis azurea*	R	LC	1	0	6
	(Black-naped Monarch)			(3.70)		(1.52)
(Muscicapidae)	*Copsychus saularis*	R	LC	0	0	11
	(Oriental Magpie-robin)					(2.79)

Order (Family)	Species (Old Name) (CN)	D	CS (LCS) IUCN 2014	Site 1	Site 2	Site 3
	Ficedula basilanica	E	V	0	1	0
	(Little Slaty Flycatcher)				(0.57)	
	Ficedula crypta	E	LC	0	3	0
	(Cryptic Flycatcher)				(1.71)	
	Muscicapa griseisticta	M	LC	0	0	2
	(Grey-streaked Flycatcher)					(0.51)
	Rhinomyias ruficauda	R	LC	0	1	1
	(Rufous-tailed Jungle-flycather)				(0.57)	(0.25)
(Nectariniidae)	*Aethopyga pulcherrima*	E	LC	0	6	3
	(Metallic-winged Sunbird)				(3.43)	(0.76)
	Aethopyga shelleyi	E	LC	1	2	13
	(Lovely Sunbird)			(3.70)	(1.14)	(3.30)
	Arachnothera longirostra	R	LC	0	1	6
	(Little Spiderhunter)				(0.57)	(1.52)
	Nectarinia jugularis	R	LC	0	0	10
	(Olive-backed Sunbird)					(2.54)
	Nectarinia sperata	R	LC	0	0	6
	(Purple-throated Sunbird)					(1.52)
(Oriolidae)	*Oriolus chinensis*	R	LC	0	0	2
	(Black-naped Oriole)					(0.51)
	Oriolus xanthonotus	R	NT	0	0	1
	(Dark-throated Oriole)					(0.25)
(Pachycephalidae)	*Pachycephala philippinensis*	E	LC	0	3	3
	(Yellow-bellied Whistler)				(1.71)	(0.76)
(Paridae)	*Parus elegans*	E	LC	0	0	5
	(Elegant Tit)					(1.27)
(Pittidae)	*Pitta erythrogaster*	R	LC	0	0	1
	(Red-bellied Pitta)					(0.25)
(Pycnonotidae)	*Ixos everetti*	E	LC	0	2	2
	(*Hypsipetes everetti*)				(1.14)	(0.51)
	(Yellowish Bulbul)					
	Ixos philippinus	E	LC	**6**	20	**36**
	(*Hypsipetes philippinus*)			**(22.22)**	(11.43)	**(9.14)**
	(Philippine Bulbul)					
	Pycnonotus goiavier	R	LC	0	0	33
	(Yellow-vented Bulbul)					(8.38)
	Pycnonotus urostictus	E	LC	2	3	15
	(Yellow-wattled Bulbul)			(7.41)	(1.71)	(3.81)
(Rhabdornithidae)	*Rhabdornis mystacalis*	E	LC	0	0	1
	(Striped-headed Rhabdornis)					(0.25)
(Sittidae)	*Sitta frontalis*	R	LC	0	0	1
	(Velvet-fronted Nuthatch)					(0.25)

Order (Family)	Species (Old Name) (CN)	D	CS (LCS) IUCN 2014	Site 1	Site 2	Site 3
(Sturnidae)	*Aplonis panayensis*	R	LC	0	0	4
	(Asian Glossy Starling)					(1.02)
	Sarcops calvus	R	LC	0	0	8
	(Coleto)					(2.03)
(Sylviidae)	*Megalurus palustris*	R	LC	0	0	4
	(Striated Grassbird)					(1.02)
	Megalurus timoriensis	R	LC	0	0	3
	(Tawny Grassbird)					(0.76)
	Phylloscopus trivirgatus	R	LC	0	1	3
	(Mountain Leaf-warbler)				(0.57)	(0.76)
	Orthotomus cuculatus	R	LC	0	4	8
	(Mountain Tailorbird)				(2.29)	(2.03)
	Orthotomus nigriceps	E	LC	0	5	4
	(Black-headed Tailorbird)				(2.86)	(1.02)
(Timaliidae)	*Macronous striaticeps*	E	LC	1	6	15
	(Brown Tit-babbler)			(3.70)	(3.43)	(3.81)
	Ptilocichla mindanensis	E	LC	0	1	3
	(Striated Wren-babbler)				(0.57)	(0.76)
	Stachyris capitalis	E	LC	0	0	1
	(Rusty-crowned Babbler)					(0.25)
(Zosteropidae)	*Zosterops montanus*	R	LC	0	0	14
	(Mountain White-eye)					(3.55)
Piciformes	*Megalaima haemacephala*	R	LC	0	2	11
(Megalaimidae)	(Coppersmith Barbet)				(1.14)	(2.79)
Psittaciformes	*Bolbopsittacus lunulatus*	E	LC	0	1	6
(Psittacidae)	(Guaiabero)				(0.57)	(1.52)
	Loriculus philippensis	E	LC	2	0	2
	(Philippine Hanging-parrot)			(7.41)		(0.51)
Strigiformes	*Otus megalotis*	E	LC	0	1	0
(Strigidae)	(Philippine Scops-owl)				(0.57)	
	Total no. of species: 83			11	44	71
	Total no. of individuals: 596			27	175	394
				(4.53)	(29.36)	(66.11)
	Total no. of endemic species: 35			8	28	27
	Total no. of threatened species					
	Endangered species: 1					1
	Vulnerable species: 4			1	3	1

Legend: CN – Common Name, D – Distribution (R – Resident; M – Migrant; E – Endemic), CS – Conservation Status (LC – Least Concern; NT – Near Threatened; V – Vulnerable; EN – Endangered), LCS – Local Conservation Status (LT – Locally Threatened; *Socio-economically important, hunted for food), Site 1 - Bega Falls; Site 2 - Enchanted Falls; Site 3 -Tiger Falls, relative abundance (), bold numbers are dominant species.

Species richness

An overall species richness of 83 was recorded in the watershed. According to Paker *et al.* (2013), richness of trees and shrubs, small lawns, and tree cover invite most bird species which shows that the watershed is likely to have enough tree cover and is rich in trees and shrubs serving as foraging site for a big number of bird species. Highest species richness and number of individuals of birds were recorded in sampling site 3. This may be due to lesser disturbances observed in the area and high structural diversity which is said to provide different micro-habitats and niches for a wide variety of bird species (Mulwa *et al.*, 2012). It was also pointed out by Soka *et al.* (2013) that a higher abundance of birds in a terrestrial habitat might be brought by the vegetation composition that forms the main element of their habitat or it may be influenced by landscape, floral diversity, anthropogenic activities, as well as predation (Prakash and Manasvini, 2013). In addition, lowest species richness was recorded in site 1. Low species richness is likely due to lesser diversity of habitat for some forest avian guilds, and may be due to elevation (McCain and Grytnes, 2010; Huang *et al.*, 2014).

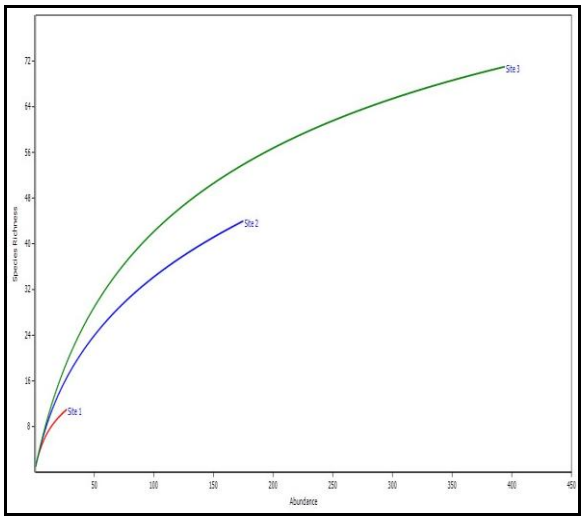

Fig. 2. Individual Rarefaction curves for avifauna in three sampling sites.

Fig. 2 shows three individual rarefaction curves. Ellis and Betts (2011) reported that rarefaction allows comparison of species richness at a standardized sample size and avoids perplexing genuine differences in species richness with differences in sampling effort and mist net efficiency. It is shown that site 3 had the highest curve. This means that the species richness is highest in this habitat and that a rigorous sampling in this site will only retrieve a few additional species (James and Rathbun, 1981; Gotelli and Chao, 2013). However, site 1 had the lowest curve which showed that species richness is lowest in this habitat. This means that more sampling effort in this site would likely to retrieve more new species (Si *et al.*, 2014).

Species Endemism

The number of endemic species was highest in site 2 (Fig. 3), comprising 80%, even if this site is disturbed. This might be due to more fruit-bearing trees present in this site compared to the other sites. Alviola *et al.* (2010) reported that birds are mainly dependent on the availability of food items for their life processes; choosing to stay in places where food is abundant. However, site 3 which is the least disturbed site also holds a considerable number of endemic species. The total number of endemic species also included five globally threatened species, of which one is endangered, and four are vulnerable as categorized by IUCN (2014).

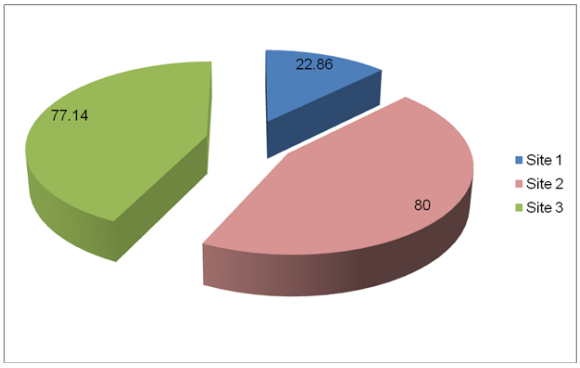

Fig. 3. Endemism percentage of the three sites.

The Philippine hawk-eagle (*Nisaetus philippensis*) was recorded only in site 3. This species is considered to be uncommon being restricted to lowland and mid-mountain forests (Gamauf *et al.*, 1998). Silvery kingfisher (*Alcedo argentata*) was recorded in sites 1 and 2, Mindanao bleeding-heart (*Gallicolumba*

criniger) was recorded in site 3, and Mindanao wattled-broadbill (*Eurylaimus steerii*) and little slaty flycatcher (*Ficedula basilanica*) were both recorded only in site 2. Silvery Kingfisher (*A. argentata*) had the largest number of individuals observed among all the species evaluated as vulnerable. This species was previously widespread and locally common but since its population was suspected to have a rapid decline as it was threatened by habitat destruction, it is now considered vulnerable (Cagod and Nuñeza, 2012). The occurrence of this threatened species is associated with the presence of streams in the area, and this species appears to be dependent on forested streams below 1000 masl and tolerates streamside vegetation within plantations, selectively logged, and secondary forests (Achondo *et al.*, 2011).

Some of the globally threatened birds recorded in this study were reported by Haribon Foundation (2014), such as *A. argentata, E. steerii, F. basilanica* and *G. criniger*. This shows that even though there are anthropogenic activities and habitat degradation seen in the area, the watershed is still able to serve as shelter to some endemic, threatened, and restricted-range species. For the survival of these threatened species, it is essential that the total forested area remain stable. Forests used for selective logging in an appropriate manner will guarantee the survival of the threatened species far better than if these forests are completely denuded (Poulsen, 1995).

Species diversity, evenness, and dominance

High species diversity (H'=3.74) was recorded in site 3 and site 2 (H'=3.254), however, site 1 had a moderate diversity value (Table 2). Batary *et al.* (2014) reported that a high species diversity of birds suggests that there is high tree diversity in the area, while Martin and Blackburn (2014) pointed out that a moderate diversity value might be due to anthropogenic activities in the area which have resulted to low niche competition. This shows that sites 2 and 3 are likely composed of diverse vegetation. The highest number of individuals and species, as well as high species diversity in site 3 (Tiger Falls), was observed to be due to the edge effects. Edge effects refer to the biotic and abiotic contrasts between adjacent habitat types. It may include alteration of the biotic and abiotic factors (Galetti *et al.*, 2003; Foggo *et al.*, 2001). Moreover, Harvey *et al.* (2006) reported that tree covers in secondary and riparian forests would be associated with higher animal species richness and abundance since they are likely to provide resources and habitat for the species originally present in the area than highly modified tree covers. This supports the high species richness and diversity in sites 2 and 3, which are secondary forests. Riparian forests are also important because this type of forest provides forage to forest-dependent bird species. Furthermore, it was shown by Styring *et al.* (2011) that canopy height, secondary canopy development, and shrub cover are important factors in increased species richness and diversity of bird communities.

Table 2. Biodiversity indices in three sampling sites.

	Number of Individuals	Species Richness (S)	Dominance	Species Diversity (H')	Evenness
Sampling Site 1 (Bega Falls)	27	11	0.1358	2.169	0.7958
Sampling Site 2 (Enchanted Falls)	175	44	0.05678	3.254	0.5887
Sampling Site 3 (Tiger Falls)	394	71	0.03495	3.74	0.5928
Total	**596**	**83**	**0.0358**	**3.781**	**0.5287**

Site 1 had the highest dominance index. Dominance results when one or several species control the environment and conditions and influence associated species. A high index implies that a dominant bird species exists in this site (Cagod and Nuñeza, 2012; Soka *et al.*, 2013). The Philippine bulbul (*Ixos philippinus*) was found to be the dominant species (22.22%) in site 1. The evenness value obtained in the three sampling sites shows that the number of individuals within each species was more or less evenly distributed in site 1 while less evenly distributed in sites 2 and 3. This indicates that site 1 may support distribution of generalist and opportunistic bird species that can exploit the available resources, given that site 1 is the most disturbed site among the three sites (Roy *et al.*, 2011).

Similarity of sampling sites

Cluster analysis (Fig. 4) shows the similarity of the three sampling sites, in which sites 2 and 3 formed the first clade which means that these sites shared mostly the same avifaunal species. These sites have the highest similarity percentage, 46.40%. This might be because sites 2 and 3 are both secondary type of forests.

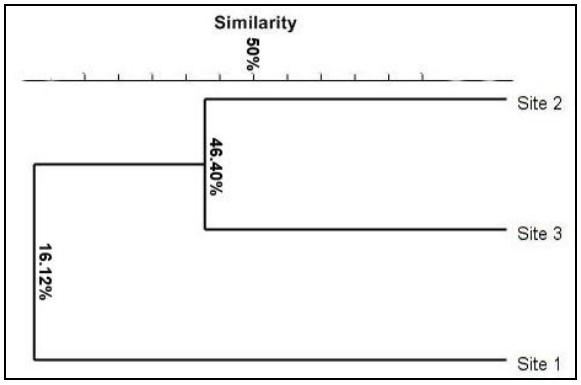

Fig. 4. Similarity of species composition of birds across three sampling sites in Bega Watershed (Bray-Curtis Cluster Analysis – single link).

Tubelis and Cavalcanti (2001) reported that sites having great similarity percentage indicate that these sites might have a similar type of habitat that is why they have a tendency of having similar species composition. Site 1 (Bega Falls) is less related to sites 2 and 3, with a percentage similarity of 16.12%, and this is probably due to the anthropogenic activities observed in the area. Cluster analysis presents a hierarchical grouping of species that may possess biological significance which indicates that sites forming the closer clades may be composed of habitat-specific bird species which are very specific about their food plants or insects (Landres and MacMahon, 1980; Joshi *et al.*, 2013).

Relationship between environmental factors and bird assemblage

Canonical correspondence analysis (CCA) showed that bird diversity and abundance are generally influenced by slope, elevation, and on-site disturbances (Fig. 5). Suwanrat *et al.* (2014) reported that steeper slopes in the lowlands are highly preferred by birds in nest-site selection as a strategy to make their nests less accessible to predators. However, in this study *Dicaeum bicolor* has lower abundance in site 1 which has 20-30^{0} slope than site 3 which has a more or less flat slope. This indicates that site 3 is likely a more favorable nesting site. Moreover, elevation affects the condition of the physical environment and the kinds and amounts of resources available for breeding and foraging activities. As elevation increases, the availability of resources for birds diminishes (Waterhouse *et al.*, 2002). *Macronous striaticeps* appears to increase in abundance with slightly higher elevation in site 3. However, this elevation is still a lowland elevation and not high enough to limit resource availability for birds. Instead, site 3 appears to be a more favorable site or the food source is available at this site.

In addition, on-site disturbances such as deforestation and slash-and-burn activity have a great impact on several number of bird species such as *Collocalia esculenta, Dicaeum australe* and *Ixos philippinus* where their abundance is lowest at most disturbed sites. According to Sheta *et al.* (2010), increases in anthropogenic activities decreases the persistence of local populations by compromising habitat sustainability, restraining feeding and

breeding opportunities, and increasing local extinctions of wildlife species.

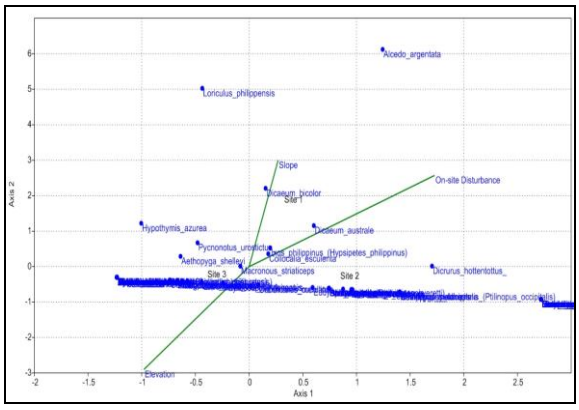

Fig. 5. Canonical correspondence analysis (CCA) diagram showing three environmental factors – slope, elevation, and level of on-site disturbance.

Threats to the avifauna in Bega watershed

Hunting and trapping of birds such as doves, was observed to be present in the area. These birds are hunted for food since they possess large and meaty bodies and are good sources of proteins. A respondent said that *Phapitreron leucotis,* or locally called "alimukon", was tasty and meaty compared to other birds, thus it is eaten favorably by the local residents. Deforestation was also observed in the watershed where a part of the forest was being turned into agroforest. Suarez and Sajise (2010) pointed out that habitat loss is one of the major drivers of biodiversity loss. Habitat complexity and specialized niches may also be lost due to deforestation. Improper disposal of garbage was also observed in the study area which causes pollution in the habitat. These factors are considered to be threats to the avifauna in the Bega Watershed, thus strong conservation measures are needed. BirdLife International (2008) reported that a number of threatening activities causes declines in bird populations. Among them are habitat conversion, logging and wood harvesting, hunting and trapping, and habitat destructing and degradation. All these threats were taken into account in the IUCN Red List which contributed serious negative impacts to some bird species causing them to be classified as globally threatened.

Conclusion

The Philippine bulbul (*Ixos philippinus*) was the most abundant species. A low endemism of 42.17% was observed in the watershed but presence of endemic species as well as migrant and globally threatened species suggests that Bega Watershed is a key conservation site. Moreover, highest number of endemic species was recorded in site 2, indicating the need for more conservation effort in this site. Site 3 had the highest species richness, comprising 71 species due to lesser disturbance present in the site. A high species diversity (H'=3.781) was recorded in Bega Watershed where site 3 had the highest species diversity (H'=3.74) among all sites. More sampling efforts in site 1 could likely yield to a higher number of species.

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