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Cover: Pseudo-flying animals and wind-dependent seed & spore dispersers – made with digital painting in Krita. © Melito Prinson Pinto



Seasonal diversity and dietary guild structure of birds in two Vindhyan gorge forests of Rajasthan, India

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Abstract: Habitat is the key factor of biodiversity conservation. In Vindhyan mountain range of India, there are many perennial and seasonal rivers which create deep gorges in their course of flow. Two Vindhyan gorges—Tahla and Chainpuriya—were studied to know their potential as bird habitat from July 2016 to June 2018 using line transect method during three season survey basis. The Tahla gorge had 74 bird species of 35 families (67 resident and 7 migratory). The Chainpuriya gorge had 60 bird species belonged to 31 families (53 resident and 7 migratory). Highest bird diversity ($H_r = 3.55$, $H_{ch} = 3.29$) and richness ($d_r = 9.63$, $d_{ch} = 8.28$) was found in summer and the least diversity ($H_r = 3.40$, $H_{ch} = 3.19$) and richness ($d_r = 7.95$, $d_{ch} = 7.49$) was found in monsoon. Birds of family Muscicapidae had highest relative diversity ($T = 9.45$, $Ch = 13.33$) in both the gorges. Insectivorous guild was most abundant followed by omnivorous, carnivorous, granivorous, frugivorous, and nectarivorous guilds. Wide range of habitats, variety of food, life resources, and undisturbed self-sustained ecosystem were important key factors for the rich diversity of birds in the gorges.

Keywords: Avifauna, Chainpuriya, gorge biodiversity, habitat, migratory birds, mountain range, northwestern India, Tahla.

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INTRODUCTION

Rising anthropogenic activities worldwide lead to destruction and fragmentation of habitats, which are the serious threats to the bird community (Baral & Inskipp 2005; Gautam & Kafle 2007). But, there are a few habitats on Earth which naturally protects biodiversity in spite of all the threats. Gorges and canyons are among these places. Gorges and canyons are deep, narrow valleys, result of continuous land erosion by the water streams (Singh 2015). The deepness of gorges keep them isolated from the rest of the world and the self-sustained ecosystem supports a variety of life forms in them. These have diverse micro ecosystems due to variation in humidity, sunlight, temperature, and other abiotic factors (Mowbray & Henry 1968; Grant 2005). Along with the diverse ecosystem, undisturbed ecology, least human interference, favorable climatic conditions with sufficiency of life resources are some peculiar features of gorge habitat which make them 'nature conserved gene reservoirs'.

Rajasthan is the northwestern state of India where in Vindhyan range is one of the important mountain range with Aravalli. It spreads from Dholpur district in east to Chittorgarh districts in southern Rajasthan. A number of rivers have their origin from Vindhyas among which Berach, Kali Sindh, Chambal, Menali, Parwan are some representative rivers. These rivers cut the soft rocks of limestone and sandstone in their path to make deep gorges which are the characteristic of the Vindhyas.

Birds are important indicators of environmental health as they quickly respond to habitat change and disturbance (Mekonen 2017). So the status of bird community of a place is a glimpse of habitat sustainability. Diversity of birds of the gorges and canyons have been studied worldwide (Parnell & Quay 1964; Taylor 1989; Hornsby 1997; Nikolov & Spasov 2005; Patten et al. 2006; Spence et al. 2011; Malan & Lerm 2013; Kopij 2013), but neglected in India (Sharma & Singh 2006; Joshi & Bhatnagar 2016). So the present study is an effort to enlighten the bird diversity of two potential but lesser known Vindhyan gorges, which are not studied earlier.

Study Area

The study was conducted in two Vindhyan gorges, i.e., Tahla and Chainpuriya located in the district of Bhilwara, Rajasthan (Figure 1). The details of the gorges are as follows:.

1. Tahla: The gorge of Tahla (25.66°N & 75.41°E) is located 70 km away from the district headquarter and

situated outside of village Tahla. The length of the gorge is 650 m. It is an open type of gorge with high east-facing cliffs (Image 1). The gorge has plenty of water in monsoon, but no surface water available in other seasons. Although, the presence of riparian vegetation indicates high ground water availability throughout the year.

2. Chainpuriya: The gorge of Chainpuriya (25.03°N & 76.46°E) is located 62 km from Bhilwara district headquarter and 1.5 km away the gorge of Tahla. It is 760 m long and comparatively narrow than the Tahla gorge (Image 2). The plateau on the terrace of the gorge is suffered from denudation. During monsoon, water collects from the highland and flows as a stream in the gorge, but does not accumulate due to lack of any pit or pond in it. High cliffs are totally wanting.

The study areas had a mixed type of vegetation including grasses, herbs, shrubs, and trees. The climate of the area was semi-dry type and the vegetation was dry mixed deciduous type having Dhauk *Anogeissus pendula*, Dhauk *Butea monosperma*, Gurjan *Lannea coromandelica*, Salar *Boswellia serrata*, Safed Dhauk *Anogeissus latifolia*, and Tendu *Diospyros melanoxylon* as principal vegetation. Riparian vegetation was also present in the bottom of the gorges near stream of water and the important were Arjuna *Terminalia arjuna*, Kadamb *Mitragyna parvifolia*, Baheda *Terminalia bellirica*, Makhania Jamun *Syzygium heyneanum*, Umara *Ficus glomerata*, Karmala *Mallotus philippensis*, and Khajoor *Phoenix sylvestris*.

MATERIAL AND METHODS

The study was conducted from July 2016 to June 2018. Three season survey (summer, winter, and monsoon) were designed for the study. Early morning visits from 0600 h to 0800 h in the summer and monsoon and 0700 h to 0900 h in winter were done. Days of rain and strong wind were avoided during monsoon. Line transect method (Bibby et al. 1998) was followed in which random transects of different length were laid on the roof and at bottom of the gorge in such a way that maximum microhabitat could be covered. Length of the transects was 520 m (roof) and 650 m (bottom) in Tahla gorge, while 470 m, 950 m (roof) and 760 m (bottom) was in Chainpuriya gorge. Birds were photographed in the field and identified using field guides (Ali & Ripley 2007; Grimmett et al. 2011) and listed according Grimmett et al. (2011).

The residential status of the birds was categorized as

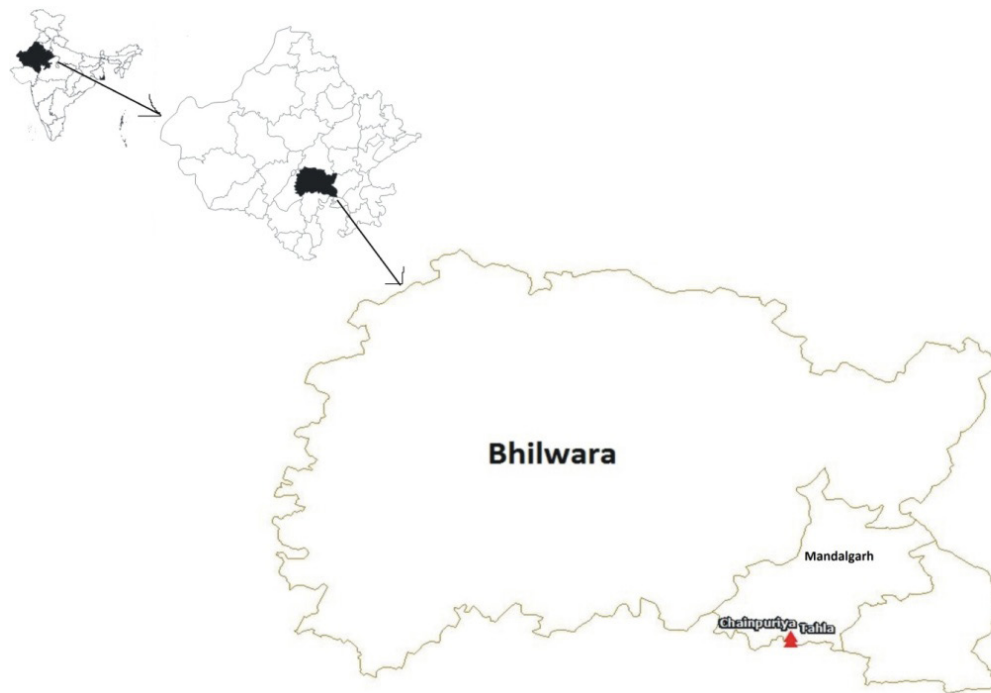


Figure 1. Location of the study area.



Image 1. Overview of Tahla gorge.



Image 2. Overview of Chainpuriya gorge.

'winter migratory', 'summer migratory', and 'resident'. Birds were also categorized according to the guild as carnivorous, insectivorous, frugivorous, granivorous, omnivorous, and nectarivorous on the basis of Ali & Ripley (2007) and field observations. Occurrence of the bird in a habitat was classified into two classes. Birds which were found in the bottom or at the wall of the gorge were classified as 'In Gorge' (IG) and the birds which were observed on the terrace or the flat terrain immediately outside the gorge were classified as birds of 'Roof or the terrace of the gorge' (RG). During field visits the birds that were found to spend more time in the part of the gorge other than terrace, were determined as the birds of gorges in true sense. The local status of birds was measured on the basis of field observations. The bird which was seen many times during a visit was categorized as 'Very Common' (VC). The birds which were sighted fewer times during the same visit were categorized as 'Common' (C) and the birds recorded only one or two times in all the field visits were kept in 'Occasional' (O) category. The relative diversity index (RDi) of bird families was calculated (Torre-Cuadros et al. 2007) using the following formula:

$$\text{Rdi} = \frac{\text{Number of bird species in a family}}{\text{Total number of species}}$$

Sorenson's index (Cs) was measured to know the similarity of bird community between both gorge habitats. This index is based on the presence-absence data of bird species. Value of the index ranges between 0 and 1. Where 0 reflects total dissimilarity and 1 reflects complete similarity. Seasonal data were pooled to understand the seasonal variation in bird assemblage. Further, we also calculated diversity indices Shannon-Wiener's diversity index (H), species evenness, and Margalef's richness index (d) using PAST 4.0 software. Threats to the habitat and biodiversity were also identified during the entire period of study and mitigation measures were suggested.

RESULTS AND DISCUSSION

A total of 74 bird species of 35 families were recorded in Tahla gorge among which 67 species were resident, four species were winter migratory and three species were summer migratory. Gorge of Chainpuriya had 60 bird species of 31 families out of which 53 were resident, five species were winter migratory and two species were summer migratory (Table 1). Seven bird species in Tahla gorge and 20 species in Chainpuriya

gorge were recorded during previous study (Sharma & Singh 2006). There was a big difference in bird species number between two studies likely due to difference in study period and methodology.

Both the gorges were located only at a distance of 1.5 km but the bird species diversity ($H = 3.46$) and richness ($d = 9.36$) was higher in Tahla gorge than the bird species diversity ($H = 3.29$) and richness ($d = 8.29$) in Chainpuriya gorge (Table 4). More diverse habitats in Tahla gorge including high cliffs, variety of vegetations, accessibility of water, food and other life needs might liable for this high diversity, as species richness in a community increases as environmental heterogeneity increases on a variety of parameters and scales (Gould 2000). This heterogeneity might offer different choices for birds in terms of food and shelter and they prefer the habitat to live. However, water was a limiting factor for the birds in Tahla gorge as there was no perennial source of water or stream available in the gorge besides the rainfall. Some water used to store in the check dam but it was found that it dried up soon after monsoon. There were some locations in the gorge from where underground water bubbled out and deposits in a small pit. This very small quantity of water was available for birds in the hot summer. The less diversity of birds observed in the gorge of Chainpuriya might be due to the lack of any perennial source of water, no water storage structures, absence of high cliffs, denuded terrace of the gorge with less diverse and less dense vegetation, absence of grassland habitat, and the man-made green area to the opposite side of the village. The village had man-made agriculture land with plantation on the opposite side of the gorge as shelter for birds. Deficiency of water and other resources made the birds to move from the gorge to this agriculture land. No water birds were reported during the study period from the gorge as there was no water storage structure found. Lack of high cliffs had made the gorge a non-favourite habitat for cliff-lover birds. Vegetation characteristics were also not lucrative for the frugivorous birds. All these factors may be collectively responsible for less diverse bird community observed in the gorge of Chainpuriya.

Sorenson's Coefficient (Cs) showed a high similarity and less Beta diversity of birds between both the habitats ($Cs = 0.782$). These two gorges are located at a small distance of 1.5 km and the habitats resemble over several parameters such as forest cover, type of vegetation, rock bed, bed pool and many other ecological factors. The small distance and habitat resemblance between gorges bring this overlapping of bird communities result in low beta diversity.

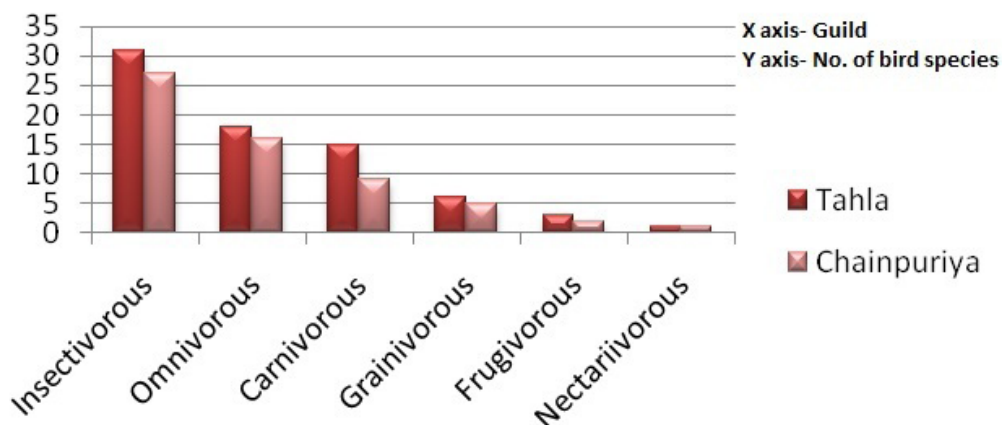


Figure 2. Guild of birds of Tahla and Chainpuriya gorges, Rajasthan, recorded from 2016 to 2018.

Analysis of data on relative diversity revealed that Muscipidae (seven species, $RDi = 9.45$) along with Accipitridae (seven species, $RDi = 9.45$) had maximum diversity in Tahla gorge. It is followed by Columbidae (six species, $RDi = 8.10$), Cuculidae, Cisticolidae (four species, $RDi = 5.40$), and Phasianidae, Strigidae, & Campephagidae (three species, $RDi = 4.05$) families. Ten families had two species ($RDi = 2.70$) and 17 families were poorly represented (one species, $RDi = 1.35$) (Table 2). In Chainpuriya gorge, the most diverse bird family was Muscipidae (eight species, $RDi = 13.33$). Columbidae, Cuculidae, Cisticolidae (four species, $RDi = 6.66$) were the second most diverse families followed by Sylviidae (three species, $RDi = 5$). Eleven families had two species ($RDi = 3.33$) and 15 families were poorly represented (one species, $RDi = 1.66$) (Table 3). Muscipidae and Accipitridae showed the highest diversity in the gorges. The reason behind the high diversity of family Muscipidae was the high density of insect (food) population in the gorges on account of high humidity and temperature variation, flowering vegetation, and grasses (Joshi & Bhatnagar 2016). Habitat characteristics of gorges like high cliffs, crevices, cavities are favourable for the birds of Accipitridae that may lead to high diversity of the birds of family Accipitridae.

In this study, the bird species were categorized into six major guilds (Figure 2) which showed that the habitat had a wide variety of food resources for the birds. The insectivorous guild was the most abundant ($T = 31$, $Ch = 27$). It was followed by omnivorous ($T = 18$, $Ch = 16$), carnivorous ($T = 15$, $Ch = 9$), granivorous ($T = 6$, $Ch = 5$), frugivorous ($T = 3$, $Ch = 2$), and nectarivorous ($T = 1$, $Ch = 1$) guilds. As it is mentioned before that the local climate and vegetation characteristics ensure high insect population for insect-eating birds. So the gorges have a

lot of food for insectivorous birds' families Muscipidae, Cuculidae, and Cisticolidae. The result is found with the study on a Vindhyan gorge of Kekariya by Joshi & Bhatnagar (2016) where the insectivorous guild was dominating. Birds of families Accipitridae, Tytonidae, and Strigidae are the birds of prey and made a significant account of carnivorous birds in the gorges. Tahla had 15 species and Chainpuriya had nine species of carnivorous birds. Besides, high cliffs, cavities, and caves in gorges are preferred habitat for the raptors. The population of grainivorous bird species of family Columbidae had supported by nearby cultivation fields and grasslands. Nectarivorous guild was represented by only a single bird species. Thus, the supporting environment and geography of the gorges is significant for the diversity of birds.

Seasonal changes in the bird richness and diversity was recorded in the gorges (Table 4). Both the gorges had the maximum bird diversity ($H_T = 3.55$, $H_{Ch} = 3.29$) in summer and the least diversity ($H_T = 3.40$, $H_{Ch} = 3.19$) in monsoon. Bird species richness was also maximum ($d_T = 9.63$, $d_{Ch} = 8.28$) in summer and the least ($d_T = 7.95$, $d_{Ch} = 7.49$) in monsoon season in both Tahla and Chainpuriya gorges. Gorges had all life resources for the birds including water. During summers these are the only place in the area for the birds to get water. In monsoon, birds can find their food and water easily in the surrounding area outside the gorge. So bird richness was recorded less in monsoon.

Breeding colonies of Long-billed Vultures *Gyps indicus* (Critically Endangered) and Egyptian Vulture *Neophron percnopterus* (Endangered) were recorded in the study. As literature stated that high cliffs are preferred nesting habitat of both Long-billed Vultures and Egyptian Vultures (Rahmani 2015; Manchiryal &

Table 1. Birds of two Vindhyan gorges, Bhilwara, Rajasthan.

Family	English name	Scientific name	RS	LG	LS	BS	Guild	Vindhyan Gorge	
								Tahla	Chainpuriya
Phasianidae	Grey Francolin	<i>Francolinus pondicerianus</i>	R	RG	O	PB	O	✓	✓
	Jungle Bush Quail	<i>Perdica asiatica</i>	R	RG	C	PB	O	✓	
	Indian Peafowl	<i>Pavo cristatus</i>	R	IG/RG	C	B	O	✓	✓
Ardeidae	Little Egret	<i>Egretta garzetta</i>	R	IG/RG	VC	B	C		✓
	Cattle Egret	<i>Bubulcus ibis</i>	R	RG	VC	B	C	✓	✓
Falconidae	Common Kestrel	<i>Falco tinnunculus</i>	WM	RG	O	NC	C	✓	✓
Accipitridae	Egyptian Vulture	<i>Neophron percnopterus</i>	R	IG	C	B	C	✓	
	Indian Vulture	<i>Gyps indicus</i>	R	IG	C	B	C	✓	
	Crested Serpent Eagle	<i>Spilornis cheela</i>	R	RG	C	NC	C	✓	
	Shikra	<i>Accipiter badius</i>	R	RG/IG	C	B	C	✓	✓
	Oriental Honey- buzzard	<i>Pernis ptilorhynchus</i>	R	RG	C	NC	C	✓	
	Short-toed Snake Eagle	<i>Circaetus gallicus</i>	R	RG	O	NC	C	✓	✓
	Eurasian Sparrowhawk	<i>Accipiter nisus</i>	SM	IG	O	NC	C	✓	
Columbidae	Common Pigeon	<i>Columba livia</i>	R	RG/IG	VC	B	G	✓	✓
	Eurasian Collared Dove	<i>Streptopelia decaocto</i>	R	RG/IG	VC	B	G	✓	✓
	Red Collared Dove	<i>Streptopelia tranquebarica</i>	R	RG	O	NC	G	✓	
	Spotted Dove	<i>Stigmatopelia chinensis</i>	R	RG/IG	C	B	G	✓	✓
	Laughing Dove	<i>Stigmatopelia senegalensis</i>	R	RG/IG	VC	B	G	✓	✓
	Yellow-footed Green Pigeon	<i>Treron phoenicopterus</i>	R	RG/IG	C	B	F	✓	
Psittacidae	Rose-ringed Parakeet	<i>Psittacula krameri</i>	R	RG/IG	VC	B	F	✓	✓
	Plum-headed Parakeet	<i>Psittacula cyanocephala</i>	R	RG/IG	C	B	F	✓	✓
Cuculidae	Jacobin Cuckoo	<i>Clamator jacobinus</i>	SM	RG	O	NC	I	✓	✓
	Common Hawk Cuckoo	<i>Hierococcyx varius</i>	SM	RG	O	NC	I	✓	✓
	Asian Koel	<i>Eudynamis scolopaceus</i>	R	RG/IG	VC	B	O	✓	✓
	Greater Coucal	<i>Centropus sinensis</i>	R	RG/IG	VC	B	C	✓	✓
Tytonidae	Barn Owl	<i>Tyto alba</i>	R	IG	O	NC	C		✓
Strigidae	SpottedOwlet	<i>Athene brama</i>	R	RG/IG	O	B	C	✓	✓
	Brown Fish Owl	<i>Ketupa zeylonensis</i>	R	IG	C	NC	C	✓	
	Mottled Wood-Owl	<i>Strix ocellata</i>	R	IG	C	NC	C	✓	
Apodidae	Little Swift	<i>Apus affinis</i>	R	RG	VC	B	I	✓	✓
Coraciidae	Indian Roller	<i>Coracias benghalensis</i>	R	RG	C	B	C	✓	✓
Meropidae	Green Bee-eater	<i>Merops orientalis</i>	R	RG	VC	PB	I	✓	✓
Upupidae	Common Hoopoe	<i>Upupa epops</i>	R	RG	C	NC	I	✓	✓
Picidae	Lesser Goldenbacked	<i>Dinopium benghalense</i>	R	RG/IG	C	B	I	✓	
	White-naped Woodpecker	<i>Chrysocolaptes festivus</i>	R	RG/IG	C	B	I	✓	
Aegithinidae	Common Iora	<i>Aegithina tiphia</i>	R/ LM	RG/IG	C	NC	I	✓	✓
Campephagidae	Large Cuckooshrike	<i>Coracina macei</i>	R	RG	C	PB	I	✓	
	Small Minivet	<i>Pericrocotus cinnamomeus</i>	R	RG/IG	C	NC	I	✓	✓
	Common Woodshrike	<i>Tephrodornis pondicerianus</i>	R	RG/IG	VC	B	I	✓	✓
Laniidae	Bay-backed Shrike	<i>Lanius vittatus</i>	R	RG	C	NC	C	✓	
	Long-tailed Shrike	<i>Lanius schach</i>	R	RG	C	NC	C	✓	
Oriolidae	Indian Golden Oriole	<i>Oriolus oriolus</i>	R/ LM	RG/IG	C	NC	O	✓	

Family	English name	Scientific name	RS	LG	LS	BS	Guild	Vindhyan Gorge	
								Tahla	Chainpuriya
Dicruridae	Black Drongo	<i>Dicrurus macrocercus</i>	R	RG/IG	VC	B	I	✓	✓
	White-bellied Drongo	<i>Dicrurus caerulescens</i>	R	RG/IG	VC	B	I	✓	✓
Rhipiduridae	White-browed Fantail	<i>Rhipidura aureola</i>	R	RG/IG	VC	PB	I	✓	
Monarchidae	Asian Paradise-flycatcher	<i>Terpsiphone paradisi</i>	R/LM	IG	C	PB	I	✓	
Corvidae	Rufous Treepie	<i>Dendrocitta vagabunda</i>	R	RG/IG	VC	B	O	✓	✓
Paridae	Great Tit	<i>Parus major</i>	R	RG/IG	VC	B	O	✓	✓
Hirundinidae	Dusky Crag Martin	<i>Ptyonoprogne concolor</i>	R	IG	VC	B	I	✓	✓
	Red-rumped Swallow	<i>Cecropis daurica</i>	R	IG	VC	B	I	✓	✓
Alaudidae	Indian Bush Lark	<i>Mirafra erythroptera</i>	R	RG	C	NC	O	✓	✓
	Ashy-crowned Sparrow-Lark	<i>Eremopterix griseus</i>	R	RG	VC	B	O	✓	✓
Cisticolidae	Ashy Prinia	<i>Prinia socialis</i>	R	RG/IG	VC	B	I	✓	✓
	Plain Prinia	<i>Prinia inornata</i>	R	RG/IG	VC	PB	I	✓	✓
	Rufous-fronted Prinia	<i>Prinia buchanani</i>	R	RG	C	NC	I		✓
	Grey-breasted Prinia	<i>Prinia hodgsonii</i>	R	RG	C	NC	I	✓	
	Common Tailorbird	<i>Orthotomus sutorius</i>	R	RG/IG	VC	B	I	✓	✓
Sylviidae	Lesser Whitethroat	<i>Sylvia cuouca</i>	WM	RG/IG	O	NC	I	✓	✓
	Sulphur bellied Warbler	<i>Phylloscopus griseolus</i>	R	RG/IG	C	NC	I	✓	✓
	Common Chiffchaff	<i>Phylloscopus collybita</i>	WM	RG/IG	O	NC	I		✓
Pycnonotidae	Red-vented Bulbul	<i>Pycnonotus cafer</i>	R	RG/IG	VC	B	O	✓	✓
Timaliidae	Large Grey Babbler	<i>Turdoides malcolmi</i>	R	RG/IG	VC	PB	O	✓	✓
	Jungle Babbler	<i>Turdoides striata</i>	R	RG/IG	VC	B	O	✓	✓
Sturnidae	Bank Myna	<i>Acridotheres ginginianus</i>	R	RG/IG	VC	B	O		✓
	Common Myna	<i>Acridotheres tristis</i>	R	RG	VC	B	O	✓	
	Brahminy Starling	<i>Sturnia pagodarum</i>	R	RG	VC	B	O	✓	✓
Muscicapidae	Indian Robin	<i>Saxicoloides fulicatus</i>	R	RG	VC	B	I	✓	✓
	Black Redstart	<i>Phoenicurus ochruros</i>	R	RG	O	NC	I	✓	✓
	Common Stonechat	<i>Saxicola torquatus</i>	R	RG	O	NC	I	✓	✓
	Pied Bushchat	<i>Saxicola caprata</i>	R	RG	O	NC	I	✓	✓
	Desert Wheatear	<i>Oenanthe deserti</i>	R	RG	O	NC	I		✓
	Brown Rock Chat	<i>Cercomela fusca</i>	R	RG/IG	C	B	I	✓	✓
	Variable Wheatear	<i>Oenanthe picata</i>	WM	RG	O	NC	I	✓	✓
	Blue Rock-Thrush	<i>Monticola saxatilis</i>	WM	RG	O	NC	I		✓
	Grey-headed Canary Flycatcher	<i>Culicicapa ceylonensis</i>	WM	IG	O	NC	I	✓	
Nectariniidae	Purple Sunbird	<i>Cinnyris asiaticus</i>	R	RG/IG	VC	B	N	✓	✓
Zosteropidae	Oriental White-eye	<i>Zosterops palpebrosus</i>	R/LM	RG/IG	O	NC	O	✓	✓
Passeridae	Chestnut-shouldered Petronia	<i>Gymnoris xanthocollis</i>	R	RG	VC	B	O	✓	✓
	Baya Weaver	<i>Ploceus philippinus</i>	R	RG	C	B	G	✓	
Estrildidae	Indian Silverbill	<i>Euodice malabarica</i>	R	RG	O	B	O		✓
	Scaly-breasted Munia	<i>Lonchura punctulata</i>	R	RG	C	NC	O	✓	✓
Emberizidae	Crested Bunting	<i>Melophus lathami</i>	R	RG	O	NC	G	✓	✓
Total								74	60

RS—Residential status | LG—Location in the gorge | LS—Local status | BS—Breeding status | R—Resident | WM—Winter migratory | SM—Summer migratory | RG—Roof of the gorge | IG—In the gorge | O—Omnivorous | C—Carnivorous | G—Granivorous | I—Insectivorous | N—Nectarivorous | B—Breeding | PB—Probable breeder | NC—Not confirm | O—Occasional | C—Common | VC—Very common.

Table 2. Relative diversity of birds of Tahla gorge.

Families of birds	No. of bird species	Relative diversity index (RDi)
Accipitridae, Muscicapidae	7	9.45
Columbidae	6	8.10
Cuculidae, Cisticolidae	4	5.40
Phasianidae, Strigidae, Campephagidae	3	4.05
Psittacidae, Picidae, Laniidae, Dicruridae, Hirundinidae, Alaudidae, Sylviidae, Timaliidae, Sturnidae, Passeridae	2	2.70
Ardeidae, Falconidae, Apodidae, Coraciidae, Meropidae, Upupidae, Aegithinidae, Oriolidae, Rhipiduridae, Monarchidae, Corvidae, Paridae, Pycnonotidae, Nectariniidae, Zosteropidae, Estrildidae, Emberizidae	1	1.35

Table 3. Relative diversity of birds of Chainpuriya gorge.

Families of birds	No. of bird species	Relative diversity index (RDi)
Muscicapidae	8	13.33
Columbidae, Cuculidae, Cisticolidae	4	6.66
Sylviidae	3	5
Phasianidae, Ardeidae, Accipitridae, Psittacidae, Alaudidae, Campephagidae, Dicruridae, Hirundinidae, Timaliidae, Sturnidae, Estrildidae	2	3.33
Falconidae, Tytonidae, Strigidae, Apodidae, Coraciidae, Paridae, Meropidae, Upupidae, Aegithinidae, Corvidae, Pycnonotidae, Nectariniidae, Zosteropidae, Passeridae, Emberizidae	1	1.66

Table 4. Bird diversity indexes in different seasons of the study period.

Gorge	Shanon's diversity index H				Species evenness				Margalef's richness index d			
	S	W	M	Mean $\pm$ SE	S	W	M	Mean $\pm$ SE	S	W	M	Mean $\pm$ SE
Tahla (T)	3.55	3.44	3.40	3.46 $\pm$ 0.04	0.69	0.56	0.75	0.67 $\pm$ 0.06	9.63	10.5	7.95	9.36 $\pm$ 0.75
Chainpuriya (Ch)	3.29	3.37	3.19	3.29 $\pm$ 0.05	0.61	0.61	0.61	0.61 $\pm$ 0.00	8.28	9.11	7.49	8.29 $\pm$ 0.47

S—Summer | W—Winter | M—Monsoon

Medicheti 2016). Tahla gorge had high east facing cliffs with no disturbance which may provide favourable habitat for these vultures. In contrary, lack of high cliffs in Chainpuriya, is not a suitable habitat for the vultures as well as other raptors.

Threats and conservation

Inspite of the rich biodiversity of gorges, several threats to the habitat and biodiversity were identified during this study. Illegal mining of sand stones and lime stones in the area, grazing pressure on the vegetation specially to the growing plants, firewood collection, soil erosion, lack of awareness regarding the rich biodiversity of the habitat and threats, and not having a proper management plan for the conservation were the principal threats. A proper strategy at both government and local level should be prepared to lighten the severity of the condition of gorge ecosystems. Restoration of deforested area is the immediate requirement to conserve biodiversity. Planned grazing in alternate areas can give enough time to restore plants. People are stakeholders of the natural resources of the gorges so these must be educated to conserve the resources for their sustainable use. Workshops for local school students should be organized near gorges to create

awareness in the future generations. Tourist activities can be promoted with some precautions to generate income for the local people.

CONCLUSION

It can be inferred from the present study that these gorges have high potential to support birds from diverse families as well as diverse habit and habitat. A large number of birds with a high ratio of resident birds in these Vindhyan gorges substantiate high capacity of these habitats to sustain and conserve biodiversity.

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