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Diet Diversity and Dietary Overlap of Two Sympatric Vulture Species in Hirpora Wildlife Sanctuary, Kashmir

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ABSTRACT

Bird species that use similar resources are expected to use variant foraging approaches and segregate in order to minimize a possible competition among them. However, if they fail to attain this exclusion, competition results. We studied the diet composition and dietary overlap between two sympatric vulture species: Himalayan vulture (*Gyps himalayensis*) and Bearded vulture (*Gypaetus barbatus*), the two important avian scavengers of Hirpora Wildlife Sanctuary of Kashmir Himalaya. Analysis of pellets collected from feeding and roosting sites of these vulture species revealed a significant variation in their food consumption with Himalayan species consuming mostly larger dead mammalian species with higher frequency occurrence of 66.66% of *Bubalus bubalus* and bearded species the smaller dead mammalian ones with highest frequency occurrence of *Ovis aries* (83.82%). Diet spectrum of Himalayan vulture was more diverse (H'=1.97) than that of Bearded vulture (H'=1.64). The values of Berger-Parker index (P_{imax}) follows the reverse order of diversity with $P_{imax=}$36.2% for Himalayan vulture and $P_{imax\ =}$48.7% for Bearded vulture. There was very low dietary overlap between the two species (O_{jk}=0.466; C=0.457) which may favor their co-existence. The management of carrions of livestock and setting up of vulture restaurants is the need of the hour for the conservation of these scavenging birds which are facing high risk of extinction in Hirpora Wildlife Sanctuary.

Key words: Diet, vultures, Hirpora, Shopian, Kashmir.

INTRODUCTION

To understand the tropic relationships in animal communities, the assessment of information on the use of food resources is of utmost importance (Pianka 1974; Bianchi 2009). When such information is available, generalizations can be made about various ecological aspects such as foraging strategies and adaptations to various habitats of organisms (Pianka 1975). When resource requirements are similar, competition between sympatric species occurs throughout the annual cycle; however, this competition is reduced by niche differentiation that allows resource partitioning and promotes co-existence (Sabo 1980; Schmutz et al. 1980; Reynolds and Meslow 1984; Golawski et al. 2020). Moreover, knowledge of diet composition and dietary preferences have key influences in the conservation of threatened faunal elements (González et al. 2006) and increase population distribution (Jones 2004). Further, observed dietary preferences are likely to be restricted because of optimum prey-species availability (Hayward et al. 2006) and these species are likely to be of considerable significance to conservation programs. Thus, a comprehensive knowledge of dietary preferences helps us to identify the obstacles before conservation programs permitting concerned shareholders to enhance their rate of success.

An important challenge before birds is to discover and utilize food resources. For this purpose, they must keep stability and equilibrium between the amounts of energy that is spent to the amount of energy that is gained (Pianka 1985; Gutiérrez 1998). An important mechanism that animals use to decrease the competition cost is to occupy different niches. So, by utilizing various methods to reduce competition, they distinguish in what, where and when to eat. If these ways and means overlap, competition may result and that is detrimental to both the species and can spark extinction in due course of time (Pianka 1985).

Generally, scavengers have not been taken into account in food web studies (Wilson and Wolkovich 2011). The availability of carrion can vary spatially and seasonally, thereby, playing an important part in movement and distribution of species feeding on it and stabilizing food

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chains and food webs (Wilson and Wolkovich 2011; Barton et al. 2013). Solid coexistence of different species on same carrion is plausible if there is resource portioning, allowing various species to get segregated in space and time. Therefore, the intervening species need to adapt behaviorally and anatomically to reduce niche overlap and maintain coexistence equilibrium (Houston 1988; Moreno-Opo et al. 2016). Competition allows more aggressive partners to monopolise resources and displace the competition when there is scarcity of resources (Hiraldo et al. 1991; Stolen 1996).

In Hirpora WLS, carrion is utilized by various scavenging animal groups. The principal aerial scavengers are represented by family Accipitridae (Order: Accipitriformes): the Himalayan vulture (*Gyps himalayensis*) (Wani et al. 2020a) and Bearded vulture (*Gypaetus barbatus*); and family Corvidae (Order: Passeriformes): Common raven (*Corvus corax*) (Pers. Obs.). Therefore, there could be competition at least among obligate scavengers for ephemeral carrion (Ballejo et al. 2017).

Vultures occupy a vital position in an ecosystem as efficient scavengers (Kichloo et al. 2020). The Himalayan vulture feeds on old carcasses and typically eat only fleshy parts (Rasmussen and Anderton 2005), whereas bearded vulture usually disdains the actual meat and take bone marrow (Hiraldo et al. 1979; Brown 1988; Wani et al. 2018). However, comparative studies on dietary overlap of Himalayan vulture and Bearded vulture are lacking. Therefore, our motive behind this study was to determine the diet composition of these two scavenging bird species from Hirpora WLS via pellet analysis. We expect a less overlap between the two vulture species that will facilitate their coexistence.

MATERIALS AND METHODS

Study Area

Hirpora Wildlife Sanctuary (33º39'55'' N latitude and 74º39'40'' E longitude), located in Kashmir Division of Jammu and Kashmir at 2546 m.a.s.l. and spreads over an area of about 341km^2. About 78% of the area is rocky (Rather 2016). The area is known for its rich floral and faunal diversity. The vegetation is divided into subalpine pastures, deciduous subalpine scrub forest and mixed coniferous forests (Ahmad et al. 2011; Ahmad et al. 2015). The main faunal elements include- *Capra falconeri*, *Moschus leucogaster*, *Vulpes vulpes*, *Gyps himalayensis* and *Gypaetus barbatus* (Wani et al. 2020b).

Pellet Collection

During field observations, the fecal pellets of Himalayan vulture and Bearded vulture were collected (in 50ml collection tubes) whenever available from feeding grounds and from their roosting places (Fig 1). However, we could not collect any fecal sample from December to February because the sanctuary remained under heavy snow cover during these months that prevented us from reaching to appropriate roosting sites for sample collection. So, we were not enable to analyze our data on seasonal basis.

Pellet Analysis

For the purpose of cuticular examination, hair samples were extracted from each collected pellet. 15g of gelatin were added to 100ml of water to prepare a gelatin solution of 10-20%. In order to fully dissolve the gelatin granules, the whole mixture was stirred constantly while heating at about 60ºC. A thin film of gelatin was prepared on the slide. Strands of hair were placed side by side on the slide using a pair of tweezers. The hairs were left overnight and then they were removed from the set gel the following morning. The imprints of the cuticular scales in the gel cast were examined under a light microscope (Cornally and Lawton 2016) and collated with reference slides and other reference keys (Faliu et al. 1980; Chehébar and Martín 1989; Teerink 1991).

Data Analysis

We expressed our results on diet composition as percentage of frequency (F%) and percentage of occurrence (O%) which correspond to number of times each item is encountered with respect to overall number of food items in all pellets and occurrence of each item with respect to overall number of pellets respectively. Dietary diversity was measured by *Shannon index* (H') dietary overlap was computed by using *Pianka's index* (O_{jk}) (Pianka 1973), *Morisita-Horn index* (C) and *Percentage overlap*. Pianka's index varies between 0 (complete separation) and 1 (complete overlap); values greater than 0.60 depict the overlap (Orlowski and Karg 2013). Similarly, we used *Berger-Parker index* (P_{imax}) to measure the dominance of one prey category in diet (Magurran 1988). To determine whether there is any significant difference in the diet selection of two vulture species we applied the X^2-test.

RESULTS

A total of 316 food items from 176 fecal pellets of vultures (Himalayan vulture (n=108), Bearded vulture (n=68)) that were collected from Hirpora Wildlife sanctuary were isolated and analyzed. From a total of 316 food items, 62.97% belonged to Himalayan vulture (n=199) whereas 37.03% belonged to Bearded vulture (n=117). X^2-test showed that there is a significant variation (X^2=91.98; df=11; P=000) in the consumption of food between Himalayan and Bearded vulture.

Diet Composition

Among 199 food items that were identified from 108 pellet samples of Himalayan vulture, most of them belonged to *Bubalus bubalus*(n=72), followed by *Equus ferus* (n=30), *Capra aegagrus* (n=27), *Ovis aries* (n=25) and others (Table 1). Consequently, the percentage frequency (%F) and percentage occurrence (%O) were highest for *Bubalus bubalus* (%F=36.18 and %O=66.66), followed by *Equus ferus* (%F=15.07 and %O=27.80), *Capra aegagrus* (%F=13.57 and %O=25.00), *Ovis aries* (%F=12.57 and %O=23.14) and others (Table 1). Overall, there were 83.41% domestic species viz. Sheep (*Ovis aries*), Goat (*Capra aegagrus*), Cow (*Bos taurus*), Buffalo (*Bubalus bubalus*), Dog (*Canis familaris*) and Horse (*Equus ferus*) present in the diet of Himalayan vulture (*Gyps himalayensis*) in which 51.25% alone composed of Buffalo (*Bubalus bubalus*) and Horse (*Equus ferus*) in Hirpora Wildlife Sanctuary.

Table 1: Diet composition of Himalayan vulture (*Gyps himalayensis*) in Hirpora Wildlife Sanctuary, Kashmir. We present the number of food items (n), Frequency percentage (%F) corresponding to the percentage of the total number of food items

		Himalayan vulture	
S. No.	Food category	N	%F
1	Sheep (*Ovis aries*)	25	12.56
2	Goat (*Capra aegagrus*)	27	13.57
3	Cow (*Bos taurus*)	12	6.03
4	Buffalo (*Bubalus bubalus*)	72	36.18
5	Dog (*Canis familaris*)	5	2.51
6	Horse (*Equus ferus*)	30	15.07
7	Markhor (*Capra falconeri*)	3	1.50
8	Musk deer (*Moschus leucogaster*)	7	3.52
9	Black bear (*Ursus thibetanus*)	0	0.00
10	Brown bear (*Ursus arctos*)	0	0.00
11	Leopard (*Panthera pardus*)	0	0.00
12	Cat (*Felis catus*)	3	1.50
13	Red fox (*Vulpes vulpes*)	5	2.51
14	Tibetan Wolf (*Canis lupus*)	4	2.01
15	Others	6	3.01
	Total no. food items	199	
	Total no. of pellets	108	

Table 2: Diet composition of Bearded vulture (*Gypaetus barbatus*) in Hirpora Wildlife Sanctuary, Kashmir. We present the number of food items (n), Frequency percentage (%F) corresponding to the percentage of the total number of food items

		Bearded vulture	
S. No.	Food category	N	%F
1	Sheep (*Ovis aries*)	57	48.71
2	Goat (*Capra aegagrus*)	25	21.36
3	Cow (*Bos taurus*)	4	3.42
4	Buffalo (*Bubalus bubalus*)	2	1.70
5	Dog (*Canis familaris*)	4	3.42
6	Horse (*Equus ferus*)	7	5.98
7	Markhor (*Capra falconeri*)	0	0.00
8	Musk deer (*Moschus leucogaster*)	5	4.27
9	Black bear (*Ursus thibetanus*)	0	0.00
10	Brown bear (*Ursus arctos*)	0	0.00
11	Leopard (*Panthera pardus*)	0	0.00
12	Cat (*Felis catus*)	6	5.12
13	Red fox (*Vulpes vulpes*)	0	0.00
14	Tibetan Wolf (*Canis lupus*)	3	2.56
15	Others	4	3.42
	Total no. of food items	117	
	Total no. of pellets	68	

Table 3: Various statistical parameters pertaining to the diet composition and dietary overlap between Himalayan vulture (*Gyps himalayensis*) and Bearded vulture (*Gypaetus barbatus*) in Hirpora Wildlife Sanctuary, Kashmir

Statistical parameter	Himalayan vulture	Bearded vulture
Shannon index(H')	1.97	1.64
Berger-Parker index (P_{imax})	36.2%	48.7%
Pianka's index (O_{jk})	0.466	
Morisita-Horn index (C)	0.457	
Percentage overlap	49.80%	
X^2-test	X^2=91.98; df=11; P=000	

Likewise, among 117 food items that were isolated and identified from 68 pellet samples of Bearded vulture, most belonged to *Ovis aries* (n=57), followed by *Capra aegagrus* (n=25) and others (Table 2). Consequently, the Frequency percentage (%F) and percentage occurrence (%O) were highest for *Ovis aries* (%F=48.71 and %O=83.82), followed by *Capra aegagrus* (%F=21.36 and %O=36.76), and others (Table 2 and Fig.3). Overall, 70.07% diet of Bearded vulture comprised of sheep and goat only.

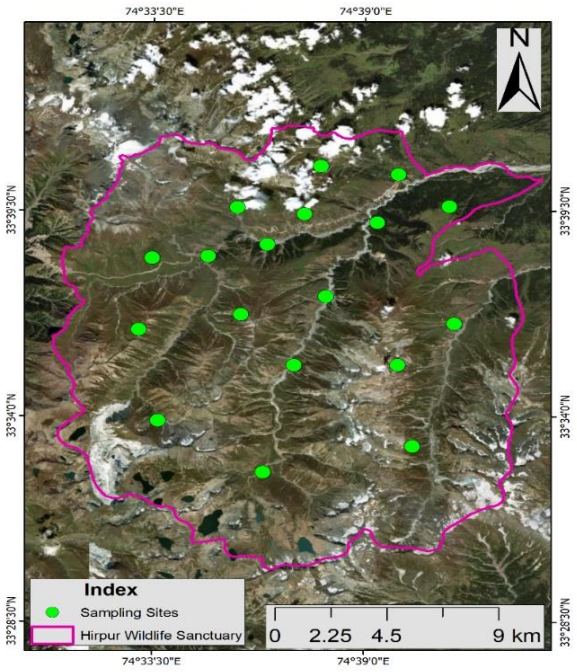

Fig. 1: Map of Hirpora Wildlife Sanctuary showing some important sampling sites.

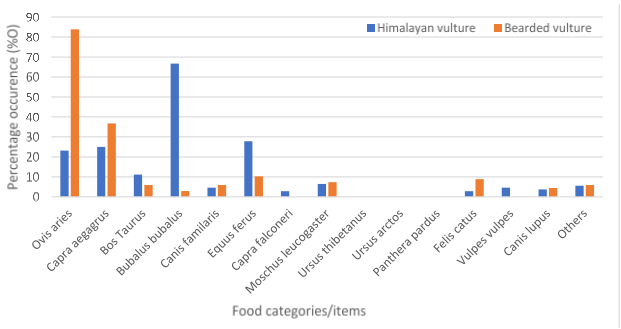

Fig. 2: Percentage occurrence of different food items in the diet spectrum of Himalayan vulture and Bearde vulture.

Diet Diversity and Dietary Overlap

Diet spectrum of Himalayan vulture (*Gyps himalayensis*) (H'=1.97) was more diverse than that of Bearded vulture (*Gypaetus barbatus*) (H'=1.64). However, prey dominance (Berger-Parker index) followed the inverse order of diversity (Table 3), with Bearded vulture (*Gypaetus barbatus*) having the lower diversity and higher dominance and Himalayan vulture (*Gyps himalayensis*) having the higher diversity and lower dominance. Piankas's index showed that there is very low dietary overlap (O_{jk}=0.466; C=0.457) between the two vulture species which was also confirmed and authenticated by Morisita-Horn index (C=0.457) (Table 3). The diet spectrum of Himalayan vulture (*Gyps himalayensis*) was dominated by *Bubalus bubalus* (P_{imax}=36.18) whereas that of Bearded vulture (*Gypaetus barbatus*) by *Ovis aries* (P_{imax}=48.71) (Table 3).

DISCUSSION

Diet Composition

Diet and food intake is a crucial component of animal ecology; therefore, their knowledge is key to the

understanding of occurrence patterns, habitat utilization and breeding success of a species (Donázar and Ceballos 1988; Litvaitis 2000; Sonerud et al. 2002; Sarà and Divittorio 2003; Zduniak and Kuczynski 2003; Pande et al. 2018). Several studies on the decline of vultures have been done (Kanaujia et al. 2013) but studies on their dietary habits and dietary overlap which are of paramount importance for the mutual and long-term survival of the sympatric species and deciphering of higher level of trophic relationships in an ecosystem (Taher et al. 2016), are limited. This study regarding the diet composition and dietary overlap of *Gyps himalayensis* and *Gypaetus barbatus* being first of its kind will set the foundation for the detailed study on various ecological parameters of these sympatric scavenging bird species. Himalayan vulture (*Gyps himalayensis*) feeds exclusively on carrion (Brown and Amadon 1986) and its diet is composed of both domestic yak (*Bos grunniens*) as well as wild ungulates such as *Equus kiang* and *Pantholops hodgsonii* (Li and Kasorndorkbua 2008; Lu et al. 2009; Virani et al. 2008). During present study the consumption of both wild as well as domestic ungulates was also observed in diet spectrum of Himalayan vulture (*Gyps himalayensis*). On Tibetan Plateau their diet is composed of about 61% of dead domestic yak (*Bos grunniens*) elucidating the importance of domestic livestock in the survival of Himalayan vulture. Our results revealed the presence of 83.41% of domestic species viz. Sheep (*Ovis aries*), Goat (*Capra aegagrus*), Cow (*Bos taurus*), Buffalo (*Bubalus bubalus*), Dog (*Canis familaris*) and Horse (*Equus ferus*) in the diet of Himalayan vulture (*Gyps himalayensis*) in Hirpora Wildlife Sanctuary and 51.25% of which is composed of Buffalo (*Bubalus bubalus*) and Horse (*Equus ferus*). The management of large sized mammals in the area is therefore, essential for the conservation of Himalayan vulture. Diet of Bearded vulture is also dominated by domestic livestock as 81.17% was composed of it. These findings are similar to that of Southern African study which has reported that domestic livestock forms over 80% of its diet (Brown and Plug 1990). Margalida et al. (2009), found that bearded vulture avoids the remains of larger species and prefers small sized species as 60% of its diet is composed of sheep and goat. Hence, it did not select prey items with respect to their availability. Such selection can be collated with cost-to-benefit ratio, that is, the energy and time spend in handling, its nutrient content and ingestion of larger bones (Margalida 2008). During current study, 70.07% diet of Bearded vulture comprised of sheep and goat, as the weight and size of their bone remains can be handled and transported easily by the bearded vulture. Hence, management of such medium-sized ungulates (both wild as well as domestic) in Hirpora Wildlife Sanctuary may be deemed as the most important consideration for conservation of *Gypaetus barbatus*.

Diet Diversity and Dietary Overlap

In order to retain a demographic balance among various populations of a community, species have specific feeding strategies and inhabit defined tropic niches. If a species moves apart from this balance, increase in niche overlap may take place, which results in competition for different resources (Pianka 1985). The diet of Himalayan vulture (*Gyps himalayensis*) was diverse than Bearded vulture (*Gypaetus barbatus*). The former feeds on almost all parts of the carcass while later prefers limbs, pieces of muscles, tendon, mid-sized viscera, mixed scraps of meat and small bones mainly from those parts with high nutritive content (Kanaujia et al. 2019). The Old-World vultures are spatially and temporally separated in use of food resources (Kruuk 1967; Blázquez et al. 2009; Cortés-Avizanda 2010; Kendall et al. 2012; Moreno-Opo et al. 2016). Various overlap indices like *Pianka's index* and *Morisita-Horn index* calculated during current study have shown very low overlap in the diet composition of Himalayan vulture (*Gyps himalayensis*) and Bearded vulture (*Gypaetus barbatus*). Also, there being apparent morphological and physiological adaptations between the two vulture species that help them in exploitation of different parts of a carrion (Margalida 2008; Kanaujia and Kushwaha 2013) with no interdependence and far less competition between the two that facilitates coexistence in them.

Conclusion

Management of carrion furnished by animals that die due to traffic on historic Mughal road or that die naturally in Hirpora Wildlife Sanctuary is an important conservation tool for scavenging birds in general and Himalayan and Bearded vultures in particular in the area. Setting up of supplementary feeding stations or vulture restaurants in Hirpora Wildlife Sanctuary may help breeding vulture populations to overcome harsh winter months when the sanctuary remains snow covered.

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Author's Contribution

HMW collected and analysed the data and prepared the manuscript. UHS prepared the map showing sampling points. MFF and SAC reviewed and approved the final version of the manuscript.

Conflict of Interests

The authors declare that they have no conflicting interests.

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