International Journal of
Life Sciences
International Peer Reviewed Open Access Refereed Journal

Int. J. of Life Sciences, 2023; 11 (1): 89-98
ISSN:2320-7817(p) | 2320-964X(o)

Research Article Open Access

Factors influencing the Selection of roost sites of vultures with special references to roosting trees in Palpur-Kuno Wildlife Sanctuary, Madhya Pradesh, India.

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Manuscript details:

Received: 04.12.2022
Accepted: 28.03.2023
Published: 24.04.2023

Cite this article as:
Ruby Yadav and Amita Kanaujia (2023) Factors influencing the Selection of roost sites of vultures with special references to roosting trees in Palpur-Kuno Wildlife Sanctuary, Madhya Pradesh, India., *Int. J. of Life Sciences*, 11 (1): 89-98.

Available online on http://www.ijlsci.in
ISSN: 2320-964X (Online)
ISSN: 2320-7817 (Print)

ABSTRACT

Vultures are the social birds of prey and they roost, soar, and if carcass availability is large enough, they also feed together in flocks. The study was carried out from May2015 to September 2018.The roosting site was observed by travelling on foot using the pedestrian path. The presence of molted feathers and droppings and pellets was used to identify roosting trees. Vultures generally roost on mature trees, cliffs, monuments, and ground during morning and evening hours. The aim of the study is to focus on the selection of roost sites with special reference to trees. Duration of sunlight, the sitting posture of Vultures toward the sun, availability of food resources, the height of trees, condition of trees (good or bad), branching pattern, presence of water body is the factors that influence the selection of the roosting site of Vultures. The result shows 77% of roost trees were in good, 15% intermediate and 8% and in bad condition respectively (based on height, greenery, and branching pattern). The canopy cover of the roost plant was 46% open, 31% flat, and 23% closed type. The mean of the roost tree branches was 4.00±1.51 in number. The mean distance from the roost tree to the breeding site was 3.20±0.84km. The mean height of roost trees was 30.07±4.87m with the mean of Dbh (Diameter at breast height) was 1.74±0.98m. The number of migratory species was higher than residential vulture species. Hence, it is concluded the Palpur-Kuno sanctuary is a major site for migratory vulture during winter and serves as an excellent paradise for vultures for roosting, resting, foraging, assemblage in Madhya Pradesh.

Keywords: Kuno Wildlife Sanctuary, Migratory vultures, Residential vultures, Roosting Site

INTRODUCTION

Roosting as behavior when seen by two or more species together is called communal roosting. Vultures roost in open areas exposed to the sun for the warm-up, regulation of body temperature (Thermo-regulation), and plumage maintenance. Roosting is the aggregation into flocks. It may be on trees, cliffs, old historical monuments (Beauchamp, 1999). It is accompanied by specific social behavior or ethological patterns, and it also has a socioeconomic or epidemiological significance (Stiefel,1976; Chick *et al*., 1980; Glahn *et al.,* 1991; Veselovský ,2005; Škorpíková and Horal, 2006; Camlík, 2011).

Roosting is also a characteristic feature of food search and togetherness among vultures. It is also observed throughout the gamut of bird species (Cramp and Simmons, 1980; Ceballos and Donazar, 1990; Whitaker and Stauffer, 2003; Elif Yamac, 2007) among social birds especially, immature and adult individuals concentrate in communal roosts (Donzar *et al.,* 1994), an example being the highly gregarious vulture species. These birds roost together, soar together and if the carcass is large enough, feed together. Even during the breeding season, birds will often nest in close proximity to a winter roost and will occasionally return to the roost for the night (Sibley *et al.,* 1989). Cinereous vulture *(Aegypius monachus*) roosted on trees nearer to breeding sites to guard the young (Cramp and Simmons, 1980). Out of nine species found in India, Madhya Pradesh has six residential and two migratory species of Vulture in the wild. These are Egyptian Vulture Neophron percnopterus, Cinereous vulture *Aegypius monachus*, Red-headed vulture (King vulture) *Sarcogyps vulture*, Long-billed Vulture (Indian Vulture) *Gyps indicus*, White-rumped vulture *Gyps bengalensis*, Slender-billed vulture *Gyps tenuirostris*, Griffon Vulture *Gyps fulvus* and Himalayan griffon vulture (Himalayan vulture) *Gyps himalayensis* (Gurjar *et al.,* 2011; Navaneethan *et al.,* 2015; Yadav *et al.,* 2018). Both resident and migrant vultures make extensive use of communal roost (Kirk and Mossman, 1998; Evans and Sordahl, 2009). It has several benefits for vultures in terms of reduced thermoregulation costs, reduced predation risk, or to increase foraging efficiency (Ward and Zahavi 1973; Eiserer1984; Hatchwell *et al.,* 2009). The number and composition of individuals in a roost may be influenced by factors such as roost location, roosting site, and abundance of birds in the roost (Rabenold, 1986; Lambertucci, 2013).

The purpose of the present study was to document the factors influencing the selection of roost sites of Vultures in KunoWildlife Sanctuary with special reference to roosting tree and observation of roosting behavior. Observation of vultures roost site in protected areas of Madhya Pradesh provided an opportunity to document the number of vulture species and roost habitat characteristics' needed for taken conservation related decision for vulture species in natural habitat.

Study Area

Kuno Wildlife Sanctuary, also called Palpur-Kuno Wildlife Sanctuary and Kuno-Palpur (25° 30'-25° 53' N and 77° 07'-77° 28' E is located in the heart of the Vindhya Range, Sheopur of northwestern Madhya Pradesh in central India (Fig.1), and encompasses an area of 344.686 sq.km with the core area of 345 sq km and an outer buffer area of 890 sq km. The Kuno River (Shahabad Kuno river) is the principal supply of water for wild animals, which divides the sanctuary from north to south. Kuno Wildlife Sanctuary (KWLS) has northern tropical dry deciduous forest, Northern Tropical Dry Mixed Deciduous forest, *Anogeissus pendula* forest, and *Boswellia* forest (Seth, 1968; Ramesh, 2011). The dominant tree species are Peepal (Ficus,religiosa), Arjun (*Terminalia arjuna*), Tendu Patta (*Diospyros melanoxylon*), Baheda (*Terminalia bellirica*), Sal (*Shorea robusta*), Salai (*Boswellia serrata*), Neem (*Azadirachta indica*), Mango (*Mangifera indica*), Jamun (*Sygigium cumini*), Mahua (*Mahua longifolia*), Babool (*Vachellia nilotica*), Semal (*Bombax ceiba*)*, Gurjan (Dipterocarpus turbinatus),and khair (Senegalia catechu)* (Bipin, 2013). Kuno wildlife sanctuary has four residential Critically Endangered Indian white-backed vultures (*Gyps bengalensis*), long-billed Vulture (*Gypsindicus*), red-headed vulture (*Sarcogyps calvus*), one endangered species (EN) Egyptian vulture (*Neophron percnopterus*) (Ramesh, 2011) and two migratory Griffon vulture (*Gyps fulvus*), Himalayan griffon vulture (*Gyps himalayansis*). Many live nests of white–backed vultures and red-headed vulture were found on rocky grieves along the Kuno river vally (Ramesh, 2011). The Kuno is rich in its faunal diversity, includes Herbivores animals such as Blue *bull, Sambar,* Spotted deer, Blackbuck, and *Chinkara,* which move in herds, are easily spotted

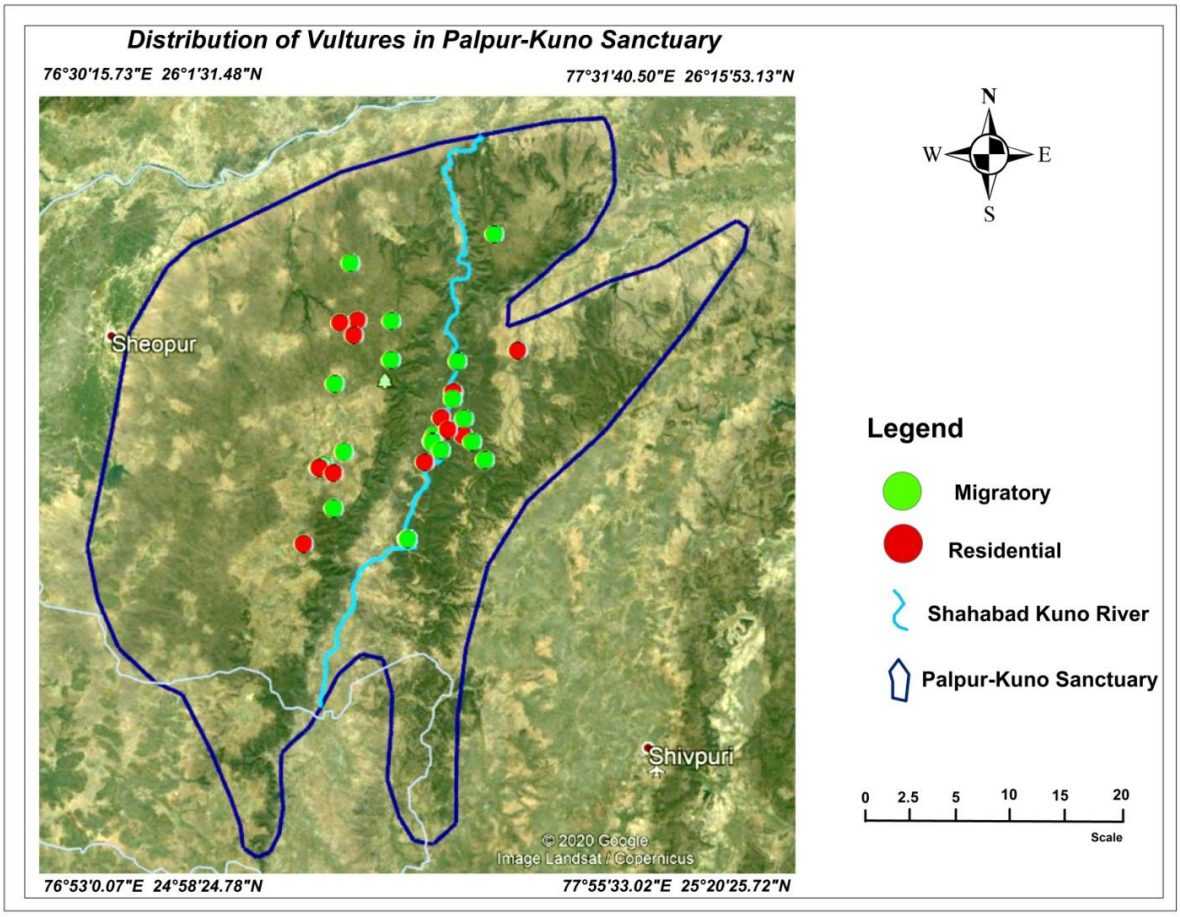


Fig.1: Distribution Map of Migratory and Residential Vulture in Palpur-Kuno Sanctuary, Palpur

here; while the carnivores, including panthers, jackals, foxes, hyenas, and bears. Kuno Wildlife Sanctuary is also rich in reptiles like the Indian screen lizard, python, cobra, viper, and krait *(Bipin CM, 2013*). It has a moderate climatic regime which is slightly arid. The annual average precipitation is 760mm, most of which precipitates between the end of June till September. During December and January, the minimum recorded temperature is about 6.3°C and soars up to 45°C in summer (Sharma, 2007).

MATERIAL AND METHODS

Roost Data Collection: Methodically Roosting sites were searched by traveling on foot using the pedestrian paths. Roosting sites were identified by the presence of molted feathers and droppings and pellets of the Vulture species that could be found on the roost tree (Ceballos and Donazar 1990; ElifYamac, 2006), and roost trees were designated is any adult vulture species could be found roost on them (ElifYamac, 2006). The following information was recorded to describe each roost tree such as roost tree species, number of vulture species roost on mature trees, the height of the tree, DBH of the tree, number of tree branches, canopy cover of Rost tree categorize into three types- (a)Open canopy (Roost trees: Whose tree branches and leaves do not overlap to form a continous canopy layer but are more widly spread, leaving open space for sun-light), (b) Closed canopy (Roost Trees: whose leaves and branches come together as ifto enclose or crown), (c) Flat canopy (Roost Trees: Whose branches spread widly and form a platform like structure). Condition of the tree (Good, Bad, Intermediate based on the evidence of fire and epiphytic growth). We also calculated the percentage of dominant roost trees on which vultures sighting occur by using IBM SPSS software version 20. Roost tree height was observed by using lazar range finder. Roost tree branches of roost trees (Roost trees on which vulture were sighted) were counted manually.

Besides roost tree characteristics', Roost trees distance to the breeding site (km), Feeding site, nearest water

body, and human habitation were also measured by GPS. We also observed the Roosting Behavior of vulture species like the orientation of the sun, sitting posture of vulture concerning the sun (Towards or opposite), (ElifYamac, 2006).

Population Estimation and Tool:

Total 30 surveys, 15 were conducted during breeding and 15 in then on-breeding season both to count the number of resident and migratory vulture by using point count method started from morning 6:30 AM to evening 4:00 PM. Other methods of species counting are distance method, multiple observer method without time were used (DeSante *et al.*, 1995). Our research group is also considering the use of the Lincoln- Petersen model with two independent observers. Record maintained by taking the image by using 700D and 70D SLR canon camera and all the roost sites coordinate recorded by using GPS (Geographical Positing System). This coordinate was used for preparing a map of roost sites of Kuno Wildlife Sanctuary, Madhya Pradesh to find out the exact location in the particular area. The map for the roost sites of residents and the migratory vulture was prepared by using QGIS 2.14 software. All the calculations were done by using IBM SPSS. 20 Software.

RESULTS

The study carried out in Kuno sanctuary Palpur that is the roosting site of vulture from 2015-2018. All the roosting sites were shared by two resident vulture species (Long-billed Vulture (*Gyps indicus*), White backed vulture (*Gyps bengalensis*), and two migratory vulture species Griffon vulture (*Gyps fulvus*), Himalayan griffon vulture (*Gyps himalayansis*) both. Around 332 residents and 347 migratory vultures recorded during the year of 2015-16 followed by 395 Resident and 477 Migratory during the year of 2016-17 and 268 residents and 409 migrants in 2017-18 on 13 tree species of 58 mature plants (Table 1). The Number of migratory vulture populations was more than the resident vultures so the Kuno Palpur sanctuary is the most appropriate residence for roosting. Kuno sanctuary is the major attraction for migratory vulture during winter. No nesting of *Gyps* vulture observed, only single nesting of King Vulture observed on the tree. In 2015-16 about 49% resident and 51% migrants, 2016-17 about 45% resident and 55% migrants, in 2017-18 about 40% resident and 60% migratory. Mean number of Vultures (Resident and Migratory) observed at the roost site from 2015-18 (Fig.2).

Table 1: Number of Migratory and Resident vultures observed during the study (2015-18) in Kuno Wildlife Sanctuary

Site	Number of Vultures (2016-17)		Number of Vultures (2017-18)		Number of Vultures (2018-19)		Total	Total
	Resident	Migratory	Resident	Migratory	Resident	Migratory	Mean ± Std dev	SE of Mean
Agra East	16	00	55	68	43	61	40.5 ±24.60	11.00
Agra West	24	14	12	23	23	44	23.3 ±10.35	4.63
Moravan East	75	45	84	43	21	14	47.0 ±25.61	11.45
Moravan West	45	75	43	87	44	52	57.66 ±17.10	7.64
Palpur East	43	85	85	117	69	82	80.16 ±22.03	9.85
Palpur West	61	105	84	97	45	123	85.83 ±26.33	11.77
Seroni South	68	23	32	42	19	33	36.16 ±16.03	7.17
Total	332	347	395	477	268	409		
X bar ± σ	47.42 ±20.45	49.57 ±36.69	56.42 ±26.96	68.14 ±31.46	37.71 ±16.67	58.42 ±2.95		
SE of Mean	8.35	14.97	11.00	12.84	6.80	13.45		

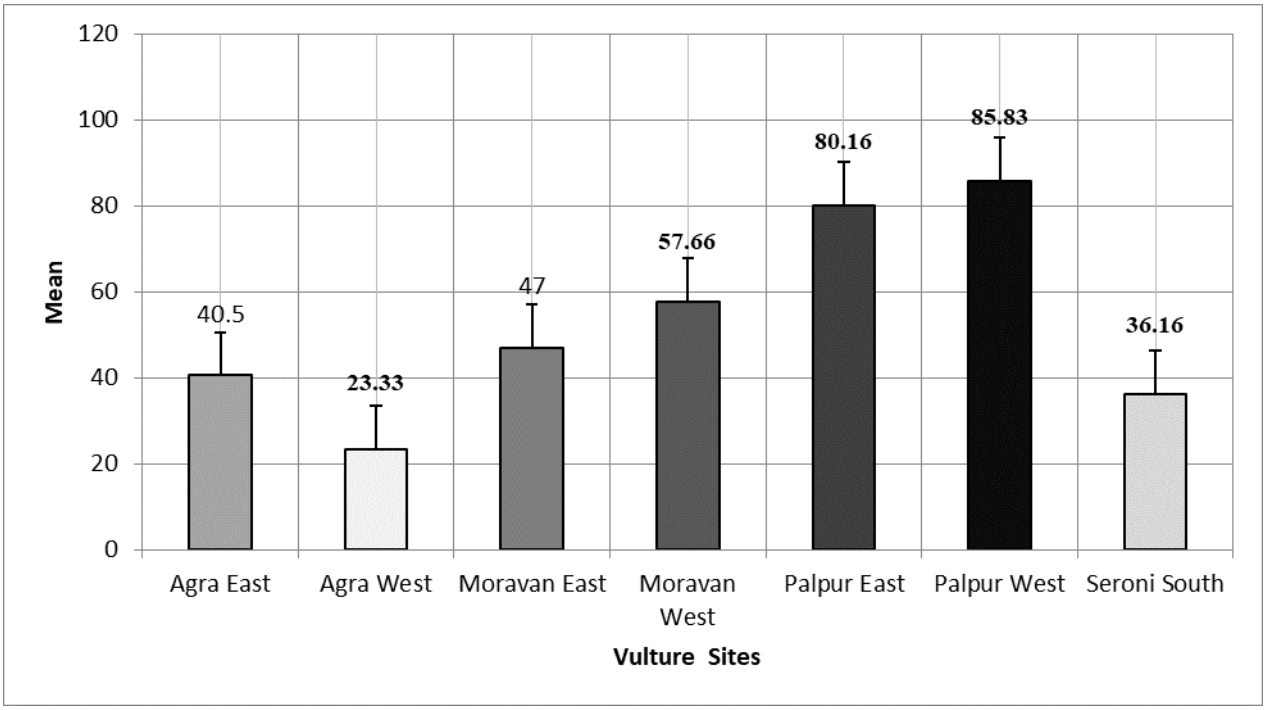


Fig 2: Mean number of Vulture (Resident and Migratory) varies on roost site year by year from 2015-18

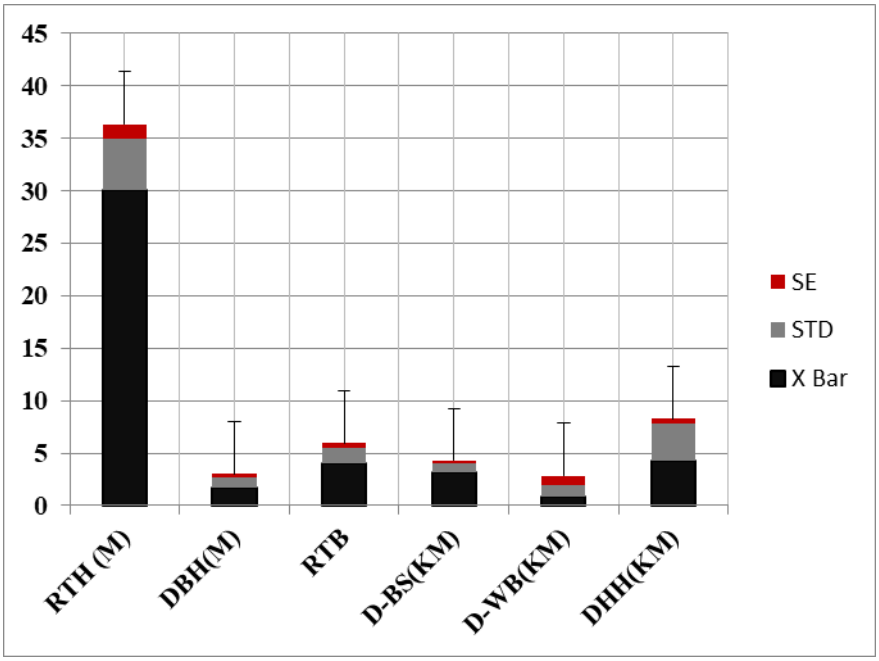
The Selection of roost trees species is varying from species to species. The dominant tree species used for roost was Semal (*Bombax ceiba*) (13%), Tendu (*Diospyros melanoxylon*) (5%), Baheda (*Terminalia arjuna*) (21%), Sal (*Shorearobusta*) (6%), Salai (*Boswellia Serrata*)10%, Babool (*Vachellianilotica*) (4%), Tamarind (*Tamarindusindica*) (7%), Neem (*Azadirachtaindica*) (6%), Mango (*Mangiferaindica*) (4%), Jamun (*Syzygiumcumini*) (3%).Vulture used 58 trees of 13 different species for roosting with the average height of (Mean = 30.07±4.87m), Diameter at breast height DBH 1.74±0.98m, Roost tree branches (4.00±1.51), roost tree distance from breeding site 3.20±0.84 in km. the study also recorded the distance of waterbody from the roost site (Mean = 0.90±1.06) and distance from human habitation (Mean = 4.29 ± 3.55) in table 2 and figure 3. The canopy cover of roost trees was 46% open, 31% flat and 23% closed type (Fig.4).77% roost trees were in good condition, 15% intermediate and 8% was a bad condition (based on height, greenery, and branching pattern) (fig.5). The total Number of Tree species with their percentage is shown in figure 6.

They roost on the top of trees, dead top of live trees, and exposed branches of deciduous species. Vulture roosts by facing back towards the sun, except two or three, but most are towards the sun (Fig.7 and 8). Most of the Vultures sites by keeping back towards the sun essential for the plumage maintenance and thermoregulation. We observed twenty-four cases in the morning time from 11:30am to 11:45am, six cases at 2:16pm to 4:45 pm at noon, and 14 cases in the evening time from 4:00pm to 5:00pm. Morning and evening roosts of turkey vultures also recorded by Davis (1979) at Malheur refuge, Oregon (Davis D, 1979). The sitting posture cannot describe when the sun at the peak of the head. They started to leave the breeding site from 9:45 am to 10:30 am and returned at 5:00 pm to 6:00 pm. Apart from food searching, resting, sleeping, and sitting together, vultures also roost for worm up in winter, temperature, and plumage maintenance.

Our Study observed that the Kuno-wildlife Sanctuary has dominant roosting sites, but surprisingly one nest of Red-headed vulture recorded on Semal Tree (Bombax ceiba) (Fig 9), one another nest of Long-billed vulture (*Gyps indicus*) on Cliff in the kuno-wildlife Sanctuary (Fig 10). It revealed that they select these roost tree species for roosting and breeding purpose also. Similarly, Jha (2015) discuss that vultures used Tree species such as Silk cotton, Sissoo, Sacred fig, Banyan, Haldu Haldina cardifolia, Axlewood (*Anogeisus latifolia*), Cluster Fig (*Ficus racemosa*) and tamarind (*Tamarindus indicus*) for both (roosting and nesting) (Kha, 2015).

Table 2: Statistical analysis of selected variable for roost trees

Tree Parameters	Height (M)	Diameter at breast height (M)	Roost Tree branches	Roost Tree Distance to breeding site (KM)	Distance to the Water body (KM)	Distance from Human Habitation (KM)
Mean ± SD	30.07±4.87	1.74±0.98	4.00±1.51	3.20±0.84	0.90±1.06	4.29±3.55
SE of Mean	1.40	0.28	0.43	0.24	0.90	0.466



RTH (M)= Roost tree Height, DBH(M)= Diameter at Breast Height, RTB= Roost Tree Branch, D-BS(KM) Roost Tree Distance to Breeding site, D-WB(KM) Roost Tree Distance to Water Body, DHH(KM)=Roost Tree Distance to Human habitation

Fig 3: X bar, Slandered deviation and slandered error of mean of roost tree parameters

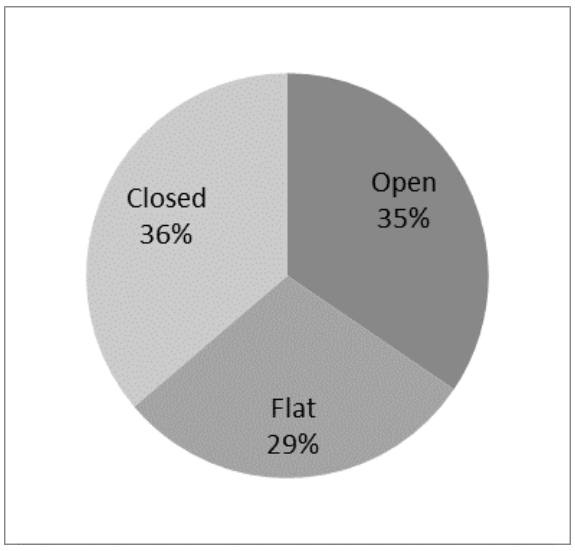


Fig. 4: Percentage of Roost Trees canopy cover

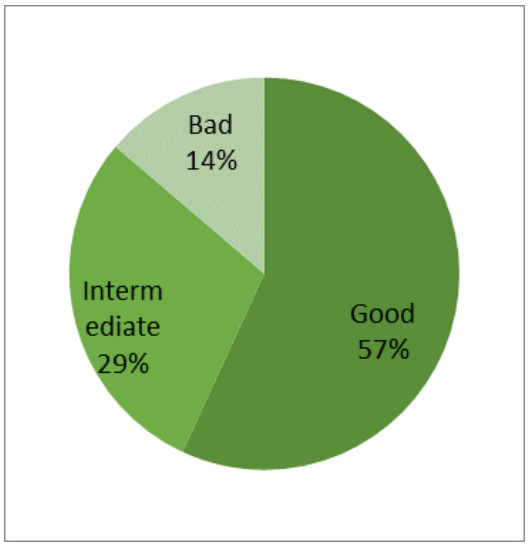


Fig. 5: Percentage of Roost tree condition

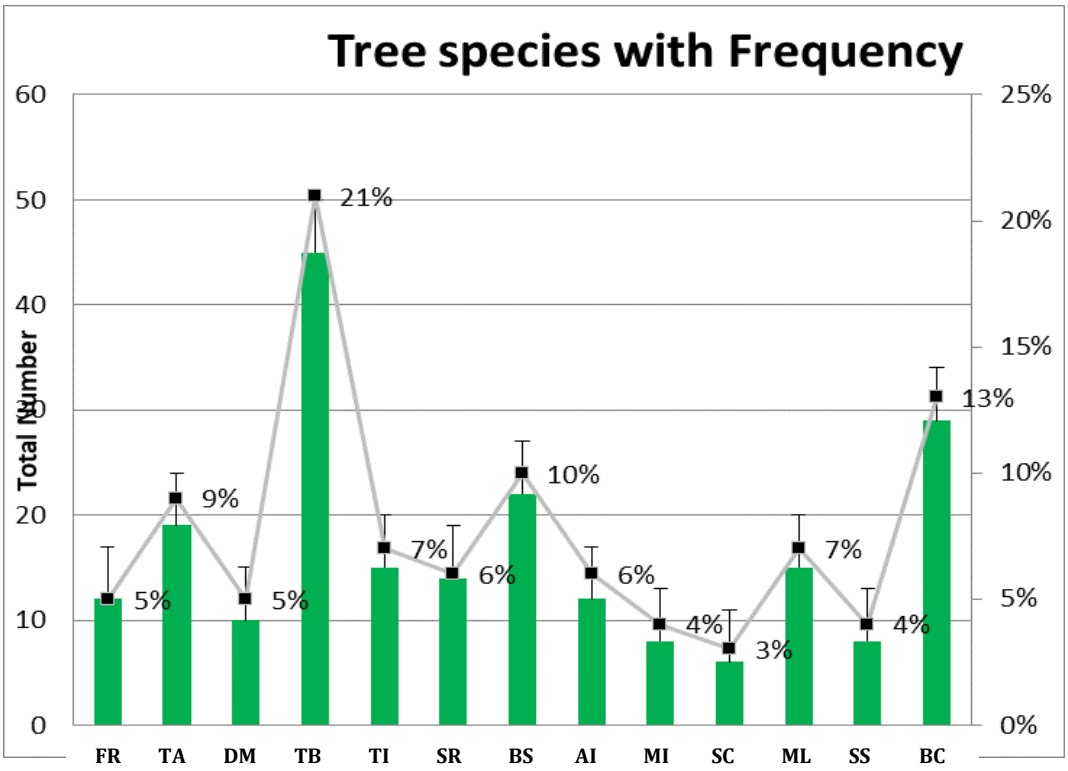


Fig.6: Graph Showing Roost Tree Percentage on which Vultures' Roost

FR=*Ficusrelligiosa*; TA= *Terminalia arjuna*; DM=*Diospyros melanoxylon;* TB=*Terminalia bellirica;* TI=*Tamarindusindica;* SR=*Shorearobusta; BS= Boswelliaserrata;* AI=*Azadirachtaindica;* MI=*Mangiferaindica;* SC=*Syzygiumcumini;ML=Mahua longifolia;SS=Senegalia Senegal;* BC=*Bmbax Ceiba*

DISCUSSION

Vulture roost for some purposes that are in response to short-term accessibility of local food resources and to find the way of food resources (Seeeney and Fraser, 1986; Coleman and Fraser, 1989). Roost is the information-sharing center between the vultures for finding the ways of food resources, habitat characteristics'.

Aggregation of roost vulture on selective roost site use is an indication as "Information centers" amongst the vultures. Vultures aggregate on roost site where unsuccessful foragers return and follow successful individuals to a known food source (Ward and Zahavi, 1973). The major benefits of roost sites attributed to communal roosting are opportunities for social interaction information exchange, and facilitation of group foraging (Rabenold, 1986, 1987; Buckley, 1996; Buckley, 1997). It is a complex progression through which the indigenous population of vultures comprehensive and transfers the information of local food resources of a particular area by forming a roosting system (Stolen and Taylor, 2003). The communal roosts have been the subject of several studies like address habitat characteristics, social behavior, movements between roosts, seasonal and daily use patterns, and population dynamics studied by (Rabenold, 1986, 1987; Wright*et al*1986; Thompson *et al.,* 1990; Buckley, 1998; Stolen and Taylor, 2003; Evans and Sordahl, 2009, Mcvey *et al.,* 2008; Lambertucci *et al.,* 2008). By sharing food with closely related individuals, successful foragers could increase their inclusive fitness (Hamilton, 1964).

Palpur-Kuno sanctuary has mature trees with the flat canopy that's why this is suitable for roost. The study carried out during winter that's the sharing of residential and migratory vulture roost seen in the sanctuary. We observed sharing of roost site by two critically endangered residential vulture species such as white-backed vultures (*Gyps bengalensis*), long-billed Vulture (*Gyps indicus*) and two migratory species Griffon vulture (*Gyps fulvus*), Himalayan griffon

Fig-7 Migratory Vultures Roost on Tree Branches

Fig-8 Residential Vultures Roost on Tree Branches

Fig-9 Nest of Red-headed vulture on Semal tree (Kuno-wildlife sanctuary)

Fig-10 Nest of Long-billed vulture (Gyps indicus) on cliff (Kuno-wildlife sanctuary)

vulture (*Gyps himalayansis*) on Semal tree (*Bombax ceiba*), Tendu (*Diospyros melanoxylon*), Baheda (*Terminalia arjuna*), Sal (*Shorearobusta*), Salai (*Boswellia Serrata*), Babool (*Vachellia nilotica*), Tamarid (*Tamarindusindica*), Neem (*Azadirachtaindica*), Mango (*Mangiferaindica*), Jamun (*Syzygiumcumini*). Sometimes these trees species also used for both (Roost and nesting) purpose (Jha KK, 2015; Khatri PC, 2015). Elic yamac in 2006 also observed roosting of Cinereous vulture *Aegypius monachus* on Black Pine tree during breeding season. That black pine tree has many more and thicker branches, relatively flatter canopies provided optimal roost sites for the vultures. Studies showed that the roost trees were also mature, belonging to the high-diameter size classes having a mean diameter at Breast height (dbh) of 39.47 cm (Elicyamac, 2006). Some vulture's select dead trees for roosting (Ceballos and Donazar, 1990) but the study of Yamac 2004 shown that cinereous vulture always chose trees in good condition. Vultures roost on ground, monument, trees, and cliffs. Vultures sometimes roost on communication and broadcast towers and similar structures. Stolen (1996) recorded 130 vultures roosting on microwave tower in east-central Florid and shown that roosting on towers by vultures will become more widespread, and the need for effective, nonlethal solutions to this problem will increase as well.

In Kuno Sanctuary Palpur roost site is perceived by both migratory and resident vulture species during winter. The number of migratory vulture species is more than the residential vulture species. Daniel A. Airola 1998 described the dynamics of an Urban

Turkey Vulture Roost in Sacramento, California with the change in seasonal pattern that the roost site used by both by migrants and by the resident**.** Dispersing of vulture roost on communication towers also studied by Michael L. Avery *et al* in 2002. Birds roosting on the tower because of their more height than surrounding trees, and vultures can be entering and departed more easily on towers that indicate that vulture chooses roosting site on the based on the size of the area, availability of food resources, less predator, the height of trees tower and cliffs, orientation of the sun, easy movement.

CONCLUSION & RECOMMENDATIONS

Our study suggests that food location, the orientation of sunlight, the posture of sitting and tree characteristic such as tree height, condition of trees (Good or Bad), branching pattern, distance of roost site from the water body, distance to human habitat, distance to breeding are the main factors considered by Vultures for roost site selection. The study observed roosting of vultures on Mature trees such as (*Bombax ceiba*), Tendu (*Diospyros melanoxylon*), Baheda (*Terminalia arjuna*), Sal (*Shorearobusta*), Salai (*Boswellia Serrata*), Babool (*Vachellianilotica*), Tamarind (*Tamarindusindica*), Neem (*Azadirachtaindica*), Mango (*Mangiferaindica*), Jamun (*Syzygiumcumini*). Study concluded that Kuno-wildlife sanctuary has dominant roost sites shared by Long-billed vulture (Residential), White-backed vulture (Residential), Eurasian Griffon vulture (Migratory), and Himalayan vulture (Migratory). These trees species also used for nesting during breeding period (September-May) by residential vultures Long billed vulture (*Gyps indicus*) and red-headed vulture (*Sarcogyps calvus*). Their fore there need to identify the possible roosting sites of Indian Vulture species. Suitable roost trees must be conserved and preserved for long term conservation management of the Kuno-wildlife Sanctuary. Logging activities and other human-induced disturbance as grazing, tree cutting, and poaching, tourist activities, Photography should be restricted for future breeding possibilities.

Acknowledgement: We are very grateful to the Director, DFO, Kuno wildlife sanctuary, and forest department Madhya Pradesh, who have helped to search the roost site and recodes the data. We also thank the Head, Department of zoology, the University of Lucknow for their valuable support for the study.

Conflict of Interest: None of the authors have any conflicts of interest to disclose. All the authors approved the final version of the manuscript.

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